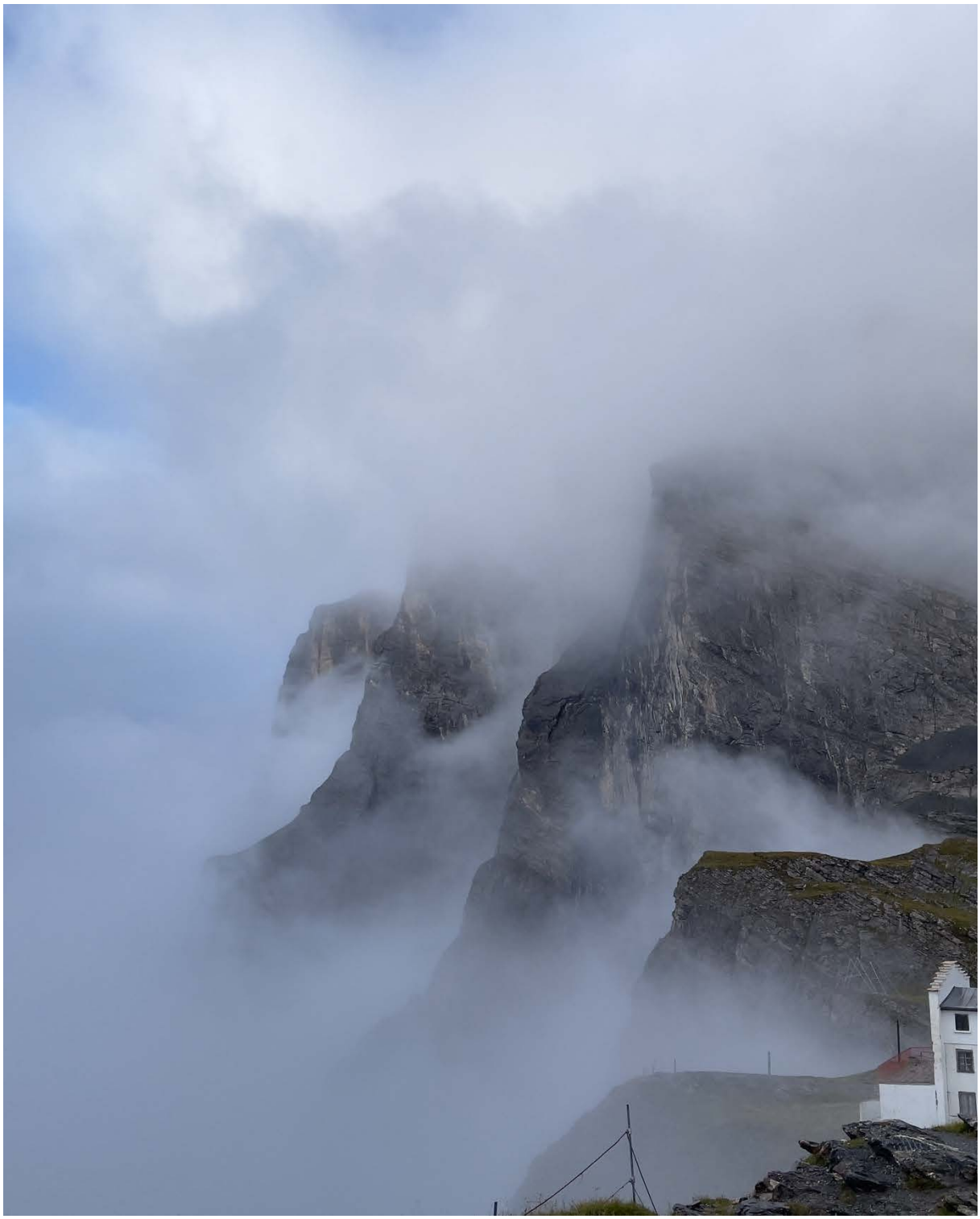
ETH zürich

Annual Report 2024

Georesources Switzerland Group
Fachgruppe Georessourcen Schweiz (FGS)

February 2025

Department of Earth and Planetary Sciences



Acknowledgements

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

Picture: View from Gemmipass towards southwest to the Daubenhorn, during BSc field course II (picture taken by Stefan Heuberger on 10.09.2024).

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 and Planetary Sciences and currently has six employees. The group is >90% third-party funded (excl. SNF) and currently raises an average annual budget of ca. 750 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 (1) mineral resources (i.e. hard rock aggregates, gravel, sand, clay, limestone, salt, critical raw materials (CRMs), 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 (map.georessourcen.ethz.ch) 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

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

2 Projects

2.1 Research projects

2.1.1 New Heat Flow Map of Switzerland

Terrestrial heat flow is an important indicator for estimating the potential of geothermal energy production and is of relevance for various subsurface storage applications. However, heat flow datasets are often characterised by low data density and quality. This is the case for temperature data from deep wells or for thermal conductivity data in general. Furthermore, heat flow is influenced by an interplay of many factors that are challenging to control, such as topography, climate, conductive fluid flow and recent geodynamic processes.

In Switzerland, the most up-to-date nation-wide heat flow map is already 30 years old (Medici & Rybach 1995). We therefore launched a project together with the Swiss Geological Survey (swisstopo), during which we are updating this map by applying state-of-the-art methods for data selection, harmonisation and processing, as well as for map interpolation. Instead of relying solely on data-based interpolation algorithms, we consider additional factors like tectonic structures, geodynamic processes (e.g., recent exhumation), and known hydrothermal systems. We aim at a consistent, more detailed new version of the Heat Flow Map of Switzerland that accounts for the newly processed heat flow data and the tectonic and hydrogeological setting.

To allow for reproducibility and future updates, we are documenting the data selection, filtering, processing and an uncertainty parametrisation in form of an explanatory report. A first version of the new heat flow map is planned to be ready by end of March 2025.

After completion of the first version, we will test different approaches to improve resulting heat flow models in the upcoming project phases: (1) compiling thermal conductivity datasets that represent conditions for vertical heat conduction through layered sedimentary sequences best, (2) improving and applying different correction algorithms for influencing factors such as topography and climate, (3) using 3D heat flow modelling including tectonic data, and (4) applying probabilistic modelling to account for a 3D heat flow domain and for data uncertainties. With this new integrated structural, thermal conductivity and heat flow model for Switzerland, we will be able to reduce uncertainties and quantify them in 3D. This will allow for deriving new insights on potentially economic heat resources and the results can directly be used to estimate reservoir potentials.

Achievements in 2024

- New Heat Flow Map of Switzerland, version 1

  We compiled all available temperature and thermal conductivity data of wells in Switzerland deeper than 500 m. Using this dataset, we calculated 117 heat flow values, applying state-of-the-art methods. We prioritised deep wells and high quality data, and assured a sufficient coverage of all regions. Including information from structural geology, fluid flow and geodynamics, we interpolated a first version of a new Heat Flow Map of Switzerland.

