



## Geoscience goes underground

Thursday, 21 November 2019

University of Fribourg  
Department of Geosciences  
Chemin du Musée 4  
CH-1700 Fribourg

### Program & Abstract Booklet

Supported and sponsored by:

**UNI  
FR**  
■  
UNIVERSITÉ DE FRIBOURG  
UNIVERSITÄT FREIBURG

sc | nat 

Swiss Academy of Sciences  
Akademie der Naturwissenschaften  
Accademia di scienze naturali  
Académie des sciences naturelles

## PROGRAM

<b>9:00 – 9:40</b>	<b>Coffee &amp; Croissant – Time to upload presentations &amp; hang up posters</b>
<b>9:40 – 9:45</b>	<b>Opening &amp; Welcome</b>
9:45 – 10:00	Evelyne Margelisch <i>Testing the applicability of He isotopes as a tracer for paleo-denudation rates in Pyroxenes from sediments of Lake Towuti, Indonesia</i>
10:00 – 10:15	Claudia Burkhalter <i>Last Glacial Maximum glaciation in the Jura mountains</i>
10:15 – 10:30	Fiona Nägeli <i>Investigation of in-situ and laboratory water content of Opalinus Clay shale</i>
10:30 – 10:45	Laura Dziomber <i>A geometric morphometric study of turtle shells</i>
<b>10:45 – 11:15</b>	<b>Coffee &amp; 1<sup>st</sup> poster session</b>
11:15 – 11:30	Mike Werfeli <i>Inferring individual flight routes of a nocturnal bird migrant</i>
11:30 – 11:45	Katarina Rybarikova <i>“Decision-making in conservation: human-wildlife or human-human conflict mitigation?” Insights from Namibia</i>
<b>11:45 – 12:15</b>	<b>1<sup>st</sup> Keynote: Gunter Siddiqi</b>
<b>12:15 – 13:15</b>	<b>Business lunch &amp; 2<sup>nd</sup> poster session incl. discussion with 1<sup>st</sup> Keynote speaker; group picture (13:15 – 13:30)</b>
13:30 – 13:45	Isabelle Buholzer <i>The Alpe Arami enigma: The subduction path of high-pressure mafic and ultramafic rocks</i>
13:45 – 14:00	Corin Jorgenson <i>Consequences of magma-CO<sub>2</sub> interaction for explosive volcanism at Colli Albani (Italy)</i>
14:00 – 14:15	Vivian Leuenberger <i>Analysing Particulate Matter found on Honey Bee Surfaces using SEM-EDX</i>
14:15 – 14:30	Robin Haller <i>Grand Canonical Monte Carlo simulations of ion sorption on 2:1 clay mineral edges</i>
<b>14:30 – 15:00</b>	<b>Coffee &amp; 3<sup>rd</sup> poster session</b>
15:00 – 15:15	Flavio Huber <i>Lake Au: Insight on tsunami events in Lake Zurich</i>
15:15 – 15:30	Sebastian Schaller <i>Deep drilling in Lake Constance: a journey through the lake’s history</i>
<b>15:30 – 16:00</b>	<b>2<sup>nd</sup> Keynote: Romain Amiot</b>
<b>16:00 – 16:15</b>	<b>Best Talk and Best Poster Award</b>
<b>16:15 – ...</b>	<b>Apéro!</b>

## EXECUTIVE COMMITTEE

Andersson Nils  
 Dziomber Laura  
 Leuenberger Vivian  
 Sapia Léo  
 Sturny Janine  
 Zimmerli Géraldine  
 Zimmermann Alice

## PARTICIPANTS

Aalstad Elin	Lausanne	Löw Noemi	Zurich
Abila Ana Lorena	Zurich	Lujic Josip	Fribourg
Aeschbach Andrin	Bern	Margelisch Evelyne	Bern
Amacher Florian	Bern	Marijanovic Mladen	Zurich
Amrein Anja	Lausanne	Marro Adeline	Fribourg
Andrey Marine	Fribourg	Mikealian Cindy	Bern
Arnold Jeremias	Zurich	Mazzotta Salvatore	Basel
Balmer Michael	Zurich	Mudzingwa Needmore Mercy	Harare (Zimbabwe)
Bongiovanni Mauro	Zurich	Müller Rhonda	Zurich
Buckley Andrea	Fribourg	Muñoz Yohualli	Bern
Buholzer Isabelle	Bern	Nägeli Fiona	Zurich
Burkhalter Claudia	Bern	Ortelli Federico	Fribourg
Caras Jennifer Robin	Quebec (Canada)	Patra Soumita	Birla (India)
Cardenas Miguel	Bern	Peris Cabré Sabí	Geneva
Da Silva Guimaraes Ewerton	Bern	Perler Dominic	Bern
Dmitrovskii Andrei	Zurich	Polasek David	Geneva
Elabsawy Alaa	Fribourg	Prieto Manuel	Fribourg
Graf Franziska	Bern	Quilici Andrea	Lausanne
Gray Timothy	Zurich	Rast Markus	Zurich
Grünert Nicolas	Basel	Richards Josh	Bern
Gutierrez Carlota Amalia	Lausanne	Rybakova Katarina	Fribourg
Haberdtz Xenia	Fribourg	Schaller Sebastian	Bern
Haller Robin	Bern	Schmid Caroline	Bern
Hirschi Jérôme	Zurich	Schmid Nicole	Bern
Hirt Janik	Zurich	Simian Lucas	Zurich
Huber Flavio	Bern	Singh Surender	Hisar (India)
Ingold Philipp	Bern	Solms Thierry	Zurich
Jiménez Alejandra	Geneva	Speckert Tatjana Carina	Zurich
Johal Simran	Zurich	Studer Lea	Zurich
Jorgenson Corin	Geneva	Studer Manuel	Fribourg
Kaltenrieder Cyrielle	Fribourg	Toorenburgh Zoë	Zurich
Klaasen Sara	Zurich	Ulrich Michelle	Bern
Koenig Cassandra	Fribourg	Ursprung Anina	Fribourg
Kumbhat Diya	Zurich	Välimäki Reetta	Fribourg
Lachat Florian	Fribourg	Werfeli Mike	Zurich
Lachavanne Carole	Bern	Wyss Michael	Fribourg
Lechtenböhmer Marius	Zurich	Zimmerli Raphael	Bern
Lesche Moritz	Zurich	Zumberhaus Jan	Fribourg
Lontsi Agostiny Marrios	Zurich		

