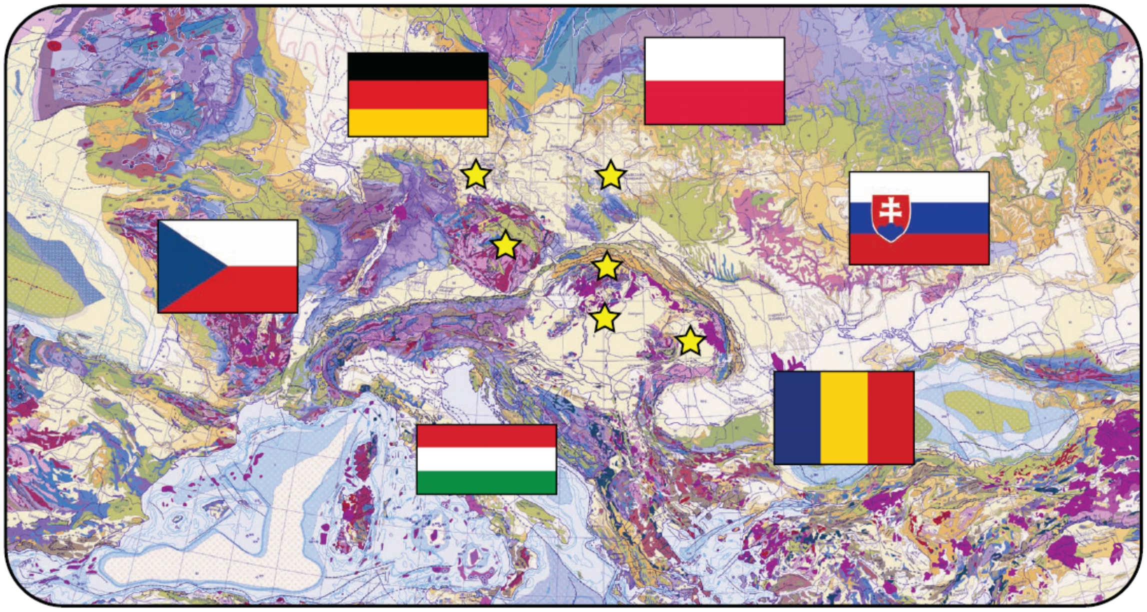
# EASTERN EUROPE

## ORE DEPOSITS FIELD TRIP 2008

APRIL 29th - MAY 14th

SEG - GAC STUDENT CHAPTER
UNIVERSITY OF BRITISH COLUMBIA



*Roşia Poieni, Romania*

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# Eastern Europe
# Field Trip Report

## April 29th – May 14th 2008

The University of British Columbia
Society of Economic Geologists and Geological Association of Canada Student Chapter

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## Acknowledgments

Our sincere thanks to the SEG, the GAC, Anglo American Ltd., Barrick Gold Corp. and Equity Engineering Ltd. for providing essential funding for the 2008 UBC-SEG-GAC student chapter mine tour. Industry participants from Teck Cominco Ltd. Hunter Dickinson Inc., Tüprag Metal Madencilik, and Wallbridge Mining Company, Ltd., and Mikkel Schau and Lyle Hansen are also thanked for their contributions in making the trip a success. Herr Kersten Kühn went out of his way to show us the historic Zinnwald mine. Frau Karin Rank and Dr. Thomas Seifert are kindly acknowledged for showing us the geoscientific collections in Freiberg. Our appreciation also extends to Dr. Slawomir Oszczepalski and the Polish Geological Institute for sharing a great day with us in the field. We would also like to express our appreciation to KGHM Polska Miedź S.A., Andrzej Banaszak, and Jerzy Wróbel for the excellent mine tour at the Rudna mine. Likewise we are thankful to ZGH Bolesław and Włodzimierz Cieślik for having the opportunity to visit the Pomorzany mine. Gabriel Resources Ltd. and the Rosia Montana Gold Corp., provided an excellent background introduction and tour of both the Rosia Montana deposit and the complex social and political issues associated with its development. Adrian Minuț is especially thanked for his help to set up the Rosia Montana visit and helping with accommodation. Cupru Min SA is thanked for access to the Rosia Poieni open pit. European Goldfield Ltd., Dan Filipescu, and Mike Woodbury presented a highly informative introduction and tour of the Certej deposit. Thanks go also to Agatha Sandor for setting up the visit of the Certej deposit and for helping with accommodation, as well as to those not mentioned who contributed to the success of the trip.

Trip participants at the Rosia Poieni open pit, Romania: (from left) Agatha Soful, Luke Beranek, Karie Smith, Stefan Wallier, Scott Blevings, Lucy Hollis, Dianne Mitchinson, Lyle Hansen, Lena Brommeland, Amber Henry, Cuneyt Atilla, Mark Rebagliati, Mikkel Schau, Joshua Bailey, Reza Tafti, Murat Cakir, Jackie Dohaney, Tamer Algun, Kirsten Rasmussen, Andrew Shannon, Alan Wainwright, Hakan Boran, Ozguner Orhaner. Not in photograph: Arda Ayhan.

## Introduction

The 2008 Ore Deposits Field Trip organized by the UBC SEG-GAC Student Chapter covered six countries in Eastern Europe, and exposed the group to a vast range of mineral deposit types and cultures.

Deposits visited during the tour were located in Germany, Poland, and Romania (Fig. 1). The historic Zinnwald underground mine in Erzgebirge, Germany, offered insight into the unique Sn-W-Li vein-hosted deposits found within rhyolitic pods surrounded by granite. Underground tours of Polish deposits were completed for a sediment-hosted Kupreschiefer Type Cu-Ag deposit at the Rudna Mine; a Mississippi-Valley Type Zn-Pb deposit at the Pomorzany Mine; and, the historic Wieliczka Salt Mine with intricately carved walls, floors and sculptures, now open as a popular tourist attraction. The last country visited, Romania, allowed tours of three open pit deposits: the controversial Rosia Montana breccia-hosted epithermal Au-Ag deposit, the Rosia Poieni porphyry Cu-Au deposit (the only mine currently in operation in Romania), and the Certej epithermal Au-Ag-base metal and Au-Te deposit. Our understanding of magmatic-hydrothermal and sediment-hosted mineralizing systems and the spectrum of associated ore deposits was also improved by a visit to an extensive mineralogical-petrological-ore deposit collection in Freiberg, Germany, and a guided geologic tour in southeastern-most Poland showcasing the formations associated with the Kupferschiefer Type deposits in the region (including a rare columnar jointed rhyolite).