- Outline for explanatory report and project documentation

  The new Heat Flow Map will be accompanied by an explanatory report that thoroughly describes the compiled dataset (Fig. 1), all applied methods, produced results and the Heat Flow Map itself. The outline of this report has been drafted in 2024.

- Talk at the Swiss Geoscience Meeting in Basel

  We presented a draft version of the new Heat Flow Map at the 2024 Swiss Geoscience Meeting on 9th November in Basel. Alongside with the map, we showed insights to the methods used, data quality and the results for geothermal gradients and thermal conductivity data. The presentation was aimed to raise attention to the ongoing work, address necessities of future additions and improvements, as

well as to advertise for support for upcoming project phases. These goals were fully achieved, with fruitful discussions starting already at the meeting.

- Abstract submission for European Geothermal Congress 2025 in Zurich

  We submitted an abstract for the European Geothermal Congress which will take place in Zurich in October 2025. We aim to present the new Heat Flow Map of Switzerland and our follow-up projects.

- Development of follow-up studies, partly in collaboration with Swiss Cantons

  We developed and promoted (to some Cantons) potentials for follow-up studies refining and extending the Heat Flow Map and datasets produced so far.

Project leader: Kevin Frings

Project members: Irina Mayer, Veronique Sieber, Lukas Nibourel, Stefan Heuberger

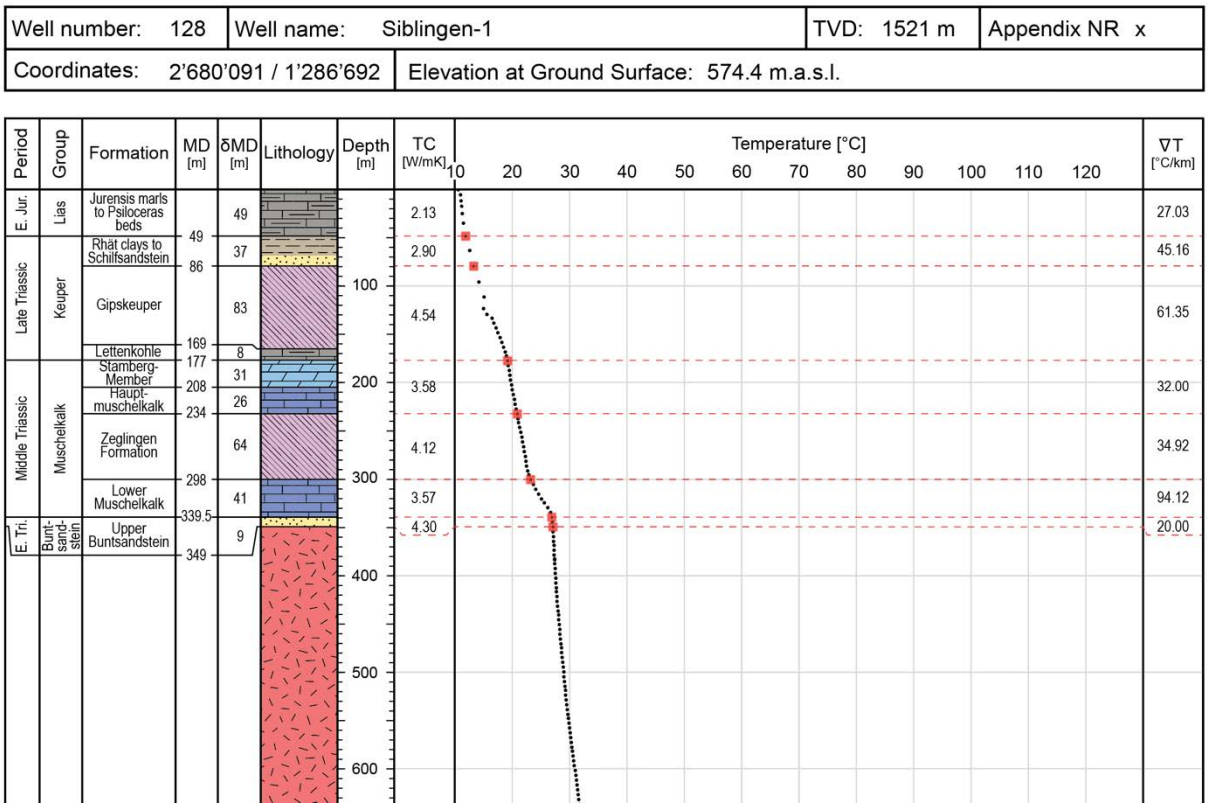


Fig. 1. Extract from the report appendix illustrating the newly established temperature profile data sheets.

2.1.2 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. The geospatial dataset and the associated documents support the relevant authorities, as well as the industrial sector, in the spatial planning process by enabling these users to locate, and possibly safeguard, the most promising hard rock occurrences.

In collaboration with the Swiss Geological Survey (swisstopo), we have finalised a country-wide geospatial dataset Hard rock aggregates: Thickness and quality of geological occurrences, which was published in July 2024, including an extensive documentation (Fig. 2). This dataset (raster cell size: 50 x 50 m) shows an estimation of the spatial distribution, the usable thickness and the quality of the hard rock-bearing geological units situated at a ground elevation lower than 1300 m a.s.l. and with a thickness exceeding 30 m. The dataset has been produced based on geological profiles, stratigraphic descriptions and through an automated workflow applied to the GeoCover dataset. Explanatory notes regarding the geological units considered and their characteristics can be found in the Hard rock catalog (Fig. 3a, Fig. 4). The method developed to automatically extract thickness data from geological maps is described in Nibourel et al. (2023, see Fig. 3b), the general workflow and modelling method used to create the dataset is documented in the Technical documentation (Fig. 3c, Fig. 5).

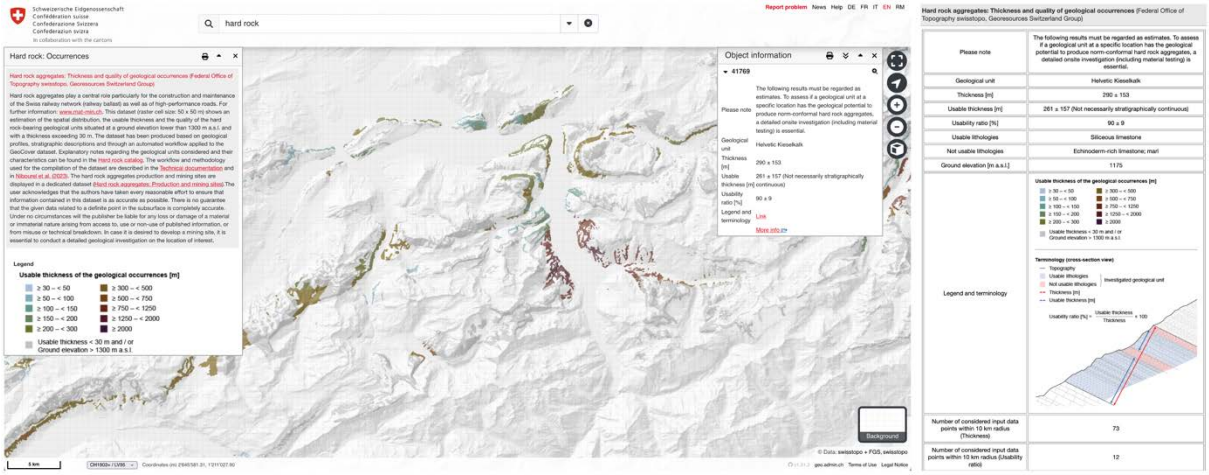


Fig. 2. Geospatial dataset "Hard rock: Occurrences", published on map.geo.admin.

