

Annual Report 2020

Georesources Switzerland Group
Fachgruppe Georessourcen Schweiz (FGS)

March 2021

Acknowledgements

This annual report was prepared by Dr. Stefan Heuberger (FGS group head) with support of all FGS group members. It was reviewed by the FGS steering committee members Prof. Dr. Maria Schönbacher (D-ERDW professor in charge of FGS) and Dr. Andreas Möri (swisstopo representative).

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1 The Georesources Switzerland Group

The Georesources Switzerland Group (Fachgruppe Georessourcen Schweiz, FGS) processes information and conducts applied research on Swiss mineral resources and their industrial application on behalf of the federal government or in collaboration with industry partners. It was founded in July 2018 at ETH Zürich and succeeds the office of the Swiss Geotechnical Commission (SGTK). The group forms an associated group in the Department of Earth Sciences with the staff (6 employees) and the premises (NO F 35) being equivalent to ones of the former SGTK office. The group is >90% third-party funded (excl. SNF) and raises an average annual budget of about 600-800 kCHF.

The close collaboration with the Swiss Geological Survey (Federal Office of Topography swisstopo) and the Federal Office of Energy (SFOE) provide a solid financial basis for the long-term focus of our applied research. We focus on collecting and compiling fundamental geological data and data related to the use of the geological resources in Switzerland. Focus areas are the mineral resources of Switzerland (i.e. gravel, sand, clay, limestone, salt, natural building stones), energy resources from the deep underground (geothermal energy and hydrocarbons) as well as geological questions related to the use of georesources and the underground in general. The group maintains a long-lasting sample and literature archive and makes those data accessible to the public by web services and through the swisstopo web portal map.geo.admin.ch.

Our group has a unique position in this field of applied research in Switzerland - and this field will remain essential in the future. Extraction of raw materials is becoming increasingly complicated because of the scarcity of materials (e.g. sand), land use conflicts and several types of emissions. Moreover, since Switzerland has neither a hydrocarbon nor a substantial mining industry, fundamental geological data on the deeper underground are still scarce. Switzerland possesses abundant mineral resources but the country does not have the uniform mineral royalty laws that most other European countries do. Thus, the mineral resources sector suffers from a lack of systematic production and resources data. This hampers the generation of reliable predictions of the national resources supply situation. In this field, our group conducts essential applied research. We process basic geological data to consolidate our knowledge on the Swiss geological underground and to improve the corresponding geodatabases, cartographic tools and 3D models.

georessourcen.ethz.ch/en

erdw.ethz.ch/en/research/associated-groups/fgs.html

2 Key projects

2.1 Machine learning algorithms to assess geoscientific datasets

Based on the Swiss energy strategy 2050, the Federal Offices of Energy (SFOE) and Topography (swisstopo) are significantly pushing forward the establishment of a solid geoscientific knowhow pool to further support and enable geothermal exploration projects. Inherently, a substantial amount of diverse geoscientific data is generated during the exploration phase. The resulting data is gathered by, curated, and locally stored at swisstopo.

Building on that, the long-term project “Automated analysis of geothermal exploration data of Switzerland” was initiated in 2019. The automated analysis is steered towards sound predictions targeting the geothermal potential using advanced statistical methods. Swisstopo hosts a revealing inventory of geological reports, archived as pdfs, containing essential information on the subsurface. We are currently focusing on retrieving information from this inventory. To achieve this task, we have piloted an R&D project with ETH juniors in 2019 named Retrieval of Geoscientific Information (RGI, formerly Gaia). To (1) further progress and (2) make the transition from development to a deployable software application, we now collaborate with the Data Science Institute at the University of Applied Sciences and Arts, North-western Switzerland (FHNW).

Achievements in 2020

- Retrieval of geoscientific data (RGD)
Managed and led the collaboration between swisstopo and the FHNW Institute for Data Science based on agile principles (Scrum) and digital leadership’s best practices. Conducted stakeholder management, reporting, and control of the project, which was kicked-off 1st of June 2020.
- Machine learning and domain knowledge
Explored graph neural network’s capabilities as learnable physics engines to combine domain (geoscientific) knowledge and machine learning.
- Profile development
Firmly shaped and established the data scientist’s profile of the Georesources Switzerland Group.