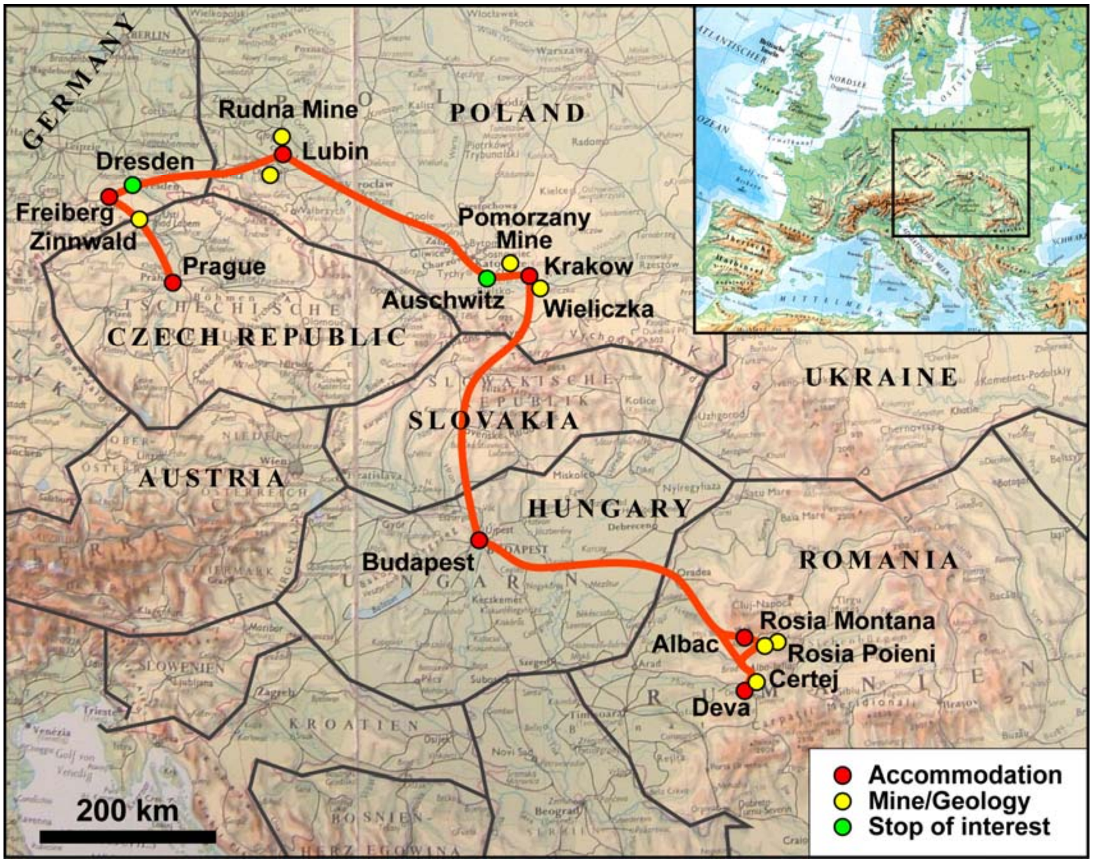

Figure 1: Map of Eastern Europe showing the trip itinerary.

## Cultural Highlights

The 2008 UBC SEG-GAC Deposits Field Trip spanned six countries in Eastern Europe. As a result, a rich variety of sights and cultures were encountered over the course of the trip. Tour participants were typically free in the evenings to explore the sights of the various stops on the tour. Cultural highlights consisted of sightseeing in some of the larger cities, and learning about the rich, often complicated cultural histories and socio-political make-ups of the Eastern European countries visited. In addition to spending time in Prague, Dresden, Krakow, and Budapest, driving between stops allowed us the unique view of some of the less traveled parts of the Czech Republic, Germany, Poland, Slovakia, Hungary, and Romania.

The tour began with a full day to explore Prague, the capital of the Czech Republic.Participants were able to wander through Prague, taking in the intricate medieval architecture of the St. Vitus Cathedral, Prague Castle, and the Charles Bridge to name but a few of the sights. Prague also offered a wonderful abundance of street cafes and beer halls where delicious Czech food and drink could be enjoyed.

On May 3rd, the tour stopped in Dresden, Germany, for an afternoon break en route from Freiberg, Germany, to Lubin, Poland. Here, participants witnessed the immaculate reconstruction of the city once devastated by bombing during the Second World War (Fig. 2). Luckily, the stop in Dresden also coincided with a local festival, as a result, the "new" part of Dresden hosted a plethora of street performers, vendors, carnival rides, and bratwurst stands.

Figure 2: Dresden, Germany. Photo courtesy of S. Blevings.

Driving from Lubin to Krakow, Poland, on May 5th the group was also able to stop at the Auschwitz concentration camp: a powerful reminder of the atrocities committed during World War II and how startlingly recent such events were. The architectural influence of the communist regime was strongest driving through the Polish country-side and cities, where blocky concrete houses and apartment buildings dominated the landscape.

On May 7th, the group arrived in Budapest, allowing tour participants a day to explore the Hungarian capital. Budapest offered a rich mixture of stunning architecture, splendid views and modern museums and shops. Boat tours were also available along the picturesque Danube (Fig. 3), which separates the city into Buda (west of the river) and Pest (east of the river). As in Prague, a rich variety of restaurants and bars were also available for sampling.

After returning our rented vehicles and meeting our hired bus and driver, the group left Hungary for Romania on May 9th, where the first two nights were spent in Albac, a small village in the picturesque Apuseni Mountains. Accommodation and meals were provided in a modest hotel in the town; in all of our travels in Europe, beers were the least expensive here (~75 cents/ea). Staying in a village provided a more authentic insight into traditional Romanian culture not experienced in the cities of Romania. The group was based in the larger city of Deva, in the province of Transylvania, for the last nights in Romania. Finally, our last night in Eastern Europe was again in the capital city of Budapest, Hungary, where we delighted in a dinner cruise of the "Blue" Danube before flying home to our respective destinations on May 14th.

Figure 3: View of the Hungarian Parliament Building from across the Danube River, Budapest. Photo courtesy of S. Wallier.

