CH-QUAT

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CH-QUAT Annual Meeting 2014

Quaternary Stratigraphy of the Swiss Foreland

Quaternary evolution of the Swiss Alpine Foreland with a special focus on the sedimentary archives and on the reconstruction of their chronology

Institute of Geological Sciences
Baltzerstrasse 3, CH-3012 Bern
Saturday 22.03.2014, 08:30 - 16:00

Program & Abstracts

Program

08:30 - 09:00	Registration
09:00 - 09:15	Welcome
09:15 - 09:45	Fritz Schlunegger (Uni Bern): *Quaternary Landscape Evolution of the Alps*
09:45 - 10:15	Wilfried Haeberli (Uni Zurich): *Radioactive waste under conditions of future ice ages: paleoglaciology, glacial erosion and overdeepenings in the northern Swiss Plateau*
10:15 - 11:00	Poster Session with coffee break
11:00 - 11:30	Flavio Anselmetti (Uni Bern): *Hunting age and extent of past glaciations along and across the Alps through 'drilling overdeepened Alpine valleys' (DOVE)*
11:30 - 12:00	Sally Lowick (Uni Bern): *The dating of Pleistocene proglacial deposits from northern Switzerland using optically stimulated luminescence*
12:00 - 13:30	Lunch & Poster Session
13:30 - 14:00	General Assembly
14:00 - 14:30	Anne Claude (Uni Bern): *Timing of the Deckenschotter Glaciations*
14:30 - 15:00	Poster Session with coffee break
15:00 - 15:30	Stefan Strasky - Alain Morard (SwissTopo): *Harmonising the Swiss geological map legends – results from the Quaternary working group (HARMOS)*
15:30 - 16:00	Open discussion and closing

Poster Presentations

Akçar N., Tikhomirov D., Ivy-Ochs S., Graf A., Schlunnegger F., Reber R., Claude A., Kubik P.W., Vockenhuber C., Hajdas I., Schlüchter C.: *The Valais Glacier: its last advance to the Alpine Foreland.*

Ambrosi C., Scapozza C., Dall'Agnolo S.: *Stratigrafia dei depositi quaternari del Mendrisiotto (Sud delle Alpi).*

Antolín F., Steiner B., Brombacher C., Kühn M., Bleicher N., Jacomet S.: *Quantifying the economic importance of large-seeded wild plants in the Neolithic lakeshore site of Parkhaus-Opéra (Central Switzerland).*

Häberle S., Fuller B.T., Nehlich O., Van Neer W., Schibler J., Hüster Plogmann H.: *Stable isotope analysis of Swiss freshwater fish from medieval and early modern sites.*

Mozafari Amiri N., Sümer Ö., Tikhomirov D., Özkaymak Ç., Ivy-Ochs S., Uzel B., Vockenhuber C., Sözbilir H., Akçar N.: *The early Holocene seismic activity of Büyük Menderes graben, Western Anatolia, Turkey: Fault scarp dating with cosmogenic 36Cl.*

Stumm D., Fischer U.H., Schnellmann M., Haeberli W.: *A review of tunnel valleys in northern Europe.*

Wüthrich L., Zech R., Haghipour N., Gnägi C., Christl M., Ivy-Ochs S., Veit H.: *Extremely eroded or incredibly young – 10Be depth profile dating of moraines in the Swiss Midlands*

Abstracts

The Valais Glacier: its last advance to the Alpine Foreland

Akçar N.[1], Tikhomirov D.[1], Ivy-Ochs S.[2], Graf A.[3], Schlunnegger F.[1], Reber R.[1], Claude A.[1], Kubik P.W.[2], Vockenhuber C.[2], Hajdas I.[2], Schlüchter C.[1]

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The northern Alpine foreland was covered by the Piedmont glaciers for the last time during the Last Glacial Maximum. Among these lobes, the Valais Glacier left the Rhone Valley and extended across the Alpine Foreland to the Jura Mountains. This mountain belt obstructed the northward extension of the Piedmont glacier and the glacier was split into two lobes. One lobe flowed to the southwest and joined to the Arve glacier, which extended ca. 20 km to the east of Lyon. Another lobe was diverted towards northeast and terminated at its maximum ca. 10 km east of Solothurn. The advance of the Valais Glacier onto the foreland occurred after 30 cal yr BP and it reached its maximum position at around 22 ka. The timing of this maximum is constrained ^{10}Be exposure ages from erratic boulders in Steinhof, Möschberg and the Jura Mountains. Although the advance of the Alpine glaciers has been reconstructed within a relatively detailed chronological framework, reconstructions of their demise have been rather vague mainly because of poor age constraints.