Project leader: G erard Perren

2.2 New heat flow map of the Swiss Molasse Basin

The most recent heat flow map of the Swiss Molasse Basin is dating back to 1995. Since then, several new temperature measurements in boreholes were conducted and, more importantly, geothermal energy became much more important in order to achieve Switzerland’s desired energy transition. Temperature data with a corresponding heat flow map are an important basis for geothermal exploration.

Mandated by swisstopo and the Swiss Federal Office of Energy, we launched this project in January 2019. Since then, we mainly compiled and analysed temperature data from deep boreholes in the Swiss Molasse Basin area. This analysis provided good constraints on the temperature distribution down to 2 km. In addition, a methodology for the qualitative assessment of the temperature data has been developed. Those intermediate results will be published in a peer-reviewed article to be submitted in early 2021, in close collaboration with Prof. E. Kissling. This paper will provide a strong basis for the next project stage aiming at establishing an interpolation procedure for the calculation of the steady-state

conductive heat flow of the Swiss Molasse Basin and finally a new heat flow map of the Swiss Molasse Basin.

In parallel, we collaborate with the Geothermal Energy and Geofluids Group (Prof. M. Saar) and their swisstopo-funded pilot study on the heat flow in the greater Aargau region.

Achievements in 2020

- Establishment of cooperation with third parties for data exchange

One of the greatest achievements of this year is the sharing of subsurface knowledge (thermal conductivity and temperature data) with private and public stakeholders (e.g. Canton of Aargau, Nagra).

- Heat flow map of northern Switzerland

The elaboration of a heat flow map is currently in progress and will provide a state-of-the-art map for the Swiss Molasse Basin.

Project leader: Loïc Pierdona

2.3 Assessment of Switzerland's gravel and sand occurrences

Quaternary deposits in Switzerland are fairly well known and mapped at the 1:25'000 scale. Dozens of regional and local companies extract more than 30 million tons of gravel and sand per year. Volume estimations of Swiss mineral resources were so far based on compilations of regional data from the cantons and the local producing industry. The absence of a country-wide, systematic resource assessment hampers reliable predictions of the national resources supply situation.

The objective of our project is to derive a methodology to systematically assess the gravel and sand occurrences of Switzerland. Our aim is to develop GIS-based tools that work at such a level of detail that these methods can be applied throughout the country (i.e. in the Alpine foreland in a first step) and can deliver results quickly and easily - provided there is sufficient harmonised spatial data available.

So far, we tested different approaches in a pilot study area covering the Lower Reuss and Lower Aare catchments. In a first approach, we have extracted areas with gravel occurrences from the published and vectorised GeoCover 1 and 2 datasets. There, we evaluated different GeoCover 2 attributes of the unconsolidated deposits layer to confine the occurrence of gravel on the surface. In a second approach we are using vector data of the groundwater tables to calculate a continuous raster of the groundwater level for the main aquifers to delimit gravel bodies above the groundwater table.

Achievements in 2020

- Map with sediment thickness above known groundwater tables

The continuous raster "top water level" has been completed for the entire pilot area. Based on that, another raster was calculated constraining the unconsolidated sediment thickness above the groundwater table. By categorising these raster values into meaningful intervals, we are now able to visualise an approximation for dry unconsolidated sediments above the known groundwater table.

- Map with polygons of at least 5 m unconsolidated sediment

To identify areas with a minimal cover of >5 m unconsolidated sediments, we have combined the data from existing models such as the seismic subsoil classes, the unconsolidated sediment thicknesses raster data from swisstopo as well as certain attributes of the GeoCover 2 dataset, to generate a map with the GeoCover 2 polygons expected to have this minimal thickness of unconsolidated sediments.

Project leader: Regina Reber

2.4 Targeting of potential hard rock aggregate units

The construction and maintenance of the Swiss railway and road infrastructure highly depends on the availability of fractured bedrock of highest physical strength and durability, commonly referred to as hard rock aggregates. Lithologies, which are typically extracted in Switzerland, are siliceous limestone and weakly metamorphic sandstone. In the past decades, Switzerland has seen a dramatic decrease of extraction sites, mostly due to conflicting interests. Quarry operators are therefore struggling to cover the domestic demand of hard rock aggregates.

