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11. Quaternary environments: landscapes, climate, ecosystems, human activity during the past 2.6 million years

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11. Quaternary environments: landscapes, climate, ecosystems, human activity during the past 2.6 million years

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Swiss Society for Quaternary Research (CH-QUAT)

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11.1
Fluctuations of the Eastern Antarctic Ice Sheet in Queen Maud Land

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Today, Sør Rondane Mountains in the Queen Maud Land acts as a barrier to the Eastern Antarctic Ice Sheet in Antarctica. This is displayed by the difference in altitude of the ice surface to the south and north of the mountain chain. To the south, ice surface reaches altitudes above 2500 meters above sea level and forms an ice plateau. Lowlands of ice are found at altitudes of around 1500 meters to the north of the mountain chain. Huge glacier tongues, such as Hansen, Gunnestad and Byrd glaciers among others, are actively draining the ice from the plateau to the lowlands. The focus of this study is on the records of deglaciation of the Eastern Antarctic Ice Sheet (EAIS) and subglacial erosion in the Sør Rondane Mountains (Figure 1). Therefore, our goal is to reconstruct the changes in the drainage pattern of the EAIS in time. To do this, we will reconstruct the chronology of deglaciation by surface exposure dating the ice margin records and determine the rates of subglacial erosion by analyzing suite of in-situ produced cosmogenic nuclides (^{10}Be, ^{14}C, ^{26}Al and ^{36}Cl) in the surfaces of glacially molded bedrock.

During the first field campaign in the Sør Rondane Mountains in the Queen Maud Land at the Princess Elisabeth Station within the BELARE 2017-2018 Expedition between January 11 and February 12 2018 under the auspices of Turkish Republic Presidency, supported by the Ministry of Science, Industry and Technology, and coordinated by Istanbul Technical University Polar Research Center, we first visited nunataks south and west of Princess Elisabeth Station: Utsteinen, Perlebandet and Teltet nunataks. Among these, we studied Utsteinen nunatak and the local terminal moraine in detail. Utsteinen is composed of granite and pegmatite. We then identified abandoned valleys. These are located few hundred meters above today's active glaciers and free of ice. Therefore, we focused on: (1) the Dubois Pass in Vikinghøgda; (2) the Dry Valley and the Ketelers Glacier in Widerøe Mountains; and (3) Nunataks on the right-lateral of the Gunnestad Glacier, to the east of the Yuboku Valley in Walnum Mountains (Figure 1). Finally, we completed the reconnaissance study of Mount Nils Larsen. These nunataks are made of Late Proterozoic Amphibolite-facies and lower-grade metamorphic rocks intruded by Paleozoic granites and pegmatites and partially covered by Quaternary tills except for the Dubois Pass, which consists of granulite facies metamorphic rocks.

In order to go back in time with the drainage pattern of the Eastern Antarctic Ice Sheet, we collected 38 surface samples from the erratic boulders left in these valleys by the ice at the time of surface lowering. We analyzed the accumulation of in-situ cosmogenic ^{10}Be, ^{14}C, ^{26}Al and ^{36}Cl in these samples and then determined the timing and amount of the thinning of the ice sheet, as well as the subglacial erosion. First results will be presented.

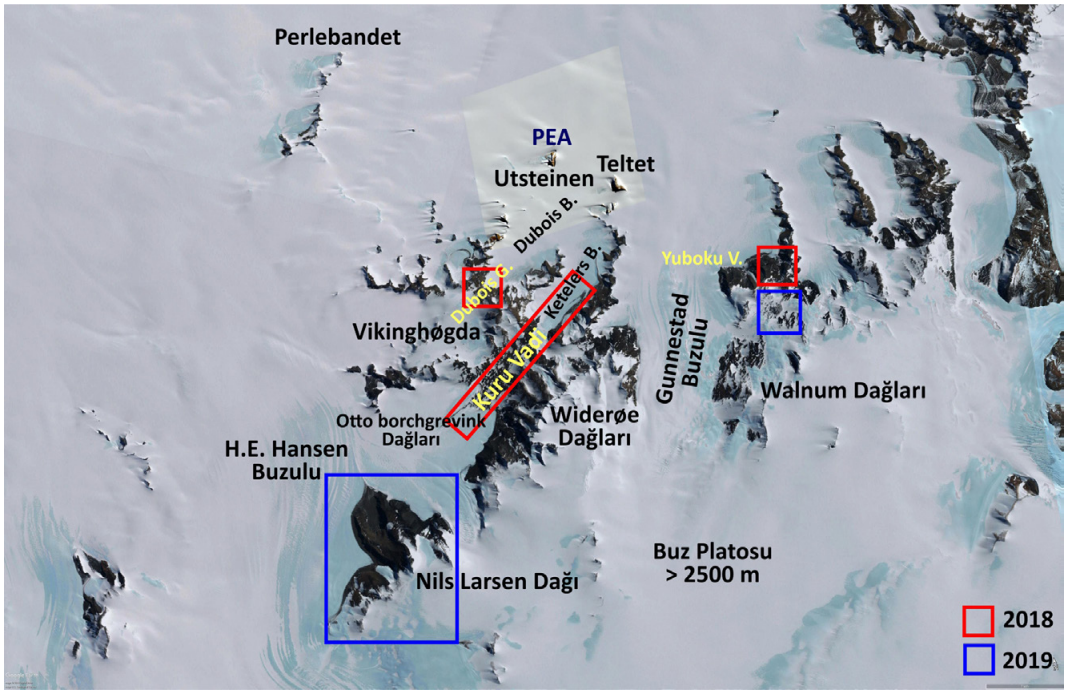

Figure 1. Location of PEA and nunataks in the western Sør Rondane Mountains. Red rectangles indicate the studied nunataks during the BELARE 2017-2018. Blue rectangles show the nunataks proposed for the BELARE 2018-2019.

11.2
An attempt to reconstruct planetary radiative imbalance over the last 40,000 years

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Global climate change arises from an energy imbalance at the top of the atmosphere (TOA). The direct measurement of TOA radiative fluxes is difficult even today, such that most assessments of it are based on changes in the total energy content of the Earth system. We apply the same approach to estimate the long term evolution of the planetary radiative imbalance in the past.

The energy budget of the climate system is dominated by the ocean's heat capacity. On Pleistocene timescales the latent heat changes associated with the waxing and waning of the large ice sheets are of similar magnitude as the ocean heat uptake. Ice core noble gas thermometry allows us to estimate changes in ocean heat content, while sea level reconstructions provide a measure for the contribution of the ice sheets from their latent heat release or consumption. The temporal derivation of the sum of these two dominant components should yield the planetary radiative imbalance.

We present measurements of noble gas derived mean ocean temperature from the EDC ice core covering the past 40,000 years. We infer TOA radiative imbalance as described above. As expected from the relatively stationary climates of the last glacial maximum and the Holocene, the radiative imbalance is close to 0.0 W/m^2 in those periods. During the deglaciation a positive imbalance is maintained for ~10,000 years, with two distinct peaks that reach up to 0.4 W/m^2, highlighting the importance of internal variability in the climate system.

11.3
Influence of the geology and meteorological conditions on indoor radon concentrations in the Jura mountains: preliminary results of the Interreg project Jurad-bat

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Radon is a natural radioactive gas present everywhere in the earth's crust and may cause lung cancer when it decays after inhalation (WHO 2009). In Switzerland, it is the second cause of lung cancer after smoking and after the Federal Office of Public Health (FOPH, https://www.bag.admin.ch): 200-300 deaths per years are linked to radon. As the product of the decay of Uranium, radon is present everywhere and preferentially on igneous rocks. In Switzerland, we find higher radon concentrations in Aples but also in the limestones of Jura. The amount of indoor radon concentrations depends on the underlying rocks but also of the permeability of the soils, routes (faults, folds, sinkholes, …) driving the gas to the surfaces (Pampuri et al., 2018) and on meteorological conditions.The goal of the Interreg (France – Switzerland) project Jurad-bat is to improve knowledge of the indoor radon risk management, to create a database collecting cross-border data on indoor air quality and to develope a WEB plateform. Through this platform, different public (such as building professionals, architects, deputy as well as large public…) will be able to share experiments, ask for questions, search for informations, training and so on.

In order to do so it is of great importance to have a better knowledge of radon dynamic at the interface in between the soil under the house and the indoor air. So we have to caracterise the influence of the geology and meteorological parameters on the fluctuations of the gas inside builings located in the Jura mountains. Figure 1a present the studied area and the results of radon measurements (national database of Swiss FOPH) exceeding the new limit value of 300 Bq/m^3 (Ordonnance sur la radioprotection, ORaP 2017). As first constatation, we can note a huge concentration of building exceeding the new reference value and that a significant amount of these points are located in the proximity of folds and geologic faults. However limestone is not known for it's uranium enrichment which is the mother of radon gas. What do explain this unusual occurrence? Does it have a specific impact on indoor radon concentration?

Considering the geology and tectonic structure of the soil to study the impact of meteorological conditions and the influence of a building on radon concentration variations, two houses were instrumented for one year. Measurements are still going. One building is a 1895 familial house completely renovated and located on Neuchâtel lake's shore. The second one is an old farm (~ 1850) partially refurbished and situated at la Brévine that is located at 1000 meters altitude. In these two buildings, we measure the same parameters in analogous conditions. The parameters are radon concentration,

temperature, atmospheric pressure, humidity, indoor and outdoor pressure differential and $C0_2$ with a timestep of 60 minutes. Measurments are also conducted in the soil around the houses. Meteorological conditions of the two places are coming from the closest meteorological stations from MeteoSwiss. Through these two cases, we noticed the influence of the human behavior and indoor conditions on radon concentration.

In Figure 1b present 10 days measurements of radon concentration and pressure in a non-isolated North-West oriented room . We can see that radon concentrations are inversly correlated with indoor pressure variations. Indeed, high radon concentrations, 1730 Bq/m^3 for the higher, correspond to lowest pressure values, 880 hPa.

To summarize, the indoor radon concentration depends on the nature of the underlying soil and rock, the meteorological conditions but also the type of building and the behavior of the inhabitant.

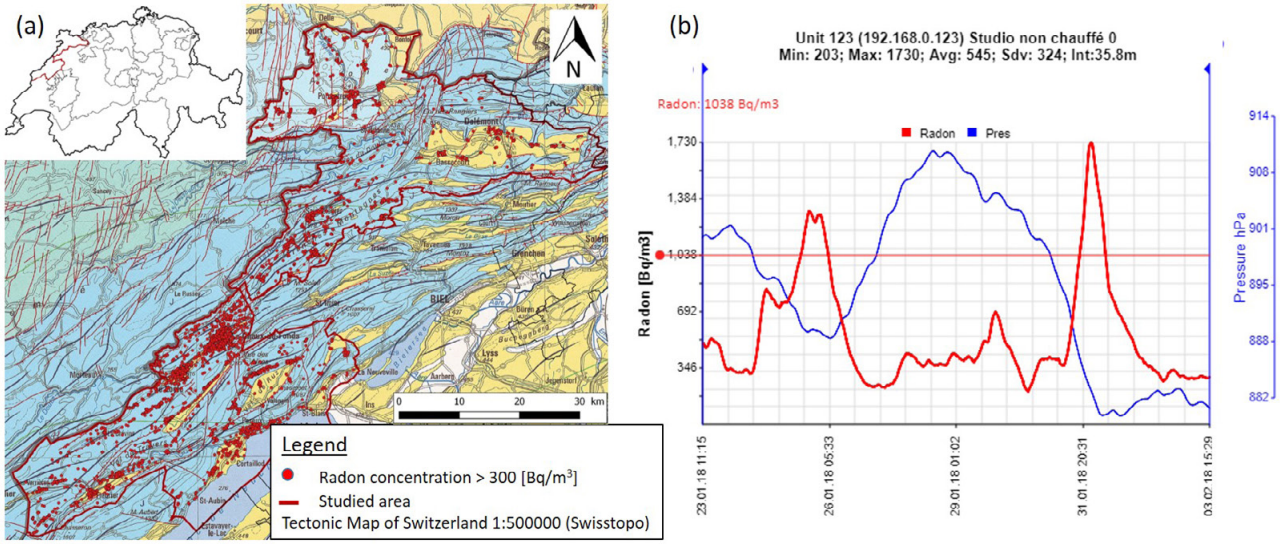

Figure 1. (a) indoor radon concentrations higher than 300 Bq/m^3 in the Jura and Neuchâtel cantons; (b) indoor radon concentration during a 10 days period and the pressure.

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11.4
Timing the deposition of Swiss Deckenschotter with cosmogenic isochron burial dating

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The landscape in the northern Alpine Foreland is the combined result of numerous glaciations as well as tectonic and climatic processes. Aggradation of glaciofluvial sediments and the subsequent fluvial incision led to the development of terraces. The oldest terraces preserved in the Foreland – the so-called Deckenschotter – are morphostratigraphically divided into the Higher and Lower Deckenschotter units which are separated mostly by a significant altitude difference of ~100-150 m. Both gravel terraces represent spatially extensive paleosurfaces and can form plateaus up to 200-300 m above the modern valley bottom. The Higher and Lower Deckenschotter terraces have originally been defined due to their specific altitude range and a strong incision event must have been occurred between. Knowing the timing of deposition and incision of these terraces is of special interest for modelling the long-term safety of the deep geological repositories for nuclear waste disposal in the northern Alpine Foreland (NAGRA, 2014). Furthermore, absolute ages of former fluvial systems are crucial to establish incision and erosion scenarios, river drainage patterns and related base-level reconstructions.

Dating glaciofluvial gravels which are much older than the age range of radiocarbon methods has been a challenge. However, Balco and Rovey (2008) presented the isochron burial dating approach to determine a depositional age of a sediment unit. The method makes use of the differential decay of an in-situ produced nuclide pair in a mineral target (here: ^{26}Al and ^{10}Be in quartz) and the fact that pebbles in the initial fluvial sediment have different nuclide signatures due to varying erosion. The measured nuclide ratios of ^{26}Al and ^{10}Be enables to reconstruct a regression through the data in the ^{26}Al-^{10}Be-Plot whose slope is indicative for the age. A recent publication proves the applicability of the method but also discusses the problems of measuring ^{26}Al in old glacial sediments (Akcar et al., 2017). The low inheritance of glaciofluvial sediments and a subsequent long burial time result in low ^{26}Al concentrations and therefore a low ^{27}Al background is required because of the ^{26}Al/^{27}Al detection limits. Accordingly, careful cleaning of the samples is needed. Samples with a sufficiently low total Al content were further processed for the analysis of cosmogenic ^{10}Be and ^{26}Al.

