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13. Limnogeology and the interdisciplinary study of lacustrine sediments: Crystalizing F.-A. Forel vision.

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13. Limnogeology and the interdisciplinary study of lacustrine sediments: Crystalizing F.-A. Forel vision.

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Swiss Commission of Oceanography and Limnology (COL)

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13.1

Varved Lake Oeschinen: quantitative assessment of climate signal in the sediments

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In the context of lake deposits as paleoclimatic archives, varved (annually laminated) lake sediments may provide quantitative insights into millennial- to Holocene long seasonally-resolved climate state variables (temperature and precipitation). Specific varve properties can be calibrated and verified against a time series of meteorological data (Blass et al. 2007). This remains a methodological challenge.

Here we present a calibration and verification study from clastic-varved Lake Oeschinen, Bernese Swiss Alps, for the period AD 1920-2008. We show that varve thickness can be used as quantitative predictors for summer (May – August) precipitation. This provides the foundation for a Holocene-long quantitative precipitation reconstruction.

Lake Oeschinen (46°30'N, 7°44'E, 1578 m a.s.l.) is a proglacial 56 m deep dimictic oligotrophic high-elevation lake with a surface of 1.2 km^2 located in the north-western Swiss Alps. It was formed by an Early Holocene rock slide. Knowledge of the catchment configuration (geology, topography and hydrology) is crucial for the understanding of the mineralogical composition, the sediment transport and the formulation of a process model for the varve formation. 30% of the catchment area is glaciated and all glaciers are located in the Jurassic limestone (up to 84% calcite) area to the southeast of the catchment with the high mountains. Tertiary Flysch and sediments with up to 60-80% siliciclastic minerals are found in the north-western part of the catchment. it is hypothesized that the amount of summer rainfall controls the amount, and mineralogical and elemental composition of the sediments transported into the lake.

We analyzed a 50-cm long sediment core that goes back to AD 1920. Mm-laminated lithoclastic sediments consist of two Facies: A (Varves) and B (Turbidites). The varve characteristics have been previously verified (from a core retrieved in 2007) by ^{210}Pb, ^{137}Cs and SCP (Spheroidal Carbonaceous Particles) counts profiles. The varves consist of laminae couplets with a coarse dark summer layer enriched in siliciclastic minerals and a lighter fine-grained calcite-rich winter layer on top deposited when the lake is frozen.

According to the varve formation hypothesis, we used the estimated process model to objectively and reliably construct an initial chronology (Fig.1A). This shows a high degree of reproducibility. We then calibrated annual varve thickness, which was identified as the best proxy, with local hydrometeorological data, following von Gunten et al. (2012). Due to varve counting uncertainties we applied a 3-year triangular filter to the time series. The results revealed that varve thickness in Lake Oeschinen was primarily controlled by cumulative summer precipitation (MJJA) ($r=0.64$ at $p<0.05$, means for AD 1920-2008), thus validating the hypothesis (Fig.2). This calibration model is now being used for a millennial-long annually resolved quantitative precipitation reconstruction for the north-western Swiss Alps.

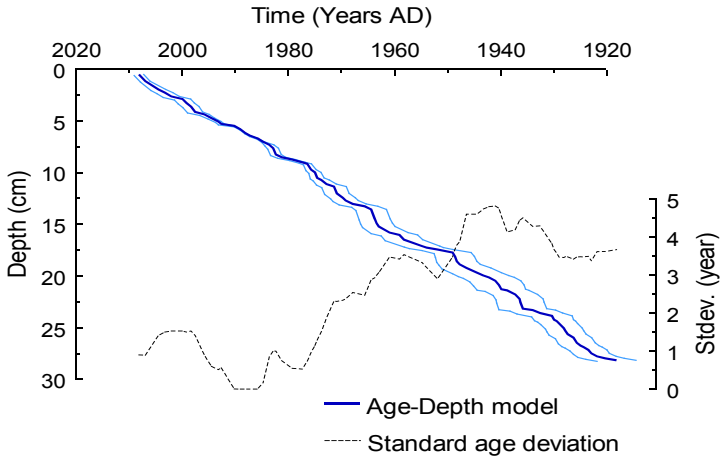

Figure 1. Varve chronology and its associated standard deviation through the sediment core. This is based on three independent varve counts.

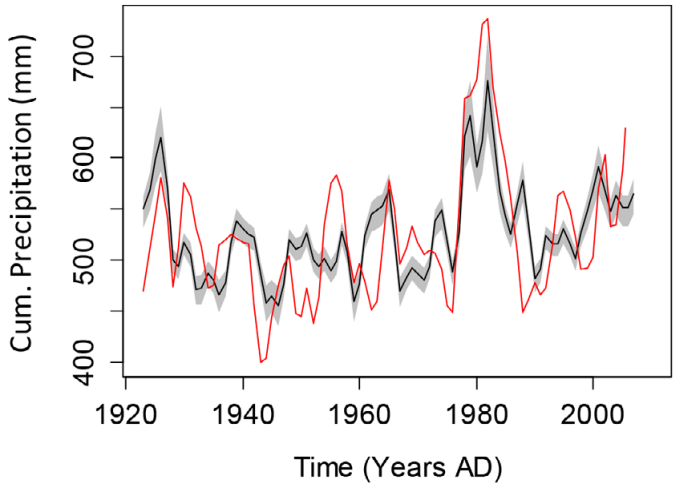

Figure 2. Graphic comparison between instrumental summer precipitation (red line) and its reconstruction (black line). The corresponding RMSE (Root Mean Square Error) is represented in grey shading through the calibration period 1921-2007. Note that a 3-year running mean was used.

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13.2

Paleoseismologic implications of the sediment stratigraphy in Lake Silvaplana (Engadine, Eastern Switzerland)

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Lakes in the perialpine realm are sinks for erosional products. Their deposits generally form a quiet, highly sensitive and complete continuous sedimentary archive so that climatic, environmental, tectonic and anthropogenic changes and events of the past are recorded. The goal of this study is to improve the knowledge of tectonic and sedimentologic processes affecting Lake Silvaplana in the Upper Engadine, which is influenced by a large fault system, the Engadine Line. Previous studies documented that severe prehistoric and historic earthquakes occurred in the area, so that investigating the sediments of Lake Silvaplana should extend this paleoseismic event catalogue.

For this purpose, high-resolution seismic profiling with a 3.5 kHz single-channel pinger was conducted, combined subsequently with recovery of a long sediment core. Seismic lines show generally a good penetration of the acoustic signal down to a maximum sub-lake floor depth of ~90 m, so that the acoustic basement (bedrock or moraines) can be identified throughout the lake. A quasi-3D analysis of the sedimentary fill of the basin was obtained from the seismic stratigraphic interpretation. Sedimentary mass-wasting processes and related deformation structures, such as mass flows and megaturbidites, are identified and mapped throughout the lake basin. Coeval mass-flow deposits and associated overlying megaturbidites are a key criterion to identify a seismic trigger mechanism. In fact, ten horizons with synchronously initiated mass-movement deposits were recognized, which thus are interpreted to have likely been triggered by earthquakes.

