Abstract Volume
6th Swiss Geoscience Meeting

Lugano, 21st – 23rd November 2008

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Swiss Society for Quaternary Research (CH-Quat)

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5.1

Anthropogenic impact on 'Findlinge' (erratic boulders) in the Alpine foreland and its implications for surface exposure dating

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'Findlinge' are allochthonous huge erratic boulders which contributed to the understanding that the Alpine glaciers advanced hundreds of kilometers into the Alpine foreland (Ivy-Ochs et al., 2004). They were once delineating the maximum extent of LGM (Last Glacial Maximum) and MEG (Most Extensive Glaciation) glaciers. Following the final retreat of LGM glaciers, the 'findlinge' were subjected to intensive anthropogenic activity, i.e. most of them have been quarried and used as construction material and/or building stone since Roman times. They have been also destroyed by dynamite in order to 'clean-up' the farmlands in modern times.

For instance, pieces of erratic boulders are generally observed in walls of the buildings and gardens, and several boulders were quarried to construct fountains (e.g. Graf et al., in prep.). Most of the survivors are now located either in the forests or at the boundary of two farms. During the last decade, few available 'findlinge' were surface exposure dated by cosmogenic nuclides (Ivy-Ochs et al., 2006; Graf et al., 2007).

In this study, we focus on the three erratic boulders on Möschberg hill close to Grosshöchstetten (BE). According to our first results, only one ^{10}Be cosmogenic exposure age of around 19 kyr correlates well with timing of LGM (sample ER1 in Ivy-Ochs et al., 2004). The second boulder exposure date reflects exhumation. The third boulder shows evidence of quarrying as it is surrounded by fragments. Thus, most of the 'findlinge' in the Alpine foreland are not suitable for surface exposure dating, show strong anthropogenic impact or have been exhumed.

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5.2

Glacier erosion rates since Little Ice age during advance and retreat of a Norwegian outlet glacier

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The Jostedalsbreen ice field is situated at the eastern end of the Nordfjord valley-fjord system. One of its outlet glaciers is the Bødalsbreen glacier. The proglacial basin is a glacially eroded and bedrock-confined basin of up to 80 m depth. The sediments in the basin are divided into four units (A-D), based on a grid of georadar profiles and Quaternary geological mapping. Unit A contains different glacial and glacio-fluvial sediments deposited during and subsequent to the deglaciation. Unit B is composed of till and morainal deposits and was formed between AD 1755 and AD 1930. Unit C consists of glaciodeltaic to glaciolacustrine sediments that accumulated in lake Sætrevatnet. Unit D is a glaciofluvial fan situated in front of the present-day glacier front of Bødalsbreen glacier. The last two units were deposited between AD 1930 and AD 2005.

As a result of the volume estimations and the corresponding catchment area, the total erosion rates are calculated to 0.8 ±0.4 mm yr^{-1} (Unit B) and 0.7 ±0.3 mm yr^{-1} (unit C/D). The total erosion rate is considered as the sum of subglacial bedrock erosion and the evacuation of subglacially stored sediment. Considering the glaciation history, two major subglacial depressions in the catchment of the glacier, and the clast maturity distribution in the lateral moraines, we conclude: (i) the total erosion rate is time dependent; (ii) the two quantities representing the total erosion rate seem to be in the same order of magnitude at present; and (iii) the estimated values of glacial erosion rates are in the same order of magnitude as other ones obtained from the region.

5.3

Glacier erosion: processes and quantification

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The impact of glacier erosion is manifested by a variety of erosional and depositional landforms indicating the former presence of glaciers. Processes of abrasion, plucking, and meltwater erosion have been widely described (e.g. Benn and Evans, 1996). During a cycle of a glacier advance and retreat, it is challenging (i) to reveal the spatial and temporal distribution of different erosional processes, and (ii) to quantify them (e.g. Sugden and John, 1976; Drewry, 1986; Benn and Evans, 1996). Answers to these questions are important in order to understand the development of single glacial-erosional landforms and the evolution of an entire glacierized landscape.

Based on a detailed literature investigation, we discuss glacial-erosional processes and models for their quantification, with the aim to better understand the processes and to evaluate their impact during future ice ages. A special focus is on linear landforms formed by subglacial meltwater erosion. By investigating gorges with a potential subglacial formation, the knowledge about their formation process will be increased. These investigations will allow more detailed predictions regarding the safety of deep depositories for nuclear waste during future ice ages (Haeberli, 2004).

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5.4

Differentiation of rock avalanche deposits from lateglacial moraines in Val Ferret (Mont Blanc Massif, Italy) using cosmogenic ^{10}Be

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On September 12th 1717 AD, inhabitants of the upper Ferret valley (Mont Blanc Massif, Italy) witnessed one of the largest rock avalanches of the Alps, destroying two small settlements with 2 causalities and lost of their cattle. This avalanche mobilized a rock volume of larger than 10 millions m^3 and huge volume of ice from Triolet glacier. This mass, composed of ice and sediment, moved more than 7.5 km down valley and reached lower part of the valley. Although this natural hazard is historically recorded, extend of its deposits in the Ferret Valley is still under discussion due to the insufficient number of absolute dates.

Quaternary deposits in the upper Ferret valley have been attributed for a long time to glacier advances (Figure 1). In the 1960's it has been suggested that rock avalanche sediments was forming only a small part of these deposits (e.g. Mayr, 1969). Later Aeschlimann (1983) argued for lateglacial moraines whereas
Orombelli and Porter (1988) controversially stated that the whole valley was covered by this rock avalanche. Using the new findings, and relative and absolute ages, Deline and Kirkbride (2008) have recently shown that 1717 AD rock avalanche was deflected along northern side of the valley floor, preserving older slope and glacial sediments along the southern side (Figure 1). Moreover, deposits of an earlier rock avalanche onto the Triolet Glacier, probably occurred before 1000 AD, was also identified (Deline & Kirkbride, 2008). Despite several radiocarbon dates on peat and wood buried in or overlying the avalanche deposit, the extend of avalanche deposits in the valley floor still remains undetermined, which in fact delimits the modeling of its propagation.

Our study focuses on the surface exposure dating of Quaternary deposits of Ferret valley with ^{10}Be. Such exposure dates would allow us to differentiate these deposits and build up their chronology. With this aim, nine samples from the granite boulders were collected (Figure 1) and prepared for AMS analysis. The first results of this study will be presented.

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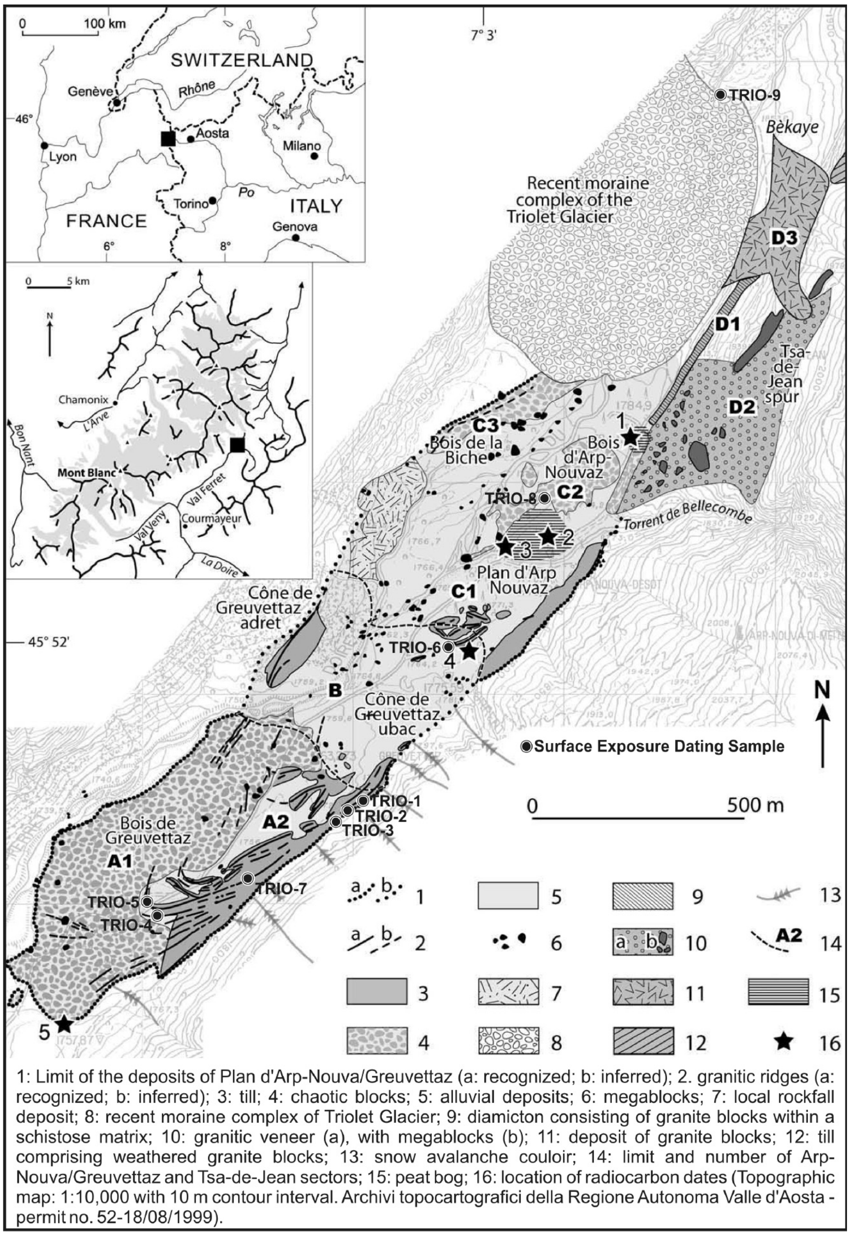

Figure 1. Map of the deposits of Haut Val Ferret and location of the surface exposure dating samples (modified from Deline & Kirkbride, 2008).

