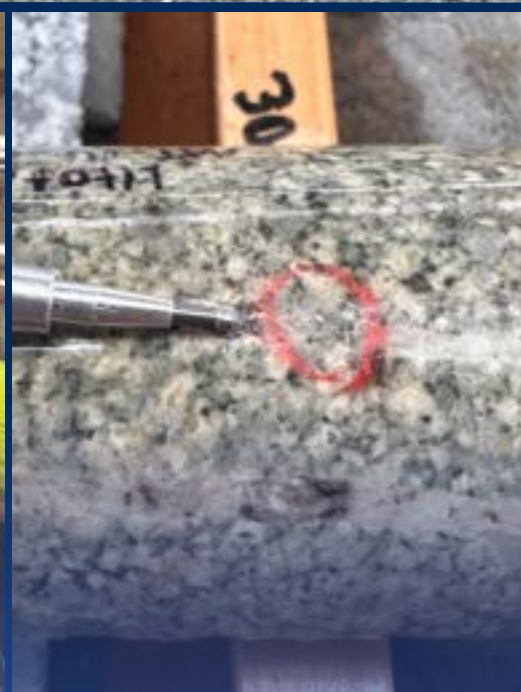




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Colombia field trip 2025

Acknowledgments

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Earth Sciences



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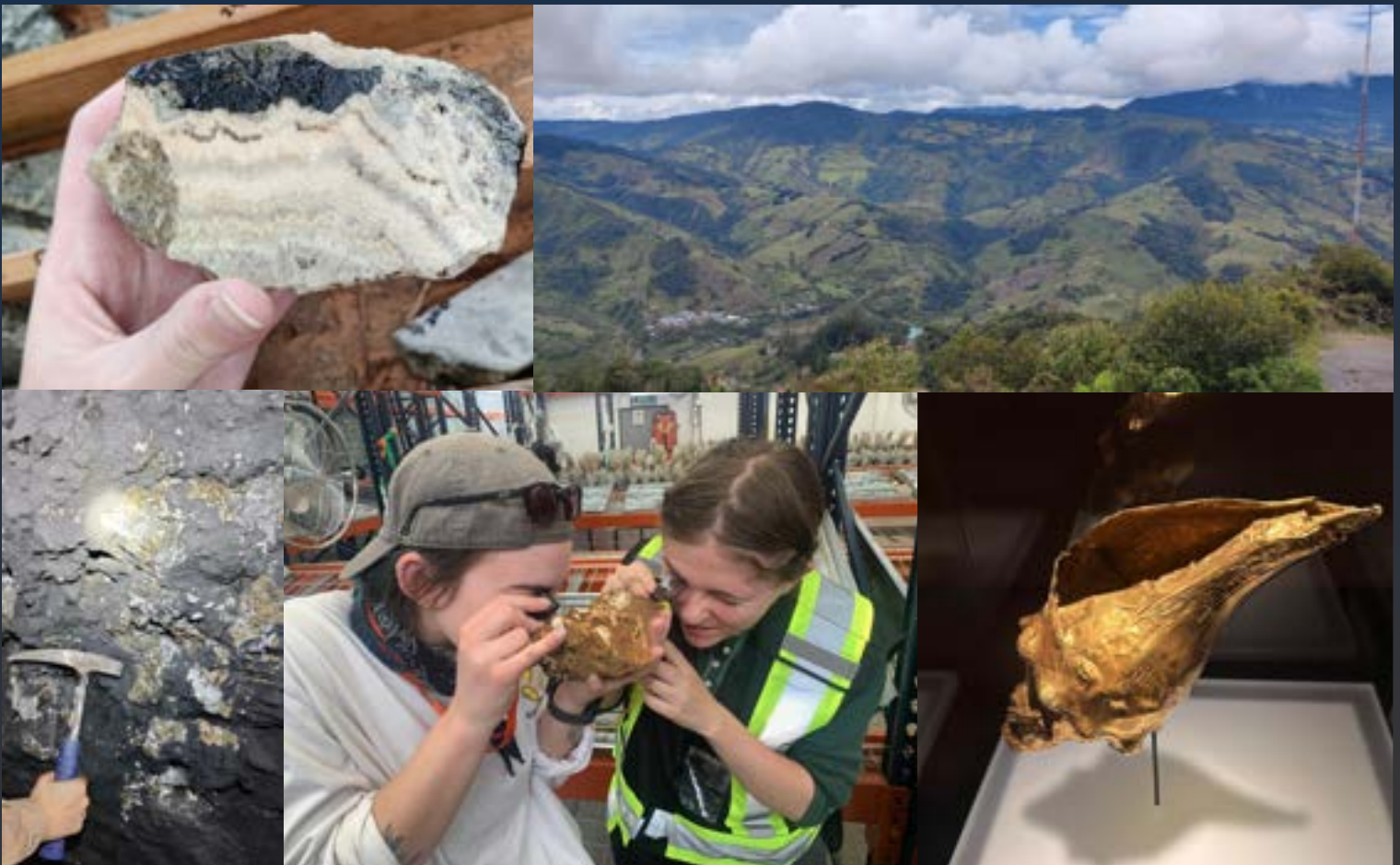
- **Daniel Gregory**, Associate Professor at the Department of Earth Sciences, University of Toronto, and our SEG student chapter academic advisor, for joining our field trip, its organization, and helping to understand the geology of the regions in Colombia
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Introduction