TALKS

- 01 Margelisch E., Vogel H. & Delunel R.**  
*Testing the applicability of He isotopes as a tracer for paleo-denudation rates in Pyroxenes from sediments of Lake Towuti, Indonesia*
- 02 Burkhalter C., Bichet V., Ivy-Ochs S. & Akçar N.**  
*Last Glacial Maximum glaciation in the Jura mountains*
- 03 Nägeli F.**  
*Investigation of in-situ and laboratory water content of Opalinus Clay shale*
- 04 Dziomber L., Foth Ch. & Joyce W. G.**  
*A geometric morphometric study of turtle shells*
- 05 Werfeli M.**  
*Inferring individual flight routes of a nocturnal bird migrant*
- 06 Rybarikova K.**  
*“Decision-making in conservation: human-wildlife or human-human conflict mitigation?” Insights from Namibia*
- 07 Buholzer I., Vieira Duarte J. & Hermann J.**  
*The Alpe Arami enigma: The subduction path of high-pressure mafic and ultramafic rocks*
- 08 Jorgenson C., Caricchi L., Weber G., Giordano G., Marxer F., Ulmer P., & Tollan P.**  
*Consequences of magma-CO<sub>2</sub> interaction for explosive volcanism at Colli Albani (Italy)*
- 09 Leuenberger V., Neururer Ch. & Grobéty B.**  
*Analysing Particulate Matter found on Honey Bee Surfaces using SEM-EDX*
- 10 Haller R., Schliemann R. & Churakov S. V.**  
*Grand Canonical Monte Carlo simulations of ion sorption on 2:1 clay mineral edges*
- 11 Huber F., Nigg V. & Anselmetti F.**  
*Lake Au: Insight on tsunami events in Lake Zurich*
- 12 Schaller S.**  
*Deep drilling in Lake Constance: a journey through the lake’s history*

## POSTERS

- P01 Bongiovanni M.**  
*The versatility of apatite as geochemical tool: an application to the porphyry Cu system in El Teniente, Chile*
- P02 Ingold P. & Wanner C.**  
*Stability and As adsorption of nanocrystalline Al-hydroxysulfates forming during acid rock drainage*
- P03 Patra S., Naegeli K. & Wunderle S.**  
*Accuracy study of snow cover maps based on AVHRR data with different spatial resolution*
- P04 Peris Cabré S., Verité J., Valero L., Roigé M., Spangenberg J., Adatte T., Vinyoles A. & Castellort S.**  
*Fluvio-marine sedimentological record and paleoclimatic signals of the Middle Eocene Climatic Optimum (MECO), Southern Pyrenees (Spain)*
- P05 Solms T. & Driesner T.**  
*Studying Au-precipitation mechanisms in an extinct hydrothermal system in SW-Iceland*
- P06 Zimmerli G., Lauper B., Jaeggi D. & Foubert A.**  
*Lithological diversity within the Opalinus Clay of Northern Switzerland: interpretation and elaboration of a subfacies model*

## KEYNOTE SPEAKERS

**Gunter Siddiqi (Swiss Federal Office of Energy/Bundesamt für Energie/Office fédéral de l'énergie)**

Mr. Siddiqi is a permanent guest of the association Geothermie Schweiz. He will tell us more about deep geothermal energy in Switzerland, its state of development, the environmental, economic, social and political issues it creates, as well as the possible future job opportunities for geoscientists in that field.

**Dr. Romain Amiot (Centre National de la Recherche Scientifique)**

Dr. Amiot is permanent researcher at University Lyon 1 (France). He conducts interdisciplinary projects between geochemistry and paleontology. His research focuses on stable isotopes, Mesozoic paleoclimate, and thermoregulation of Mesozoic reptiles. He comes to talk about his experience in academics.

**01****Testing the applicability of He isotopes as a tracer for paleo-denudation rates in Pyroxenes from sediments of Lake Towuti, Indonesia**

Evelyne Margelisch\*, Hendrik Vogel\*, Romain Delunel\*

\*Institute of Geological Sciences, University of Bern, Baltzerstrasse 3, CH-3012 Bern, Switzerland (evelyne.margelisch@students.unibe.ch)

The aim of this Master Thesis was to test the applicability of Helium (He) isotopes as a tracer for paleo-denudation rates in detrital pyroxenes (Px) from Pleistocene sediments in Lake Towuti, Indonesia. In order to do so, a method was developed, in which the Px have been extracted from a sediment core. <sup>3</sup>He is produced in-situ in mafic minerals upon bombardment by cosmic radiation. This <sup>3</sup>He production is dependent on the intensity and exposure time to cosmic rays. Hence, <sup>3</sup>He/<sup>4</sup>He analysis can be used as a quantitative proxy for surface processes such as denudation or paleo-climatic evolution through time, etc.

Lake Towuti is located near the equator on the island of Sulawesi in Indonesia. It is a tectonically active area with a tropical climate. The lake is surrounded by mafic-ultramafic bedrock, mainly peridotite. The 17 investigated samples from one of the drill cores, were collected in 2015 within the framework of the ICDP co-sponsored Towuti Drilling Project and cover the upper about 100 m of sideritic clays, capturing about 1 Myrs of lacustrine sedimentation.

In different laboratories, the lake samples went through decarbonisation by 1M hydrochloric acid (HCl), density separation with the heavy liquid LST ( $\rho=2.8 \text{ g/cm}^3$ ), silica and diatom dissolution by 3% hydrogen fluoride (HF), siderite dissolution by 1M sulfuric acid (H<sub>2</sub>SO<sub>4</sub>), magnetic separation, sieving and handpicking. Due to the fact, that the amount of remaining clays in the samples was too high, only one sample was finally measured.

For data comparison, a bedrock sample (peridotite) from approx. 25 km NW of the drill core, was crushed in a Selfrag, thus the Px could be elected with a tweezer under the binocular.

Finally, the <sup>3</sup>He/<sup>4</sup>He isotopes of the Px grains from the lake sediments ( $\mu\text{m}$ -range) and the bedrock ( $\emptyset$  1 mm) were measured on a noble gas mass spectrometer at the Centre de Recherches Pétrographiques et Géochimiques (CRPG) in Nancy, France.

Both, the lake and the bedrock sample, showed identical, surprisingly low <sup>3</sup>He/<sup>4</sup>He ratios, equal to Atmospheric ratios. Those results conclude to a short exposure/exhumation time of a so far old (Cretaceous) assumed ophiolite (Kadarusman, 2004). A possible explanation of those oppositional seeming outcome might be found in the extremely fast geodynamics, which cause an erosion as efficient as exhumation.

## 02

**Last Glacial Maximum glaciation in the Jura mountains**

Claudia Burkhalter\*, Vincent Bichet\*\*, Susan Ivy-Ochs\*\*\*\*, Naki Akçar\*

\*Geologisches Institut, University of Bern, Baltzerstrasse 1+3, CH-3012 Bern (claudia.burkhalter@students.unibe.ch)

\*\*Laboratoire Chrono-environment, Université de Franche-Comté, 16 route de Gray, 25030 Besançon cedex, France

\*\*\*Labor für Ionenstrahlphysik, ETH Zürich, Otto-Stern-Weg 5, CH-8093 Zürich

During the Last Glacial Maximum (LGM;  $22.1 \pm 4.3$  ka; Shakun and Carlson, 2010), a local ice-cap covered the Jura Mountains. Outlet glaciers advanced all the way down to the lowlands, and reached amongst others the valley d'Ain. Glaciers blocked the Ain River and caused the building of an ice-dammed lake in the valley. As the glacial geomorphic features and deposits have not been subjected to building, construction and/or production activities, they are well-preserved. LGM advance and deglaciation of the glaciers are geomorphologically well documented (J.F. Buoncristiani & M. Campy 2004, C. Kasse 2013). However, their chronology is only reconstructed indirectly, for instance, by analysing the palynology of the lacustrine deposits, counting of annual varves in the lake sediments and correlating the stable isotopes (e.g.,  $\delta^{18}O$ ) with the global marine isotope stages (J.F. Buoncristiani & M. Campy 2004).