5.5

Environmental and climatic history of an overdeepened and filled glacial basin in Northern Switzerland

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Origin, age and sedimentation history of overdepeened glacial valleys in the alpine foreland are still intensely debated. Geological studies in the Wehntal, 20 km northwest of Zürich suggest the presence of a deep trough cut by Pleistocene glacial erosion into Neogene Molasse beds; containing a sedimentary archive covering several glacial-interglacial cycles. Most of the narrow valley was filled by lake sediments and peat deposits. Between 2003 and 2006 an interdisciplinary project investigated a mammoth remains-bearing peat horizon exposed in construction pits at Niederweningen (3–5 m below surface). Results proved that the peat with its famous mammal fauna was deposited during the last glacial cycle (45–65 ka ago, Middle Würmian) in a shoaling lake (Furrer et al. 2007, Drescher-Schneider et al. 2007, Coope 2007, Preusser & Degering 2007, Tütken et al. 2007). In October 2007, a 30 m-deep core was drilled nearby to investigate the depositional, palaeoenvironmental and climatic history of the upper part of this glacial basin in the foreland of the Swiss Alps. A first study has been recently finished (Riedi 2008), other results are in a preliminary stage.

The mammoth peat was drilled between 4.6 and 5.3 m, underlain by silty and sandy lake sediments (5.3–12 m, OSL ages of ≈65–100 ka). Another peat was recovered in 12–14 m depth, which was deposited at the end of the last interglacial (late Middle–Late Eemian, MIS 5e) suggesting a hiatus of several thousand years (Early-early Middle Eemian) at its base. The uppermost beds of the underlying silts yield a mollusc fauna and many characeans together with a typical 'late glacial' palynoflora (≈130 ka). The lower part down to 30 m with mainly laminated silts is nearly free of organic material and coarser layers, suggesting a depositional environment in a distal location of a cold proglacial lake. The OSL age from the base of the core is 190 ka. Deformed layers, increased shear strength and erosional unconformities between 18.5 and 20 m suggest an important event at about ≈150 ka (MIS 6), probably caused by overriding of the sediments by an advancing glacier.

The interpretation of a recently completed seismic campaign in the Wehntal (summer 2008) provides new insights into the deeper structure of the valley down to 70–140 m depth. A proposed deep drill core in the most promising section of the valley, planned for winter 2008/09, will shed new light on the sedimentary infilling history of this glacial basin and potentially recover a unprecedented archive of multiple glacial-interglacial successions.

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5.6

Dating old bones: Study case mammoth from Niederweningen, ZH

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Preparation of bone material for radiocarbon dating is still a subject of investigation. In the past the most problematic ages appeared to be the very old bones i.e., with ages close to the limit of the dating method. Development of preparative methods requires sufficient amounts of bone material as well as possibility of verification of the ages. In the peat section at Niederweningen, ZH Switzerland numerous bones of mammoth and other animals were found in the late 19th century. The first AMS radiocarbon ages of those bones from 1890/1891 excavations placed the age between 33,000 BP and 35,000 BP. The excavations in 2003/2004 provided additional material for radiocarbon dating. The age of 45,870±1080 BP was obtained on base cleaned gelatine from mammoth bone, which was very close to the age of 45,430±1020 BP obtained for the peat layer that buried the mammoths (Hajdas et al. 2007). This study shows that three pre-treatment methods base+Longin, Longin+Ultra-filtration, and Base+Longin+Ultraflitration (Fig. 1) give the ages consistent with each other and also consistent with the age of peat section.

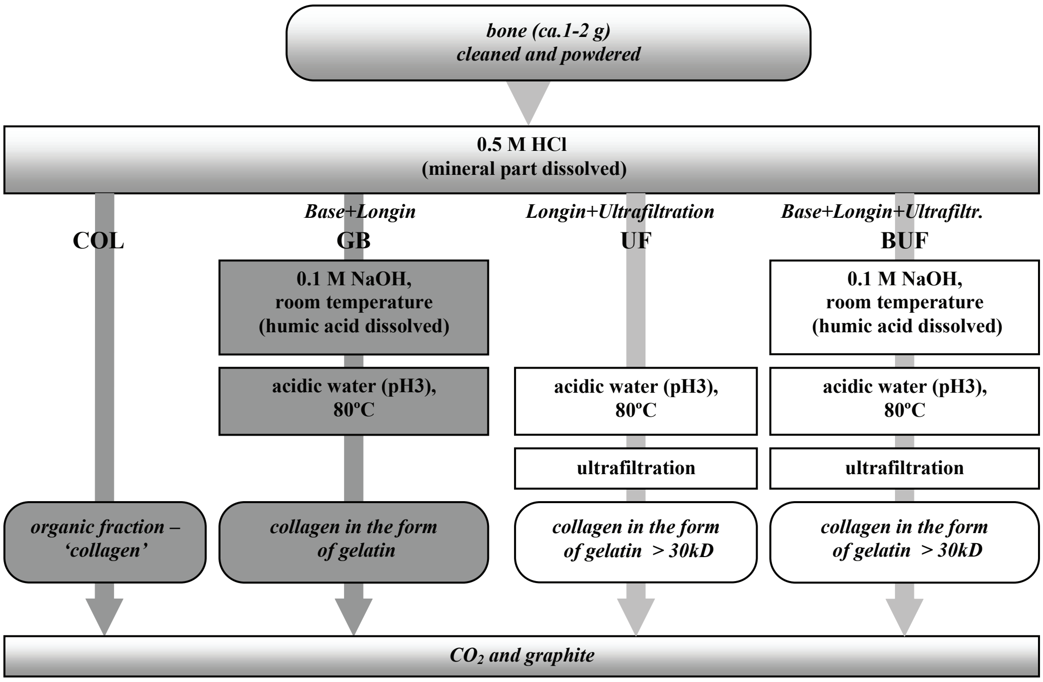

Figure 1. Schematic diagram of the chemical preparation of the dated bones. Grey colour marks steps of preparation methods applied in previous studies (Hajdas et al. 2007), while white colour indicates steps of methods used in this study.

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5.7

Chronology and development of the postglacial beach plain NE of Lake Neuchâtel on Swiss Plateau, using OSL*- and ^{14}C-Data.

*Optically Stimulated Luminescence

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After the LGM-glaciers melted down, they left behind plains which were successively infilled with erosional debris transported by big Alpine rivers (Rhone, Aare, Rhine and Reus). These plains have been influenced by Late Pleistocene and Holocene climate change, by lake level and shore line shifting, and also by human settlement and rural land use during the last 9.0 ka. Within the plains sand ridges have been recognized at different sites in the NW Alpine foreland in Switzerland and France (Rhine Valley, Swiss Plateau, Lower Wallis Valley and south of Lake Geneva). The sand ridges mount glacio-fluvial or limnic deposits and are located within the outer limits of the LGM – moraine belt. This project is aiming at highlighting the remaining open questions about the interrelation of landscape forming factors, as mentioned above, and also at better understanding of the processes and times which control the creation and preservation of the fossil beach landscapes in the NW Alpine foreland. New results derived from six excavations in Grosses Moos, a fossil beach plain NE of Lake Neuchâtel, as well as from OSL- and ^{14}C-dating, will be presented.

The sedimentary structures as well as the OSL- and ^{14}C- ages suggest continues sedimentation and marsh development responsible for silting up the NE part of the Lake Neuchâtel and for the construction of the Grosses Moos beach plain. The beach plain grows from the NE towards the present shore line of Lake Neuchâtel. Climatic oscillations and changes of the hydrological regime are assumed to be responsible for rapid emergence and drying of the pre-existing littoral ridges. Subsequently they have been wind reworked and accumulated as a dune. Hence, as their shape along the present NE lake shore already suggested, the sand ridges of Grosses Moos give evidence for the stepwise regression of Lake Neuchâtel since the Bölling-Alleröd period. Paleochannel infilled with "Seelandschotter" (13.3 ± 1.1 ka) and peat (12.5 – 13.3 cal ka) underlying the "Islerendüne" (the most NE-stern sand ridge) provides evidence of this sedimentary period. The Younger Dryas cold period gave rise to building of the "Islerendüne" sand ridge (12.9 ± 1.1 ka) which continued into the Boreal (9.8 ± 0.9 ka). On few spots on the "Islerendüne" the original Luvisol has been preserved, whereas Cambisol and Arenosol are predominant. As the OSL-ages suggest, the formation of the aeolian sequence of the "Islerendüne" started in the Younger Dryas consequently, the Luvisol must be of Holocene age.

As the "Rundidüne" (next SW to the "Islerendüne") hasn't been sampled yet, the only hint at its age is provided by the archaeological finds dated to about 9.0 ka BP (Nielsen 1991). Those human settlements may also be responsible for the reshaping and the widespread erosion of the Luvisol on the "Islerendüne".

The profile of the "Nusshofdüne" (next SW to the "Rundidüne") revealed Younger Dryas lake sediments (10.95 ± 0.8 ka) covered by reeds (age not yet determined) and organic - rich littoral sediments of early middle Holocene age (7.2 ± 0.7 / 6.4 ± 0.9 ka). Lake regression created a dune (5.5 ± 0.5 ka) on the top of this formation. The ^{14}C – data suggest an input of older organic material into the littoral sequence due to peat erosion in the hinterland. The "Witzwilerdüne 1" – profile (next SW to the "Nusshofdüne) reveals Roman Period marsh (2.5 ± 0.2 ka / 2.4 – 2.2 cal ka) covered by coastal dune accentuating a lake regression at the turn to the past millennium (2.07 ± 0.3 ka). In the "Witzwilerdüne 2"-profile (a small sand ridge close to the lake shore) a small dune mount over Little Ice Age lake deposits (0.5 ± 0.06 ka). The dune developed after the lake level had gone down due to the JGK* (0.15 ± 0.03 ka), as the OSL-ages suggest.

