University of Toronto
SEG Student Chapter Field Trip
Iberian Pyrite Belt
Spain - Portugal

May 2024

Acknowledgments

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- Department of Earth Sciences, University of Toronto
- Society of Economic Geologists (SEG) - Stewart R. Wallace Funding
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University of Toronto Department of Earth Sciences

Society of Economic Geologists Founded 1920

KINROSS

PDAC

TGDG Toronto Geological Discussion Group

MDD Mineral Deposits Division Geological Association of Canada

We would also like to give special thanks to the following individuals and companies:

- Atalaya Mining (**Angelo Farci and Alberto Lavandeira**) for offering a visit to the project in the Rio Tinto district, even though the visit was not possible due to scheduling conflicts on the part of our chapter.
- **Daniel Gregory**, Associate Professor at the Department of Earth Sciences, University of Toronto, and our SEG Chapter Academic Advisor, for joining our field trip, its organization, and guiding us through the geology of the Iberian Pyrite Belt.
- **Enrique Olivas**, Geology Manager at Minera Los Frailes, for leading our visit to the Los Frailes project and for guiding our group into the best spots to see in Seville.
- **Eva Stueeken**, University of St. Andrews, and **Simon Jones**, University College Dublin, for their valuable insights of projects and specifics points to visit in the Spanish zone of the Iberian Pyrite Belt.
- **Filipa Luz**, Greenfield Exploration Manager at ALMINA – Aljustrel, for leading the visit and for coordinating the visit of our group to the Lousal mine area. We also acknowledge the staff of the ALMINA geology department for presenting drillcore and industrial facilities at the Aljustrel mine site, and for joining our group to visits to the Algares Adit 30 and Lousal mine tours.
- **Isabel Bermejo**, Head of the Communications department at MATSA Aguas Teñidas, for coordinating and receiving our group. **José Manuel Marcelo**, Head of Geology, and the geology team at MATSA Aguas Teñidas, for leading the visit.
- **James Siddorn**, President at SRK Consulting Canada, and our SEG Chapter Industry Advisor, for connecting our group with scientists and projects in Spain and Portugal, kickstarting the planning of this field trip.
- **João Matos**, from the Portuguese Geological Survey (Laboratório Nacional de Energia e Geología, LNEG), for leading visits to the LNEG office in Aljustrel and to the Lousal mine in Portugal.
- **Meghan Jackson**, Principal at Ossifrage Exploration Consulting, for leading our visit to the Rio Tinto mining district and collaborating with the logistics of the Spain leg of the trip.
- **Rita Rodrigues,** PhD student at Université Laval, for her suggestions and recommendations for the fieldtrip
- **Sergio Gelcich**, VP Exploration, **Vitor Arezes**, Chief of Geology, and geology staff of Ascendant Resources for giving the group an overview and a comprehensive drillhole review of the Lagoa Salgada project.
- **Tina Tsan**, Former SEG UofT Chapter President 2022-2023, for her guidance and advice to organize this field trip