A 10.5 m-long sediment core was recovered from the deepest lake basin using an Uwitec percussion piston-coring system. Density, magnetic susceptibility, and grain-size, as well as the lithologic succession were determined. Sediment chronology was achieved using radiocarbon measurements and gammaspectroscopic measurements of ^{210}Pb and ^{137}Cs radionuclides. A precise core-to-seismic correlation allowed finally dating the event horizons defined in the seismic profiles.

Four seismically-detected events were recorded in the long core and dated to 1801, 1723, 821 and 596 AD. The ages of the other six events were estimated using a constant sedimentation rate to 1200, 1400, 2900, 4800, 7400, 8000 BC. These prehistoric earthquakes are compared with the existing historic and prehistoric earthquake catalogues, the latter derived from mass-movement deposits in surrounding lakes (Lake Como, Lake Sils). Eventually, this study allows expanding the earthquake catalogue of the Eastern Swiss Alps and the neighboring northern Italian area, providing novel insights for the regional seismic hazard assessment.

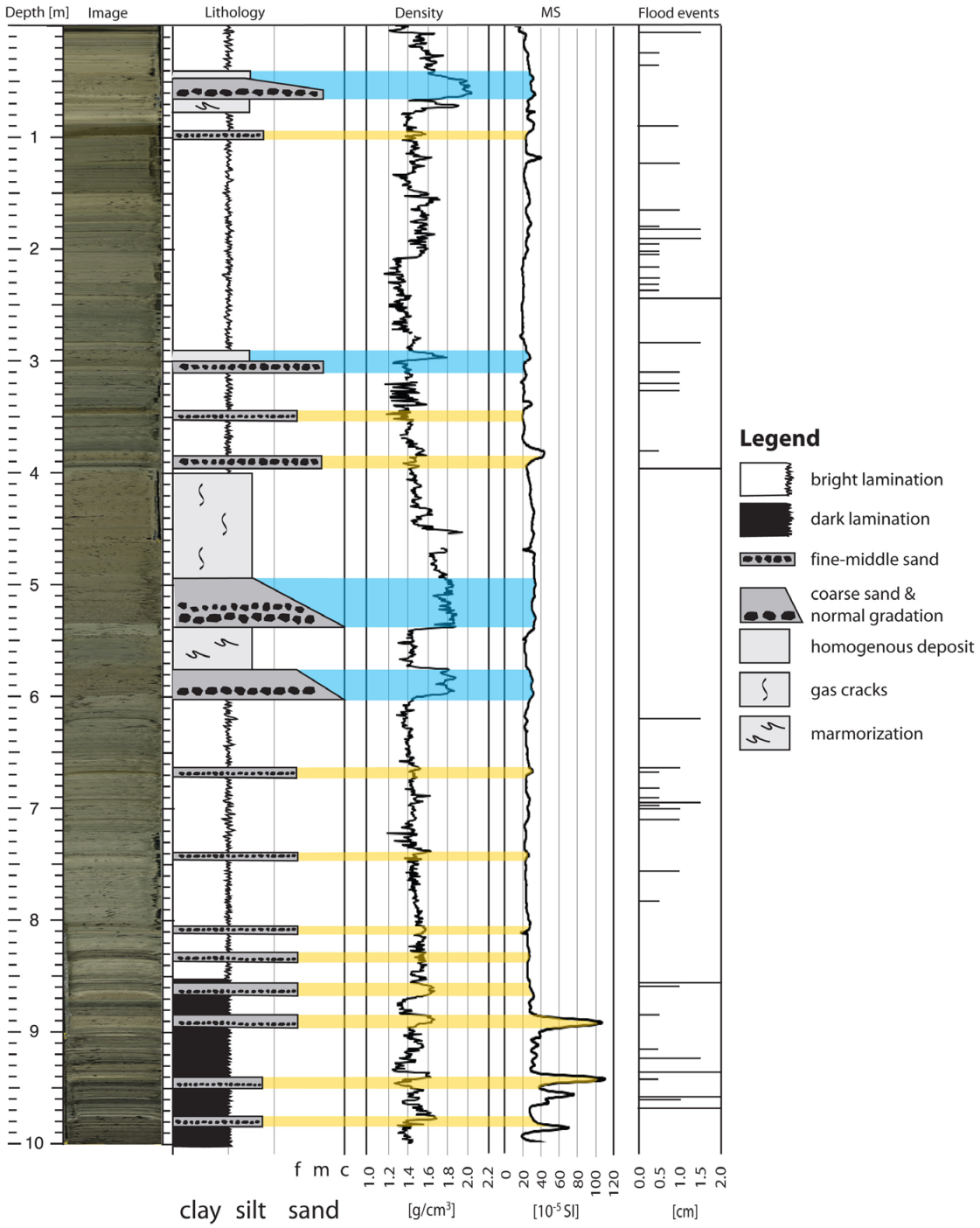

Figure 1. Core photograph, lithological column and petrophysical properties of the long sediment core. Colored bars show correlations of petrophysical properties with event layers (yellow: floods, blue: earthquakes). Flood layers with a thickness of up to 2 cm are displayed on the right. Between 4 and 6 m core depth, the most striking multiple-slide event layer was described. This mass movement, consisting of two phases, i) an underlying mass flow covered by ii) a megaturbidite, can be perfectly correlated with the seismic data. The volume of the megaturbidite was calculated to $292 \cdot 10^3$ m^3, with a maximal thickness of 2 m in the basin center.

13.3

Evolution of the ostracod fauna in Lake Geneva since the pioneer work of F.-A. Forel

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François-Alphonse Forel, while not being an expert on ostracod systematics, mentioned these tiny arthropods when he described the living fauna of Lake Geneva in 1904. After a taxonomic revision of Forel's inventory, it can be deduced that Lake Geneva was oligotrophic and that deep water was cold and well oxygenated at that time. The study of the living population of ostracods in western Lake Geneva ('Petit Lac') more than 100 years after the pioneer work of F.-A. Forel indicates that several species disappeared or became restricted to small ecological niches at intermediate water depth. This change in ostracod population could be related to the anthropogenic degradation of water quality during the 20th century.

The study of ostracod fossil assemblages in Lake Geneva enables an estimation of the impact of water eutrophication on benthic community as well as a better understanding of sedimentary conditions during such environmental changes. The division of Lake Geneva in two sub-basins with distinctive morphological characteristics with similar nutriment overload during the 20th century makes it particularly suitable for such a case study. Lake Geneva provides the opportunity to study the induced environmental changes in a basin where deep water has always remained well oxygenated (Petit Lac) as well as in a basin where oxygen depletions occurred periodically (Grand Lac). In addition, physico-chemical parameters have been measured by the CIPEL on a monthly basis in both basins since 1957. The evolution of ostracod fauna can, therefore, be compared to a large and detailed set of environmental data.

