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

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20. 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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20.1

The Valais Glacier: its disappearance from the Alpine Foreland

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The northern Alpine foreland was covered by the Piedmont glaciers for the last time during the Last Glacial Maximum (LGM; Bini et al., 2009). Among these lobes, the Valais Glacier left the Rhone Valley and extended across the Alpine Foreland to the Jura Mountains. This mountain belt obstructed the northward extension of the Piedmont glacier and the glacier was split into two lobes. One lobe flowed to the southwest and joined to the Arve glacier, which extended ca. 20 km to the east of Lyon. Another lobe was diverted towards northeast and terminated at its maximum ca. 10 km east of Solothurn (Figure 1; Ivy-Ochs et al. 2004; Graf, 2008; Bini et al. 2009). The advance of the Valais Glacier onto the foreland occurred after 30 cal yr BP (Schlüchter, 2004) and it reached its maximum position at around 22 ka. The timing of this maximum is constrained ^{10}Be exposure ages from erratic boulders in Steinhof, Möschberg and the Jura Mountains (Figure 1; Ivy-Ochs et al. 2004; Graf, 2008; Akçar et al., 2011). Although the advance of the Alpine glaciers has been reconstructed within a relatively detailed chronological framework, reconstructions of their demise have been rather vague mainly because of poor age constraints.

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

Our results indicate that the Valais glacier reached Finsterhennen after 29 cal kyr BP. Erratic boulders from the left lateral position yielded an age of ca. 22 ka, which is consistent with the existing exposure ages. Our model age from the cosmogenic ^{36}Cl depth-profile indicate that at around 18 ka the margin of the Valais glacier was still located to the northeast of Finsterhennen. Furthermore, because the earliest non-glacial deposits, which were encountered at the archeological site Rouges Terres at the border of Lake Neuchâtel ca. 15 km to the southwest of Finsterhennen, were dated to ca. 16 kyr cal BP (Hajdas et al., 2004), the demise of the Valais glacier in the foreland occurred within less than 2 ka, which is shorter than previously thought. Finally, a practical implication of this study is that ages ranging up to hundreds of thousands of years can be determined for the top-most layers (e.g. terraces) simply by measuring cosmogenic ^{36}Cl depth-profiles in cores or trenches of 2-4 m depth, independent of lithological composition of the sediment and sample size.

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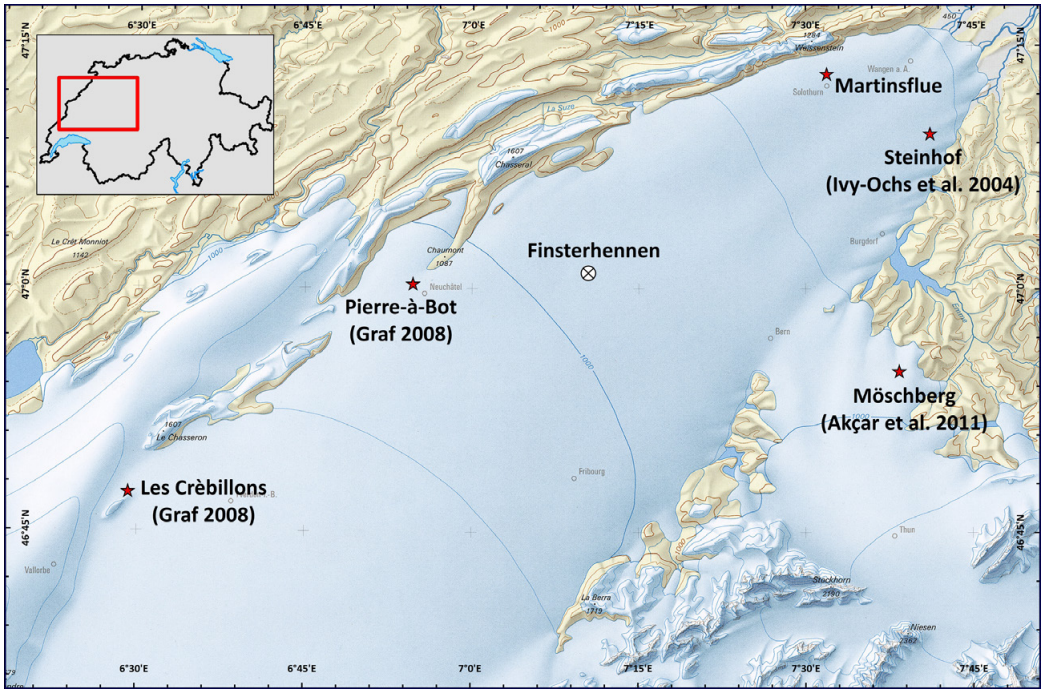

Figure 1. The LGM Valais Glacier and study sites (after Bini et al., 2009). Red stars indicate the locations of exposure dated erratic boulders, while crossed-circle show the gravel pit at Finsterhennen.

20.2

Scanning reflectance spectroscopy (380-730 nm) for Paleo-environmental and climatic changes assessment

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High resolution quantitative reconstructions of climate variables for the last 2,000 years are recognized as one of the primary targets for current climate research (PAGES 2k 2013). Paleodata from natural paleoclimatic archives are one of the few means to obtain this information beyond the instrumental period.
In this context, varved (laminated) lake sediments are valuable paleoclimatic archives due to their potential to preserve past climate over long periods of time at very high resolution (annual) and with good chronological precision.

However, one of the fundamental methodological obstacles is that most of the analytical techniques for proxy data acquisition are very time consuming and expensive. This limits the number of data points generated and, in turn, restricts the temporal resolution and lengths of paleoclimate records (Ojala et al. 2012).
To avoid this problem, we present here the potential of scanning visible reflectance spectroscopy (VIS-RS, 380-730nm spectral range) using the portable device "Spectrolino" on biogeochemical varves. This tool provides a rapid, non-destructive high-resolution technique for data acquisition with direct measurement on the fresh sediment core surfaces.
We show that VIS-RS data may be used for relating primary productivity in biogeochemical lake sediments, thus providing a strategy for rapid exploratory assessments of paleoenvironmental changes.

Ideal sediments for this purpose were found in Lake Żabińskie (Masurian Lake District, NE Poland), a dimictic, 44-meter deep lake which is ice-covered from January to March (Tylmann et al. 2006). It exhibits biogeochemical varves with a high content of organic matter from different sources (terrestrial, aquatic plants, algae and bacteria), a simple inorganic composition (predominantly summer-precipitated autigenic calcite) and high annual sedimentation rates (5-8mm). We retrieved and analyzed a short sediment core (50-cm long) that covers the last 80 years. Pigments were extracted following standard protocols (Reuss et al. 2010) with freeze drying and extraction in acetone, followed by analysis of pigments by High Performance Liquid Chromatography (HPLC). Biogenic silica (BiSi) as well as loss on ignition and Carbon-Nitrogen-Sulfur elemental analyses were also analysed to provide additional information.

The combination of proxies first highlights a recent eutrophication of the Polish lake (Fig.1) detected notably by depth-constrained cluster analysis.
After deriving a series of spectral indices, we calibrated VIS-RS data with composition and concentration of pigments in Żabińskie's sediments. The results (Fig.2) revealed that VIS-RS data best reflect concentrations of *Chlorophyll a* and its diagenetic products (*Pheophytin a* and *Pyro-pheophytin a*).

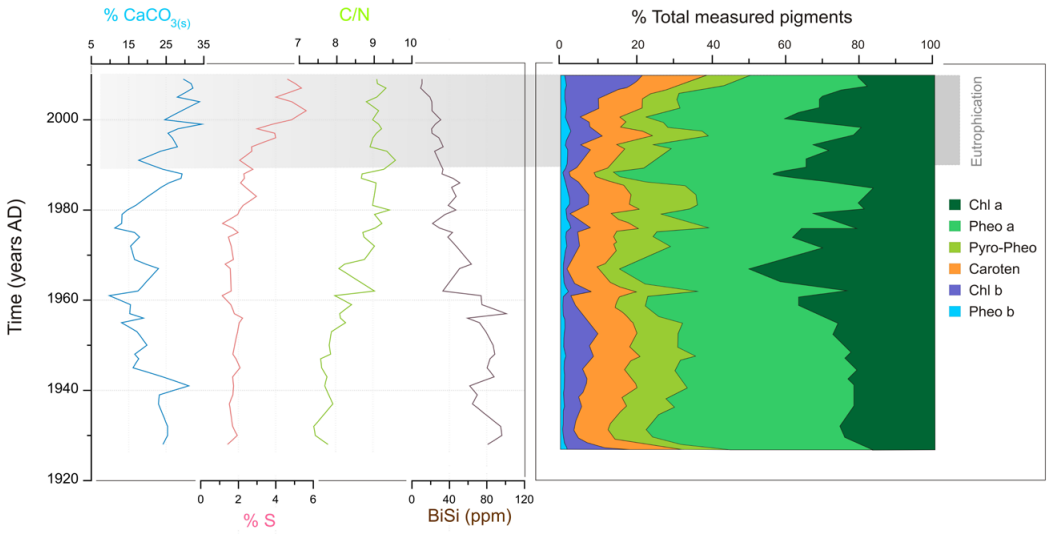

Figure 1. Time series of the proxy data. The recent (last 20 years) eutrophication of Lake Zabinskie is marked by the shaded grey area.