* Jura Gewässer Korrektur

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5.8

Exposure dating of the Chironico landslide, Leventina, Switzerland

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The Chironico landslide is composed of several million cubic meters of granitic gneiss that detached from the eastern wall of the Ticino River valley along 25-30 degree dip slopes and was deposited along the western valley side up to elevations of around 800 m. ^{14}C ages from wood fragments in lake sediments in a former lake north of and dammed by the landslide yield a minimum age of about 13,500 cal yr BP (Antognini and Volpers, 2002). Samples for cosmogenic ^{10}Be exposure dating were taken from quartz veins on upper surfaces of huge boulders in both lobes of the landslide to the north and south of Ticinetto stream. The study will be presented in the framework of other dated landslides in the Alps. After Koefels (Tyrol Austria), which is 9800 yr old, the Chironico slide is one of the largest slides in crystalline rock in the Alps. The Chironico slide is also one of the oldest, with only the Almtal slide (Upper Austria) being older at 15,600 yr (van Husen et al., 2007). In contrast most of the identified large landslides in the Alps (Koefels, Flims) occurred during the early Holocene (Ivy-Ochs et al., 2008).

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5.9

Late glacial tree-ring chronologies reflecting environmental changes - last steps towards an absolute chronology back to 14,250 cal BP

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During the last years, significant progress has been made in the development of Lateglacial tree-ring chronologies in Switzerland, Germany and Southern France with different sites to combine existing chronologies of fossil Scots pines and to extend these throughout the whole Bølling-Alledrød Interstadials [BØ, AL] into the Younger Dryas Stadial [YD].

In France finds along Durance River and tributaries have yielded several floating chronologies extending back into the very important first half of YD ant the end of AL. In Germany the chronology from Reichwalde spans 864 years between approx. 14,080 and 13,220 cal BP. Parallel to it run two chronologies from Danube valley (709 yrs) and Warendorf (465 yrs). Two further chronologies from Danube valley (334 and 190 yrs) extend towards the end of AL at approx. 12,750 cal BP. A series from Northern Italy (Carmagnola, Turin) incorporates the BØ back to 14,250 cal BP spanning 308 yrs.

In Switzerland new series built with trees from two highway-tunnel construction sites (Zurich Gaenziloh and Zurich Landikon) afforded to combine most of the floating chronologies from Daettnau (Winterthur) and Wiedikon (Zurich) to a extensive one that spans 1605 years between approx. 14,250 and 12,650 cal BP. Both series from Switzerland and Germany

have been built independently but have been dendro matched to each other.
Additional radiocarbon dated floating chronologies from Zurich, the floaters from Durance Valley and several single trees appear to bridge the ≈200 year gap between the absolute chronology (12,593 cal BP). The filling of this gap will result in nearly a two millennia extension of the absolute chronology.
Lateglacial pines usually grew under geomorphic stress and were gradually buried by loamy alluvia until the aggrading sediment killed the trees. Crossdating is complicated by both growth disturbances during the first 100 years of a trees life and the poorer preservation of the outer sapwood cells. Crossdating is normally based on an overlap of 50 up to 100 rings. Numerous decadal high precision ^{14}C-age determinations assisted and verified the dendrochronological crossdating. While fluctuations in the chronology are driven in part by local geomorphic activities, fluctuations may also coincide with short stadials and interruptions such as Older Dryas [OD], volcanic events (e.g., Laacher See eruption) and the Gerzensee deviation. Splitting the spline-detrended dataset from Zurich into subgroups demonstrates the potential for detecting common environmental signals. Variations in age-related trends indicate changes in environmental conditions over the 2500 years of AL, YD and Preboreal. Comparisons of tree growth and life span of trees between AL and YD suggest the YD to be rather a period of reduced winter temperatures than of low temperatures during the growing season.
The dendroclimatic-style analyses presented are the first performed on Lateglacial tree-ring chronologies. Future efforts should focus on robustly preserving lower-frequency environmental variations and comparisons with other high resolution archives to quantify and calendrically date the main climatic fluctuations during Lateglacial and early Holocene.

5.10

Oxygen isotopic composition of lacustrine cellulose and authigenic calcite – new insight into Late Glacial and Holocene temperature changes in central Poland

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The $\delta^{18}O$ of lacustrine calcite potentially provides information about both temperature and $\delta^{18}O$ of lake water. If the $\delta^{18}O$ of lakewater is strongly controlled by the $\delta^{18}O$ of local precipitation, such as in a groundwater-fed lake having rapid throughflow, and lakewater temperature covaries with climatic temperature, then $\delta^{18}O_{calcite}$ may serve as a direct palaeothermometer.
The "calibration" of the thermometer will be determined by two opposing relationships: temperature-dependent changes in the $\delta^{18}O_{precipitation}$ (c. +0.64‰/K for Poland; Duliński et al., 2001) and changes in the temperature-dependent equilibrium fractionation between calcite and water (c. – 0.23‰/K; Craig, 1965):

$$\Delta\delta^{18}O_{calcite} / \Delta T = 0.64‰/K - 0.23‰/K \approx 0.4‰/K \qquad (1)$$

Equations like (1) have been used in many situations to reconstruct palaeotemperatures, including, for example, the development of a Holocene palaeotemperature record from $\delta^{18}O_{calcite}$ in the sediments of Lake Gosciaz. A source of significant uncertainty in this approach, however, is the possibility that changes in the hydrologic balance of a lake may alter the relation between $\delta^{18}O_{precipitation}$ and $\delta^{18}O_{lakewater}$, potentially adding spurious non-temperature-dependent signals.

Here we report results from a pilot study to test the $\delta^{18}O_{calcite}$ thermometer in Lake Gosciaz sediments by using aquatic cellulose $\delta^{18}O$ to directly estimate the $\delta^{18}O$ of lakewater at times in the past. Since the isotopic fractionation between cellulose and lakewater is believed to be constant (Edwards and McAndrews, 1989; Wolfe et al., 2007), this allows us to isolate the effects of temperature-dependent calcite-water fractionation to obtain estimates of absolute temperature changes during and between selected intervals over the past 12,000 years, without interference from possible changes in the hydrologic balance of the lake. The calibration of the cellulose-calcite thermometer in this case is described by:

$$\Delta T = (\Delta\delta^{18}O_{calcite} - \Delta\delta^{18}O_{cellulose})/(-0.23 ‰/K) \qquad (2)$$

Our data from Lake Gosciaz yield some striking differences in estimated temperature changes. For example, for the Younger Dryas/Preboreal transition, equation (1) gives an increase in lakewater temperature of about +5K, meanwhile equation (2) suggests +20 K, because of the incorporation of a pronounced shift of +6.5 ‰ observed in $\delta^{18}O_{cellulose}$. This shift in $\delta^{18}O_{cellulose}$ almost certainly reflects the influence of increased evaporative enrichment of the lakewater in response to drier conditions, which obviously cannot be accommodated by equation (1).

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5.11

Variation of denudation rates in the partially fluvially and partially glacially scupltured Hörnli region, Switzerland

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The Hörnli region has long been recognized for its landscape with opposite appearance: the lower regions (mainly the western Hörnli/Glatt valley and eastern Hörnli/Thur valley) are glacially overprinted and have smooth surface expressions; whereas the inner part of the Hörnli region (the Töss valley and surrounding highs) is a fluvial overprinted landscape. This fact is a result of an ice free "Hörnli-nunataker", at least during the Würm glaciation (Hantke, 1980). Slopes, relief, river longitudinal and cross profiles complement this view, being U-shaped, subdued and partially filled with terraces or V-shaped and steep, in glacial or fluvial settings, respectively. Currently, U-shaped valleys are getting incised due to the lowering of the base-level further outward and transmission of this base-level change headward, producing step-morphologies. This is a common feature observed in the Alps. Such morphologies are characterized as being in a transient stage - in the transition from the glacial to a fluvial dominated system (Schlunegger et al., 2002).
However, it is controversial to what extend and with what rates the inherited shape and form of a landscape (glacial vs. fluvial) or a transient stage of a valley form controls short and long-term denudation rates.

The Hörnli region is an ideally suited field area to study those denudation processes because it is uniform in lithology (Upper Sweetwater Mollasse), tectonics (being very slow but uniform uplifted) and climate. As such, crucial parameters in controlling denudation rates can be ignored and focus can be given to isolate parameters such as inherited topography and relief (von Blanckenburg, 2006).

In order to quantify denudation rates in such a two-process dominated landscape we have sampled various rivers around the Hörnli region for catchment-wide denudation rate estimations using cosmogenic nuclides (^{10}Be, ^{21}Ne; in a second step we aim to analyze ^{14}C to capture short-term variations in a steady or transient stages of erosion). The dataset comprises samples from rivers which show completely fluvial, glacial or a combination of both morphologies. Sample analysis however is ongoing. Preliminary results from samples of the Töss river and tributaries yield denudation rates that are on the order of rates previously acquired for Swiss Middleland rivers (Norton et al., 2008; Wittmann et al., 2007), though denudation rates tend to be higher in glacially compared to fluvial overprinted catchments. Additionally, local variations occur which are not directly linkable to a glacial or fluvial origin. So far ^{10}Be and ^{21}Ne concentrations and denudation rates correlate poorly, which is largely due to obtain precise low ^{21}Ne-concentration in our samples.

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5.12

Regional synthesis of Mediterranean atmospheric circulation during the Last Glacial Maximum

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Atmospheric circulation leaves few direct traces in the geological record, making reconstructions of this crucial element of the climate system inherently difficult. Here, we produce a regional Mediterranean synthesis of palaeo-proxy data from sea-surface to alpine altitudes. This provides a detailed observational context of change in the 3-dimensional structure of atmospheric circulation between the Last Glacial Maximum (LGM; ≈23-19 ka) and Present. The synthesis reveals evidence for frequent cold polar air incursions, topographically channelled into the northwestern Mediterranean. Anomalously steep vertical temperature gradients in the central Mediterranean imply local convective precipitation. We find the LGM patterns to be analogous, though amplified, to previously reconstructed phases of enhanced meridional winter circulation during the Maunder Minimum (Little Ice Age).