## Zinnwald, Erzgebirge, Germany (May 2, 2008)

On our first official geology day we drove from the Czech Republic to the historic Sn-W-Li Zinnwald Mine in the Erzgebirge district of Eastern Germany. We were met at the mine museum by Herr Kersten Kühn, a former mine geologist who made the trip especially to take us on a geological tour of the old underground workings. Inside the museum we were joined by two museum guides, Herr Gunter Herklotz, a man perfectly suited for leading large groups of people through low-ceilinged mine shafts (truly – he was tiny and all business), and Herr Danie Großer, who quietly headed up the rear of our underground excursion. After a brief overview of the regional geology and the distribution of safety equipment, our guides declared the traditional "Glück auf!" ("good luck!") and lead us into the Tiefer-Bünau-Stollen gallery of the historic mine (Fig. 4). As the Sn-W mineralization straddles the Czech-German border, the deposit has been mined for hundreds of years by both countries. Miners of both nationalities would often try to steal ore from across the underground border while avoiding miners and workings from the opposing mine. During the tour we were able to cross the Czech-German border at over one hundred meters below surface! The year 1990 saw the end of ore production on the Czech side of the Zinnwald deposit, and construction of the mining museum began in 1992.

Figure 4: Underground in the historic Zinnwald Sn-W-Li Mine. Photo courtesy of S. Blevings.

In the Erzgebirge district, three generations of Li-rich mica-bearing granites (ca. 305 Ma) have intruded rhyolitic country rock, an ignimbrite body of the Teplice volcanic complex. Mineralization occurs as greisens and veins, with greisen bodies hosting the highest Sn-W grades. Greisens are restricted to alteration in a granite intrusion, whereas mineralized veins are found both within the granite massif and the adjacent wallrock. Greisen bodies are irregularly shaped, reaching diameters of 150 meters, and display fine-grained disseminated mineralization. Cassiterite and zinnwaldite (a Li-rich mica) are the dominant greisen ore minerals, with quartz, lepidolite, and topaz as other important constituents. Veins occur as two mutually crosscutting sets, oriented sub-horizontally and steeply dipping, respectively, and range from 10 cm to several metres in width (Fig. 5). Vein fill is dominated by quartz, with zinnwaldite, small disseminated cassiterite, and large wedge-shaped wolframite, the latter typically forming at, and perpendicular to the quartz-mica interface (Fig. 6). Post-mineralization deformation in the region is restricted to Late Cretaceous faults which visibly offset the shallowly dipping veins.

Figure 5: A shallow-dipping, high-grade Sn-W quartz vein with dark, sub-metallic cassiterite and wolframite visible at vein margins and with a wide greisenized halo. Photo courtesy of K. Rasmussen.

Figure 6: Representative quartz vein with elongate wolframite and stubby cassiterite, and zinnwaldite along vein margin. Sample is 10cm high. Photo courtesy of K. Rasmussen.

After viewing the underground miners' mess hall, toilet facilities, and historic mining tools and methods, as well as a 'modern' underground banquet hall and a concert gallery with wheelchair access, we headed back to the surface for further discussion and purchases in the museum gift shop. We then piled into the vans to make it to our next stop of the day; a schnitzel lunch followed by a tour of the mineralogical-petrological-ore deposit collections of Freiberg, Germany.

## Mineralogical-Petrological-Ore Deposit Collections of Freiberg, Germany (May 2, 2008)

The geoscientific collection of the Technische Universität Bergakademie Freiberg, Germany, is one of the world's five most important collections of its kind. Opened in 1766, the collections are subdivided into six sections that are stored in two buildings. Large parts of the collections are open to the public and even more extensive stores can be used by researchers from all over the world.

Our main interest was in the mineralogical, petrological, and ore deposit collections, which are all housed in the same building (Fig. 7). We were welcomed by Frau Karin Rank, the director of the collection. After a short introduction about the location, she introduced us to Dr. Thomas Seifert, the temporary head of the Department of Economic Geology and Petrology. In the following, Dr. Seifert guided us through the collections and focused on specimens from ore deposits of the Erzgebirge. After his insightful tour and some time for exploring the collections, Dr. Seifert asked us to come to the lecture hall where he gave a detailed and excellent presentation about the geology and ore deposits of the Erzgebirge.

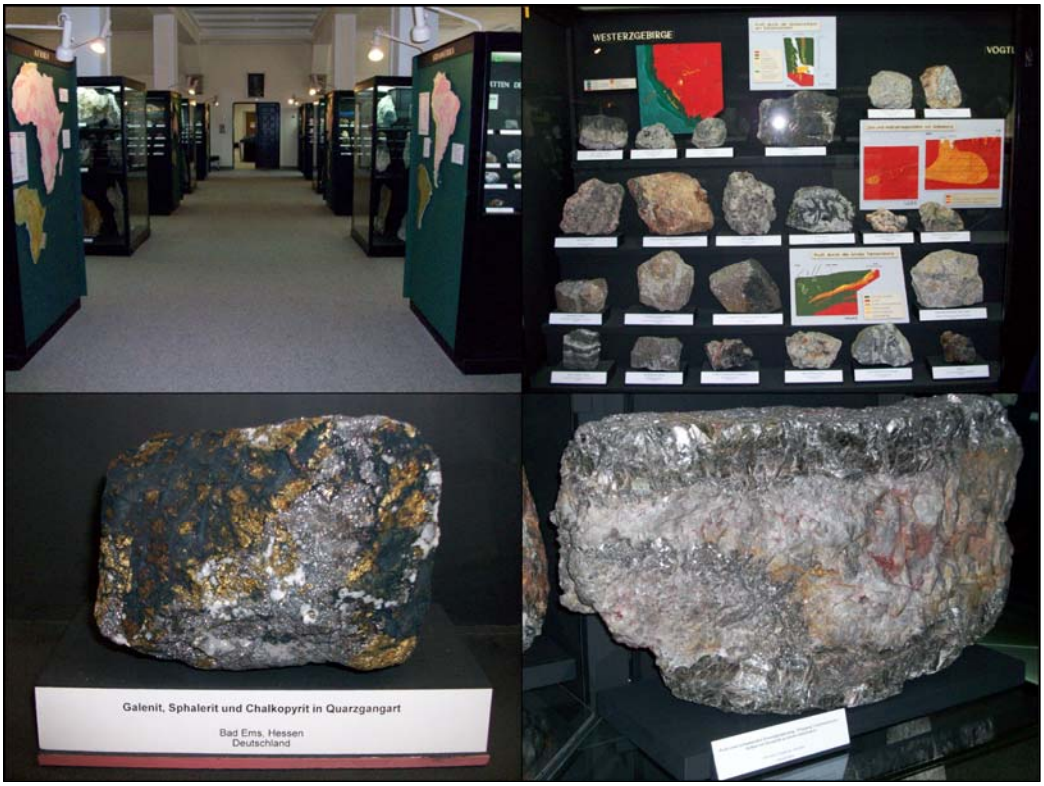

Figure 7: Mineralogical-petrological-ore deposit collections of the Technische Universität Bergakademie Freiberg, Germany. Photos courtesy of A. Soful.