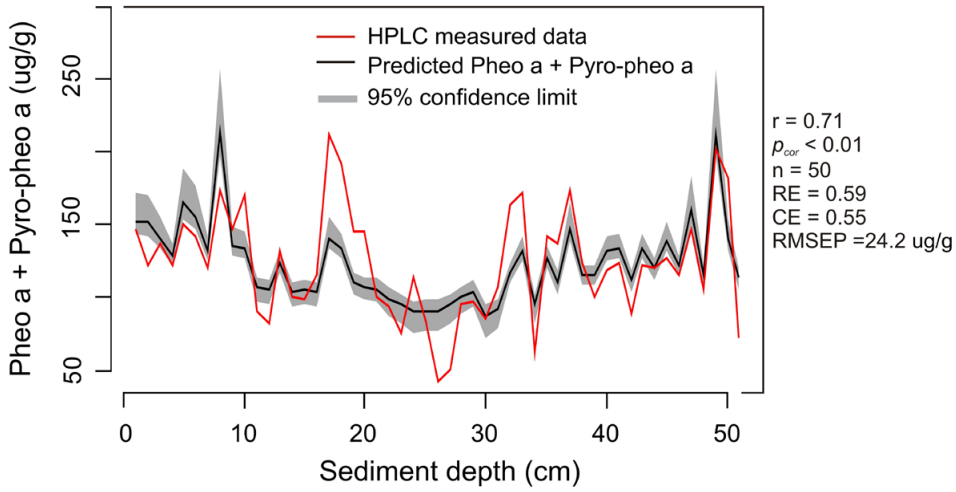

Figure 2. Proxy-proxy calibration. VIS-RS data is used as a predictor for *chlorophyll a* derivatives (*pheophytin a* and *Pyro-pheophytin a*).

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20.3

The challenge of dating Swiss Deckenschotter with cosmogenic nuclides

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Deckenschotter (cover gravels) are Quaternary sediments, which cover Tertiary Molasse or Mesozoic bedrock and are located beyond the limit of the Last Glacial Maximum. The Deckenschotter are a succession of proximal glaciofluvial gravels of the Northern Alpine Foreland, showing locally an intercalation with till and overbank deposits from (paleo-) valleys (Graf 1993). These deposits, which can be differentiated by their distinct topographical position, are divided into two main geomorphic units: Höhere (Higher) and Tiefere (Lower) Deckenschotter. Even though the Höhere Deckenschotter occupies a topographically higher position, it is older than the Tiefere Deckenschotter as the two are separated from each other by a phase of incision. Both Höhere and Tiefere Deckenschotter bear evidence of at least four glacial advances that reached the Alpine foreland and are, therefore, complex lithostratigraphic sequences.

The chronology of the Deckenschotter is poorly constrained. In the Höhere Deckenschotter at the Irchel site, mammalian faunal assemblages (MN17) were found which place the Deckenschotter between 2.5 and 1.8 Ma (Bolliger et al. 1996). This is the only age available until this study. They are therefore the oldest Quaternary units in the northern Swiss Alpine foreland known so far. Reconstruction of the chronology of these glaciofluvial units will provide fundamental information about the onset of Quaternary glaciation in the Alps as well as about the timing and magnitude of incision on the foreland.

In this study, we collected 54 samples from three sites: Pratteln (BL), Stadlerberg (ZH) and Irchel (ZH) for depth-profile dating with cosmogenic ^{10}Be and/or ^{36}Cl and for isochron-burial dating with ^{10}Be and ^{26}Al (Figure 1). Depth-profile dating uses the fact that cosmogenic nuclide build-up diminishes with depth following the known physical principles, while isochron-burial dating is based on the decay and on different pre-burial and same post-burial histories of the quartz clasts stemming from the same time-line. In addition to the cosmogenic nuclide dating, we are also determining the lithological composition of the Deckenschotter. We are doing detailed lithostratigraphy of several sites by examining the petrography of the pebbles.

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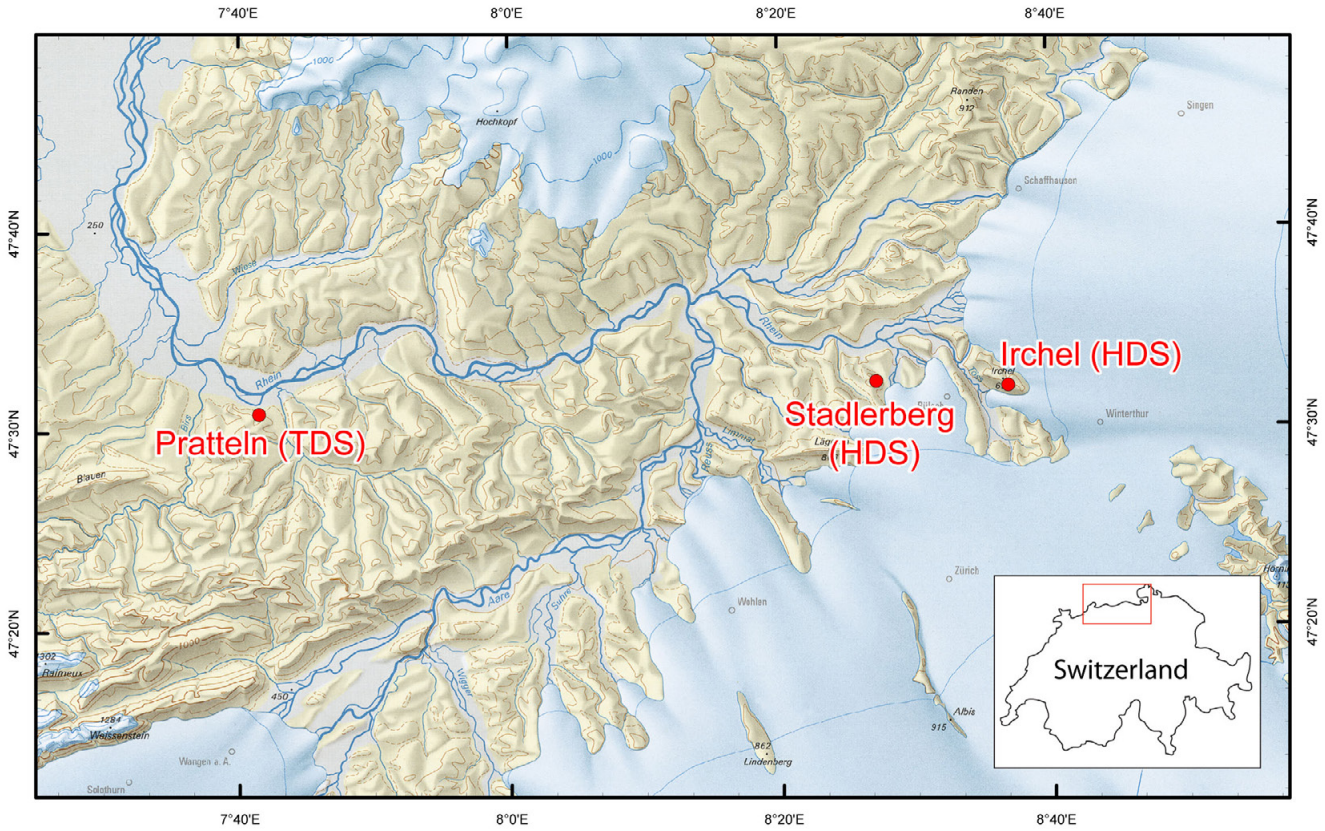

Figure 1. Location of the Pratteln, Stadlerberg and Irchel study sites in the map showing the extent of Last Glacial Maximum (Bini et al. 2009).

20.4

Worldwide acceleration of mountain erosion under a cooling climate

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Climate influences the erosion processes acting at the Earth surface. However, the impact of Late Cenozoic cooling, including the onset of Plio-Pleistocene Northern Hemisphere glaciation (~2-3 Ma), on global erosion rates remains elusive. The uncertainty mainly arises from a lack of consensus on the use of the sedimentary record as a proxy for erosion3,4 and the difficulty of isolating the respective contributions of tectonics and climate to erosion. Here we show that mountain erosion rates have increased since ca. 6 Ma and most rapidly since ca. 2 Ma. To quantify erosion for the source areas that ultimately produce the sediment record at a Myr timescale, we have compiled about 18,000 bedrock thermochronometric data from around the world and use a formal inversion procedure to estimate temporal and spatial variations in erosion rates. The observed increase of erosion rates is expressed at all latitudes, but is most pronounced in glaciated mountain ranges, indicating that glacial processes played a significant role. Because mountains represent a significant fraction of the global production of sediments, our results imply an increase of sediment flux at a global scale that tightly coincides with enhanced cooling during the Late Plio-Pleistocene. These findings have important implications for potential feedbacks between global climate and erosion.

20.5

Mid to late Holocene environmental change in the Bolivian Amazon reconstructed from paleosols and archaeological sites.

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The Llanos de Moxos (LM), in the Bolivian lowlands, is a seasonally flooded savannah (Mayle et al. 2007). The recent discovery of the oldest archaeological sites in the region shows that the LM has been inhabited since the beginning of the Holocene (Lombardo et al. 2013). These sites have long remained unnoticed because they were buried by fluvial sediments, together with several paleo surfaces, mostly paleosols, in the southern part of the LM. Linking together paleo-ecological reconstructions and archaeology, this research hopes to shed new light on the large scale environmental changes that took place in south-western Amazonia during the Holocene, the nature of human-environment interactions at the time and the potential value of these archaeological sites as paleo-environmental proxies.