The equilibrium line altitude (ELA) of glaciers contains information on the vertical structure of the atmosphere, which can be reconstructed by in-situ dating of glacial advances and retreats. Small temperate glaciers in circum-Mediterranean mountain chains are (and were) exposed to well-mixed air masses and are known to have been sensitive to even small changes of the ELA, typically responding by advance or retreat within several years to decades. The ELA responds to both temperature and precipitation change, and it is possible to differentiate between these two factors only in particularly well-studied regions, such as Corsica (Kuhlemann et al. 2008). For this island, we present new information on the LGM ELA, including a deconvolution of the two main controlling processes. For the ELA depression of LGM glaciers in the wider Mediterranean region, we use previously published information, which – as a first-order end-member solution – we calculate as pure temperature change, using a standard free atmospheric lapse rate of 6.5 °C decrease per km of increasing elevation. The potential overprint of precipitation changes is then considered where anomalous results are found. The error ranges on the resultant ELA reconstructions amount to up to +100 m in Corsica and +150 m in other Mediterranean mountains. We thus develop a regional synthesis of glacial vertical temperature gradients in the lower atmosphere. Next, we compare the ELA-based LGM cooling at alpine altitudes with estimates of LGM reduction of Mediterranean sea-surface temperatures (SST) derived from the difference between foraminiferal assemblages and alkenone data. When comparing the temperature equivalent of the ELA depression with SST reduction in the LGM relative to the present (Fig. 1), we consider that a shift of similar magnitude would indicate a constant atmospheric lapse rate.
Our analysis reveals an LGM pattern of southward extending lobes of ELA depression in mountainous regions of Italy and the Dinarides, which suggests frequent higher-altitude southward advances of polar air. Iberia is characterized by a steep gradient from the northern and northwestern coastlines towards the interior and southeast, which likely results predominantly from barrier effects of near-coastal mountain ranges. Especially the data from Corsica identify a lobe of ELA depression that extends over the Gulf of Lions towards the south and east, indicating significant invasion of polar air from the north. The temperature difference inferred from the recent ELA and our LGM reconstruction generally decreases from north (10-11 °C) to south (6-7 °C) (Fig. 1). Both SST and ELA-determined atmospheric temperatures (T_{ELA}) underwent similar (within +2 ºC) changes, relative to the present, across the northern Bay of Biscay and western sector of the western Mediterranean. LGM SST seems less reduced than T_{ELA} in the Atlantic Ocean offshore Iberia and Morocco, which likely reflects the southward displacement of the relatively warm Gulf Stream during glacial times. The warm anomaly in the central Mediterranean basin, however, can hardly be attributed to advection of warm surface waters from the western basin because of land barriers.

We propose that advection of warm desert air from the Sahara and relatively cloud-free subtropical conditions over the central/eastern basin largely account for the minor LGM cooling of SSTs in this region.

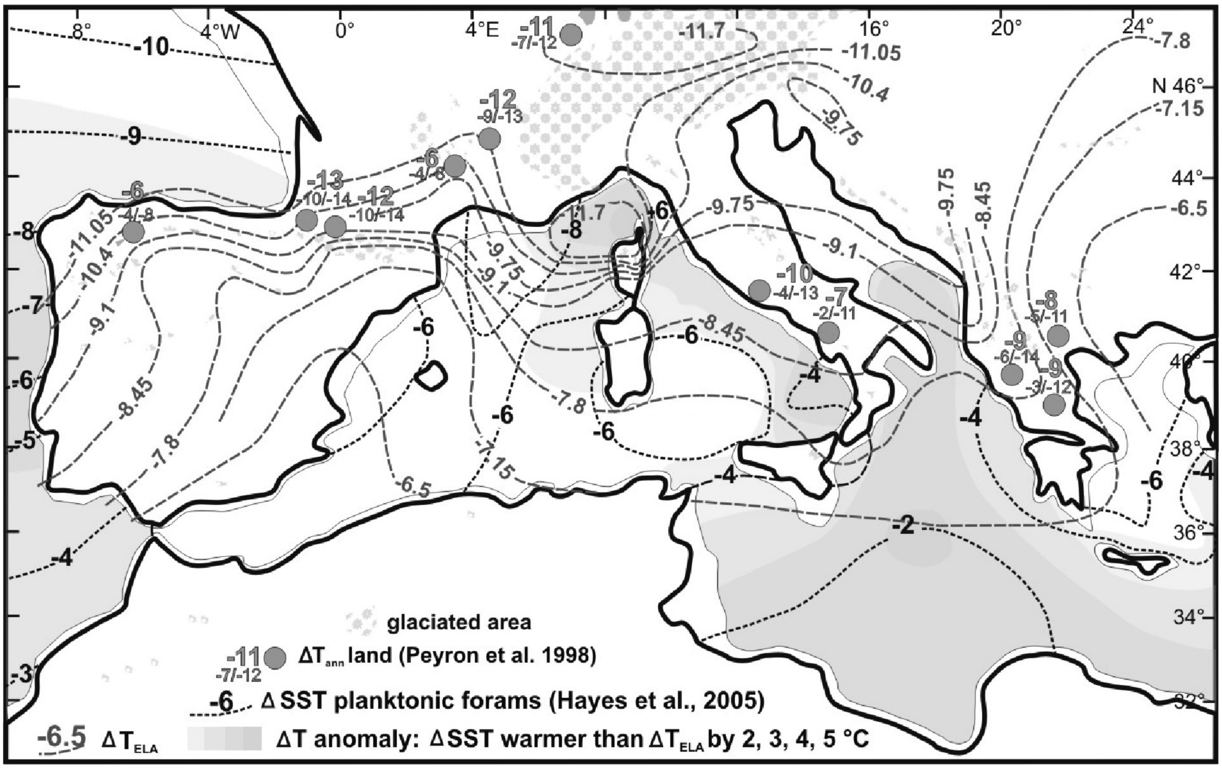

Figure 1: Map of the temperature difference between recent and LGM SST, and temperature equivalent of the ELA depression (6.5 ºC km^{-1} lapse rate), respectively. The error range of this estimate is +1°C for the Mediterranean in general, and +0.7°C in Corsica.

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5.13

Reconstructing the fluvial history of the Llanos de Moxos, NE Bolivia – approaches, challenges and first results

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The reconstruction of past fluvial environments and their changes over time is a major issue in Quaternary sciences. This is particularly true for the lowlands of South America where the late Quaternary history of many extensive fluvial systems has remained virtually unexplored. The Moxos plains (Llanos de Moxos), NE Bolivia, are among the largest inundated savanna landscapes in the world (Fig. 1A). They are drained by the large meandering fluvial systems of the Río Beni and the Río Mamoré, and are subject to annual flooding (e.g. Hamilton et al. 2004). Frequency and magnitude of these flood events, however, have varied significantly over the last centuries, probably in relation to larger scale atmospheric phenomena (e.g. Aalto et al. 2003; Ronchail et al. 2005). However, no data exist regarding changes on millennial or late Quaternary time scales.

Therefore, this study aims at i) documenting the large complexity inherent to the fluvial systems in the Llanos de Moxos, ii) discussing selected approaches and possibilities for their reconstruction, and iii) presenting and interpreting preliminary field data from the Río Mamoré area:

Outcrops along the *active Río Mamoré meander belt* (Fig. 1B) represent an archive of Río Mamoré overbank deposition and flooding activity. Several profiles extend into the late Pleistocene, even though ^{14}C dating of these sedimentary sequences still bears some limitations. The analyses of paleosols and geochemical parameters (grains size, total elements and mineralogy) indicate reduced flooding intensities during the early to mid-Holocene.
Several abandoned meander belts and paleochannels testify to large scale channel avulsions and changes of fluvial regime in the past. These meander belts are considered valuable archives for paleoenvironmental reconstruction: i) Their fluvial geometries were measured along the paleo-Mamoré (Fig. 1C) and compared to the present floodplain, pointing to markedly reduced channel forming discharges in the past. ii) Partly filled oxbows may serve as an excellent archive for reconstruction by means of higher-resolution proxies and the analysis of a first coring transect is currently in progress. iii) Rectangular lake basins, canals and dams are features of possible anthropic origin (e.g. Mann 2000), which are superposed onto the abandoned Río Mamoré meander belt. The dating of the underlying fluvial and lacustrine sediments provides maximum ages for these features, and thereby allows for the first time the establishment of a chronological framework for the late Holocene pre-Columbian human interference into the hydrological system of the Llanos de Moxos.

In conclusion, the presented work documents a dynamic fluvial history of the Llanos de Moxos since the late Pleistocene. Thus, this new information adds valuable data to questions regarding the paleoenvironmental evolution as well as the degree and type of pre-Columbian human impact in lowland Amazonia.

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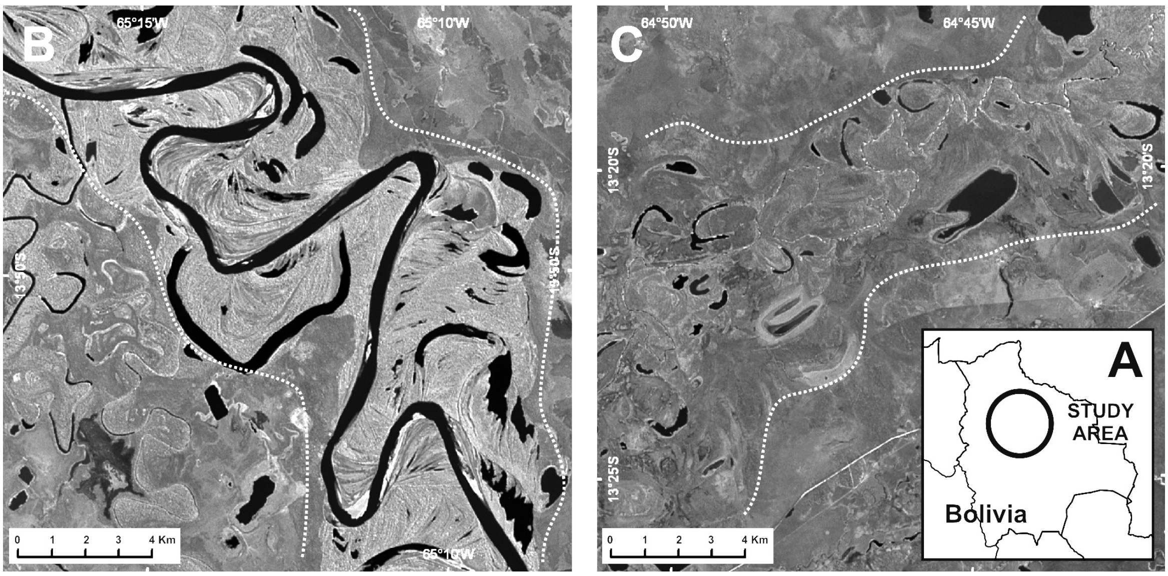

Figure 1: A) Location of the study area (Llanos de Moxos) in Bolivia; B – Landsat image of the modern Río Mamoré meander belt outline by white dotted line (232-70, RGB 742, 19/9/2001, Source: http://edcsns17.cr.usgs.gov/Earth Explorer); C – Landsat image of the Paleo-Mamoré meander belt outlined by white dotted line including several partly infilled oxbow lakes and other lakes (232-69, RGB 742, 19/9/2001, Source: http://edcsns17.cr.usgs.gov/Earth Explorer/).

