

Annual Report 2021

Georesources Switzerland Group
Fachgruppe Georessourcen Schweiz (FGS)

February 2022

Acknowledgements

This annual report was prepared by Dr. Stefan Heuberger (FGS group head) with support of all FGS team members.

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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 (currently 4 employees, Fig. 2) 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 currently raises an average annual budget of ca. 600 kCHF.

The close collaboration with the Swiss Geological Survey (Federal Office of Topography swisstopo) provides a 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. 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 Projects

2.1 Research projects

2.1.1 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 potential 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 the GeoCover geological vector dataset.

Achievements in 2021

- Matlab routine to extract layer thickness from geological maps

We have finalised our Matlab routine, which is now able to automatically extract the orientation (dip-direction/dip) and stratigraphic thickness of a given layer from a geological map. The script was optimised to facilitate thickness analyses over larger areas and including multiple target units. The preparation of the input geological and digital elevation model data was also automated. The reliability assessment and filtering of extracted orientation and thickness values based on different numeric parameters was further improved. Publication of a peer-reviewed paper (to be submitted to Journal of Structural Geology), in which we present the approach, is in preparation. Several map sheets have been tested to date and the results look very promising.

Up to now, the parameters for the reliability assessment and filtering were chosen by visually comparing the Matlab thickness output to independent thickness data from published cross sections. Joël Morgenthaler has initiated a routine which automatically finds the optimal filtering parameter set by (1) minimising the mismatch between the filtered Matlab output and independent literature thickness data and (2) by maximising the thickness output. The routine uses open-source components like geopandas, pandas, GDAL, QGIS, sklearn, matplotlib and numpy.

Overall, the approaches complement each other and exploit all typical features of a geological map. Key improvements with respect to commonly used 3D model approaches are, objectivity, rapidity and the possibility to classify and/or filter orientation and thickness data after reliability. The methods are designed to support authorities and the private sector to perform a rapid screening and identification potentially promising areas for an eventual mineral extraction project.

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

The list of potential hard rock units has been finished in 2021 and is being reviewed by experts. These data sets and the report are in a final preparation stage and will be finalised in 2022. The collected data and attributes are stored in a geospatial database, which will be published on the Swiss geportal map.geo.admin.ch and in our group's map viewer map.georessourcen.ethz.ch.

- Estimation of thickness and quality (grade) from literature data

We have completed the data compilation of literature data for the pilot area covering central Switzerland. 626 layer thickness values and 188 estimates of the potential, extractable thickness (grade) have been collected from more than 450 documents and for 8 potential hard rock units. The results have been stored in a geospatial database (see paragraph below) and are a perfect independent data set to test the performance of the Matlab approach described above.

- Field investigations in the Swiss Alps July-September

Field investigations at selected sites of the pilot area covering central Switzerland helped to complete or verify our thickness data set and to collect samples for more detailed petrophysical and chemical analyses. In her BSc thesis, Maira Coray investigated the hard rock potential of the Hohgant-Sandstein in the Entlebuch area. According to her results, the unit does have some potential, but her results also highlight that the evaluation of sandstones is very challenging and needs further, petrological and physical testing. Maira's work, and our groups applied georesources background, have been portrayed in a ETH GLOBE article (see link in Chapt. 4.5 and Fig. 1).

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

Another key product of this early project phase is a map highlighting relevant (i.e., sufficiently thick and high-grade) hard rock occurrences, covering a test area in central Switzerland. We created a semi-automated GIS-routine which selects these occurrences based on clear quantitative criteria (see link to the project report "GIS routine to find potential areas for the extraction of hard rock aggregates for Swiss railway and road infrastructures" by Nibourel et al. below). The routine produces reproducible and objective results which is very important in the process of reducing potential conflicts associated with the extraction of hard rock. The routine also allows a clear focus on relevant areas in the future. A definitive version of this occurrences map will be produced once the Matlab thickness data are available for the entire test area.