Despite their similar aspect, early Holocene archaeological sites are often located in very different geomorphological and stratigraphic settings.

Preliminary results of geo-archaeological research on these sites in south-eastern LM will be presented, together with new stratigraphic data from 3 outcrops and 10 cores taken along a 230 km transect crossing the south-western LM.

The data from the archaeological sites suggests that the early Holocene landscape, in which the first hunter-gatherers settled, was significantly different from what we see todays. One of the sites, associated with an early to mid-Holocene paleosol, has been almost totally buried by fluvial sediments and only its topmost 30-40 cm has remained above the alluvium that forms the current savannah (Fig. 1). The second site, currently outcropping in the middle of a flat swamp, was actually located on a sandy fluvial levee and subsequently flooded and partially buried by peat-like sediments. There is evidence suggesting that during the mid to late Holocene, the Rio Grande entered a highly active avulsive phase which led to the deposition of a sedimentary lobe which covered the south-eastern LM (Lombardo et al. 2012). However, the causes behind the mid to late Holocene activation of Río Grande are still unclear. The 230 km long stratigraphic transect shows an extensive presence of buried organic horizons, probably paleosols, in the south-western LM, suggesting that the avulsive phase of the Río Grande was not an isolated event but part of a wider change in environmental conditions that took place at a regional scale. The activation of the fluvial network during this period reshaped the whole southern LM, covered most of the early Holocene landscapes and archaeological sites and created a new landscape which remained stable at least for the past 2500 years.

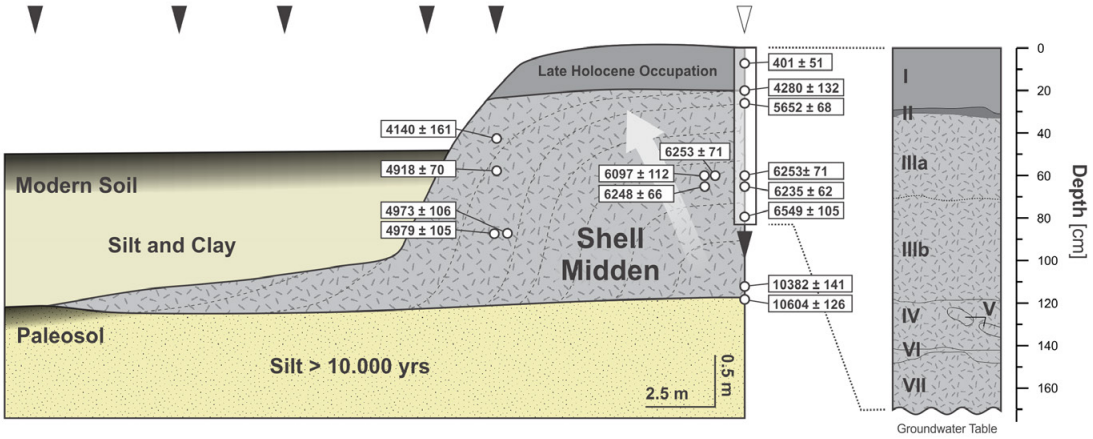

Figure 1. Cross-section transect of the shell midden SM1. Dashed lines and grey arrow highlight the onion-like growth of the midden reflected in the ^{14}C dates. The black triangles above mark the coring locations and the white triangle the excavation site.

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20.6

A speleothem record of the Last Glacial Maximum from the western Swiss Alps

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Several lines of evidence from alpine cave environments suggest that karstification is not solely restricted to warm interglacial periods. Indeed, dissolution of carbonate rock may also arise without the intervention of biogenic (soil-derived) CO_2, e.g. by the oxidation of pyrite present in the aquifer hostrock (Atkinson, 1983). Providing there is sufficient water available speleothem deposition may therefore also occur under temperate glacier cover (Spötl and Mangini, 2007; Luetscher et al. 2011). Here we present a speleothem record from the Sieben-Hengste cave system (Swiss Alps) covering the Last Glacial Maximum (LGM), the first of its kind from Central Europe.

Two coeval stalagmites were sampled at approximately 160 m below the modern ground surface (i.e. 1540 m a.s.l.), in an alcove at the base of a vadose shaft. 49 high-precision uranium-series ages reveal a continuous deposition between 30 and 14.7 ka b2k. Both stalagmite time series correlate fairly well in the overlapping segments and, therefore, likely responded to a same hydrological forcing. While the $\delta^{13}C$ stays remarkably constant at +4.4±0.4 ‰ supporting the absence of biogenic CO_2 contribution, $\delta^{18}O$ values vary between -10.5 and -13.5 ‰ and show a remarkable similarity to other Northern Hemisphere isotope records, both on orbital and millennial timescales. However, in marked contrast e.g. to NGRIP, the Sieben-Hengste record shows a $\delta^{18}O$ minimum centred on 25.3 ka synchronous with the maximum Alpine glacier advance. We propose that the first-order variance in our $\delta^{18}O$ values primarily records changes in the trajectories of the storm tracks reaching the Swiss Alps which is consistent with the build-up of large ice domes south of the present weather divide (Florineth and Schlüchter, 2000). This hypothesis is currently being tested by modelling oxygen isotopes along different trajectories.

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20.7

Late Quaternary Glacial History in northeastern Anatolia

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The reconstruction of paleoglaciers is a terrestrial climate approximation for cold and wet periods but also a sensitive archive for rapid warming. Then the rates of deglaciation can correspondingly be used in determining the loss of ice volume and this will help to better understand feedback mechanisms and rates of climate changes (e.g. Schlüchter 2004). Paleoglacier reconstructions in the circum-Black Sea area are incomplete, mainly due to the lack of absolute chronology. In this study, we mapped the glacial deposits in the Başyayla Valley in north eastern Anatolia in detail and reconstructed the chronology of glacier advances with surface exposure dating with cosmogenic nuclides (Figure 1).

The Başyayla Valley is a ca. 6 km long east-west oriented tributary valley in the northern side of the Eastern Black Sea Mountains. Based on the detailed mapping, three glacier advances, which are constrained with terminal moraines, were identified in the field. The inner and outer terminal moraines are geomorphologically well constrained, whereas the middle one is poorly preserved because the mountain village was built on this moraine. 40 samples from the glacially transported boulders and one from the bedrock outcrop on the crest line of the north-western valley flank were sampled for cosmogenic ^{10}Be and ^{26}Al analysis.

Our results show that the Başyayla glacier advanced ca. 40 ka down to an altitude of 2350 m a.s.l., but it did not reach the main valley system. The next advance extended down to an altitude of 2440 m a.s.l. and its timing is attributed to the Early Last Glacial Maximum (LGM) based on the exposure ages of the boulders from the left lateral moraine. The last advance of the Başyayla glacier was down to 2480 m a.s.l. and at ca. 22 ka during the global LGM (Shakun and Carlson 2010). In the upper part of the valley, exposure ages from boulders on a retreat position at an altitude of ca. 3050 m a.s.l. indicate that the valley was ice-free since around 17 ka. Hence, the terminus of the glacier must have been restricted to the cirque in the upper most part of the valley during the Lateglacial.

Our study presents the first evidence for a pre-LGM advance in the Anatolian mountains, which is more extensive than the LGM advance. Pre-LGM glaciations are still to be explored in Anatolia. The global-LGM advance of the Başyayla paleoglacier ca. 22 ka and its retreat at around 17 ka is comparable with the paleoglacier reconstructions in the neighbouring Kavron and the Verçenik Valley systems (Akçar et al. 2007; 2008), as well as the other Anatolian mountains (Zahno et al. 2009). Finally, glacier advances in the Başyayla Valley indicate similar climatic conditions between around 40 ka and 22 ka, which resulted in the ice build-up and oscillations, whereas almost the deglaciation of the valley at around 17 ka may imply rapid change in these conditions.