In this study, we complement the existing chronological dataset with new ages inferred from a depth profile at Finsterhennen where we analyzed depth-dependent variations of cosmogenic ^{36}Cl concentration for the LGM basal till of the Valais glacier. We use the concentration pattern to: (1) test the suitability of cosmogenic ^{36}Cl for age assessments; and to (2) improve the chronology of the ice retreat. Finally, we calculated a model age for its deposition. We also found a piece of wood at the bottom of this till and dated it with radiocarbon. Furthermore, we dated the exposure of three erratic boulders close to the left lateral ice margin in Martinsflue with cosmogenic ^{10}Be.

Our results indicate that the Valais glacier reached Finsterhennen after 29 cal kyr BP. Erratic boulders from the left lateral position yielded an age of ca. 22 ka, which is consistent with the

existing exposure ages. Our model age from the cosmogenic ^{36}Cl depth-profile indicate that at around 21 ka the margin of the Valais glacier was still located to the northeast of Finsterhennen. Furthermore, because the earliest non-glacial deposits, which were encountered at the archeological site Rouges Terres at the border of Lake Neuchâtel ca. 15 km to the southwest of Finsterhennen, were dated to ca. 16 kyr cal BP, the demise of the Valais glacier in the foreland occurred within 5 ka. Finally, a practical implication of this study is that ages ranging up to hundreds of thousands of years can be determined for the top-most layers (e.g. terraces) simply by measuring cosmogenic ^{36}Cl depth-profiles in cores or trenches of 2-4 m depth, independent of lithological composition of the sediment and sample size.

Stratigrafia dei depositi quaternari del Mendrisiotto (Sud delle Alpi)

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Nell'ambito del rilevamento geologico del Foglio 1373 Mendrisio (Atlante geologico della Svizzera 1:25'000), è stata rivisitata la stratigrafia dei depositi quaternari nell'area dell'avampaese sudalpino. La disponibilità di datazioni su differenti tipologie di depositi ha permesso di comporre una stratigrafia regionale basata su eventi glaciali e su proxies climatici a scala continentale e/o globale che ha permesso di differenziare quattro principali unità cronostratigrafiche.

In particolare sono stati raggruppati Depositi del Postglaciale (0-0.0117 Ma) riferiti all'Olocene, Depositi dell'Ultimo Massimo Glaciale e del Tardoglaciale (0.0117-0.029 Ma) e Depositi precedenti all'Ultimo Massimo Glaciale (0.029-0.781 Ma) entrambi riferiti al Medio e Tardo Pleistocene, Depositi del Pleistocene inferiore (0.781-2.588 Ma) riferiti al Primo Pleistocene.

Tale approccio è stato tradotto nella legenda della Carta Geologica permettendo una rappresentazione immediata sia delle facies, sia delle età dei depositi. Oltre a permettere una definizione delle unità cronostratigrafiche applicabile ad altre carte geologiche nel medesimo contesto regionale (cartografia armonizzata), tale tipo di rappresentazione consente una rapida visualizzazione dell'estensione dei principali eventi morfoclimatici (per es. l'estensione massima dell'Ultima grande glaciazione rispetto alle glaciazioni precedenti).

Una rappresentazione di questo tipo ha facilitato anche la comprensione delle dinamiche dei principali flussi glaciali nella regione del Mendrisiotto confermando un importante ruolo giocato dal lobo lariano del ghiacciaio dell'Adda rispetto al lobo del Ceresio.