From 1st to 9th May 2025, the executive team of the University of Toronto SEG Student Chapter organized a 8-day trip to Colombia's Eastern Cordillera and Middle Cauca Belt. The field trip was designed to immerse students in the study of Au-Cu magmatic-hydrothermal deposits within the Miocene Middle Cauca Belt, as well as unique sediment-hosted emerald and salt deposits. The primary objective was to provide participants with a valuable opportunity to enhance their knowledge of mineral deposits in various geological environments, such as volcanic arcs and back-arc basins, while studying the associated geology, mineralogy, structural domains, geochemistry and mineralising processes.

Beyond its technical focus, the trip also aimed to highlight the cultural and historical significance of these natural resources for the Indigenous civilizations and local communities that have inhabited Colombia for centuries. Furthermore, students gained valuable insights into the environmental and social challenges faced by the mining industry in Latin America, particularly within Colombia's biodiverse landscapes. The experience was further enriched by exploring how precious metals, and gemstones are mined and processed in the region.

Guided geology and mine tours were led by multiple geologist, engineers, and miners including Miguel Vallejo (Salt Cathedral of Zipaquirá), Luis Enrique Urrego (Chivor emerald mine), Javier Garcia Toloza (CDTEC gemlab), Laura Daniela Velez (Colombian Geological Survey), Marcelo Trujillo (Collective Mining), and Leonardo Santacruz (Aris Mining). The trip was led by SEG student chapter executive team, along with Daniel Gregory, associate professor in economic geology, University of Toronto.



Trip Attendees

Fourteen participants from the department of Earth Sciences, University of Toronto, attended the field trip:

- **Daniel Gregory** - Assistant Professor and SEG chapter Academic Advisor
- **Juan David Bello Rodríguez** - PhD student and SEG chapter president
- **Nicole Schoenherr** - BSc student and SEG chapter Undergraduate Vice-president
- **Jennifer Cann** - MSc student and SEG field trip coordinator
- **Nyah Bay** - PhD student and SEG chapter treasurer
- **Oya Ak** - PhD student and SEG chapter secretary
- **Zhongzheng Yuan** - PhD student
- **Sarah Mount** - PhD student
- **Elizabeth Xu** - MSc student
- **Jordan Pawlowski** - MSc student
- **Hannah Eaton-Tessier** - MSc student
- **Zhen Wang** - BSc student
- **Marlon Hoover** - BSc student
- **Nathan Mallia** - BSc student



Itinerary May 2025

- 1st - Salt Cathedral of Zipaquirá
- 2nd - Chivor emerald mine
- 3rd - Gold Museum and CDTEC gemlab
- 4th - Volcano Observatory of Manizales - SGC
- 5th - Collective Mining - Guayabales project
- 6th - Aris Mining - Marmato gold deposit
- 7th - Coffee Tour
- 8th - Explora Park and Botanical Garden



Colombia maps



Middle Cauca Belt



Eastern Cordillera

Salt Cathedral of Zipaquirá

May 1st

Miguel Arturo Vallejo, who has worked at the site for over 15 years, guided our visit to the Salt Cathedral of Zipaquirá. Located in a current salt mine about 30 km north of Bogotá, the cathedral was inaugurated in December 1995 after the original structure was closed due to structural stability problems, and it was later selected as the first wonder of Colombia.