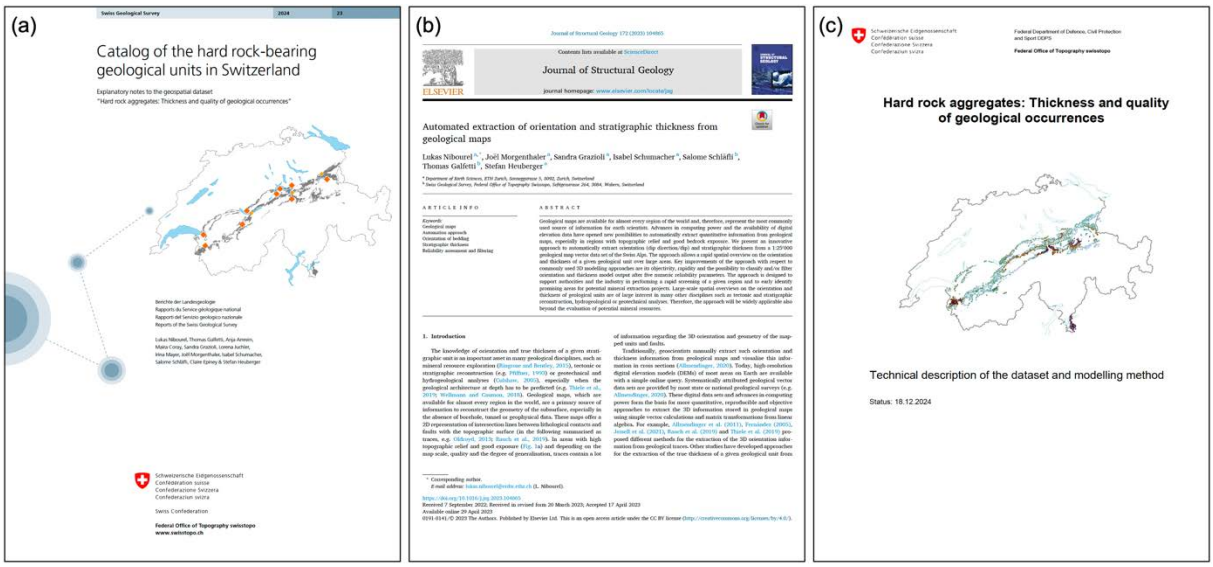


Fig. 3. Documents related to the geospatial dataset "Hard rock: Occurrences". (a) Hard rock catalog, serving as explanatory notes for the geospatial dataset. (b) Peer-reviewed paper describing the automated extraction of thickness data from geological maps, which was applied to highlight occurrences with favorable geometry. (c) Technical documentation describing the dataset and modeling method.

Achievements in 2024

- Publication geospatial dataset "Hard rock aggregates" on map.geo.admin.ch

  The complex geospatial dataset, including all associated text and figure files, were translated into German, French, Italian and English. The dataset was published in July 2024 (Fig. 2).

- Publication of the Catalog of the hard rock-bearing geological units in Switzerland

  This swisstopo report includes further information regarding the petrophysical properties and the thickness of the 13 investigated geological units (Fig. 3a). It summarises the data from more than 230 investigated publications, ca. 1400 petrophysical field and lab analyses as well as around 10'000 automatically extracted thickness values. As an example, Figure 4 shows the thickness variation of the North-Helvetic Flysch Group across the northern Swiss Alps.

- Publication of the Technical documentation describing the modelling method

  The technical report documents the input data, modelling method, workflow and uncertainties/limitations associated with the geospatial dataset "Hard rock: Occurrences". It is partly based on a peer-reviewed paper by Nibourel et al. (2023) and on the MSc thesis by Juchler (2022). Figure 5 highlights the difference (in %) between the automatically extracted and the literature-derived thickness estimates within a radius of 500 m, giving an impression of the uncertainties in the data set.

- Three oral presentations at various meetings

  We gave talks at the German Geological Society (DGGV) Annual Meeting 2024 (GeoSaxonia) in Dresden, at the SBB-Tagung at the Balmholz quarry and in a lunch seminar at the Swiss Geological Survey at swisstopo in Wabern.