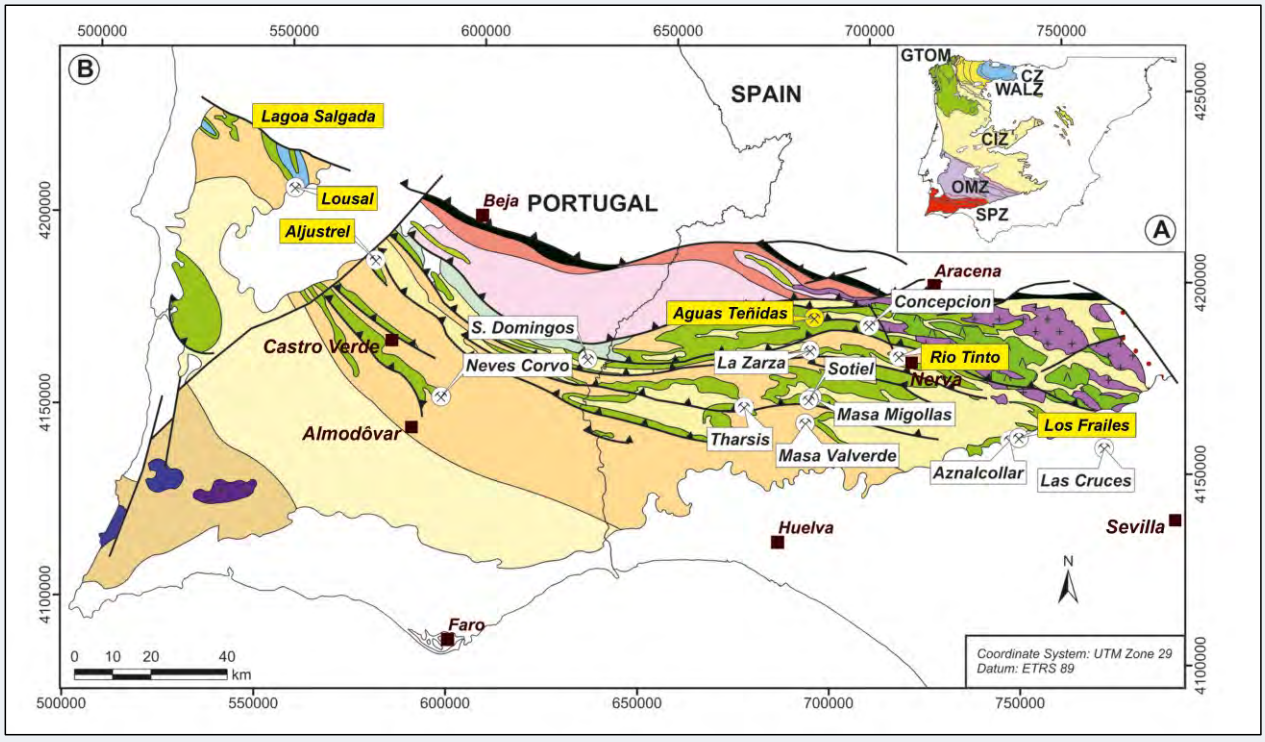
Trip Attendees

Fifteen participants from the Department of Earth Sciences, University of Toronto, attended the field trip:

- Daniel Gregory - Assistant Professor and SEG Chapter Academic Advisor
- Nelson Román – PhD Student and SEG Chapter President
- Juan David Bello Rodríguez – PhD Student and SEG Chapter Graduate Vice-President
- Matthew Dunkerley – BSc Student and SEG Chapter Undergraduate Vice-President
- Olivia Filson – MSc Student and SEG Chapter Treasurer
- Eve Carrothers – BSc Student and SEG Chapter Secretary
- Oya Ak-Kaykun – PhD Student
- Nyah Bay – MSc Student
- William Munro – MSc Student
- Jamie Chow – BSc Student
- Ma Gilda Desuyo Seguiza – BSc Student
- Daniel Giannotti – BSc Student
- Clemence Korwin-Szymanowska – BSc Student
- Lauren Murray – BSc Student
- Eva Yu – BSc Student

Itinerary May 2024

- 19th - Rio Tinto Mining District Tour
- 20th - Los Frailes VMS project visit - Seville
- 21st - Aguas Teñidas mine visit
- 22nd - Almina Aljustrel mine visit
- 23rd - Laboratório Nacional de Energia e Geologia visit and Lousal mine
- 24th - Lagoa Salgada VMS project visit



