Field trip in Val de Travers

8 – 11 July, 2017

Participants:

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Introduction

This field trip in Val de Travers, Switzerland, took place between the 8th and the 12th of July, 2017. Eleven members of the RING Team (1 professor, 2 associate professors, 2 research engineers and 6 PhD student members of the IAMG student chapter) discovered the geology of this area. The main objectives of this trip were to observe geological outcrops (the team's main focus is on their numerical representation), to create an emulation environment with our Swiss colleagues for scientific discussions, and to discover our co workers in a different context.

Several geologists from the University of Neuchâtel were involved in the organization of this field trip and were our guide during the visits:

- Philippe Renard, Professor
- Benoît Valley, Associate Professor
- Cécile Vuilleumier, PhD Student
- François Pasquier, retired geologist.

We would like to thank them for their involvement and availability.

Day 1 - 8th July: overview of the geology of the area

The first day, François Pasquier, a retired geologist who built the geological map of the area, took us to several outcrops. This provides us a global understanding of the geology and hydrology of the area.

Stop 1: Noiraigue spring

We made a first stop at the Noiraigue Spring to observe the stratigraphy. The bottom the sequence is composed of an Argovian shale layer. The spring is located within an alternance of shale and carbonates deposed during the Sequanian. The Sequanian layers are overlaid by a thick carbonate Kimmeridgian layer, clearly visible in the landscape.

The water of the Noiraigue spring come from the Vallée des Ponts, where was our next stop. The Noiraigue spring is the location of one the first documented dye tracing (using starch and methylene blue).

Stop 2: Vallée des Ponts

La Vallée des Ponts (i.e., *Valley of the Bridges*) is long of 20 kilometers, for a width of nearly 4 kilometers. It is filled by Quaternary deposits, covering thick molasse deposits. Cretaceous carbonates are outcropping (Figure 1) on both sides of the valley.

Figure 1: We stand in a former and now dried morainic lake. The lake used to be 40 meters deep during glaciation, but the lowland is now a bog and wooded. The hill on the opposite side is made of highly deformed Cretaceous carbonates.

Stop 3: Affleurement de la Fromagerie

The next-stop was at the *Fromagerie* (cheese-factory). Datations on Rudists (bivalvs) indicate that the series is Urgonian. The position of some of the Rudists indicates that the serie is inverted, and an unconformity can be seen, with the Urgonian above the marine molasse. This molasse is a grey-greenish sandstone sequence thick of 50m to 100m.

Stop 4: Lac des Taillères

We stop (rapidly, due to the poor weather) at the Lake of Taillères. This lake is situated within molassic sediments and the water flows down through the carbonates. The water that goes through the karstic network is the one that feeds the Areuse, whose spring have been observed soon after.

Stop 5: Areuse spring

The water resurgence is located at the Areuse spring, forming a lake within oolithic carbonates. The water flows out from an intensely faulted and fractured part of the rock. However, in this area, it is not possible to explore the karstic network.

Figure 2: (a) Limestone layers strongly dipping close to the Areuse spring. (b) The water flows from an intensely fractured area within the limestone.

Figure 3: a) Oolithic limestone with milimetric oolith. (b) One particularly large oolith.

Day 2 - 9th July: Exploring the karstic systems

Figure 4: Location of the two karstic sites visited on day two.

Karstic systems are natural systems generated by the progressive chemical alteration of, generally, carbonate rocks by water. Consisting in highly connected networks of conduits and caves, these geobodies strongly influence underground flows. These systems are partially inaccessible, and simulation methods are so developed to better assess the uncertainties related to these highly exploited environments. Thus, karstic systems count among the various geobodies that the RING team works on.

This second day was dedicated to the exploration of karstic systems thanks to two symbolic sites of the region: the “Glacière de Monlési” and the “grotte de la cascade” in Môtiers.