Two short cores were collected in the deepest zones of Grand Lac at 300 m water depth and Petit Lac at 58 m water depth. Lithology and ostracod fossil assemblages have been determined for the two cores. The results indicate that before the 20th century, the profundal ostracod population of both basins was dominated by *Candona neglecta* and *Cypria ophtalmica* forma *lacustris* while *Limnocytherina sanctipatricii* and *Leucocythere mirabilis*, although less abundant, were continuously present. This fossil assemblage, and especially the presence of the latter two species, indicates that oligotrophic condition, namely cold deep water, good oxygen supply and low sediment organic content prevailed before the 20th century. During the first half of the 20th century, the populations of *L. mirabilis* and *L. sanctipatricii* started to decline in both basins while the sediment organic content increased gradually. During the second half of the 20th century, *C. lacustris* colonized the profundal zone of Petit Lac and dominated rapidly the population. During the same time period, the total individual abundance (especially for *C. neglecta* and *C. lacustris*) raised strongly while the sediment organic content remained high all along. In contrast, the population in Grand Lac experienced pronounced modifications during the second half of the 20th century, with high abundances during periods of moderate to high oxygen levels and almost complete lack of ostracods at time of low oxygen levels.

The changes in ostracod population can be attributed to several causes. Higher supply of organic matter sinking from epilimnion led to a change of sediment texture at the bottom of the lake. This resulted in the disappearance of species sensitive to habitat degradation such as *L. mirabilis* and *L. sanctipatricii* even if oxygen levels remained high. In contrast, more tolerant species, such as *C. neglecta* or *C. lacustris* benefited from higher food supply and were favoured. Yet, as oxygen level dropped in Grand Lac, the whole ostracod fauna declined progressively and vanished almost completely. During cold winters, complete overturn of water column could occur, restoring high oxygen level at depth. Return of adequate levels of oxygen led to a rapid proliferation of the ostracod population until oxygen began to drop again.

Pb-210, Cs-147, and C-14 dating are still in progress. They will allow us to better compare our data with historical measurements to constrain the sedimentary changes more accurately and to reconstruct oxygen and primary productivity levels through the last centuries. Last but not least, the analyses of isotope composition of ostracod valves will provide helpful information on water temperature and carbon cycling at time and place of valve calcification.

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13.4

Carbon fluxes from sediments of a Mediterranean semiarid freshwater wetland and comparison with other continental sediments

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Sediments are an active biogeochemical compartment in continental waters. Sediments in freshwaters, particularly in lakes and wetlands, sequester carbon by burying inorganic and organic carbon. However, not all organic carbon deposited in wetland sediments can be considered as being permanently trapped because it undergoes oxidation processes with production of CO_2 but also of a large variety of organic compounds, ranging from refractory organic matter (ROM) to labile low-molecular-weight molecules. These organic compounds may diffuse from the interstitial waters to the water column depending on existing concentration gradients.

Although dissolved organic carbon (DOC) fluxes from wetlands may be high (Moore et al., 1997), not much is known about DOC cycling in these systems. Moreover, most of what has been published deals with boreal and forested peatland areas. We have measured fluxes of DOC in wetland sediments from a semiarid freshwater wetland, the Tablas de Daimiel, Spain by using passive diffusion samplers (peepers) (Filella et al., 2012). The system –characterised by highly variable hydroperiodicity conditions– was completely flooded at the time of sampling (February 2011). Not only dissolved organic carbon (DOC) concentration profiles were measured in sediment porewaters but refractory organic matter (ROM, usually known as humic substances) was also quantified by using a novel voltammetric method. Although the Tablas de Daimiel wetland is known to act as a long-term carbon sink (Domínguez-Castro et al., 2006), at the time of the observations waters experimented a 7-fold increase in measured ROM concentrations from the inlet to the outlet, which points to a net exportation of ROM from the wetland and to the existence of an internal source, most probably diffusion from the sediments. These observations suggest that intermittently-flooded freshwater systems may act in some periods as net exporters of organic carbon.

To put these results in a wider context and to get a better understanding of the possible role of sediments as a source of DOC in freshwater systems, we have thoroughly revised the limited number of published studies reporting organic matter profiles in sediment interstitial waters and estimated the corresponding fluxes when possible.

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13.5

Enhanced occurrence of extreme precipitation events during periods with cool summers: A 2500-year long Northern Alpine flood reconstruction

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Severe floods caused by heavy precipitation represent a major natural hazard in the alpine realm. With current climate change, the frequency of flood events caused by heavy precipitation events is expected to be subject of considerable modifications that could substantially increase social and economical damage due to flood events. To assess the natural variability of this natural hazard and hence to better predict future flood risk, we reconstruct the frequency of flood events during the past 2500 years in Northern Switzerland by using lake sediments. Lakes record flood events by specific sedimentary deposits, i.e. 'turbidites' or flood deposits. They are composed of terrigenous material that is mobilized during heavy precipitation in the catchment area and is deposited at the bottom of the next downstream lake with the intense riverine in-wash (Gilli et al. 2013). This allows the reconstruction of flood-recurrence rates in the past, offering time series reaching far beyond the relatively short time interval covered by instrumental and historical data.

To provide a spatially and temporally highly resolved 2500-year long flood chronology of large-scale heavy precipitation events in the Central Northern alpine region, we apply a multiple-lake approach, investigating 10 individual lakes along a transect from the Swiss Plateau to high-alpine environments (from 447 m a.s.l. to 2065 m a.s.l.). In total, 825 flood events, recorded as in individual and dated flood layers, are combined to obtain a regional dataset.

The observed flood occurrence is characterized by high-amplitude decadal to centennial fluctuations, with site-specific average flood-recurrence rates between 16.7 and 80.7 years. This indicates a high variability in the absolute number of recorded events, reflecting varying susceptibility of the lakes to record floods. In order to establish a flood chronology representative of the entire Northern alpine region, we compiled the 10 individual records into one, by weighting each lake equally and normalizing the records to a 'flood activity' reaching from 0% (corresponding to no flood layers) to 100% (maximum number of flood deposits) within a time window of 50 years. Furthermore, we verified the established flood reconstruction of the Northern Alps by comparison with an independent historical flood reconstruction for the same study area covering the past 500 years (Schmocker-Fackel and Naef 2010). The two independent datasets are in good agreement, characterized by three coinciding peaks. This confirms our approach and validates its applicability even during times with intense human impact.