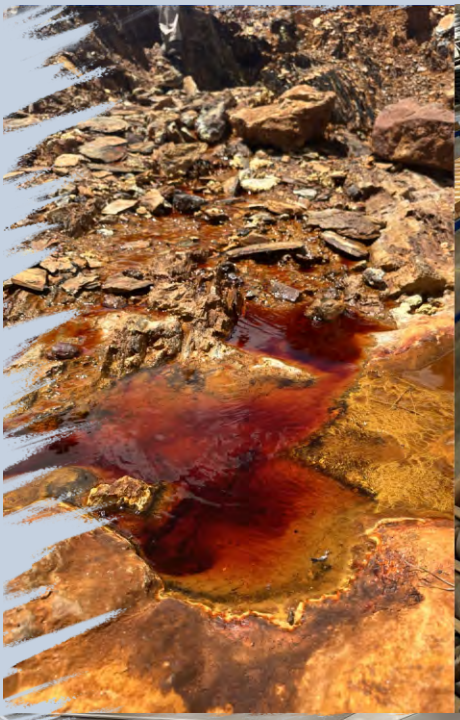
Geological map of the IPB showing the main locations visited in this field trip (highlighted in yellow). Modified after Gisbert et al., (2021).

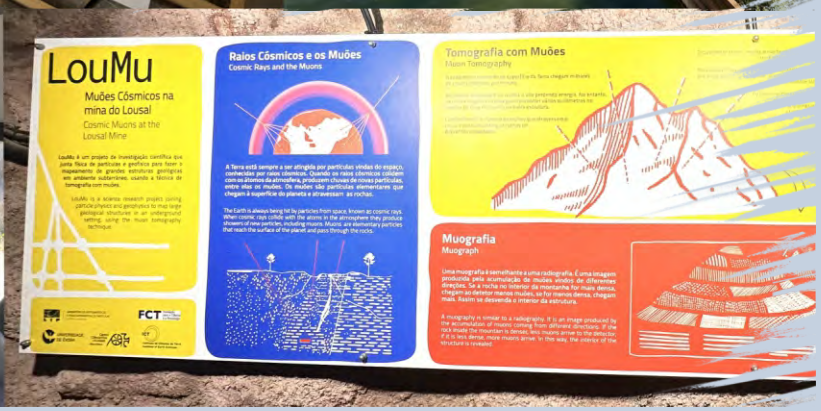
Introduction

The University of Toronto SEG Student Chapter Executive Team organized an 8-day trip to the Iberian Pyrite Belt (IPB) in southern Spain and Portugal from May 18 to 25, 2023. Guided geology and mine tours were led by Meghan Jackson (Ossifrage Exploration Consulting), Enrique Olivas (Minera Los Frailes), José Manuel Marcelo (MATSA Aguas Teñidas), Filipa Luz (ALMINA), João Matos (Portuguese Geological Survey) and Sergio Gelcich (Ascendant Resources). The trip was led by Daniel Gregory (Assistant Professor in Economic Geology, University of Toronto) along with the SEG Chapter Executive Team.

The field trip focused on the volcanic-hosted massive sulfide (VMS) deposits of the IPB. The main goals of this trip were: (1) to give the attendees an opportunity to learn about the geology, mineralogy, architecture, structure, geochemistry and mineralizing processes associated with VMS deposits, (2) to expose Earth Sciences students to the environmental challenges of mining, such as acid mine drainage and its control, and (3) to provide insights into the metallurgical and extractive aspects of the mining of base metals.

The trip was attended by six graduate students (three PhD, three Msc), and eight undergraduates from various Earth Sciences programs at the University of Toronto. Additionally, the group was joined by Yamila Cajal (Postdoc at CODES) and Poliana Vidal (PhD student at CODES) during the visit to the Rio Tinto district, and by ALMINA geology staff during the visit to the Lousal mine





Rio Tinto mining district tour
May 19th

Our Rio Tinto mining district visit was led by Meghan Jackson, Principal at Ossifrage Exploration Consulting. Geological, historical, and socio-environmental aspects of the mining activities in the district were discussed during several stops through the day. The tour began with an overview of the Embalse Cobre deposit and Gossan, where we were able to see how large tailing storage facilities can be in the district. A visit to the Cerro Colorado open pit lookout allowed us to look into the current modern mining operation by Atalaya Mining. At short distance from the active mine lookout, the Roman Necropolis cemetery provided a sharp contrast, demonstrating centuries of mining activity in Rio Tinto.