In collaboration with the Swiss Geological Survey (swisstopo), we develop and maintain a countrywide geospatial database of potential hard rock occurrences. This dataset will support cantonal and federal spatial planners in securing the access to these important raw materials. The standardised evaluation procedure focuses on the estimation of (1) the thickness and orientation and (2) the petrophysical properties of the target lithologies. Thickness estimates are based on published geological maps and cross-sections or processed through a Matlab-based routine which automatically extracts orientation and layer thickness data from vectorised geological maps.

Achievements in 2020

- Matlab routine development

We further developed the Matlab routine and we are now able to automatically extract thickness values for any lithostratigraphic unit shown on a geological map and to classify the results after reliability. Early results show good agreement with independent field-based thickness data from the literature, which highlights the potential of the approach.

- Field investigations in the Swiss Alps July-September

The petrophysical properties of potential hard rock units are assessed through the compilation of published lithostratigraphic descriptions. Field investigations at selected key sites in the Helvetic of the Swiss Alps helped to complete or verify our results and to collect samples for more detailed physical and chemical analyses.

- List and internal report of stratigraphic units with hard rock potential

One key product of this early project phase is a list and an internal report of stratigraphic units with hard rock potential. These data sets and the report are in a final preparation stage and will be finalised in 2021. The collected data and attributes are stored in a geospatial database, which will be published on the Swiss geoportal map.geo.admin.ch and in our group's map viewer map.georesourcen.ethz.ch.

- Updated occurrence map of hard rock aggregate units in a test area

Another key product of this first project phase is an updated occurrence map of hard rock aggregate units covering a test area in central Switzerland. It will be based on our new results regarding the thickness and grade and is in a final preparation stage and will be finalised in 2021.

- Evaluation of laser-induced breakdown spectroscopy (LIBS) tools

To potentially apply a LIBS for future rapid, mineralogical field analysis of rocks we are in contact with Giorgio Senesi (CNR/ISTP Bari). We are planning a testing campaign in a Swiss pilot area in summer 2021.

Project leader: Lukas Nibourel

Project members: Sandra Grazioli, Isabel Schumacher (Hilfsassistentinnen)

2.5 Natural stones online portal

The ETH Materials Hub (MATHUB) is the materials platform at ETH Zurich which harnesses materials expertise for research and teaching. This knowledge can be publicly accessed via the online materials database Material-Archiv (materialarchiv.ch), a cooperation project of eight Swiss educational and cultural institutions (incl. the ETH library). As part of the MATHUB focus project "Naturstein" initiated in 2016, we are producing fact sheets on natural stones in collaboration with the MATHUB and with the support of the Swiss Natural Stone Association (NVS). We are responsible for new contributions and the review of existing ones. The former SGTK and today our group compiled fact sheets for all the natural stones currently quarried in Switzerland. In 2019, the focus was extended to include natural stones from abroad that are either used in contemporary architecture or are of historical significance although some of which are no longer mined today. Furthermore, we compose explanations of geological terms.

Achievements in 2020

- New fact sheets on quarried natural stones

Funded by the Swiss Natural Stone Association (NVS), we reviewed the fact sheets of 22 still quarried natural stones like for example the famous Greek Thassos marble, the Ligurian Nero Portoro or the Portuguese Estremoz marble, which were already produced since at least Roman times.

- Fact sheets on raw materials

We revised material-archiv.ch texts on the mineral talc, the volcanic rock pumice and cryptocrystalline quartz nodules also known as flint.

Project leader: Donat Fulda

Project member: Sandra Grazioli (Hilfsassistentin)

2.6 Geological Atlas (1:25'000) Map Sheet "Val Bregaglia"

In November 2018 we started this 3-year mapping project mandated by the Swiss Geological Survey. We are producing the new geological map sheet "Val Bregaglia" (Geologischer Atlas der Schweiz 1:25'000, sheet 1276) including the corresponding explanatory notes. The field area is located in the Central Alps in southeastern Switzerland (Bergell area).

The main tasks of this project are the compilation and digitisation of the 200 km² map sheet as well as writing the explanatory notes. The map sheet compilation is based on more than 30 local field mappings mainly carried out by MSc and PhD students during the last 60 years. In addition, we use some published, regional map sheets from the first half of the 19th century. The compilation and digitisation work is done in the ToolMap software, the output is processed with QGIS. Field mapping is carried out in places (1) where detailed mappings are missing or lacking quality, (2) where inconsistencies between map templates occur or (3) to quality check the existing map templates.