Hunting age and extent of past glaciations along and across the Alps through 'Drilling overdeepened Alpine valleys' (DOVE)

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A recently submitted ICDP drilling proposal targets formerly glaciated areas, which are often characterized by deeply incised structures filled by thick Quaternary deposits. These buried troughs and valleys were formed by glacial overdeepening, likely caused by pressurized subglacial meltwater below warm-based glaciers. The proposed multinational drilling initiative consists of 14 drill sites in six different countries, all linked by the fact that they surround a formerly glaciated, densely populated mountain range, the European Alps. Being the best studied mountain range, the Alps will serve as textbook example allowing application of drilling results to other glaciated areas around the world.

Recent drill holes in overdeepened valleys in the Northern Alpine foreland have produced local knowledge of the timing of glacial activity. Results indicate a complex erosional-depositional history that could be dated and linked in the context of past glaciations. However, only an alpine-wide drilling initiative will allow to reconstruct the full spatial and temporal scale of glacier advances and erosion and related landscape-forming processes over several glacial-interglacial cycles. The drill holes, to be cored all the way to bedrock, will explore the type and age of the infillings of these overdeepened troughs. Such drill cores, paired with matching geophysical and instrumental data, hold the keys to understand how and how fast mountain ranges and their foreland are shaped by repetitive glaciations. The overarching goal will be to date the age and extent of past glaciations and their connection to paleoclimate, paleoecology and landscape history. As of today, it is not known how these glaciations varied along and across the Alps during

the past, and to what extent the ice build-up along and across the Alps reflects changes in atmospheric circulation patterns.

Next to these paleoglacial, paleoecological and paleoclimatic aspects, the thick valley fills hold large, untapped aquifers. In the light of an increasing demand for water resources likely amplified by the projected climate change, testing these aquifers in the framework of this project is of high relevance for future hydrogeological applications. Related to this role, these drill holes may be used for shallow geothermal applications, which, however, to date rely on poorly constrained physical properties of the infilling sections. In addition, the areas represent areas of high seismic hazards related to their unfavorable seismic site effects.

All these goals will be first addressed by state-of-the-art geophysical surveys that quantify the geometry of the overdeepenings. Drillholes will be analyzed by downhole logging, groundwater sampling and subsurface biosphere testing. Sedimentological, geochemical and palaeobiological analyses will characterize the sediment cores, and a combination of different approaches (biostratigraphy, luminescence dating, cosmogenic nuclide dating, magnetostratigraphy, and tephrastratigraphy) will establish the chronological framework. Eventually, the results from the above approaches will be cross-checked with the outcome of modeling both glacial flow and erosion and atmospheric circulation.

Quantifying the economic importance of large-seeded wild plants in the Neolithic lakeshore site of Parkhaus-Opéra (Central Switzerland)

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Excavations conducted in the car park of the Opera House of Zürich during 2010 uncovered several settlement phases of a large Neolithic lakeshore site. This presentation is focused on Layer 13, dendrodated to around 3230 BC (early Horgen Culture). This is a cultural layer of a maximum of 32 cm of thickness expanding over more than 3000 m^2. It consists of organic debris, as well as loam heaps and other mineral components. Layer 4 of the nearby site Kanalisation Seefeld in Zürich is the only comparable settlement phase dated to this period.

Lakeshore sites allow an excellent preservation of plant macroremains, therefore they offer a unique opportunity to approach human-environment interactions in a quantitative way. The high concentration of seeds and fruits in these kinds of samples has resulted in the generalized study of small samples in most archaeobotanical studies. Nevertheless, after previous work carried out in other lakeshore settlements of central Europe, it was concluded that large-seeded taxa were underrepresented in small samples. Therefore, a new systematic sampling strategy based on bulk samples (of c. 10 litres of volume) was applied on the whole excavated surface. Over 1100 litres of sediment were sieved with the wash-over technique and fully-quantitative analyses were done for the large-seeded taxa (>2 mm). The premise of this study is that the quantified results obtained through this analysis provide a reliable overview of the economic importance of these plant resources at the site.

The results obtained show that the role of large-seeded wild plants at the site was of major significance and that their role in the economy might have been underestimated in previous approaches. We assume that some kind of tending for a better yield of fruit trees as crab apples, acorns, hazelnuts, sloe etc. must have existed. It is for this reason necessary to develop new models for the relationship between Neolithic societies and their environment.