Further, we learned about the general disposition of geological units by observing the Atalaya pit. We studied a red jasper outcrop and discussed its relevance for evaluating the formation environment of VMS deposits and the associated physicochemical conditions. Red jasper units are common in the IPB deposits, normally capping the mineralized rock package.

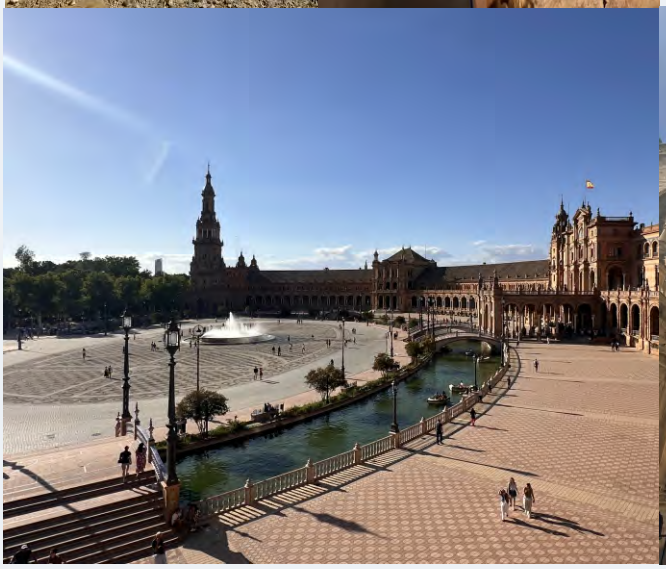
Towards the end of the day, the group visited the Peña de Hierro open pit and the Rio Tinto Headwaters. We measured the pH of the crimson-colored waters currently flowing along the streams, where the lowest values were of pH 2, clearly demonstrating the occurrence of active acid rock drainage in the area. pH was noticeably low in the streams carrying waters that had interacted with waste rock material extracted from Peña del Hierro. This activity was a direct way to experience, first-hand, the effect of exposing acid generating materials to the surface, and our responsibility to control its potential detrimental effects on the environment and population.

Los Frailes project visit - Seville May 20th

For our second visit in Spain, we traveled to the easternmost part of the IPB to visit the Los Frailes Project (Grupo Mexico). The project intends to revitalize mining activity in the Aznalcóllar-Los Frailes area. Mine development here is particularly difficult from an environmental and social perspective due to the 1998 Doñana Disaster, where the collapse of a tailings dam in Aznalcóllar ended in widespread distribution of toxic materials and pollution through rivers, even reaching the Doñana national park, more than 40 km south of the tailings storage facility. In consequence, this project mixes the challenges of a pre-mining exploration project and a post-mining closure and remediation one.

The group was hosted by Enrique Olivas, Geology Manager at Minera Los Frailes. First, we were given a presentation that covered the deposit geology, future development plans and an overview to Los Frailes' technosols project, an effort to control the hazards related to sulfide-rich tailings materials for remediation purposes. We then visited the Aznalcóllar and Los Frailes open pits. While there we had discussion that involved the Doñana disaster, the current water management plan on site, plans for mine production, and an overview of geology and geometry of the mineralized bodies at the Los Frailes open pit. We collected rock samples from stockpiles near Los Frailes, with the help of our guide. To conclude the visit, we studied a representative drillhole from Los Frailes, where we investigated the host felsic volcanic-volcaniclastic rocks, the pyrite-dominated massive sulfide body and stockwork zone.

To finish the day, we were able to immerse into Spanish culture by visiting Seville, with stops at the Seville Cathedral and Plaza de España, and a walk along the Guadalquivir riverside.



