Report on the geological field trip to the Central Andes (February 20 to March 3, 2017) by the participating students of the Institute of Geology (Hamburg University)

On our geological field trip through the central Andes in Argentina under the guidance of Prof. Dr. Ulrich Riller, we visited impressive rock formations, volcanos, geomorphic characteristics as well as variable climate zones including savanna, rainforest and hyper-arid areas. Argentina is the second largest country in South America and stretches 3700 km in North-South direction. Elevation in the central Andes ranges from about 1000 m to 6000m in the area that we visited. Consequently, climate zones and local weather vary considerably, notably in the wet season, which we experienced on our field trip by witnessing storms, massive rainfall as well as almost freezing conditions and rather warm temperatures.

Prior to the field trip, Dr. Petrinovic, a volcanologist from the Centro de Investigaciones en las Ciencias de la Tierra in Córdoba, visited the field trip participants in November 2016 at Hamburg University in preparation of the field trip jointly with Prof. Riller. In the course of his visit, Dr. Petrinovic gave a lecture in the Geodynamics graduate course, where he spoke about the geological and geochemical setting of volcanism in the Andes. He also attended the seminars of the structural research group, in which the field trip participants gave short presentations on assigned topics pertaining to what we examined during the field trip. During these meetings, Dr. Petrinovic discussed geological issues as well as climatic and cultural aspects in great detail. Dr. Petrinovic's visit to Hamburg prepared as well for the field trip and his volcanological expertise contributed tremendously to make the trip a great learning experience.

Our field trip started in the City of Salta located at an elevation of 1187 m above sea level (asl) and ended on the rim of the Negra Muerta collase caldera at an elevation of 5000 m asl. After the group met in Salta, we embarked on a rented bus driven by Gustavo, a professional driver. Joined by Dr. Ivan Petrinovic and a student from Córdoba, two field trip loops took as around the eastern margin of the Puna Plateau and the Eastern Cordillera. To avoid mountain sickness, we gently gained elevation over a period of 5 days. Nonetheless, one could feel the air becoming thinner every day, as we reached our highest destination of the first loop, the Piedra de Molina to 3348 m asl. During the first loop, we stayed overnight at hotels or simple guesthouses, usually only one night in the same village.

Quebrada de las Flechas near Angastaco.

The first field-trip loop lead us through the Eastern Cordillera – the eastern flank of the central Andes and the boundary to the central Andean high plateau, the Puna – through the towns of Cafayate and Cachi. Along this famous road, the Ruta 40, we examined sedimentary rock units of the so-called Salta Group, which make up a large portion of the Eastern Cordillera, and the Paleozoic Cerro Durazno granitoid pluton. This pluton is part of the basement rocks of the Salta Group and hosts impressive mylonite and ultra-mylonite rocks.

Giant stromatolites in the Quebrada de Escoipe and Cretaceous-Tertiary rift (yellow) and post-rift (red) sedimentary rocks of the Cerro Tintin.

Uplift of the Cordillera commenced during the Tertiary, about 50 Ma ago, and still continues. Deposition of the sedimentary rock units began prior to the Andean uplift in the Cretaceous. Deposition occurred during crustal extension in a large rift basin, which extended from Argentina to Bolivia and Paraguay with multiple sub-basins in the region of the Salta Province. Crustal extension decreased with the end of the Cretaceous leading to a broad change in the sedimentary environment. The resulting sedimentary sequences are known as post-rift sedimentary rocks and overlay the Cretaceous syn-rift rocks. All of the rift deposits form the so-called Salta Group.

Along with crustal shortening and progressive uplift of the central Andes in the Tertiary, the sedimentary environment shifted from a rift environment to a foreland basin environment. The central Andean foreland basin developed as a consequence of thickening of the Earth's crust induced by tectonic shortening. Due to the increase in crustal thickness, the thickened crustal root of the Andes sank into the mantle, thereby flexing the adjacent crust underlying the foreland downward. This process generated the foreland basin geometry in front of the Eastern Cordillera.

Collectively, sediments deposited in the foreland basin make up the Payogastilla Group. Deposition in this ancient foreland basin continued until the end of the Tertiary at around 2.6 Ma before Present. Along the road from Cafayate to Cachi, following the Calchaquí River, the sedimentary rocks of the Payogastilla Group were the primary target of this part of the field trip. We continued to follow the Calchaquí River up to the town of La Poma. The history of this small town demonstrates all too well that tectonic activity in the central Andes has not stopped. After a devastating earthquake in 1930 destroyed the whole town, La Poma was rebuilt and relocated. Toward the end of the first loop, we visited the memorial site of La Poma, which was built in the ruins of the old town center, before returning back to Salta.

Besides seeing a number of picturesque villages, a touristic highlight of the first loop was the visit of the highest winery in the world, the Bodega Colomé near the town of Molinos.

Memorial site of the town of La Poma and bells of the church destroyed by the 1930 earthquake.

The second field trip loop brought us up the high plateau of the central Andes, the Puna, which has an average elevation of 4000m asl. On the first day of this loop, we drove over the eastern orographic barrier onto the plateau to San Antonio de los Cobres, where we stayed duration the second half of the field trip. On our way there, we examined the Salinas Grandes, one of the large salt lakes of the Puna. These salt lakes form in internally drained basins where the precipitation of the surrounding mountain ranges is concentrated. Evaporation of the water in these lakes leads to high concentrations of salt within the remaining water.

Salinas Grandes and strong rainfall at the orographic barrier of the eastern Puna.

The focus on the second loop was on volcanism in this region. We visited several different types of volcanic centers, including the monogenetic Negro de Chorillos volcanos, the Cerro Aguas Calientes collapse caldera and the Tuzcle stratovolcano. All of the above mentioned volcanic centers are part of the Calama – Olacapato – El Toro transverse volcanic belt. The formation of the volcanic centers, such as the Cerro Aguas Calientes caldera, appear to be driven by tectonics. This caldera erupted in two episodes, at 17.15 Ma and 10.03 Ma before Present. As a result of increasing pressure inside the magma chamber underlying the caldera, the roof of the chamber collapsed and vast amounts of volcanic ash and pyroclastic mass flows covered the surrounding area. We inspected several of these volcanic ash and pyroclastic flow deposits in the Puna.




Top row: Dr. Ivan Petrinovic explaining volcanism of the Agual Calientes caldera.
Bottom row: The Cerro Tuzcle and one of its lava flows. Note person in front of the lava flow for scale.

At the end of the second loop, on our way back from the Puna down to Salta, we made a final stop at the Abra de Acay looking down on the Negra Muerta collapse caldera from 5000 m asl. From our position we enjoyed an outstanding view over the Puna plateau to the North of us and over the 7.4 Million years old caldera and the Calchaquí Valley to the South, which we had been travelling up during our first loop.

Our field trip to Argentina was accompanied by many positive experiences. We learned how to communicate with the native people without talking their language, and how to deal with prices in a different currency. But the most important thing is that we learned a lot about the beautiful country and countryside, the people, the ecosystems, the style of living, and especially the outstanding geology of Argentina. It was a great adventure to get to a place you've only dreamed of and see mountains like the Andes and animals like Lamas, Vicuñas and Nandus. We saw big lava flows, ash deposits and were able to imagine how violent some volcanic eruptions might have been. We also stood at the edge of the Negra Muerta volcanic complex at 5.000m asl, looking into the Negra Muerta caldera. It was a great advantage for our studies and a few of our group even found a topic for their master thesis. In summary, this field trip was one of the most fascinating and informative trips we have ever been on and would like to acknowledge support from Hamburg University (PROMOS Program).