## Geology of the Lubin-Glogow mining district, Poland (May 4, 2008)

On Day 4 of the trip we were lead on a tour of the Lubin-Glogow mining district by Dr. Slawomir Oszczepalski from the Polish Geological Institute. Dr. Oszczepalski first presented an overview of the tectonic setting of the Lubin-Glogow district, with a focus on the setting of the sedimentary sequences hosting the Polish Kupferschiefer Type copper deposits. The geology of the area most strongly reflects the tectonic events that took place during the Variscan orogeny. In the Lubin-Glogow district, the epi-Variscan platform is divided by the NW-SE trending Fore-Sudetic Block, an uplifted block made up of Proterozoic to Lower Paleozoic basement rocks. In the ore-bearing basinal sequences to the north and south of the Fore-Sudetic Block, Rotliegendes (Lower Permian) clastic sedimentary rocks and bi-modal volcanics are overlain by the Zechstein (Upper Permian) ‘basal limestone’, a thin unit occurring immediately below the organic matter-rich Kupferschiefer black shale. The Kupferschiefer shale unit into limestone and evaporitic units. Mineralization occurs predominantly in the Kupferschiefer shales, and to a lesser extent within sandstones and basal limestone below, and within the limestones above this unit.

The first stop of the tour visited an outcrop of quartz-porphyritic rhyolite known as the Organy Wielislawskie (Wielislaw Organ), which acquired its name from the rare and incredible columnar-jointing it displays (Fig. 8). This outcrop represents volcanic stratigraphy in the lower Permian basinal sequences: a possible source of metals for the overlying Polish Kupferschiefer deposits.

Figure 8: The “Organy Wielislawskie”: a columnar jointed rhyolite outcrop in the Lubin-Glogow mining District, Poland. Photo courtesy of S. Blevings.

The group proceeded to the next stop, a the overgrown Nowy Kosciol open pit wall where the main ore-bearing stratigraphy of the Kuperschiefer type mineralization is exposed locally. The sequence here encompasses the Kupfermergel unit (Kuperschiefer equivalent), consisting of a lower Spotted Marl unit and upper Copper-Bearing Marl, and overlying limestone beds (Fig. 9). The Kupfermergel unit exhibits minor amounts of Cu-oxides (malachite) as evidence of the presence of copper. Small amounts of chalcocite, the most significant Cu-bearing ore mineral of the Kuperschiefer deposits, were also noted. The underlying Spotted Marl is significant in that the <10 cm sized red spots signify an important redox front, below which Cu-sulfides are oxidized and pyrite replaced by hematite, and above which fluids were reduced by organic matter, forming Cu-Fe sulfides. The final outcrop visited, another overgrown wall to a different open pit, was an example of the immediate Kupferschiefer ore stratigraphy, although at this location, the red hematite spots occur above the copper-rich marl units as well as below, indicating a complex fluid history and redox environment.

To complete the tour, Dr. Oszczepalski showed us the restored pre-WWII Lena copper smelter and the associated infrastructure where we saw a monument that pays tribute to the mine ‘hobbit’ or guardian. Old mining legends say he is the owner of all of the treasures underground, who both protects minors and rules over their dead souls.

Figure 9: The mineralized Kupfermergel (Kuperschiefer equivalent) sequence containing Spotted Marl (lower 0.5 metres of exposure) and Cu-Bearing Marl (the recessive brown beds); Unit H of the Zechstein Limestone caps the Kuperschiefer sequence (the thickest resistant pale grey limestone bed). Photo courtesy of K. Rasmussen.

## Rudna Mine, Poland (May 5, 2008)

The Rudna mine is one of three zones of Kuperschiefer Type mineralization developed by KGHM (Kombinat Górniczo-Hutniczy Miedzi). It is located in south-western Poland, and covers an area of 467.7 $km^2$ referred to in Poland as the Legnica-Głogów Copper Belt. Copper mining in this region has resulted in one of the largest modern industrial regions in Poland. The copper ore deposit currently being worked lies at a depth of from 600 to 1380 m (KGHM, 2006). The ore body is related to a formation of monoclinal Permian limestone inclined towards the north-east.

Our group was split up into two groups to explore two different shafts on the property. We were given safety gear, and some excellent protective clothing and led down more than a kilometer to an extensive network of impressive underground room-and-pillar. Our guides showed us several locations with typical copper sulphide mineralization (Fig. 10). In the copper deposit and the surrounding rocks, over 110 ore minerals have been identified. The most important are chalcocite, bornite, and chalcopyrite. The mineralization is focused along three lithological rock zones: Rotliegendes sandstone, lower Zechstein shale, and the "dolomite", and is concentrated as an ore seam with thicknesses ranging between 0.5 to 20 m (averaging ~4.84 m). The ore is typically located at the contact between the sandstone and the shale. Daily extraction by the Rudna mine is around 41,570 t of ore, with annual extraction of 13 Mt. Copper content in ore in 2007 was 1.92 %, with 50 g/t of silver (KGHM, 2006).

Figure 10: Mine geologists W. Kaczmarek and M. Mrzygolód explain the geology and mineralization of the Kupferschiefer in the Rudna underground mine. Photo courtesy of L. Hansen.

After our tour was complete, each member of our trip was given a certificate that roughly translated states:

> "In accordance with the eternal rite in the brotherhood of ancient mankind, I have
> the honor of presenting the holder of this certificate: *Our Names*
> Accomplished on the 5th of May 2008 at the KGHM (Polish survey) Copper
> Mine in Poland, reached the depth of 1000 meters below the earth, with the
> traditions and customs, honor, all sympathies and appreciation joins old and
> warranted with "Rudnej" (Rudna)".