During the tour, we learned about the mine's history, society and mining activities. The mine exploited one of the region's largest salt diapirs, with an approximate volume of 1 km^3 . This diapir formed during the Cretaceous period in a nearby basin, which generated evaporites, mainly halite (NaCl). Around 70 million years ago, tectonic activity, coupled with the density contrast between the halite and the surrounding rock, enabled the halite to move plastically, forming several diapirs in the area.

The exploitation of salt at Zipaquirá began when indigenous communities collected saltwater from the mountain and evaporated it in earthenware vessels to harvest salt crystals. Later, colonisers developed an underground mine using the chambers-and-pillars method. As mining techniques advanced, the second and third levels, Potosí and Fabricalta respectively, continued this approach. Fabricalta introduced long chambers, which boosted safety and efficiency and eventually led to the construction of Colombia's iconic Salt Cathedral. The fourth level represented another significant development with the in-situ method, which involved deep drilling and water injection at depths of 300–400 metres to extract brine, which was then processed through evaporation. Today, Zipaquirá's salt mine stands as a symbol of Colombia's cultural heritage and human ingenuity in resource extraction.

We visited one of Colombia's largest underground mines, which is now also a tourist attraction related to the early beliefs of the miners but also offers insights into mining and the importance of natural resources in our daily lives.



Chivor Emerald Mine

May 2nd

For our second visit in the Eastern cordillera, we traveled to Chivor, a town renowned for its high-quality emeralds, as its located in one of Colombia's largest and most historically significant mining districts, the eastern belt. This district exhibits sediment-hosted emerald deposits that are an exceptional global example of unconventional emerald formation, associated with hydrothermal sedimentary processes.

Luis Enrique Urrego led the visit. We were welcomed at the top of the emerald mine, offering a spectacular view of the landscape. Later, we entered one of the largest underground emerald mines in Chivor. Inside, we were able to recognize the host rock, primarily organic matter-rich shale, and evidenced strong hydrothermal alteration and indentified that emerald mineralization occurs within quartz-carbonate-pyrite veins and breccias.

The mineralization dates back approximately 65 million years. These emeralds formed through the interaction of highly saline brines, migrated by tectonic activity, with the surrounding black shales. This process triggered metasomatism, releasing multiple elements such as Be, Cr, and V from the shale and allowing emerald formation. The emeralds are notably low in Fe, as Fe was removed from the system due to the pyrite formation, enhancing the brilliant colour characteristic of Colombian emeralds. The unique features of these emeralds, such as their high Cr concentration, result in a distinctive red fluorescence under UV light.

The mining system primarily follows a chamber and pillars method along the emerald-bearing veins. This region has been exploited since pre-hispanic times, with emeralds holding significant cultural value for the Muisca people, Indigineous community in the area. Currently, multiple companies operate within the same underground network, each targeting different veins.

After the mine tour, we visited the tailings to search for potential emeralds and, more importantly, to connect with local people, who generously offered us some samples.



Gold Museum and CDTEC gemlab

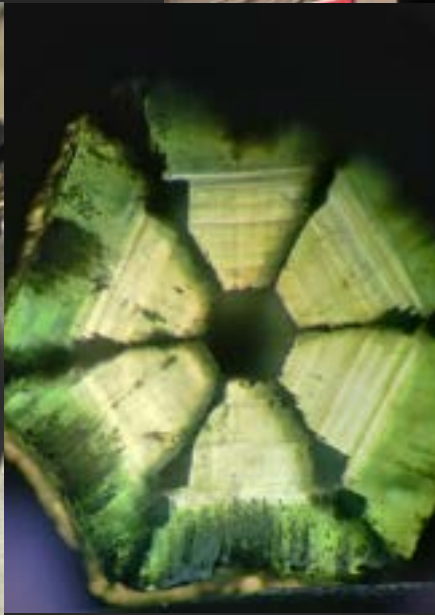
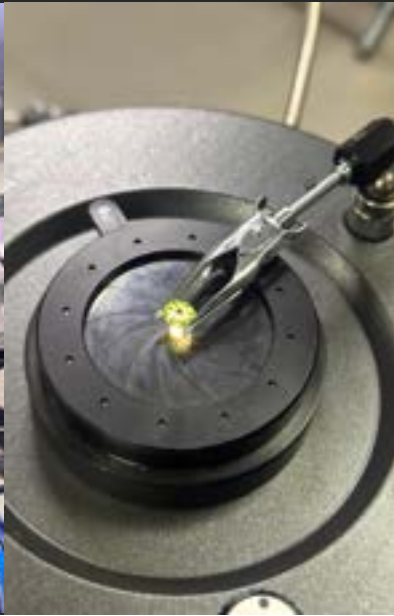
May 3rd

On the last day of our visit to the eastern cordillera, we explored the gold museum and the CDTEC gemlab in Bogotá. These two places offered us a different perspective on gold and emeralds, focusing on more than just their geology.