Project leader: Lukas Nibourel

Project members: Sandra Grazioli, Isabel Schumacher (Hilfsassistent:innen),
Maira Coray (BSc student), Joël Morgenthaler, Stefan Heuberger

2.1.2 Automated analysis of geoscientific datasets

Based on the Swiss Federal energy strategy 2050, the Swiss Federal Office of Energy (SFOE) and the Swiss Federal Office of Topography (swisstopo) are significantly pushing forward the establishment of a solid geoscientific knowhow pool to further support and enable geothermal exploration projects. A substantial amount of diverse geoscientific data is generated during prospection and exploration of geothermal projects. Those data are collected, compiled and stored by the Swiss Geological Survey at swisstopo and represent the basis of our project "Automated analysis of geoscientific datasets" that started in 2019. The overall goal is to be able to make well-supported predictions for the geothermal potential in Switzerland within the next few years using modern statistical methods.

We are currently focusing on two subordinate projects. The project planners of the geothermal projects should hand over their collected geoscientific data to swisstopo as uniformly, structured and harmonised as possible. In order to ensure this, our first subproject aims to develop concrete delivery specifications, which agree with the data models of the Swiss Geological Survey as well as with the current geological (measurement) standards. With that, the new data can be easily analysed and processed.

On the other hand, the Swiss Geological Survey already hosts a large inventory of comprehensive geological reports and data which are mainly archived as PDF documents and contain essential information about the Swiss subsurface. As a second subproject, we focus on the targeted retrieval and extraction of information starting from these reports. Based on that inventory we are building a search engine customised to query geological terms. Along this process, semantically similar reports will be classified

into geoscientific classes using Natural Language Processing methods. And, geological report elements such as borehole profiles, maps and figures are automatically identified, extracted and stored separately for further digitisation.

Achievements in 2021

- Re-evaluation of archive data utilising deep learning (GAIA project)
During the last 1.5 years, we developed machine learning pipelines for analysing the geological scanned paper archive at swisstopo together with experts from the Institute for Data Sciences at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW). As a result, we are now able to query information from the archive by employing Optical Character Recognition (OCR) and state-of-the-art text classification and object detection models
- Final technical report on GAIA project 2020/2021
Methods and results of the project phase 2020/2021 are documented in a technical report. Corresponding scripts and code are freely available and published on Gitlab: <https://gitlab.ethz.ch/swisstopo/revaluatearchive>
- Draft article in Swiss Bulletin of Applied Geology
A manuscript on the methods and results of the GAIA project phase 2020/2021 will be submitted to the Swiss Bulletin of Applied Geology in February 2022.
- Geodata from Swiss geothermal exploration projects
Compilation of current use cases and needs at swisstopo. Initiation of a structured data transfer from geothermal project acquisitions to swisstopo.

Project leader: G rard Perren (until May) / Jo l Morgenthaler (since March)

2.1.3 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. FGS took over the archives, reports, rock collections and digital inventories of SGTK. Initiated by the Swiss Academy of Sciences and the Swiss Federal Council in 1899, the SGTK team 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.

We compiled a retrospection 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 2021

- Manuscript accepted
The manuscript was submitted to Swiss Journal of Geosciences in May and a thoroughly revised version was resubmitted in November and accepted in December.

Project leader: Stefan Heuberger

Project members: Lukas Nibourel, Donat Fulda

2.1.4 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. 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 and completed it in June 2021. During those 2.5 years, 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. We originally planned to publish those intermediate results in a peer-reviewed article. This paper would 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.

Achievements in 2021

- Completion of project in June
The borehole data compilation, analysis and corrections were completed by June. Together with the data, a brief project documentation was handed in to swisstopo.
- Interpolations towards a heat flow map of northern Switzerland
Initial tests of with draft interpolations of the temperature data were performed. The swisstopo team plans to complete these works and publish the results in some to be defined form.