5.14

Chronostratigraphy of the Quaternary of Switzerland

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While Early Quaternary glacial deposits are exposed in northern Switzerland (Deckenschotter complex, cf. Graf 1993), the so far best investigated and dated Middle to Late Pleistocene record is known from the Aare Valley and surrounding regions. The oldest unit here is the water-lain till from the base of the Thalgut drilling, followed by lake deposits that are, based on palynostratigrapy (40 % Fagus, Pterocarya), attributed to the Holsteinian Interglacial. The Holsteinian corresponds to either Marine Isotope Stage (MIS) 11 (≈ 400 ka) or MIS 9 (≈ 300 ka). A glacial advance subsequent to this interglacial is recorded in the Thalgut sequence. A prominent discontinuity following this glaciation is interpreted to result from interglacial weathering and erosion (cf. Schlüchter 1989). Sediments presumably corresponding to this time gap have been identified at Meikirch (Preusser et al., 2005). According to sedimentology, luminescence dating and re-interpretation of pollen data originally published by Welten (1982, 1988) the Meikirch Complex represents three warm phases with interglacial character that belong to MIS 7. A similar tripartition of MIS 7 has been identified in the loess sections of Sierentz (Upper Rhine Graben, Rentzel et al., submitted) and Wels (Austria, Preusser and Fiebig, 2008).

Controversially discussed has been the question if glaciers reached the Swiss lowlands during MIS 6. With the re-interpretation of Meikirch, an important argument against such a glacial advance, for which substantial evidence is available from other parts of the planet, has ceased to exist (cf. Preusser et al. 2005). Furthermore, two recent studies provide dating evidence for an extensive glaciation of the Swiss lowlands. Graf et al. (2007) present first surface exposure ages implying that at least some of the erratic boulders from the Jura Mountains may be deposited during MIS 6 and luminescence dating of high lying gravel deposits (“Höhenschotter”) from Emmental support extensive glaciation during that time (Preusser, unpubl. data).

The chronology of the last glacial cycle has been discussed in detail by Preusser (2004) and will only be summarised here. Welten (1982, 1988) und Wegmüller (1992) identified two stadials and two interstadials during the Early Würmian in Swiss pollen records. Cold but relatively humid conditions during MIS 5d (ca. 105 ka) may have triggered a glacial advance beyond the boarder of the Alps at that time (Welten 1982, Preusser et al. 2003). A further glacial advance during MIS 4 (ca. 65 ka) has been dated by Preusser et al. (2007) in Seeland. The Middle Würmian (MIS 3, ca. 55-30 ka) is best recorded in the Gossau section, showing an alternation between cool and temperate conditions. Peat deposits with vertebrate remains from Niederweningen with an age of ca. 45 ka are probably on of the best investigated terrestrial MIS 3 deposits world-wide (Furrer et al. 2007), although reflecting only are quite short period of time. The last glacial advance reached the Swiss lowlands shortly after 30 ka and this area was ice-free by 20 ka ago (Ivy-Ochs et al. 2004).

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5.15

Reconstruction of Jordan palaeoenvironments (≈25 000 BP - present day): the Water Life and Civilisation project

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Early Holocene climatic variations have frequently been cited as 'prime movers' in the transitions to sedentism and agriculture in the Near East. Variations in water availability, which has probably played a crucial role in the development of the first permanent settlements and first farming communities, are strongly dependant on climatic conditions, which underwent significant changes throughout the Late Quaternary period. The Levant, and more particularly the Jordan Valley, represents an ideal context for studying the impact of late Quaternary climate change on past human settlements, in particular in nowadays arid to semi-arid areas.

As part of the Water, Life and Civilisation (WLC) project based in Reading (UK), our group aims to reconstruct prehistoric, historic and modern palaeoenvironmental conditions for parts of the Jordan Valley and south Jordan using a range of techniques including the study of isotopes (stable and radiogenic) in carbonate systems. Data obtained are integrated with results from other WLC groups (hydrology, climate modelling, social geography and archaeology) to explore the relationship between water, environment and human society within Jordan from ≈25,000 BP to the present day, and beyond.
Our current work focuses on case studies investigating the potential for spring-related carbonate sequences outcropping near archaeological sites (especially in southern Jordan) to record environmental variations, which may be linked to contemporaneous histories of human occupations.

Research into the local environment at Beidha, the famous Neolithic site near Petra in southern Jordan excavated by Diana Kirkbride in the 1960s, encompasses studies of landscape feature variations, a reconstruction of local climatic variations via stable isotopic (oxygen and carbon) contents of spring-carbonates and soil carbonate concretions, and the obtention of new radiocarbon dates from the archaeological site early occupation layers. Beidha was occupied during Natufian (two discreet phases) and Pre-Pottery Neolithic B (PPNB) times. The new dates help in refining the time-scale of human settlement at Beidha for the Late Natufian and the start of the Neolithic occupation, and in comparing it with the environmental records.
Selected root-related and other carbonate concretions from the landscape features surrounding the site were dated by U-series. The results, alongside a geomorphological reconstruction of the area including indices of riverine aggradation and down-cutting, were integrated into an initial reconstruction of environment at Beidha during human occupation. A sequence of carbonate precipitations related to a fossil spring, outcropping <100 m W of the site, allowed us to reconstruct climatic variations between <16,500 years BP and ≈8,400 years BP (U-series dating) by the use of carbon and oxygen stable isotope analyses.
The results of the palaeoenvironmental study were compared with the archaeological evidence, to provide a detailed picture of the relationship between human occupation and local climatic variability.
Overall, periods of human occupation, both during the Natufian and Neolithic times, seem to correspond to more favourable environmental conditions. The fossil spring itself stopped flowing around 8,500 years BP, coeval with the abandonment of the PPNB settlement. A phase of extended vegetation colonization, marked by the presence of large root concretions, took place on top of wind-blown sand dunes around 11,500 years BP. Wetter conditions therefore appear to have been present at Beidha before the PPNB, which may raise the question of a possible Pre-Pottery Neolithic A (PPNA: ≈12,000 – 10,600 cal. BP) occupation at Beidha.

Similar investigations are ongoing at Wadi Faynan, where a study of the isotopic composition of carbonate precipitations adjacent to PPNA to Byzantine settlements is being compared to archaeological information and hydrological models for this site.

Information gained from these case studies are being integrated with other available data sets (e.g., lake and sea levels, botanical and sedimentological studies, paleosols occurrences) on a broader regional scale. This review contributes to our understanding of the past environments of the Levant, and especially of its most arid regions, and therefore helps to refine palaeo-climatic models.

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Proposing IR stimulated luminescence to date Quaternary phreatomagmatic eruptions from central Madagascar

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The Ankaratra volcanic field in central Madagascar is closely linked to extensional tectonics that affects the area since the middle Miocene. This intracontinental rifting in Madagascar possibly represents a continuation of the East African Rift (Bertil and Regnoult, 1998). The latest phase of the rift-related volcanism in central Madagascar occurred in the southern part of the Ankaratra volcanic field during the late Quaternary. The existing dates for the eruptions in this region are only of indirect nature or based on geomorphological observations and absolute ages are lacking. It is therefore of great interest to directly date the Quaternary volcanism in order to establish a reliable temporal framework for the youngest neotectonic and magmatic events in central Madagascar.

Unfortunately, the available methods for directly dating volcanic rocks of quaternary, especially late Pleistocene to Holocene age, are rather scarce and possess some inherent pitfalls like the necessity of closed system behaviour, usable estimations of initial ratios (U/Th disequilibria) or finding suitable sample material (e.g. organic material for ^{14}C). The young age and the geochemical and petrological composition causes further problems for radiogenic dating with K/Ar or Ar/Ar methods, as the bulk of the potassium is dispersed in the vitreous to aphanitic matrix and a noted absence of juvenile sanidine is observed. Luminescence dating would be a potential target technique for acquiring ages in the timeframe in question, and Tsukamoto et al. (2007) have shown that red isothermal TL on volcanic quartz can be used to date rhyolitic tephras back to 388 ± 25ka. However, as the alkaline ultramafic volcanic rocks of the Ankaratra region are mostly silica undersaturated and alkaline feldspars are scarce or occur only as microcrysts in an aphanitic matrix, neither quartz nor suitable feldspars are available for luminescence dating. However, at least one phreatomagmatic eruption occurred during the early stages of most Quaternary volcanic centres. Due to the nature and the immense energy release of the explosive eruptions, large volumes of crystalline basement material were disintegrated and ejected as ash and sand sized particles over large areas of several tens to hundreds of square kilometres. The bleaching potential during the relatively long aerial transit-time of up to several hours (Bonadonna et al., 2005) and the potential resetting of the luminescence signal by hydrostatic pressure or frictional heating during the eruption (Zöller et al., 2007) suggests that quartz or feldspar grains from this kind of deposit might be suitable for luminescence dating.