In this study, we aim to reconstruct the chronology of the Deckenschotter units along a transect in space and time at three locations: the gravel pit Tromsberg in Kirchdorf (AG) and Feusi in Oberweningen (ZH) which both represent the Higher Deckenschotter (HDS) of the Dürn-Gländ region and a nearby gravel pit at Bärengraben in Würenlingen (AG) representing the Lower Deckenschotter (TDS) of the Iberig region. Previous age estimates for HDS suggest an age range of 1.5 ±0.2 Myr based on isochron burial dating at the nearby site Siglistorf which is farther north of the sampled sites (Akçar et al., 2017) and 1.8 to 2.5 Myr based on mammalian faunal assemblages (MN17) at site Irchel (Bolliger et al. 1996). At all three sites, a combination of pebbles from various lithologies, sand lenses and amalgated vein quarz clasts were sampled at the base of the 10-15 m high outcrops in order to maximize the spread in the data.

Additionally, two sites representing valley fillings during the period of the Hochterrasse (HT) are attempted to date. A gravel pit in Beringen (SH) representative for the Klettgau valley filling was chosen for a cross-calibration with recently established luminescence chronologies (Lowick et al., 2015). The latter question a previously established age estimates based on the interpretation of sedimentary facies and lithostratigraphy (Graf, 2009) making an independent age estimate desirable. Here, sands and pebbles at the base of the active, 40 m deep gravel pit were collected assuming that shielding was nearly complete and postburial production is negligible. The same principle of “true” or simple burial dating was applied to a drillcore from Glatttal valley filling (drill core Bülach, Buechi et al. (2018)). Again, existing luminescence data serve as an opportunity to cross-calibrate the age of the sediment deposition.

We will present some initial field and preliminary analytical data. First age estimates from sites with a solid data base will be presented and discussed in the context of landscape change.

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11.5
Glacial chronology of the Bale Mountains and its implications for the early human occupation of the southern Ethiopian Highlands

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The Bale Mountains in southern Ethiopia represent the largest afro-alpine environment above 4,000 m on the African continent (Miehe & Miehe 1994). Even though ice caps and outlet glaciers are absent in the southern Ethiopian highlands nowadays, typical landscape features (U-shaped valleys, cirques, moraines, erratic boulders, roche moutonnées etc.) as well as geomophological phenomena (e.g. large sorted patterned grounds) indicate different phases of extensive glacial and periglacial activity in the Bale Mountains during the Pleistocene (Osmaston et al. 2005). Detailed knowledge of the glacial history and palaeo-climate in the region is still lacking, as it is for most of the high African mountains, except for Mt. Kenya, Kilimanjaro and Rwenzori (Mark & Osmaston 2008). Information on the timing and extent of the maximum glaciation in southern Ethiopia are contributing to a better understanding of the palaeo-climate and landscape evolution of the alpine environment. They serve as an important proxy for palaeo-ecologists and archeologists to answer the question whether humans already migrated to the more humid and meltwater-supplying mountains in East Africa during the late Pleistocene – a period when the lowlands were dry and probably uninhabitable. The extent of palaeo-glaciations in southern Ethiopia is determined by extensive mapping of terminal and lateral moraines in the field as well as on high-resolution satellite imagery. Surface exposure dating is applied to 75 boulders from the Bale and Arsi Mountains to constrain the timing of the different glacial stages.

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11.6
Twannberg: Meteorite strewn field and glacial transport

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Since the find of the first 15.9 kg piece of the Twannberg meteorite in 1984, numerous additional specimens have been found, mainly 2015-2018. By end of August 2018, >1130 specimens with a total mass of ~120 kg were known. Twannberg is part of the extremely rare type IIG class of iron meteorites (Hofmann et al. 2009, Wasson & Choe 2009), which allows the easy recognition of new finds as being part of the same fall event. Twannberg meteorites occur in three find areas (Fig. 1): A mass-sorted strewn field relict of 5.7x1 km is present on Mont Sujet (altitude 1000-1370 m), while finds in the Twannberg-Magglingen area are distributed over 3.2x0.9 km (altitude 950-1080 m), show no mass-sorting and are associated with glacial till external of the Last Glacial Maximum (LGM). A series of smaller fragments was found in the Twannbach canyon, where they likely were eroded out from pre-LGM till. The mass-sorted Mont Sujet finds indicate a fall direction from northeast to southwest. Twannberg was a large meteorite with a pre-atmospheric mass of at least 250 t (Smith et al. 2017). The age of the Twannberg fall is 202±33 ka based on $^{41}Ca/^{36}Cl$ (Smith et al. 2017), possibly lower by ~20 ka when using an updated half life for ^{41}Ca (Smith et al. 2018).

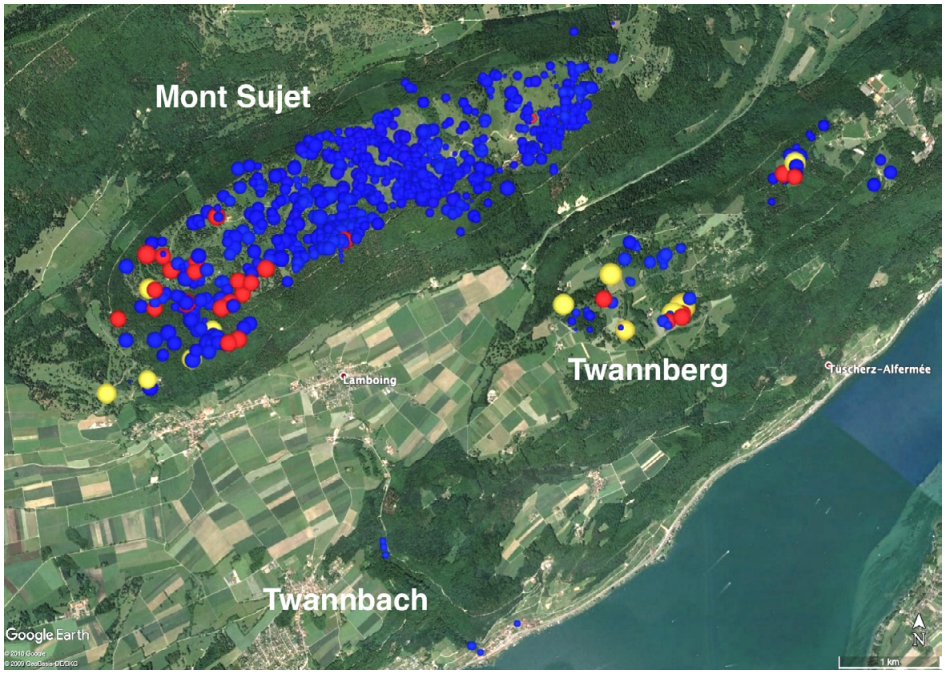

Figure 1. Known distribution of Twannberg meteorite finds as of August 2018. Blue: <0.4 kg, red: 0.4-1 kg, yellow: >1 kg. Lake of Biel is at bottom right. Image: Google Earth.

The terrestrial age is surprisingly high, but consistent with associated glacial sediments of the second last glaciation (Beringen or MIS6). The currently observed distribution of meteorite fragments in the Twannberg-Magglingen area requires glacial transport in direction northeast over a distance of at least 5-10 kilometers shortly after the fall event.
Absence of mechanical wear, as demonstrated by preserved fusion crust on some transported specimens, indicates a transport on the ice, and not at the base of the glacier. The most likely scenario is a fall on the ice, followed by transport over several kilometers. The presence of a part of the undisturbed strewn field on Mont Sujet shows that moving ice did not affect the higher parts of Mont Sujet above ~1200 m altitude at the time of the fall. The distribution of Twannberg meteorite fragments therefore provides information about the minimum extent of the second last glaciation in the Swiss Jura. Attempts to date meteorite-hosting loess-like soils on Mont Sujet and a glacial boulder at ~1300 m altitude in the area are currently underway.

The search for Twannberg meteorite fragments is mainly carried out by a group of meteorite collectors-enthousiasts in close collaboration with the Natural History Museum Bern, the “Abteilung Naturförderung, Amt für Landwirtschaft und Natur (LANAT)” of the Canton of Bern and the Archaeological Survey of the Canton of Bern.

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11.7
^{10}Be exposure dating reveals multiple glacier advances and still stands in the southern Écrins massif (French Alps) during the Late Glacial and the Early Holocene

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The chronology of post-Last Glacial Maximum (LGM) glacier fluctuations in the French Alps is poorly understood and only few chronological constraints on Late Glacial and Early Holocene glacier variability have hitherto been obtained (e.g. Chenet et al. 2016). This study aims at filling this gap by mapping and dating moraines in two neighbouring valleys in the southern part of the Écrins massif. Some of the pre-Little Ice Age (LIA) moraines in one of the valleys have already been mapped and assigned to the Late Glacial/Early Holocene transitional period (Hofmann 2016). Therefore, these moraines were considered a suitable target to obtain additional chronological benchmarks to enable palaeoclimatic as well as palaeogeographic reconstructions.

As a first step of the study, aerial photographs from the French National Institute of Geographic and Forest Information (IGN) were used for establishing a Digital Surface Model (DSM) and an orthophoto of the study area through the use of the structure-from motion approach. The moraines in the studied area were mapped using a combination of a DSM-based hillshade, field notes and photographs and were numbered based on their relative position in the field to finally establish a morphostratigraphy.

Secondly, the ^{10}Be concentration in the quartz mineral fraction of 41 boulders from selected moraines was determined to infer the duration of their surface exposure to cosmic rays. The obtained ^{10}Be exposure ages were then compared with previously published ^{10}Be exposure ages from moraines at key sites across the Alps, recalculated according to the most recent published production parameters for suitable comparison.

As a third step, the Equilibrium Line Altitude (ELA) depression relative to the end of the LIA during the deposition of all pre-LIA moraines in the study area was reconstructed to allow for stratigraphical correlations of non-sampled moraines with dated moraines. The GlaRe ArcGIS toolbox (Pellitero et al. 2016) was used to establish digital elevation models of the palaeoglaciers during moraine deposition. The application of a second ArcGIS toolbox (Pellitero et al. 2015) enabled their ELAs to be determined, whereby an accumulation area ratio of 0.67 was assumed throughout, as done elsewhere in the Alps (Ivy-Ochs 2015).

A ^{10}Be exposure age from a large boulder on the distal side of the lowermost sampled moraine indicates that this moraine may have been shaped during a temporary halt in glacier recession or the culmination of a glacial re-advance before the onset of Greenland interstadial 1. Given the location of the moraine at the confluence of two valleys, the moraine was probably deposited at the common margin of the glaciers from both valleys. During this potential event, the ELA of the palaeoglacier from the southern valley was depressed by about 210 m relative to the LIA ELA, whereas the ELA of the formerly confluent two glaciers from the northern valley must have been situated at a 500-600 m lower elevation than at the end of the LIA. The moraine was certainly reached or re-occupied by the palaeoglacier from the southern valley at the onset of Greenland Stadial 1 (GS-1) when the ELA was 220 m lower than at the end of the LIA. The ^{10}Be exposure ages indicate multiple glacier advances or still stands during GS-1 and potentially during the Early Holocene which were associated with ELA depressions of 120-220 m relative to the end of the LIA.

The review of data from regional and hemispheric palaeoclimatological archives other than glaciers suggest that the lowermost sampled moraine was shaped or re-occupied during a glacial re-advance which was triggered by the hemispheric cooling at the onset of GS-1. The agreement of our new ^{10}Be exposure ages with recalculated exposure ages from moraines at other sites in the Alps that have been assigned to the Egesen and the Kartell stadials, suggest a common climatic origin of the glacier advances or still stands. Since the reconstructed ELA depressions in the southern Écrins massif during the Late Glacial/Holocene transitional period are in good agreement with the results of previous studies from

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the Austrian and Swiss Alps (Ivy-Ochs 2015), it can be inferred that these regions were then subjected to atmospheric circulation patterns similar to those at the end of the LIA. Overall, the new ^{10}Be exposure ages contribute to a significant refinement of the chronology of post-LGM glacier fluctuations in the Écrins massif.

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11.8
Quantifying subglacial erosion beneath the Tsanfleuron glacier, Switzerland

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Knowledge of subglacial erosion rates is critical for understanding the long-term evolution of the shape of the Alps. In most cases subglacial erosion rates are estimated over the whole glacier footprint by measuring the sediment (entrained and dissolved) load in the outflowing meltwater. As production of cosmogenic nuclides drops-off predictably with depth down into rock, measurement of their concentrations allows quantification of the depth of erosion into bedrock beneath a glacier (Wirsig et al., 2017). Both methodologies, meltwater sediment yield and cosmogenic nuclides, have thus far only been used in crystalline bedrock. Subglacial erosion on a limestone bed has rarely been directly, quantitatively measured before. In contrast to a crystalline bed, the presence of karst plays a decisive role. Therefore our primary scientific question is: To which extent and in which way does the presence of subglacial karst affect the hydrological drainage system and influence glacial erosion rates and patterns across the bed of the Tsanfleuron glacier.

We use a combined approach of detailed geomorphological mapping and cosmogenic nuclide measurements to ascertain how much the Tsanfleuron glacier has eroded its limestone bed over the last several millennia. The Tsanfleuron glacier (ca. 3 km^2 in 2015) is located on a gentle slope near Sanetschpass in the western Swiss Alps. Since the Little Ice Age, ongoing glacier retreat revealed more and more of the polished limestone bed. Furthermore, abundant straight and sinuous subglacial Nye-channels, as well as scallops on the lee-side of roche mountonnées can be observed. Karst features of the glacier forefield include swallow holes and pervasive fault-controlled linear drainage entryways. Study of these features was enabled by high resolution imagery and digital elevation model (8 cm) acquired with a drone (E-Bee; https://www.sensefly.com/drones/ebee.html), which supported field mapping and production of a detailed geomorphological map.

A first set of 14 samples were taken inside and outside of the prominent LIA moraine and analysed for ^{36}Cl concentration. To calculate the subglacial erosion rates the MECED model by Wirsig et al. (2017) was used. The combination of the detailed map and the determined erosion rates give new insights on how karst drainage of subglacial meltwater affects subglacial abrasion by the Tsanfleuron glacier. These preliminary results will be complemented in summer 2018 with additional samples taken very close to the current ice margin. Multi-decimetre drill cores of the limestone will be used to look at the ^{36}Cl production depth profile to provide additional information about erosion patterns in the former glacier bed.

