ETH zürich

Annual Report 2023

Georesources Switzerland Group
Fachgruppe Georessourcen Schweiz (FGS)

February 2024

Department of Earth Sciences

Acknowledgements

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

Picture: On top of Daubenhorn (VS), view towards east, during Feldkurs II on Gemmi-Pass (14.9.2023).

Content

1 The Georesources Switzerland Group

The Georesources Switzerland Group (Fachgruppe Georessourcen Schweiz, FGS) processes information and conducts applied research on Swiss mineral and energy resources and their industrial application on behalf of the federal government and in collaboration with industry partners. Our group forms an associated group in the Department of Earth Sciences and currently has 5 employees. The group is >90% third-party funded (excl. SNF) and currently raises an average annual budget of ca. 650 kCHF.

The close collaboration with the Swiss Geological Survey (Federal Office of Topography swisstopo) provides the financial basis and defines the long-term focus of our applied research. We focus on compiling fundamental geological data and data related to the use of the mineral and energy resources in Switzerland. Important topics are for example (1) non-metallic mineral resources (i.e. gravel, sand, clay, limestone, salt, natural building stones) and (2) reservoir rocks and energy resources in the deep underground. The group maintains a sample and literature archive taken over from the Swiss Geotechnical Commission (SGTK), and makes these 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 - a field that will remain essential in the future. Extraction of raw materials is becoming increasingly complicated because of the scarcity of materials, land use conflicts and several types of emissions. In the context of the aimed energy transition, understanding the reservoir and cap rocks in the deeper Swiss underground is becoming more and more important regarding for example the utilisation of deep geothermal energy or the sequestration of CO_2. Switzerland has no hydrocarbon and no substantial mining industry. Therefore, fundamental geological data on the deeper underground are still scarce. Switzerland possesses abundant mineral resources, but the country does not have uniform mineral royalty laws like most other European countries. 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 generate and 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

Hard rock aggregates play a central role particularly for the construction and maintenance of important transport routes. They are used as main component of the superstructure of the Swiss railway network (railway ballast) as well as of high-performance roads (mat-min.ch/de/hartstein). Lithologies, 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 have developed a country-wide geospatial database of potential hard rock occurrences. We developed a standardised evaluation procedure focusing on (1) the thickness and (2) the petrophysical properties of 13 potentially hard rock-bearing geological units. Thickness estimates were based on published geological maps and cross-sections or processed through a Matlab- and python-based routine, which automatically extracts orientation and layer thickness data from the GeoCover geological vector dataset (Nibourel et al., 2023). A map example showing thickness variations of the Helvetic Kieselkalk Formation is shown on Figure 1.

The petrophysical properties of these units were estimated based on stratigraphic descriptions, petrophysical tests and technical reports from existing or past extraction sites. At key sites, the data were validated in the field. Our final product shows an estimation of the spatial distribution, the thickness and the quality of the hard rock-bearing geological units situated below 1300 m a.s.l. and with a thickness larger than 30 m. In July 2024, this dataset will be published as a new layer "Hard rock aggregates: Thickness and quality of hard rock occurrences" on the swisstopo web portal map.geo.admin.ch. A map extract of the final hard rock occurrences map is shown is Figure 2. Supplementary information regarding the hard rock-bearing geological units will be listed in a swisstopo report (Hard rock catalog). The workflow and methodology used for the compilation of the dataset will be described in a "Technical documentation" accompanying the data set.

Achievements in 2023

- Field investigations at key sites

  Field investigations at selected key sites helped to complete and verify the data compiled from the literature and to test the physical properties of the rock material.

- Publication of peer-reviewed paper

  The manuscript describing and discussing the performance of a Matlab-based routine for the automated extraction of orientation and thickness data from geological maps was published in the Journal of Structural Geology (Nibourel et al. 2023).

- Development of automation routine to evaluate potential hard rock occurrences

  A python-based routine was developed to automatically evaluate the hard rock-bearing geological units based on the thickness and quality input data. Key steps are (1) the collection of input data from different sources, (2) the data pre-processing and validation, (3) the interpolation of input point data and (4) the quantification of the uncertainty of the output.

- Switzerland-wide automated extraction of thickness data

  Thickness data were collected across entire Switzerland. The methods of Nibourel et al. (2023) and Jucher (2022) were combined to map spatial variations of thickness of the hard rock-bearing geological units in Switzerland (see for example Figure 1). Many calculations could be performed simultaneously using the Euler supercomputer infrastructure at ETH Zurich.