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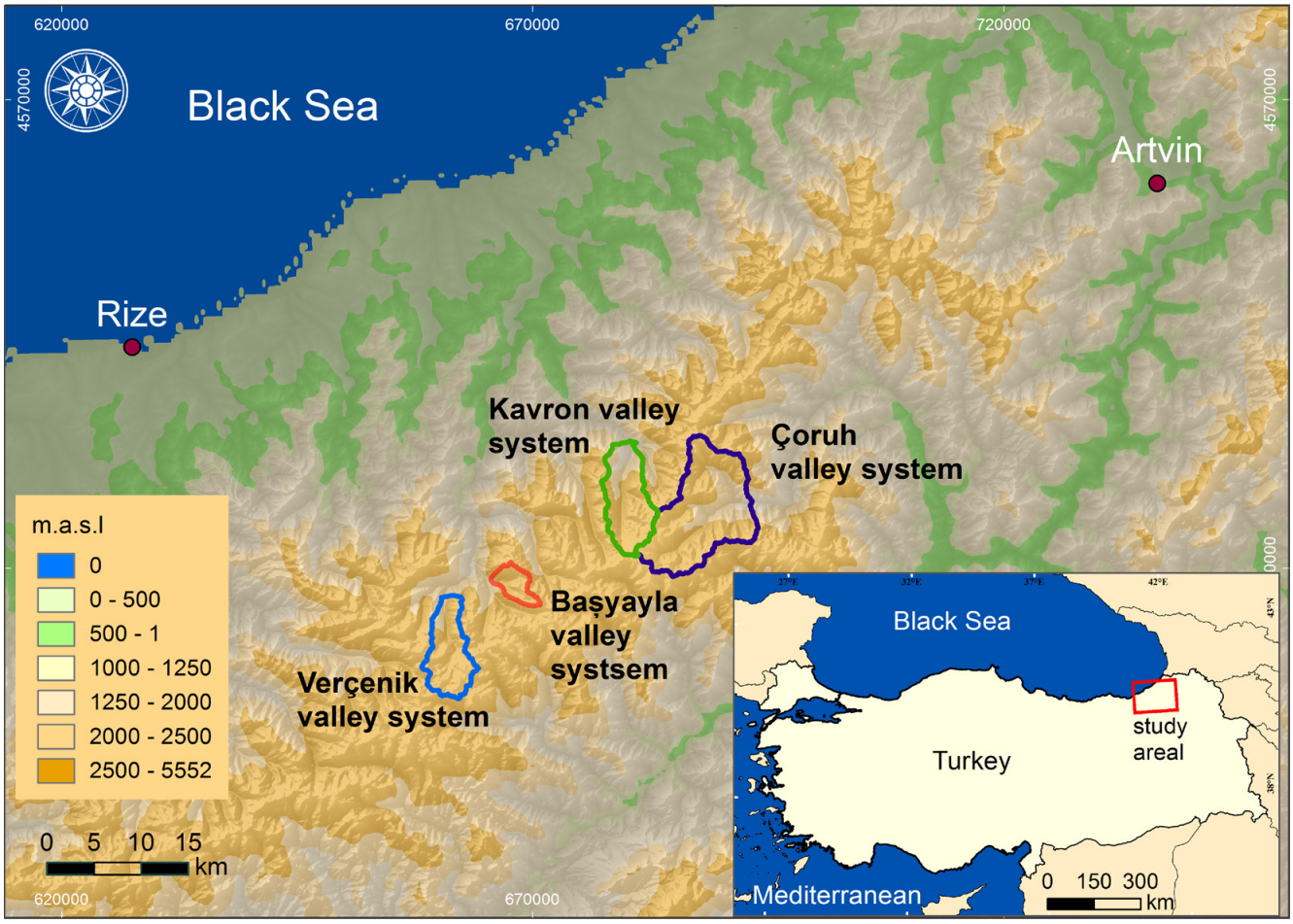

Figure 1. Location map of studied valley systems in north eastern Anatolia (Reber et al. *in prep*.).

20.8

An insight into the morphology of pre-Columbian raised fields in different landscapes in the Llanos de Moxos, Bolivia

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Since the beginning of the 1960s, research in the Amazon has revealed that in pre-Columbian times, landscapes that were regarded as hostile living environments were nevertheless altered and settled in several ways. In South-eastern Amazonia, one of the most impressive way pre-Columbians altered the landscape was through the construction of raised fields.

Pre-Columbian raised fields are earth platforms of differing shape and dimension that are elevated above the landscapes natural surface. The Llanos de Moxos (LM), situated in the Bolivian Lowlands is one of the areas with the highest density of raised fields.

The LM itself hosts an enormous variety of distinct landscapes and soils where numerous types of raised fields have been described (Denevan 2002; Erickson 1995; Lombardo 2011; Walker 2004)

Theories about raised fields have given rise to interesting debates on the function of these cultivation systems. The opinion is greatly divided in matters concerning their productivity and management. Some have proposed that raised fields are a very productive cultivation method, able to generate high yields without the need of fallow periods (Erickson 2006) others have suggested that the construction of raised fields have mostly served as a prevention method for protecting their harvests against severe flood events (Lombardo 2011).

In spite of the high interest in raised field agriculture, very few field-based investigations have been performed. As a result, there is still little explanation concerning their construction, management or for what time frame they were in use.

We studied five different sites with raised fields of the LM having in mind their specific landscape, soils and hydrology. Laboratory tests concerning fertility parameters where carried out in 2012 and suggest rather unfertile conditions for productive agriculture.

Recently, more detailed investigations have been performed on raised fields located in the vicinity of San Borja situated in the south-east of the Andes in the Beni department of Bolivia. It turned out that this site is of special interest because fields where built on different types of sediments ranging from clay to sand. For this study we have applied a virtual grid onto an area of 450x64m consisting of 90 rectangles (~16x20m) (see Fig 1). In each rectangle we carried out sampling for grain size every 20cm up to 100cm depth. The area could be divided into seven different land use types within or away from raised fields. To understand the construction history of the different raised fields, five trenches were excavated extending from the elevated part of the bed to the lowest point in the canal. For comparison three reference profiles outside raised fields where dug. Description and standard soil horizon/layer identification procedures were carried out followed by sampling every 10 cm for particle size distribution and standard soil lab analysis. Additionally samples for thin section preparation were taken.

The findings derived from the field description of the profiles seem to challenge the assumption that raised fields were managed through continuous transport of sediments from the canal to the field. By contrast, our results suggest that these raised fields were more likely built during single episodes as large construction events. Furthermore raised fields could have allowed the pre-Columbian population to extend the cultivation ground and also its time frame for example during the wet season when unraised land is flooded.

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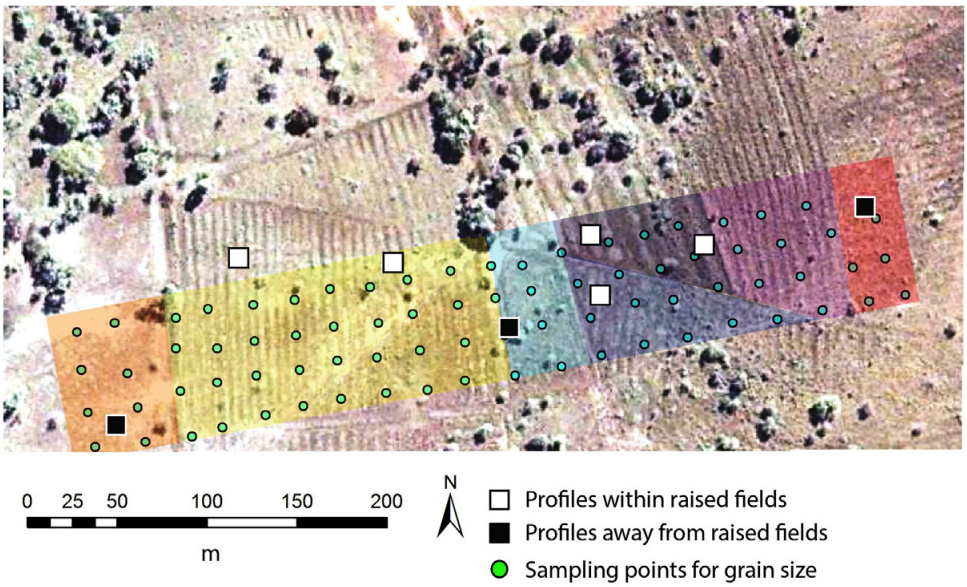

Figure 1. Land use-map with raised fields in San Borja, Bolivia. Each color represents a specific land use.

20.9

Advanced model for limestone fault scarp dating and paleoearthquake history reconstruction

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One of the most challenging applications of terestrial cosmogenic nucleides is the reconstruction of paleoearthquake histories. In this method, 36Cl accumulated by exposed footwall of normal fault scarp is used to date past seismic events and to estimate their magnitude. Time span of the method is about a few tens of kiloyears; precision is about 0.5 kiloyear. Modern earthquake chronologies are based on instrumental data and historical observations during the last 2500 years, therefore methods operative beyond this limit are essential for producing long-term earthquake models.

The fault scarp dating method shares the same general principles with surface exposure dating. In the simplest case, there is a footwall of infinite height and accumulated colluvium that covers the lower part of the footwall. During an earthquake footwall is moving upwards and exposing a new segment. Complex geometrical shielding and periodical displacements of footwall during active history of the fault scarp complicate interpretation of accumulated concentration profile. Hereupon, previous researches on fault scarp dating were supplied with special models and calculation codes (Schlagenhauf et al., 2010).

We present an advanced model for limestone fault scarp dating and paleoearthquake history reconstruction. The model is realized in practice as a MATLAB® code with user-friendly interface (Figure 1). The code uses state-of-the-art model of 36Cl production and special model for fault scarp shielding factors calculation (Tikhomirov et al., 2013). Monte-Carlo method is finally applied to achieve best fit between measured and modeled concentration profiles, as well as to find ages of seismic events and displacements caused by them. Reanalysis of two fault scarp data sets (Schlagenhauf et al., 2010, Akçar et al., 2012) give comparison with previously published models and example of code application.