Timing of Deckenschotter Glaciations

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Although the timing of Late Quaternary glacial advances in the Alpine Foreland is well established, not much is known about the chronology of the Deckenschotter (cover gravels) glaciations. In this study, we thus aim to build the chronostratigraphy of Swiss Deckenschotter in order to reconstruct the timing of Early and Middle Pleistocene glaciations in the Alps. Deckenschotter are Quaternary sediments, which cover Tertiary Molasse or Mesozoic bedrock and are located in the Northern Alpine Foreland, beyond the limit of the Last Glacial Maximum. These sediments that are a succession of proximal glaciofluvial gravels are topographically distinct and discontinuous archives, showing a reverse stratigraphic relationship, i.e. older deposits are located at higher altitudes and vice versa.

The main focus of this study is the Higher Deckenschotter site at Stadlerberg, located in the canton of Zurich, close to the German border at an elevation of around 600 m. In an abandoned gravel pit, depth-profile dating with cosmogenic ^{10}Be was applied on 7 sediment samples. This dating method uses the fact that the build-up of cosmogenic nuclides decreases with depth following the known physical principles. First results yielded a model age of deposition of approximately 1.7 Ma. Additionally, we also studied the lithostratigraphy in detail at this site. Petrography of the pebbles indicated that this Deckenschotter unit originates from the catchment of the Rhein-Linth Paleoglacier.

Furthermore we provide an insight into the isochron-burial dating method with cosmogenic ^{10}Be and ^{26}Al of samples from the Higher Deckenschotter at Irchel, which are situated 10 km to the east of Stadlerberg and at an elevation of approximately 670 m. Isochron-burial dating is based on the decay of cosmogenic nuclides and uses the difference in half-lives of ^{10}Be and ^{26}Al. The samples were collected from the same time-line and thus have different pre-burial but the same post-burial histories.

Stable isotope analysis of Swiss freshwater fish from medieval and early modern sites

Häberle S., Fuller B.T., Nehlich O., Van Neer W., Schibler J., Hüster Plogmann H.

Freshwater fish were exploited on a large scale in medieval and early modern time Switzerland. For the reconstruction of the importance of fish in human diet, stable isotope analysis is becoming an established tool. Due to the present lack of medieval and early modern Swiss fish isotope data, the study was initiated to survey carbon and nitrogen isotopic signatures of archaeological pike (*Esox lucius*), perch (*Perca fluviatilis*) and barbel (*Barbus barbus*).

The isotopic signature of freshwater fish depends on diverse influences, including their own diet, feeding grounds, age, and water quality. In addition, high intra-species variation within and between fish populations complicate the interpretation. The evaluation of these parameters could nevertheless provide insight into research fields besides human diet such as the ecology of former aquatic ecosystems, water pollution, the origin of fish, and possibly even the use of artificial fish ponds.

Radioactive waste under conditions of future ice ages: paleoglaciology, glacial erosion and overdeepenings in the northern Swiss Plateau

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The time dimension over which high-level radioactive waste must be isolated from the biosphere (on the order of one million years) involves the probable future occurrence of ice ages. Ice age conditions can potentially impact repositories by effects of surface and subsurface ice formation and corresponding changes in groundwater hydraulics but also through deep glacial erosion. The envisaged repository sites in the northern Swiss Plateau are not only within the reach of large ice-age piedmont glaciers and periglacial to subglacial permafrost but also close to marked overdeepenings from glacial erosion. Understanding the characteristics of these overdeepenings and the processes involved with their formation is essential for an optimal site selection but closely related to questions of the timing with respect to the involved sequences of deep erosion and sediment filling.

Systematic efforts are undertaken in Switzerland to compile the best possible knowledge base concerning these questions. Special focus is on quantitative paleoglacialogical information, 3D-transient flow modeling with thermo-mechanical coupling, glacier erosion with special emphasis on subglacial hydraulics/sediment evacuation and morphological characteristics of overdeepenings in the Plateau as well as in the beds of modern mountain glaciers and ice sheets. Two workshops with international experts helped to formulate key questions related to these aspects.