The explanatory notes will describe the more than 140 bedrock units derived from the existing mappings. The notes furthermore will contain cross-sections through the area and describe the tectono-metamorphic evolution, use and occurrence of mineral resources and the quaternary of the area.

Achievements in 2020

- Mapping in progress

We strongly focused on the compilation and digitisation of the map and have finalised the area of the Bregaglia main valley including Val Forno and the Maloja region.

- 30 field days for local improvement and verification

Field mapping was done in the Val Bergalga, the remote Val dal Märç region and along the sedimentary cover of the Tambo nappe where the few available map templates were insufficiently detailed, inconsistent or of insufficient quality. Verifications at specific outcrops were done in the Bregaglia main valley and Val Forno.

- Explanatory notes

We set up the basic structure of the text document and extended our literature database. Based on the field work results, the stratigraphic sequence and the definition of formation needed to be slightly adjusted (upper part of Forno unit).

Project leader: Donat Fulda

2.7 Resources Information System (RIS)

FGS runs a freely accessible web portal (map.georessourcen.ethz.ch) providing detailed information on occurrences and extraction sites of mineral resources in Switzerland. This includes data on cement raw materials, brickyard raw materials, crushed stones, natural building stones, gypsum and salt, all of which currently being extracted in Switzerland. Furthermore, the RIS also contains data on currently not produced mineral resources like energy resources, metals and metallic ores. The RIS thus represents the only platform that aggregates comprehensive information on mineral resources at a national scale. Thanks to mutual linking with the web portal of the Federal Office of Topography [swisstopo map.geo.admin.ch](http://swisstopo.map.geo.admin.ch) our data are accessible for a large user group.

In 2019, we started fundraising for a new 2-year project in order to make more unpublished but valuable raw materials databases publicly accessible. In that 2-year project we aim at creating an inventory of historical extraction sites of natural building stones in Switzerland, based on a comprehensive compilation of data already available at FGS. The final product will be publicly available on the RIS and map.geo.admin.ch platforms; a dataset of great use for curators of monuments and architects.

Achievements in 2020

- Keeping RIS up to date

Several necessary content-related and technical updates of the RIS have been carried out.

- Fundraising for a new project on historical extraction sites in Switzerland

We continued our fundraising and networking efforts to get funding for a new project. An abstract (Heuberger et al. 2021) for an oral presentation at the annual meeting of the “Gesellschaft für Bautechnikgeschichte” 2021 was submitted but could not be considered. We also met the new ETH professor Silke Langenberg (Bauforschung und Konstruktionsgeschichte) to further evaluate the potential use of this dataset. We agreed to further collaborate on this topic, potentially in future BSc or MSc projects and/or in a forthcoming SNF and ICOMOS project in Prof. Langenberg's team.

Project leader: Donat Fulda

2.8 Reviews of geothermal exploration funding applications

As part of the Swiss Energy Strategy 2050, the revised Energy Act and the CO₂ Act provide improved support policies for the development of geothermal energy. Prospecting and exploration activities for geothermal power projects can now be supported by a financial contribution of up to 60% of the costs for subsurface exploration and development. Such exploration projects are evaluated by a group of experts nominated by the Swiss Federal Office of Energy (SFOE). These experts assess the technical,

economical, legal, HSE (health safety environment) and organisational aspects of a project before providing a recommendation to SFOE on whether subsidies are to be granted. A key aspect is the requirement to the projects to apply innovative technologies to make exploring for geothermal resources more reliable, safer and commercially viable; as well as its relevance to the development of geothermal energy in Switzerland. The composition of the expert committee depends on the nature of the project, i.e. whether it is in the prospecting or exploration phase. Usually there is a geologist and/or a geophysicist, a reservoir engineer and a well engineer. There is always a representative of the Swiss Geological Survey (swisstopo). Among those experts, Stefan Heuberger is nominated as expert for geology and geophysics.

In 2018 and 2019, three project applications were reviewed: (1) A project in the greater Geneva area called "SIG GEotherm", run by SIG (Service Industriels de Genève) and carrying out a comprehensive 2D and 3D seismic survey campaign in the Geneva Basins as well as at least 4 deep boreholes, (2) a project at Riehen near Basel, called "geo2riehen", where a small 3D seismic survey shall be carried out to find a location for another deep well, and (3) a project in the La Côte area between Lausanne and Geneva, called "Energie La Côte", where an extensive 2D seismic campaign is planned.