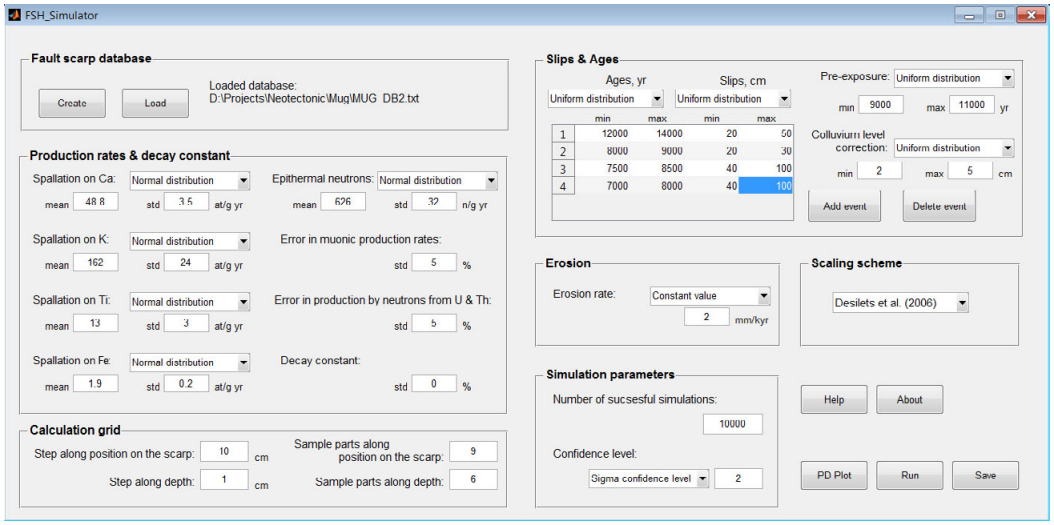

Figure 1. Screen shot of program interface

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20.10

Towards a 'true' age of LGM ice surface decay in Oberhaslital

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During the Last Glacial Maximum (LGM) the Alps were nearly completely covered by ice. In Switzerland, geomorphological mapping in the previous century allowed to reconstruct a system of ice domes located in the high Alps that fed enormous piedmont lobes extending far into the foreland (Florineth & Schlüchter, 1998). Concerning the understanding of the chronology of events, surface exposure ages of the end moraines of these piedmont lobes as well as radiocarbon ages of lake sediments indicate an ice free alpine foreland no later than 18-19 ka BP (e.g. Ivy-Ochs et al., 2004). In contrast, attempts to date the lowering of the ice surface so far yield maximum ages of only around 17 ka (e.g. Kelly et al., 2006). Here we will discuss possible explanations of this apparent discrepancy. In addition, we will present a model suitable to test our hypotheses at the specific case of our study site at Gelmersee in Oberhaslital.

Grimsel Pass, ice transfluence -> sensitive location
Ice cover – set of low altitude boulders -> model
Inheritance – Cl/Be ratio
'true age'? ice surface decay likely synchronous to retreat from foreland. But possibly non-erosive ice masses remain until lateglacial in flat high-altitude settings.

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20.11

Dating glacial deposits in the western Swiss lowlands using cosmogenic ^{10}Be

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During the Pleistocene, glaciers advanced repeatedly from the Alps into the Swiss Molasse basin. The exact extent and timing are still under debate, even for the last glacial advances. Decalcification depths, for example, increase from west to east in the western Swiss lowlands and have been interpreted to indicate that the Valais (Rhone) glacier might have been most extensive not synchronous with the global Last Glacial Maximum (LGM) at 20 ka, but early during the last glacial cycle (Bitterli et al. 2011).

In an attempt to provide more quantitative age control, we applied 10-Be depth profile dating (Hidy et al. 2011) on moraines at two locations. First, a gravel pit near Niederbuchsiten, which presumably lies outside the last glacial ice extent (Bitterli et al. 2011). The second location, Steinhof, is located south of Herzogenbuchsee. Here, two boulders have been dated to the global LGM (Ivy-Ochs et al. 2004), but the decalcification depth is unexpectedly high with 3.9 m.

The results show that depth profile dating using 10-Be at our sites can only be applied successfully, when erosion is sufficiently constrained independently. Assuming no erosion would yield unrealistic, too young ages of 12.2 (+2.4/- 2.0) and 10.6 (+1.4/- 1.3) for Niederbuchsiten and Steinhof, respectively. A recent, anthopogenically induced loss of the uppermost 40 cm of sediments would yield ages of 19.4 (+ 5.3 /- 1.2) ka for Steinhof and 23.5 (+ 1.0/- 3.4) ka for Niederbuchsiten. Several meters of sediment must have been eroded to obtain a penultimate (marine isotope stage 6) age for Niederbuchsiten.

We conclude that deposition of the tills at both our research locations was likely during the global LGM (marine isotope stage 2) and that the Rhone Glacier might have been more extensive at that time than hitherto assumed. Further research is necessary to independently constrain erosion and to evaluate, to which degree decalcification depths are influenced by different original carbonate contents in the till.

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P 20.1

Sedimentological and paleoenvironmental study of quaternary alluvial formations Zeïet Oued, Ain Zerga W Tébessa. N-E Algeria.

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The Quaternary deposits in Tébessa regions (Algeria) have been studied extensively. This study of these deposits especially on river terraces. The objective of this work is the study of processes and environmental change through their recent sedimentary records in the fluvial terrace located along the Zeïet Valley that is localized in Aïn Zerga catchment's area. We preferred methods to obtain information on the depositional environment and the chronology of events such as sedimentological analysis (grain size analysis and determination of sedimentological parameters, morphoscopy, exoscopy, calcimetry, mineralogical (X-ray diffraction for clay fraction). The exoscopy helped differentiate the depositional history of quartz (weathering, transport continental water, ice and sometimes back) The tests carried out using a scanning electronmicroscope on the surfaces of these grains have led to the identification of various figures that can be connected either with the original crystal lattice of quartz or with actions specific corrosive medium of alteration.the study of clay minerals in sediments allowed us to conclude for both units,the origin of sediments of smectite,Kaolinite and Illite must be sught within the catchment areaof this study.in conclusion,we proposed a reconstruction of environmental conditions during the formation of the terrace.

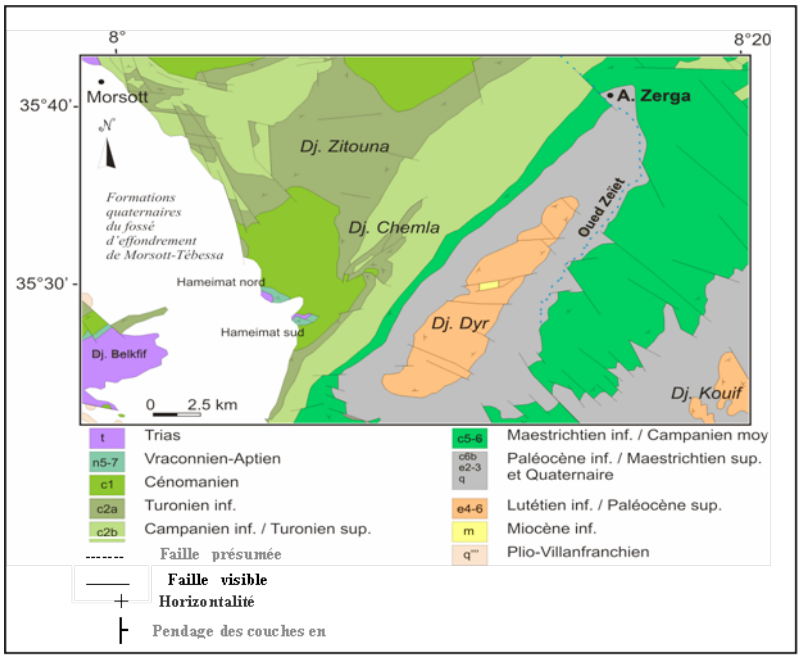

Figure 1. geological and Structural diagram of the study area (from the geological map of Morssot scale 1:50,000).

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P 20.2

Multiphase depositional and erosional history recorded in the infill of the glacially overdeepened Lower Glatt valley, Northern Switzerland

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Glacially overdeepened valley fills are a direct record of glacier presence and absence in the Northern Alpine foreland for the Middle and Late Pleistocene. As such, they provide an important archive reflecting environmental processes during the Middle and Late Pleistocene. While the formation of these overdeepened valleys (tunnel valleys) by subglacial processes of warm based glaciations is undisputed (Cook & Swift 2012), the timing of erosional and subsequent infilling phases are poorly constrained. It is known that many of these unconsolidated valley fills contain a nested sedimentary architecture reflecting the multiphase erosion and deposition history (e.g. Preusser et al. 2010, Dehnert et al. 2012).

We are currently investigating the overdeepened valley fill of the Lower Glatt valley, Northern Switzerland, by integrating existing drilling and outcrop data with five recently drilled cores (65-190 m long) that are being investigated in detail. There is evidence for preservation of sediments from several glaciations, due to the shifting magnitude and focus of subglacial erosion. Our project aims to develop i) a model for sedimentary processes in glacial overdeepenings and ii) a chronology based on luminescence dating. Our contribution will present first results of the detailed sedimentary analysis and dating of glaciolacustrine sediments.

This project is a pilot-study in the context of the international drilling initiative "Drilling overdeepened Alpine valleys" (DOVE) that aims to drill overdeepened valleys all around the Alps involving all Alpine countries (ICDP proposal status). More information is available here:
http://www.icdp-online.org/front_content.php?idcat=1739

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P 20.3

Origin of unexpected tropical carbonate mounds (TCM) in northern Cameroon – Carbonate accumulation context: hypotheses and challenges.