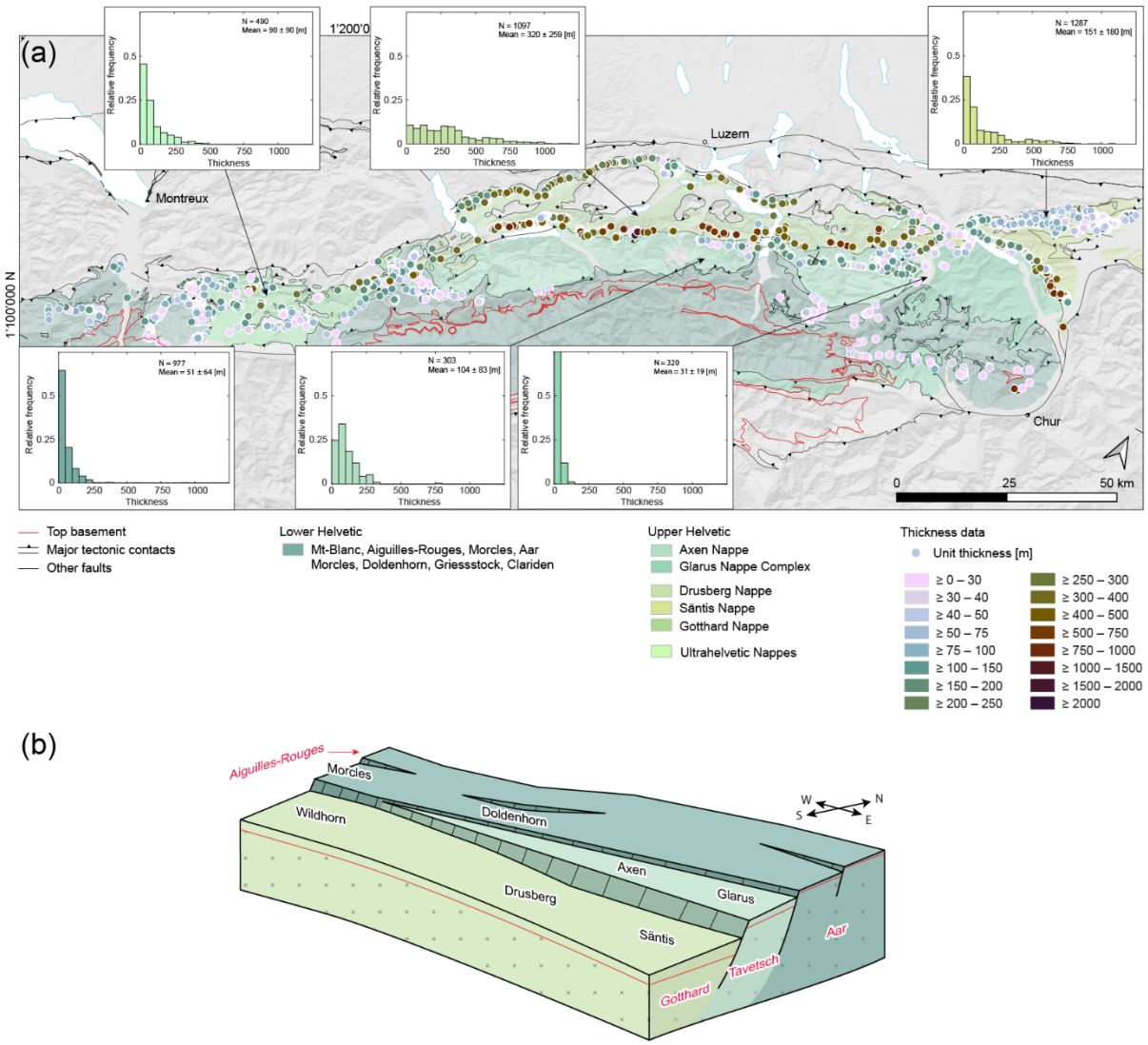

Fig. 1. (a) Literature-based and automatically extracted thickness data of the Helvetic Kieselkalk Formation. The thickness data points on the map and selected histograms highlight very systematic thickness variations across the Lower Helvetic and different Upper Helvetic nappe systems. N = the number of thickness data points per histogram. (b) A simplified schematic sketch highlighting the close relationship between the suggested paleogeography during the Lower Cretaceous (the time of deposition of the Helvetic Kieselkalk Formation) and the thickness of the unit observed in (a). The approximate paleogeographic position of the Helvetic Nappes is given in the sketch. The names of the corresponding basement units are given in red.

- Evaluation of potential hard rock occurrences

  The automated evaluation routine described above was used to generate the first draft versions of the Switzerland-wide map of the Swiss hard rock occurrences (see Figure 2).

- Four oral presentations and one poster at various meetings

  We gave talks and presented posters at the Swiss Geoscience Meeting in Mendrisio, at the 3D-Workshop at swisstopo in Wabern, at the General Assembly of the Verband Schweizerischer Hartsteinbrüche in Altdorf, and during the ELSTE Journée Lémanique at the University of Lausanne.