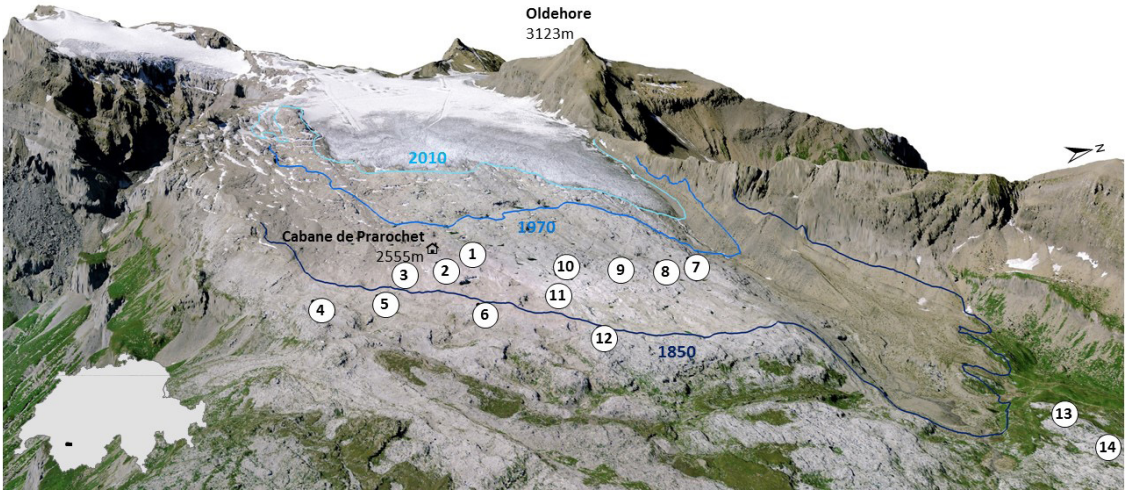

Figure 1. 3D view of the Tsanfleuron glacier, produced with a SWISSIMAGE 1 m and 25 cm resolution on the swissALTI3D (2 m resolution), Geodata © swisstopo.White numbered dots show sample location and number. The glacier is, at its front, approximately 1.7 km wide

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11.9
Neotectonics drove landscape evolution in SW Amazonia

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A growing number of studies suggest that the Holocene has been a period of important paleoecological and landscape changes in SW Amazonia. These changes have been triggered by a combination of factors: neotectonics, climate change and river avulsions.We know that the southern movement of South American Summer Monsoon caused an increase in precipitations at about 4 to 3 kyr BP and the southward expansion of the Amazonian rainforest into north-eastern LM at the expense of the savannah; and that large scale river shifts formed fluvial distributary systems that covered most of the Bolivian Amazon. However, despite clear evidence of neotectonic activity during the Holocene, the contribution of this to the shaping of the landscape of SW Amazonia is still unclear. Here, I will present new data, retrived from remote sensing and field work in the Bolivian Amazon, showing how and when neotectonic events controlled both vegetation and river dynamics.

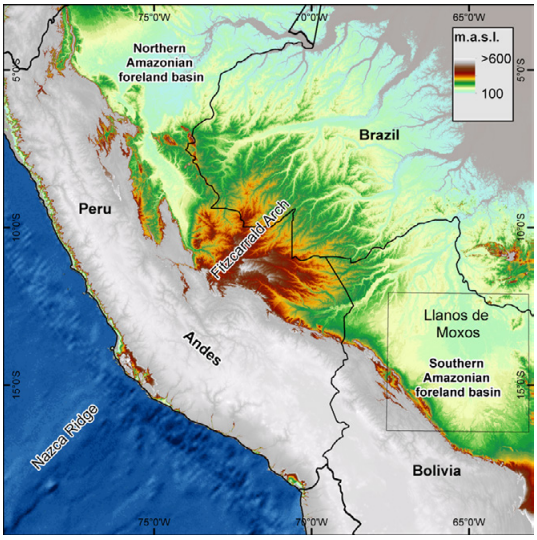

Figure 1. Topographic map of western South America with some important geological features. The south-eastern part of the Fitzcarrald Arch constitutes the LM's north-western border, which, together with the Brazilian Shield, to the north-east of the LM, forms a continuous barrier which impedes the drainage of the LM

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11.10
A new speleothem record of the last interglacial (MIS-5e) from the Sieben Hengste

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Quantifying the duration and magnitude of past interglacials is of prime importance to understand ecological adaptation to a warmer world. The Swiss Alps are particularly sensitive to even small hydroclimatic changes and thus require reliable records to unravel the complex spatial response. Here, we present a new speleothem record (7H-12) from the Sieben Hengste cave system, Switzerland, encompassing the last interglacial period (MIS-5e). The onset into the interglacial is dated at 129.8± 0.8 ka, consistent within error with other recently published records of Termination II for the European Alps (Häuselmann et al., 2015; Moseley et al., 2015). However, in marked contrast to these speleothem records, 7H-12 shows a rapid increase in $\delta^{18}O$, which reaches a climax at 128.4±0.8 ka and is followed by a gradual depletion until 117.5 ka. This distinct pattern, characterized by low interannual variability, suggests that 7H-12 was little affected by local processes and, thus, may represent a robust archive for the last interglacial at a regional scale. Pollen extraction from the speleothem calcite reveals concentrations of ca. 20 palynomorphs per gramm, with tree pollen assemblages dominated by *Alnus*, *Hedera, Corylus* and *Picea.* Several of these species are presently absent from the cave's hydrological catchment area, clearly indicating warmer conditions consistent with the stalagmite $\delta^{18}O$ record. Overall, this sample offers a unique opportunity to quantify the amplitude of the climate signal and its regional paleoenvironmental response over the entire last interglacial.

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11.11
New insights into the detachment mechanism, runout and age of the Kandersteg rock avalanche

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In this study, improved understanding of the timing and process of the Kandersteg rock avalanche was achieved through a combination of field and remote mapping, cosmogenic nuclide dating and runout modelling. The Kandersteg rock avalanche is one of the largest rock slope failures in the Alps. Its volume was estimated to about 750 - 900 million m^3 and the landslide deposit stretches over about 10 km^2.

The event has previously been suggested to have occurred 9600 years ago based on dating lacustrine deposits underlying reworked rock avalanche material (Tinner et al. 2005). However, new ages derived from direct dating of the blocky landslide deposit can be presented in this study. This new understanding of the time of failure puts the Kandersteg rock avalanche in a new context.

Structural analysis of the source area shows that the basal sliding plane largely follows bedding. Bedding planes of Oehrlikalk with interbedded marl layers must have acted as a weakness zone crucial for the detachment of the event. Today's prominent lateral scarp of the rock slope failure is marked by a steeply dipping fault oriented NW-SE. This fault can be assigned to a prominent discontinuity set in the study area which is oriented normal to the fold axis of the regional-scale Doldenhorn fold. In the head scarp of the Fisistock release area both bedding planes and a steeply NW dipping discontinuity set are exposed.
It can be concluded that the structural setting of the Kandersteg rock avalanche fulfills the typical criteria for the development of large translational rock slope failures. The Kandersteg rock avalanche can hence be seen as an impressive and classical example for a structurally controlled rock slope failure.

Through field observations, structural analysis and runout modelling using DAN3D one can separate four main phases of rock avalanche emplacement. In a first phase, the rock mass detached from the upper fold limb of the recumbent Doldenhorn nappe along pre-existing discontinuities. The sliding body then fragmented and hit the valley floor and steep valley sides near Kandersteg causing intense crushing of the main landslide body but preserving a characteristic boulder carapace. In a next phase the dry fragmented rock avalanche propagated northward over a substrate of fluvial sediments. The source rock stratigraphy was preserved in the deposit. Tertiary sandstones outcropping high up on the Fisistock were deposited farthest from the source while Kieselkalk boulders are found predominantly in the proximal parts of the deposit overlying the main landslide body composed of Oehrlikalk. Internal tensile deformation of the landslide body led to the formation of hummocky terrain with transverse ridges. In a final phase the landslide became more fluid through entrainment of water and water-rich sediments. Landslide movement continued northwards where it stopped at a distance of around 10 km from the source approximately 8 minutes after initial failure. The results of this study hence provide fundamental information on emplacement processes of long-runout events that evolve into more fluid mass movements due to the entrainment of sediment substrate.

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11.12
Seismic analysis of overdeepened Quaternary deposits, northern Switzerland

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Quaternary deposits in overdeepended valleys in northern Switzerland provide important data for the site selection of geological repositories for radioactive waste in Switzerland (Nagra, 2014). Specifically, high-level radioactive waste must be placed deep enough not to be critically affected by future glaciation periods and related erosion processes. In order to improve the characterization of Quaternary deposits around Glatt and Thur rivers (Figure 1), Nagra undertook a 2D reflection seismic campaign in the winter of 2016/17. In this article, we outline the survey design, data acquisition, summarize its processing and highlight key interpretation results.

The project design was guided by (1) identification of geologically significant sections across the Glatt and Thur valleys, (2) proximity of borehole information, and (3) feasibility of seismic data acquisition with respect to topographic and cultural obstacles. The seismic survey included 16 seismic lines with a total length of 41.7 km (ca. 5200 shot points; 63% by vibrator and 37% dynamite sources). Individual line lengths varied from 1.5 to 6.6 km. The acquisition density and related field parameters also varied and were chosen with respect to the expected target depths. The seismic data acquisition itself was commissioned to a contractor (DMT, Germany).

The seismic data processing involved geometry setup, static corrections (restricted to the mostly thin weathering layer), signal enhancement, stacking velocity analysis, normal moveout correction, residual statics, stacking and post-stack Kirchoff time migration. A key advance of the time imaging analysis was to limit the static corrections to shallow depths, thereby keeping relatively low velocities in the Quaternary deposits. For this reason, reflections from underlying Tertiary and deeper deposits presented an artificial curvature.

We corrected this artificial curvature by application of a wave-equation post-stack depth migration procedure. This procedure required line-specific velocity fields that were developed using an iterative process combining interpretation and processing techniques. Information from the boreholes, preliminary deposit shapes and geological plausibility criteria were combined with velocity measurements to construct the velocity fields.

The resulting time and depth migrated images were used to provide new insights of the Quaternary deposits by developing geologically plausible shapes of the base Quaternary horizons. Typical truncations of reflectivity were generally recognised in the survey areas, resulting in a new record of the valley flanks. The Quaternary-internal structure was assessed by projecting lithological markers and units from available boreholes onto the seismic lines. Moreover, the linking of lithological units with a certain seismic signature guided the characterisation of the Quaternary infill.

This study provides important new advances into the infill record of the overdeepend valleys. Furthermore, it served as important database for the siting of new Quaternary exploration boreholes. The core material from these boreholes in combination with the results from this study promise new insights into the complete infill record of overdeepend valley-forming processes.

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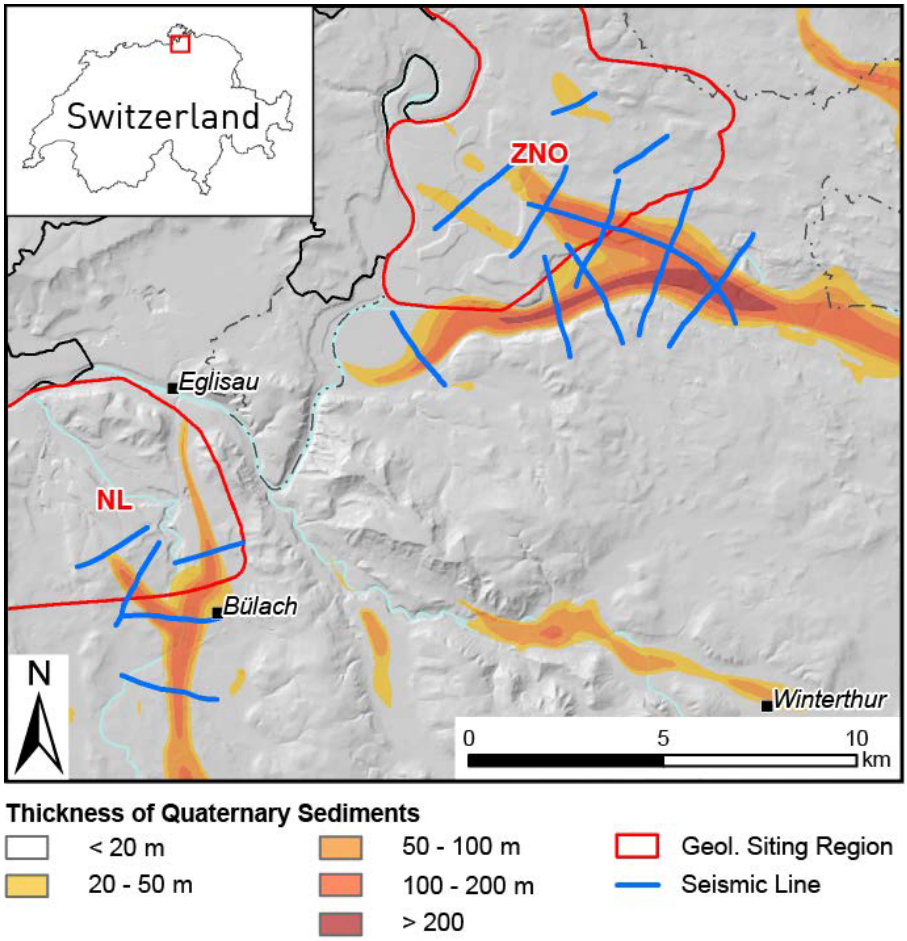

Figure 1. Map showing overdeepend Quaternary deposits in the siting regions for high-level radioactive waste Nördlich Lägern (NL) and Zürich Nordost (ZNO). The seismic line layout is shown in blue.

11.13
Increased nutrient supply to the Southern Ocean during the Holocene and its implications for the pre-industrial atmospheric CO_2 rise

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A rise in the atmospheric CO_2 concentration of ~20 parts per million over the course of the Holocene has long been recognized as exceptional among interglacials and is in need of explanation. Previous hypotheses involved natural or anthropogenic changes in terrestrial biomass, carbonate compensation in response to deglacial outgassing of oceanic CO_2, and enhanced shallow water carbonate deposition. Here, we compile new and previously published fossil-bound nitrogen isotope records from the Southern Ocean that indicate a rise in surface nitrate concentration through the Holocene. When coupled with increasing or constant export production, these data suggest an acceleration of nitrate supply to the Southern Ocean surface from underlying deep water. This change would have weakened the ocean's biological pump that stores CO_2 in the ocean interior, possibly explaining the Holocene atmospheric CO_2 rise. Over the Holocene, the circum-North Atlantic region cooled, and the formation of North Atlantic Deep Water appears to have slowed. Thus, the 'seesaw' in deep ocean ventilation between the North Atlantic and the Southern Ocean that has been invoked for millennial-scale events, deglaciations and the last interglacial period may have also operated, albeit in a more gradual form, over the Holocene.

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11.14
How was the amount of precipitation perturbed during the Late Pleistocene in North Africa?