We had a guided tour of the Gold Museum, one of the largest of its kind in the world, focusing on the “working of metals” exhibition. We explored various aspects of gold and its importance in indigenous civilizations. We learned how ancient metalworkers extracted, processed and shaped metals. In Colombia, Muisca and other communities used the metals, especially gold, to create religious artifacts, decorative objects, and tools. They developed sophisticated metalworking techniques such as lost-wax casting and the creation of alloys by combining gold with other metals like copper, silver, and platinum. The gold collection includes artifacts dating from 200 B.C to A.D. 1200.

Later, at the CDTEC gemlab, Javier Toloza, Juan David Avila, Cristian Ochoa, and Avril Corredor provided us with valuable insights into the gemology and chemical analysis of emeralds, particularly regarding the identification of their quality and origin. They use multiple geochemical techniques, including Raman and UV spectroscopy, fluorescence and Fourier Transform Infrared (FTIR) spectroscopy to identify different chemical components in emeralds and help to increase their value. In addition, they are conducting multiple studies to better understand the formation of these unique emerald deposits in Colombia.

Overall, these two visits perfectly complemented our mine sites visits, providing a comprehensive understanding of gemstones and precious metals within both society and academia. Afterward, we visited historical landmarks in Bogotá such as the Bolivar square, the Chorro de Quevedo and the 7th street in downtown Bogotá.





Volcano Observatory of Manizales

May 4th

The second leg of the field trip was in the Middle Cauca Belt between the central and western cordillera. We flew from Bogota to Pereira, in the central cordillera or the current Colombian volcanic arc.

We began with a visit to the Volcano Observatory of Manizales from the Colombian Geological Survey. There, Laura Daniela Veléz gave us a tour to the observatory. The visit started with an excellent talk about the geology environment (subduction zone) and volcanic systems where we were and the evolution of volcano monitoring in Colombia since the Armero tragedy where more than 20 thousand people died from a lahar. Then we visited the control room where all the systems are constantly monitoring the Nevado del Ruiz Volcano, by using different techniques such as geophysics, gas monitoring, terrain deformation, and real time video of the crater.

This visit allowed us to gain a great perspective about volcanic arcs and give us the first approximation to understand the geological environment where the gold and copper magmatic-hydrothermal deposits of the Middle Cauca Belt formed.

Following the visit, we drove to Supia, in preparation for the visit to Collective Mining facilities.



Collective Mining - Supia

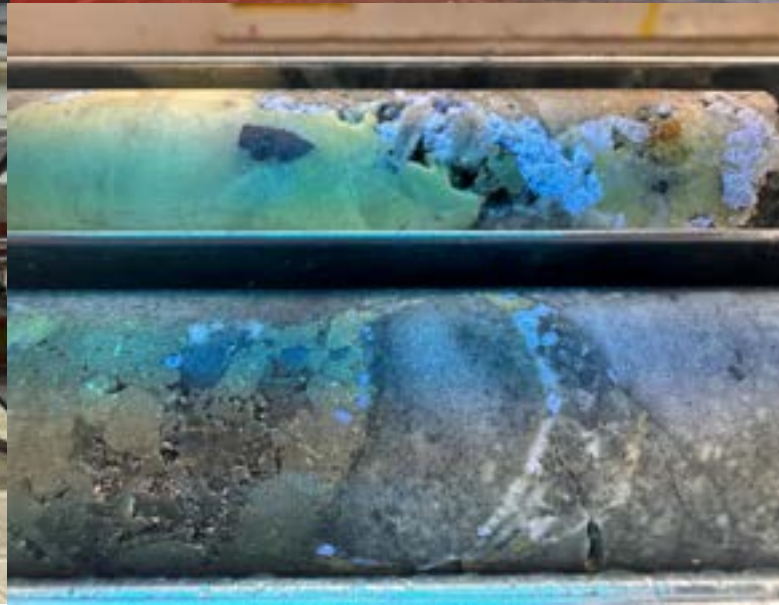
May 5th

The first mineral deposit project we visited in the middle Cauca Belt was Guayabales, operated by Collective Mining. It is located in the town of Supía in the Western Cordillera.