Project leader: Lukas Nibourel

Project members: Anja Amrein, Stefan Heuberger, Maira Coray

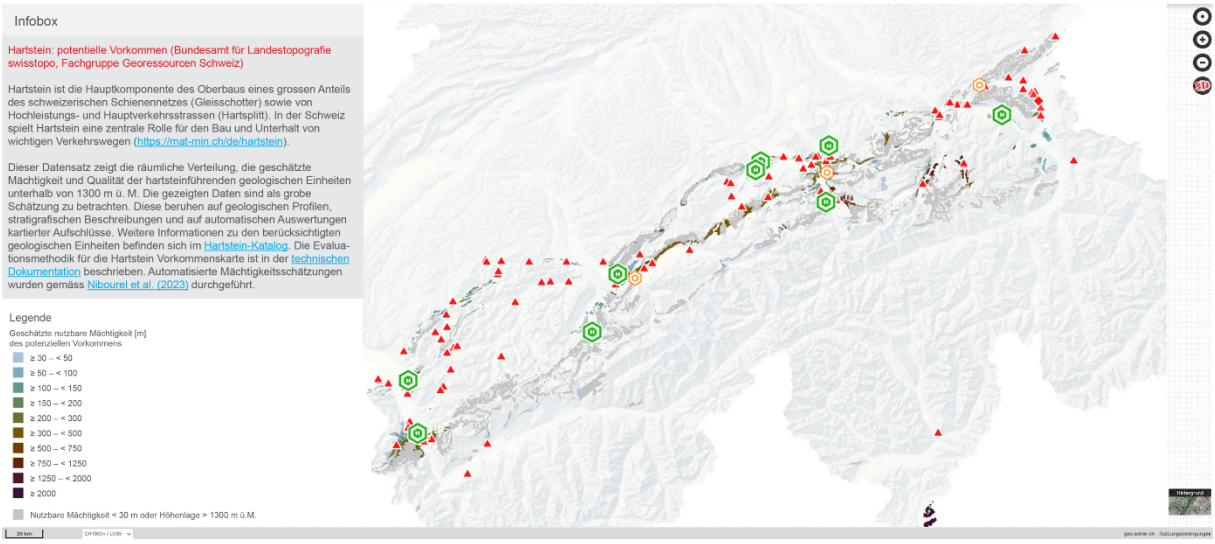

Fig. 2. Extract of a preliminary version of the final dataset showing an estimation of the spatial distribution, the thickness and the quality of the hard rock-bearing geological units situated below 1300 m a.s.l. and with a thickness larger than 30 m. A sample of what the infobox and legend on map.geo.admin.ch will look like is shown on the left.

2.1.2 Lithium from geothermal brines

The production of geothermal energy coupled with the extraction of lithium or other critical metals from deep aquifers could provide an important economic incentive to scale up geothermal exploration and production in Switzerland. A review of the literature reveals that lithium, globally, has become one of the key critical raw materials needed for the energy transition, especially for the storage of energy. Therefore, the focus of lithium exploration has recently expanded to include geothermal brines, as an alternative to conventionally exploited hard rock occurrences or salar brines. Deep geothermal aquifers are known to occasionally contain significant concentrations of lithium. Although research pilot wells are well advanced (e.g. in Germany or the USA), no lithium is commercially produced from a geothermal well at industrial scale yet.

We have compiled 79 lithium concentrations from the publicly accessible wells in Switzerland deeper than 100 m. Lithium concentrations in the aquifers encountered are, with two exceptions, below 33 mg/l. Two wells in the Swiss Molasse Basin, at Pfaffnau and Berlingen, have elevated lithium concentrations of 82 mg/l and 144 mg/l, respectively. Both measurements originate from the Upper Muschelkalk aquifer. These concentrations are lower than the highest concentrations recorded so far in the Upper Rhine Graben (100-210 mg/l, Fig. 3) or in several regions of Italy (up to 480 mg/l). The process of lithium enrichment in geothermal fluids at depth is yet poorly understood. Our data reveal that geothermal fluids with high TDS (total dissolved solids) values also have elevated lithium concentrations and are predominantly located in areas with high heat flow. In Switzerland, areas with high heat flow are located in the Basel and Lower Aare Valley regions as well as in the area of Lake Constance. An up-to-date heat flow map could thus provide useful indications for the exploration of metal-rich geothermal brines.

To better understand the spatial distribution and key parameters controlling the concentration of critical raw materials such as lithium in deep aquifers, and to provide a robust basis for further investigations,we propose the following measures: (i) update the data base with recent and not publicly available well data, (ii) repeat lithium concentration measurements at key sites with high concentrations but low confidence (if the well data or water samples are still accessible), (iii) analyse the geological setting (stratigraphy, reservoir properties, regional heat flow, local tectonics) in areas with high lithium concentrations to enhance the understanding of the process of lithium enrichment, and (iv) establish a sampling and well testing protocol to guide the permitting authorities at Canton level and the operators

of the future, federally-subsidised geothermal projects, to obtain comprehensive hydrochemical analyses of the deep fluids.

Achievements in 2023

- Final report published

  Our report was officially released on 15.03.2023 and published on the FGS website and on the ARAMIS information system of the Swiss Federation.

