Sediment production and erosion in the Lütschinen valley based on in-situ ^{10}Be

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Introduction and aim of the study

This study aims to calculate a sediment budget based on chemical fingerprints and detailed geomorphological mapping in the Lütschinen valleys in order to answer the following questions:

Which are the dominant sources of sediment?

How high is the contribution of each of the main processes (figure 1) to the overall sediment production?

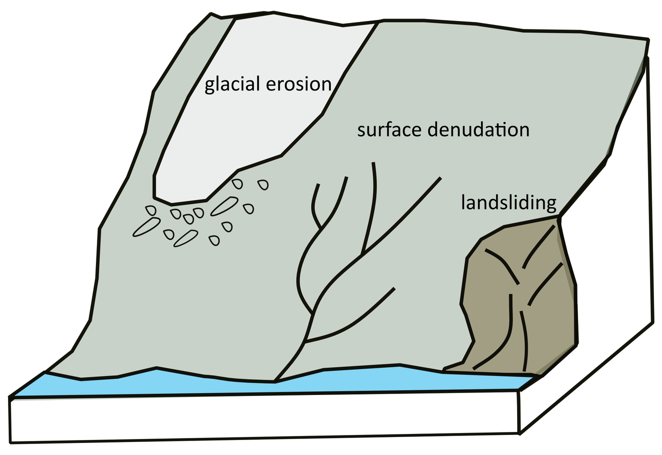


Figure 1: Most dominant erosional processes in the study area, according to field observations.

Methods

The first step in resolving the sediment sources is detailed geomorphological mapping using remotely sensed data of the study area to map evidence for the dominant erosional processes and calculate theoretical connectivities for each subcatchment. Chemical "fingerprints" are measured for each sample using concentrations of whole-rock major elements for the sand and finer fraction as well as ^{10}Be concentrations. These allow to calculate sediment budgets.

Detailed geomorphological mapping with GIS

+

"Fingerprinting" with ^{10}Be and major oxides of suspension load

+

"Fingerprints" for overall catchment

+

Mixing calculation

↓

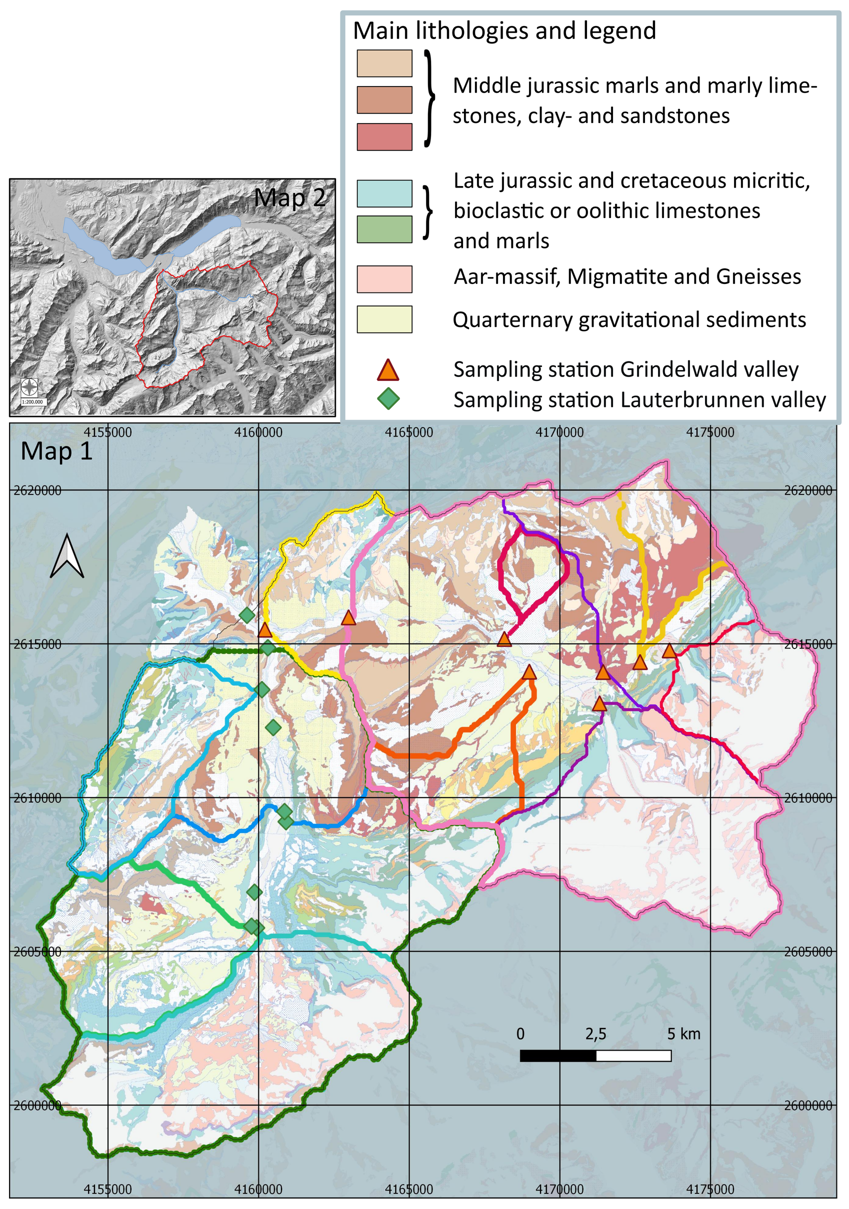
Spatially resolved sediment budget for overall catchment

Figure 2: workflow applied for sediment budget calculations.