Project leader: Lukas Nibourel

Project members: Irina Mayer, Stefan Heuberger

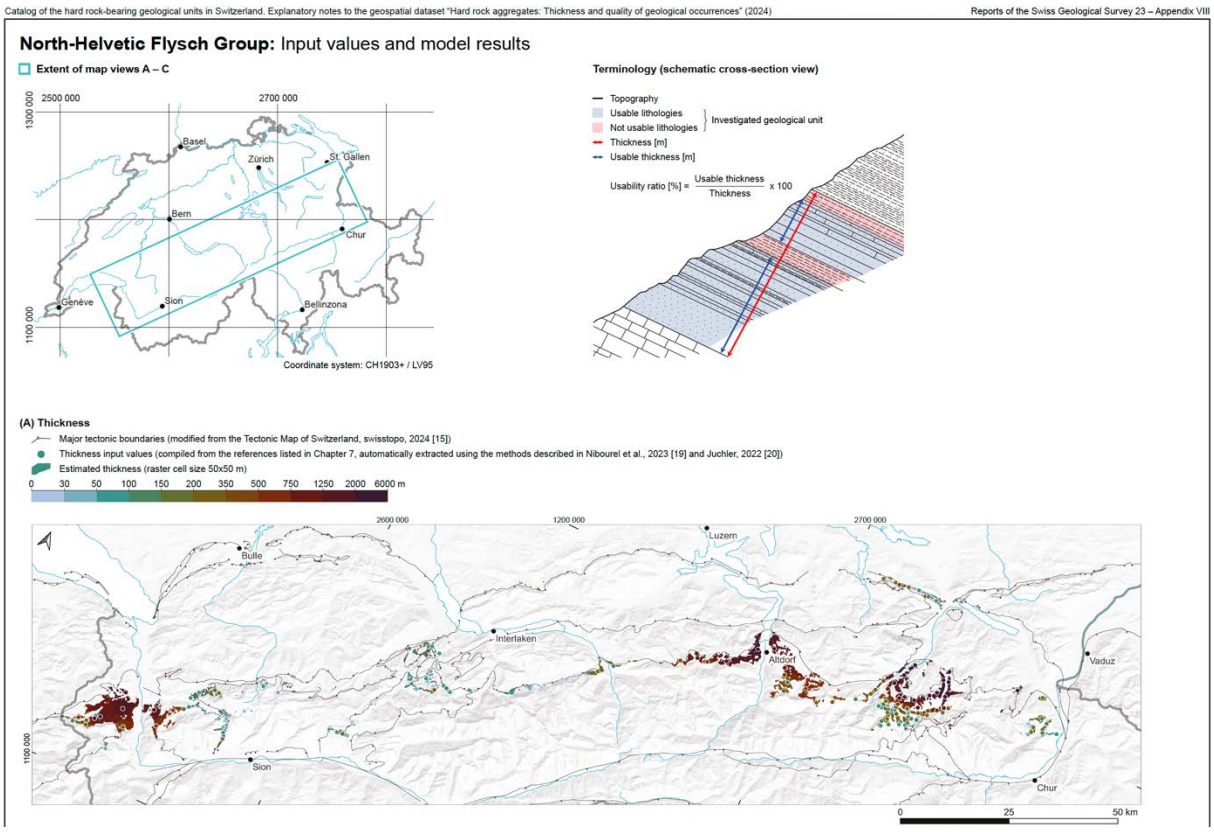


Fig. 4. Extract from the Hard rock catalog appendix showing the thickness variation of the North-Helvetic Flysch Group in map view.

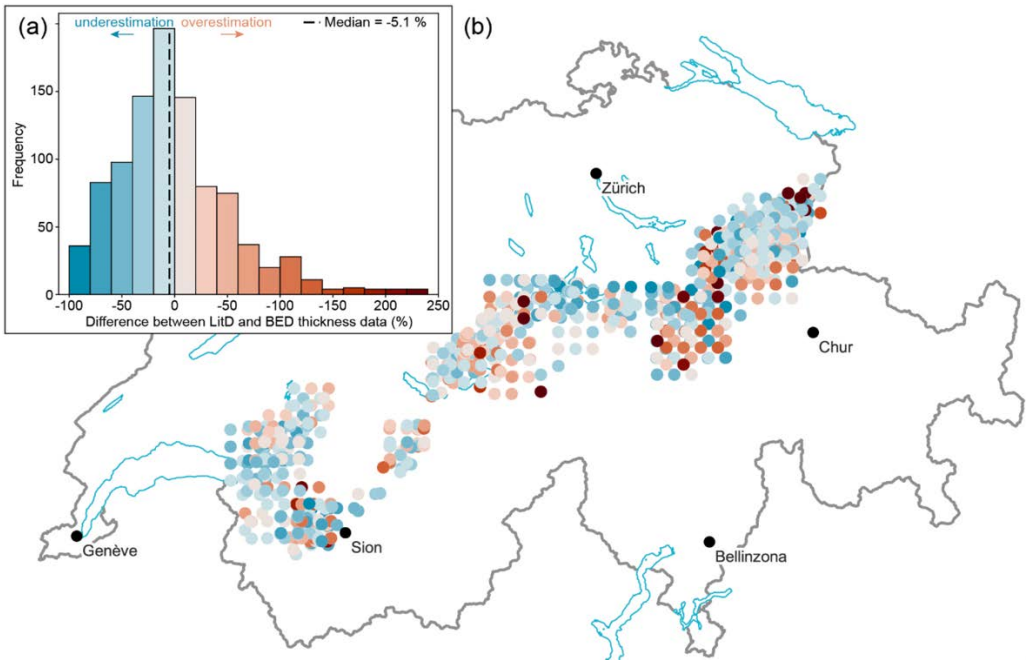


Fig. 5. (a) Map and (b) histogram plot showing the normalised difference between the automatically extracted and the literature-based thickness data within a radius of 500 m (see the Technical documentation, Nibourel et al. 2024, for further information).

2.1.3 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.

Cement is produced in Switzerland in six cement plants. At all these sites, locally occurring limestones, marls and sometimes clays are processed to produce cement. To estimate the national potential of substituting clinker by calcined clays, it is key to understand, if and where suitable clays are available in the vicinity of the cement plants

Our study aims at producing an overview of the clay-rich geological units in Switzerland within a 50 km radius around the cement production sites and below a ground elevation of 1300 m a.s.l. Based on the publicly available GeoCover dataset and on an extensive review of the stratigraphy and available literature, the area of interest is investigated at a scale of 1:25'000 to locate clay-bearing units and systematically estimate their clay content. As the geological map data do not quantitatively specify the clay content, we have developed a quantification scheme to approximate the clay content from the lithological descriptions of the geological units. Only the bedrock units were assessed. In the absence of sufficiently dense and systematically attributed borehole and GeoCover data and given the high degree of

geological complexity, the unconsolidated deposits were not yet evaluated. In summer 2024, we finalised a first version of the "Indication map of clay-rich geological units in Switzerland".

In autumn 2024, we started the project phase two that focusses on a Switzerland-wide field assessment, in order to sample and analyse key clay-rich units regarding their clay mineralogy. Main analyses will be XRD to obtain the whole rock mineralogical composition, measuring the total organic/inorganic carbon (TOC/TIC) and XRF to get the elemental whole rock composition. For selected samples, we might consider doing XRD analyses on the 2 μm fraction, measure the cation exchange capacity (CEC), and carry out thermogravimetric analyses (TGA).

Fig. 6. Lukas Nibourel and BSc student Nicholas Heini taking samples from Late Triassic "Bunte Mergel" series in the former Seebi quarry near Beggingen SH (picture taken by Stefan Heuberger on 15.03.2024).

Achievements in 2024

- Assessment of clay-rich formations in the GeoCover dataset

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

- Clay-indication map and explanatory report

  We produced a first version of the indication map of clay-rich geological units in Switzerland together with an explanatory report ("Indication map of clay-rich geological units in Switzerland - Basis for the exploration of raw materials for calcined clay cements and of clays in general - Work Package 1: Status report on the preliminary assessment".

- Field investigations in key clay and marl pits

  Based on a pilot sampling campaign in spring in the framework of a BSc thesis (see chapt. 3.3), and on a desktop study using the GeoCover dataset, topography maps and digital elevation models to identify good outcrops, we started the project's phase two with a clay rocks sampling campaign in fall 2024. We collected 27 samples from 12 key, clay-rich geological units (categories 1 and 2), i.e.

from the Klettgau, Staffelegg, Opalinusclay, Passwang, Klingnau, Bärschwil and Wildegg formations, as well as from Siderolithikum and Molasse (UMM, USM) units.

- Inititation of clay mineralogical analyses in the Clay Lab

  We initiated the clay mineralogical analyses in collaboration with M. Plötze in his Clay Lab at D-BAUG.

