



EARTH
SCIENCES

*ADVANCED GEOLOGICAL FIELD METHODS
TRIP REPORT
SOUTHERN SPAIN
FEBRUARY 15TH-22ND 2020*

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Molino Rio Alájar



Field Trip Summary

Ten senior Earth Science students and one alumni from St. Francis Xavier University (StFX) participated in an seven-day advanced geological field methods course held in Southern Iberia from Feb 15th to 22nd. Southern Iberia offers unique and varied geology, including spectacular exposure of an ancient continental collision zone that formed during the collision of Gondwana and Laurussia, during the amalgamation of the supercontinent Pangea. This ancient suture zone stitched ancestral North America to Europe approximately 300 million years ago, and provides a rare exposure of this important geological relationship. The region also hosts the world famous Iberian Pyrite Belt, a geological terrane rich in copper, lead and zinc that is actively mined today. The trip focussed on educating students on geological mapping and tectonic interpretation, economic geology, as well as surface and underground mining and exploration operations in Spain and Portugal.

Department of Earth Sciences professor Dr. James Braid, with the help of Dr. Donnelly Archibald, organised and led the trip. During eight intensive days in the field, students practised observation, mapping, interpretation, and presentation skills. The area afforded a rare opportunity for students to view examples of many important geological processes that they had only learned about in theory in the classroom. The first 3-days were guided field activities, followed by a three-day independent mapping project that allowed students to expand and apply their skills. Each of the first 3-days had a different geological theme, and ended with evening projects and group discussions. The final deliverable of the 3-day independent mapping project was to create a detailed report and a digital map.

The international field school was made possible through *Dr. David Palmer (Probe Metals), Lundin Mining, PDAC, the StFX Dean of Science and StFX VP Research, the StFX Department of Earth Sciences, Black and MacDonald, Canso Co-op, Canso Lions Club, Dartek, Stark Oil, Little Harbour Farm, Leblanc Fisheries, and Ardness Construction.*

Program of the Field School:

Feb 15th - Practical field methods review: Geological mapping of Rio Alájar and Gil Marquez led by Dr. James Braid

Feb 16th - Magmatism and deformation in an evolving orogeny: Igneous textures and magmatic systems evolution led by Dr. Donnelly Archibald

Feb 17th - Ore deposits in the heart of Pangea: Mapping of the Iberian Pyrite Belt field Led by Dr. Braid and Dr. Archibald.

Feb 18th-20th - Independent mapping project

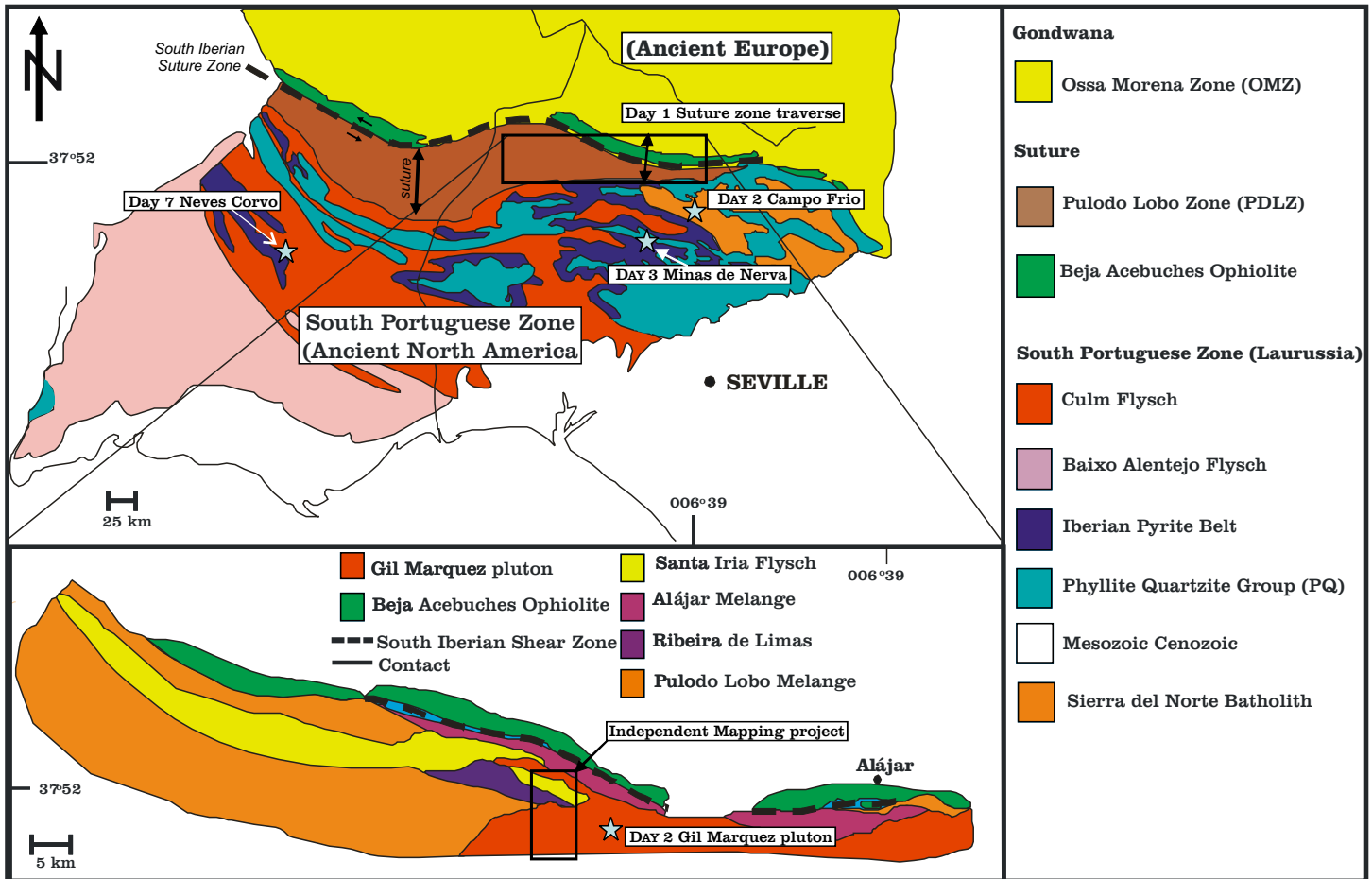
Feb. 21st - Underground mine and processing plant tour of Neves Corvo Cu-Pb-Zn Mine in Portugal