Project leader: Loïc Pierdona (until June)

2.1.5 Assessment of Switzerland's gravel and sand occurrences

Dozens of regional and local companies in Switzerland extract more than 30 million tons of gravel and sand per year. Volume estimations of those occurrences 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.

We planned to derive a methodology to systematically assess the gravel and sand occurrences of Switzerland. We aimed at developing GIS-based tools that work at such a level of detail that these methods can be applied throughout the country and can deliver results quickly and easily - provided there is sufficient harmonised spatial data available. We tested different approaches in a pilot study area covering the Lower Reuss and Lower Aare catchments. There, we evaluated different GeoCover 2 attributes of the unconsolidated deposits layer to confine the occurrence of gravel on the surface. From groundwater table vector data we calculated a continuous groundwater level raster for the main aquifers to delimit gravel bodies above the groundwater table. 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.

Achievements in 2021

- Project report and completion of project in August
A report documenting the ArcGIS-based data repository and the test analyses and interpolation was handed in to swisstopo in August.

Project leader: Regina Reber (until August)

2.2 Service projects

2.2.1 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 2021

- New fact sheets on quarried natural stones

Funded by the Swiss Natural Stone Association (NVS), we reviewed the fact sheets of 15 still quarried natural stones like for example the famous Italian Carrara marble, the Proterozoic gabbro "Nero Impala" from South Africa or the "Tauerngrün Serpentin" from the Penninic Tauern window.

Project leader: Donat Fulda

Project member: Sandra Grazioli

2.2.2 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 2021

- Digitisation complete

With the processing of the northern half of the mapping area, the digitisation of the main geological features on the 200 km² map sheet could be completed.

- 25 days of field work

Field work was mainly done (1) in the Val Bergalga to map out different formations within the

metasediments of the Avers nappe, (2) in the Septimer pass area to re-map the complex relationships between the tectonic units in the hanging wall of the Turba Mylonite Zone and (3) on the south-east exposed valley slope of the Upper Engadine north-east of Lake Sils to be able to compile the widely differing existing maps of the area

Project leader: Donat Fulda

Project member: Peter Nievergelt

2.2.3 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.

Achievements in 2021

- Providing feedback to RIS-related enquiries

We provided individual feedback on requests related to data published on the Resources Information System (RIS). The enquiries covered a wide range of topics, such as extraction volumes of dimension stone quarries, occurrences of lithium-bearing minerals or locations of historical mining sites of pisolitic iron ore in northern Switzerland.

- Keeping RIS up to date

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

Project leader: Donat Fulda

2.3 Reviews

2.3.1 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. The expert committee usually consists of a geologist and/or a geophysicist, a reservoir engineer and a well engineer, depending on the nature of the project, i.e. whether it is in the prospecting or exploration phase. Among those experts, Stefan Heuberger is nominated as expert for geology and geophysics.

Project applications reviewed so far (2018-2021): (1) "SIG GEotherm" (greater Geneva area), (2) "geo2riehen" (Riehen near Basel), (3) "EnergeÔ La Côte" (La Côte area between Lausanne and Geneva), (4) "GeoCogen Eclépens" (Eclépens area)

Achievements 2021

- Completion of initial review report of project (4)
- Intermediate review reports in projects (1) to (3)
- Look back workshop with other review team experts

Expert for SFOE: Stefan Heuberger

2.3.2 Review of UNCONGEO project

The objective of the UNCONGEO project is to assess the impact of hydrocarbon occurrences 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, (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 mid 2023. In 2020, an external audit group was installed by swisstopo with geoscience experts from the hydrocarbon industry and from Swiss academia, including Stefan Heuberger.

Achievements 2021

- Audit meeting in December

The annual audit meeting was held in December. A short report was compiled by the audit group for the attention of the project sponsors and the project team.