Achievements 2020

- First round of follow-up of "SIG GEotherm"
- Completion of review of "Energie La Côte" project
- Planning for follow-up of "Energie La Côte"
- Initiation of review for the new project "Eclépens GeoCogen"

Expert for SFOE: Stefan Heuberger

2.9 Review of UNCONGEO project

The objective of the UNCONGEO project is to assess the impact of hydrocarbon resources (natural gas and/or oil) on the development of geothermal resources, with taking into account different exploration risk aspects but also the potential use of co-produced hydrocarbons. Four main scientific and technical objectives, are pursued: (1) assessment of the hydrocarbon resource potential in the Swiss Molasse Basin by characterising the tectonic and thermal history of the sedimentary basin with the methodology developed in the framework of the 2015-2017 UNCONGAS project, (2) reducing uncertainties and assessing the risks associated with the presence of hydrocarbons for exploration and production of geothermal energy, (3) implementation of an analytical workflow to facilitate the periodic updating of the knowledge gained even after termination of the research project, and (4) recommendations to the Federation concerning the usage of the project deliverables to improve the regulation of geothermal projects. The project is carried out by the Geo-Energy Reservoir Geology and Sedimentary Basin Analysis group team at University of Geneva. It is sponsored by SFOE and swisstopo and runs since late 2017 and will last until 2023.

This year, an external audit group was installed by swisstopo with geoscience experts from the hydrocarbon industry and from Swiss academia, including Stefan Heuberger.

Achievements 2020

- Audit meeting and review report in December
A first comprehensive audit was performed reviewing the last 4 four years of work, and short report was compiled by the audit group for the attention of the project sponsors and the project team.

Expert for swisstopo: Stefan Heuberger

2.10 Retrospection of 120 years of research on Swiss georesources

With the dissolution of the Swiss Geotechnical Commission (SGTK) in 2018, a phase of 120 years of institutional applied research on Swiss georesources came to an end. Initiated by the Swiss Academy of Sciences and the Swiss Federal Council in 1899, SGTK and its experts in geoscience and raw materials carried out hundreds of studies on Switzerland's geological resources. In the late 19th and early 20th century these were mainly energy resources like coal, peat, oil and gas. Key focus for a long time was also on metallic ores, natural stones, clay, salt and gypsum. In the mid-late 20th century, the focus changed significantly. Metals and hydrocarbons almost completely lost their importance, instead the field of activities diversified a lot.

As our group (FGS) took over the archives, reports, rock collections and digital inventories of SGTK, a retrospection is carried out on what research has been done and how these projects were organised and funded. A special aspect plays the role of SGTK carrying out geological and geophysical surveying in Switzerland, whereas most other European countries had national geological surveys since the mid-19th century. In Switzerland, the Geological Survey was founded only in 1986. This also changed the role of SGTK.