StFX Earth Sciences students overlooking the Day 1 transect from Pena Alájar

Saturday February 15th, Day 1:

After a long travel day from Antigonish via Halifax, Toronto and Madrid, students arrived in Seville, Spain, and travelled by car to the field camp located near the town of Alájar, Spain. The first day focussed on observation skills, proper note taking, basic geological field skills, and an introduction to some of the important geological features of the region. The morning began with a short drive to the Pena Alájar (715 m elevation), that overlooks most of the significant geological features of the area. Students then hiked the Alájar River for the remainder of the day.



Maps showing the regional geology of Southern Spain and Portugal, and the locations visited by StFX Earth Sciences students



StFX Earth Sciences students examining an outcrop along the Rio Alájar transect

In pairs, students navigated a beautiful trail along the river to eleven stations with the goal of interpreting the geological story recorded in the rocks in the area. Students collected field data to create a map and geological cross-section

of the area. The hike traversed the suture zone between ancestral North America and Europe in the heart of the ancient supercontinent Pangea that formed over 300 million years ago.



StFX Earth Sciences students Nicholas Maddock (left), Rebecca Sheehan and Shae Nickerson pause for photos along Rio Alájar

Sunday, February 16th, Day 2:

On the second day, the students visited two outcrops that recorded magmatism associated with the formation of Pangea. The first stop, the Campo Frio pluton, displays textbook examples of magma mixing and mingling textures. Students were tasked with applying the concepts learned in their igneous petrology classes to unravel the sequence of intrusive events. These textures are interpreted to represent the injection of one magma into another. Some geologists posit that these processes occurring at depth are triggers for volcanic eruptions or ore deposit formation.



Magma mingling textures at Campo Frio

At the second stop, the Gil Marquez pluton, the students described a granite pluton emplaced concurrently with the collision between Laurussia and Gondwana. The textures preserved in the plutonic rock indicate shallow emplacement and deformation before the magma was completely crystalline.



StFX Earth Sciences students examining the Gil Marquez pluton



StFX Earth Sciences students Alex McGrath (left) and Colin Glencross examine the Gil Marquez pluton

Monday, February 17th, Day 3:

On the third day, students were introduced to the geology of the Iberian Pyrite Belt near a copper mine in Rio Tinto, Spain. The field site, Minas de Nerva, is located in an area that has been mined since Roman times. The mine is located on the eastern side of the Iberian Pyrite Belt (IPB) of the South Portuguese Zone – the lower continental block that accreted to the Gondwanan (ancient European) margin during Pangea formation. The IPB hosts massive sulfide deposits with some of the highest concentrations of Cu and Zn in the world. These mines have produced gold, silver, copper, lead, tin, and iron.

The ore deposits are Volcanogenic Massive Sulfide (VMS) deposits; however, there are uncertainties as to the exact processes associated with the formation of the ore bodies. The host rocks form an important part of the story of the ancient collision between North America and Europe. Students spent the day exploring the geology of the Minas de Nerva, and mapping along a 2-km transect of the Rio Tinto river.

Students created a geological map detailing the geology recorded in the exposed rocks. In the evening, students presented and defended their map and geological history. The Nerva section is an excellent example of the typical IPB stratigraphy, and contains a variety of lithologies with interesting features (e.g. pillow basalts; bimodal volcanism) and preserved contacts that provided important clues about the tectonic evolution of the area.