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During the Late Pleistocene, several studies have identified climate oscillations in North Africa based on changes of paleodischarge and sediment loads from the Atbara, Blue Nile and White Nile and from cave speleothems in northern Africa and southern Europe (Foucault and Stanley, 1989; Hoffmann et al., 2016). These studies concluded that climate oscillations during the Late Pleistocene were associated with six well-documented wet phases between 65 ka and 10 ka ago.

Independently of the above mentioned studies, several generations of inverted channel segments in the southern part of Egypt and northern part of Sudan have been identified by field and remote sensing studies (Giegengack, 1968; Zaki and Giegengack, 2016; Giegengack and Zaki, 2017). These river channels evidence that much wetter conditions existed in the past in the Sahara Desert. A chronological framework for these geomarkers is necessary to propose a robust paleoclimate reconstruction. Several of these outcrops are now submerged beneath the waters of Lake Nasser, however in this study, we collected samples from other outcrops in the southern part of Egypt in order to explore their potential association with the wet phases of the Late Pleistocene and the implications for landscape response to extreme climate change. The analyses planned involve ^{14}C, Optically-Stimulated Luminescence, and cosmogenic nuclide dating to constrain the ages of these outcrops and the timing of incision and infilling of the preserved channels. In addition, we will present new data on channel geometry, grain size and inferred paleoslopes with the aim of estimating paleodischarge.

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P 11.1
Temperature reconstruction using speleothem fluid inclusions from Milandre cave, Jura Mountains, Switzerland

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Apart from the well-known ice core archive in the polar region, speleothems are a great alternative for providing a direct witness of the past water cycle for low to middle latitudes. Among speleothems, stalagmites constitute a well preserved and precisely dated continental climate archive that record past environmental and climate changes namely through carbon ($\delta^{13}C_c$) and oxygen ($\delta^{18}O_c$) isotope composition of the calcite. Furthermore, stalagmites contain fluid inclusions (micrometric voids in the calcite matrix) that are filled with fossil water from past precipitation falling above the cave at the time the inclusions were formed, and thus are able to provide hydrogen (δD) and oxygen ($\delta^{18}O_{fi}$) isotopes of past drip water. All these parameters were measured for the last 14'000 years on two stalagmites coming from Milandre Cave (Jura Mountains, NW Switzerland), an area that have climate conditions representative for Western and Central Europe. Whereas the time resolution is high for calcite measurements (mean resolution of 4 years), block samples used for fluid inclusion measurements shows a ~10-20 years for the last 2000 years and ~50 years resolution beyond.

For the study site, there is a strong isotope-temperature dependency for recent precipitation allowing paleotemperature reconstruction from oxygen and hydrogen isotopes, whereas changes in $\delta^{13}C_c$ are mainly related to changes in soil microbial activity and vegetation type and activity above the cave. Moreover, connecting the fluid inclusion results to the available calcite oxygen isotope data may significantly increase the temporal resolution of past temperature reconstructions.

P 11.2
Variations in near-bottom flow of ACC during the past glacial cycle in SW Indian Ocean

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The meridional overturning circulation of the ocean plays a key role in global climate variability by storing and redistributing heat, fresh water, carbon and nutrients. In the North Atlantic surface water sinks to the abyss, but a major part of this cycle is the return path from the ocean's interior through upwelling in the Southern Ocean. This upwelling is largely regulated by the latitudinal position of the Southern westerly winds associated with the deep-reaching Antarctic Circumpolar Current (ACC) (Rintoul et al. 2001).

Observations in the last few decades show progressively poleward intensifying winds and climate models suggest a possibly related increase in ACC transport and southward shifting of its mean position and increased upwelling. However, a number of recent numerical studies have shown that the sensitivity of the large-scale circulation in the Southern Ocean may be reduced by eddy-effects (Böning et al 2008).

As there remains significant uncertainty regarding the degree of sensitivity of the Southern Ocean circulation to wind stress and the response of the Antarctic circumpolar transport, our aim is to investigate the temporal and latitudinal evolution of the ACC dynamics over the last glacial cycle.

Previous studies suggested a stronger ACC during glacials in the Indian Ocean (Mazaud et al. 2010), but more recent studies in the Drake Passage and Scotia Sea indicate less throughflow during glacials and lateral differences in current speeds (McCave et al. 2014, Lamy et al. 2012). Here we present the sortable silt mean-size of a series of cores across the ACC in the SW Indian Ocean, the mean-size of the re-deposited silt fraction being proportional to the near-bottom flow velocity. Combining this with the ^{230}Th-data and the assuption that its rain rate is equivalent to its production from the decay of ^{234}U in the overlying water column allows a characterization of lateral sediment redistribution on the sea floor within the ACC flow regime.

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P 11.3
Gravity model of the overdeepenings from the Bern area

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The Swiss plateau has been covered by glaciers, which cut valleys several hundreds of meters in depth into its bedrock. These features are called tunnel valleys or overdeepenings (Preusser et al. 2010; Reber et al., 2016) and were possibly formed prior to 200'000-300'000 years before present, as new dating has shown (M. Schwenk, pers. comm. 2018, Preusser et al., 2010). The goal of this work is to understand which mechanisms lead to the formation of these morphological structures through their imaging by a high-precision gravity survey. We plan to measure the density difference between the Quaternary valley fill and the enclosing Tertiary Molasse (Matter et al. 1980). The collected gravity data will be analysed through computing, with the aim to reconstruct probable 3D models of the overdeepenings. We will then use the reconstructed geometry to better understand the origin of these overdeepenings and the mechanisms that formed them. In particular, we plan to test whether these morphologies are relict features of e.g. riverbeds of yet unknown age, inherited architectures that were reactivated by the passage of glaciers or if they represent purely glacigenic features, formed by burst of melt water or by a continuous subglacial flow.

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P 11.4
Macro- and micro-fauna from cold-seeps in the Palmahim Disturbance Zone (off-shore Israel)

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Seepage related features sediments were sampled during the EU Eurofleets SEMSEEP Cruise on the RV Aegaeo in 2016 along the Israeli continental slope (Makovsky et al., 2017).
A box corer with a sampling area of 30 x 30 cm and a maximal penetration of 60 cm was used to collect the sediment surface samples and subcores.
Samples for living foraminiferal studies were processed following the protocol of Schönfeld et al. (2012). Samples from subcores were washed with a 32µm mesh sieve.
The most relevant occurrence of seeps offshore Israel is in the Palmahim Disturbance Zone (PDZ), a large-scale (~50x15 km) rotational slide, rooted in the Messinian evaporites on the southern Israeli margin.
In the Eastern Mediterranean evidence of chemosynthetic life has been so far described from mud volcanoes (e.g., Corselli and Basso, 1996) and other localities characterized by cold seeps such as the Alboran Sea and Gela Basin (Taviani, 2014).
A typical and endemic methane seep benthic foraminiferal fauna has not been documented in the PDZ, however, benthic foraminiferal assemblages are characterized by the genera *Bolivina, Bulimina, Uvigerina, Lenticulina, Globobulimina* and *Chilostomella* defined as highly tolerant species of low oxygen environment.
Chemosynthetic macro-faunal assemblages were recovered in the PDZ. They are characterized by loose and articulated shells of mytilids (e.g. *Idas ghisottii*), lucinids (e.g. *Lucinoma kazani, Myrtea spinifera*), thyasirids (e.g. *Thyasira biplicata*), vesicomyids (e.g. *Isorropodon perplexum*) and gastropods (e.g. *Taranis moerchii, Lurifax vitreus).* Fragments of the callianassid decapod *Calliax* sp. are consistently present and abundant in the samples.
The coupling of low oxygen benthic foraminiferal species with chemosynthetic molluscs suggest that the two groups of organisms share the same chemosynthetic environment.

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P 11.5
Using chironomids to constrain Late Glacial climate trends in Burgäschisee, Switzerland

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There are very few chironomid based temperature reconstructions for the Late Glacial period prior to 14,700 cal. BP in Switzerland, and none that are temporally well constrained. This represents a significant gap in our understanding of late glacial temperature dynamics prior to reforestation of the Swiss lowlands. Furthermore, this knowledge gap is exemplified by new vegetation reconstructions indicating climatic warming events as early as 16,000 cal. BP (Rey et al. 2017) which do not currently have any local independent temperature proxies with which to compare. Lake sediments have been retrieved from Burgäschisee, a small lake on the Swiss plateau, and have been used to produce the first reliably dated chironomid record between 18,000 - 14,700 cal. BP in Switzerland. The record displays changes in chironomid composition on a centennial scale and will be presented and discussed alongside extracts from the Burgäschisee pollen record (Rey et al. 2017), allowing a comparison of these independent proxies and facilitating a more robust interpretation of early climatic warming in the Swiss Late Glacial.

Initial interpretations of the chironomid record suggest a gradual increase in summer temperatures across the study period. At the earliest part of the record ca. 18,200 cal. BP the chironomid assemblages consist almost entirely of cold stenotherms such as Micropsectra radialis-type and Corynoneura arctica-type. Over time, types associated with warmer temperatures, such as Tanytarsus glabrescens-type and Dictrotendipes nervosus-type, replace many of the cold stenotherms. Sergentia coracina-type, also a cold stenotherm, remains the dominant type for the entire record, which suggests that although temperatures were increasing, cold environments in the lake persisted. Despite persistence of cold water types and gradual chironomid assemblage change, detrended correspondence analysis suggests a distinct separation between assemblage compositions from earlier than and from later than 16,000 cal. BP (Figure 1), corresponding with the early warming event observed in the pollen record (Rey et al. 2017).

Further work is required to evaluate the chironomid assemblage response to climatic change, and determine if the separation at 16,000 cal. BP is a threshold response to gradual warming or indeed a distinct warming event. This will include the development of a chironomid-based temperature reconstruction, which will attempt to quantitatively assess July air temperature change in the Swiss lowlands during the Late Glacial.

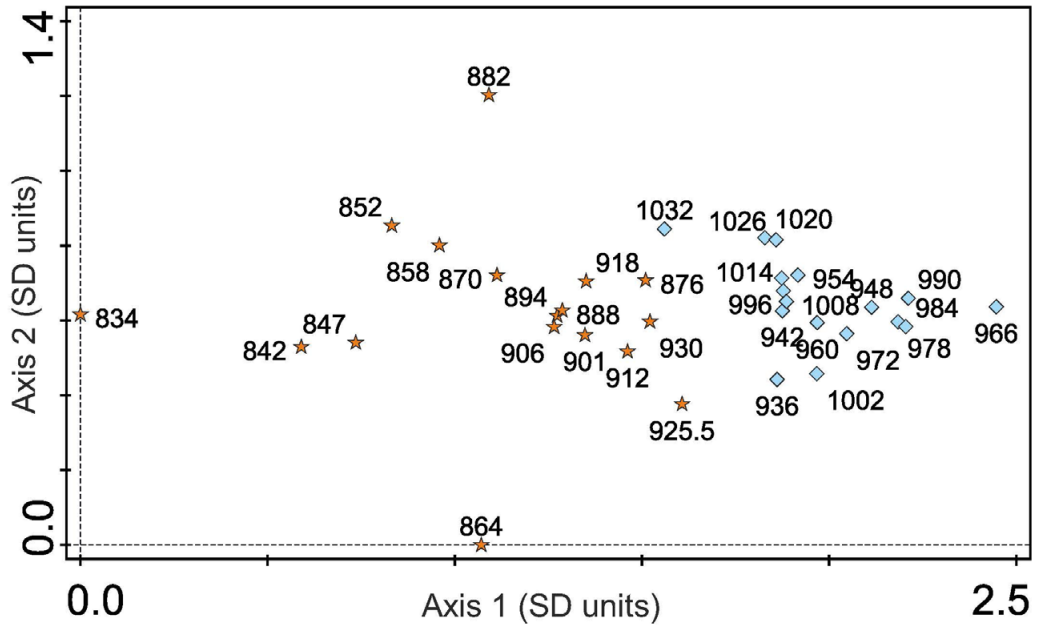

Figure 1. Detrended correspondence analysis of chironomid assemblages in the Burgäschisee sediment core. Axis 1 appears to be representative of temperature change, lower values (to the left) representing assemblages typical of warmer conditions. Blue diamonds are samples from earlier than 16,000 cal. BP and orange stars are from samples later than 16,000 cal. BP. Numbers labeling the aforementioned symbols, represent the depth of the corresponding sample in the Burgäschisee core (cm).

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P 11.6
Sedimentology of the glacial facies within the Deckenschotter of Northern Switzerland

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The Höhere and Tiefere Deckenschotter Groups of Northern Switzerland are dominated by fluvial to fluvio-glacial sediments. In some outcrops, the gravelly facies is associated with diamictons interpreted as glacial tills (e.g. Heim 1891, Frei 1912, Graf 1993). Despite the importance of these presumed glacial deposits as markers of ice-contact during the Early Pleistocene, they remain relatively poorly studied. We present results from an ongoing project to better constrain the depositional environment of these diamicts at selected key sites using detailed macro- to microscale sedimentology, fabric and geotechnical analyses. Our analyses will help to better constrain the extent and characteristics of glacier advances related to the first extensive glaciations of the Alps.

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P 11.7
The evolution of the fluvial environments and the history of human settlements during the Late Holocene on the Piano di Magadino (Cantone Ticino, Switzerland): new sedimentological and geoarchaeological data

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In recent times many sedimentological, geomorphological and geoarchaeological studies were carried out at many locations on the Piano di Magadino, trying to reconstruct the evolution of the paleoenvironmental conditions of the area during the Late Holocene subepoch. The age and stratigraphy of the deposits were determined using the radiocarbon dating method on organic matter debris and on charcoals. This, combined with an accurate sedimentological characterization of the deposit, archaeological observations and dating, allowed interpreting the depositional context for the sedimentary and archaeological sequences found on the Piano di Magadino.

This contribution focuses on new dating and stratigraphy determined in two archaeological sites in Progero (Gudo, RFD 1078; 2'715'900/1'114'530, CH1903+/LV95) and in Gudo (RFD 80; 2'716'720/1'114'800, CH1903+/LV95).

In Progero two main phases of enhanced hydrosedimentary activity shown by coarse alluvial deposits could be observed. The first phase consists in a palaeochannel at the bottom of the lithostratigraphy. The fine sandy to clayey layers overlaying it indicate a calm period which was dated by radiocarbon geochronology on charcoal between 1440 and 1285 BC (Middle Bronze Age). The following second alluvial phase shows many events with coarse material deposits succeeding and crosscutting each other. These deposits are attributed to lateral alluvial fans or debris flows from the valley slope. After this phase, the first records of human settlement in the area are observed, which consist of anthropogenic backfillings containing some ceramic debris of the Bronze Age. Afterwards two events of finer deposits of fluvial origin are present; both are intercalated by remnants of Bronze Age human constructions. These deposits are most probably attributed to a temporary palaeomeander of the Ticino river, which allowed the sudden deposition of very fine material by rapid decantation. The presence of anthropogenic pavements at that time confirms the proximal position to the river (both the stream from the valley slope and the Ticino river) of the human settlements.