The complete flood chronology is characterized by eleven well-distinct periods of high flood frequency that are developed around 1860, 1730, 1630, 1310, 1150, 850, 590, 350, 120 C.E. and 150, 340 B.C.E.
Regarding the best-characterized climatic periods during the past 2500 years, i.e. the Little Ice Age (1430 -1850 C.E.; LIA) and the Medieval Warm Period (950-1350 C.E.; MWP), we find a generally enhanced flood activity during the LIA compared to the MWP. These findings are in good agreement with other studies reconstructing flood events, which have also observed increased flood activity during LIA in central Europe (e.g. Schmocker-Fackel and Naef 2010).

In addition, all major peaks in flood activity of the Northern alpine flood chronology coincide with periods of low mean summer temperatures reconstructed based on tree-ring records for Europe of the last 2500 years (Büntgen et al. 2011) and correlate to major advances of the Lower Grindelwald Glacier (Holzhauser et al. 2005). Therefore, we propose a temperature-dependent change in circulation patterns, which favour the occurrence of floods during cooler periods in the last 2500 years. The apparent discrepancy of cooler temperatures and more frequent extreme precipitation, contradicting the basic Clausius-Clapeyron equation of higher atmospheric moisture-transport capacity with increasing temperature, can be explained by a regional circulation pattern overruling the temperature effect. This pattern of more floods with cooler temperatures is thus representative for the Northern alpine region only and must not represent a global signature.

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13.6

Advection of particle-bound contaminants in Vidy Bay, Lake Geneva, Switzerland

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Understanding sediment and particle dynamics is paramount in determining the fate of hydrophobic pollutants within an aquatic ecosystem. Knowledge of pollutant dispersal to sediments provides insight into accumulation zones, or "hot-spots", which aids in mitigating future economic, health, social, and environmental impacts from acute or chronic contamination. Vidy Bay is of great concern due to the presence of a wastewater treatment plant (WWTP) outlet pipe and combined-sewer overflows dumping directly into the bay.

Natural radionuclides, such as ^{7}Be, ^{210}Pb, and ^{234}Th are used as surrogates for hydrophobic pollutants since they behave similarly within a lacustrine environment (with respect to adsorption and transport). In addition, the varied half-lives of these radionuclides, aid in the differentiation between short and long-term dynamics. These analytes, combined with more traditional parameters, such as carbonate and organic matter content, and particle size diameter were investigated.

Samples in Vidy Bay area were collected via sediment traps and sediment cores. Atmospheric inputs were monitored using an atmospheric trap situated in Versoix. Local water conditions, 5m above the lakebed, were monitored using a RCM-9 MKII Current Meter. Parameters measured include current velocity and direction, temperature, and turbidity, during the twenty-two month study.

Sites within the bay, exhibit an overall winnowing effect, while a site just outside the bay, showed an overall focussing effect (as exemplified in Fig 1.). The hydrodynamic parameters measured at the sediment surface show daily mean currents as high as 15cm/s. They also show evidence of a gyre know to prevail within the bay, along with down welling and Ekman spiral formation during seasonal wind events. Results show evidence of an overall sediment advection from the bay, towards the main basin of the lake.

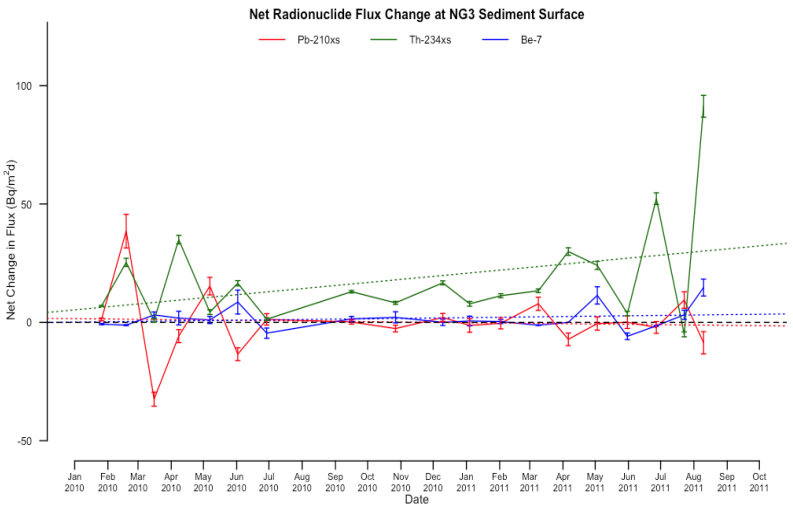

Figure 1. Radionuclide flux differences monitored at site NG3

13.7

Paleolimnology study and causes of Sudden decrease in water level of Urmai Lake

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Urmia Lake is one of the biggest and hyper saline Lakes in the world. It is located at the northwestern part of Iran. Today, it has been endangered by drying up processes. This environmental hazard is one of the most significant geological problems of Iran. Verification of evolutionary history of Holocene and understanding the reasons for sudden downfall of Urmia Lake water level is the main subject for current study. In this research, remote sensing examinations for a period of 35 years, 55-year climatic data processing and their relationship with Lake Water fluctuations were implemented, and undisturbed sedimentary cores of western coast of Lake sediments were prepared by Auger coring method. 16 cores having a maximum depth of 9 meters, and totally 98m of the Lake sub-floor sediments were verified. Sedimentary facies were separated by color, grain size, mineralogy specifications, sedimentary fabrics and evaporative minerals. With regard to vertical sedimentary facies (from surface to sub-surface areas) changes, geography, climatic conditions and Lake water level fluctuation were re-constructed. Results indicated 17 separable types of sedimentary facies in cores. Facies are from Lacustrine, Swamp, fluvial and terrestrial environments. Coring and verification of Lake Sub-environment sedimentary facies indicate that sequential drying up tracks are visible in the coastal areas of Urmia Lake. However, the main part of the Lake has had Lacustrine environment (6.5m of the Lake floor sediments) for 13000 years. Sedimentation was continuous during the mentioned period and seismic data confirm this issue. Climate change and particularly evaporation increment are significant agents in downfall of Lake Water. But these are not the main causes for drought in Urmia Lake region. Iran has experienced a long-term drought since 13000 years ago up to now. Hence, shallow Lakes, such as Maharloo, Mirabad and Zarivar were frequently dried. It is important to note that Urmia Lake has never experienced dryness except in coastal areas. The main stage of Urmia Lake region drought commenced about 13000 years ago. This event indicated coincidence with the last Ice Age. Regarding the Ice Age, downfall of moisture and Lakes' water levels of North Africa and southern Asia was pointed out. Therefore, today, the important agent in downfall of the Urmia Lake water is anthropogenic factor (building more than 20 dams on the Urmia Lake Rivers).