- Contributions to, and review of newly established "Guideline for the assessment of hydrochemical composition and metal content of (geothermal) deep fluids".

  As follow-up product of the above literature and data review, the Swiss Geological Survey and the Swiss Federal Office of Energy are setting up a new guideline to sample and analyse geothermal fluids regarding their metal content. We supported the establishment of that guideline.

- Presentations at meetings and workshops

  We presented posters at the Swiss Geoscience Meeting in Mendrisio and at the Geothermie-Workshop at University Bern.

Project leader: Stefan Heuberger

Project members: Joël Morgenthaler

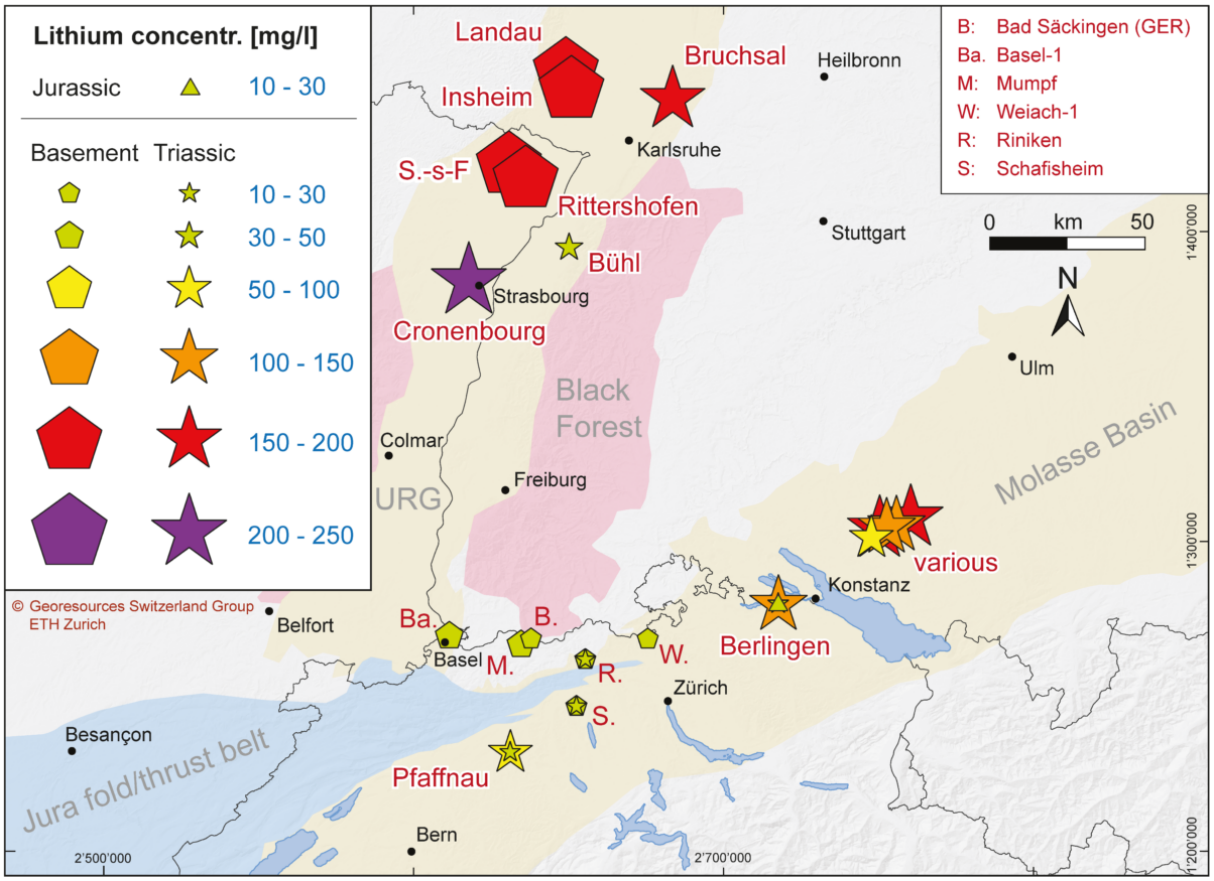

Fig. 3. Lithium concentrations in Swiss wells compared to the ones in the Upper Rhine Graben (URG) and the southwesternmost German Molasse Basin, with well symbols according to the geothermal aquifer formation. Only lithium concentrations >10 mg/l are shown.

2.1.3 Site evaluation for the long-term storage of hydrochar

Our group was commissioned by a leading Swiss retail company to conduct a feasibility study to investigate potential hydrochar storage sites in Switzerland. In our study we show that the most feasible way to store hydrochar in large quantities (1 mio. m^3) in Switzerland would be a surface landfill. Existing underground structures (e.g. abandoned mines) are not suitable for storing hydrochar because they do not meet the volumetric, technical and geological requirements for safe storage.

