



Federal University of Rio de Janeiro
Brazil



UFRJ Society of Economic Geologists
Student Chapter

Iron Quadrangle (Minas Gerais, Brazil)

Field Trip - 11/22/22 to 11/26/2022

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1. Introduction and Objective

Our field trip's primary goal was to conduct technical visits to a selection of mineral occurrences in the state of Minas Gerais's Iron Quadrangle (Quadrilatero Ferrifero) region (Brazil). We received direction from professors and business experts who helped us better comprehend the geological setting, current economic environment, as well as the commodities involved in the mining operations, all of which we as students were still unfamiliar with. The majority of the members present in this field trip had never been to mines and operations which involved learning about actual, practical industry standards while visiting open pit and underground mining. Additionally, members of our chapter had the fantastic opportunity to learn about the realistic day-to-day activities in the mining industry, including the most popular softwares, effective planning techniques, regular field work, how work is managed by teams of employees in the mines, as well as safety and security measures, work ethics and many other important professional aspects related to this industry

2. Present members:

Member	Occupation	Affiliation
DSc. José Carlos Sicoli	Professor	SEG Fellow/Academic Advisor
DSc Atlas Correa Neto	Professor	Not associated
Amanda Mendes	Undergraduate Student	SEG Member
Gabriela Carvalho	Undergraduate Student	SEG Member
Leticia Cardoso	Undergraduate Student	SEG Member
Mateus Ferreira	Undergraduate Student	SEG Member
Matheus Violante	Undergraduate Student	SEG Member

3. Costs and SW Fund application:

The Student Chapter's fund had an amount of R\$ 7379,01 that was conceded to us back in 2019 for a field trip that had to be postponed and was later canceled due to the global COVID-19 pandemic. This sum was then used to cover the costs of this current field trip.

The table below shows the costs for transportation, lodging and other expenses that we were able to cover with this concession:

Costs	Description
R\$ 530,41	Bus Tickets: Rio de Janeiro (RJ) to Belo Horizonte (MG)
R\$ 1.063,50	Bus Tickets: Ouro Preto (MG) to Rio de Janeiro (RJ)
R\$ 1.576,50	Belo Horizonte Inn (from 22/11/2022 to 25/11/2022)
R\$ 840,00	Ouro Preto Inn (from 25/11/2022 to 27/11/2022)
R\$ 1870,00	Car rental + Parking costs + Car Cleaning + Road Toll
R\$ 437,07	Gasoline
R\$ 75,87	Uber trips in Belo Horizonte
R\$ 125,00	"Mina do Veloso" (Veloso's Mine) entrance costs
R\$ 860,66	Food (divided equally between the five committee members)
R\$ 7379,01	Total Costs

4. About Quadrilátero Ferrífero:

The Iron Quadrangle region is a significant producer of iron, gold, and gems in the global scenario, being, situated in the state of Minas Gerais, Brazil. Since the 15th century, it

has been the main location for bedrock gold mining in our country. Itabira is the most significant iron mining district in the region, while the region between Itabira and Nova Era is a very important gem mining sector.

The Cauê Formation, a typical Banded Iron Formation (BIF) of the Lake Superior Type and the intermediate chemical member of the Paleoproterozoic meta-sedimentary Minas Supergroup, is the host rock for the iron ore deposits. The BIFs, also known as itabirites locally, have undergone metamorphism and undergone severe oxidation. The Minas Supergroup is less deformed and still retains some of its original sedimentary formations in the western edge of the Iron Quadrangle. The greenschist facies was affected by the metamorphism in this area. Within the itabirites, the iron ore deposits appear as discontinuous lenses of various sizes and forms. There are two primary categories of iron ores: hematite ore, which is high-grade ($\text{Fe} > 64\%$), and itabiritic ore, which is intermediate-grade (64% to 52% of Fe).

Several mines, especially in the district's northern and southern regions, produce gold deposits. The deposits are contained in supracrustal strata of iron-rich cherts and carbonate and oxide facies BIFs from the Archean and Paleoproterozoic. As a result, gold is extracted from some of the iron ore reserves. The largest emerald mining region in Brazil, Gem Mines is situated between Itabira and Nova Era. Morganite and aquamarine can also be found in the Iron Quadrangle.