## Pomorzany Mine, Poland (May 6, 2008)

Our second mine tour in Poland was of the Pomorzany deposit in the Upper Silesia District of southern Poland, the most well-endowed MVT district in the world, where several clusters of Mississippi Valley-Type (MVT) Zn-Pb mineralization occur in Middle to Upper Triassic platformal carbonates (Muschelkalk Formation). Pomorzany, currently the only active mine of three large deposits, including Boleslaw (mined from 1954) and Olkusz, (mined from 1968), in the "Olkusz" cluster went into operation in 1974. Near-surface silver mineralization in the area had, however, been mined since the 1600's but Zn-Pb mineralization was not found until after WWII. Approximately 10,000 t of ore are mined each day from 3 shafts and the mine produces close to 2.5 Mt ore grading ~4% Zn and 1.5% Pb each year. The ore is enriched in silver (dominantly in galena) and cadmium (found in sphalerite and pyrite/marcasite, but not extracted). Gangue consists of calcite, dolomite, and pyrite/marcasite, although the iron sulphides are actually also recovered for sulphuric acid. The Pomorzany mine now has a total ~50 Mt of reserves from several newly discovered nearby orebodies, extending the projected mine life to a total of 15-20 years.

Regionally, the Pomorzany deposit lies within a graben-system developed in sub-horizontal platformal limestone and dolostone, precipitated during uplift and sub-aerial exposure resulting from the break-up of the East European Pangean continental shelf. Permeability that resulted from paleo-karst development in the Muschelkalk Formation during sub-aerial exposure, along with the presence of steeply dipping faults that have been reactivated several times and the dolomitization of platformal limestone are all interpreted to have played a significant role in the formation of the MVT mineralization. Ore deposition is considered coeval to the reactivation of steep structures. The Muschelkalk Formation is immediately overlain by Tertiary Keuper Formation clays and a thick package of Quaternary sands.

At Pomorzany, Zn-Pb mineralization is found at depths of 80-175 m below the surface in the Lower Muschelkalk carbonates, within a local down-dropped graben (offset ~70 m). The ore occurs as stratabound nests, pods, and tabular sub-horizontal lenses from 1-40 m thick, and about 95% of the ore occurs within a 5-80 m-thick package of several dolostone (+/- limestone lenses) units (a regional package termed the "Ore-Bearing Dolostone", or OBD) within the Muschelkalk Formation. The best ore grades at Pomorzany, however, occur at the contact of the dolostones with the underlying Gogolin Limestone, in which limited mineralization also occurs. Mineralization where we observed it is typically in the form of colloidal and banded galena and sphalerite, with spherolitic marcasite/pyrite (Fig. 11). Four breccia units have also been observed at Pomorzany; one exposure noted in the roof had sphalerite clasts cemented with galena. Veins of sulphides were also observed at one exposure underground in the Gogolin Limestone, and barite occurs locally but, unlike the other deposits in the district, barite is not abundant at Pomorzany. In addition, several precipitate minerals have also been noted in parts of the mine, including melanterite (pale green stalactites that form from the decomposition of Fe-sulphides), sommairite (a Zn-rich variety of melanterite forming white globules on the roof), and hexahydrite (a hydrated Mg-sulphate in the form of fine white fuzz coating the walls).

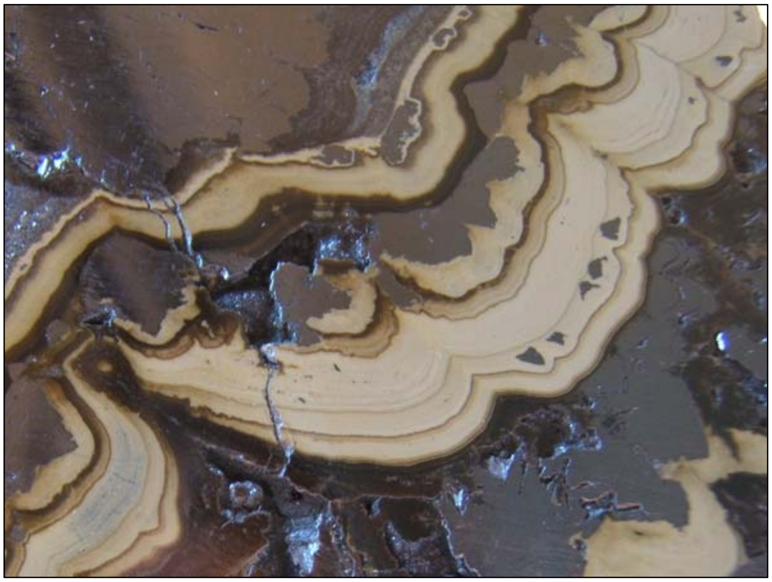

Figure 11. Polished slab of banded colloidal sphalerite (pale brown to dark brown) and galena (silvery) mineralization at Pomorzany Mine, Poland (image is 10 cm across). Photo courtesy of S. Blevings.

Mining is by two methods: a) room and pillar, with 5x5 meter pillars, recovers about 25% of the ore; and, b) shortwall/face, which is used for the higher grade ore lenses and recovers about 8% of the mineralization. Ore lenses are mined from bottom to top and rooms are filled by hydraulic backfilling. Aside from local ground issues near faults, the largest technical challenge that the mine faces is the inflow of extensive underground water. Over 200 cubic meters of water are pumped out of the mine each minute (Fig. 12).

Figure 12. An example of the water problems faced at the Pomorzany Mine, Poland. Photo courtesy of S. Wallier.

## Wieliczka Salt Mine, Poland (May 6, 2008)

The Wieliczka salt mine, located on the southeast outskirts of Krakow, has been worked for its salt for 900 years. The mine had been producing table salt since the 13th century, until continuous operations ceased in 2007. It was one of the world's oldest operating salt mines (the oldest being Bochnia, Poland), was granted status as a UNESCO World Heritage Site in 1978, and is the world's largest museum of mining.

As visitors to the mine we were invited to walk to a depth of 150 m below the earth's surface, in the oldest part of the mine. The tour started on a downward route, following an ominous wooden stairway, consisting of 400 steps, extending downwards as far as the eyes could see. The shaft was dug in the 17th century and originally used to transport salt to the surface, but now serves to carry the hordes of tourists descending into the mine. The mine stretches to a depth of 327 m and is greater than 300 km long. Astonishingly, the mining produced some 2,040 caverns of varied sizes! However, the tourist route traversed just 20 of these caverns, all of which display various sculptures and carvings.

For many in the group, the highlight of the tour was the Chapel of St. Kinga (Fig. 13): one of the largest underground chapels present in the mine, with its impressive size (54 m long, 18 m wide and 12 m high). Decorated with sculptures, several a bas reliefs of religious scenes including an intricate 'The Last Supper', salt-crystal chandeliers, a rock salt altar, and salt floor polished by the treading of many a tourist's feet. The chapel was laid out in the space created after the excavation of a huge salt block, and is essentially a subterranean church still used for regular church services and weddings to this day.