The site of Gudo is located northeast compared to the first site, closer to the valley slope and in a higher stratigraphical position. For this site four layers with coarser grain size deposits were observed suggesting four events of major hydrosedimentary activity in the area, which were constrained by radiocarbon dating: 400–370 BC (Early Iron Age), 200–170 BC (Middle Iron Age), 10–340 AD (Roman Period), 540–1000 AD (Early Middle Ages). A wall of Iron Age found between the two first events confirms the dating and suggests a stable human settlement in the area during the Iron Age, as well as the need to build a dam for containing the floods, most likely coming from the Ticino river. The Early Middle Ages increase in hydrosedimentary activity was documented also by historical informations and by new radiocarbon dating in the Ticino river alluvial plain.

The observations and dating carried out in Progero and in Gudo allowed highlighting six phases of hydrosedimentary activity (Figure 1); these can be completed by more recent information from historical sources, adding two others phases of hydrosedimentary activity in 1178 AD and between 1690 and 1868 AD, which means during the last phase of the Little Ice Age. Therefore, the integration of archaeological information in classical geomorphological and historical studies on the evolution of fluvial environments on the Ticino river catchment allowed the definition of eight phases of hydrosedimentary activity since the Early Bronze Age (Figure 1).

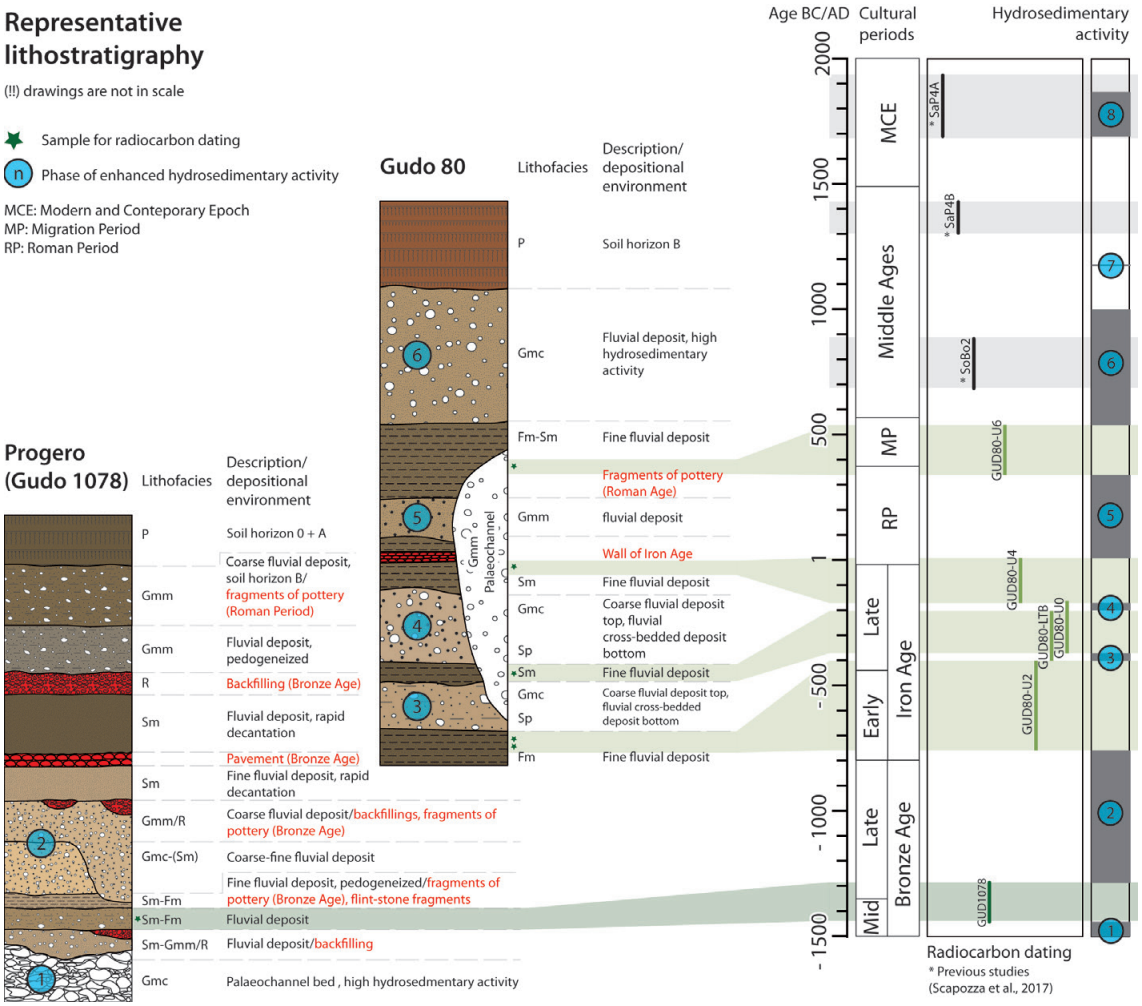

Figure 1. Representative stratigraphy of the two studied sites and derived phases of enhanced hydrosedimentary activity.

P 11.8
Isochron-burial dating of Swiss Deckenschotter

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During the past 2.6 Ma, at least 13 glaciations have overriden the northern Swiss Alpine Foreland (Schlüchter, 1988). The imprints of these advances can be found in four distinct units, which are divided by their morphostratigraphy and topography (Graf, 1993). They show a reversed stratigraphic relationship. This means that deposits at a higher elevation are considered to be older than deposits at a lower elevation. The four units are from the oldest to the youngest: Higher Deckenschotter (HDS; Höhere Deckenschotter), Lower Deckenschotter (TDS; Tiefere Deckenschotter), Higher Terrace (HT; Hochterrasse) and Lower Terrace (NT; Niederterrasse) (Graf, 1993, 2009). The HDS and TDS deposits represent the oldest Quaternary deposits in Switzerland and are characterised by a succession of glacio-fluvial gravels intercalated with glacial and/or overbank deposits (Graf, 1993). They are separated by a significant phase of incison (Graf and Müller, 1999). Recently, HDS and TDS deposits at several sites were dated to around 2 Ma and to around 1 Ma by depth-profile and isochron-burial dating techniques using the cosmogenic nuclides ^{10}Be and ^{26}Al (Akçar et al., 2014; Claude et al., 2017; Akçar et al., 2017). The recently established chronology is challenging the attributed morphostratigraphy as deposits of around 1 Ma are located at the same elevation as ca. 2 Ma old deposits. Therefore, how far can the approach "*same elevation means same age*" explain the chronology?

The aim of this study is to date HDS and TDS deposits at new sites to disentangle the sequence of events into a more complex model than thought so far as well as to reconstruct the landscape evolution in the northern Alpine Foreland. For this reason, we concentrate on additional sites at Irchel as well as the region around Mandach and Lake Constance as the might represent analogues to the Irchel. For each site sediment analysis will be applied to identify the provenance, the transport meachanism and the depositional envrionment. The chronology will be established by isochron-burial dating using in-situ produced cosmogenic ^{10}Be and ^{26}Al. The combination of the results allows to reconstrcut the landscape evolution. The sampling for this study has taken place at 11 HDS and TDS sites: three HDS sites at Irchel, three HDS and three TDS sites in the Mandach region, as well as one HDS and one TDS site in the region of Lake Constance. For each site, one sediment sample consisting of quartz pebbles and at least nine clasts of various lithologies, shapes and sizes were collected. After the physical separation of quartz, seven samples and the sediment sample will be further processed for the accelerator mass spectrometry measurements of cosmogenic ^{10}Be and ^{26}Al at the ETH Zurich.

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P 11.9
In quest of a pre-LGM (sub-)glacial history: drilling the overdeepened Lower Aare Valley

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During the Pleistocene, extensive and repeated glaciations have carved the foreland of the European Alps and left deeply incised trough structures, overdeepened valleys, behind. Subsequently, these sediment traps were infilled with sub- and proglacial deposits, often related to multiple glaciations. Therefore, overdeepened valleys can serve as excellent archives of pre-LGM glaciations, whose relics were otherwise largely obliterated by the following ice advances.
To gain insights into the pre-LGM glacial and fluvial history of northern Switzerland and to constrain the process of subglacial erosion, we currently investigate the Lower Aare Valley with four scientific drillings targeted at the overdeepened Gebenstorf-Stilli trough and the Rinikerfeld paleochannel. Our study area is situated just beyond the local LGM, at the confluence of the Aare with Reuss and Limmat, where the valley is deeply incised into limestones of the Lägern structure (southeastern margin of the Swiss Jura). The recovered drill cores are evaluated in terms of sedimentology, geotechnical properties and geochronology as well as /and complemented by outcrop studies. We present the current status of the project and include first results from the already completed boreholes.

P 11.10
Spatial focusing of lake sedimentation by wind driven circulation

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Sedimentation patterns in aquatic systems affects the biosphere as well as utilitarian water resources management. We investigate grain size specific sedimentation patterns in the perialpine Lake Biel, greatly influenced by the upstream diversion of the Aare River into the lake. The majority of the river supplied sediment arrived to the lake in short term suspended sediment concentration (SSC) events. These were linked to weather systems originating out over the Atlantic Ocean, resulting in seasonal varying sediment supply. The Atlantic weather systems, besides controlling the temporal frequency of the SSC events in the river, furthermore focused the sedimentation inside the lake. This led to large amounts of sediment being deposited on steep topography, resulting in series of subaqueous slides. Furthermore, the high flow speed in both river inlets and outlets caused selective sedimentation of particle sizes, with increased mass occurrence rate of sand (63 to 2000 µm) in high energetic environments, while smaller sized silt and clay (< 63 µm) clearly dominated in the low energetic deeper parts of the lake.

P 11.11
Subaquatic slope instabilities due to river correction and artificial dumps (Lake Biel, Switzerland)

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The “Jura water corrections” was the largest river engineering project ever undertaken in Switzerland. It completely changed the Lake Biel system. Our study documents an effect that is likely the consequence of the deviation of the Aare River into the lake in 1878.
Several mass-transport deposits (MTD) were identified along the lake’s shore from bathymetric, high-resolution seismic reflection and sediment core datasets. Individual MTDs were dated from radionuclide activities. MTD’s from the 1960s-1970s are attributed to dumping of excavated material, when the channels flowing into and out of Lake Biel were widened and deepened. But two nearby earthquakes in 1964 and 1965 cannot be ruled out as possible triggers. Three additional medium-scale mass movements followed in 1970s-1990s (uncertain dating), 2000 and 2009 and have unknown triggers. Together with the largest - and slightly older - MTD, they form a recent large mass-movement complex, specific of Lake Biel and not observed in other peri-alpine lakes of Switzerland. The cause of these repeated slope failures is likely linked to the large increase of sediment delivered by the Aare River since its deviation into Lake Biel. This enhanced sediment input resulted in sediment overloading, which may have caused large mass movements on the eastern shore along the flow path of the Aare in the lake.

P 11.12
Fe-Mn nodules in young soils of Grand-Saconnex (Geneva, Switzerland): encrustation hampered by the Late Neolithic soil drainage?

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Perialpine areas have undergone significant changes following the last glaciation and particularly through the Holocene. This study relies on geochronological, mineralogical and geochemical clues to explain the formation and paleoenvironmental significance of Fe-Mn nodules in young soils (~4.5 ka BCE) of Geneva Basin. The nodules, with an average 2 mm in diameter, have an onion-like and quasi-layered internal architecture defined by selective enrichments in Fe and Mn. Fe-rich mica, present in soil matrix, has been proved to serve as a main source of Fe and Mn. Several steps in mica weathering were recognised leading to the formation of nodules – vermiculitization, microcracking, Fe-Mn segregation and re-precipitation. Mineral alterations were boosted by long periods of summer warm climate during Boreal and Atlantic times as suggested by clay content of analysed colluvium. Moreover, archaeological ages and radiocarbon dating of charcoal yielded coherent Fe-Mn encrustation ages (4.8–4.3 ka BCE and 4.5–4.4 ka BCE, respectively) that coincide with the Holocene temperature maximum (~4 ka BCE) in Central Europe. Terrain morphology that led to better water retention formed prior to ~8 ka BCE ago during undefined Late Glacial time. This promoted seasonal changes in redox conditions that facilitated the mobilization, distribution and re-precipitation of Fe and Mn. Established conditions lasted until Late Neolithic (3.4–2.2 ka BCE) when different agricultural practices changed favourable hydromorphic environment effectively putting an end to further nodule formation.

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P 11.13
Constraining the maximum glacial timing of the Lyon Lobe, French Alps, Using OSL dating

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Detailed reconstruction of former glacier maxima in the European Alps indicate that large ice expansion occurred on the northern side of the Alps, with wide piedmont lobes spreading over more than 50 km into the Swiss, German, Austrian and French lowlands. Maximum glacial extents are relatively well constrained chronologically in the northern Alps, suggesting a glacial maxima around 22-24 ka (Wirsig et al., 2016), in phase with the global records. However, the timing of the Late Pleistocene glaciation maximum of the Lyon Lobe, French Alps, is controversial due to major discrepancy between geomorphic evidence and modelled glacier extent (Seguinot et al., 2018). A clear and robust chronological constrain of the Lyon Lobe is critical as it would have major implication in term of past atmospheric circulation pattern. Traditional dating techniques such as radiocarbon and cosmogenic nuclides exposure are challenging in this area due to the scarcity of organic material incorporated within glacial deposits and the lack of in-place moraine boulders. In these circumstances, Optically Stimulated Luminescence (OSL) techniques, which allow the dating of buried sedimentary material, offer a promising alternative.
In this study, we investigate the feasibility of using OSL to date the glacial deposits of the Lyon lobe, and present a preliminary timing of its Late Pleistocene maximum extent.

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P 11.14
Reconstructing the sequence of massive rock-slope failures in Valle di Tovel, Trentino (Italy)

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Using field mapping, remote imagery interpretation (2 m lidar kindly provided by the Autonomous Province of Trento) and cosmogenic ^{36}Cl exposure dating we reconstruct the origin of the blocky deposits in the upper reaches of the Valle di Tovel in the Adamello Brenta Geopark in the Brenta Dolomites. Blocky deposits cover nearly the whole valley floor for a length of about 10 km from an elevation of 1900 down to 900 m a.s.l. Oetheimer (1992) estimated a total volume of more than 300 Mm^3. Although several independent bodies, sourced in the steep surrounding rock walls which reach up to 2700 m a.s.l., are apparent (Oetheimer 1992, Ferretti and Borsato 2004) detailed reconstruction of the timing and sequence of the catastrophic events is challenging.