The aim of this study is to explore the Late Pleistocene deposits and related geomorphologic features in the valley d'Ain in detail and to reconstruct the chronology of the glacio-lacustrine deposits. To reach this goal, a detailed geomorphological map will be prepared. In addition, detailed sedimentological analysis (grainsize distribution, clast petrography, morphometry and fabric) will be conducted to investigate the catchment area, transport mechanisms and depositional environment. In the end, the chronology of the sediments will be reconstructed by depth-profile dating with terrestrial cosmogenic nuclides.

## REFERENCES

Buoncristiani Jean-Francois & Campy Michel 2004: Expansion and retreat of the Jura ice sheet (France) during the last glacial maximum, *Sedimentary Geology* 165, 253-264.

Kasse Cornelis 2013: Fluvial response to rapid high-amplitude lake-level changes during the Late Weichselian and early Holocene, Ain River valley, Jura, France, *Boreas*, Vol 43, 403-421.

Shakun Jeremy D. & Carlson Anders E. 2010: A global perspective on Last Glacial Maximum to Holocene climate change, *Quaternary Science Reviews*, Vol 29, 1807-1816.

## 03

### **Investigation of in-situ and laboratory water content of Opalinus Clay shale**

Fiona Naegeli\*

\*ETH Zürich, Clausiusstrasse 25, CH-8092 Zürich, Switzerland (naegelif@student.ethz.ch)

The newly constructed A2 Belchen highway tunnel proved to be a great opportunity to study the behavior of Opalinus Clay shale after tunnel excavation by a tunnel-boring machine (TBM). Regarding the swelling processes, the analysis of water content can help indicate self-sealing of excavation damaged zones (EDZ). This is important because self-sealing can reduce the hydraulic conductivity of host rocks for repositories for nuclear waste after excavation by a TBM. In the frame of my Bachelor's thesis, gravimetric water contents (GWC) of Opalinus Clay shale from a core drilled to install a TDR borehole probe were measured in the laboratory. Grain densities were determined using helium pycnometry, and bulk densities were methodologically obtained by a method using silica sand (DryFlo) as displacement medium. The volumetric water content (VWC) and porosity were then calculated. Laboratory VWCs were compared to VWC measured in-situ in the new Belchen highway tunnel by the TDR borehole probe. Further, the lithology of the Opalinus Clay shale, which was examined both macroscopically in cores and in thin sections thereof, were addressed. During my talk, an outline of these procedures and a discussion of the results will be given.

## 04

### A geometric morphometric study of turtle shells

Laura Dziomber\*, Christian Foth\*, Walter G. Joyce\*

\*Department of Geosciences, University of Fribourg, Chemin du Musée 6, CH-1700 Fribourg, Switzerland (laura.dziomber@unifr.ch)

The turtle shell is unique among tetrapods and its presence defines the clade Testudinata. Turtles have proven themselves to be successful since they first appeared in the Late Triassic as they colonized a large diversity of environments, ranging from dry land to ponds, rivers, and the open ocean, and survived all major extinction events.

Although the turtle shell is universally composed of the dorsal carapace and the ventral plastron, variation is apparent in its exact composition (i.e., the number of bones and scutes) and in its morphology, ranging from domed, to flat, to tectiform, and tear-drop shaped. The turtle shell has been hypothesized to provide several adaptive advantages to its owner, including not only physical defense against predators, but also perhaps thermoregulation, pH regulation, and mate recognition. The shell has also been proposed to possibly have ecological significance, in that herbivorous turtles may have more voluminous shells, terrestrial turtles more highly domed shells, or aquatic turtle more stream-lined shells, but only a few of these purported correlations have been investigated in a global context. This is one reason why the ecology of the most basal known turtles is still under discussion.

To explicitly test for a correlation between shell shape and ecology, we assembled a 3D dataset of 70 extant turtles and 3 fossils, in particular, the Late Triassic *Proganochelys quenstedti* and *Proterochersis robusta* and the Late Jurassic *Plesiochelys bigleri*, all from Central Europe. 3D models were obtained using surface scanning and photogrammetry and morphology was captured through the use of landmarks and semi-landmarks. The known habitat ecology of turtles was classified using the webbing of their forelimbs as a proxy. Principle component analysis (PCA) highlights much overlap between habitat groups, but phylogenetic discriminant analysis (pFDA) suggests significant differences. However, while *Plesiochelys bigleri* tends to cluster with marine turtles, the two Triassic species do not cluster with extant forms at all. It, therefore, may not be possible to characterize their ecology using the methods we chose.

## 05

### Inferring individual flight routes of a nocturnal bird migrant

Mike Werfeli\*

\*Remote Sensing Laboratories, Department of Geosciences, University of Zurich, Winterthurerstrasse 190, CH-8057 Zürich, Switzerland (mike.werfeli@uzh.ch)

Bird migration is a complex phenomenon, where bird populations travel between sites visited in an annual cycle. Thereby, bird populations migrate from breeding grounds to wintering sites in fall and back to the breeding grounds in autumn.

Tracking bird migration enables us to understand these processes and to analyse environmental factors influencing the route and stop over choice. Furthermore, it enables us to understand the processes within the different flight stages of an entire migration. Small birds like Hoopoes (*Upupa Epops*) are tracked using geolocators which record light intensities, used to compute the birds' position.

For this study tracking data of 20 European Hoopoes were used. These geolocators recorded light levels, air pressure and temperature, acceleration, pitch and the magnetic field. Bird positions are estimated using the SGAT package on R, where threshold-based twilight models are used. To simulate bird migration route, different data are incorporated and combined statistically in a Kalman Filter (KF) or Brownian Bridge Movement Model (BBMM). Kalman Filter correct the computed bird position considering movement models. BBMM generate a probability spaces, where the bird was able to pass considering the given parameters.

06

## **“Decision-making in conservation: human-wildlife or human-human conflict mitigation?” Insights from Namibia**

Katarina Rybarikova\*

\*Department of Geosciences, University of Fribourg, Chemin du Musée 4, CH-1700 Fribourg  
(katarina.rybarikova@unifr.ch)

In a time threatened by climate change and undergoing biodiversity losses, the urge for conservation is at its strongest. Globally implemented policies addressing this issue are generally based on a biological framework compromised by important conceptual weaknesses and the neglect of a social perspective. Human-wildlife conflict (HWC) mitigation overlooks all too often conflicts occurring between the different human stakeholders around conservation, hindering decisions. In Namibia, a community-based natural resource management (CBNRM) is advertised as a silver bullet to tackle needs in conservation and simultaneously empower communities. An analysis of practices in such a system through a political ecology perspective questions the new approach of nature conservation. Establishing the complex constellation of identities affected by a HWC policy allows to first pinpoint the power relations involved and second situate what is at stake. As much as the commodification of nature generates an undeniable economic interest, the present work tries to emphasize that other types of logic must also be considered when conservation policies are to be discussed.