The Glacière de Monlési is a natural reserve located near Val-de-Travers. It is large cave characterized by a thick layer of permanent ice that has even been exploited in the 50’s. The total volume of the ice is estimated around 6000m3 in summer. The cave, a karstic doline, contains 3 wells, one of them equipped to allow human visits (Figure 5, Figure 6). The main room of 40m long is completely covered by the ice, which comes from the snow accumulation in winter. In summer, the particular configuration of the cavity keeps the fresh air, denser, in the cave. The ice beginning to melt if temperatures become slightly positive, the maximal temperature is always 0°C (Figure 7). Our visit in this ice cave was a unique occasion for most of us to discover this particular phenomenon. The Glacière de Monlési appears to be the biggest ice cave of Switzerland, and nice ice karstic features were observable like ice stalagmites and stalactites (Figure 7). Unfortunately, according to the speleologists who made the visit with us, the ice layer is obviously diminishing, probably due to the global warming.

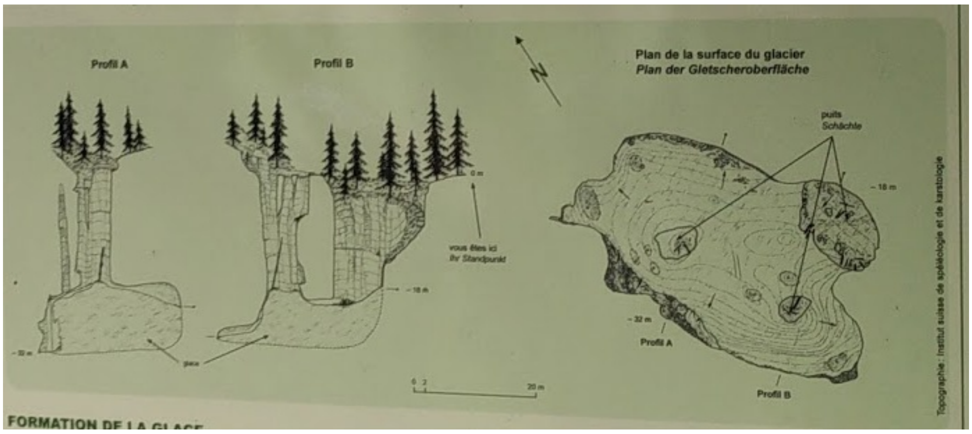

Figure 5: An extract of the panel describing the cave at its entry.

Figure 6: Main access to the Glacière de Monlési.

Figure 7: Some karstic ice features that can be observed in the cavity: here, ice stalagmites.

We visited Môtiers cave, also called "*Grotte de la Cascade*" in the afternoon. For almost all of us, it was the first time we practiced speleology. We entered the karst through the main access near the *Sourde* source (Figure 8). Motiers cave explorable part is approximately 200m of long and ends up on a siphon. At the time of our visit, the very low water level allowed us accessing to almost all known galleries. We were thus able to see the lowest cave which directly opens on the phreatic table (Figure 9). During the exploration, we took time to notice the various karstic features generated by water-rock interaction like "*cupules*" or "*coups de gouges*" (Figure 10). The abrupt variations of karst conduit dimensions, noticed in our previous numerical statistical studies, were interesting to visually confirm. Also, it was a good occasion, for some of us who work on karsts, to show the others the importance of inception surfaces on the shapes of conduits (Figure 11): stratigraphic inception features like horizons, but also tectonic ones, as most of the passages follow sub-vertical faults. Despite mud, everybody delighted went out from this first speleological excursion (Figure 12).

Figure 8: The main entrance of the karstic system of Môtiers, near the Sourde source (on the right).

Figure 9: Exploring the access to the phreatic table.

Figure 10: A zoom on a particular karstic feature witnessing the action of water: the “coups de gouge”.

Figure 11: Karstic passages showing the preferential developments of conduits along inception surfaces: on the left a stratigraphic inception surface, generating lateral incisions in the gallery; on the right, a sub-vertical fault.


Figure 12: Out from the karst: despite mud, everybody smile, happy from this first speleological excursion.

Day 3 - 10th July: Creux du Van walk

The Creux du Van is a natural rocky cirque approximately 1,400 metres wide and 150 meters deep, on the north side of Le Soliat. This morphology is due to fluvial erosion on top of a major fault (Figure 13a)). A local glacier eroded even more the cirque and caused landslides of a semi-circular shape. The region is a nature reserve since 1870.