Hypotheses for the age and origin of the blocky deposits range from a Lateglacial rock-slope failure onto a glacier (Oetheimer 1992) to mainly 16th century events. At that time, blocking of the outflow led to lake level rise of about 18 m as shown by dendrochronological ages of drowned trees, many of which are still standing on the lake bottom. The lake itself is renowned for the red color due to algal bloom it had during summers up until 1964 (Kulbe et al. 2005).

Interpretation of the evolution of the valley involves disentangling the numerous interfering deposits of megablocks released intermittently from the exceptionally steep valley walls. Although there are distinct differences in the amount of vegetation in the different sectors this is clearly not directly translatable into age, and other factors may play just as important a role. Present permafrost is likely restricted to ridge tops above about 2500 m a.s.l. (Boeckli et al. 2012), nevertheless cooling atypical for the elevation of the blocky deposits due to processes like the ‘chimney effect’ (Delaloye et al. 2003) over the course of the Holocene cannot be ruled out.

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P 11.15
Tackling North-South differences of the Last Glacial Maximum in the Alps

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During the last glacial cycle, temperatures and precipitation patterns were markedly different from today and shifts in the North Atlantic atmospheric circulation distinctly affected moisture delivery to Europe. Sensitive to climate change, glaciers quickly respond to altered precipitation patterns that manifest as spatial and temporal rates of glacier growth. The timing and extent of glacial maxima in the Alps therefore provide basic information on changing moisture sources throughout the last glaciation. The position of LGM Rhine and Ticino/Toce glacier directly North-South of each other with an existing linkage in their accumulation area, qualifies them to study the main controls of spatial and temporal patterns of glacier growth. However, the lack of detailed chronological information currently restricts their use for paleo-climatic reconstruction. This project aims to overcome these limitations by using geomorphological and sedimentological mapping, remote sensing and surface exposure dating to constrain the timing of LGM, recessional/ re-advance stages and ultimate withdrawal from the forelands for both glacier systems. Precisely dated LGM ice margins will help to understand similarities and differences in glacier timing North and South of the Alps and will have the potential to unravel variations in past moisture distribution. Gained results will further serve as point of comparison for the validation of glacier models in collaboration with the Laboratory of Hydraulics, Hydrology and Glaciology (VAW ETHZ).

P 11.16
What do speleothems in Western Europe record? Assessing regional and temporal trends in speleothem $\delta^{18}O$ with the SISAL database

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Speleothems can provide very high resolution palaeoclimate records with exceptional chronological control, and thus have become powerful archives of past terrestrial climate variability. The stable oxygen isotope ratio ($\delta^{18}O$) in speleothems provides information principally on past changes in temperature, precipitation, and atmospheric circulation, and is increasingly used for the evaluation of isotope-enabled climate models.

Here we make use of the recently published SISAL (Speleothem Isotopes Synthesis and Analysis) database, resulting from the effort of an international PAGES working group (Atsawawanunt et al., 2018). Our objective is to review and assess the potential of available speleothem $\delta^{18}O$ records from Western Europe. We investigate how the spatial distribution of the records in the database is representative for climate conditions in Europe, and compare modern speleothem data to precipitation $\delta^{18}O$. Overall, speleothem $\delta^{18}O$ mirrors the spatial trends found in precipitation $\delta^{18}O$, highlighting the potential of this archive for palaeo-precipitation and -temperature reconstructions. Coherent regional trends in speleothem $\delta^{18}O$ are found over stadial-interstadial transitions of the last glacial, especially in high altitude Alpine records that reflect a dominant temperature signal. Over the Holocene and the last 2000 years, regional trends are more difficult to capture, due to lower signal-to-noise ratios in interglacial climate at mid-latitude sites, as well as issues with chronological uncertainty and resolution in the records. These results highlight the potential of Western Europe for speleothem palaeoclimate reconstruction, and the usefulness of these records for the evaluation of climate model outputs.

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P 11.17
Reconstruction of ecological evolution of lakes based on multidisciplinary proxies: the case of Lake Liambezi, Botswana.

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Lake Liambezi is an ephemeral lake that is seasonally replenished from several distinct sources of water. It is located at the Eastern side of Caprivi Strip, straddling the border between Namibia and Botswana. The drainage basin of the lake is a large, flat wetland, including some woodlands, which contains a typically slow-flowing floodplain river (Seaman et al., 1978; Peel et al., 2015). Seaman et al. (1978) estimated a drainage basin of some 300 km^2, of which 100 km^2 is open water at its full size. The Lake changes its shape, size, and depth seasonally and over the years due to fluctuating contributions of water from its distinct source regions. Its depth averages about 2.5 m (Seaman et al. 1978) but can reach 7 m at its peak (Peel et al. 2015). The lake forms two elongated basins with a South-West to North-West direction joined by a main channel.

The main source of water for Lake Liambezi is the Zambezi River with two different entries during years of flooding. A first entry is through the Chobe River, which can reverse its flow direction and enter the lake from the east of the southern basin. A second entry is via the Bukalo Channel from the Caprivi floodplain of the Zambezi River and it enters the lake from the northeast of the northern basin. Another source of water is the Kwando River that percolates through the wetlands out via the Linyanti Channels. Its waters flow eastward along the Namibia-Botswana border into the lake from the west of the two basins. Rainfall and runoff from the area north of the lake also contributes to the water inputs. Depending on the lake level, an outflow from the lake is permit via the Chobe River (Seaman et al. 1978, and Peel et al. 2015).

The present study is based on two field campaigns: one, a reconnaissance study during the dry season (September 2016), while a second one was conducted at the end of the rainy season during March 2017. Water from multiple sources of ground and surface waters were collected to better understand the drainage and hydrodynamics in this relatively flat area (Dyer, 2017). It was also established that the present climate supports a vegetation representing both the C3 and C4 photosynthetic cycles (Ballif, 2018). While the former is favored in wet/cold environments, the latter is pronounced in dry/warm settings. These two functional types differ profoundly in their physiology, metabolism, water-use efficiency, resource acquisition and growth form. They also discriminate very differently against ^{13}C during photosynthesis, such that the C-isotope composition of organic matter accumulated in soils or sediments may provide valuable information on the local ecosystem. In parallel to these geochemical studies the endospore forming communities have been analysed together with physical (grain size) analyses. During the second field campaign three cores of 40 cm each were sampled. One in the Northern basin a second in the Southern basin and the last one in the northern part of the channel between the two basins. Sediments of the cores were first characterized by scanning electron microscopy that indicated a large fraction of diatoms in the sediments. Subsequent isotope analysis of carbon ($^{13}C/^{12}C$ and ^{14}C), nitrogen, hydrogen and oxygen of the organic matter and also RockEval measurements will evaluate the composition and quality of the organic matter as it is expected to be largely of autochthonous origin within the sediments of the lake. The lithogenic fraction is analysed via X-ray diffraction and fluorescence for the mineralogy and bulk chemical composition. Collectively, these analyses should allow for good estimates of the sedimentation rates, age of the sediment and a paleoecological interpretation that will then be compared to information obtained from endospore forming communities, a novel biological marker proposed in paleoecological reconstructions.

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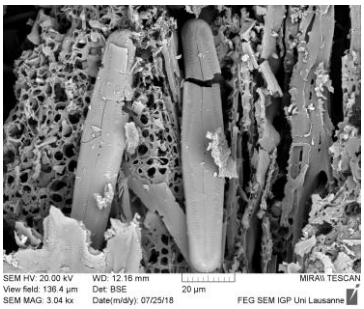

Figure 1. Southern Basin of Lake Liambezi during the dry season (September 2016). The water level is low during this season. Lehmann A.

Figure 2. SEM image of a core sample showing coal and diatoms. The core samples show diatoms and organic matter as major content.

P 11.18
Evolution of local topography by fluvial and hillslope processes: a GIS-based study in the eastern Jura Mountains and the Wutach valley (southern Germany)

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Landscape erosion is a key aspect in assessing the long-term safety of a deep-geological repository for radioactive waste in Switzerland. Besides large-scale processes, such as the glaciation of the Alpine Foreland or major changes in the Aare-Rhine fluvial system, fluvial incision along local tributaries and hillslope processes directly contribute to erosion on the siting region scale. Here, aspects of these smaller-scale processes are analysed in a comparative study for two lithologically similar regions with different incision history: the Nagra siting region Jura Ost (JO) and parts of the Wutach valley (Southern Germany). Following a prominent drainage reorganization about 18ka ago, where parts of the Danube headwaters ("Donau-Wutach") were deflected towards the Rhine, the Wutach valley experienced Late Pleistocene river downcutting of up to 150m within only 6ka (Einsele & Ricken 1995). In contrast, JO is considered to have seen minor incision during the same period.

To evaluate the processes, I used a GIS-based analysis, including 1) the extraction of tributary stream longitudinal profiles and 2) manual mapping of "hillslope process domains" based on digital terrain models, geological maps and orthophotos. Step 2 provides an area-covering terrain classification, separating "non-hillslopes" from "hillslopes", and within the latter, different degrees of landslide evidence. Results are analysed with respect to potential controlling factors, such as lithology and local relief.

The marked Late Pleistocene base level fall in the Wutach valley is still manifested in the present-day landscape. According to the mapping result, nearly the entire hillslope domain is characterized as landslide morphology.
The corresponding areal proportion in JO, in contrast, is smaller and variable depending on the lithostratigraphic unit; increasingly more landslides are observed in JO from calcareous to marly and finally clay-rich formations. Lithological effects on erodibility are further observed in tributary stream longitudinal profiles in both study areas, where knickpoints spatially coincide with more resistant bedrock. This behaviour reduces the magnitude of fluvial incision in the upstream sections, at least temporarily contributing to the conservation of upland low-relief areas with presumably low erosion rates, i.e. the "Bözbergplateau" in JO and the relict "Donau-Wutach" landscape. The extensive landslide morphology of the Wutach valley below such knickpoints reflects the high geomorphic process rates following the Late Pleistocene incision (see also Einsele & Ricken 1995). The two different study areas, which represent temporally different times in landscape evolution and morphological adjustment, provide valuable insights for describing potential future erosion scenarios on the siting region scale.

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P 11.19
Spatial patterns of glacial erosion in the Alpine foreland: Morphometric analysis of overdeepenings

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Alpine overdeepenings consist of widespread geomorphic features shaped by glacial erosion, with up to hundreds of meters carving over the Quaternary. The biggest features in Switzerland are located in the Alpine foreland in the form of major lakes (e.g. Léman, Biel or Neuchâtel) or sediment infills (e.g. in the Bern area).

Their occurrence and geometry in the Swiss foreland have been investigated (Dürst-Stucki & Schlunegger 2013), however both their spatial distribution, morphometric characteristics and Quaternary evolution during successive glaciations remain poorly constrained (e.g. Preusser et al. 2010).

This study consists on the morphometric analysis of glacial overdeepenings in the Alpine foreland to get quantitative constrains on their shape characteristics and spatial occurrence. The aim is to understand how much the bedrock resistance, local settings (lithological contrasts, faults, foreland vs mountain) or drainage network control the location and geometry of overdeepenings. To that aim, differences in their spatial trends (area, length, width and thickness) and the potential influence of lithology, faults/folds and hydrological network will be investigated.

A combined bedrock model derived from Mey et al. (2016) and Dürst-Stucki & Schlunegger (2013) models was generated so as to better constrain the Quaternary sedimentary thickness in flatter regions (Alpine foreland) and in the high-relief regions (Swiss Alps).

Besides, cross-section profiles, shape-factor computation, upstream drainage confluence locations and valley symmetry for big overdeepened features (individual features with areas > 2 km^2) are undergoing analysis. This will, ultimately, provide an overview of the main spatial trends and possible controls related to overdeepenings formation and development. This will allow a broader understanding on the erosive processes by glaciers during Quaternary times.

The study of overdeepenings has implications both for human habitability and for targeting potential geo-resources. Further information about subglacial processes and paleoclimatic conditions involved in deep foreland erosion at the km-scale will require numerical ice flow modeling (ie: Egholm et al. 2012). This will further enhance our comprehension on the evolution of these geomorphic features.

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P 11.20
Erosional dynamics of steep high alpine headwalls revealed by exposure ages (Eiger mountain, Central Swiss Alps)

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Exposure ages of various landforms, such as moraines, fluvial terraces, fault scarps or previously ice-covered bedrock have been routinely determined by measuring concentrations of in-situ terrestrial cosmogenic nuclides (TCN) over the last decades.
We applied this method to a steep and vertical headwall (the Eiger north face) by measuring ^{36}Cl concentrations on 5 depth profiles within the Eiger limestones. To achieve this, we benefited from the unique situation of a railway tunnel that was drilled through the mountain and that has several connections to the surface. This enabled us to collect depth-profile samples at 2 sites within the north face and at 3 sites in the southern flank (Fig. 1). The mountain itself displays distinctive differences in morphology with a step-like, over-steepened and very rough north face compared to a steep and comparatively smoother southern flank.

Our results show low cosmogenic ^{36}Cl concentrations for the surface samples, translating into young apparent exposure ages of <2 ka. Interestingly, samples at depth yielded concentrations that translate to much older apparent exposure ages. Subsequent depth profile modelling allowed to confirm the robustness of the young surface exposure ages, while constraining the thickness of the eroded rock to <5m and hinting at significant nuclide inheritance. This consistent TCN pattern suggests a complex erosional history governed by small scale (cm to meter sized blocks) episodic rockfall events rather than large scale (tens of meters) landslides or steady state erosion from chemical weathering.

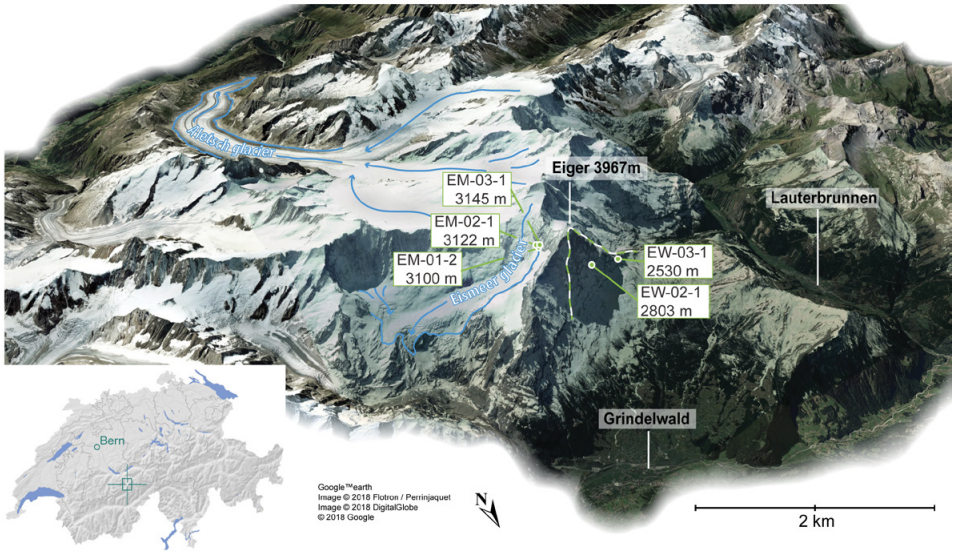

Figure 1. Sample sites for the ^{36}Cl depth profiles around the Eiger mountain.