We commissioned laboratory analyses that revealed previously unknown material properties of the hydrochar produced by our commissioner. The results show that total organic carbon in the solid fraction and ammonium and dissolved organic carbon in the leachate are significantly above the permitted limit values for waste deposition in a landfill defined by the Swiss waste ordinance. However, the other chemical parameters measured (elements and heavy metals) do not exceed the thresholds. In addition, our study reveals that the legal situation for hydrochar storage in Switzerland is unclear and needs further discussion and regulations by cantonal and federal authorities.

We propose that the material properties of hydrochar to be fine-tuned (i.e. optimised) further to ensure safe storage. Furthermore, we recommend to carry out a pilot study for testing the hydrochar storage in a landfill under real conditions.

Achievements in 2023

- Initiation and completion of feasibility study

  We planned, initiated, conducted and completed this feasibility study with a tight schedule.

- Submission of final report to the client

  We handed in our project report as planned after 6 months. Besides describing our findings we came up we a condensed list of recommendations and for planning a more in-depth follow-up study.

Project leader: Niklaus Kressig
Project member: Stefan Heuberger

2.1.4 Calcined clays for sustainable concrete

The cement industry is working intensively on measures to reduce its process-related CO_2 emissions. In Switzerland, cement production was responsible for 5.3% (4.2 million t CO_2-eq) of the total Swiss CO_2 emissions in 2019. Currently, cement production generates between 500 and 700 kg of CO_2 per tonne of cement produced (around 1/3 from the fuels used to fire the cement kiln and 2/3 from the chemical reaction (calcination) used to create the clinker).

Many companies have set themselves the goal of reducing CO_2 emissions through a number of direct and indirect measures. These include the production of low-clinker cements or the replacement of part of the clinker with reactive/calcined clays. With the LC_3 process (LC_3 = Limestone Calcined Clay Cement) developed by EPFL with the support of the Swiss Confederation, for example, a cement mixture is to be produced that consists of only 50% clinker (today: 65 to 80%). The remaining part consists of about 30% calcined clay, 15% limestone and 5% gypsum. The calcination of clay requires a lower temperature than that of limestone (800°C instead of 1450°C) and does not produce geogenic CO_2 emissions.

An up-to-date overview map showing all the clay-rich geological formations is missing today in Switzerland. Therefore, we are aiming at producing a pilot version of such a clay indication map. For that, we review different types of published geological maps at various scales (GeoCover, Geotechnical Map, Lithological Petrographical Map). Our final map product will be based entirely on the mapped units published in the GeoCover 1:25'000 maps. Through a systematic analysis and interpretation of these maps, combined with an in-depth literature review, we are producing an indication map for clay occurrences Switzerland, in perimeters of 50 km around the 6 cement production factories. Furthermore, we aim at

classifying the occurrences into three classes specifying the estimated approximate amount of clay in the mapped geological unit.

Achievements in 2023

- Assessment of clay-rich formations in the GeoCover dataset

  We completed a preliminary assessment of the GeoCover dataset across Switzerland to identify the all the clay-bearing/rich geological formations and members. This included a literature review in the area the Jura fold-and-thrust belt and the northwestern part of the Swiss Molasse Basin.

- Testing several filters for bedrock and unconsolidated GeoCover units in a pilot area

  In a pilot study area covering six map sheets in the northwestern Switzerland we tested several filters in QGIS for extracting clay-rich units (formations, members) from the GeoCover dataset. We have learned that a simple filtering approach is not feasible. We needed to shift to select members and formations first, based on geological/lithological evidence. And then select those units in the GIS GeoCover dataset.

Project leader: Veronique Sieber
Project member: Stefan Heuberger

2.2 Service projects

2.2.1 Cartographic earthquake risk visualisation

We are collaborating with the Swiss Seismological Service (SED) at ETH Zurich and support the production of different sorts of earthquake occurrences and risk maps.

As a first project, led by Michèle Marti (SED), we have helped developing a fact-based colour representation of the new Swiss earthquake risk model as a map. The SED's new national earthquake risk model combines detailed data on earthquake hazard, the local geological subsurface, the vulnerability of buildings, and the people and values potentially affected by an earthquake. The new model makes it possible for the first time to quantify the impacts of earthquakes in Switzerland.

Achievements in 2023

- Earthquake risk map

  We have finalised the visualisation variant of the Swiss earthquake risk map that was chosen as the preferred version by the Swiss public in a representative online survey. We co-authored the corresponding technical report as well as a talk at SGM and a peer-review paper (see below).

- Co-authored the peer-review paper (Dallo et al. 2024)

- Co-authored an oral presentation of the Swiss Geoscience Meeting in Mendrisio (Dallo et al. 2023)

Project leader: Donat Fulda

2.2.2 Geological Atlas Map Sheets "Val Bregaglia" and "Campodolcino"

The Val Bregaglia mapping project, mandated by the Swiss Geological Survey (swisstopo), was extended for another two years (2022-2023). We are producing the new geological map sheet "Val Bregaglia" (Geologischer Atlas der Schweiz 1:25'000, sheet 1276) and now also the easternmost third of the

neighbouring sheet "Campodolcino", including the corresponding explanatory notes. The field area is located in the Central Alps in southeastern Switzerland (Bergell-Avers area).