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Carbonate accumulations are observed in the area of Maroua (northern Cameroon). Their presence is unexpected as the catchment basin geology is strictly carbonate-free. At the landscape scale, accumulations have a metric mound shape when they are exhumed from the surrounding pediment red sediments. When they are still partially buried, they display a dark circle section on the ground. What could be the hypotheses to explain such carbonate accumulations?

During the Holocene, climatic conditions varied from wetter to drier conditions. It is assumed that carbonates could be deposited during a wetter period. Three hypotheses of carbonate production can be proposed (fig. 1).

First hypothesis refers to a "Vertisol context". Vertisols are characterized by heavy clay content with high proportion of swelling clay (FAO, 2006). Their colour generally is dark and pH can be very alkaline, generally > 9. Carbonate nodules are commonly observed in Vertisols, particularly into those from northern Cameroon (Nguetnkam et al., 2008). At the landscape scale, Vertisols can display metric mound shapes known as "gilgaï landscape" (Kovda et al., 1996).

The second hypothesis refers to a "Termite system". Soil feeding termites are known to modify soil properties. Clay proportions, pH, and elements such Ca, Mg, and K are generally in higher amounts than in surrounding soil (Mujinya et al., 2011). Furthermore, although carbonate nodules are observed, it is still unclear if carbonates come directly from termite guts (implication of oxalotrophy?), where pH is alkaline, or if they are inherited carbonate brought during soil bioturbation (upward movements).

Third hypothesis refers to an "Oxalogenic-oxalotrophic system". In tropical forests, unexpected carbonate accumulations, resulting from the oxalate-carbonate pathway (or OCP), are observed in soils surrounding oxalogenic trees, e.g. Milicia excelsa (Cailleau et al., 2011). OCP leads to the transformation of atmospheric CO_2 into pedogenic $CaCO_3$. Oxalate is released from plant tissues during litter decay, and then oxidized by soil oxalotrophic bacteria. This process induces a pH increase, which can reach values beyond the stability pH for calcite. As a consequence, calcium carbonate can precipitate in originally acidic soils associated with oxalogenic trees.

In order to explain tropical carbonate mounds (TCM) formation a two steps approach is planed. After deciphering diagenetic and post-carbonate sedimentary settings, the aim is to characterize the primary accumulation process. How did TCM formed over time in such a carbonate-free environment? What are the timing and the nature of processes causing carbonate accumulations?

Figure 1 shows the general framework and geomorphological context in which TCM are observed. To take up the challenges raised by the various hypotheses, two TCM (one exhumed and one buried) are investigated using a combined geomorphological, petrographic, and biogeochemical approach.

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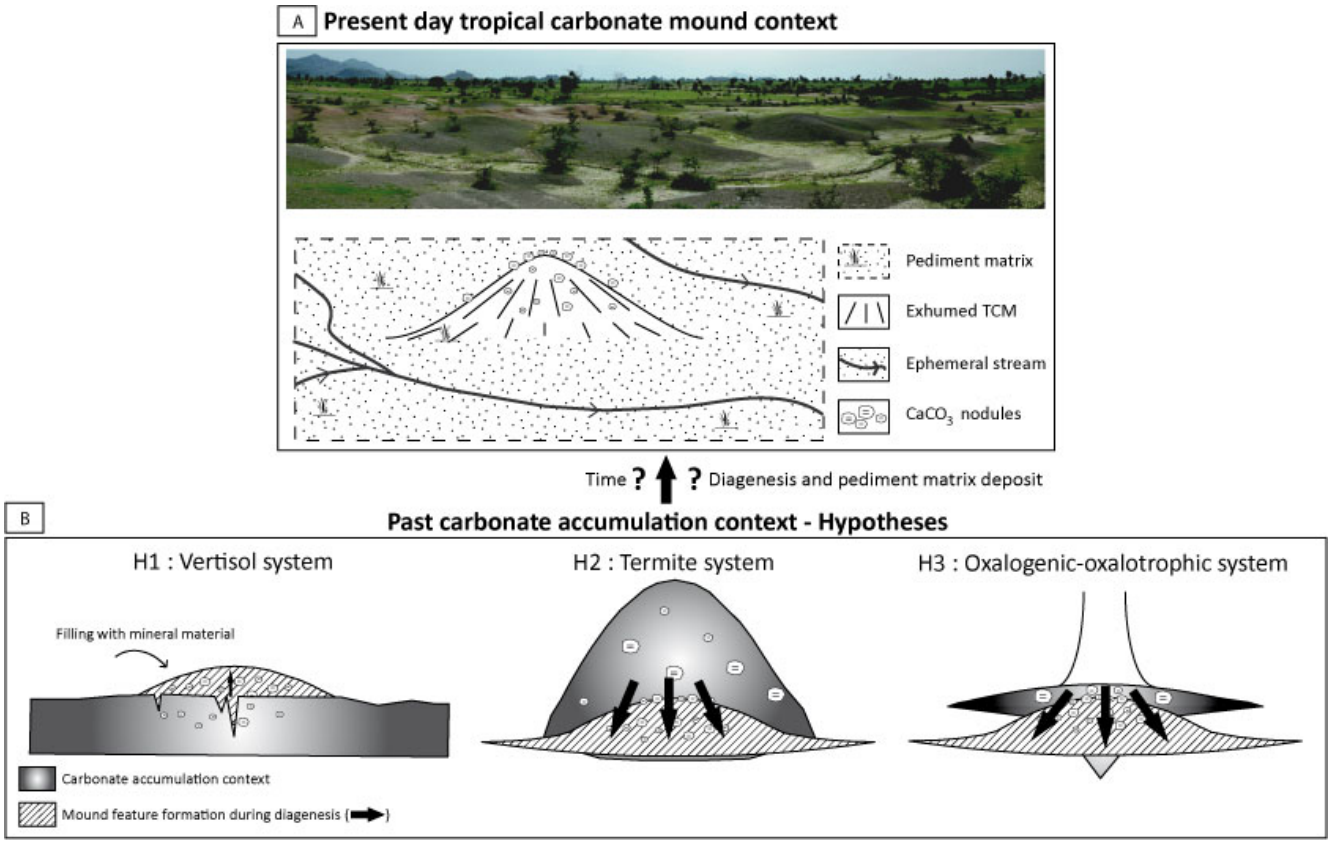

Figure 1: A- Present-day geomorphological context of TCM near Maroua (northern Cameroun). B- Hypotheses for carbonate accumulations: H1- Desiccation processes in Vertisols with mineral material in cracks, forming a gilgaï landscape (Kovda et al., 1996). Accumulation of carbonate in termite mounds (H2) or carbonate formation through a oxalogenic-oxalotrophic system (H3) undergoing diagenetic processes leading to observed present-day mounds.

P 20.4

Middle Würm radiocarbon chronologies in the Swiss Alpine foreland - first results from the TiMIS project

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The COST funded TiMIS project aims at refining the radiocarbon chronology of the middle part of the last glacial cycle (middle Würm: 50 to 25 ka) focussing on the records preserved in the Swiss Alpine forelands where huge piedmont glaciers expanded during the Last Glacial Maximum (LGM). We perform radiocarbon dating of selected key sites in the Alpine foreland to add high-resolution chronological information crucial for understanding the phase of ice build-up just prior to the LGM and to provide important links to other records of Marine Isotope Stage 3 (MIS 3). TiMIS results are integrated into the COST Action ES0907 INITMATE, which is centered on integrating ice, marine and terrestrial records for paleoclimate reconstructions between 60-8 ka.

The Swiss foreland fossil peat deposits are one of the best records available for the ca. 25 ka just before the LGM. Although many peat sections have already been described by the Swiss Quaternary scientists of the 1960s and 70s, reliable age data are not widely available. One important peat deposit, which has been largely exploited throughout the 19th century, is situated at Dürnten, SE of Zürich. Based on detailed pollen analysis in three drill cores, Welten (1982) has reconstructed climate variability since the Riss glacial stage and proposed several stadial-interstadial cycles throughout the Würm. Here, we present first radiocarbon ages from two outcrops of fossil peat deposits at Dürnten. Preliminary ages from peat and wood samples range from 40-45 ka BP and agree very well with ^{14}C ages of ~45 ka reported from peat layers of the Gossau and Niederweningen sites (Schlüchter et al. 1987; Hajdas et al. 2007). Gossau and Dürnten are both located within the LGM extent of the Linth/Rhein glacier and clearly document a phase of moderate climate and glacier absence during the early middle Würm.

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P 20.5

The new luminescence laboratory at the University of Lausanne

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Luminescence dating is a Quaternary dating method which is widely utilised to constrain the timing of Quaternary events. The technique exploits the time-dependent accumulation of charge within certain minerals, when they are exposed to naturally occurring radiation. Quartz and K-feldspar are the most commonly used minerals, and ages can be generated over timescales of 10^1 to 10^6 years.

Optically stimulated luminescence dating can be used to date a wide variety of landforms in different depositional settings, including glacial, marine, aeoloian and fluvial sediments as well as human artefacts. In addition to its conventional applications, luminescence dating has also recently been proposed as a low-temperature thermochronometer (Herman et al., 2010). This is because in addition to being light-sensitive, the luminescence signal is also sensitive to temperature.