Expert for swisstopo: Stefan Heuberger

Tracking down track ballast

22.09.2021 | Globe magazine | Report

By: Felix Würsten

Switzerland may soon be facing a shortage of railway ballast. ETH geologists are heading into the wilds to track down new sources of crushed rocks.



Electronic devices may be useful, but Maira Coray also relies on a traditional field book. (Photo: Daniel Winkler / ETH Zurich)



Stefan and Lukas are hard at work, hammering away at the hard rock to break off samples. (Photo: Daniel Winkler / ETH Zurich)

Fig. 1. Two extracts from the online version of ETH Globe article about the Maira Coray's BSc project supervised by Lukas Nibourel and Stefan Heuberger.

3 Personnel



Fig. 2. FGS team, from left to right: Lukas Nibourel, Sandra Grazioli (Hilfsassistent), Joël Morgenthaler, Isabel Schumacher (Hilfsassistent), Donat Fulda, Stefan Heuberger. Picture taken by Peter Nievergelt on 01.10.2021 near Fuorcla Grevasalvas (GR, Switzerland).

Employee	Function	max. contract/funding until	Pensum
Dr. Stefan Heuberger	Group Head, Senior Scientist Technology	permanent	100%
Donat Fulda	Technical Specialist II	permanent	80%
Dr. Lukas Nibourel	Scientific Assistant II	03/2031 *	80%
Joël Morgenthaler	Scientific Assistant I	03/2023	100%
<i>Dr. Gérard Perren</i>	<i>Scientific Assistant II</i>	<i>Until 05/2021</i>	<i>80%</i>
<i>Loïc Pierdona</i>	<i>Scientific Assistant I</i>	<i>Until 06/2021</i>	<i>80%</i>
<i>Dr. Regina Reber</i>	<i>Scientific Assistant II</i>	<i>Until 08/2021</i>	<i>60%</i>
Sandra Grazioli	Hilfsassistentin	05/2022	20%
Isabel Schumacher	Hilfsassistentin	12/2021	20%
Current total FTE			4.0

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.



Fig. 3. Top: Lukas Nibourel and BSc students at the Lochsite outcrop of the Glarus Thrust during the *Erdwissenschaftliche Exkursionen I – Glarnerland* on 29.5.2021. Bottom: Stefan Heuberger and Gillian Iten taking samples during field work in Gillian's MSc project in the Säntis nappe (NE Switzerland).

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 - Glarnerland	BSc	1	main responsibility
Erdwissenschaftliche Exkursionen I - Gotthard	BSc	1	lead: L. Nibourel
Feldkurs II Sedimente, Gemmipass	BSc	3	lead: V. Picotti
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
Erdwissenschaftliche Exkursionen I - Molasse Schaffhausen	BSc	1	lead: Iwan Stössel
Integrierte Exkursionen I	BSc	1	lead: A. Rudow (D-USYS)
Swiss Alpine Archaeology Summer School	MSc	3	run by Uni Bern & Uni Zürich
Geological city excursion in Zürich	public		by focusTerra

Lukas Nibourel

Course title	Level	ECTS	Comments
Erdwissenschaftliche Exkursionen I - Gotthard	BSc	1	main responsibility
Erdwissenschaftliche Exkursionen I - Glarnerland	BSc	1	lead: S. Heuberger
Erdwissenschaftliches Kartenpraktikum I	BSc	2	lead: J. Ruh
Swiss Tectonic Studies Group excursion "Aar Massif"	MSc, PhD		main responsibility

Sandra Grazioli

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

4.2 MSc projects

Project	Runtime
<i>Age and temperature conditions of folding and thrusting in the Säntis nappe and the adjacent Subalpine Molasse from U-Pb dating and clumped isotopes on calcite.</i> MSc candidate: Gillian Iten. Supervision: Stefan Heuberger , Lukas Nibourel , Stefano Bernasconi, Nathan Looser	FS 2021 - FS 2022
<i>Semi-automated targeting of crushed hard rock aggregates in an Alpine setting.</i> MSc candidate: Lorena Juchler. Supervision: Stefan Heuberger , Lukas Nibourel , Jonas Ruh	HS 2021 - FS 2022
<i>Reconstruction of the preconditions, timing and runout of the Voralpsee landslide.</i> MSc candidate: Isabel Schumacher, Supervision: Susan Ivy-Ochs , Andrea Wolter, Lukas Nibourel	FS/HS 2021