Key Words: Urmia Lake, Paleolimnology, Lake water level, Sedimenty core

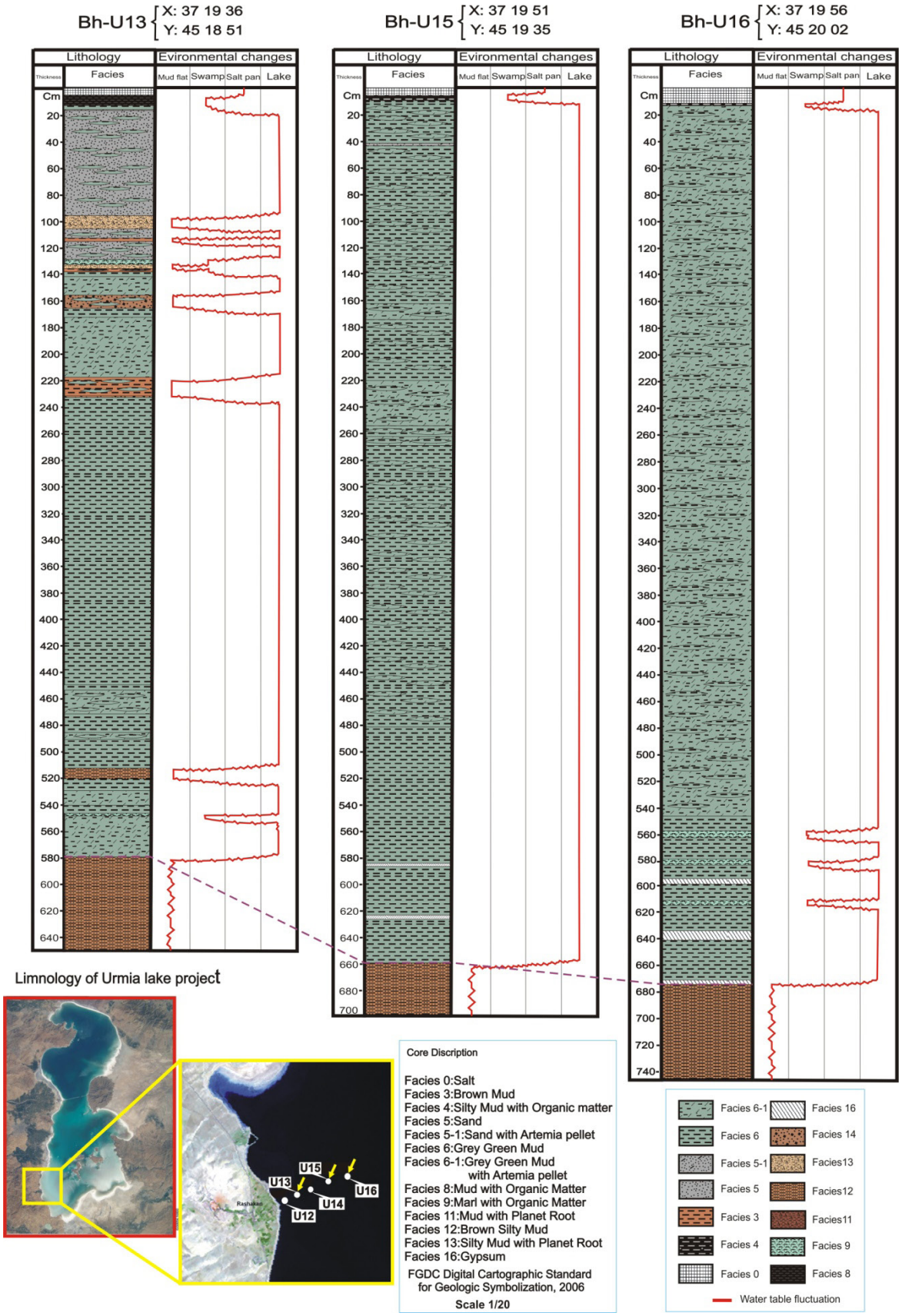

Fig1: Stratigraphical column of Urmia Lake cores

13.8

Thermal structure and circulation patterns of Lake Geneva (Lac Léman)

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Abstract: Hydrodynamic processes in Lake Geneva (Switzerland and France) have been studied since the pioneering work of F.A. Forel (1892, 1895, 1904) who initiated the science of limnology as a branch of oceanography. Lake Geneva is characterized by a thermal stratification of the water column from spring to autumn and a homogenization from late winter to the beginning of spring. Lake Geneva is a "monomictic" lake according to the classification of Hutchinson (1957).

A three-dimensional finite element model, SHYFEM, with the ability to simulate the temperature structure and water movement was applied for Lake Geneva. The finite element grid, superimposed on the bathymetric data, has a resolution of 8149 triangular elements and 4553 nodes, covering the two lake basins: Petit-Lac and Grand-Lac. The model was run for a period of one year (2005) with continuously updated weather data. The model solves the equations for the conservation of mass transport, dynamics and temperature, which can simulate the water temperature, current velocity and direction. The annual thermal cycle begins with isothermal conditions in winter, followed by thorough mixing in late winter, and by stratification from May to October. The annual cycle of temperature distribution in the Grand-Lac shows strong seasonal trends. Depending on the difference in volume and morphology of the basin, cooling and warming during the transition periods (spring and fall) are slower in the Grand-Lac than in the Petit-Lac. Minor differences within the basins could be linked to local circulations between coastal areas and deep areas, as well as the influence of fluvial input, including the Rhone.

Over much of the year, the waters of Grand-Lac circulate in a gyre turning counterclockwise. The size and lifetime of the vortex varies depending on weather conditions. Appendices of the main gyre are found in major bays of the northern shore, in Morges and Vidy (Lausanne). These are less stable than the main gyre and their direction may switch depending on wind direction. In the transitional area between the Grand-Lac and the Petit-Lac a gyre oriented clockwise is established. The western end of the Petit-Lac is characterized by a counterclockwise circulation system. In the Petit-Lac, flow towards the Rhone outlet mainly occurs in surface waters and along the borders of the basin, while the return currents to the Grand-Lac are deeper-water currents and found in the central part of the basin. In the Grand-Lac, the downstream flow from East to West follows the northern edge of the basin, while the return current, from the western to the eastern part of the basin, predominantly follows the southern border.

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P 13.1

Sedimentological processes in the Rhone Delta subaquatic canyons (France-Switzerland)

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Deltas are very sensitive environments and highly vulnerable to variations in water discharge and the amount of suspended sediment load provided by the delta-forming currents. Human activities in the watershed, such as building of dams and irrigation ditches, or river bed deviations, may affect the discharge regime and sediment input, thus affecting delta growth. Underwater currents create deeply incised canyons cutting into the delta lobes. Understanding the sedimentary processes in these subaquatic canyons is crucial to reconstruct the fluvial evolution and human impact on deltaic environments, and to carry out a geological risk assessment related to mass movements, which may affect underwater structures and civil infractructure.