In this study we test the potential of IR stimulated luminescence (IRSL) for directly dating phreatomagmatic explosion layers from late Quaternary eruptions from the Ankaratra volcanic field. Multiple feldspar samples from several volcano-stratigraphically linked explosion horizons were studied by single aliquot regenerative IRSL. The quartz samples were not measured, as they exhibited an unusually low saturation level for laboratory irradiation, the cause of which is not clear, but might be related to the violent fragmentation process of the eruption.

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5.17

Glacier advances during the Lateglacial to Holocene transition in the Swiss Alps

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Dating of glacial deposits (e.g. erratic boulders) through surface exposure dating (SED) can provide important information concerning the mechanisms and rates of climate change and hence, can improve the chronology of climate records. During the Lateglacial, stadial and interstadial transitions are abundant (e.g. Björck et al. 1998). Glacial response to rather short lived climatic fluctuations seems to be dependent on various factors such as type of glacier (valley or cirque glacier), exposition of the individual glacier system or size of the catchment area.

Focussing on the end of the Lateglacial, the Gschnitz stadial (≈15.4 to 17 ka, Ivy-Ochs et al. 2008) is the first distinct post-Late Würmian readvance of mountain glaciers, followed by the Clavadel/Senders, the Daun and the Egesen stadial and subsequent advances during the early Holocene (Preboreal). The Egesen stadial in the European Alps is assumed to be related to the Younger Dryas (YD) event. In the Northern Alpine Foreland the YD chron was dated at 12100-11000 cal. yr BP (Hajdas et al. 2004) and represents the last recurrence to near glacial conditions prior to the onset of the Holocene. It is characterized, amongst other things, by significant shifts in temperature at its onset and termination (Dansgaard et al. 1989). At several sites the Egesen stage comprises two or three phases, whereas two of them (Egesen 1 – Maximum, Egesen 2 - Bocktentälli) may directly be associated with the YD (Ivy-Ochs et al. 1996, 2008). For an occasionally appearing third phase of glacial deposits from the Egesen (Kartell stage) it still remains controversial whether it may be associated with the late YD chron or with the early Preboreal chron (11550-10180 cal. yr BP, Ivy-Ochs et al. 2008).

In order to understand different glacier response times and mechanisms, the adjacent valleys of (a) Belalp and Great Aletsch and (b) Val Cristallina and Val la Buora are investigated and compared to each other.
The slow responding Great Aletsch valley glacier shows only one confirmed moraine ridge related to the Lateglacial (Egesen stadial, Kelly et al. 2004). However, the rather fast responding small Unterbächl cirque glacier at the Belalp, a similarly exposed - and tributary valley to the Great Aletsch valley, features up to 6 individual moraine ridges related to Lateglacial and early Holocene times. In contrast, the latter two valleys, also similarly exposed, but interestingly the Val Cristallina with the larger catchment area features up to 6 moraine ridges whereas the smaller Val la Buora seems to have only one prominent moraine ridge related to the Lateglacial.
These results are based on geomorphological mapping and surface exposure ^{10}Be dating of glacially transported boulders or deglaciated bedrock. All ^{10}Be/^{9}Be measurements were carried out at the accelerator mass spectrometer at the ETH/PSI tandem facility in Zurich.

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5.18

Application of “clumped-isotope” thermometry to paleotemperature reconstructions in lacustrine carbonates.

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“Clumped-Isotope” Geochemistry (Eiler, 2007) is a novel method for temperature determination form carbonate minerals. It is based on the measurement of the abundance of carbonate molecules containing the two rare isotopes ^{13}C and ^{18}O. Gosh et al. (2006) have shown that the difference in abundance of the ^{13}C-^{18}O bonds from a stochastic distribution in carbonate minerals is dependent on the temperature of mineral formation and independent from the $\delta^{18}O$ of the water and the δ13C of the dissolved inorganic carbon. Therefore, with this method it is possible to obtain a temperature estimate that can be used in combination with the $\delta^{18}O$ of the carbonate to precisely reconstruct the oxygen isotope composition of the water. This method, and the necessary analytical techniques are still in development and its application to various climate archives still has to be tested to further reveal its potential and limitations.

We will present first data obtained from the successful application of “clumped-isotope” thermometry to lacustrine carbonates from Lake Zurich. Lacustrine carbonates, because of their wide distribution, are important archives of climate change on the continents. However, the extraction of climatic information from carbonate oxygen isotope records is difficult due to the dependency of $\delta^{18}O$ of the carbonates from both the temperature and the isotopic composition of the lake water. These two parameters are important because water temperatures are correlated with air temperatures and the $\delta^{18}O$ of the lake reflects the $\delta^{18}O$ of precipitation and thus is also dependent on mean annual temperature and atmospheric circulation. “Clumped-isotope” thermometry is independent from the $\delta^{18}O$ of the water and the $\delta^{13}C$ of the DIC and therefore allows an independent temperature determination and $\delta^{18}O$ calculation of the original water body.
We are evaluating the potential of the method by analysing lake Zurich sediments and comparing it with historical water temperature measurements for the last 60 years. In addition we are collecting authigenic calcites in the surface waters to establish a calibration for lacustrine carbonates. We have analysed samples from a short core collected at the deepest point of the lake and annual varves were sampled from the years 1907 to 2000. The measurements were carried out with a Thermo Finnigan Kiel IV Carbonate Device connected to a Delta V plus dual inlet mass spectrometer, equipped with a Faraday cup configuration, designed to measure simultaneously CO_2 of masses 44 to 48, which allows to measure up to 46 samples in a totally automated run. The sample weight is ≈200μg and the external reproducibility of δ47 lies between 0.04‰ and 0.1‰.
We will show a comparison from the annual mean temperature of the Lake Zurich surface water derived by “clumped-isotope thermometry” from measured varves compared to recorded temperatures as well as first data from the authigenic carbonates, precipitated this year in the surface water of Lake Zurich.
This will represent the first calibration of clumped isotope thermometry for lacustrine carbonates and we are planning to apply this method for paleoclimatic reconstructions to other lakes and paleolakes in the future.

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5.19

Soil carbon dynamics on annual to millennial timescales – the experimental approach

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Knowledge of soil organic matter (SOM) turnover rates is very important for the quantification of soils as sources and sinks of atmospheric CO_2. Research on the dynamics of especially the recalcitrant fraction of soil organic carbon (SOC) − ultimately responsible for long-term carbon storage - is challenging due to its complex nature, the multitude of physical and chemical processes, and the timescales involved. We present the methods and first results of two different approaches to gain further understanding of the dynamics of especially the recalcitrant SOC fraction:

1. Newly formed or exposed landscapes provide a natural experiment to investigate the roles various mechanisms of OM stabilization play. We present insights in the early development of alpine soils that were gradually exposed after glacier retreat in Central Switzerland, thereby creating a chronosquence of very young to 140 year old soils. First, an inventory of the total carbon content in the forefield as well as the measurement of CO_2 fluxes and the export as dissolved inorganic and organic carbon gives further insight in the carbon dynamics of these young developing soils. Followed over the chronosequence, initial SOM accumulation is clearly present, which shows an exponential increase in TOC content (Figure 1). Second, chemical and physical separation techniques combined with chemical fingerprinting techniques of size and density fractions along the chronosequence, as well as analysis of specific compounds, gives further insight in the build-up and relative importance of the various SOM 'pools' (e.g. chemically stable, or protected by mineral adsorption) over time. More specifically, the use of radiocarbon analysis as natural tracer for the age of various organic carbon pools is explored. Comparison of the total carbon content and ^{14}C content of various physically and chemically separated fractions, including specific compounds, provides further insight in the mechanisms that play a role in carbon dynamics.

2. We build further on the successful approach of Smittenberg et al. (2006), where the terrestrial SOC pool is followed through a well-preserved and well-dated sedimentary sequence covering the Holocene (Figure 2). More specifically, the radiocarbon ages of soil-derived molecular compounds and organic matter fractions are compared to those with the actual age of deposition of the sediment. In this way, the build-up of the terrestrial SOC pool can be reconstructed, providing for instance information whether some 'steady state' has been reached or if there is still a continuous and ongoing accumulation of recalcitrant SOC. We have started to investigate laminated and well-dated sediments from the Meerfelder Maar, Germany, and lakes from the Lofoten, Norway, both spanning approximately the last 15,000 year, from which we will present some first results.

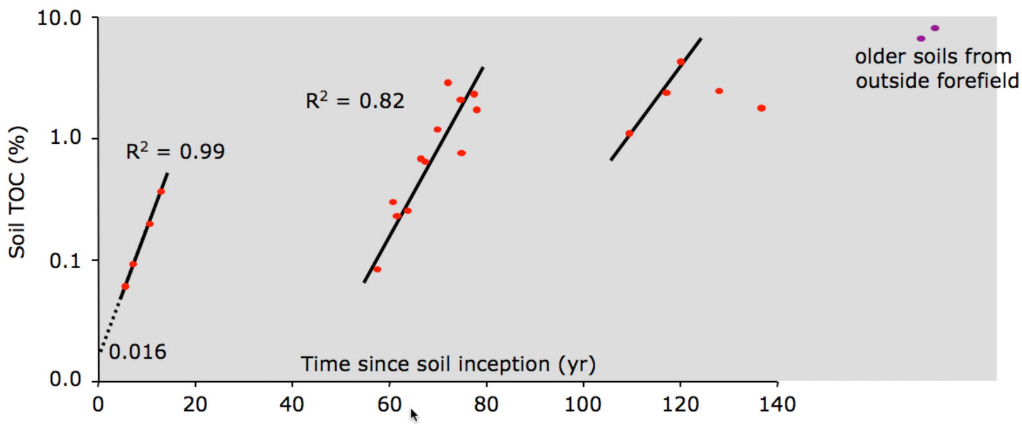

Figure 1. Exponential increase of Total Soil Carbon over the 140yr long chronosequence of the Damma forefield, Switzerland, Kanton Uri.