Dr. James Braid discussing structural geology with the StFX students at the beginning of the Nerva transect



View of the ancient mine workings at Nerva

February 18st-20th , Days 4-6:

The next three days of the advanced geological field methods course involved students working on a geological map of the Alájar region. Students worked in pairs to collect field data, rock descriptions, and structural measurements while traversing the Rivera de los Baños.

The region consists of similar rock types to those observed on the guided field days, as well as many new and interesting geological relationships that provide tangible examples of the processes and relationship the students have learned about in their undergraduate courses. The students were tasked with creating a geological map of the area and to write a report discussing the rock types, rock relationships, structural geology, geological processes, and overall tectonic history of the area.

Upon returning to StFX, the students defended their maps and reports in an oral exam administered by the course instructors.



StFX Earth Sciences student Alison Barkhouse examining the Gil Marquez pluton



StFX Earth Sciences students Kirsty Malay and Mark Argento taking notes during the final mapping exercise



StFX Earth Sciences students Nicholas Maddock and Colin Glencross discuss an outcrop with Dr. James Braid

Friday, February 21st, Day 7:

On day seven, students travelled to the Neves-Corvo mine in Portugal. Seven students of the students went underground to learn about the underground mining processes with Neves Corvo chief geologist Nelson Pacheco, and the other students toured the processing plant at the surface. The mine extends to >1200m below the surface and there are >200km of roads underground!

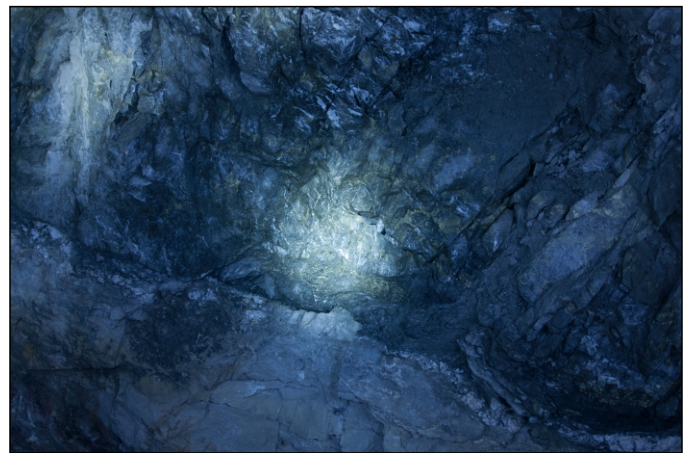
A Canadian Company (Lundin Mining) owns the Neves-Corvo mine and the local Portuguese company Somincor operates it in the western part of the IPB. The morning began with a safety briefing and an introduction to the geology of the area. Students learned that the Neves-Corvo VMS deposits occur within the volcanic-sedimentary complex that consists of felsic volcanic rocks separated by shale, and a discontinuous black shale horizon that is located immediately below the massive sulfide (ore) lenses. Thrust-faults duplicate the stratigraphy of volcano-sedimentary and younger sedimentary units that complicates mining and exploration in the area. The whole assemblage was folded into a gentle anticline oriented NW-SE that plunges to the southeast, resulting in ore bodies distributed on both limbs of the fold. At Neves-Corvo, they are actively mining in four of the six ore bodies that they have discovered.

The students who visited the underground mining operations travelled to a depth of >600 m to look at actively mined faces of the massive-sulfide lenses, and to witness underground drilling in action!

The other students experienced a tour of the on-site ore processing plant that mills and separates the ore into concentrates that the mine exports to smelters in China and elsewhere in Europe. Both the underground and surface tours were an amazing opportunity for students to get a taste of an active mine environment. The geologists and metallurgists who guided the students were exceptional and answered any questions asked by the students. They also allowed the students to collect rock samples in the mine to take as souvenirs of their experience.



StFX staff and students underground at the Neves Corvo Mine, Portugal.



A freshly blasted rock face of Cu and Zn ore underground at the Neves Corvo Mine



StFX Earth Sciences students and mine geologists at the Neves Corvo Mine, Portugal. Rebecca Sheehan (back left), Nicholas Maddock, Colin Glencross, Colin Potts, Kirsty Malay, Lauren Macquarrie, Shae Nickerson, and Dr. Donnelly Archibald. In the front row are two geologists who guided the trip underground



StFX Earth Sciences students pose for a photo at the end of their geological mapping exercise. Mark Argento (left), Rebecca Sheehan, Nicholas Maddock, Alex McGrath, Alison Barkhouse, Colin Glencross, Lauren Macquarrie, Steven Selinger, Colin Potts, Kirsty Malay and Shae Nickerson.

Thank you again to our supporters: Dr. David Palmer (Probe Metals), Lundin Mining, PDAC, the StFX Dean of Science and StFX VP Research, the StFX Department of Earth Sciences, Black and MacDonald, Canso Co-op, Canso Lions Club, Dartek, Stark Oil, Little Harbour Farm, Leblanc Fisheries, and Ardness Construction.