Recently acquired high-resolution multibeam bathymetry on the Rhone Delta in Lake Geneva (Sastre et al. 2010) revealed the complexity of the underwater morphology formed by active and inactive canyons first described by Forel (1892). In order to unravel the sedimentary processes and sedimentary evolution in these canyons, 27 sediment cores were retrieved in the distal part of each canyon and in the canyon floor/levee complex of the active canyon. Geophysical, sedimentological, geochemical and radiometric dating techniques were applied to analyse these cores. Preliminary data show that only the canyon originating at the current river mouth is active nowadays, while the others remain inactive since engineering works in the watershed occurred. However, alternating hemipelagic and turbiditic deposits in the easternmost canyons, evidence underflow processes during the last decades. Two canyons, which are located close to the Rhone river mouth, correspond to particularly interesting deeply incised crevasse channels formed when the underwater current broke through the outer bend of a meander in the proximal northern levee. In these canyons, turbidites were observed in the sediment record indicating ongoing sediment dynamics during whether extreme flood events or mass-movements due to deltaic scarp failures. The active canyon shows a classic turbiditic system with frequent spillover processes in the canyon floor/levee complex. Geotechnical measurements, a decrease in the frequency of turbidites and a fining upward sequence along the levee suggest that erosion dominates sedimentation in the canyon floor, while sedimentation dominates in the rapid levee building-up process, with sedimentation rates that exceed 2.5 cm/yr in the proximal areas. Therefore, mechanisms controlling the sedimentary evolution on the active canyon represent a complex interplay between erosion and sedimentation.

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P 13.2

Triggering mechanisms and geomorphological implications of debris flows in subaquatic canyons: The Rhone delta (Lake Geneva, Switzerland, France)

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Subaquatic canyons in deltas are major pathways for the transport of particles from rivers / the upper delta slops to the deep basins. They represent active environments with frequent deltaic failures and massmovements potentially bearing hazard-related (tsunami waves) and economic (infrastructure damages) implications. Understanding sedimentary processes and mass-movement triggering mechanisms is crucial to assess related consequences and to carry out geological risk assessments.

The Rhone River delta in Lake Geneva (Switzerland, France) is a complex underwater structure with several active and inactive subaquatic canyons, similar to marine deltas but at a smaller scale. The difference between two bathymetric surveys in 1986 and 2002 revealed an inversion in the topography of the distal active canyon, as a former distal canyon was transformed into a mound-like structure. A 12 m-thick layer was deposited in the canyon and modified the sediment transfer conduit. Sediment cores from this deposit were retrieved in-situ in 2002 and 2011 via the "F.-A. Forel" and Russian MIR submersibles, respectively. These cores contained a homogeneous, sandy material. Its sediment texture, grain-size, high density and shear strength, and low water content suggests that it corresponds to a debris-flow deposit that possibly took place after the initiation of a mass movement due to a scarp failure in proximal areas of the canyon. In addition, in-situ geotechnical tests on the modern canyon floor have shown a soft top layer above a stiffer substratum. This soft layer, which increases in thickness towards distal areas, may act as a basal surface for hydroplaning, and might have allowed the debrite to be transported 9 km away from the source of the scarp failure. Similarities in textures and grain-size of the debris flow and levee deposits hint at the proximal northern levee as the source of this material. Rapid sediment loading in this area, at the rate of >2.5cm/yr, steep slopes in the canyon walls and increased pore pressure due to high methane concentrations may have reduced the stability of the canyon wall in this area. Discrete sandy intervals show very high methane concentrations and thus could correspond to potentially weak layers prone to scarp failures. Nevertheless, the probable cause for the 2000 AD Rhone delta event was an exceptional flood in October 2000 which undercut the slope, and subsequently decreased the stability by increasing the shear stress and triggered the mass failure in the already unstable canyon walls. Besides economic and hazard-related implications, such mass failures represent significant and underestimated causes in morphological evolution of underwater canyons by damming the channel and, eventually, forming short-term meanders susceptible to further erosion, as seen in a recent multibeam bathymetric map obtained in 2012.

P 13.3

Lake Geneva sediments as archive for past environmental changes and human activity during the last 3000 years

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Lake sediments are excellent archives of environmental changes in the watershed and provide high-resolution records of regional paleohydrological variability. Lake Geneva is the largest peri-alpine lake in western Europe, with a maximal water depth of 309 m. It is part of the Rhone river system and was formed during the Pleistocene by glacial erosion. Our study focuses on the deepest part of the lake basin, where sedimentation is mainly controlled by fluvial input from the Rhone and Dranse rivers. These two river systems are sensitive to regional climate variations in the alpine realm and to human activity that affect the discharge regime and sediment delivery to the lake.

In Lake Geneva, high resolution seismic reflection profiles reveal two distinct units in the late Holocene sedimentation history. One unit (Unit 1) consists of a succession of five large lens-shaped seismic sub-units, characterized by transparent/chaotic seismic facies with irregular lower boundaries, interpreted as mass-movement deposits. These sub-units are interbedded within parallel, continuous, high-amplitude reflections, interpreted as the 'background' lake sediment. The second unit (Unit 2) consists of 5 m-thick 'background' seismic facies with parallel geometry. It displays alternating dm-thick chaotic/transparent and continuous, high amplitude reflections, which are interpreted as hemipelagic layers punctuated by turbidites. This turbidite layers, are interpreted as floods- and mass movement-related deposits.

Four 7- to 12-m long sediment cores were retrieved with a modified Kullenberg system from the deepest part of Lake Geneva. The sedimentary sequence spans the last 3000 years. Magnetic susceptibility and density were measured by Geotek Multisensor Core Logger at 0.5 cm resolution. X-ray fluorescence was carried out using an Avaatech core scanner from the University of Barcelona at 1-cm resolution. This technique provides semi-quantitative information of the sediment elemental composition. Clastic-related elements such as Ti, K or Si records extreme precipitation events in the lake watershed while the Fe/Mn ratio and Calcium in the sediment provides information about the redox conditions in the lake bottom and the calcite endogenic precipitation in the epilimnion respectively. The sedimentary record suggests a complex hydrological variability during the last two millennia during different climatic facies such as the Medieval Warm Period (MWP) and the Little Ice Age (LIA). However, the climate signals are certainly also overprinted by human activity during the last 3000 years, and particularly during last centuries with river regulation and dam building on the Rhone river and disentangle both forcing mechanisms is needed in order to achieve an adequate paleoclimatic reconstruction.

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P 13.4

Subaquatic landslides and sediment deformation structures within the geologic archive of Lake Neuchâtel

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Lake sediments are highly sensitive archives of past environmental changes and geological events, such as earthquakes. Sublacustrine landslides deposits are important components in the sedimentary infill of lakes. Previous studies linked sublacustrine mass-transport deposits to historical earthquakes. They thus calibrated the use of sediment instabilities recorded within lacustrine sedimentary archives as indicators of past seismic events (Schnellmann et al., 2006; Strasser et al., 2006). Synchrony of multiple mass-transport features at different locations within a basin is the main criterion to postulate seismic triggering. We aim to study the sublacustrine mass-movement deposit inventory of Lake Neuchâtel, as it provides great insight into past seismotectonic activity and natural hazards since Late Glacial times, when lakes in their existing form within the study area were formed and continuous lake sedimentation set in.