Project leader: Veronique Sieber, Niklaus Kressig

Project members: Lukas Nibourel, Nicholas Heini (BSc student), Stefan Heuberger

2.1.4 CO_2-Plume Geothermal potential evaluation for Switzerland

CO2-Plume Geothermal (CPG) uses CO2 as a geothermal working fluid to extract geothermal energy from naturally permeable reservoirs at ~2–5 km depth. Using CO2 typically doubles to triples the geothermal energy extraction rate, while ultimately all CO2 is permanently stored in the subsurface. CPG is therefore regarded as a CCUS technology: CO2 is both utilised as well as stored.

A project consortium led by the research group of Prof. Martin Saar at ETH Zurich is mandated by the Swiss Federal Institute of Energy (SFOE) to carry out a study to evaluate the CPG potential in Switzerland. Our group is part of the project consortium and we are contributing by (1) compiling and reassessing the (deep) subsurface data in Switzerland (mainly seismic and well data), and in (2) evaluating the deep CCS potential (CO2 storage capacity volume) of Switzerland.

Achievements in 2024

- Compilation of permeability data from deep wells

  We compiled permeability data from deep wells in Switzerland. Focus was on primary target reservoir formations in the lower Mesozoic (Trigonodus dolomite, Bundsandstein)

- Set up Common Risk Mapping (CRM) approach

  Together with the project team, we established a GIS-based approach to derive common risk segments for selected reservoir units in the Swiss Molasse Basin. We basically used the published GeoMol horizon and structural data. The outcome is a table containing all the physial properties of the reservoir areas that serves as input for the TANGO model established by the team of Prof. M. Saar. The TANGO tool then allows for a techno-economic assessment of the feasibility of CPG in the deeper Swiss Molasse Basin. First results are planned for summer 2025.

Project leader: 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.

Starting in 2022, as a first contribution to a 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.

In 2024, we focused on improving the presentation of the SED earthquake maps published online.

Achievements in 2024

- Online earthquake maps

  As part of the relaunch of the SED website, we developed improved representations of the online earthquake maps both on the website and the interactive map portal. The aim was to enhance the clarity and accessibility of the information displayed on the maps and their legends for users, reflecting the latest advancements in risk communication while also exploring alternative visualisations of seismicity data. After an internal evaluation of the proposals by the SED, the preferred map was finalised and published in autumn 2024.

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

Project leader: Donat Fulda

2.2.2 Geological Atlas Map Sheets «Val Bregaglia» & «Campodolcino»

The Val Bregaglia-Campodolcino mapping project, mandated by the Swiss Geological Survey (swisstopo), was completed in summer 2024. We have produced the new geological map sheet "Val Bregaglia" (Geologischer Atlas der Schweiz 1:25'000, sheet 1276) and also the easternmost third of the neighbouring map sheet (1275) "Campodolcino". The field area (see examples in Fig. 7 and Fig. 8) is located in the Central Alps in southeastern Switzerland (Bergell-Avers area).

Fig. 7. Piz Lunghin south-soutwest face, seen from Piz dal Sasc (2'770'703, 1'142'093). The Piz Lunghin summit is composed of dark green serpentinite of the Upper Penninic Platta nappe that was thrusted over the greyish-brown gneisses of the Salassic Margna Nappe. Note the folded slice of Margna gneiss and Mesozoic sediments within the serpentinites in the summit area (picture taken by Donat Fulda on 30.07.2024).

The main tasks of this project were the compilation and digitisation of the 200 km2 "Val Bergaglia" and 60 km2 of the "Campodolcino" map sheets (excerpt in Fig. 9) as well as compiling 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 used some published, regional map sheets from the first half of the 20th century. The compilation and digitisation work was done in the ToolMap software, the output was processed with QGIS. Field mapping was 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.

Note that the map and the explanatory are not published yet but are now being reviewed by the Swiss Geological Survey team.

Fig. 8. Mylonitised and folded light grey augen gneiss in contact with overlying greenish-grey amphibolite (2'777'227, 1'138'471) within the Fora Subnappe (Margna Nappe), southeast of Piz da la Margna. The lithologies were slightly displaced by a late-stage brittle fault. View direction towards east-northeast (picture taken by Donat Fulda on 24.8.2024).

Achievements in 2024

- Completion of the digitisation

  In summer 2024, we completed the digitisation of both map sheets. The finalised version of the map was officially handed over to the Swiss Geological Survey (swisstopo) at the end of 2024.

- Explanatory notes, including cross-section and tectonic overview map

  A main effort was needed to write and finalise the exhaustive chapter on the stratigraphy. There are more than 150 units of bedrock and Quaternary deposits. We described in detail the occurrence and lateral extent of the lithologies, their contact with the footwall and the hanging wall, and provided a

lithological characterisation (both macro- and, where available, microscopic), along with examples of representative outcrops.

We constructed five SW-NE and three SE-NW oriented geological cross-sections, primarily perpendicular but also parallel to the strike of the main units. They are based on the geological map, existing cross sections from research studies and power plant projects conducted in the 1950s in the Bergell region, as well as own structural measurements taken in the mapping area. The geological units were projected from the surface down to a maximum depth of 1.5 to 2 km.

Using our newly compiled geological map, along with tectonic maps from previous studies, we created a tectonic map for the mapping area and its surroundings at a scale of 1:100,000. This map combines existing with newly collected data to provide an up-to-date representation of the area's tectonic setting, such as tectonic boundaries and faults.