We walked from the top of the Creux du Van through the Gorges de l'Areuse to Boudry.

Figure 13: (a) Amazing and cloudy view from the top of the Creux du Van. (b) Wildlife (not so wild) at the beginning of our walk.

The cliffs of the Creux du Van consist of Kimmeridgian and Sequanian limestones. They kept the South soils of the cirque from warming up. Those soils are still affected by the permafrost of the last glaciation. This permafrost restrict the growth of the spruces and keep the temperature of the Fontaine Froide to approximately 4°C throughout the year (Figure 14a)).

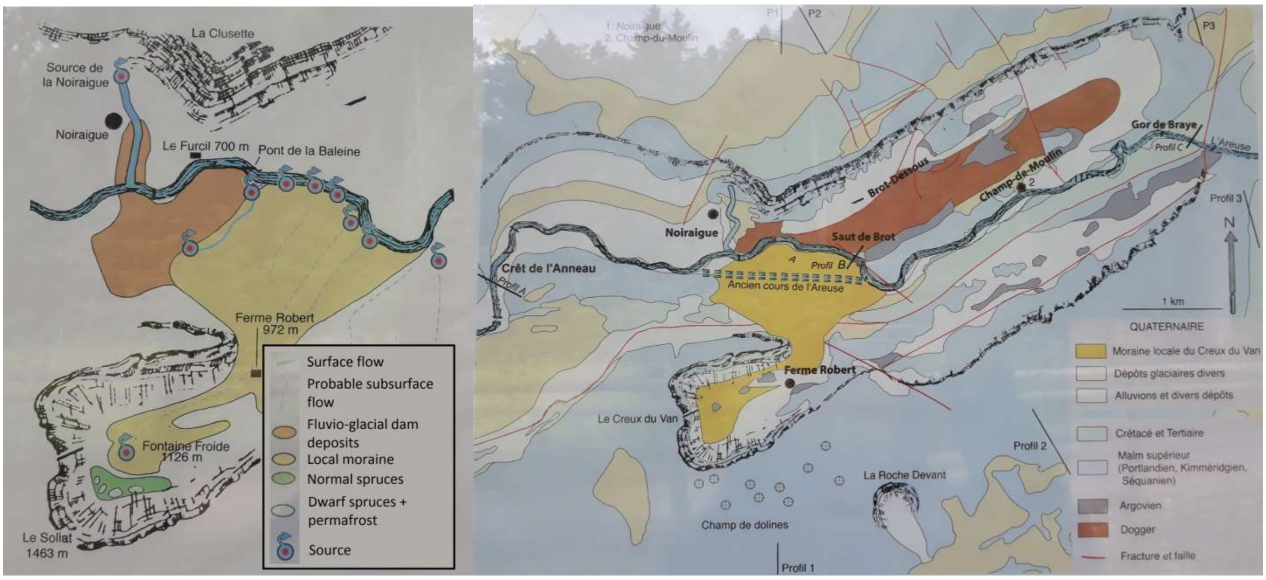

Figure 14: Two extracts of the panel in the Creux du Van cirque. (a) Close-up of the Creux du Van. (b) Val-de-Travers valley.

The Creux du Van glacier retreat formed an impressive moraine at the bottom of the cirque. Those rocks and the following landslides erected a dam on the Areuse course. A lake formed from 10 350 - 10 000 BC to 5 650 - 3 700 BC [Matthey, 1971]. The actual Areuse course was avulsed from its original course (Figure 14b)).