Banded Iron Formation in Iron Quadrangle

5. Trip Itinerary:

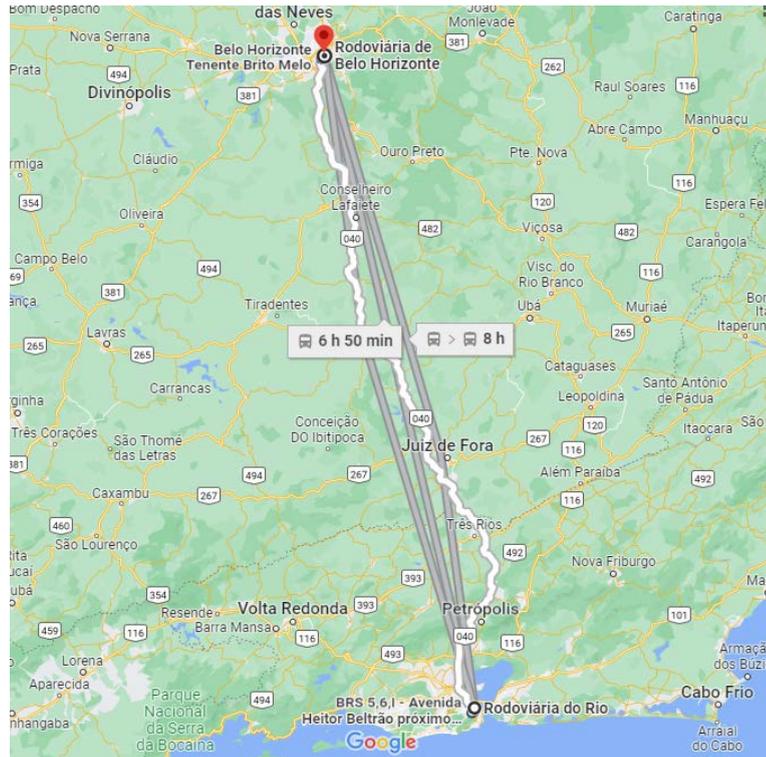
November, 22-26 of 2022

Date	Main Activities
11/22/2022	Arrival in Belo Horizonte (Minas Gerais, Brazil)
11/23/2022	Turmalina Gold Mining - Jaguar Mining
11/24/2022	Casa de Pedra - CSN
11/25/2022	MLF Geomechanics/Museum
11/26/2022	Regional/State Park of Itacolomi/Mina du Veloso

- **Arrival in Belo Horizonte (Minas Gerais, Brazil)**

Professors and UFRJ SEG members have taken a bus from Rio de Janeiro's Novoriorio bus station to Belo Horizonte's Israel Pinheiro terminal. After renting a 7-seat car, we made our way to the BH Palace hotel where we would spend the next 3 days.

Hotel Address: Av. Augusto de Lima, 1147 - Barro Preto, Belo Horizonte (MG, Brazil)



Estimated route taken from Rio de Janeiro to Belo Horizonte. Source: Google Maps (February 2023)

- **Turmalina Gold Mining - Jaguar Mining**

Turmalina Gold Mining is a mining operation located at Conceição do Pará, west of Iron Quadrangle (State of Minas Gerais), where Jaguar Mining conducts gold exploration. The mineralization occurs associated with supracrustal sequences of rocks from the Pitanguí Group, situated stratigraphically above an Archean granitic basement. This segment consists of pyroclastic deposits, ultramafic and intermediate volcanic rocks, and the greenstone belt sequence. Gold occurrences are associated with schists and banded iron formations in the greenstone belt.



Satellite view of Tourmaline Mining. Source:

It was a very unique day because it was our first field day and many of us had never been to an actual mining site before. There, we had a chance to take in the mine's environment and workflow. We were given a tour by their exploratory geologists, who were people we knew, and they taught us about the regional and local geology. They also clarified for us that the mineralization is contained within the arsenopyrite's (Apy) structure and that the structural trend of the mineralization is primarily NW-SE, possibly connected to a shear zone. They also led us to their core sample storage and displayed a number of instruments and pieces of equipment that reflect more recent technological advancements related to mining operations, particularly in terms of core sample extraction and analysis. We also got to meet other professionals from several different areas, who shared their knowledge on the daily tasks in the mine, methods of operation and employed softwares. We also discussed the value of effective office communication.



SEG students members and professors at Turmalina Gold Mining. Source: The authors.



(a) Open pit visit. (b) Core sample measurement technology equipment. (c) Core sample with sulfide mineralization, contained within one of the lithotypes of host rocks that occur in the area. (d) Sulfide mineralization, taken from the underground mining operation.