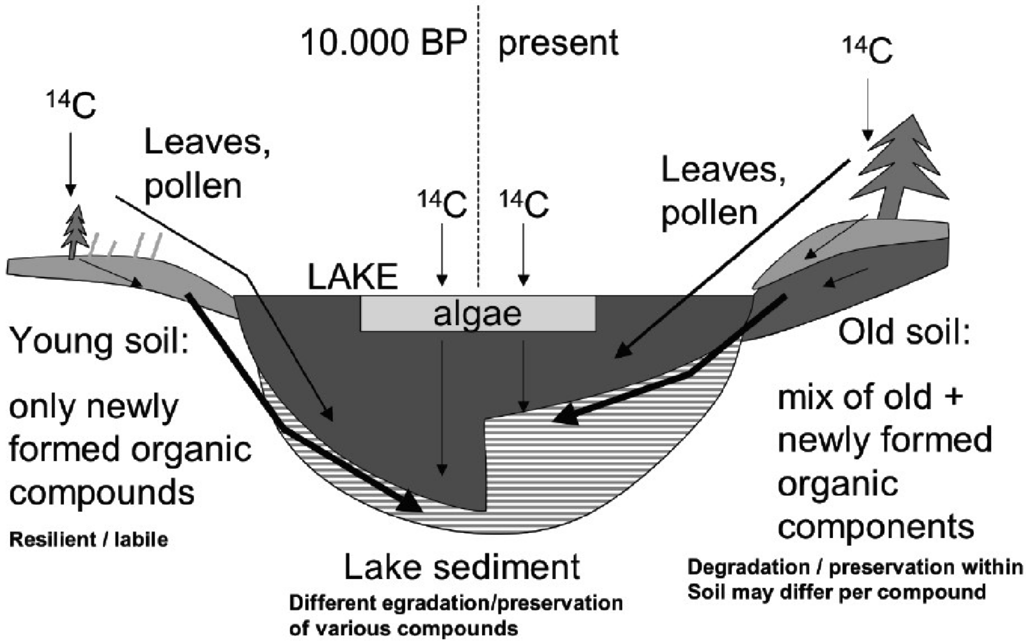

Figure 2. Cartoon of carbon fluxes into a lake sediment. Resilient organic matter builds up in soils. In the past, as well as at present, a small fraction of the soil erodes, and the sediment receives thus each year a 'snapshot' of the soil carbon pool, that can be dated using ^{14}C.

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5.20

Record of past environmental and climatic changes in the sediments of Lake Pfafforet (Valais, Switzerland)

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A 5 m long sediment record of Lake Pfafforet (Valais, Switzerland) indicates significant changes in paleo-climate, paleo-vegetation and paleo-hydrology over the last ≈4000 yrs BP in the Pfyn-Forest. These changes are correlated to nearby situated archaeological sites, which show a long history of human occupation in the area.

Lake Pfafforet is situated within the Pfyn-Forest in the Rhone valley between Leuk and Sierre. The Pfyn-Forest is characterised by a special micro-climate, with very hot summers and cold winters that are more extreme than average. The undulating and irregular morphology of the area is built up by slide deposits from the rockslide of Sierre, which is estimated to be ≈15'000 years old (Burri 1997), although no precise dating exists today. Within the Pfyn-Area, archaeological excavations on relicts from the Iron Age, the Roman Period and Mediaeval Period were carried out, which triggered interest in the climatic and the environmental situation during these historic times. As Lake Pfafforet is the deepest natural lake in the Pfyn-Forest (Bendel et al., 2006), its sediment record was targeted to get information about the past climatic and environmental evolution.

Sediment cores were taken at four different sites in the lake. Several chemical, physical and biologic analysis were carried out, including MSCL (density and magnetic susceptibility), XRF & XRD (elemental and mineralogical composition), carbon and oxygen isotopes, carbon content, smear slides, pollen and grain size measurements. The sediment consists of a complex succession of organic-rich, authigenic lake sediments intercalated by light-coloured, detrital layers. These detrital layers consist mainly of quartz, calcite and mica and they are interpreted as Rhone sediments, probably brought into the lake by floods. Together with the age model (C-14 datings), a detailed reconstruction of the climatic and environmental changes in the past is proposed. The longest sediment core Pf07-1_2, taken in the middle of the lake, shows a complete sediment record of the last ≈4000 yBP and reveals the climatic cold phases from Löbben (≈3000 yBP and older) to the Little Ice Age (13th-19th century). The end of the Iron Age, the Roman Period, as well as the mediaeval times could be identified in the pollen and C-14 data, indicating human impacts like forest fires, pasturing, agriculture and forest-clearings. The whole sediment record could additionally be correlated in detail with the glacial advance and retreat curve of the Aletsch glacier (Holzhauser, 1995) and other glacial data (Maisch 2000, Röthlisberger 1986) showing the influence of the Central Alpine climate to the sedimentation regime in Lake Pfafforet. The advance periods of the Aletsch glacier correlate well with the deposition of detrital sediment layers, indicating a connection between detrital sediment input into the lake and cold climate phases.

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5.21

Evidence for climatic cooling at Grizzly Lake (Alaska) around 2800 cal. yr. BP

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Recent studies revealed climatic changes at about 2800 BP in several regions of the northern and southern hemisphere (e.g. Chambers et al. 2007; Swindles et al. 2007). In order to understand environmental and climatic changes as manifestations of this event in northern high latitudes, we investigated a 20 cm sediment core section from Grizzly Lake (Alaska) covering about 900 years of sedimentation. We conducted a high-resolution multiproxy study to reconstruct vegetation and climate changes with a focus on interrelations of different ecosystem aspects and climate. The sediment archive of Grizzly Lake is particularly suitable for paleoenvironmental studies as direct anthropogenic influence is negligible before ≈1950 AD. The high-resolution measurements of numerous proxies enable detailed investigation of leads and lags within the environment.

Analyses on pollen, plant macrofossils, charcoal, chironomids and diatoms allude to a potential cooling event similar to the Little Ice Age (Tinner et al. 2008) just before 2800 cal. yr. BP. Preliminary chironomid-assemblage analysis indicates a dramatic change at a core depth of 95.5 cm (about 2900 yrs. cal. BP) where cold stenotherm taxa such as *Micropsectra, Corynocera oliveri, Tanytarsus lugens* and *Heterotrissocladius* emerge or increase in abundance. Interestingly, tree pollen (especially *Picea glauca*) increase at the same time. At 92.75 cm (about 2750 yrs. cal. BP) a marked decrease in tree pollen abundance (*Picea mariana, Picea glauca*, and *Betula*) coincides with an increase in pollen from shrub taxa, such as *Alnus viridis*, a species highly adapted to disturbance (e.g. landslides, avalanches, fire, windthrow).

Optical core descriptions classified the sediment mainly as dark brown gyttja with a light brown silt layer at 94-91.5 cm (about 2800-2680 cal. yr. BP). Complementary sedimentological, mineralogical and geochemical analyses were conducted to verify the macroscopic and paleoecological observations. Ultra-high-resolution XRF scans were used to analyse the elemental composition along the core section. These data, combined with thin section and XRD analyses, reveal constant quiet sedimentation with very little autochthonous material within the dark sediment of the core section.

The pale silt interval consists of at least seven event layers, each between 1.5 and 5.5 mm in thickness and some with an erosional base. Every layer shows a gradation with coarse bottom depositions containing high amounts of Si and Ca (evidence for quartz and carbonate) and fine top layers with high amounts of Fe, K, Ti and Al (evidence for feldspars and clays). We interpret these sediments to be washed into the lake from the Alaska Range in the North as a result of the preceding cooling event and associated reduction in forest cover and emerging higher erosion. A potential increase of precipitation that may have altered the hydrological cycle and the lake thermal stratification will be further tested by diatom-assemblage analysis.

We suggest that these inferred changes in vegetation and concurrent higher erosion mark the final stage of the cold event. Pollen data and preliminary chironomid analysis reveal a fast recovery of the ecosystem after this series of erosion events and organic rich sediments prevail again after 91.5 cm (about 2680 yrs. cal. BP).

All hitherto existing results consolidate the conclusion that the chironomid assemblage denotes the beginning of a cold event. With a lag of about 150 years the vegetation finally responded and forests collapsed, possibly in response to high frost-induced mortality of trees, which were close to their upper distributional limit (see interpretation for Little Ice Age, Tinner et al. 2008). The collapse of forests induced a phase of high erosion events marking the final stage of this period. Taken together our data suggests that the cooling event around 2800 cal. yr. BP had distinct impacts on the environment around Grizzly Lake and presumably large areas of south-central Alaska.

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5.22

From the 'Kanderschnitt' to the 21st century: Human impact and natural hazards in the Lake Thun sediment record

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Lake Thun sediments provide an excellent archive to reconstruct the history of human impact and natural disasters occurring in the lake and the watershed during the last 300 years. 1714 AD is a key year in this history, as it marks the deviation of the sediment load- and carbonate-rich Kander river as new major sediment input to the lake (also called 'Kanderschnitt'). On the basis of a high-resolution reflection seismic survey and sediment cores (2.5 m maximum length) the consequences of this human-induced change in the lake sedimentary system are investigated.

On seismic data, the onset of the Kander input is characterised by proximally deposited sediments imaged on seismic data by chaotic/transparent facies, indicating frequent subaquatic mass-movements certainly released from the overloaded Kander delta slopes. This mass-movement material is deposited distally in the form of turbidite beds imaged seismically with onlapping high amplitude reflections. In the sediment record, the onset of the Kander river input is detected by a relative increase in carbonate elements as Ca, inorganic carbon and Sr, and a decrease in magnetic susceptibility, all reflecting the carbonate-rich input of the Kander river.

Around 1850 AD, a second sedimentological change in the lake system occurred, expressed in the seismic data as a general substitution of 'mass-movement' facies with parallel and continuous reflections. In the sediment record, a change towards finer-grained flood turbidites and very fine- and in the main part homogeneously-grained mass-movement-related turbidite deposits in the core material. The factors responsible for this change are presumably lake-level regulations, Kander river corrections and gravel withdrawal at the Kander delta and in the Kander river, all contributing to a stabilisation of the Kander delta slopes. The Kander is the source for the majority of Lake Thun flood events (Röthlisberger, 1991) and their corresponding flood-related turbidite deposits. However, small tributaries along the lake north shore can locally generate coarse grained flood-related turbidite deposits.