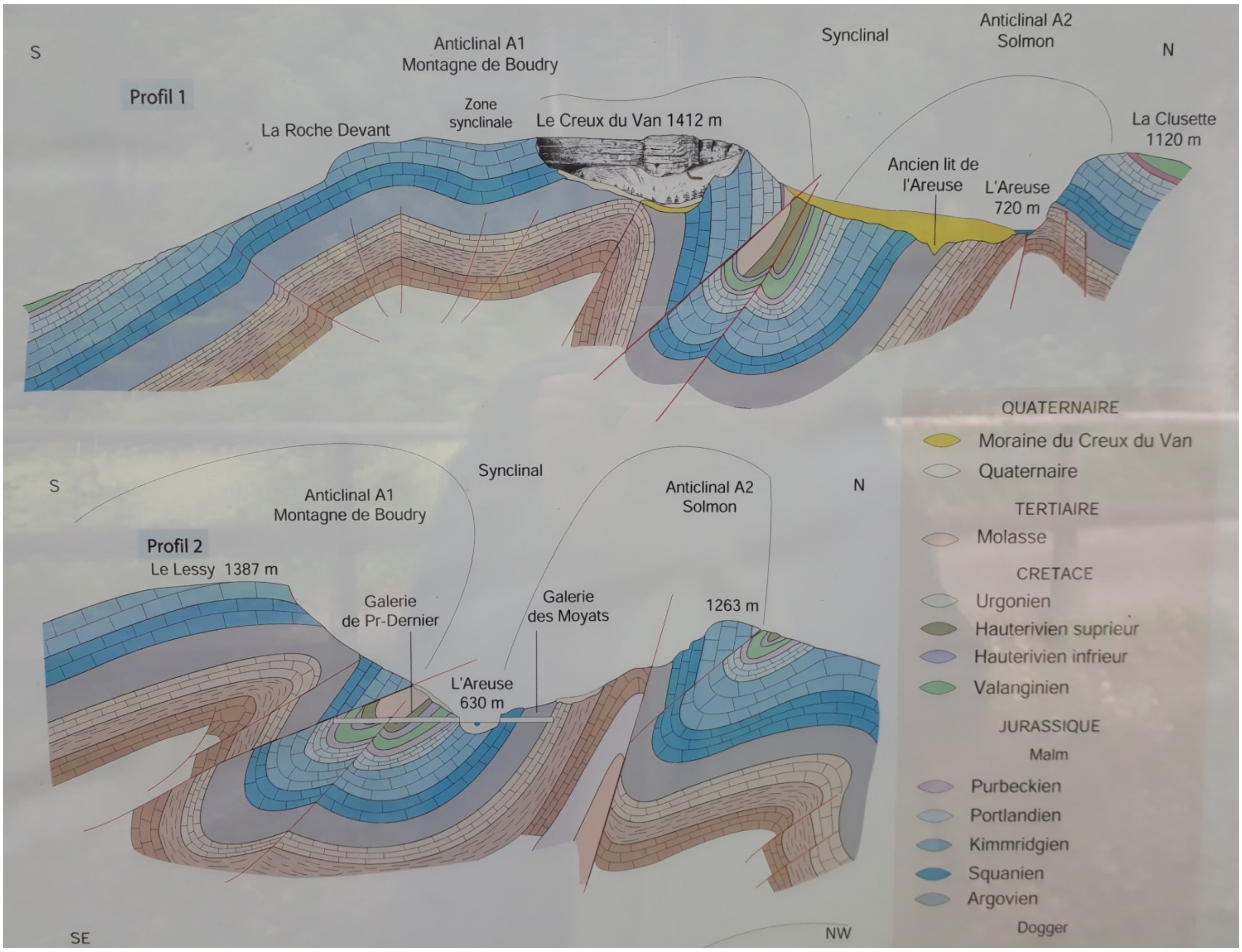

Figure 15: Two geological cross-sections through the Val de Travers valley.

The Moyat waterworks exist since 1887 to fetch water from the Areuse for the La Chaux-de-Fonds city. The water is lifted outside of the Areuse gorge to Jogne, where the gravity pushes it into the La Chaux-de-Fonds reservoirs. Downstream the Creux du Van, the Moyat tunnel was digged in 1922 to fetch even more water from a source in the Jurassic limestones - la Dalle Nacrée (Figure 15).

The hiking path crossed two half transverse valleys: the Saut de Brot between the Val-de-travers and the Champ-de-Moulin valleys and the Gor de Braye between the Champ-de-Moulin and the Neuchâtel lake (Figure 14b).