In this study, we present preliminary results from newly acquired high-resolution reflection seismic and swath bathymetry data, which we integrate with seismic airgun data acquired by Gorin et al. (2003), as well as with piston-core data by Schwalb (1992). Extensive reflection seismic and swath-bathymetry measuring campaigns on Lake Neuchâtel took place in winter 2011 and spring/summer 2012. Swath-bathymetry data (Kongsberg EM 2040 multibeam) provide precise high-resolution lake floor morphological data. Dense grids of high-resolution reflection seismic data (3.5 kHz pinger source) are used to image the sedimentary infill of the Lake Neuchâtel basin with decimeter-scale vertical resolution. This allows systematical mapping of mass-movement deposits, landslide scars and lake-floor deformation structures. Seismic-stratigraphic correlation is used to determine the chronostratigraphic relations between deformation events.

Correlation of initial seismic-stratigraphic interpretation with piston cores by Schwalb (1992) indicates sequences of lacustrine background sedimentation, interbedded with turbiditic deposits, which are intercalated with mass-transport units. First results show strong evidence for at least one distinct seismic horizon with multiple, basin-wide subaquatic landslides and sediment deformation features.

Lake Neuchâtel is a perialpine lake located on the border between the Swiss Molasse basin and the Jura mountains, an area of low overall seismicity. In the study area, however, a zone of increased seismicity gives evidence for neotectonic activity along distinct fault zones (Gorin et al., 2003; Kastrup et al., 2007). It remains to be further investigated if the observed multiple landslide horizon may relate to past seismic activity along such faults. Additionally, next to sediment deformation-structures, some of these potentially active fault zones may be marked by fluid expulsion structures on the lake floor. In fact, several of those have been mapped, and future analysis will reveal whether these truly indicate active fluid migration along such faults, or, alternatively, may relate to a karstic groundwater system. Eventually, the present study investigating and discussing depositional and post-depositional sedimentary processes in Lake Neuchâtel, aims to link sedimentological data to neotectonic activity.

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P 13.5

Lake Biel sediment record during the last 7500 years and impact of the Aare river deviation in 1878 AD.

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Lake sediments are excellent archives of environmental and climate changes as well as human impact on lake- and river-systems. Lake Biel is a medium-sized peri-alpine lake in Switzerland, with a maximum depth of 74 m, and lies at an altitude of 429 m a.s.l. Lake Biel, which formed during the Pleistocene by glacial erosion, is situated downstream Lake Brienz and Lake Thun and is currently part of the Aare river system. Our study focuses on the south-west part of the lake basin, where the lake sedimentation was naturally mainly controlled by autochthonous sedimentation, and since the Aare river deviation through the Hagneck canal in 1878, is now under the strong influence of water and sediment input from this river catchment.

A 10.05 m long composite sediment sequence, cored from a 52 m water depth in September 2011, was built from two long cores retrieved with the ETH Zurich/Eawag Uwitec system. The retrieved sedimentary sequence begins in 1975 and spans the last 7500 years, as dated by seven ^{14}C datings, and correlated to previous short core radioisotope stratigraphy for the 1.5 m upper part (Thevenon et al., submitted). Magnetic susceptibility and density were measured by Geotek MultiSensor Core Logger at 0.5 cm resolution at the ETH Limnogeology Laboratory. Granulometry was measured with a CILAS grain sizer at the University of Geneva every ~10 cm, and X-ray fluorescence was carried out using an Avaatech core scanner at the University of Barcelona at 1-cm resolution. This technique provides semi-quantitative information of the sediment elemental composition and shows how runoff and river input (Ti, Al, Si) or redox conditions (Fe/Mn) vary through time.

Lake Biel sediment record suggests marked environmental changes, with runoff decrease linked to climate and vegetation change during Atlantic chronobiozone, as well as a complex climate-human impact during the 'La Tène' and Roman cultural times. The most remarquable feature, is the 10-times increase of sediment rate which happens after the Aare river was deviated through the Hagneck canal into Lake Biel in 1878, and which is also linked to a massive and sudden Ti increase, and inversely massive Ca decrease, in xrf data. This record reveals the magnitude of sedimentary changes happening in a lake system when it shifts from a relatively closed basin to a river and delta-influenced basin.

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P 13.6

Traces of the Great Lisbon Earthquake (AD 1755) in the sediments of Walchensee (Bavaria, Germany)?

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This study investigates evidences of the Great Lisbon Earthquake. It occurred in AD 1755 and is preserved in the sediments of Walchensee (799 m a.s.l., Bavarian Alps, Germany), a lake located in more than 2'000 km distance of the epicenter. Although strong ground motions are not expected at such large distances, historical reports indicate that strong water movements were indeed observed on Walchensee immediately after the earthquake. Recent paleoseismic studies of other peri-alpine lakes demonstrate that historic earthquake- triggered slope failures caused water waves (tsunamis) and oscillations (seiches), which have been recorded in the fine-grained lacustrine sediments. Consequently, a limnogeological approach has also been performed in Walchensee.

Within the younger sediments of Walchensee, we identified multiple mass-movement deposits intercalated with background sedimentation using high-resolution seismic sequence stratigraphy and multi-proxy analysis of twelve short gravity cores. The reflection seismic survey was made in 2009 using a 3.5 kHz 4-element pinger source. The cores were investigated with 1) GEOTEK multisensor core logger, 2) XRF core-scanner, 3) microscopic grain-size analysis and 4) geochemical carbon analysis. We dated the sediments with radionuclides (^{210}Pb, ^{137}Cs) and an inventory of historic events, which included nearby earthquakes and anthropogenic disturbances such as the construction of a hydropower plant and the subsequent catchment enlargement in the 20th century.

Geochemical analyses reveal that the turbidites of Walchensee have constant and elevated density and magnetic susceptibility values. These results were confirmed by high-resolution XRF analysis of terrestrial runoff indicators (Fe, K, Si, Al, Sr and Ti), which were also constant for these event layers. High Al and K values at the top of several event layers indicate a higher clay mineral content in the finest topmost layer, most likely transferred to deep lake areas by flood events. One thick deposit, a sequence of repeating coarse sandy layers in the lowest core section may be related to a seismic trigger mechanism. At the base of this megaturbidite, Ca values are very high while Fe, Al, K and Ti are low. It is unlikely, however, that this depositional event was formed during the devastating Lisbon earthquake of 1755 AD because the age model indicates a too young age. Furthermore, a major seismically-caused and basinwide event with multiple mass movements overlain by a megaturbidite with more than 1 m thickness, as seen on seismic data, was not reached by our short cores. Seismic data indicates that it occurs a few centimeters below the lowest core sediment section. This major event thus remains a candidate to be caused by the Lisbon earthquake, though the age model is not conclusive. The overlying event layer with a sandy base then may have been triggered by an earthquake occurring in the vicinity of Walchensee around 1794 AD.