Known earthquakes events (Fäh et al., 2003) could be correlated to deformation structures and mass-movement-related turbidite deposits in sediment cores. An earthquake in Kandersteg 1898 (M = 4.8, I = VII) is with high probability responsible for deformation structures and a 'homogenite' bed. Earthquakes in Wengen 1825 (M = 4.3, I = VI) and Interlaken 1937 (M = 4.2, I = VI) can be correlated to coarse-grained mass-movement-related turbidites. These events were not of large magnitude but probably strong enough to trigger subaquatic mass-movements on the instable Kander delta slopes. The biggest registered earthquake in the Lake Thun region (Frutigen 1729; M = 5.6, I = VI) could not be assigned to a particular deposit because of frequently occurring subaquatic mass-movements in the decades after the 'Kanderschnitt'.

The Lake Thun sediment record of the last 300 years presents an interrelation of human impact and natural disasters. In fact, human activities in the catchment area and the lake influence the properties and frequency of deposits provoked by natural disasters as flood events or earthquakes.

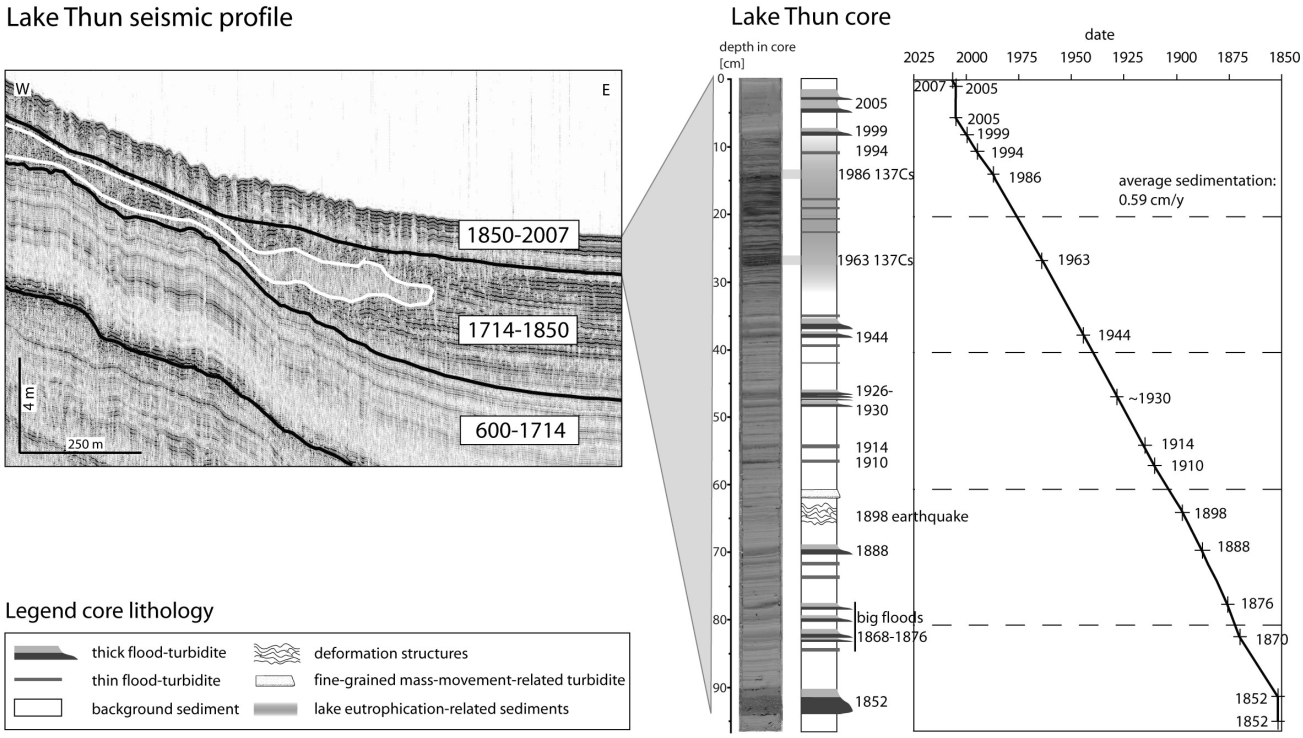

Figure 1. Lake Thun seismic profile and sediment core illustrating constant sedimentation rate from 1850 to 2007 and instable sedimentation with mass-movements (white on seismic profile) from 1714 to 1850.

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Paleoclimates since the MIS 3 on the NE Qinghai-Tibet Plateau: a comparison with SCS and European records

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Seismic profiles, piston cores and a 26m drill core were recovered from Lake Qinghai by the Sino-Swiss limnogeological expedition in 1985 and 1987 (Kelts et al. 1989; Lister et al. 1991; Yu & Kelts 2002). The reconstructed history of lake-level fluctuation and paleoenvironmental change for the China's largest closed-basin lake is an indispensably important record not only for the study of the Asian monsoon changes but also for an intercontinental correlation of paleoclimate records since the MIS 3.

Lake Qinghai lies on the NE corner of the Qinghai-Tibet Plateau at 3194m above sea level. As located at the outer margin of the Asian summer monsoon, the lake and its large catchment are climatically under a conjunct influence of the monsoon circulation and prevailing westerly winds. Because the large lake lacks surface outlets and groundwater discharge, past changes in water chemistry and lake level are the sensitive indicator of paleoclimate changes. Results from investigation on paleoshorelines, cores from the central subbasins of the lake and seismic profiles indicate that both lake size and temperature during the MIS 3 did not exceed those of the Holocene and the MIS 3 environment was neither fully glacial nor fully interglacial (Yu 2008). The paleo-lake during the LGM separated into smaller lakes and windblown loess-like sediments deposited, indicating an extremely cold and arid climate. The arid Younger Dryas equivalent at 10.7-10 ka (AMS ^{14}C age) was followed by an abrupt onset of a warm early-Holocene climate. The effective moisture at 10-8 ka was however much lower than that of today. A permanent expansion of Lake Qinghai occurred at 10 ka and the lake began to increase towards the present-day dimension from about 8 ka. This reflects a stepwise enhancement of summer rainfall on the NE Qinghai-Tibet Plateau.

The G. *rubber* $\delta^{18}O$ record from a northern South China Sea (SCS) core suggests that the main pattern of climate change since the MIS 3 is consistent with that documented in the Greenland GISP2 $\delta^{18}O$ record. The SCS during the MIS 3 was overall under the conditions of a strong winter monsoon and weak summer monsoon precipitation, as also indicated by low fluvial clay content and high modal grain size. The proxy record clearly indicates deteriorated conditions during the LGM. The correlation of the SCS record with Lake Qinghai suggests that the paleoenvironmental conditions of the western Pacific marginal seas and the WPWP had a substantial impact of moisture availability on the outer margin of the Asian summer monsoon, which determined that the strength of the summer monsoon during the MIS 3 was weaker than the Holocene. During the LGM, a combined impact of southward-shifted polar front and an about 100 m decrease of the WP marginal sea levels resulted in a further increase of aridity on the NE Qinghai-Tibet Plateau.

The MIS 3 and LGM conditions in terms of temperature change on the NE Qinghai-Tibet Plateau were in general consistent with the European record. A short-term setback to cold climate conditions at the YD chronozone is however uncertain. The Lake Qinghai record implies that mountainous glaciers on the NE plateau advanced during the period of MIS 3 more than the cold and arid period of the LGM. This indicates that the difference of atmospheric circulation between Europe and East Asia existed during the MIS 3 and LGM.

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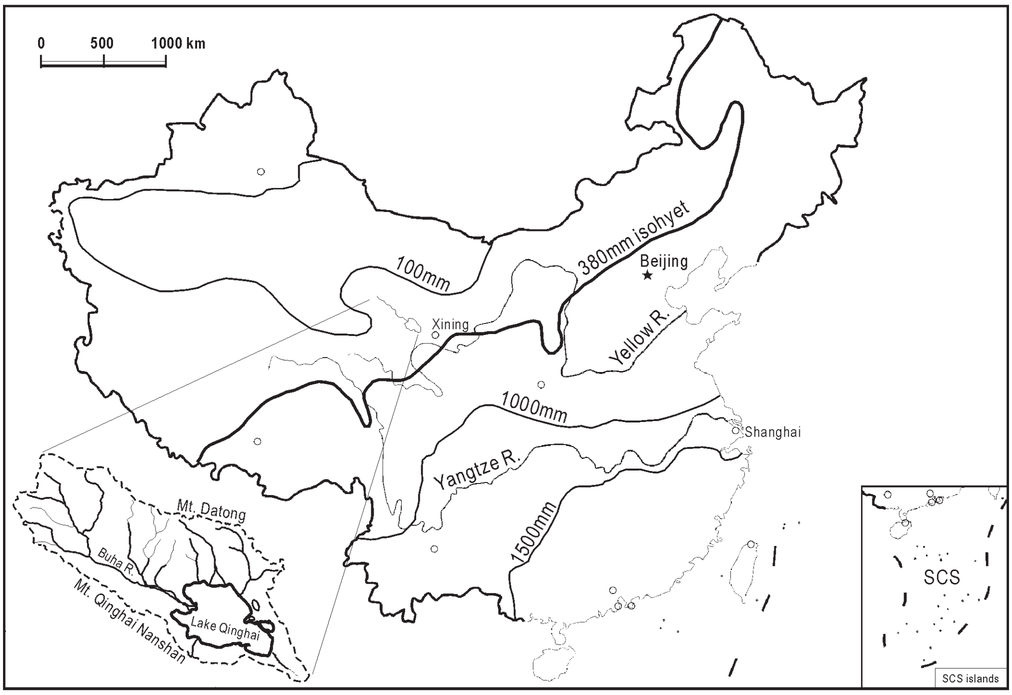

Figure 1. Precipitation gradient to the northwest decreasing steadily from the southeast coast of China towards the drainage basin of Lake Qinghai, reflecting the pattern of the East Asian monsoon rainfall.