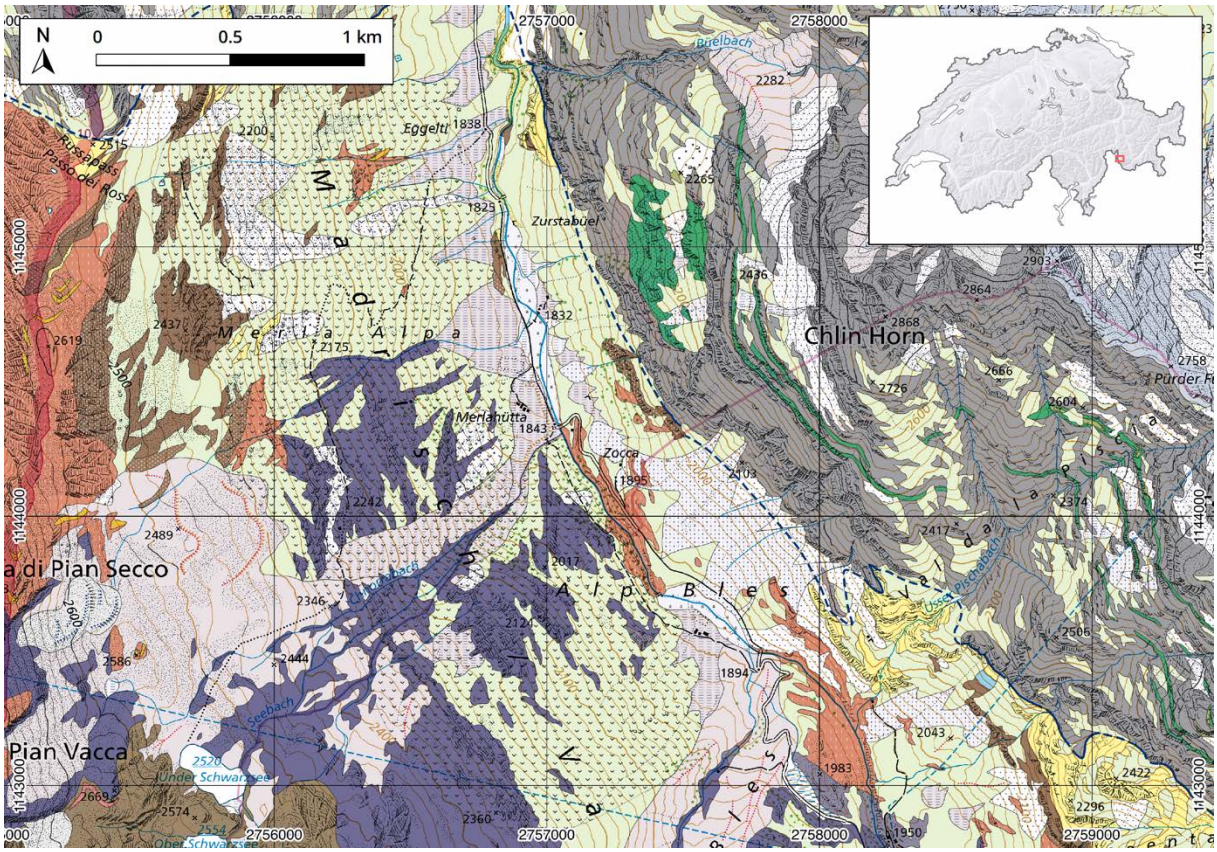


Fig. 9. Excerpt from the geological manuscript map of the central Val Madris (Grisons, Eastern Switzerland). The northeast-dipping metamorphic rocks of the Suretta Nappe on the western side of the valley are composed, from southwest to northeast, of (1) pre-Variscan gneiss of the basement (grey-brown), (2) the Paleozoic Valle-di-Lei formation (purple), (3) the Permian Russapass formation (orange) – the latter two were both dated by the FGS supported MSc thesis of Maira Coray (2023) – and (4) overlying Mesozoic sediments (brown, yellow). On the eastern side of the valley, these units are overlain by the Avers Nappe, consisting of metasediments (grey) with lenses of metabasic rocks (green) and metaultrabasic rocks (olive green).

Project leader: Donat Fulda

Project members: Peter Nievergelt, Lukas Nibourel, Irina Mayer

2.2.3 Natural stones online portal

The ETH Materials Hub (MATHUB) is the materials platform at ETH Zurich provides expertise on materials 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", we are producing fact sheets on natural stones with support of the Swiss Natural Stone Association (NVS).

Achievements in 2024

- New fact sheets on quarried natural stones

  We revised and expanded the fact sheets of 15 European natural stones, providing detailed information about their geological and petrographic properties, as well as their formation history. One example is the «Adnet marble», a fossil-rich limestone with grey, yellow, and reddish colours that has been used since Roman times. Some of its workpieces show spectacular cross-sections of fossil corals. See the complete list of studied rock in chapter 0.

Project leader: Donat Fulda

Project member: Irina Mayer

2.2.4 Resources Information System (RIS)

Our group's freely accessible web portal map.georessourcen.ethz.ch provides detailed information on occurrences and extraction sites of mineral resources in Switzerland. This includes data on cement raw materials, brickyard raw materials, hard rock aggregates, 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 2024

- Connecting the RIS with swisstopo's Topographic Landscape Model TLM

  We supported the Swiss Geological Survey (swisstopo) to establish a collaboration with the Topographic Landscape Model (TLM) team in order to connect the TLM with the RIS. This year's focus was on the identification and classification of active extraction sites. By the end of the year, we extended the RIS with a new feature that allows the TLM team to instantly access a list of currently active extraction sites.

- 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.

- RIS Roadmap 2025 and beyond

  In collaboration with the Swiss Geological Survey (swisstopo), we refined the existing roadmap by defining new objectives for 2025. We aim to further enhance the functionalities of the RIS, improve its user-friendliness, and introduce multilingual capabilities.

Project leader: Donat Fulda

Fig. 10. FGS team members studying a silver-zinc-lead mineralisation in an abandoned mine near S-charl (picture taken by Stefan Heuberger on 30.09.2024).

Fig. 11. FGS team, from left to right: Stefan Heuberger, Kevin Frings, Niklaus Kressig, Irina Mayer, Veronique Sieber, Lukas Nibourel, Donat Fulda. Picture taken by Peter Nievergelt at ETH main building, Zurich on 17.04.2024.

3 Teaching

3.1 Teaching at D-EAPS 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: S. Volante
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

Kevin Frings

Course title	Level	ECTS	Comments
Feldkurs II Sedimente, Gemmipass	BSc	3	lead: V. Picotti

Donat Fulda

Course title	Level	ECTS	Comments
Swiss International Summer School for Alpine Archaeology	MSc	3	run by Uni Bern & Uni Zürich
NVS-Weiterbildungskurs "Naturwerkstein - Das Material und dessen Anwendung"			in collaboration with NVS

Niklaus Kressig

Course title	Level	Comments
Geological city excursion in Zürich	public	In collaboration with focusTerra
NVS-Weiterbildungskurs "Naturwerkstein - Das Material und dessen Anwendung"		in collaboration with NVS

3.2 MSc project

Project	Runtime
Geometries and kinematics of faults in the Lower Helvetic, Tödi area (Switzerland). ***See Fig. 13***. MSc candidate: **Irina Mayer**. Supervision: **Lukas Nibourel**, **Stefan Heuberger,** Tobias Diehl.	2024-2025

3.3 BSc project

Project	Runtime
Exploration of clay-rich sedimentary formations in northern Switzerland: a mineralogical analysis to promote the use of calcined clays for clinker reduction for a more sustainable cement production. BSc candidate: **Nicholas Heini**. Supervision: **Stefan Heuberger**, Michael Plötze, **Veronique Sieber**.	2024

Fig. 13. MSc student and FGS Hilfsassistant Irina Mayer during field work in her MSc study area in the Clariden-Tödi area, standing on folded contact of Mesozoic blueish grey limestones (Öhrli Fm.) with brownish Cenozoic (Paleogene) sandstones of the Ultrahelvetic (2'713'066, 1'190'382). View towards N (picture taken by Lukas Nibourel on 21.10.2024).

4 Public outreach

4.1 Public talks

Heuberger, S. (2024). Lithium aus Schweizer Tiefenwässern, Kalzinierte Tone für nachhaltigen Beton. AGAB-Fachtagung 2024, ETH Zürich, 30.-31.1.2024.