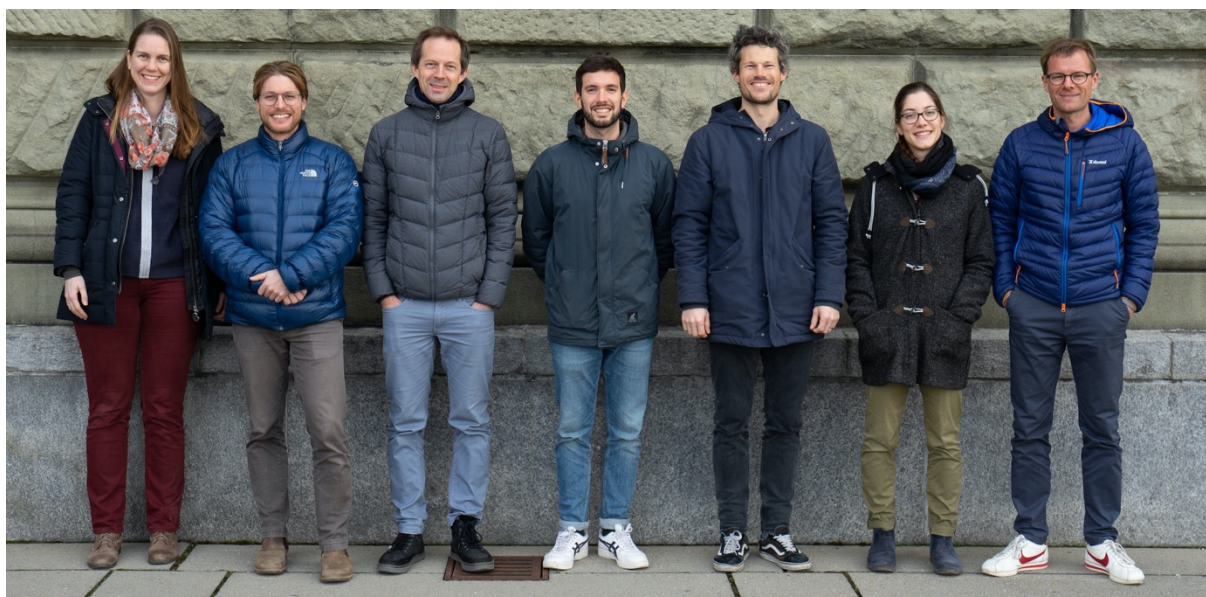
Achievements 2020

- Draft manuscript

A peer-review article is under way. All historical investigations and the figures are completed; the text is almost finished. The article will be submitted to the Swiss Journal of Geosciences in early 2021.

Project leader: Stefan Heuberger

3 Personnel 2020



From left to right: Regina Reber, Gérard Perren, Donat Fulda, Loïc Pierdona, Lukas Nibourel, Sandra Grazioli, Stefan Heuberger. Not on the picture: Isabel Schumacher. Picture taken on 8.1.2020.

Employee	Function	max. contract/funding until	Pensum
Dr. Stefan Heuberger	Group Head, Senior Scientist Technology	permanent (since 11.2020)	100%
Donat Fulda	Technical Specialist II	permanent	80%
Dr. Lukas Nibourel	Scientific Assistant II	03/2031 *	80%
Dr. Gérard Perren	Scientific Assistant II	06/2031 *	80%
Dr. Regina Reber	Scientific Assistant II	08/2021	60%
Loïc Pierdona	Scientific Assistant I	06/2021	80%
Sandra Grazioli	Hilfsassistentin	12/2021	20%
Isabel Schumacher	Hilfsassistentin	12/2021	20%
Total FTE			5.2

Contractor	Function	contract & funding until	Pensum
Peter Nievergelt	third-party collaborator	10/2021	

* project duration and funding are longer than the possible maximum contract duration for scientific personnel at ETH.

4 Teaching and public outreach

4.1 Teaching at D-ERDW and other departments or universities

Stefan Heuberger

Course title	Level	ECTS	Comments
Integrierte Erdsysteme III	BSc	5	main responsibility
Erdwissenschaftliche Exkursionen I	BSc	1	main responsibility f. Glarus-Exkursion
Feldkurs II Sedimente, Gemmipass	BSc	3	lead: V. Picotti
Integrierte Exkursionen I	BSc	1	lead: A. Rudow (D-USYS)
Architectural Design V-IX: Material Gesture - Stone	BSc	14	lead: Prof. A. Holtrop (D-ARCH) "Natural Stones of Switzerland"
Signal propagation in source to sink for the future of earth resources and energies	PhD		Horizon2020 proj., supporting contribution to Uni. Bern (Prof. F. Schlunegger)

Donat Fulda

Course title	Level	ECTS	Comments
Swiss Alpine Archaeology Summer School	MSc	3	run by Uni Bern & Uni Zürich (postponed to 2021)
Natural building stones in Switzerland "Vom Naturwerkstein zur Geologie"			Further education 2-days course by NVS (Natural Building Stones Association Switzerland) (postponed to 2021)

Lukas Nibourel

Course title	Level	ECTS	Comments
Erdwissenschaftliche Exkursionen I	BSc	1	Glarus-Exkursion, lead S. Heuberger
Erdwissenschaftliches Kartenpraktikum I	BSc	2	lead J. Ruh
Swiss Tectonic Studies Group excursion "Aar Massif"	MSc, PhD		September 2020 (postponed to 2021)

Sandra Grazioli

Course title	Level	Comments
Geological city excursion in Zürich	public	by focusTerra

4.2 Outlook 2021

Stefan Heuberger

Course title	Level	ECTS	Comments
Erdwissenschaftliche Exkursionen I	BSc	1	Gotthard-Exkursion, lead L. Nibourel