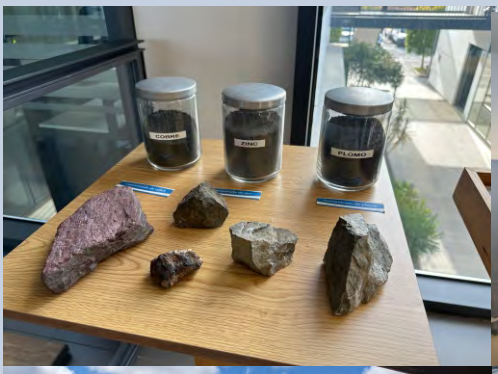
Aguas Teñidas visit

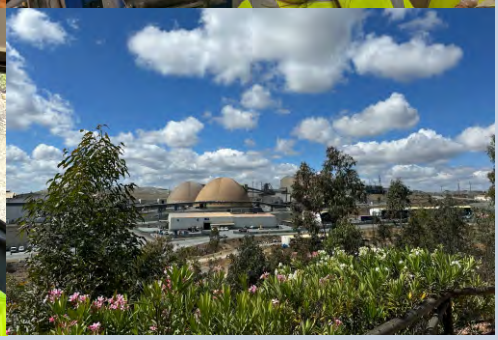
May 21st

The Spanish leg of the field trip ended with a visit to the MATSA Aguas Teñidas, one of the largest mining operations in the Spanish side of the IPB. It is comprised of three underground mines, Aguas Teñidas, Sotiel and Magdalena.

After a comprehensive presentation about the mining operations and deposit geology by José Manuel Marcelo, Head of Geology at MATSA, we visited the Mine Operation Control (MOC) room and the remote operation room, where we witnessed how the mining operation is run remotely in real time, dramatically increasing safety for operators. Next, the group observed the mineral processing plant from an overlook, and then examined and discussed drillcore at the coreshack. To finalize, Aguas Teñidas geology staff kindly provided our chapter with samples from the massive sulfide rocks currently in production from the Magdalena deposit, which will support teaching activities in our Earth Sciences Department.

Following the visit, we drove to Aljustrel, Portugal, in preparation for the visit to the Aljustrel mine.



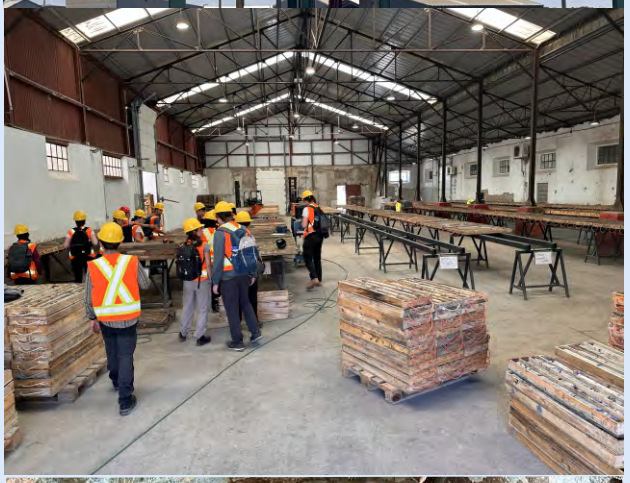


Aljustrel mines visit May 22nd

The first visit in Portugal was to Aljustrel mine, operated by ALMINA. Like Rio Tinto, mining in Aljustrel pre-dates Roman times. At least five massive sulfide deposits have been recognized in the district (Feitais, Estacão, Algares, Moinho and St. João). The visit was to the industrial area close to the Algares and Feitais deposits.

Our guide and host for this day and the following one was Filipa Luz, Greenfield Exploration Manager at ALMINA. Dr. Luz's presentation covered the main geological features of the deposits in Aljustrel and also provided a general overview of the general geology of the IPB, serving as a great way to consolidate the information learned in the days prior. Two representative drill cores from the deposit were discussed. These drillholes crosscut important features found in the Aljustrel deposits, namely, the flysch unit including pyrite-rich black shale in its base, the characteristic magnetite-hematite-bearing red jasper unit, the felsic volcanic rocks and asocciated "wine" shales, and importantly, the massive sulfide and stockwork zones. We could observe how the copper contents increased towards the bottom of the massive sulfide horizons and the stockwork zone beneath these units. The tour also included a visit to the area around the concentration plant including ball mills, flotation cells and tailings facilities.