First results show that the large piedmont lobes like the one of Rhine Glacier were polythermal but warm-based over large parts due to ice-build-up in more cool/humid conditions than the dry cold LGM extent. The geometry of overdeepenings is extremely variable with adverse slopes often much higher than critical limits for supercooling and floatation; only weak indications exist for maximum depth with optimal elongation. Key questions are related to effects of depth erosion by subglacial meltwater in connection with subglacial hydraulics.

The dating of Pleistocene proglacial deposits from northern Switzerland using optically stimulated luminescence

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Most of the widely accepted knowledge concerning the glaciation history of the Alps is still based on the early recognition by Penck and Brückner (1901/09) of evidence for at least four discrete glaciations in the Bavarian lowlands since the beginning of the Pleistocene. This glacial scheme has since been shown to be far more complex in some Alpine areas, and with many more glaciations than first recognized. For Switzerland, four or five potentially distinct glacial periods from the Middle Pleistocene to present, have been recognised from a lithostratigraphic study of the northern Alpine foreland (Graf, 2009), but numerical dating is vital in order to place these deposits within a chronological framework. Evidence for three of these glaciations, Habsburg, Hagenholz and Beringen, is understood to outcrop in the Klettgau valley, just west of Schaffhausen in northern Switzerland. This study was supported by some of the first optically stimulated luminescence (OSL) ages applied to Swiss sediments more than ten years ago, and these have now been re-measured. New samples have also been taken in the valley for luminescence dating from silt and sand lenses within each of three distinct gravel units; various luminescence signals from fine and coarse grains, of both quartz and feldspar have been measured in order to assess various protocols. These results are being assessed and will be used to better constrain the glacial history of the area.

References

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The early Holocene seismic activity of Büyük Menderes graben, Western Anatolia, Turkey: Fault scarp dating with cosmogenic ^{36}Cl

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Tectonic activity of the roughly N-S extending West Anatolia, since the early Miocene, caused the formation of three major graben systems: The Gediz, Küçük Menderes and Büyük Menderes. These systems are bounded by large scale normal faults which are built in carbonate bedrock and recorded surface faulting during the Pleistocene-Holocene. In the Eastern Mediterranean and Middle East region since 464 B.C.; destructive earthquakes are historically and instrumentally recorded, which in turn, reveal the occurrence of 78 earthquakes before 1900 and 72 after 1900. The timing and slip rate provide information on the importance of the faults regarding the probability of occurrence and of return periods of the large earthquakes. For a long-term earthquake modelling, information about the paleo-earthquakes prior to 464 B.C. is needed.

Preservation of fault scarp in carbonate bedrock resulted in efficient recording of the past earthquakes and makes the fault scarp an ideal natural laboratory to examine periods of sporadic seismic activity and quiescence. ^{36}Cl is the only element to determine and date the rupture event on a carbonate fault scarp. With each rupture, a buried section of the limestone scarp is exposed to the surface and interacts with cosmic rays which consequently results in speeding up of ^{36}Cl concentration during period of inactivity. By measuring the ^{36}Cl concentration along the fault, it is possible to determine the rupture and its timing.

With the aim of identifying and better understanding the tectonic activity of the Büyük Menderes graben beyond the historical archives, we sampled the Priene-Sazlı Fault, located on the most western part of the graben for fault scarp dating. To measure ^{36}Cl concentration, 117 slabs of limestone have been collected from four continuous strips along the fault. After measuring the

^{36}Cl concentration and analyzing the chemical composition of each sample, we used a Matlab code to model the remarkable ruptures and their timing. Our first results indicate evidence of enhanced seismic activity along the Büyük Menderes graben during the early Holocene.

Quaternary landscape evolution of the Alps and its underyling driving forces

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The Quaternary evolution of the Alpine landscape and its foreland has largely been characterized by erosion either through glacial sculpting and/or fluvial and hillslope processes. Although progress has been made on measuring the rate of erosion at various scales, the interpretation of the underlying driving forces has been a matter of debated in the past years. Here, I will show that while lithospheric processes rooted in deep crustal levels have driven erosion at the scale of the entire Alps over the past millions of years (including the Quaternary), glacial processes, and particularly the landscape's inheritance related to glacial sculpting after the Middle Pleistocene transition, largely explains the pattern and rates of geomorphic processes operating on the modern surface.