## 07

## The Alpe Arami enigma: The subduction path of high-pressure mafic and ultramafic rocks

Isabelle Buholzer\*, Joana Vieira Duarte\*, Jörg Hermann\*

\*Institute of Geological Sciences, University of Bern, Baltzerstrasse 3, CH-3012 Bern, Switzerland  
(isabelle.buholzer@students.unibe.ch)

Alpe Arami in the Central Alps is well known for extensive, well-preserved outcrops of both high pressure and high temperature metamorphic rocks, particularly garnet peridotites. The formation of the Alpe Arami garnet peridotites has been controversially discussed in recent years, with debate focussed on the tectonic environment and maximum depth of equilibration.

Some studies have suggested a high pressure, subduction zone origin with the rocks coming from 660 km (Green et al. 1997) or 250 km depth (Bozhilov et al. 1999). Whereas a more recent study favoured a shallow, subcontinental mantle origin (Trommsdorf et al. 2000).

The aim of this study is to look at the local context of these rocks and perhaps find a way to solve the enigma of Alpe Arami. To achieve this, we studied the petrology and geochemistry of not only the garnet peridotites, but also the spatially proximal eclogites, peridotites and pyroxenites.

The major and trace element chemistry of each lithology was determined by first producing nanoparticulate pressed powder pellets, which were then measured by laser ablation ICP-MS. Pyroxenite veins distributed within the peridotites show a geochemical signature similar to the eclogites. The magnesium number of the pyroxenites is lower than of the garnet peridotites, which should be similar if they equilibrated at the same depth. Compared with the serpentinite-derived garnet peridotite and chlorite harzburgite of Cima di Gagnone, located elsewhere in the central Alps, (Scambelluri et al. 2014), the rocks in Alpe Arami show a similar trace element patterns. The negative europium anomaly in the pyroxenites shows that the protolith or, alternatively, subsequent modification, occurred in the plagioclase stability field, which indicates a low-pressure origin.

The results of this study so far demonstrate that the story of Alpe Arami is significantly more complex than previously thought. Our new data clearly does not support a super high-pressure origin of the ultramafic assemblages, and instead points to a lower pressure origin.

### REFERENCES

- Bozhilov K., Green II H., Dobrzhinetskaya L. 1999. Clinoenstatite in Alpe Arami Peridotite: Additional Evidence of Very High Pressure. *Science*, 284, 128-132.
- Scambelluri M., Pettke T., Rampone E., Godard M., Reusser E. 2014. Petrology and Trace Element Budgets of High-pressure Peridotites Indicate Subduction Dehydration of Serpentinized Mantle (Cima di Gagnone, Central Alps, Switzerland). *Journal of petrology*, 55, 459-498.
- Trommsdorf V., Hermann J., Müntener O., Pfiffner M., Risold A. 2000. Geodynamic cycles of subcontinental lithosphere in the Central Alps and the Arami enigma. *Journal of Geodynamics*. 30. 77-92.
- Green II H., Dobrzhinetskaya L., Riggs E., Zhen-Ming J. 1997. Alpe Arami: a peridotite massif from the Mantle Transition Zone? *Tectonophysics*. 279. 1-21.

## 08

## Consequences of magma-CO<sub>2</sub> interaction for explosive volcanism at Colli Albani (Italy)

Corin Jorgenson\*, Luca Caricchi\*, Gregor Weber\*, Guido Giordano\*\*, Felix Marxer\*\*\*, Peter Ulmer\*\*\*, Peter Tollan\*\*\*\*

\* Department of Earth Sciences, University of Geneva, Rue de Maraîchaire 13, CH-1205 Genève, Switzerland (corin.jorgenson@etu.unige.ch)

\*\*Department of Science Geology, Università Degli Studi Roma Tre, Via Ostiense, 159, 00154 Roma, Italy

\*\*\*Department of Earth Sciences, ETH Zurich, Sonneggstrasse 5, 8092 Zurich, Switzerland

\*\*\*\*Institute of Geological Sciences, University of Bern, Baltzerstrasse 1+3 CH-3012 Bern, Switzerland

Understanding the processes that trigger explosive eruptions in densely populated areas is important for volcanic hazard assessment. Located 30 km from the city of Rome, Colli Albani is a caldera complex that is currently experiencing seismic and degassing activity, and intermittent uplifts possibly related to magmatic intrusions. This ultrapotassic volcano has produced a series of large eruptions between 600 and 355 ka (up to 63 km<sup>3</sup> DRE per eruption) creating pyroclastic flows extending up to 33 km from the eruptive centre (Giordano & CARG team, 2010). These ignimbrites are mafic in composition, which is rarely observed for such explosive events, as the rheological properties of mafic melts typically favour effusive eruptions. The cause of this unusual explosivity is thought to be related to magma-CO<sub>2</sub> interaction (Freda et al. 2011; Giordano & CARG team, 2010). However, the origin of the CO<sub>2</sub> and its role in driving explosive volcanism are not well constrained. We test this hypothesis by analysing crystal zonation patterns and melt inclusions in products of both explosive and effusive eruptions to determine the evolution of magma chemistry and volatile content before eruption and to determine whether the explosivity of the eruptions is linked to specific magma properties. Melt inclusions hosted in leucite and clinopyroxene have been homogenized using piston cylinder experiments at 7 kbar, temperatures ranging from 1200-1350 °C and run times from 0.5-4 hours. Detailed petrography and mineral chemistry will be combined with determination of volatile contents to gain quantitative insights into magma source conditions, accumulation and/or loss of the excess fluid phase, and the evolution of intensive parameters prior to eruption. These data will be used in conjunction with thermodynamic modelling (rhyolite-MELTS) to evaluate if magma-CO<sub>2</sub> interaction is a physically plausible scenario for driving explosive volcanism at Colli Albani and to assess whether magma-CO<sub>2</sub> interaction at Colli Albani is better explained by carbonate assimilation or by flushing of a magma reservoir with CO<sub>2</sub> from depth.

### REFERENCES

- Freda, C., Gaeta, M., Giaccio, B., Marra, F., Palladino, D.M., & Scarlato, P. 2011: CO<sub>2</sub>-driven large mafic explosive eruptions: The Pozzolane Rosse case study from the Colli Albani Volcanic District (Italy). *Bull Volcanol.* 73(3), 241–56.
- Giordano, G., & CARG Team. 2010: Stratigraphy, volcano tectonics and evolution of the Colli Albani volcanic field. *The Colli Albani volcano. Geol Soc London, Spec IAVCEI Publ.* 3, 43-98.