Figure 13: Chapel of St. Kinga in the Wieliczka Historic Salt Mine, Poland. Photo courtesy of K. Rasmussen.

## Roşia Montană, Romania (May 10, 2008)

The Roşia Montană epithermal Au-Ag deposit is located in the northern part of the South Apuseni Mountains in Romania. The total reserve of 10.1 Moz of Au makes it the largest Au deposit in Europe. Roşia Montană was our first mine visit out of the three in the the "Golden Quadrilateral" ore district of the South Apuseni Mountains, where the majority of epithermal Au-Ag and porphyry Cu-Au deposits are found in Romania. These deposits were formed in conjunction with Miocene calc-alkaline magmatic and hydrothermal activity. This activity was associated with local extensional tectonics within a strike-slip regime related to the indentation of the Adriatic microplate into the European plate during the Carpathian orogenesis. The Roşia Montană deposit is owned by the Roşia Montană Gold Corporation SA (RMGC), a joint venture between the Canadian Mining Company Gabriel Resources (80 %) and the Romanian State Mining Company Minvest SA (19.3 %; three minority shareholders hold the remainder 0.7 %). Witnessed by more then 140 km of galleries, the Roşia Montană deposit has been mined for over 2000 years, and has been an important gold deposit since the Roman Times. Only for the last two years, the deposit has not been exploited. A fully planned large scale open pit project by the RMGC is actually on hold due to environmental and political issues, waiting for a mining concession expected with a change in political regime this November.

The mine tour started in the information centre of the RMGC. Adrian Minuț, chief geologist of the RMGC, welcomed us around a miniature model displaying the new Roşia Montană mine project. He explained us the project that involves four open pits and the resettlement of parts of the Roşia Montană village, and he talked about the problems they have to face in order to obtain a mining concession. Following this introduction, we moved into the conference room, where Adrian Minuţ gave a presentation about the past, present, and future of the Roşia Montană deposit, and he gave an overview of the geologic framework of the district and the deposit.

Roşia Montană is a low- to intermediate-sulfidation epithermal Au-Ag deposit with a current reserve of 214.9 Mt at an average grade of 1.46 g/t Au and 6.9 g/t Ag for a total reserve of 10.1 Moz Au and 47.6 Moz Ag (0.6 g/t Au cut-off). The deposit is mostly hosted in a Miocene breccia unit that emplaced within Cretaceous flysch-type sedimentary rocks and was intruded by Miocene dacite dome structures. Mineralization occurred in hydrothermal breccias, veins, stockworks, and impregnations, where the highest ore grades are related to a multi-phase hydrothermal breccia body forming the centre of the deposit, and which was the focus of the historic mining (Fig. 14). However, relatively constant ore grades of 1 to 2 g/t Au as impregnations (gold mainly occurs as micro inclusions in pyrite) throughout vast parts of the dacite dome structures and the adjacent breccias contribute a large amount to the total reserve, and make the deposit favorable for open pit mining. The deposit shows low sulfidation alteration assemblages of chlorite-calcite-smectite at the periphery of the system, grading into illite-pyrite and eventually quartz-adularia alteration and silicification towards the centre of the deposit. Finally, the mineralization is cut by late rhodochrosite-telluride veins (evidence for a late, intermediate sulphidation state of the hydrothermal system) (Fig. 15).

Figure 14: Monomict dacite breccia with dark pyritic matrix (grades ~2g/ton Au), intermediate to a dacite with stockwork-style brecciation and the polymict breccias endmember breccia phases (with breccia clasts of dacite, andesite, basement metamorphic rocks, country rock sediments, etc.) within the hydrothermal breccia body. Photo courtesy of K. Rasmussen.

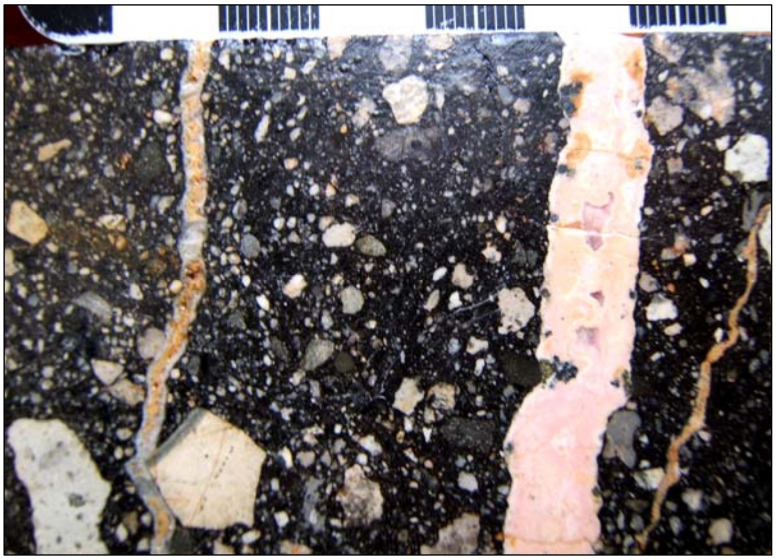

Figure 15: Polished slab with late-stage, steeply dipping rhodochrosite-telluride veins cutting black polymict breccia (the most marginal breccia phase; darkened by incorporation of shaley country rocks). Photo courtesy of K. Rasmussen.

After the insightful presentation, we received safety gear and then we walked up to the Cetate open pit where we got the chance to see the different rock and breccia types, as well as the different styles of alteration and mineralization (Fig. 16). Further up close to the Cîrnic open pit, we were led underground into almost 100 year old galleries, caverns, and rooms on pillars, where we were able to see various veins, breccias, and cross-cutting relationships. Back in the information center, we were offered a late but excellent lunch, after which we got on our bus and drove from the Roşia Montană village down to the core shack in the main valley, where we could examine three characteristic drill cores. We were particularly amazed by the constant ore grades of 0.5 to 2 g/t Au along almost the entire drill cores, even where the rocks seem to be unmineralized (Fig. 17).

Figure 16: Exploring the Cetate open pit at the Roşia Montană Au-Ag deposit. Photo courtesy of S. Blevings.