The new luminescence laboratory at UNIL has been established by the Earth Surface Dynamics group led by Professor Frédéric Herman. In addition to sedimentary and rock sample preparation facilities the laboratory is equipped with a Risø luminescence TL/OSL reader, which has capacity for time-resolved and single photon counting experiments. A second reader, with the facility for single-grain quartz and feldspar analyses has been ordered and will be available from Spring 2014.

For further information on OSL dating and the new OSL facilities available at UNIL and to discuss potential collaborations, please contact Dr Georgina King (georgina.king@unil.ch).

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P 20.6

Archaeometric evidence of foodways in the South-Central Andes: Prehispanic maize consumption in West Tinogasta (Catamarca, Argentina)

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Pre-Hispanic Andean societies depended economically to a large degree on the extensive horticultural production of maize (*Zea mays*), the main staple food crop in the region. Carbonized maize and maize-based food residues can be identified in archaeological ceramics by a combination of chemical and stable carbon isotope analyses of preserved lipids by the use of bulk and molecular isotopic techniques combining gas chromatography and mass spectrometry (GC-MS, GC-C-IRMS; e.g. Reber & Evershed 2004, Seinfeld et al. 2009).

Archaeological finds at the West Tinogasta area in the Catamarca Province, NW Argentina record a long and discontinuous history of pre-Columbian human occupation from early hunter-gatherers to the highly developed Inka civilization in the south-central Andes. Here we report the results of the first chemical and isotopic analyses of organic residues in ceramic potsherds recovered from sites at Tinogasta covering two distinct periods, the Formative Period (450-1020 cal. AD) and the Inka State Period (1400-1550 cal. AD) that overlaps with the first Hispanic contact. The results were compared with reference samples derived from i) typical Andean food products including local maize landraces, beans (*Phaseolus vulgaris*), algarrobo (*Prosopis* sp.), and animal fat obtained from native llama (*Lama glama*) and introduced cattle (*Bos taurus*), and ii) three replicate test pots used each for cooking traditional Andean maize-based recipes, such as *locro*, *mazamorra* and *pochoclo*. The extracted lipids were analysed by TLC, GC-FID, GC-MS and GC-C-IRMS. The reference food products showed a high concentration of triacylglycerols (TAG), low concentrations of diacylglycerols (DAG), monoacylglycerols (MAG) and free fatty acids (FFA), and significant amount of sterols. Relatively high amount of lipids were recovered from the test pots (up to 18 mg/g) and the Tinogasta potsherds (0.5 mg/g). The test pots had higher concentration of DAG, MAG and FFA than the food products, due to degradation during cooking. The archaeological samples had mainly FFA and sterols, with low amounts of partially hydrolysed acylglycerols, most probably due to degradation at the burial site. Andean maize landraces have similar fatty acid methyl ester (FAME) profiles to those of commercial maize species, with high levels of oleic (18:1) and linoleic (18:2) acids. The FA distributions in the archaeological samples compare favourably to test pots, and are typical of degraded mixtures of vegetable oils (18:2) and animal fats (myristic and stearic acids; 14:0, 18:0). Polyunsaturated acids tend to disappear in more degraded samples. Differences in the FA profiles within the archaeological samples set suggest that various types of food products were stored/cooked in the pots. The $\delta^{13}C$ values of the main fatty acids in 22 archaeological samples were compared with those of the references samples (symbols and fields in Figure 1). The Tinogasta samples plot between the fields for C_3 plants and maize, clearly indicating a mixed C_3-C_4 ecosystem. Principal component analysis and cluster analysis of the FAME concentrations and $\delta^{13}C$ values permit to define the compositional associations and group the archaeological samples. Most archaeological samples are close to the pre-industrial composition of llama fat. They were mostly cooking pots where meat and/or grease were stewed with C_3 (beans and American algarrobo) and C_4 (maize) vegetables. Further evidence for such mixtures provides the microscopic identification of *Zea mays*, *Phaseolus vulgaris* and *Prosopis* sp. starch grains in the organic crust covering the inner wall of several potsherds. For the first time combined microscopic, molecular and isotopic direct evidences indicate that Pre-Columbian societies in the south-central Andes had maize and maize-based food as an important part of their daily foodway.

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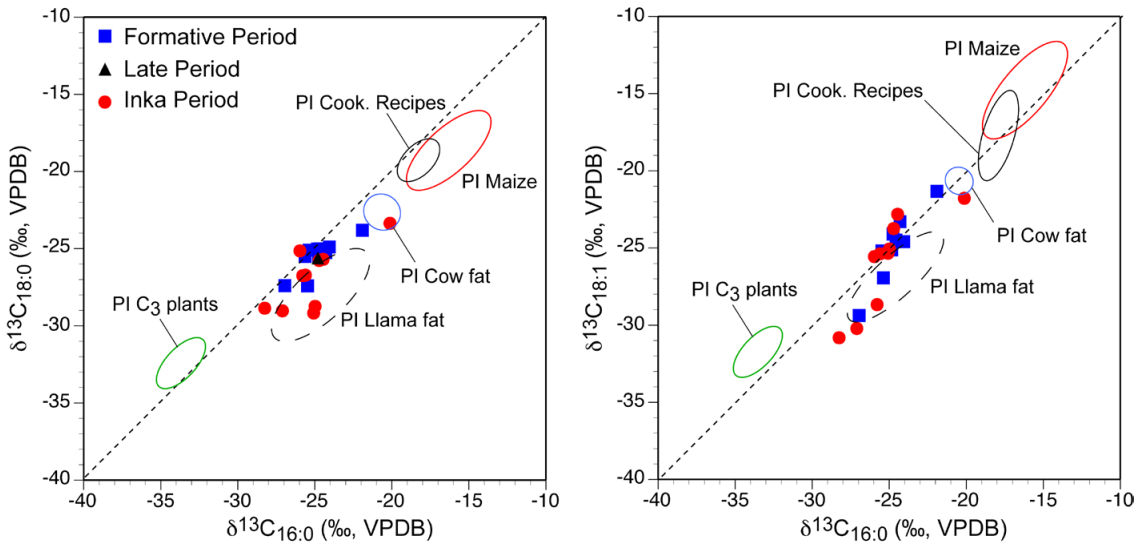

Figure 1. Comparison of the carbon isotope composition of stearic acid ($\delta^{13}C_{18:0}$) and oleic acid ($\delta^{13}C_{18:1}$) acid versus palmitic acid ($\delta^{13}C_{16:0}$) of the organic residues in Tinogasta potsherds and pre-industrial animal and plant foodstuffs. The isotopic fields for pre-industrial (PI) animal and plant fats were determined assuming an atmospheric CO_2 enriched in ^{13}C by ~1.6‰ than in present time.

P 20.7

GIS-based geomorphological mapping, dating of selected landforms and landscape evolution during the Lateglacial and Holocene, in the region of Val Tuoi, Grisons, Switzerland

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The study of glacial and periglacial landforms provides important information about the climate and glacier history of the region and the related processes. Since the Last Glacial Maximum (LGM) glaciers in the Alps have left distinct traces of their activities. The Val Tuoi, Grisons, Switzerland offers a wide range of glacial and periglacial landforms. In order to reconstruct the landscape evolution and the regional climate history during the Lateglacial and the Holocene a detailed understanding of the geomorphological settings and an optimally designed application of the corresponding relative and absolute dating methods are compulsory. Based on current and former topographic maps, vector data, orthophotos, digital elevation models (DEM) and fieldwork, a detailed geomorphological map (1:25'000) was produced and digitalized with ArcGIS. Geochronological investigation with Schmidt-hammer was applied on debris cones, moraines, as well as relictic and inactive rock glaciers. To obtain absolute ages, rock surface samples on moraines and other striking features (rockslide deposits) have been collected and examined with the ^{10}Be exposure dating method. Furthermore, five former stadials of the Val Tuoi glacier where reconstructed based on the Accumulation Area Ratio (AAR) method. For each stadial the equilibrium line altitude (ELA) and the ELA-depressions with reference to the Little Ice Age (LIA) are calculated and compared with the sequence of Lateglacial re-advances of the Eastern Alps. Combining the new dating results with ELA estimations, a critically reviewed synthesis is worked out to show the correlations with the known stratigraphy and the related climate history (Lateglacial and Holocene). It includes a tentative morphostratigraphic system of the selected glacial and periglacial features in the Val Tuoi with promising new results on the chronology of the stadials that are older than the Younger Dryas (Daun, Clavadel).

P 20.8

Using cosmogenic ^{36}Cl to determine periods of enhanced seismicity in western Anatolia, Turkey

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The West Anatolian Extensional Province, one of the seismically most active and rapidly extending regions in the world, is dominated by three major E-W trending graben systems, namely Gediz, Küçük Menderes and Büyük Menderes. These are formed in response to approximately N-S continental extension and geomorphologically characterized by well exposed limestone normal fault scarps.

Because seismicity and thus rupture along these high angle normal faults is sporadic, periods of marked uplift of the footwall block alternate with periods of quiescence. During period of quiescence, cosmogenic ^{36}Cl builds up in the exposed limestone scarps. Consequently periods of seismic activity and inactivity can be examined based on the distribution of measured ^{36}Cl concentrations.