The main tasks of this project are the compilation and digitisation of the 200 km^2 "Val Bergaglia" map sheet, 60 km^2 of the "Campodolcino" 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 20th 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 inaccurate, (2) where inconsistencies between map templates occur or (3) to quality check the existing map templates.

The explanatory notes will (1) describe the more than 150 bedrock units and the Quaternary deposits, (2) contain a series of cross-sections, (3) describe the use and occurrence of mineral resources and (4) discuss the tectonometamorphic evolution of the area.

Fig. 4. The FGS and swisstopo mapping team at the boundary between the Permo-Triassic pebbly quartz conglomerate (on the right) and the underneath pre-Permian Valle di Lei Formation in the southern Val Madris west of Wissberg (2'760'174, 1'140'287). View towards NW (4.7.2023).

Achievements in 2023

- Digitisation of the "Val Bregaglia/Campodolcino" map sheet completed

  We completed the digitisation of the Campodolcino part of the map sheet based on the fieldwork in summer 2023. This includes editing of remaining gaps in the lithological map elements and the editing of structural features (faults, nappes boundaries) and bedding/foliation measurements.

- Field work mainly on the Campodolcino map sheet area

  We mapped the Permo-Triassic sedimentary cover of the Tambo nappe in the Swiss and the Italian part of the Campodolcino map sheet. So far, this is the first map of these cover sequences at a scale

of 1:25'000. The Tambo basement, which is cropping out on the steep, densely wooded southern slopes of Val Bregaglia and consists mainly of orthogneisses, was only mapped cursorily. The mapping of the Paleozoic and Permian units of the Suretta nappe in the Val Madris area was refined based on the results of the U-Pb dating of garnets and detrital zircons from Maira Coray's MSc thesis.

- Explanatory notes

  We compiled the chapters on hydrogeology and mineral resources and defined the traces of eight geological cross sections across the map sheet.

- MSc thesis of Maira Coray

  In her MSc thesis, Maira Coray successfully distinguished two metasedimentary formations between the older basement of the Suretta nappe and the Permo-Mesozoic cover units by geological mapping, petrographic analyses and U-Pb detrital zircon and garnet geochronology. She presented her findings with a poster at the 2023 Swiss Geoscience Meeting in Mendrisio.

Project leader: Donat Fulda

Project members: Peter Nievergelt, Maira Coray, Irina Mayer, Niklaus Kressig

2.2.3 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 support of the Swiss Natural Stone Association (NVS). We are responsible for editing new contributions and reviewing existing ones. The former Swiss Geotechnical Commission (SGTK) and today our group compiled fact sheets for all 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 2023

- New fact sheets on quarried natural stones

  We reviewed the fact sheets of 17 natural stones like for example the historical "Pierre Jaune de Neuchâtel", a limestone widely used from roman times to the early 20th century or the Permian Baveno granite with its characteristic rose-coloured feldspar still quarried today in northern Italy.

Project leader: Donat Fulda

Project member: Niklaus Kressig

2.2.4 Resources Information System (RIS)

We are running 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 a platform that aggregates comprehensive information on mineral resources at a national

scale. In addition, the RIS is mutually linked with the web portal of the Federal Office of Topography swisstopo map.geo.admin.ch.

Achievements in 2023

- Providing feedback to user requests

  We provided individual feedback on requests mainly from research institutions, journalists or students related to data published on the RIS. The enquiries covered predominantly topics on raw materials quarried in Switzerland today.

- Keeping RIS up to date

  We have made a few content-related and technical updates in the RIS database.

- Roadmap RIS 2024 onwards

  In collaboration with the Swiss Geological Survey (swisstopo), we developed a roadmap with measures to put RIS back into productive service in 2024. As a first product, currently active sand and gravel pits will be included.