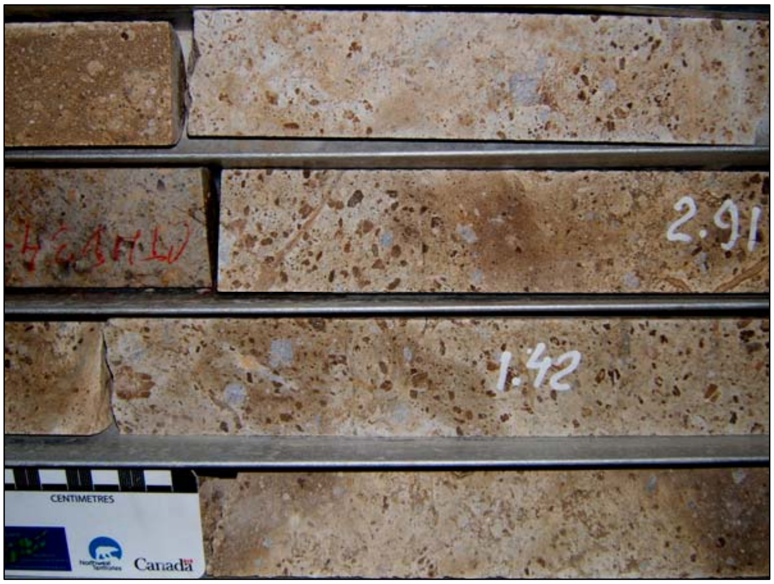

Figure 17: Mineralized dacite with “QIP” or quartz-illite-pyrite alteration (brown) and silicification (unoxidized) in core from the Cetate orebody. Photo courtesy of K. Rasmussen.

Thankful for the comprehensive whole-day deposit tour at Roşia Montană, we returned to our hotel in the small town of Albac in the Apuseni Mountains, where we enjoyed a traditional Romanian dinner with soup, sarmale (cabbage rolls), and polenta.

## Rosia Poieni, Romania (May 11, 2008)

The next day, the group departed from Albac to visit Rosia Poieni – the largest porphyry Cu-Au deposit in the South Apuseni Mountains. The Romanian mining company Cupru Min S.A. has the exploitation license for the deposit, but the companies Cuprom and Energomineral are operating the open pit and the processing plant. The deposit has been open pit mined since 1986 and is currently in the waning stages of production. It hosts estimated resources of 431 Mt at 0.55% Cu and 0.25 g/t Au. The mine tour was led by V. Auca, one of the current employees at the mine; however, the mine was not in operation during the tour because it does not operate on Sundays. The group was first taken to the top of the pit walls for a panoramic view of the open pit, then down into the open pit where the group was allowed to examine the existing open pit walls (Fig. 18).

Figure 18: Panorama of the open pit at the Rosia Poieni Cu-Au Mine. Alteration is visible as a red supergene cap, adjacent palest grey advanced argillic alteration, and pale-medium yellowy grey phyllic alteration in gradational contact with darkest grey potassic alteration in the lower pit walls and the pit floor. Photo courtesy of A. Soful.

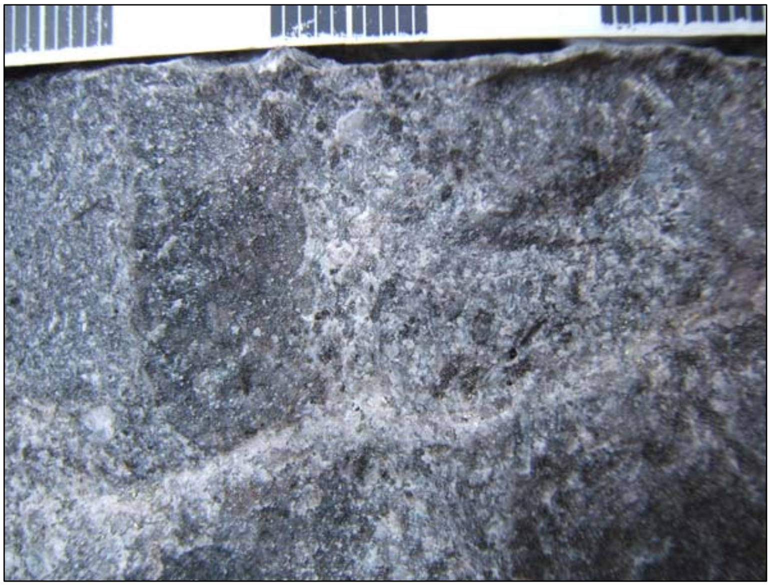

Figure 19: Potassic alteration with ragged black secondary biotite pseudomorphing amphibole phenocrysts and as disseminations; chalcopyrite-pyrite are disseminated throughout, and associated with siliceous veining. Photo courtesy of K. Rasmussen.

The Rosia Poieni deposit is hosted mainly within the Poieni diorite porphyry that is part of the surrounding and overlaying Rotunda andesites. A central zone of potassic alteration hosts the majority of the Cu-Au mineralization and occurs mainly in the central part of the porphyry intrusion (Fig. 19). Ore minerals consist mainly of chalcopyrite with minor bornite and molybdenite. Outwards from the central potassic zone, alteration grades to phyllic +/- argillic, and propylitic styles. Quartz-pyrite-enargite veins and vein breccias with vuggy-quartz and alunite alteration (or, advanced argillic alteration) cut through the center of the porphyry copper mineralization and can be followed to the periphery of the open pit. The youngest veins also cut though the center of the deposit and are polymetallic quartz-carbonate-sphalerite-galena-tetrahedrite-chalcopyrite-gold veins with a sericite alteration halo; these veins are evidence for a late, high-sulphidation hydrothermal system cross-cutting the deposit (Fig. 20).

Figure 20: Example of evidence for late-stage, high sulphidation hydrothermal system: steeply dipping quartz-pyrite-enargite veins with vuggy silica alteration (SiO2 destructive) halos cross-cutting porphyry mineralization. Photo courtesy of K. Rasmussen.

After the tour of the Rosia Poieni deposit, the group continued south to the city of Deva in the south Apuseni Mountains.

## Certej, Romania (May 12, 2008)

Following the visits to the Rosia Montana and Rosia Poieni deposits, the tour continued with a final stop at the Certej Au-Ag deposit, located within the historic “Golden Quadrilateral” mining district, roughly 15 km northeast of Deva, Romania. Certej is presently a joint venture between European Goldfields Ltd. (80%) and the Romanian state based Minvest SA (20%). The Certej deposit previously produced an estimated 2.34 Moz gold equivalent and although the deposit is not presently in production, a feasibility study was completed in 2007, resulting in a published resource of 44.1 Mt at 1.9 g/t Au (2.63 Moz) and 10 g/t Ag (13.5 Moz). European Goldfields provided an introductory presentation to the deposit, as well as access to exploration diamond drill-core and the existing open pit during the site visit.