Nibourel, L., Galfetti, T., **Amrein, A., Juchler, L., Morgenthaler, J.**, Mizrahi, L., Schläfli, S., Epiney, C., **Coray, M., Mayer, I. & Heuberger, S.** (2024). Mächtigkeitsschwankungen im Helvetikum: Implikationen für Rohstoffkarten, Paläogeografie und Tektonik. swisstopo lunch talk, 16. Mai 2024.

Nibourel, L. & Galfetti, T. (2024). Hartstein und Gleisschotter – Unendlich vorhanden? SBB-Tagung, Balmholz, 17.6.2024.

4.2 GeoGuides on raw material extraction sites in Switzerland

As there is no mining or hydrocarbon extraction in Switzerland, people often have the impression that Switzerland is poor in mineral resources. However, a look at the history and the local geology shows that until a few decades ago, mineral resources were more intensively explored and mined. But this was rarely the case at a large industrial scale. Such mining was often unprofitable. Nevertheless, some raw materials, in particular gravel, sand, clay, marl, limestone and various types of natural stone, are still mined in Switzerland today. With regard to geopolitical tensions and the aimed energy transition, other geological raw materials (e.g. metal ores) are increasingly coming back into focus.

With our Geoguides we present excursions to scenically and geologically attractive (former) extraction sites in order to inform the interested public on the past and present raw material extraction in Switzerland. Our GeoGuides provide a brief overview of the mined raw material, the mining history and the local geology. In addition, the access and the route are described in such a way that these excursions can be undertaken independently. The Guides are currently available as prototypes (Fig. 14).

Fig. 14. Examples of two GeoGuides cover sheets.

4.3 Reportages, Articles and Online Posts

Beobachter (2024). Jetzt beginnt der Streit um den Untergrund. Article by R. Paganini with Interview with **S. Heuberger**, 16.05.2024. beobachter.ch/umwelt-klima/umweltpolitik/jetzt-beginnt-der-streit-um-den-untergrund-710236

geo-sports.org (2024). Zurich 2024 road races. The geology along the UCI men's road race route. Blog post (Fig. 15) by **Stefan Heuberger** on geo-sports.org.

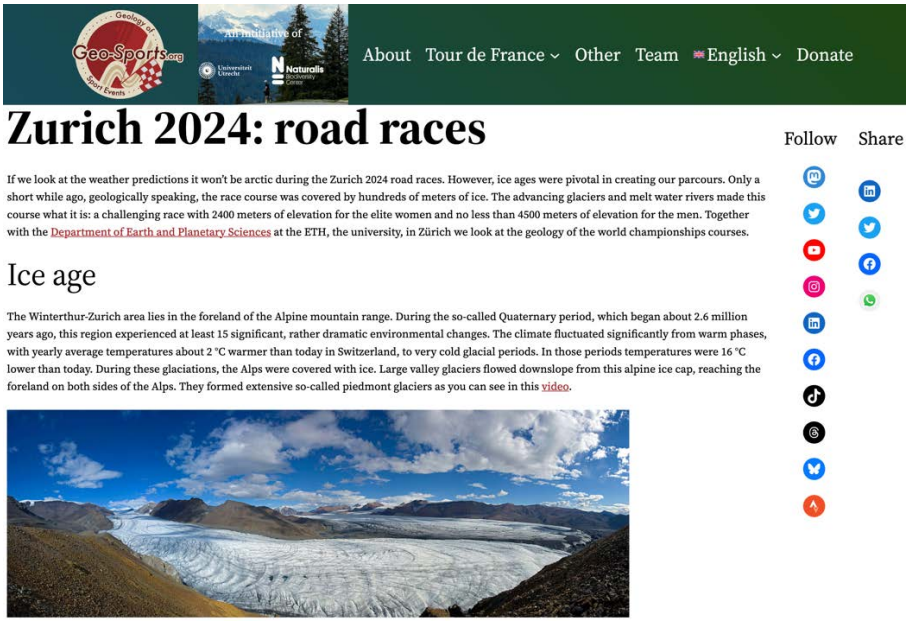


Fig. 15. Exerpt from geo-sports.org blog page on the geology along the UCI road cycling race route.

5 Publications

Papers

Dallo, I., Schnegg, L. N., Marti, M., **Fulda, D.**, Papadopoulos, A. N., Roth, P.,Danciu, L., Valenzuela, N., Wenk, S. R., Bergamo, P., Haslinger, F., Fäh, D., Kästli, P. and Wiemer, S. (2024). Designing understandable, action-oriented, and well-perceived earthquake risk maps – The Swiss case study. Frontiers in Communication 8:1306104.

Reports

Nibourel, L., Galfetti, T., **Amrein, A., Coray, M., Grazioli, S., Juchler, L., Mayer, I., Morgenthaler, J., Schumacher, I.,** Schläfli, S., **Epiney, C. & Heuberger, S.** (2024). Catalog of the hard rock-bearing geological units in Switzerland. Explanatory notes to the geospatial dataset "Hard rock aggregates: Thickness and quality of geological occurrences". Reports of the Swiss Geological Survey 23.

Nibourel, L., Galfetti, T., **Amrein, A., Juchler, L., Morgenthaler**, J., Mizrahi, L. & **Heuberger, S**. (2024): Hard rock aggregates: Thickness and quality of geological occurrences. Technical description of the dataset and modelling method. – Federal Office of Topography swisstopo, Wabern.

Datasets

map.geo.admin.ch, layer "Hard Rock: Occurrences" (Link)

Abstracts (Talks)

Frings, K, A., **Heuberger, S.** & Madritsch, H. (2024). Revising the heat flow map of Switzerland for an improved assessment of national geoenergy potentials. 22nd Geoscience Meeting 2024, Basel.

Nibourel, L., Galfetti, T. & **Heuberger, S.** (2024). Large-scale semi-automatically generated thickness maps: better paleogeographic understanding helps to identify mineral occurrences with favorable geometry. Geosaxonia 2024, German Geological Society (DGGV) Annual Meeting 2024

Fact sheets

Rocks (see examples in Fig. 16)

Note that the fact sheets are still being reviewed by the MATHUB team. As soon as they are online, they can be found here materialarchiv.ch

Material-Archiv (2024). Adneter Marmor
Material-Archiv (2024). Anröchter
Material-Archiv (2024). Clauzetto
Material-Archiv (2024). Elazig Visne
Material-Archiv (2024). Fior di Pesco Carnico
Material-Archiv (2024). Gollinger Konglomerat
Material-Archiv (2024). Kirchheimer Muschelkalk
Material-Archiv (2024). Lindabrunner Konglomerat
Material-Archiv (2024). Maulbronner Sandstein
Material-Archiv (2024). Norwegischer Rosenmarmor
Material-Archiv (2024). Otta-Schiefer
Material-Archiv (2024). Savonnières
Material-Archiv (2024). Schwarzenseer Marmor
Material-Archiv (2024). Ternitzer Konglomerat
Material-Archiv (2024). Untersberger Marmor