Day 4 - 11th July: Asphalt mine

Our field trip in Val de Travers ended with the visit of La Presta Asphalt Mines. Asphalt is a heavy hydrocarbon product mixed with carbonates. It has been used since the Antiquity for its impermeable properties (for embalming, and the sealing of building and ship hull), and for road asphalting since 1849.

The La Presta deposit was discovered in 1711 by a Greek scholar, Eyrini d'Eyrinis, and its exploitation began in 1712 as an open-pit mine. As the surface outcrops were running out, galleries were progressively drilled to track the asphalt layer underground. From 1873, the exploitation entered an industrial era and became flourishing. It ended in 1986 as the deposit was no more profitable.

The mines count almost 100 km of galleries, divided into the lower mine (80 km) which was the first in exploitation and is now completely flooded, and the upper mine (20 km) which opened thanks to the progresses of mechanical extraction. More than two million tons of asphalt ore were extracted in 275 years. Nowadays, a museum recounts the mine history and the asphalt industry of the Neuchatel canton and some tunnels can be visited in the upper mine.

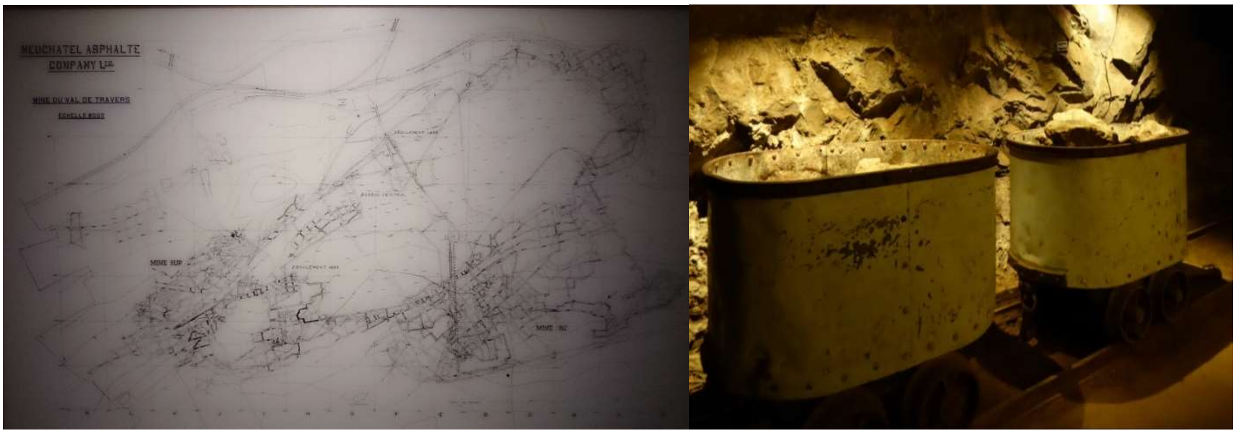

Figure 16: (a) This 2D map shows the lateral extent of the quarry. (b) Mine trolley were moved manually by the pit workers.

The processing of asphalt ore is simple: once ore blocks have been extracted, they are reduced to a powder which is heated until melting. Different materials (other bitumen, sand, etc.) can be added depending on the properties wished for the final asphalt, and the mix is poured into hexagonal molds and cooled down. These blocks of pain asphalt were exported throughout the world, in particular in the former British Colonies.

Figure 17: The RING Team at the end of the visit of the asphalt mine. This field-trip was also a wonderful opportunity to strengthen our team spirit.

Conclusion

Thanks to the IAMG funding, we had the opportunity to make a field trip far from our computer laboratory. We discovered the morphology and the geological history of the Jura Mountains. We also explored the hydrography of the Areuse, the related karstic systems and a former asphalt mine. During these days, we enjoy the quality of the scientific discussions we had with our Swiss colleagues as well as the local gastronomy.

Bibliography

Matthey, F. (1971). *Contribution à l'étude de l'évolution tardi-et postglaciaire de la végétation dans le Jura central*. H. Huber.

Annex: Expanses

accommodation (including some meals)	-1921,3
food	-628,10
oil	-167,43
visits	-188,64
gifts to Swiss colleages	-79,2
IAMG funding	2500
ASGA funding	137
remaining money on student chapter account	350
balance	2,33