The aforesaid fault systems are the main structures in the West Anatolian Extensional Province representing extensional activity along with evidences of surface faulting during the Pleistocene and Holocene. Consequently, we apply surface exposure dating with cosmogenic ^{36}Cl to better understand the tectonic outline of this seismically active province by revealing patterns of past seismic activities.

In this study, we collected more than 300 limestone samples from well-exposed sections of bedrock fault scarps along the Manisa Fault (the main segment of the Gediz graben), the Yavansu and the Kalafat Faults (related to Küçük Menderes graben) as well as the Priene-Sazlı Fault (related to Büyük Menderes graben) to measure ^{36}Cl concentrations. In order to reconstruct the chronology of the seismic events, a new Matlab code will be run to identify the timing of periods of significant ruptures. Then the average slip rates for each event will be estimated. Our first results reveal enhanced seismic activity during the early Holocene in the Gediz Graben.

P 20.9

Timing of deglaciation on the Southern Swiss Alps

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The detailed Quaternary geological mapping of Southern Switzerland (Mendrisiotto and neighbouring regions in Italy) and the compilation of several radiocarbon dating data allow the reconstruction of the geometry and chronology of the Last Glacial Maximum (LGM) in the Southern Swiss Alps (Episodio Cantù). Moreover, they allow obtaining a detailed chronostratigraphy of the main recessional stadials during the Lateglacial and the beginning of the Holocene. The defined glacial stadials were correlated with the Greenland isotopic record of the borehole NGRIP.

For the LGM and the Pleniglacial, data are not exclusively from the Ticino glacier (Verbano lobe and a part of the Ceresio lobe), but also from the Adda glacier, which came from Valtellina (Lombardy, Italy) and occupied the Mendrisiotto by the Lario and Ceresio lobes. The analysis of calibrated maximal and minimal ages of the LGM allow proposing an age of the Episodio Cantù (the LGM extent equivalent in the Southern Swiss Alps, as defined by Bini 1997) comprised between ca. 25'500 and 18'000 14C BP (≈ 30'200–21'250 cal BP). The Episodio Cantù was then correlated with the Greenland stadial GS-3, comprised between 27'400 and 22'700 cal BP (Scapozza et al. 2012).

For the Pleniglacial and the transition Pleniglacial/Lateglacial, the first recessional phases after the LGM were placed between ca. 22'500 and 21'000 cal BP, and correspond probably with the two first cold events of the Greenland stadial GS-2c.

The first Lateglacial stadial was the Melide phase, and may match with one of the two cold events of 20'450 and 19'850 cal BP. Then, five glacial stadials (defined for the first time by Hantke 1983 and Renner 1982) were highlighted for the Oldest Dryas (Biasca, Faido, Airolo, Fontana and All'Acqua), two for the Younger Dryas (Maniò and Alpe di Cruina) and one (Val Corno) in correspondence with the Greenland Holocene event GH-11.2. Thanks to the correlation with the Greenland isotopic record, it was also possible to propose a relationship between the stadials defined in the Southern Swiss Alps and the "classical" glacial stadials defined in the Eastern Alps.

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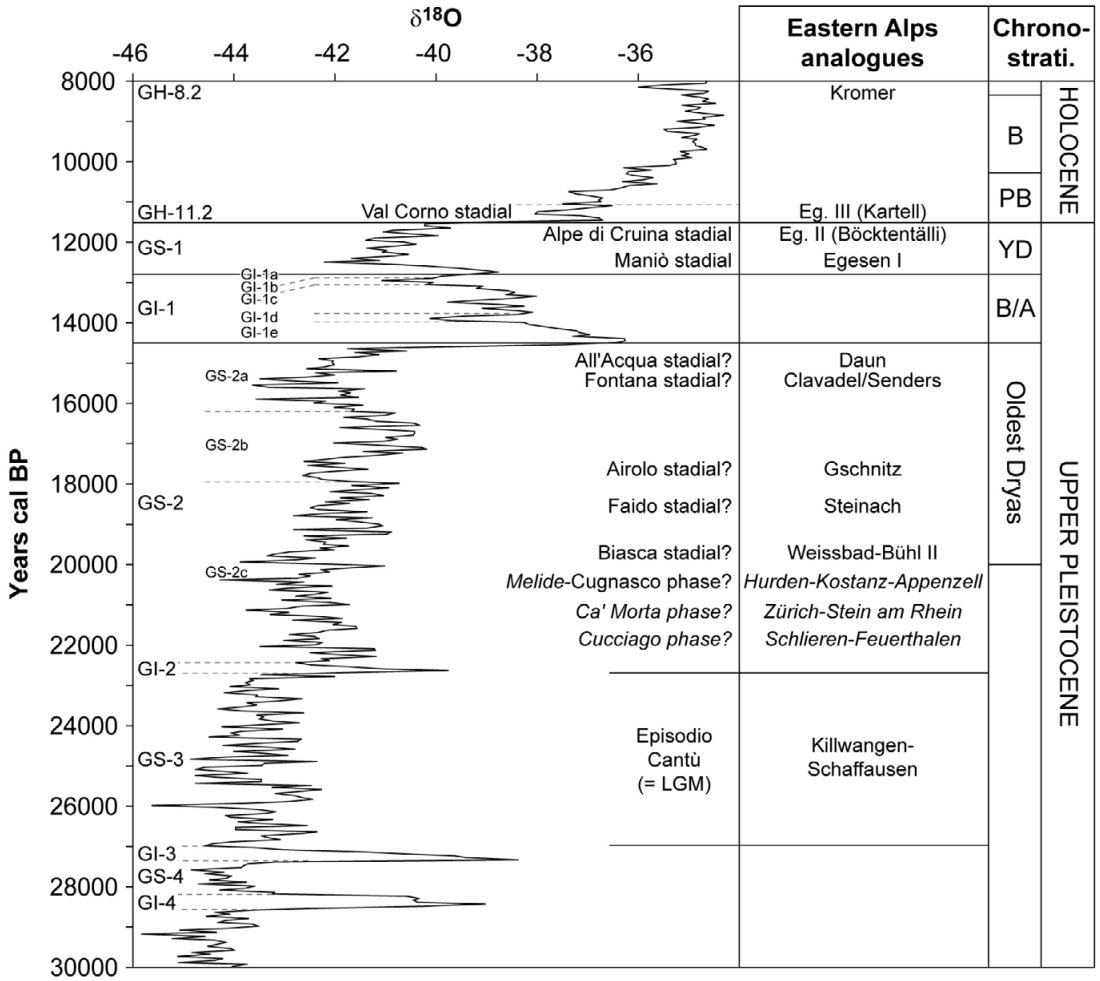

Figure 1. Hypothesis of correlation of the LGM and of the main Lateglacial stadials of the Ticino and Adda glaciers in the Southern Swiss Alps with the Eastern Alps analogues and with the isotope stratigraphy of the Greenland ice core NGRIP (numerical data from NGRIP-Members 2004). For the Ticino glacier, the phases marked in italic have been defined in the Mendrisiotto-Luganese on the basis of studies carried out on the Ceresio lobe of the Ticino glacier and, especially, on the Ceresio and Lario lobes of the Adda glaciers. For the Eastern Alps analogues, the recessional stadials of the Linth-Rhine complex are reported in italic. B/A = Bølling/Allerød; YD = Younger Dryas; PB = Preboreal; B = Boreal.

P 20.10

Paleoenvironmental study of the Lago d'Alzasca (Ticino, Switzerland) during the last 10'000 years

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This research is mainly based on the study and the analysis of a 10 meters thick lacustrine sediment cores with good age control and covering a period of almost 10'000 years. 300 samples were collected from cores drilled in the alpine Alzasca lake, located at 1855m in the Soladino Valley, a lateral valley of the Maggia Valley (Ticino, Southern Switzerland). The main goal of this study is to decipher Holocene paleoenvironmental and paleoclimatic changes that characterized the southern swiss Alps using a multiproxy approach including sedimentology, mineralogy and geochemistry. Overall, TOC and HI/OI index Rock data as well as C/N ratio and $\partial^{13}C$ results revealed a mixed source of organic mater, of predominant lacustrine origin. Granulometry and bulk mineralogy have also been carried out, qualifying sediments as sandy-silt dominated by detrital components such as that quartz, K-feldspaths, Na-plagioclases and phyllosilicates. Phosphorus concentrations are sometimes very high particularly in the first 2m of the core, with values ranging between 2'000 and 20'000 ppm, suggesting that glacial erosion may be an important P source, which may subsequently boost lake productivity.

Warm and cool periods with similar and distinct sedimentary characteristics were therefore identified. In warmer periods, the data are consistent with stable conditions indicated by a relatively constant composition of sediments (elevated HI values, low phosphorus concentrations and relatively high TOC content). Moreover, framboidal pyrite has been observed in sediments deposited during the Holocene thermal optimum (between 8'000 and 6'000 cal yr. BP), meaning that bottom waters were anoxic. In contrast, sediment composition appears to be more unstable during colder periods with high variability in HI-OI, TOC and phosphorus trends). Interestingly, trace elements data highlight the beginning of human impact on the environment. Lead, in particular, shows a gradual increase from the Roman epoch, and a maximum near the top of the core (almost 500 ppm) that corresponds to the intensive use of lead in gasoline.