Our visit was guided by geologists Marcelo Trujillo, Jonathan Orozco, and Mario Castaño. We began with a presentation outlining the general process of mineral exploration in this region and its challenges, which involves multiple stages, including literature review, field work (stream sediment, soil and rock sampling), followed by target delineation supported by geophysical techniques such as gravimetry and magnetometry. We then learned about the Apollo system, a gold-silver-copper-tungsten magmatic-hydrothermal deposit characterized by multiple mineralization and brecciation events. Its main feature is an intermineral breccia body overprinted by gold-rich carbonate base metal veins, providing clear evidence of successive hydrothermal alteration types and their overprinting relationships.

Afterward, we observed the discovery drill hole, where we identified the country rocks belonging to the Cajamarca group, mainly metamorphic rocks, including graphitic schist. We observed various types of hydrothermal alteration such as propylitic, chlorite-sericite and biotite alteration. In addition, we recognized multiple mineralization stages marked by the presence of pyrite, pyrrhotite, sphalerite, galena and gold. The abundance of pyrrhotite is noteworthy, as it suggests a highly reduced system, likely caused by significant interaction between the graphitic schist wall rock and the ore fluids, effectively reducing the system.

This visit offered an excellent introduction to the dynamics of magmatic-hydrothermal systems, including fluid-rock interaction, oxygen fugacity, and the key controls on mineral precipitation and metal transport processes.



Aris Mining - Marmato

May 6th

On our third day in the Middle Cauca Belt, we visited the Marmato deposit, operated by Aris Mining. This deposit is one of the oldest continuously operating gold mines in Colombia, with over 500 years of mining.

Our visit started with a series of presentations highlighting the importance of safe operational practices, community engagement, environmental impact mitigation, and remediation strategies. The presentations also covered future operational plans, as most of the deposit has been exploited in its upper levels, with upcoming operations focusing on deeper areas.

We then received a presentation detailing the overall process of core logging, data quality assurance and data accuracy (QA/QC), data collection and processing, resource modeling, and mining methods. Afterwards, geologist Leonardo Santacruz presented of the genesis and evolution of the Marmato deposit. The deposit is divided into two main zones: an upper level characterized by high-grade gold veins, and a lower level, where gold mineralization is primarily associated with bismuth-quartz sheeted veins related to multiple intermineral intrusive bodies. This lower level displays features of both porphyry and intrusion-related systems. Similar to what we observed at Apollo, the interaction between highly reduced country rocks and ore forming fluids appears to have reduced the system, influencing variations in metal transport and precipitation mechanisms. Finally, we had the opportunity to observe marmatite, an iron-rich variety of sphalerite, first identified in this deposit in the 19th century. The first scientific paper on the Marmato deposit focused on this mineral.

This visit also emphasized the environmental and social challenges faced by regions with a long history of mining and underscored the importance of improving mining practices to minimize environmental impact and foster positive, cooperative relationships with local communities.



Coffee tour, Explora park and Botanical garden

May 7th and 8th

Our field trip to Colombia included a visit to Jericó, a traditional coffee-growing town in the southwestern part of Antioquia. There, we participated in a coffee tour and had the opportunity to experience the entire coffee production process — from planting and harvesting to the selection and roasting of coffee beans. We also learned about the significance of coffee farming for local communities and Colombia's economy.

We wrapped up our field trip our field trip with visits to Explora Park and the Botanical Garden in Medellín, the largest city in the Middle Cauca Belt. At Explora Park, we visited the Mind Room, the Time Room, and the aquarium, where we observed Colombia's rich aquatic biodiversity. At the Botanical Garden, we visited the mariposarium (butterfly house) and an exhibition of prehistoric plants, where we learned about cycads — ancient plants that have existed on Earth for at least 250 million years. These plants peaked during the Jurassic period, likely dominating much of the prehistoric landscape.

Finally, we returned to Toronto, flying out of José María Córdova International Airport in Medellín.



SEG Student Chapter 2025



Thank you - Gracias