Project leader: Donat Fulda

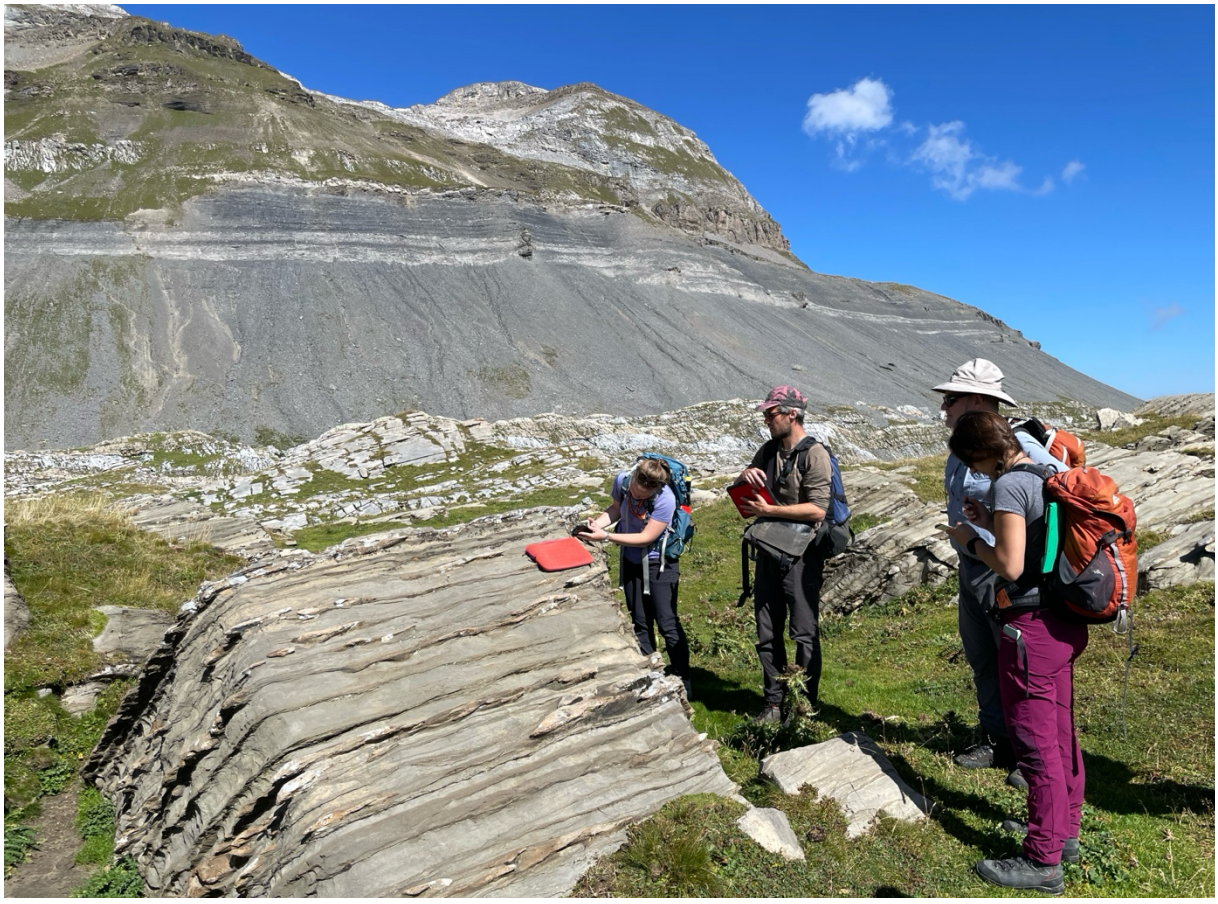

Fig. 5. Measuring bedding in the Helvetischer Kieselkalk Formation on Lämmerenplatten (VS). Feldkurs II on Gemmi-Pass (10.09.2023).

3 Funding

3.1 Framework agreements

Project	Sponsor	Runtime	Budget
Teaching contribution to D-ERDW	D-ERDW	ongoing	58 kCHF/y
Long-term swisstopo framework agreement	swisstopo	ongoing	200 kCHF/y
Long-term SED (Swiss Seismological Service) framework agreement	SED	ongoing	18 kCHF/y
Total			**276 kCHF/y**

3.2 Applied research projects

Project	Sponsor	Runtime	Budget
Assessment of mineral resources of Switzerland	swisstopo & SFOE	2018-2031	1'858 kCHF
Semi-automated mapping of hard rock lithologies of Switzerland	swisstopo	2023	95 kCHF
Mapping of Geologischer Atlas map sheet "Campodolcino"	swisstopo	2022-2024	124 kCHF
Compilation of Swiss borehole data regarding lithium content	swisstopo & SFOE	2022-2023	52 kCHF
Evaluation of HTC coal storage sites in Switzerland	industry sponsor	2023	98 kCHF
Characterisation of the clay occurrences of Switzerland	swisstopo	2023-2024	60 kCHF
Total			**2'287 kCHF**

3.3 Service projects

Project	Sponsor	Runtime	Budget
Characterisation of natural building stones	ETH MatHub & NVS	2018-2024	36 kCHF
Total			**36 kCHF**

4 Personnel

Employee	Function	max. contract / funding until	Pensum
Dr. Stefan Heuberger	Senior Scientist, Group Head	permanent	90%
Donat Fulda	Technical Specialist II	permanent	80%
Dr. Lukas Nibourel	Scientific Collaborator I	02/2029 / 12/2031	80%
Anja Amrein	Scientific Assistant I	12/2023	80%
Niklaus Kressig	Scientific Assistant I	03/2025	90%
Veronique Sieber	Scientific Assistant I	09/2024	80%
		Total FTE	**5.0**

Maira Coray	Hilfsassistentin	until 07/2023	20%
Maira Coray	Praktikantin	11/2023-01/2024	60%
Irina Mayer	Hilfsassistentin	Since 09/2023	20%
		additional FTE	**0.2-0.6**

Guest	Function
Peter Nievergelt	third-party collaborator

Fig. 6. Lukas Nibourel sketching on the one-day excursion «Erdwissenschaftliche Exkursionen I – Gotthard» near Steinen (SZ) above Lauerzersee on 9.6.2023. View to the depositional area of the Goldau landslide.