Study area

The project is set in the Bernese Oberland, in the Lauterbrunnen and Grindelwald valleys. They are drained by the Black (Grindelwald) and the White (Lauterbrunnen) Lütschine, carrying the sediments produced in the catchment area. The rivers converge at Zweilütschinen and ultimately flow into Lake Brienz (see Maps 1&2).

Three main lithologies are observed in the study area: marly limestone, sand- and mudstones from the Middle Jurassic, bioclastic, micritic or oolithic limestones from the Late Jurassic and Cretaceous as well as migmatites and gneisses from the Aare Massif. According to observations in the field, morphology (and therefore ongoing erosive processes) of the valleys are strongly influenced by the local lithology. The study area covers all three mentioned erosive processes and was split into subcatchments for sampling, to capture the diverse lithologic and morphologic characteristics influencing sediment production.



Map 1: overview over study area with sampling locations, main lithologies on the Geocover-vectordata (©swisstopo) and calculated subcatchments for each sampling point.

Map 2: Location of study area within switzerland / the Bernese Oberland on the DEM swissALTI3D (©swisstopo).

Foto 1: sampling location GW2 in the Grindewald valley. Foto Jana von Allmen, June 2022.

Results - physical and chemical separation

First results were obtained from the physical and chemical separation of pure quarz grains for the cosmogenic ^{10}Be analysis. After crushing and sieving the samples to achieve a high amount of a grainsize fraction of 0,25 to 0,4 mm, the collected samples were separated from their magnetic fraction. Samples were then treated with 10% HCl to decalcify the sample. Depending on the lithological origin, the amount of extracted quarz varies. A minimal amount of quarz per sample has to be achieved to perform a successful accelerator mass spectrometry (AMS) spectrometry.

Table 1: Sample size losses in percent after treatment (magnetic separation and 10% HCl.

Sample	Non-magnetic fraction	loss in decarbonization	Left for further steps
GW4	44%	16%	36%
GW5	18%	74%	5%
GW7	36%	26%	27%
GW8	37%	26%	27%
LB3	68%	95%	4%
LB9	58%	35%	37%
ZL1	48%	36%	31%

Conclusions and outlook

We strive to attain a map similar to figure 2, summarizing our results. The contribution of each sediment source to the overall budget will then be estimated in percent. Measured 10Be concentrations for each erosional process will be applied in hydro- / sedimentological modelling in similar catchments (cf. Battista et al. 2020).

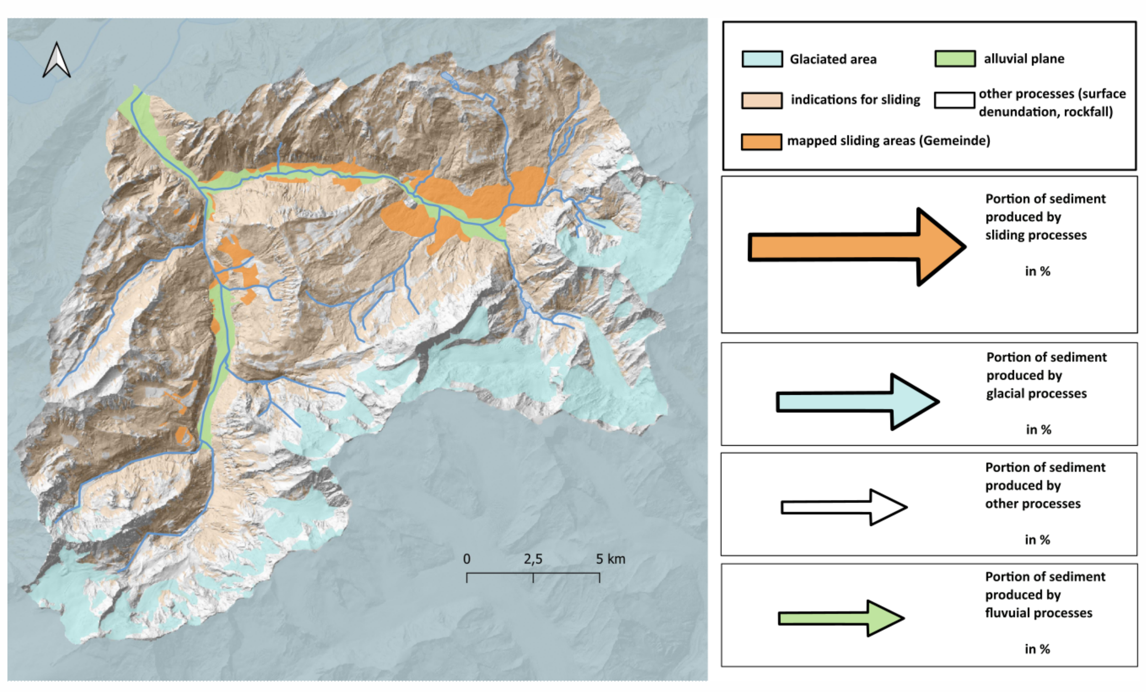


Figure 3: Spatial distribution of erosional processes in the Lütschinen valleys. Data based on earlier mapping of the area (©swisstopo, © Kanton Bern). Legend and diagram to the right: exemplary depiction of expected results. Concept according to Delunel et al. 2014.

References:

Battista, G., Schlunegger, F., Burlando, P., and Molnar, P. (2020) Modelling localized sources of sediment in mountain catchments for provenance studies. Earth Surf. Process. Landforms, 45: 3475– 3487. https://doi.org/10.1002/esp.4979

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Federal Office of Topography swisstopo, Geological Vector Datasets GeoCover.

Federal Office of Topography swisstopo, swissALTI3D monodirectional Hillshade.