Lukas Nibourel

Course title	Level	ECTS	Comments
Erdwissenschaftliche Exkursionen I	BSc	1	main responsibility Gotthard-Exkursion

4.3 New MSc project 2021/2022

Project	Runtime
<i>topic still to be discussed, but including geological field mapping in Switzerland</i> , MSc candidate: Gillian Iten. Supervision: Lukas Nibourel, Stefan Heuberger, N.N.	FS 2021 - FS 2022

4.4 New BSc projects in 2021

Project	Runtime
"Hohgant-Sandstein als Hartgestein?", BSc candidate: Maira Coray. Supervision: Lukas Nibourel & Stefan Heuberger	FS 2021
"Sandstein-Brüche am oberen Zürichsee, deren Abbaugeschichte und Verwendung", BSc candidate: Silas Mauchle. Supervision: Stefan Heuberger & Donat Fulda	FS 2021

5 Publications

Papers *(accepted)*

Nibourel, L., Berger, A., Egli, D., Heuberger, S. and Herwegh, M. (2021). Structural and thermal evolution of the eastern Aar Massif: insights from structural field work and Raman thermometry. *Swiss Journal of Geosciences* 114 (9).

Papers *(submitted)*

Nibourel, L., Rahn, M., Dunkl, I., Berger, A., Herman, F., Diehl, T., Heuberger, S. and Herwegh, M. (*subm.*). Orogen-parallel migration of exhumation in the eastern Aar Massif revealed by low-T thermochronology. *Submitted to Journal of Geophysical Research: Solid Earth*.

Papers *(in preparation)*

Heuberger, S., Nibourel, L., Fulda, D. & Vernooij, M. (*in prep.*). 120 years of georesources research in Switzerland - the Swiss Geotechnical Commission (1899-2018). *To be submitted to Swiss Journal of Geosciences, early 2021*.

Fabbri, S. C., Affentranger, C., Krastel, S., Lindhorst, K., Wessels, M., Madritsch, H., Allenbach, R., Herwegh, M., **Heuberger, S.**, Wielandt-Schuster, U., Pomella, H., Schwestermann, T. and Anselmetti, F. S. (*in prep.*). Neotectonic faulting unraveled by multivintage reflection seismic data in Lake Constance (Austria, Germany, Switzerland). *To be submitted to Frontiers in Earth Science, early 2021*.

Abstracts (Talks/Posters)

Heuberger, S., Fulda, D. & Vernooij, M. (2021). Historische Naturwerksteinbrüche in der Schweiz - Aufbau eines Online-Nachschlagewerks. Fünfte Jahrestagung der Gesellschaft für Bautechnikgeschichte 2021. 10.-12.06.2021.

Nibourel, L., Galfetti, T., Kurmann-Matzenauer, E., Schläfli, S., Grazioli, S., Schumacher, I. and Heuberger, S. (2020). Semi-automated rapid targeting of potential mineral deposits in an Alpine setting: the hard rock aggregates example. EAGE Mineral Exploration Symposium 2020, 17.-18. September 2020, Online.

Pierdona, L., Glaus, L., Kissling, E. and Heuberger, S. (2020). Analysis of Temperature Data from Deep Borehole Measurements in Switzerland. Cermak 7 - 7th International Meeting on Heat Flow and the Geothermal Field. 12–14. May 2020 (postponed to 2021), Potsdam, Germany

Factsheets

Rocks

- Material-Archiv (2019). Ettringer-Tuff. materialarchiv.ch/de/ma:material_283 [last retrieved: 3.12.2020]
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6 Network

6.1 Active committee memberships

Organisation	FGS member	Function	Since
NEROS (Network for Mineral Resources in Switzerland)	S. Heuberger	member of the steering committee	2019
SASEG (Swiss Association of Energy Geoscientists)	S. Heuberger	member of the steering committee	2019
SGPK (Swiss Geophysical Commission)	S. Heuberger	visiting guest	2017
NVS (Natural Building Stones Association Switzerland)	D. Fulda	member of the quarry commission	2018

6.2 Review committees for the Swiss Federation

Organisation	FGS member	Function	Since
SFOE (Swiss Federal Office of Energy) expert panel for reviewing funding applications of geothermal exploration projects	S. Heuberger	member of expert panel	2018
swisstopo (Swiss Geological Survey) UNCONGEO project, sponsored by SFOE and swisstopo	S. Heuberger	member of audit team	2020

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