The search for the controls on erosion at the large scale has centered on the question of whether or not the erosion rates of the Alps and its foreland have increase during the past millions of years. Alpine sediment budgets over the past 35 Ma (Kuhlemann et al. 2002: IJES), and inversion of apatite fission-track ages into an erosional history of the Alps (Herman et al., 2013: Nature) disclosed a substantial increase in the erosion rate between c. 5 Ma and the presence. This increase was used to call for a climate driver (Cederbom et al., 2004: Geology; Herman et al., 2013: Nature), mainly because it was not accompanied by an acceleration of tectonic convergence rates across the Alps during this time period. We have recently synthesized sediment budgets from the foreland and apatite fission-track ages from the orogen, based on which we have disclosed a large ellipsoidal, orogen-crossing pattern of erosion, centered along the western Alps and its foreland (Baran et al., 2014: Lithosphere). According to this synthesis, erosion of the Alpine foreland has been highest in front of the western Alps (between 2 and 0.6 km during the past 5 Myr), and has decreased eastward over a distance of 700 km to the Austrian foreland basin (c. 200 m). For the western Alps, erosion rates averaged of 5 Myr have exceeded 0.6 km/Ma, while erosion rates for the eastern foreland basin and the adjacent eastern Alps have been less than 0.1 km/Ma, except for a small-scale signal in the Tauern window. We

have suggested that accelerated erosion of the western Alps and their foreland has occurred in response to regional-scale surface uplift, related to lithospheric unloading of the Eurasian slab the beneath the western Alps. We have considered this mechanism as the primary driving mechanism for the erosion of the Alps over the past millions of years including the Quaternary (Baran et al., 2014: Lithosphere).

At a shorter scale, the formation of large trunk glaciers that started sometime after the Middle Pleistocene transition (Häuselmann et al., 2007: Geology; Valla et al., 2011; Nat. Geosc.) has resulted in the scouring of overdeepened trunk valleys (e.g., Rhone and Rhine valleys) where glacial sculpting has been driven by thick ice. However, glacial carving in the tributary valleys was less mainly because of the presence of thinner and thus less erosive ice. The result is a topographic step between trunk and tributary valleys, and the occurrence of oversteepened inner gorges that form the communication link. ^{10}Be-based erosion budgets imply that most erosional work has been accomplished in these gorges during the most recent past (e.g., van den Berg et al., 2012: Earth Surf. Process. Landf.). This configuration has resulted in the largest amount of erosional unloading particularly at the bottom of the Rhein and Rhone valleys where elevation differences between tributary and trunk valleys are at their maximum, and where the density of oversteepened inner gorges is larger than the average.

In conclusion, while deep seated lithospheric forces can explain the erosion pattern of the Alps and their foreland at the large scale over millions of years including the Quaternary, glacial sculpting since the Middle Pleistocene transition and the resulting landscape's inheritance of these glaciations has substantially contributed to a modulation of the erosional picture that is still measurable today.

Harmonising the Swiss geological map legends – results from the Quaternary working group

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Today 143 map sheets of the Geological Atlas of Switzerland 1:25000 cover about 65 % of Switzerland's territory. To accommodate customers' needs for datasets in electronic format, the Swiss Geological Survey transferred the traditionally printed map sheets into high-quality GIS datasets. Furthermore, during the last four years, the Swiss Geological Survey has spent considerable effort in completing the missing 35 % of the Geological Atlas of Switzerland 1:25000 with GIS compilations, based on the best available geological maps. Thus, geological GIS maps – although of different qualities – are now available for the whole of Switzerland.