**09****Analysing Particulate Matter found on Honey Bee Surfaces using SEM-EDX**

Vivian Leuenberger\*, Christoph Neururer\*, Bernard Grobéty\*

\*Department of Geosciences, University of Fribourg, Chemin du Musée 6, CH-1700 Fribourg  
(vivian.leuenberger@unifr.ch)

Particulate matter (PM) is defined as a mixture of microscopic solid or liquid particles suspended in air, which is more and more identified as a threatening health problem (EKL, 2013). An unconventional, but well working method to sample these particles are honey bees (*Apis mellifera*): by collecting nectar and pollen, other particles accumulate on the bee surface. With Scanning Electron Microscopy coupled with X-ray Spectroscopy (SEM-EDX) the particles can be chemically and morphologically characterized, which helps to determine their source (Negri et al., 2015).

Honey bees were sampled around beehives at four sites in the Canton of Fribourg. Different background settings were chosen (urban - Fribourg, rural – St. Silvester, close to highway – Düdingen, and close to a quarry – Plasselb), to compare the frequency and type of particles from different possible contamination sources.

To analyse the bees in the SEM, they were dried in high vacuum and coated with 30nm carbon. The particles on the bee surface were selected manually, systematically going from one body part to the next. With the aid of the chemical composition and the morphology of the particles, a rough determination of the source can be done. All samples contain particles in the form of pollen, iron rich and soil-derived particles in a size range of 1 to 100µm. Due to carbon coating, the organic particles like pollen or carbon particles (soot) cannot be differentiated by EDX. A gold coating would be the alternative. The bees from the rural site in St. Silvester exhibit heavy metal particles like Pb, Ba, Cu, Hg, Zn and Sn, identified as gunshot residue from a shooting range 300m away from the beehive. About 7% of all the particles on the “shooting-range” bees were detected as heavy metals, which raises the question, if the honey as product could be contaminated. A honey analysis will be done in a further step.

**REFERENCES**

- Eidgenössische Kommission für Lufthygiene (EKL) 2013. Feinstaub in der Schweiz 2013. Bern.  
Negri, I. et al. 2015. Honey Bees (*Apis mellifera*, L.) as Active Samplers of Airborne Particulate Matter. PLoS ONE, doi: journal.pone.0132491.

## 10

## Grand Canonical Monte Carlo simulations of ion sorption on 2:1 clay mineral edges

Robin Haller\*, Rene Schliemann\*, S.V. Churakov, \*, \*\*

\*Institute of Geological Sciences, University of Bern, Baltzerstrasse 3, CH-3012 Bern, Switzerland (robin.haller@students.unibe.ch)

\*\*Laboratory for Waste Management, Paul Scherrer Institute

Due to high specific surface area and large pH buffering capacity, phyllosilicate minerals are one of the most important sinks for pollutants in soils and subsurface sediments. The entrapment of contaminants onto the mineral surfaces is the primary factor determining their transport, deposition, reactivity and eventually their effective toxicity.

High sorption capacity of phyllosilicate minerals is explained by particular electrostatic properties of their surfaces. Phyllosilicate minerals are built by alternating sheets of silica tetrahedra (T) and sheets of octahedral cations (O) in form of TOT or TO layers. Hetero-valent substitutions in octahedral and/or tetrahedral sheets result in permanent structural charge of the TOT layer. Excess surface charge of phyllosilicate particles is compensated by hydrated and bare cations, occupying the interlayer space between TOT layers. The oxygen sites on the edge of clay minerals can be in protonated or deprotonated state depending on the pH of the equilibrium solution at the mineral-fluid interface. Thus, the surface charge at the edge sites of clay minerals can change from strongly negative at high pH, to neutral and even positive at acidic conditions.

Titration Grand Canonical Monte Carlos simulation (GCMC) method is a powerful tool to examine systems sorption behaviour of mineral surfaces at an atomic scale in a wide range of chemical conditions (Churakov et al., 2014). In this work, the surface charge and sorption properties of Illite, Montmorillonite, Pyrophyllite and Vermiculite (110) edge surfaces were investigated in 0.001, 0.01, 0.1 and 0.5 M solutions of NaClO<sub>4</sub>, Ca(ClO<sub>4</sub>)<sub>2</sub> and Al(ClO<sub>4</sub>)<sub>3</sub> electrolytes at pH ranging from 2 to 12. Mineral surfaces were presented as three different titration sites (aluminol, silanol and bridge sites and several hetero-valent isomorphous substitutions). The equilibrium protonation state of surface sites is controlled by the protolysis constants assigned to each site according to recent estimations by ab initio simulations (Churakov and Liu, 2018), and the electrostatic interaction with ions in the electrolyte solution. The ion-ion and ion-surface interactions were described by primitive model of electrolytes. In such a model ions were represented by charged hard spheres and the solvent was treated as dielectric continuum. The simulations were performed using an 8000 nm<sup>3</sup> nearly orthogonal simulation cell.

The simulations provide surface speciation, surface charge density and amount of adsorbed ions as function of pH and the background electrolyte concentrations. Rising pH was found to have a strong influence on the amount of adsorbed ion. Contrary, permanent surface charge due to isomorphous substitutions in the TOT layer was found to have little effect on sorption at edge surface. Ca<sup>2+</sup> and Al<sup>3+</sup> have higher surface affinity than Na<sup>+</sup>. It can be concluded that cations with higher charge have stronger interaction with the surface and displace other cations with lower valence. The evolution of the surface charge of montmorillonite obtained in this study differs slightly from the earlier results reported by (Delhomme et al., 2010). The observed discrepancies can be attributed to the use of different ion-

specific radiuses of hard spheres and non-planar surface sites distribution applied in our work. Comparison of the simulation results with the experimental data reveal deviations at high and low pH conditions. Better agreement with experimental data could be obtained considering hydrolysis of aqueous ions and evolution of the surface structure due to preferential leaching of octahedral and tetrahedral sheets as function of pH.

#### REFERENCES

- Delhorme, M., Labbez, C., Caillet, C. and Thomas, F. 2010. Acid-Base Properties of 2:1 Clays. I. Modeling the Role of Electrostatics. *Langmuir* 26, 9240-9249 [10.1021/la100069g](https://doi.org/10.1021/la100069g).
- Churakov, S.V., Labbez, C., Pegado, L. and Sulpizi, M. 2014. Intrinsic acidity of surface sites in calcium-silicate-hydrates and its implication to their electrokinetic properties. *Journal of Physical Chemistry C* 118, 11752–11762.
- Churakov, S.V. and Liu, X. 2018. Quantum-chemical modelling of clay mineral surfaces and clay mineral–surface–adsorbate interactions, in: Schoonheydt, R., Johnston, C.T., Bergaya, F. (Eds.), *Surface and Interface Chemistry of Clay Minerals*. Elsevier, pp. 49-87.