5 Teaching and public outreach

5.1 Teaching at D-ERDW and other 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)

Lukas Nibourel

Course title	Level	ECTS	Comments
Erdwissenschaftliches Kartenpraktikum I	BSc	2	lead: J. Ruh
Feldkurs II Sedimente, Gemmipass	BSc	3	lead: V. Picotti
Rock and Soil Mechanical Lab Practical	MSc	3	lead: L. de Palézieux & C. Madonna
Erdwissenschaftliche Exkursionen I - Gotthard	BSc	1	main responsibility
Erdwissenschaftliche Exkursionen I - Glarnerland	BSc	1	lead: S. Heuberger

Donat Fulda

Course title	Level	ECTS	Comments
Swiss International Summer School for Alpine Archaeology	MSc	3	run by Uni Bern & Uni Zürich

Maira Coray

Course title	Level	Comments
Geological city excursion in Zürich	public	In collaboration with focusTerra

5.2 MSc projects

Project	Runtime
Reconstruction of the lithostratigraphy of the Paleozoic units of the Suretta Nappe by U-Pb dating of detrital zircons. MSc candidate: Maira Coray. Supervision: **Stefan Heuberger**, Andrea Galli, **Donat Fulda, Peter Nievergelt**	HS 2022 - FS 2023

5.3 Co-initiation of new session at Swiss Geoscience Meeting

Co-initiation of new SGM session "Thinking the future of geoscience education in Switzerland to meet the challenges of sustainable development and exploration for resources and energy" together with S. Castelltort (Prof., University of Geneva) and N. Andenmatten-B. (Head Swiss Geological Survey).

5.4 Public talks

Heuberger, S. (2023). Kies – wichtigster geologischer Rohstoff der Schweiz. Sonderausstellung "Kleiner Kiesel ganz gross". Naturmuseum St.Gallen, 6.9.2023.

Fig. 7. One-day excursion «Erdwissenschaftliche Exkursionen I – Glarnerland» in the Landesplattenberg slate quarry in Engi (Glarus area) on 12.5.2023.

6 Publications

Papers

Nibourel, L., Morgenthaler, J., Grazioli, S., Schumacher, I., Schläfli, S., Galfetti, T. & **Heuberger, S.** (2023). Automated extraction of orientation and stratigraphic thickness from geological maps. *Journal of Structural Geology* 172, 104865.

Dallo, I., Schnegg, L. N., Marti, M., **Fulda, D.**, Papadopoulos, A. N., Bergamo, P., Wenk, S. R., Valenzuela, N., Roth, P., Danciu, L., Haslinger, F., Fäh, D., Kästli, P. & Wiemer, S. (*subm.*). Designing understandable, actionable, and well-perceived earthquake risk maps – the Swiss case study. Submitted to *Frontiers in Communication*.

Reports

Heuberger, S. & **Morgenthaler, J**. (2023). Lithium in geothermal brines – status report on the current situation in Switzerland and in neighbouring countries. Technical report, Georesources Switzerland Group, ETH Zurich, 43 p.

Kressig, N. & **Heuberger, S.** (2023). Site evaluation for the long-term storage of hydrochar in Switzerland - A feasibility study. Technical report, Georesources Switzerland Group, ETH Zurich, 82 p.

Nibourel, L. (2023). Catalog of the relevant hard-rock units in Switzerland. Explanatory notes accompanying the geospatial dataset "Hartstein". Technical report, swisstopo & Fachgruppe Georessourcen Schweiz.

Stopelli, E. (*in prep.*). Guideline for the assessment of hydrochemical composition and metal content of (geothermal) deep fluids. Swiss Geological Survey (swisstopo) and Swiss Federal Office of Energy (SFOE). With contributions of T. Galfetti, N. Lupi and **S. Heuberger**.

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7 Committee memberships

Organisation	FGS member	Function	Period
Paul Niggli Foundation	S. Heuberger	board member	2022-today
KBGeol (Federal Coordination Body for Geology)	S. Heuberger	member without voting rights	2021-today
NVS (Natural Building Stones Association Switzerland)	D. Fulda	member of the quarry commission	2018-today
SGPK (Swiss Geophysical Commission)	S. Heuberger	visiting guest	2017-today

Fig. 8. Mapping course (Feldkurs II Sedimente) on the Gemmi pass. Vincenzo Picotti explaining the local stratigraphy on the Lämmerenplatten (VS). View towards NE (10.9.2023).

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