P 11.21
Long-term high-resolution productivity and meromixis dynamics on the Swiss Plateau (Lake Moossee, Switzerland) inferred from Hyperspectral Imaging

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The Anthropocene has seen unprecedented environmental change and fundamental ecosystem services are increasingly at stake. Anthropogenically altered biogeochemical cycles, combined with climate change have resulted in adverse ecosystem impacts, increased productivity and anoxia in freshwater systems (Chapman, 1998; Hecky, 2010). However, little is known about lake eutrophication and episodes of hypoxia and meromixis in the past, because this is difficult to measure analytically. Here, we discuss recent developments in novel hyperspectral imaging HSI techniques by our group. The aim is to show how and when meromixis/hypoxia has developed over Holocene time scales and how meromixis has been modulated by anthropogenic impacts (deforestation, erosion, nutrient cycling).

A sound scientific assessment of such changes must rely on a long-term perspective and high-resolution data. Hyperspectral Imaging (HSI) is a novel, fast, non-destructive and cost effective scanning method able to detect diagnostic sedimentary pigments at very high spectral (3 nm) and spatial (40 µm pixel size) resolution .The reflectance spectrum depends on the absorption properties of organic and inorganic substances under the sensor field, and can be used to characterize the sediment composition (e.g. sedimentary pigments). These provide quantitative information about paleoproductivity, past mixing regimes and anoxia in lakes over long (i. e. Holocene) time scales (Butz et al, 2015, 2017).

We are currently focusing on small eutrophic lakes on the Swiss Plateau, Lakes Moossee and Burgäschisee with biogenic varves. Further work is planned in biochemically varved lakes in the Masurian Lakeland, NE Poland (Lakes Żabińskie, Łazduny and Jaczno). We use hyperspectral indices to infer quantitatively Chl a and chlorins as an indicator for aquatic productivity and Bacteriopheophytin a (Bphe a) as an indicator for meromixis (Butz et al, 2016). Bphe a is a diagenetic product of Bacteriochlorophyll a (Bchl a), produced by anoxygenic phototrophic bacteria in the chemocline. Pigment compositions are inferred from sets of spectral indices, such as the Relative Absorption Band Depths (RABD). Indices are calibrated with absolute pigment concentrations of selected samples as measured by HPLC, using linear regression (e.g correlation coefficient of $R=0.94$, $p < 0.001$ with a coefficient of determination of $R2 = 0.89$) (Butz et al, 2015).

Lake Moossee contains a complete paleoproductivity and meromixis record at annual resolution (varve years) for the Holocene and Late-Glacial times (past 15,500 years). Hyperspectral imaging data provide evidence for repeated meromixis events in the mid-Holocene. Pollen data suggest that repeated coming and going in meromixis was related to substantial human disturbance in the catchment (Neolithic and Early Bronze Age land use, deforestation and reforestation after land abandonment). In this period, meromixis appears/disappears repeatedly for long periods of ca. 300 years and shows how land use changes affected the biogeochemical cycle in the lake.

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P 11.22
Investigations on different rock types used in Urartian Gavur castle in Azerbaijan Province, NW Iran

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The Azerbaijan area in NW Iran includes more than 80 Urartian historical buildings ruins, belonging to the Iron Age (Kroll, 2011). Limited studies on these buildings ruins are on archeological aspects and there is no published account on their geo-archeological features, including the nature of rock materials used in the construction of these buildings. The Urartian Gavur Castle, located at the south of the Aras Araz River was selected for geo-archeological studies and detecting the possible source of the used materials, due to the variety of lithologies used in the construction of this castle. The results of this study can be used in further investigations on geo-archeological aspects of the Urartian buildings in NW Iran and the adjacent countries. Petrographical and geochemical investigations show more than fifteen different types of the sedimentary and igneous rocks are used in the construction of the Gavur Castle, among which the Upper Cretaceous turbiditic sandstones make more than 90% of the materials used. Andesite and granite are used as rectangular blocks in the castle walls. There is a wide range of sedimentary and mafic, intermediate and felsic igneous rocks as debris resulted from the destroying walls. This debris appears as pebbles with good roundness and sphericity. More likely these rocks are collected from the Pliocene polymict conglomerate at the south-west of the castle.

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P 11.23
Pleistocene palaeo-environmental changes in the Danakil Depression (Northern Afar, Ethiopia)

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The Danakil Depression, located in the northern apex of the Afar triangle, Ethiopia, is part of an active rifting zone due to the break-up of the Afro-Arabian plateau since Oligocene times. The Danakil Depression is nowadays a dry desert with elevations of 120m below sea level in the central part of the basin. According to seismic data and new core analyses, a 2km thick evaporite sequence alternating with marine marls evidence several episodes of Red Sea incursions followed by desiccation since the Neogene.

The presence of at least two fringing coralgal reef terraces outcropping at the the western margin of the basin, confirms that open marine Red Sea conditions were established during interglacial Marine Isotope Stages (MIS) 5e and 7 (Jaramillo-Vogel et al. 2018). Monospecific bivalves, associated microbialites, aragonitic crusts and coeval spherules, present on top of the coralgal reef units and pre-dating massive gypsum deposits, indicate the intermediate step-wise closure of the connection with the Red Sea and the systematic shift towards more hypersaline environments.

Interestingly, in several outcrops along the margin it is possible to observe lacustrine sediments that are intercalated between the two marine terraces. The occurrence of these unconsolidated carbonaceous sediments, rich in gastropods and charophytes, can be followed along several kilometers. They follow an erosive surface caused by the desiccation of the basin after MIS7. But, the transition to the marine deposits of MIS5e is gradual, implying that no major change in lake level preceeded the marine deposition.

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P 11.24
Quantification of chemical and mechanical denudation in karst landscapes and mechanisms for steep and high carbonate topography on the island of Crete

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Quantifying chemical versus mechanical weathering in carbonate catchments has proven problematic due to the difficulties estimating the long-term total or mechanical denudation in carbonates. On Crete —as with many other regions worldwide— carbonate massifs form high mountain ranges whereas topography is lower in areas with clastic-metamorphic rocks. This observation suggests that differences in denudation between more carbonate rich rocks and more quartzofeldspathic units imparts a fundamental control on topographic form. Here we present 16 new cosmogenic ^{10}Be and 8 cosmogenic ^{36}Cl basin-average denudation rate measurements from clastic and carbonate bedrock catchments to quantify substrate erodibility. We compare total denudation rates to dissolution rates calculated from 70 new and published water samples from Crete to quantify the amount of dissolution responsible for long-term denudation. Basin-average denudation rates of clastic-metamorphic units in western Crete are ~ 0.1 mm/a, which is one magnitude lower than coastal uplift rates measured in southwestern Crete. Basin-average denudation rates derived from 36Cl in the 8 carbonate catchments are slightly higher than catchments draining clastic-metamorphic rocks; however, these carbonate catchments have greater relief as they are at the margins of the elevated carbonate plateaus. Average dissolution rates measured from all different water sources in carbonate areas yield a mean dissolution rate of ~ 0.06 mm/a, suggesting that only about half of the mass-loss is attributable to dissolution processes and that mechanical weathering plays an important role at the catchment scale weathering of carbonates. We develop a numerical model for carbonate denudation incorporating mechanical and chemical weathering components to test which parameters besides erodibility are likely to control high and steep carbonate topography. We find that the loss of runoff from surface to groundwater drainage in karst regions is an efficient way to steepen topography and maintain erosion rates that balance the uplift field. We apply this model to Cretan karst landscapes where we calculate water budgets for 4 carbonate catchments and observe losses of up to 90 % of runoff to groundwater. Therefore, we suggest that the loss of runoff in carbonate catchments imposes a first order control on steep and high carbonate topography.

P 11.25
Occurrence and significance of sepiolite deposits in the Chobe enclave (Northern Kalahari Basin, Botswana)

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The Chobe Enclave (Northern Botswana) is situated in a present-day semi-arid climate. It is characterized by a flat high plateau undergoing neotectonism, with an active faulting structure, possibly related to a western branch of the East African Rift System (Bufford et al., 2012). Belonging to the large sand Kalahari Basin, the Chobe enclave includes some meter-thick carbonate deposits, which are not yet clearly explained although previously interpreted as Quaternary calcretes (Burrough et al., 2008). Some of these carbonate layers contain sepiolite-rich beds, which were not detected until now. Sepiolite is a trioctahedral Mg-rich clay commonly formed in saline lacustrine-palustrine environments under the influence of groundwater of high Mg+Si/Al ratios (Galan and Singer, 2011). In Botswana, these sepiolitic layers are composed of pure neoformed sepiolite (Fig. 1A, B), associated with Ca-carbonate (as micrite and microsparite) and amorphous silica phases, as well as some detrital quartz grains (Fig. 1C). Consequently, recent data question the calcrete interpretation, pointing to a more complex lacustrine/palustrine origin. Sepiolite needs alkaline waters (8 < pH < 9.5) to precipitate, as well as solutions supersaturated regarding Si and Mg ions (Galan and Singer, 2011): these conditions seriously challenge the source of such solutions in this siliceous basin. In conclusion, as hydrothermal and/or evaporitic environmental settings are frequently invoked to explain the formation of this fibrous clay, sepiolite authigenesis has probably taken place in the Chobe Enclave in a closed lacustrine/palustrine slightly evaporitic basin, with an intermittent input of groundwater influenced by regional hydrothermalism.

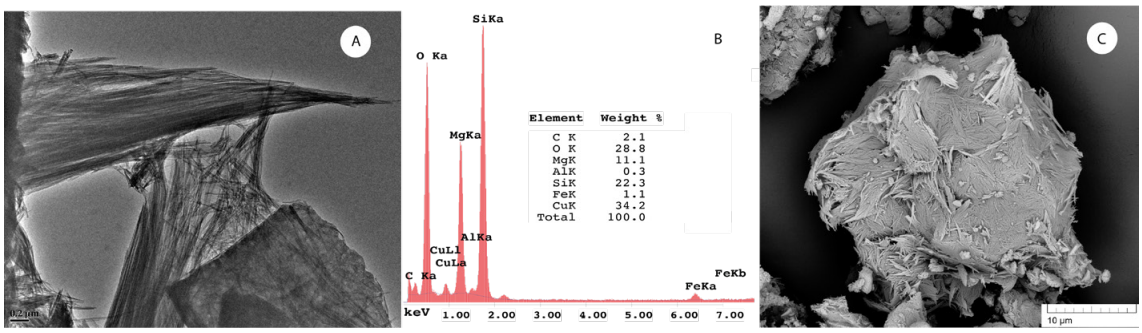

Figure 1: Microscopic aspect, with a representative EDAX analysis, of the sepiolite-rich bed. (A) Transmission Electron Microscope image showing the fibrous nature of the clay; (B) EDAX analysis of sepiolite crystals in (A) with the two major elements, Si and Mg, composing sepiolite. (C) Scanning Electron Microscope image of a quartz grain coated by a mesh of dense sepiolite.

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P 11.26
Origin and preservation of pre-Eemian lacustrine deposits in overdeepenings along the Aare Valley between Thun and Bern

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Repeated glacier advances affected the Swiss Plateau during the Quaternary. Deeply carved valleys, where the bedrock surface is located far below the current drainage level, are a prominent feature on the Swiss Plateau. How and when the glaciers lead to the formation of so-called overdeepenings is still a matter of debate.

A detailed model of the bedrock surface is available for the Aare Valley between Thun and Bern (Dürst Stucki, 2010). The model discloses a large, elongated overdeepening along the Aare Valley and a set of adjacent, minor overdeepenings. Furthermore, former investigations showed that a large portion of sediment infill in the overdeepenings could be of pre-Eemian age (Preusser & Schlüchter, 2004; Preusser et al., 2005). However, the three investigate locations along the Aare Valley do not suffice for a credible correlation.

In order to narrow down a probable, minimum age of overdeepening formation in the Aare Valley we will try to resolve its sedimentary framework. Therefore, we will conduct two scientific drilling in the area around Bern. A minor overdeepening is located SW of Bern-Bümpliz. There, lacustrine deposits crop out at the former clay pit REHHAG. Preliminary results of luminescence dating of the lacustrine sediments yield a minimum age of 220 ka. Furthermore, the sediment succession, taken from public drill log data, appears to mirror the one found in the scientific drilling near Meikirch (Preusser et al., 2005). Not only do both locations show a similar sedimentological succession, the thickness and elevation/absolute position of the lacustrine sediments at both locations are about the same.

Therefore, we decided to locate our first drilling at the former clay pit REHHAG to attempt a correlation between the two sites. In the framework of this task, we will include more pre-Eemian lacustrine deposits along the Aare Valley. Therewith, we plan to resolve the depositional conditions of these widespread lacustrine deposits. Eventually, we will correlate these deposits with the glacial and interglacial framework of the formation and filling of the overdeepenings in the Aare Valley.

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P 11.27
Alpine Glacier Fluctuations and Paleoclimatic Reconstructions

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Several paleoclimate studies provide evidence for a shift in Alpine atmospheric circulation during the Last Glacial Maximum (LGM), at the onset of Alpine glaciers retreat (Florineth and Schlüchter, 2000; Monegato et al., 2017). Before the LGM, the Alpine precipitation regime was probably dominated by southwesterly advection of atmospheric moisture from the Mediterranean, due to the southward migration of the North Atlantic storm track. After the LGM, the North Atlantic storm track moved northward and present-day atmospheric circulation was established, controlled by northerly atmospheric moisture coming from the Atlantic (Luetscher et al. 2015). However, both the exact timing of this shift in atmospheric circulation and the connected magnitude change in precipitation rates and associated glacier response remain elusive.

The overall aim of this research project is to shed light on Alpine paleoclimatic conditions since the LGM, by using glacier fluctuations in Aosta Valley (Italy) as proxy. Indeed, because glacier mass-balance is highly sensitive to both temperature and precipitation changes, past ice-extent and thickness can be used as quantitative markers of paleoclimatic conditions (e.g. Ivy-Ochs et al., 2008).