In the afternoon, we visited the Aljustrel Mining Park, courtesy of ALMINA and the park administration. Exhibits in the museum didactically explain how mining activity in Aljustrel started in pre-historical times until the present day. We observed important archeological pieces in the exhibition, including a replica of the Bronze Boards of Vipasca, which contain information about mining law during Roman times. The tour included a guided visite to the Algares 30-level adit and, an actual production gallery showing evidence of mining since Roman times (Vipasca mine). The adit crosscut two gossans emplaced within felsic volcanic rocks. Stockwork mineralization areas are also recognizable. Supergene mineralization is the most remarkable feature of the adit, where melanterite and chalcantite forms spectacular stalactites, botryoidal aggregates, and provide vibrant green and blue colors to the adit walls.

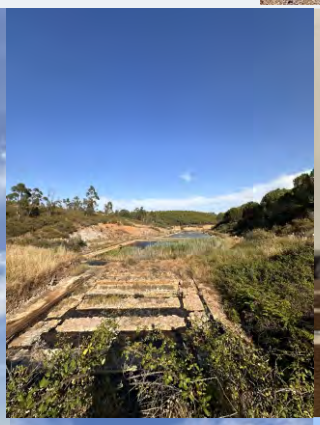


Visit to the LNEG and Lousal
May 23th

Our second day in Portugal began with a visit to the Portuguese Geological Survey (LNEG) in Aljustrel, with the objective of learning how the survey aids exploration and mining companies to find new VMS deposits in the IPB. The group was guided by João Matos, who presented in detail a representative drillcore from the Lagoa Salgada project in northwest Portugal, in preparation for the visit of the following day. Additionally, geophysical signatures of mineralization were discussed by the group for the Neves Corvo district in Portugal.

After the LNEG visit, the group drove to Lousal, where we visited the Lousal Cience Center (Centro Ciência Viva do Lousal), built in the vicinity of the closed Lousal pyrite mine. For the visit, we were joined by ALMINA Aljustrel exploration crew led by Dr. Luz. Important outcrops surrounding Lousal were explained by Dr. Matos, including gossan after massive sulfides, supergene argillic alteration zone, how faults control the arrangement of mineralized bodies in the district, and the aspect of the phyllite-quartzite package around Lousal. Active generation of acid rock drainage was seen and discussed, as well as the remediation measures in place within the mining park. The visit included an underground adit tour under Lousal.

We ended the day with a delicious traditional dinner in Messejana, where we also admired the architecture and vibe of the small towns of Alentejo.



Lagoa Salgada project visit

May 24th

The last visit of our field trip was to the Lagoa Salgada exploration project coreshack, in Grândola, Portugal. Lagoa Salgada is one of the main exploration projects spearheading the new generation of potentially productive VMS deposits in the IPB, and it is the northwesternmost deposit in the belt.

Vitor Arezes presented a comprehensive overview of the project, including geological, geochemical, geotechnical, structural and mineralogical aspects, among others. Emphasis was put on how exploration for VMS deposits is driven in covered areas, highlighting the potential for finding blind deposits in the IPB. After the presentation, the discussion moved to the drill core, where the key mineralization features of the project were explained by Sergio Gelcich and the Lagoa's geology staff. Participants were able to see in drillcore the cover rock that conceals the Lagoa deposit, gossan rocks that evidence that the deposit was once exposed, and the sulfide mineralization itself. The visit concluded with a superlative home-cooked Alentejo-style lunch on site, courtesy of the Lagoa's team. Obrigado!

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Thank you - Gracias - Obrigado

Ossifrage Exploration Consulting