# 11

## Lake Au: Insight on tsunami events in Lake Zurich

Flavio Huber\*, Valentin Nigg\*, Flavio S. Anselmetti\*

\*Institute of Geological Sciences and Oeschger Centre for Climate Change Research, University of Bern, Baltzerstrasse 1+3, CH-3012 Bern (flavio.huber@students.unibe.ch)

Extensive subaquatic mass-movement deposits in Lake Zurich were mapped by means of seismic reflection data (Strasser et al., 2006 and Strupler et al., 2015). Such large underwater mass movements are able to trigger basinwide tsunamis such as the 1601 tsunami in Lake Lucerne.

This study is part of the SNF Sinergia Project 'Lake Tsunamis: Causes, Controls, and Hazard', which currently characterizes the phenomena of lake tsunamis. In order to study tsunami deposits, which are deposited during tsunami inundation and backwash, we collected sediment cores at the coastal Lake Au, a small lake separated by narrow flat plains from Lake Zurich. During tsunami inundation, Lake Au should be flooded so that sedimentary traces are deposited that could be related to large subaquatic mass movements. The collected sediment cores are currently sedimentologically analysed by means of CT-scanning, density measurements, grain-size variability, mineralogical composition and radiocarbon dating method. The most promising sedimentary features are layers of shells, which might be related to a former tsunami event on Lake Zurich.

### REFERENCES

- Strupler M., Hilbe M., Anselmetti F. S., Strasser M., 2015, Das neue Tiefenmodell des Zürichsees: Hochauflösende Darstellung der geomorphodynamischen Ereignisse im tiefen Seebecken, *Swiss Bull. angew. Geol.*, Vol. 20/2, p. 71-83.
- Strasser M., Anselmetti F., Fäh D., Giardini D. und Schnellmann M., 2006, Magnitudes and source areas of large prehistoric northern Alpine earthquakes revealed by slope failures in lakes, *Geological Society of America*, v. 34, no. 12, p. 1005–1008.

## 12

### **Deep drilling in Lake Constance: a journey through the lake's history**

Sebastian Schaller\*

\*Institute of Geological Sciences and Oeschger Centre for Climate Change Research, University of Bern, Baltzerstrasse 1+3, CH-3012 Bern (Sebastian.schaller@students.unibe.ch)

A drilling project into the deep basin of Lake Constance aims to unravel the postglacial history of the lake. One goal was to test a newly developed drilling system and a new platform type, which was developed by the company Uwitec, funded by the Deutsche Forschungsgemeinschaft (DFG). With these new tools, the to-date longest core in Lake Constance was recovered to a sediment depth of 24 m. The sediment record opens a new chapter in the history of the lake by reaching back to Late Glacial stage when a young postglacial lake records ice-proximal processes by depositing sediments sourced by the retreating Rhein-Glacier. This presentation includes a discussion of the modern bathymetric and the seismic-stratigraphic data that were used to determine a promising drill site. A brief summary of the workflow will show the executed steps in handling and analyzing the drill cores of this multidisciplinary international project. The analysis of the petrophysical core properties and the sedimentologic signatures provide a first look into the past depositional environments. Future prospects include establishing an age model for the core, geomicrobial analysis and a provenance study.

**P01****The versatility of apatite as geochemical tool: an application to the porphyry Cu system in El Teniente, Chile**

Bongiovanni M.\*

\*Institute of Geochemistry and Petrology, ETH Zürich, Clausiusstrasse 25, 8092 Zürich, Switzerland (maurobo@student.ethz.ch)

The most common phosphate, apatite, is widespread in very different types of rock and it can incorporate more than half of the stable elements present on Earth. Among these, volatiles like H<sub>2</sub>O, S, F and Cl, together with rare earth elements, are particularly useful for gathering information about magmatic and volcanic processes. Several authors, in the past, proved that apatite can record both magmatic and hydrothermal signatures, highlighting its great potential to be an indicator mineral for different types of ore deposits.

In this study, apatite grains from the different lithologies from the porphyry Cu system of El Teniente, Chile, have been analyzed in order to obtain information about the magmatic-hydrothermal processes undergone. The different types of alteration associated with this porphyry Cu deposit are reflected in both major and minor elements contents and distribution.

The comparison of the data from El Teniente and La Huifa-La Negra (located 4km apart) reveals the evolution of magmatic Cl-rich apatite towards a progressively Cl-depleted and F-enriched composition linked to hydrothermal alteration.

The development of porosity and the presence of monazite micro-inclusions witness the Dissolution - Reprecipitation Process (DRP) undergone by apatite in contact with hydrothermal fluid, with an extent dependent on the type of alteration (minor in potassic, intense in sericitic alteration). Depletion of elements linked to the coupled substitution mechanism in apatite structure, such as Na, S, Si and REE, in sericitic-altered samples confirm the hypothesis of the mentioned process.

Finally, the distribution of trace elements like Mn, Fe, V, As and Eu in the apatite grains analyzed indicates distinct redox states of the fluids responsible of the diverse types of alteration, likely derived from different wall-rock interaction conditions, in terms of temperature and pH. Because of this it is possible to distinguish between the various types of alteration based on the geochemical signature in apatite in the studied area.

In conclusion, apatite has a unique potential to carry geochemical information, but its high sensitivity can make difficult to interpret the data as several events can superimpose on each other. There is necessity to gather more data about this mineral in different contexts for a better understanding of how to properly use apatite as a geochemical proxy, especially in ore deposits exploration.

**P02****Stability and As adsorption of nanocrystalline Al-hydroxysulfates forming during acid rock drainage**

Philipp Ingold\*, Christoph Wanner\*

\*Rock-Water Interaction Group, Institute of Geological Sciences, University of Bern, Baltzerstrasse 3, CH-3012 Bern, Switzerland (philipp.ingold@students.unibe.ch)

In the streambed of a small acidic ( $pH \sim 4.0$ ) mountainous stream located in the Engadin area, Switzerland, white precipitates can be observed, which have formed on boulders (Fig. 1). These precipitates form due to the neutralization of the stream by mixing with several circumneutral tributaries. A Pre-cent study identified basaluminite, a nanocrystalline hydroxysulfate with an idealized stoichiometry of  $Al_4OH_{10}(SO_4) \cdot 3-5H_2O$ , as the dominating phase of the white streambed coating (Wanner et al., 2018). Chemical analyses revealed an elevated As concentration of up to 600  $\mu g/g$ , which is inherited from adsorption of As on basaluminite as well as an anion exchange reaction where  $SO_4^{2-}$  in the basaluminite structure is replaced by arsenate anions ( $H_2AsO_4^-$ ). Similar Al-hydroxysulfates are observed downstream of the Fe-Cu mine Servette-Chuc, located in the Aosta Valley in Northern Italy (Tumiati et al., 2008). Their rather low  $SO_4$  content, however, does not seem plausible with the precipitation of pure basaluminite. A potential explanation for the low sulfate content is the transformation of previously formed basaluminite to Al-hydroxides (e.g.  $Al(OH)_3$ ) due to the alkaline pH of ca. 8.0 to which the Aosta Valley precipitates are exposed to during most of the year.