- **Casa de Pedra - CSN (Companhia Siderúrgica Nacional)**

CSN Mineração S.A. is a main subsidiary in the sector, being the second largest exporter of iron ore in Brazil and the sixth in the world. This mining operation is located in the Quadrilátero Ferrífero, being referred as the Casa de Pedra mine, in Congonhas (MG).

Our group was guided by two exploration geologists in the mine, with all the safety and security measures necessary for such a large-scale operation. The scale of a base metal mining operation, specially in a mine with a high tonnage, was a very impactful sight for us students, specially considering that the pits and the residue storage areas were a few orders of magnitude greater than the mine we had visited in the previous day.

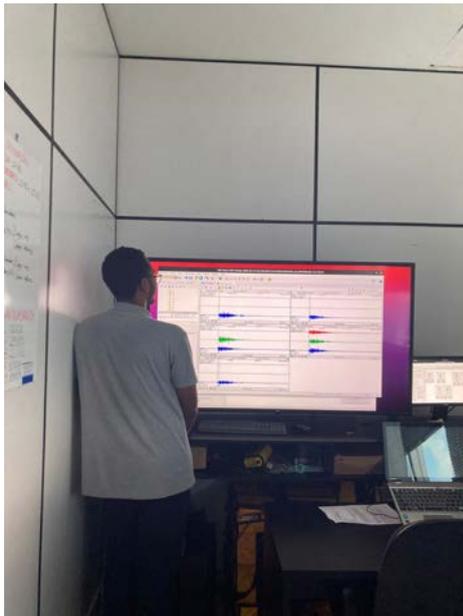
We learned about the different types of iron oxide occurrences within the context of the mine, their physical and chemical properties and the challenges and specificities in relation to their extraction and processing. Also, we learned about the confluence of two megascopic syncline structures (the Dom Bosco syncline and the Moeda syncline) that heavily influence the disposition of the mineralization. In this day, we had the wonderful opportunity to go into the field, view the rocks and structures for their true nature, and discover more about the mining and local geology.

- **MLF Geomechanics**

We were invited by a former SEG member (Calvin Ferreira) to visit his workplace, MLF Geomechanics, in Nova Lima (Minas Gerais). We had the chance to observe how microseismic monitoring procedures are done, in action. This method of monitoring is a relatively new geophysical technique, and due to the wide range of applications, it is growing quickly. Passive interferometry is mostly used for tailings dam monitoring. Therefore, we learned about this method's operation through theory and practical application, as well as about the company's routine for using software and other modern tools while conducting fieldwork.



Seg members at the MLF Geomechanics office



A live explanation of typical software usage



(a) Uniaxial Sensor (b) Triaxial sensor

- **MM Gerdau Museum**

The Mining and Metal Museum is a social and educational project of the steel manufacturer Gerdau and is situated in Belo Horizonte, Minas Gerais. This project's primary goal is to highlight and protect the geological and cultural assets, not only of our country, but of the world. The main mining locations in the state of Minas Gerais are documented in this museum using scientific knowledge. With more than 4000 samples, they have the largest and rarest mineral collection from Brazil. Additionally, they emphasize the fundamental contribution that the manufacturing of metals makes to the advancement of technology and changes in society. We had a great time at the museum as we had the opportunity to understand and learn about the history of mineral exploration and spread knowledge. Therefore, we had the chance to visualize high quality and representative mineral specimens, as well as learn a bit more about the history of Minas Gerais' mineral exploration.