4.3 BSc projects

Project	Completed
<i>Hohgant-Sandstein als potentielles Hartgestein.</i> BSc candidate: Maira Coray. Supervision: Lukas Nibourel (main) & Stefan Heuberger	FS 2021
<i>Kartographische und petrographische Rekonstruktion der Abbaugeschichte des Bollinger-Sandsteins.</i> BSc candidate: Silas Mauchle. Supervision: Stefan Heuberger (main) & Donat Fulda	FS 2021

4.4 New BSc project in 2022

Project	Runtime
<i>High-quality sandstones for the use as hard rock aggregates? - Petrophysical properties of the Hohgant Sandstone member.</i> BSc candidate: Irina Mayer. Supervision: Lukas Nibourel (main) & Stefan Heuberger	FS 2022

4.5 In the news

Interviews

Heuberger, S. (2021). Die verlorene Bedeutung der Bergwerke. *Schweizer Radio und Fernsehen (SRF)*, Regionaljournal Sommerserie 21. 15. July 2021. <https://www.srf.ch/audio/regional-diagonal/sommer-21-die-verlorene-bedeutung-der-bergwerke?id=12016503>

Reportage

ETH Globe magazine (2021). Tracking down track ballast. Reportage on the Georesources Switzerland Group. Text: Felix Würsten, Fotos: Daniel Winkler. no. 3/2021, p. 40-43. <https://ethz.ch/en/news-and-events/eth-news/news/2021/09/tracking-down-track-ballast.html>



Fig. 4. BSc students visiting the *Landesplattenberg* slate quarry in Engi (Glarus area) on the *Erdwissenschaftliche Exkursionen I – Glarnerland* on 29.5.2021.

5 Publications

Papers

Nibourel, L., Rahn, M., Dunkl, I., Berger, A., Herman, F., Diehl, T., **Heuberger, S.** and Herwegh, M. (2021). Orogen-parallel migration of exhumation in the eastern Aar Massif revealed by low-T thermochronology. *Journal of Geophysical Research: Solid Earth*, e2020JB020799.

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).

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. (2021). Active faulting in Lake Constance (Austria, Germany, Switzerland) unraveled by multi-vintage reflection seismic data. *Frontiers in Earth Science* 9: 670532.

Papers *(accepted)*

Heuberger, S., **Nibourel, L.**, **Fulda, D.** & Vernooij, M. *(accepted)*. 120 years of georesources research in Switzerland - the Swiss Geotechnical Commission (1899-2018). *Swiss Journal of Geosciences*.

Abstracts (Talks/Posters)

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Fig. 5. Lukas Nibourel taking Schmidt Hammer measurements during field campaign as part of the hardrock aggregate units' project.

6 Network

6.1 Active committee memberships

Organisation	FGS member	Function	Since
KBGeol (Federal Coordination Body for Geology)	S. Heuberger	member without voting rights	2021
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	Time
SFOE (Swiss Federal Office of Energy) expert panel for reviewing funding applications of geothermal exploration projects	S. Heuberger	member of expert panel	2018-2021
swisstopo (Swiss Geological Survey) UNCONGEO project, sponsored by SFOE and swisstopo	S. Heuberger	member of audit team	2020-2023

FGS Fachgruppe
Georessourcen
Schweiz

ETH Zurich
Department of Earth Sciences
Georesources Switzerland Group
Sonneggstrasse 5, NO F 35
8092 Zurich

georessourcen.ethz.ch/en
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