To study the potential transformation of basaluminite and to assess the fate of As during such reactions, we have experimentally investigated (i) the initial formation of Al-hydroxysulfates by titrating the acid mine drainage solution collected at the Servette-Chuc mine in the Aosta Valley ( $pH \sim 3.0$ ) and (ii) the fate of basaluminite sampled in the Engadin area when exposed to a solution with a pH of 8.0 (i.e. stability experiments). Infrared spectroscopy and acid digestion followed by ICP-OES analyses of the precipitates obtained from the titration experiment demonstrate that the precipitates found downstream of the Servette-Chuc mine initially refer to basaluminite. Applying the same analytical techniques to the precipitates used in the stability experiments suggests that the transformation of basaluminite to  $Al(OH)_3$  is indeed occurring at pH 8.0 within a few weeks. Chemical analyses of the corresponding solutions, however, showed that such transformation is only associated with a minor mobilization of previously sorbed As. This confirms that basaluminite of similar Al-hydroxysulfates may serve as powerful filter material for the treatment of As contaminated groundwater (Mertens et al., 2012).



Figure 1. Photograph of basaluminite precipitates forming along “Ova Lavirun”, a mountainous stream in the Engadin area.

#### REFERENCES

- Tumiati S., Godard G., Masciocchi N., Martin S. and Monticelli D. 2008. Environmental factors controlling the precipitation of Cu-bearing hydrotalcite-like compounds from mine waters. The case of the “Eve verda” spring (Aosta Valley, Italy). *European Journal of Mineralogy*, 20, 73-94.
- Wanner C., Pothig R., Carrero S., Fernandez-Martinez A., Jäger C. & Furrer G. 2018. Natural occurrence of large amounts of nanocrystalline Al-hydroxysulfates: Insights on formation, Al solubility and heavy metal retention. *Geochimica Et Cosmochimica Acta* 2018, 218, p. 259-269.
- Mertens J., Rose J., Kägi R., Chaurand P., Plötze M., Wehrli B. & Furrer G. 2012. Adsorption of arsenic on polyaluminium granulate. *Environmental Science & Technology*. 46, 7310-7317.

**P03****Accuracy study of snow cover maps based on AVHRR data with different spatial resolution**Soumita Patra<sup>\*,\*\*</sup>, Kathrin Naegeli<sup>\*</sup>, Stefan Wunderle<sup>\*</sup>

<sup>\*</sup>Institute of Geography and Oeschger Centre for Climate Change Research, University of Bern, Hallerstrasse 12, CH-3012 Bern, Switzerland (soumita.patra@guib.unibe.ch)

<sup>\*\*</sup>Birla Institute of Technology, Mesra, Jharkhand, 835215, India

Snow is an essential natural resource and geophysical parameter that represents the largest part of the cryosphere. The significance of snow cover for the climate at a regional and global scale is already recognized. Thus, the proper monitoring of spatial and temporal variability of seasonal snow cover is crucial to understand changes in the climate system including hydrological processes, water management or snow-melt runoff.

The Advanced Very High Resolution Radiometer (AVHRR) provides the unique opportunity to retrieve long time series of more than 35 years to study earth surface process at a global scale on a daily basis. It is important to note that, Local Area Coverage (LAC) and Global Area Coverage (GAC) data from the AVHRR sensor was broadly used for snow cover mapping in the Alps individually. However, the main challenge is the availability of finer resolution LAC data (1.1 km) at a global scale. Therefore, we use reduced resolution GAC data (4.4 km) due to its global availability. To the best of our knowledge, the differences in snow maps occurring due to different resolution from both LAC and GAC data has not yet been investigated. In this study, we thus carry out an in-depth assessment of differences and similarities of winter snow cover products over different topography and land cover types based on AVHRR LAC and GAC data, aiming at estimating the accuracy of GAC snow cover maps for the European Alpine environment.

Here, we present preliminary results of the comparative assessment of LAC and GAC snow cover products. In particular, the influence of the topography and varying land cover types are investigated in order to be able to describe possible reasons for variations between the products. Pixel-wise fractional snow cover extent is obtained by applying the Normalized Difference Snow Index (NDSI) in combination with other band-related thresholds. A series of two winters is used to address the research aim in the regional context of the European Alps. This comparison of snow products based on LAC and GAC data shows their individual assets, points out discrepancies and highlight crucial information to be considered for the derivation of consistent fundamental climate data record.

**P04****Fluvio-marine sedimentological record and paleoclimatic signals of the Middle Eocene Climatic Optimum (MECO), Southern Pyrenees (Spain)**

Sabí Peris Cabré\*, Jean Verité\*\*, Luis Valero\*, Marta Roigé\*\*\*, Jorge Spangenberg\*\*\*\*, Thierry Adatte\*\*\*\*, Andreu Vinyoles\*\*\*\*\* and Sébastien Castelltort\*

\*Department of Earth Sciences, University of Geneva, Rue de Maraîchers 13, CH-1205 Genève, Switzerland (Sabi.Peris@etu.unige.ch)

\*\*Géosciences Rennes, University of Rennes, Campus Beaulieu - Bâtiment 15, 35042 Rennes, France

\*\*\*Departament de Geologia, Universitat Autònoma de Barcelona, Av. de l'Eix Central s/n, 08193 Cerdanyola del Vallès, Spain

\*\*\*\*ISTE, Geopolis, University of Lausanne, 1015 Lausanne, Switzerland

\*\*\*\*\*Facultat de Ciències de la Terra, Universitat de Barcelona, Carrer Martí i Franquès s/n, 08028 Barcelona, Spain

Throughout the Paleogene, a series of transient and extreme warming events occurred. These “hyperthermals” are associated with abrupt increase in temperature and perturbations in the carbon cycle, which could be triggered by several causes. Among them, the Middle Eocene Climatic Optimum (MECO) took place about 40 Ma, interrupting the Middle Eocene cooling trend with a relatively long-lasting period of ca 500 ky. The timing and environmental impact of the MECO is particularly recorded in the marine isotope record, but it is not well constrained on land yet (Bohaty et al., 2009).

The southern Pyrenean foreland basin (SPB) represents an exceptional study area, because of the occurrence of continuous outcrops from source (Trempe-Graus-Ainsa continental basins) to sink (Jaca marine basin). A comprehensive study in this area will help to gather insights about the interaction between different depositional systems and their response to the MECO.

Prior hyperthermal events in the Pyrenees evidence an extreme boost of the hydrological cycle, an increase of water discharge, and subsequent increase in sediment transport (Chen et al. 2018; Foreman et al. 2012). The aim of the study presented here is to explore the possibility that the long-lasting MECO disturbed the sedimentary systems in a similar way as prior hyperthermals. We track the associated environmental changes in a source-to-sink transect by means of high-resolution stratigraphy and geochemical data before, during and after the MECO. Finally, these data will be used to identify changes of facies and depositional environments in order to determine the sedimentary system's response to the MECO, and discuss the possible driving processes.