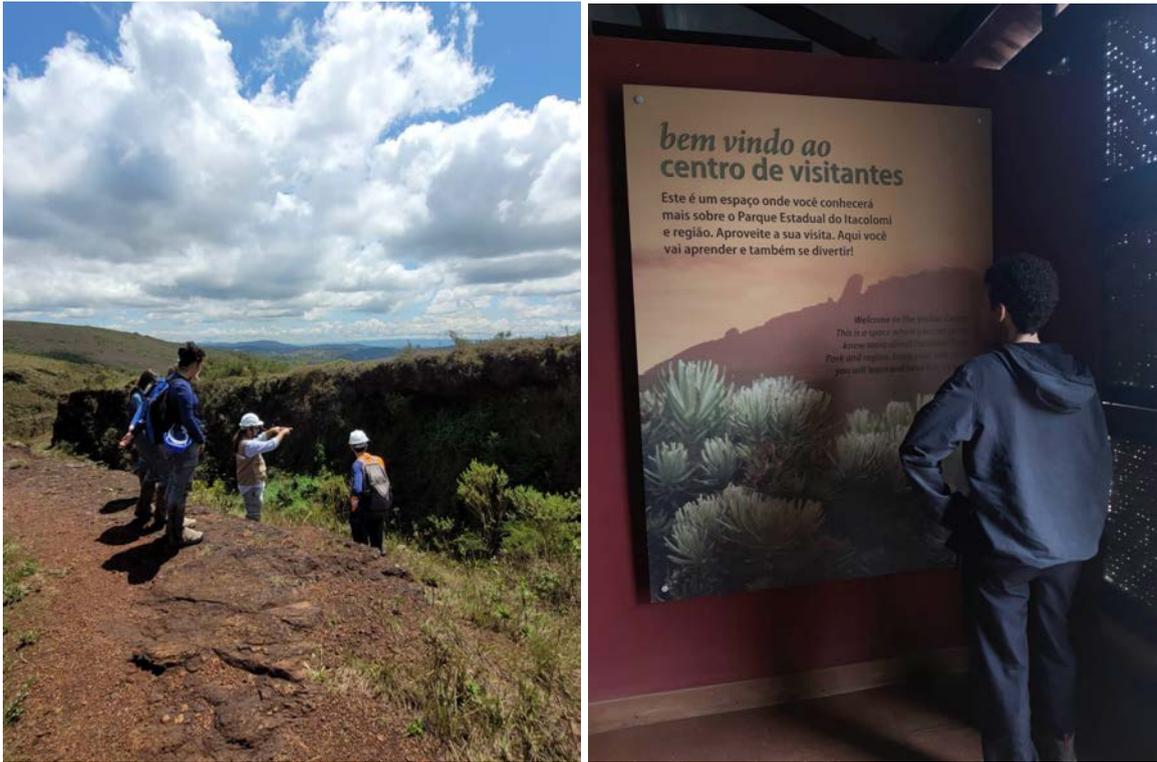


(a) Entrada do Museu MM Gerdau (b) Exposição de carbonatos

- **Regional Geology/State Park of Itacolomi**

Topo do Mundo - In this famous vantage point, we discussed about the nature and organization of the folded strata of Supergrupo Minas as it occurs in the Moeda syncline and had the chance to draw a cross section where the relation between the Paleo-proterozoic metasedimentary rocks and the basement rocks (TTG terrains) was made clear.

Parque do Itacolomi - This state park is one of the most famous tourist locations in the city of Ouro Preto. There, we had the chance to see metamorphosed sandstones and mudrocks of the upper units of Spg. Minas. The park has a few educational posters and interactive materials as well, intended to be used as a way to educate the general public about the physical aspects of the environment represented within the park's perimeter. The Itacolomi Park's area is clearly visible from Ouro Preto's center and its tallest point is represented by the "Pedra do Itacolomi" (Itacolomi's Stone), which is a boulder of metric size that creates an unusual geomorphological geometry.



(a) Anthropogenic valley at Topo do Mundo, probably sculpted to serve as a mining gallery used to reach the Fm. Moeda's conglomerates, known for being bearer's of gold. (b) Welcome card, inside of Itacolomi Park's visitor center.

- **Mina do Veloso (Ouro Preto, Minas Gerais)**

During our stay at Ouro Preto (MG), we invited a professor from the Federal University of Belo Horizonte, Alexandre Raphael Cabral, to be our guide in the visit to a deactivated, subterranean gold mine.

This mining operation represents the gold cycle in Brazil between the XVII and XIX centuries of the colonial period. Nowadays, the mine is no longer active, and the visitors are solely led by the descendants of the slaves who once worked there. Through this initiative, they are able to disseminate very crucial information about our history, how mining ties with our colonial past and the ethical and philosophical aspects that will forever remain entangled with our profession as Geologists and all of those that partake in any natural resource exploration.

Alexandre Cabral, as local researcher, provided leadership to our chapter's members. The Rio das Velhas and Minas Supergroup's quartzite, itabirite, phillite, and schist units are associated to the gold mineralization in this area within a huge structural control.

Our members had the opportunity to acquire knowledge about the local mining's historical, scientific, and cultural significance during the guided tour. They also taught us about the mining pit's construction and usefulness as well as the colonial era's exploring methods.



(a) The mine's main guide (b) Our members watching as the guide shares his knowledge on the geological and historical facts about the mine. (c) Visit to the underground mine, with all the safety equipment required, as our guest professor Alexandre Cabral explains the peculiarities of the gold occurrence in the mine, as well as its relation to the structural geology and the prospective guides used by the colonialists in order to predict areas with greater potential.



Folded structures in the underground mining