The reconstruction of post-LGM ice thickness and extent fluctuations will be achieved using detailed geomorphological mapping together with high-resolution rock surface dating of glacially polished bedrock and erratics (in-situ produced Terrestrial Cosmogenic Nuclides, TCN) and glacio-fluvial and glacio-lacustrine deposits (Optically Stimulated Luminescence,OSL), in different glacial catchments of Aosta Valley with contrasted orographic exposure. The dataset coming from the combination of these two dating techniques will provide high-resolution spatial and temporal reconstructions of paleo-glacier oscillations, during both the Late-glacial and the Holocene times.

Differences in glacier responses between Aosta Valley glacial catchments are expected because of distinct orographic conditions and moisture sources, therefore constraining a shift in paleo-atmospheric circulation.

These time-transgressive paleo-glacier responses will in turn be used as calibration constraints for ice modelling to quantify changes in paleo-precipitation rates and patterns since the LGM and to better understand the glacier response to these changes.

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P 11.28
Living benthic foraminifera from cold water coral ecosystems in the Mellilla Mound Field, Alboran Sea, Western Mediterranean

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Quantitative investigation on living (stained) benthic foraminifera, TOC, $\delta^{13}C_{org}$ and $\delta^{15}N_{org}$ from cold-water coral (CWC) surface sediments form 5 box cores recovered on the Melilla Mounds Field (MMF) in the Alboran Sea, western Mediterranean Sea, are presented for the first time.

Benthic foraminiferal assemblages are more diverse on-mound offering more numerous ecological niches than off-mound. The mud layer covering the coral rubbles debris suggests that the MMF is today exposed to sediment siltation.

Geochemical characterization shows that these sediments contain relatively fresh (labile) organic carbon but also reworked refractory components. The $\delta^{15}N$ of the organic fraction suggests that important atmospheric N_2-fixation and degradation processes occur at the MMF and/or that specific hydrographic conditions provide the mound-tops with freshly exported phytodetritus.

P 11.29
Reconstruction of sea surface temperature gradients in the Southern Indian Ocean over the last glacial cycle

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Over glacial-interglacial cycles, the Southern Ocean exerts a major leverage on atmospheric CO_2 concentrations and thus Earth's climate[1]. The Antarctic Circumpolar Current (ACC) plays a crucial role in the global heat and nutrient distribution, Antarctic sea ice dynamics, and the upwelling of CO_2- and nutrient-rich subsurface waters. As micronutrients and light are limiting primary production in this area, nutrients that are brought up to the surface are not completely consumed, engendering a degree of inefficiency in the biological pump thereby allowing for CO_2 to escape to the atmosphere. Due to its dynamical association with the Westerlies, changes in the strength and/or equatorwards shifts of the ACC during glacial periods has been hypothesized. However, paleoceanographic reconstructions are still ambiguous and changes in ACC dynamics on glacial/interglacial timescales remain to be under debate[2,3].

We make use of the strong latitudinal temperature gradients observed over the different zones north and south of the ACC today[4], that act as a main driver of the flow strength. Thus, we reconstructed TEX86-based sea surface temperatures (SSTs) for three cores located in the modern Antarctic Zone (AZ), Polar Frontal Zone (PFZ) and Subantarctic Zone (SAZ), respectively. These data allow us to calculate changes in the temperature gradients since the penultimate glacial period, inferring the dynamics of changing ACC strengths. We argue that larger SST gradients during warm periods accelerated the ACC flow and consequently upwelling intensities, ultimately leading to enhanced CO_2 outgassing. Smaller glacial SST gradients had the opposite effect, thus helping to sequester more CO_2 in the deep ocean.

These results will help to better understand past changes in ACC dynamics, provide a more complete picture of the past Southern Ocean and its relevance for CO_2 sequestration over glacial-interglacial cycles.

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P 11.30
High-resolution eutrophication history records and phosphorus retention in Lake Burgaschi (Switzerland) since ~1800 AD

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Increasing primary productivity in lakes (eutrophication) has been a detrimental environmental problem since the industrial revolution. In most cases, excessive phosphorus (P) inputs are considered as the main contributor to lake eutrophication. It has been widely accepted that internal P loading from lake sediments can also have a profound impact on the trophic state and prevent the lake from recovery (Cao et al. 2016). However, the relevance of different P forms in the sediments for eutrophication process has received little attention so far.

Burgaschi lake is classified as eutrophic to highly eutrophic since 1970s. Although recent eutrophication history in Burgaschi lake is well documented, very little is known about how the trophic status of this lake changed since 20th century even in the further past. Since 1970s, some in-lake restoration techniques have been applied in this lake aiming to mitigate eutrophication and improve the lake status. It is not well known about how the lake sediments have recorded and responded to these treatments.

In the study, we will address critical knowledge gaps for longer eutrophication history reconstruction of Burgaschi lake and develop new insights into the relevance of P fraction of the sediments to eutrophication. We will analyze varved lake sediments from Lake Burgaschi. Green pigments (Chl *a* and chlorins) inferred from high-resolution hyperspectral imaging scanning will be used to reconstruct the productivity history of the lake since ~1800 AD. A sequential P-extraction with five fractions will be performed to uncover P species retention in the sediments (Lukkari et al. 2017).

The current results show that when the primary productivity of the lake was higher, P retention in the sediments was decreased. The work is still under way. More results will be shown in the meeting then.

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P 11.31
Fungus-growing termites as geological agents transforming savanna landscapes

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This research aims at evaluating the biogeochemical, mineralogical, and physical impacts of fungus-growing termites in soils covering savanna landscapes. In 1990, Julia Allen Jones was the first to earmark the concept of “ecosystem engineer” in tropical and sub-tropical savanna ecosystems, referencing to the role of fungus-growing termites. Fungus-growing termites (subfamily Macrotermitinae, Isoptera) share an exosymbiosis with fungi belonging to the Termitomyces genus. In order to maintain the symbiosis possible, Macrotermitinae must maintain specific hydric and thermic conditions. Therefore, fungus-growing termites build large biogenic structures as large epigeal mounds, easily visible in sub-tropical areas of Africa and Asia. By doing so, fungus-growing termites are able to increase by an order of magnitude of 3 to 4 the alkalinity of soils. They also increase their carbonate contents, the C/N ratios and concentrate nutrients such as potassium and phosphorus. Through the process of selection and transportation of sand grains in their bucal cavity and their mixing with saliva, fungus-growing termites modify the chemical compositions and the mineralogical propreties of clays. They also act as accelerating agents of clay alteration and chemical weathering in tropical ecosystems. The activities of fungus-growing termites tend to slightly raise locally the land surface providing some recolonization advantages.They concentrate nutrients, forming a pattern of fertile lands, and enhancing the growth of vegetation by creating islands of fertility.The selection of very fine sands, in order to meet the construction requirement for their mounds, create patches of clayey sands that have the property to retain water for long periods of time, producing scattered pockets of water in semi-arid regions.

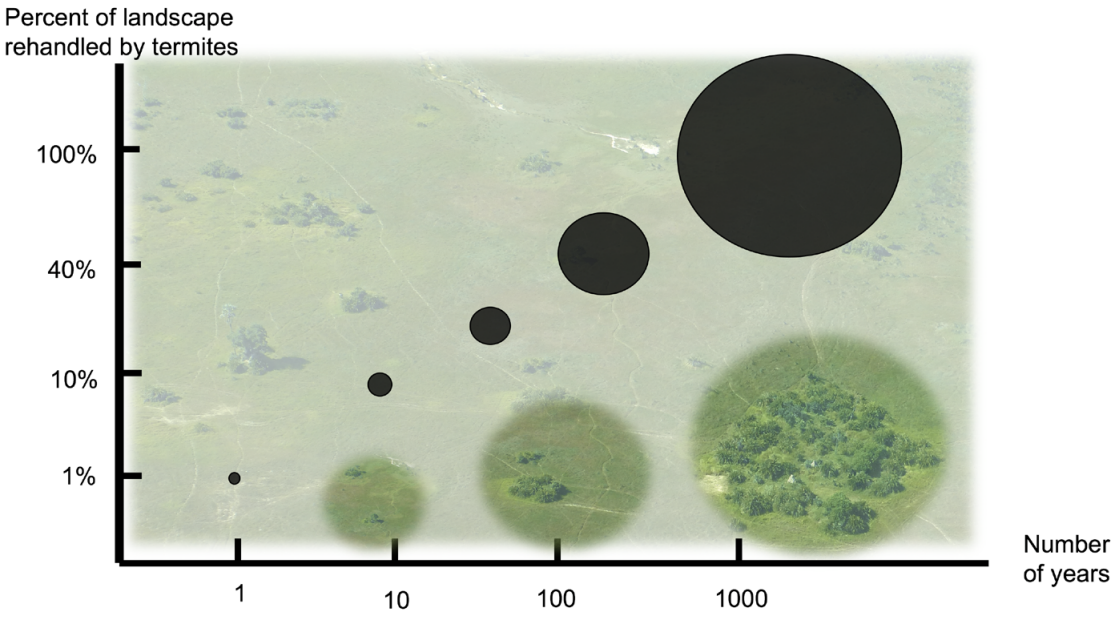

Figure 1. With a density of approximatly 12 mounds per hectare averaging 10 square meters on the ground surface, and knowing that most mounds are occupied for 10 to 20 years Holt et al.(1980), it can be estimated that at this rate, every 100 to 1000 years the entire soil surface of an hectare of semi-arid savanna has been rehandled by fungus-growing termites.

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P 11.32
A high-resolution late-glacial lake sediment record of climate changes and associated environmental impacts from Moossee (Switzerland)

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The transition from the last glacial to the current interglacial (i.e. Holocene) comprises several abrupt major and minor climatic excursions. Lake sediments deposited during this time interval represent valuable terrestrial archives, since they have the potential to show past climate changes at high-resolution. In this study, the stable oxygen isotope composition of lacustrine carbonates from Moossee (Switzerland) was analyzed in order to receive a high-resolution climate record for the last glacial termination and the onset of the Holocene (ca 15,000 a BP to 11,000 a BP). Moreover, a precise age-depth model has been established by the correlation of the oxygen isotope record measured on the lacustrine carbonates and oxygen isotope records from Greenland ice-cores (i.e. NGRIP). During the Oldest and Younger Dryas as well as during minor cold oscillations interrupting the Bølling/Allerød interstadial, the comparison of the stable oxygen isotope record and XRF data on the elemental composition of the sediment allowed to resolve leads and lags between the onset of these cold periods (i.e. negative shifts of the oxygen isotope values) and the reaction of the sedimentary system (i.e. elevated detrital input into the lake). The comparison with the lacustrine record from Gerzensee (van Raden et al., 2013) indicates that large-scale climate changes as well as local factors had an influence on the records during the last glacial termination. Finally, the combination of the measured $\delta^{13}C$ and XRF data has been used to show the importance of biological activity in the lake for the stable carbon isotope record.

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P 11.33
Evidence for a local last glacial maximum during the MIS-3 in eastern Turkey

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As Turkey is located in the Alpine-Himalayan mountain belt, it has a mountainous landscape with ranges extending parallel to the coast in the north and south. This landscape causes moist air masses to leave precipitation mostly in the coastal regions. Therefore, the central parts of Turkey have lower precipitation compared to the coast, and the continental climate prevails. This inbalance results in different equilibrium line altitudes (ELA) on the coast and inland. In order to explore, in this study, how this inbalance in the past was and how it was changing in time and space, we focus on the remnants of past glaciations in the eastern Turkish mountains, where significant evidence of past glaciations are present, but poorly constrained. To do so, we studied the glacial geology in the Kavuşşahap Mountains, Mount Bingöl, Munzur Mountains and Tahtalı Mountains in detail and reconstructed the glacial chronology with surface exposure dating.

In the field, we mapped the glacial landforms and erosional features in detail and collected surface samples from erratic boulders on the moraines for cosmogenic ^{36}Cl analysis. Detailed geomorphological mapping indicate that these areas have experienced several glacial advances. For instance, glaciers reached a maximum length of 17 km in the Narlıca Valley in the Kavuşşahap Mountains and descended to an altitude of 2350 m above sea level. The reconstructed chronology in this valley show that the oldest glacial advance, thus the local last glacial maximum extent occurred during the MIS-3 (Marine Isotope Stage 3) in this valley. We found that the ELA was 1150 m lower than today, which point to about 10^{o}C decrease in average yearly temperature in the region.

P 11.34

TCN dating of high-elevated rockfalls in the Mont Blanc massif. A new method of dating rockfalls in the Mont Blanc massif using reflectance spectroscopy

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Rockfalls and rock avalanches are active processes in the Mont Blanc massif, with infrastructure and alpinists at risk. Thanks to a network of observers (hut keepers, mountain guides, alpinists) set up in 2007 current rockfalls are well surveyed and documented. Rockfall frequency has been studied over the past 150 years by comparison of historical photographs, showing that it strongly increased during the three last decades, likely due to permafrost degradation caused by the climate change. In order to understand the possible relationship between rockfall frequency and the warmest periods of the Lateglacial and the Holocene, we study the morphodynamics of some selected high-elevated (> 3000 m a.s.l.) rockwalls of the massif on a long timescale.

Since rockfall deposits in glacial areas are evacuated by the glaciers, our study focuses on the rockfall scars. ^{10}Be TCN dating of a rockwall surface gives us the rock surface exposure age, interpreted as a rockfall age. Here we present a dating dataset of 80 samples carried out between 2006 and 2016 at six high-elevated rockwalls in the Mont Blanc massif. The resulting ages vary from present (0.04 ± 0.02 ka) to far beyond the Last Glacial Maximum (*c*. 100 ka). Three clusters of exposure ages are correlated to i) two Holocene Warm Periods (7.50 - 5.70 ka), ii) the Bronze Age Optimum (3.35 - 2.80 ka) and iii) the Roman Warm Period (2.35 - 1.75 ka). A fourth age cluster has been detected with ages ranging 4.91 – 4.32 ka. The biggest cluster, ranging 1.09 ka – recent, shows rather small volumes (< 15,000 m^3). This is interpreted as the normal erosion activity corresponding to the current climate.

Furthermore, a relationship between the colour of the Mont Blanc granite and its exposure age has been established: fresh rock surface is light grey (e.g. in recent rockfall scars) whereas weathered rock surface shows a colour in the range grey to orange/red: the redder a rock surface, the older its age. Reflectance spectroscopy is used to quantify the granite surface colour. We explored the spectral data in order to find an index to measure the rock weathering evolution along time, thus allowing to date the rock surface exposure age using reflectance spectroscopy: the GReen Infrared GRanite Index (GRIGRI), based on the Remote Sensing-used GRVI Vegetation Index. GRIGRI uses the ratio between Green (530 nm) and Photographic Infrared (770 nm) reflectance to obtain the index, directly related to the granite exposure age (r= 0.861). The GRIGRI method has been tested for 8 samples where TCN dating failed, and for two samples where ^{10}Be exposure age is considered outlier. The resulting ages, according to the geomorphology of the scars and their surroundings, are plausible.