## REFERENCES

- Bohaty, S.M., Zachos, J.C., Florindo, F. and Delaney, M.L. 2009. Coupled greenhouse warming and deep-sea acidification in the middle Eocene. *Paleoceanography*, 24(2).
- Chen, C., Guerit, L., Foreman, B. Z., Hassenruck-Gudipati, H. J., Adatte, T., Honegger, L., and Castelltort, S. 2018. Estimating regional flood discharge during Palaeocene-Eocene global warming. *Scientific reports*, 8(1), 13391.
- Foreman, B. Z., Heller, P. L., and Clementz, M. T. 2012. Fluvial response to abrupt global warming at the Palaeocene/Eocene boundary. *Nature*, 491(7422), 92.
- Zachos, J., Pagani, M., Sloan, L., Thomas, E., and Billups, K. 2001. Trends, rhythms, and aberrations in global climate 65 Ma to present. *Science*, 292(5517), 686-693.

**P05****Studying Au-precipitation mechanisms in an extinct hydrothermal system in SW-Iceland**

Thierry Solms\*, Prof. Dr. Thomas Driesner\*

\*Institute of Geochemistry and Petrology, ETH Zürich, Clausiusstrasse 25, 8092 Zürich, Switzerland (tsolms@student.ethz.ch)

Even though geothermal fluids in Iceland were recently found to be Au-oversaturated in some cases (Hannington et al., 2016), significant Au enrichment in host rocks is rare, potentially due to a lack of sufficient focussing and precipitation mechanisms in the upper crust.

Mógilsá, near the Esja mountain range, and Thormodsdalur, 10 km east of Reykjavik are two locations spatially close to each other where Au is significantly enriched in hydrothermal veins. Au transport and precipitation mechanisms for these occurrences are inconclusively known. To address this lack of knowledge in regard to the enrichment at Mógilsá, fieldwork was carried out to study key outcrops and to retrieve samples for petrographic and geochemical analysis.

Fieldwork showed that circulating hydrothermal fluids affected the basaltic lava flow successions and intrusive bodies over a length of approximately 1.3 km. Outcrops vertically expose the formerly active hydrothermal system from sea level to at least up to 250 m a.s.l., thus providing a unique glance at an extinct hydrothermal system. It was also found that the study area features evidence of shallow magma chamber emplacement, variations in hydrothermal fluid composition, and tectonic faulting.

Sulfide mineralization is hosted primarily in the proximity of and within sulfide-rich veins, but was also found to occur in disseminated form in intrusive and extrusive volcanic host rocks, and as massive sulfides (pyrite + pyrrhotite) in rare cases. Alteration halos of different dimensions were found around several veins. Evidence of widespread chlorite alteration and local silica alteration was found. The occurrence of up to 10 cm thick, bladed calcite veins indicate that boiling fluids were present in the study area, representing a potential Au precipitation mechanism. Evidence of tectonic brecciation was found, and heterogeneous breccia clasts found in breccia zones could represent the products of former hydrothermal eruptions.

This study will allow to constrain the physical and chemical properties of the hydrothermal fluids that produced Au enrichment in the basaltic host rocks. Establishing the causal link between tectonic setting, host rock mineralogy, fluid properties and ore deposition will allow to gain insights into the formation of hydrothermal Au deposits in a geological setting which was previously overlooked in regard to Au deposit formation.

Preliminary results from the sampling campaign and analytical results will be presented, highlighting the physical and chemical characteristics of the Au-depositing hydrothermal fluids.

**REFERENCES**

Hannington M., Harðardóttir V., Garbe-Schönberg D. and Brown K. L. 2016. Gold enrichment in active geothermal systems by accumulating colloidal suspensions. *Nature Geoscience*, 9(4):299.

## P06

## Lithological diversity within the Opalinus Clay of Northern Switzerland: interpretation and elaboration of a subfacies model

Géraldine Zimmerli\*, Bruno Lauper\*, David Jaeggi\*\* & Anneleen Foubert\*

\*Department of Geosciences, University of Fribourg, Chemin du Musée 6, CH-1700 Fribourg, Switzerland (geraldine.zimmerli@unifr.ch)

\*\* Federal Office of Topography swisstopo, Seftigenstrasse 264, CH-3084 Wabern, Switzerland

The Mont Terri underground rock laboratory (St-Ursanne, Jura) is an important international test site for researching argillaceous formations. In Switzerland, the Opalinus Clay, a mudstone formation, is the preferred host rock for the disposal of high-level radioactive waste. The formation has important properties: low permeability, high retention capacity for radionuclides and self-sealing of fractures (e.g. Bossart and Thury 2008).

At Mont Terri, the Opalinus Clay is subdivided into three lithofacies: a sandy facies, a shaly facies and a carbonate-rich sandy facies (e.g. Hostettler et al. 2017). The Opalinus Clay consists mainly of clay minerals, carbonates and quartz, as well as minor feldspar, pyrite, siderite, micas and organic carbon. It formed during Toarcian and Aalenian times in an epicontinental sea covering central Europe.

Besides the m-scale lithofacies variations, intra-facies variations at dm- to cm-scale also occur (Lauper et al. 2018). The aim of this study is to identify and understand this lithological diversity, and contribute to the improvement of an existing subfacies classification scheme. Detailed petrographic and mineralogical investigations (thin section analyses, X-ray diffraction) will be performed, as well as bulk C and O stable isotopes and Rock Eval analyses. A 3D distribution of the sedimentary and bioturbational structures of each subfacies (computed tomography) will also be investigated. Two drillcores together with an outcrop will be studied. Eventually, a depositional and paleoenvironmental interpretation model at different scales will be proposed.

### REFERENCES

- Bossart, P., Thury, M. 2008. Mont Terri Rock Laboratory – project, programme 1996 to 2007 and results. Swiss Geological Survey, Wabern, report, 3.
- Hostettler, B., Reisdorf, A.G., Jaeggi, D., Deplazes, G., Bläsi, H.-R., Morard, A., Feist-Burkhardt, S., Waltschew, A., Dietze, V., Menkveld-Gfeller, U. 2017. Litho- and biostratigraphy of the Opalinus Clay and bounding formations in the Mont Terri rock laboratory (Switzerland). *Swiss Journal of Geosciences*, 110, 22-37.
- Lauper, B., Jaeggi, D., Deplazes, G., & Foubert, A. 2018. Multi-proxy facies analysis of the Opalinus Clay and depositional implications (Mont Terri rock laboratory, Switzerland). *Swiss Journal of Geosciences*. doi: 10.1007/s00015-018-0303-x.

## ACKNOWLEDGEMENTS

We would like to thank the Swiss Academy of Sciences (SCNAT), that financially supported us in the organisation of this event. Special thanks to Pierre Dèzes for assisting us in the website set up and the communication with the SCNAT.

We thank Nicole Bruegger and Nicole Equey, the two secretaries of the Departement of Geosciences for their big help in room reservation and other administrative works. Thanks to Bernard Grobéty and Jon Mosar for the informations, suggestions and linkage of the Master Congress to the SGM. We further thank Antonio Scinto for providing the spaces, and Julia Pürro for logistic assistance.

A special thanks goes to our two keynote speakers, Gunter Siddiqi and Romain Amiot, that kindly accepted to contribute with their experience to this congress.

Thank you!