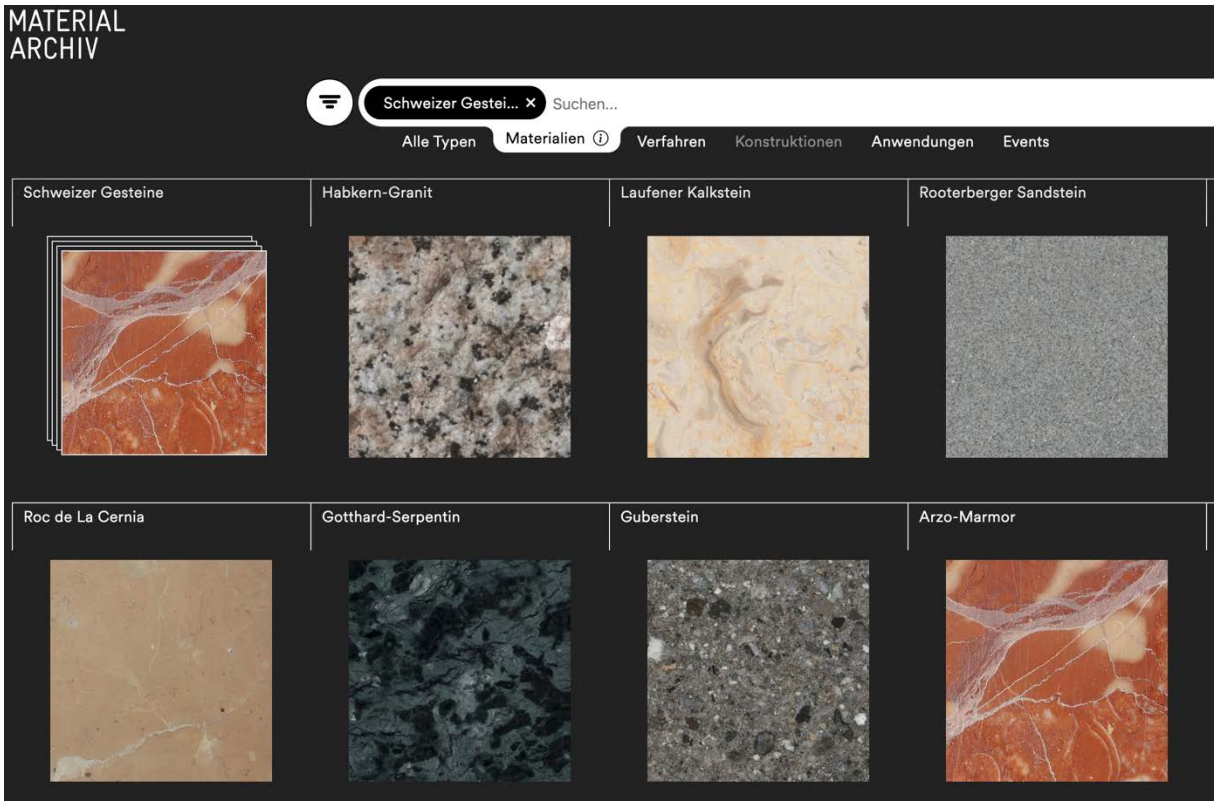


Fig. 16. Exerpt from the materialarchiv.ch page showing a part of the factsheets for Swiss natural stones.

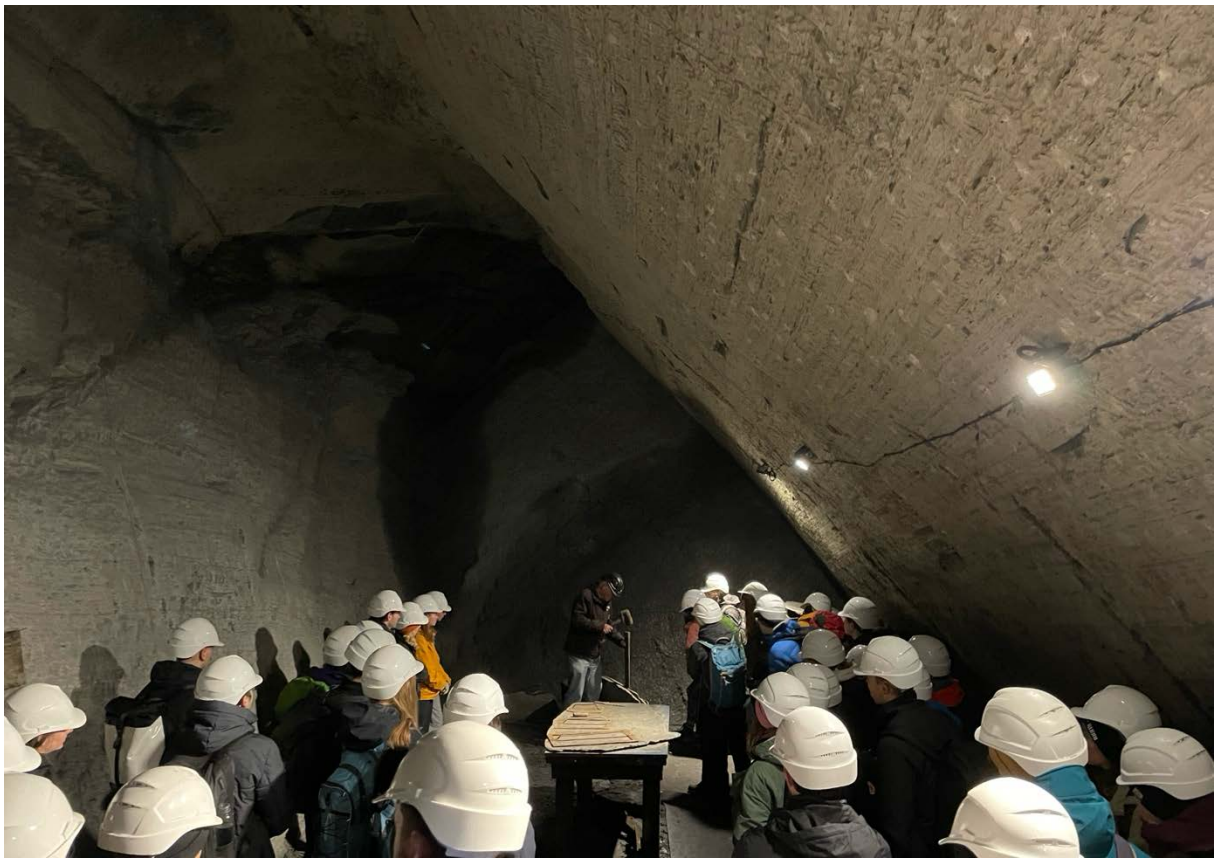


Fig. 17. One-day excursion «Erdwissenschaftliche Exkursionen I – Glarnerland» in the Landesplattenberg slate quarry in Engi, Glarus area (Picture taken by Stefan Heuberger on 19.04.2024).

6 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

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Publisher: Georesources Switzerland Group
Editor: Dr. Stefan Heuberger