The Certej deposit hosts variable mineralization styles including: vein-hosted and disseminated Au-Ag (±Cu-Pb-Zn) mineralization, polymetallic (Pb-Zn-Ag-Au) vein and disseminated mineralization and vein hosted Au-Te mineralization (Figs. 21 and 22). The Certej deposit formed during Neogene magmatism generated by northeast-directed Alpine subduction. Mineralization is dominantly hosted along pre-existing fractures in Cretaceous andesite (Hondol and Sacaramb) and Cretaceous and Neogene sedimentary rocks. Discrete zones of hydrothermal brecciation also occur along fractures and are associated with mineralization. Alteration at Certej consists of separate zones of potassic, potassic-silica, argillic and silica alteration. Gold occurrence varies with respect to the alteration zones as pyrite-gold, micronic gold (potassic-silica zone), gold-electrum, zonal pyrite (argillic zone), and Au-Ag-tellurides (silica zone).

The deposit is interpreted to have formed when magmatic-dominated fluids ascended along pre-existing fractures from an underlying crystallizing calc-alkaline intrusion. Ore deposition resulted from cooling and buffering of mineralizing fluids by surrounding country rocks. Neogene andesite (Baiaga) underlies the deposit but hosts negligible mineralization. Mineralizing fluids are interpreted to have been in relative equilibrium with the Baiaga Andesite, which is why ore deposition only occurred when fluids ascended across the lithologic contacts with the Baiaga Andesite. This style of mineralization is similar to epithermal-style mineralization, but with negligible external fluid input.

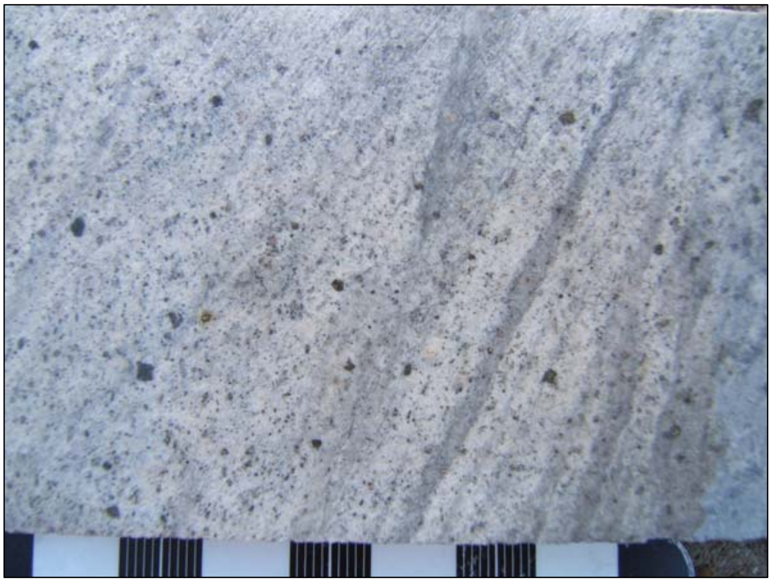

Figure 21: Drill core showcasing high-grade (4.17g/ton Au), banded, argillically altered andesite (with sericite in feldspar) from the East zone, Certej Au-Ag epithermal deposit. Gold mineralization is found within the pyrite cubes. Photo courtesy of K. Rasmussen.

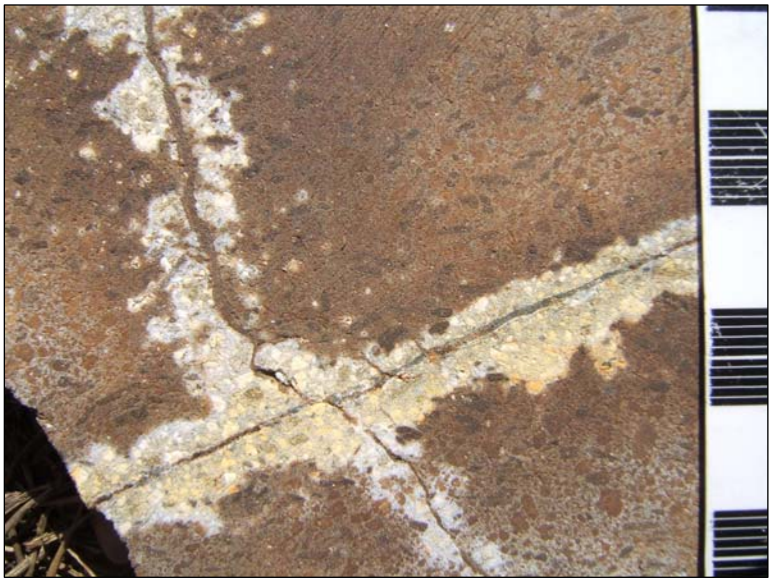

Figure 22: Drill core of a 1-6g/ton (up to 100 g/ton!) vein stockwork with a siliceous halo cutting potassic and possibly later argillic alteration in andesite from the West zone or the Certej Au-Ag epithermal deposit. Photo courtesy of K. Rasmussen.

Figure 23: Exploring the open pit at the Certej deposit. Photo courtesy of A. Soful.

## Summary

The 2008 UBC SEG-GAC Student Chapter mine tour of Eastern Europe exposed the student and industry participants to a variety of mineral deposit types, as well as insight into the historic and current importance of mining in Eastern European countries. The Zinwald Sn-W deposit in Germany illustrated some historical underground mining practices on a deposit that straddles political boundaries. The mine sites in Poland exposed participants to current underground mining methods employed in Poland on both sediment-hosted copper and MVT Zn-Pb deposits. Finally, the Romanian deposits provided excellent exposure to magmatic-hydrothermal systems in the porphyry-epithermal environment, in addition to some insight into mining practices during the Romanian Communist Era and current challenges faced by exploration companies working in Romania. The deposit visits were complemented by the extensive tours of the Freiburg mineral collection, with representative specimens of minerals and mineralization from all over the world, and the full day tour of the geology of the Lubin-Glogow District in southeastern Poland.  Finally, our experiences were enhanced by the rich culture and fascinating history of Eastern Europe.