Each map still however has its own sheet specific lithostratigraphic legend. The HARMOS project, which was initiated in 2011, aimed to harmonise the individual map legends and produce a single set of standard lithostratigraphic legends for the whole of Switzerland. Nine working groups, composed of more than 40 experts in the field of stratigraphy, developed the standard map legends according to the guidelines for stratigraphic nomenclature as defined by Remane et al. (2005). An adapted lithostratigraphic concept was needed for crystalline rocks and Quaternary deposits. The concept and nomenclature of Quaternary deposits as described by Graf & Burkhalter (2013) was considered for the Quaternary. This concept has been – and will be – applied to map sheets of the Geological Atlas of Switzerland 1:25000. However, the mapping basis of most GIS datasets is too poor and thus did not allow this detailed concept to be used. A more general concept was needed. After various considerations the Quaternary working group came to the conclusion that the most effective way of harmonising the Swiss Quaternary map legends would be by means of morphostratigraphy. In order to harmonise Quaternary deposits in an extra-LGM position, the following four super-units were proposed, from youngest to oldest: Niederterrasse, Hochterrasse, Tiefere Deckenschotter and Höhere Deckenschotter. The intra-LGM deposits were subdivided into the following proposed super-units: Niederterrasse and 'older Quaternary deposits'. In addition to detailed descriptions of the morphostratigraphic

super-units, a correlation scheme was defined, which places the proposed harmonisation concept into a chrono-, litho- and eventstratigraphic framework.

This simplified standard Quaternary legend will now be used to harmonise the existing Quaternary map units and, together with the standard legends of the Swiss tectonic domains, provide the basis for a future seamless, semantically harmonised, nationwide geological GIS map of Switzerland at a scale of 1:25000.

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A review of tunnel valleys in northern Europe

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The existence of buried Quaternary valleys indicates that glacial erosion is an important process in shaping the landscape of the Swiss Alpine foreland. Considering the period of concern of 1 Ma for high-level nuclear waste repositories, glacial erosion needs to be addressed for assessing their long-term safety. As one approach to better understand the formation processes of Quaternary valleys, a literature review of tunnel valleys outside the alpine realm was carried out. The focus of the review is on tunnel valleys in northern Europe, which have been investigated in detail.

Tunnel valleys are defined as large, elongated, overdeepened depressions cut into sediments or bedrock. They occur as individual segments or as an anastomosing network, are often several kilometres long, maximum a few hundred metres deep and hundreds of metres up to a couple of kilometres wide. Usually they are steep-sided with flat undulating bottoms, begin and terminate abruptly and are open or filled with sediments. Tunnel valleys are formed below past ice sheet margins, and are generally oriented parallel to the subglacial hydraulic potential gradient. The most important formation processes of tunnel valleys discussed in the literature include meltwater drainage, catastrophic outbursts (jökulhlaups) and sediment deformation, and are occasionally combined with direct glacial erosion.

Extremely eroded or incredibly young – ^{10}Be depth profile dating of moraines in the Swiss Midlands

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During the Pleistocene, glaciers advanced repeatedly from the Alps into the Swiss Midlands. The exact extent and timing are still under debate, even for the last glacial advances. Decalcification depths, for example, increase from west to east in the western Swiss Midlands and have been interpreted to indicate that the Valais (Rhone) glacier may have been less extensive during the global Last Glacial Maximum (LGM) at 20 ka than assumed so far (Bitterli et al., 2001).

In an attempt to provide more quantitative age control, we applied ^{10}Be depth profile dating (Hidy et al., 2010) on moraines at two locations. Steinhof has previously been dated to the global LGM based on exposure ages from four boulders (Ivy-Ochs et al., 2004), and Niederbuchsiten presumably lies outside the last glacial ice extent (Bitterli et al., 2001). The ^{10}Be concentrations at both sites decrease consistently with depth, but are very similar. Assuming only a few decimeters of erosion since moraine deposition, we obtain apparent exposure ages of ~20 ka. Niederbuchsiten would thus be incredibly young, implying a much more extensive extent of the LGM glacier than assumed so far. Alternatively, if the till at Niederbuchsiten was deposited during or before the penultimate glaciation (>130 ka), the surprisingly low ^{10}Be concentrations indicate several meters of erosion during the last glacial cycle and/or the Holocene, which seems to be at odds with the deep and intensive soil formation.

References

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