Key words: Lisbon earthquake, lake sediments, Walchensee, Germany, limnogeological approach, tsunamis, natural hazard

P 13.7

The PASADO sediment record: paleoclimatic and paleoenvironmental changes in Southern Patagonia since the Late Pleistocene

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Laguna Potrok Aike is a maar lake located in the southernmost Argentinean Patagonia, in the province of Santa Cruz. Being one of the few permanent lakes in the area, it provides an exceptional and continuous sedimentary record. The sediment cores from Laguna Potrok Aike (Fig. 1), obtained in the framework of the ICDP-sponsored project PASADO (Potrok Aike Maar Lake Sediment Archive Drilling Program), were sampled for diatom analysis in order to reconstruct a continuous history of hydrological and climatic changes since the Late Pleistocene. Diatoms are widely used to characterize and often quantify the impact of past environmental changes in aquatic systems. We use variations in diatom concentration and in their dominant assemblages, combined with other proxies, to track these changes.

Diatom assemblages were analyzed on the composite core 5022-2CP with a multi-centennial time resolution. The total composite profile length of 106.09 mcd (meters composite depth) was reduced to 45.80 m cd-ec (event-corrected composite profile) of pelagic deposits once gaps, reworked sections, and tephra deposits were removed. This continuous deposit spans the last ca. 51.2 cal. ka BP. Previous diatomological analysis from the core catcher samples of core 5022-1D, allowed us to determine the dominant diatom assemblages in this lake and select the sections where higher temporal resolution was needed. Over 200 species, varieties and forms were identified in the sediment record, including numerous endemic species and others which can be new to science. Among these, a new species has been described: Cymbella gravida sp. nov. Recasens and Maidana. The quantitative analysis of the sediment record reveals diatom abundances reaching 1.5 billion valves per gram of dry sediment, with substantial fluctuations through time. Variations in the abundance and species distribution point toward lake level variations, changes in nutrient input or even periods of ice-cover in the lake. The top meters of the record reveal a shift in the phytoplakton composition, corresponding to the previously documented salinization of the water and the lake level drop, indicators of warming temperatures and lower moisture availability during the early and middle Holocene. The new results presented here on diatom diversity and distribution in the Glacial to Late Glacial sections of the record bring much needed information on the previously poorly known paleolimnology of this lake for that time period.

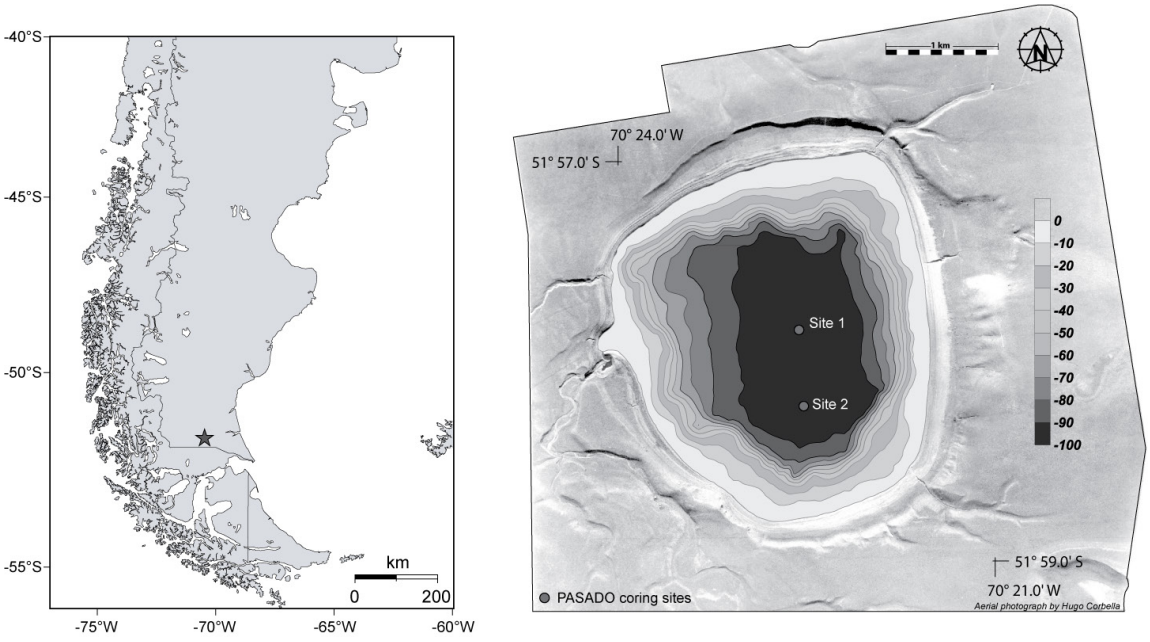

Figure 1. Map of Patagonia showing the location of Laguna Potrok Aike and bathymetric map of the lake with the location of the two drilling sites from where cores were retrieved.

P 13.8

New insights into the formation and burial of Fe/Mn accumulations in Lake Baikal sediments

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Lake Baikal is the deepest and oldest lake on Earth. Extraordinary features of the lake are manganese and iron enriched layers and crusts occurring at different depths within the sediment. They can be broadly subdivided into an upper accumulation at the O_2/Mn(II) redox boundary and one or more layers buried within the reducing part of the sediment. The processes leading to their formation and peculiar distribution within the sediment have remained subject of debate, in particular whether the burial of vast amounts of Mn and Fe-oxides results from a steady-state process or if it is the consequence of singular events, such as changes in sedimentation rate, bottom water oxygen concentrations, or the mass accumulation rate (MAR) of organic carbon (C_{org}), Mn or Fe. We retrieved short cores from the South basin, the North Basin, and Academician Ridge, determined sedimentation rates, contents of C_{org}, Mn and Fe, and estimated pore water fluxes from concentration profiles of O_2, NO_3^-, Mn(II), Fe(II), SO_4^{2-} and CH_4. A consistent picture emerged from the data showing that the upper Fe/Mn layer formed at the lower end of the oxygen penetration depth as a dynamic pattern, moving upwards with the growing sediment. Thereby, reductive dissolution of Mn(IV) occurred at the lower margin. Upward diffusing Mn(II) was oxidised with O_2 forming the upper boundary of the Fe/Mn accumulation. The buried Fe/Mn layers were immobilised within the sediment and underwent slow reductive dissolution mainly driven by the anaerobic oxidation of CH_4. The process leading to the detachment of the 'active' Fe/Mn layer from the top redox interface is not unambiguously clear. However, we suggest a cyclic pattern where the burial of a Fe/Mn layer is accompanied by the generation of a new enrichment at the O_2/Mn(II) redox boundary, which is subsequently nourished by the slowly dissolving old layer (see Figure 1).

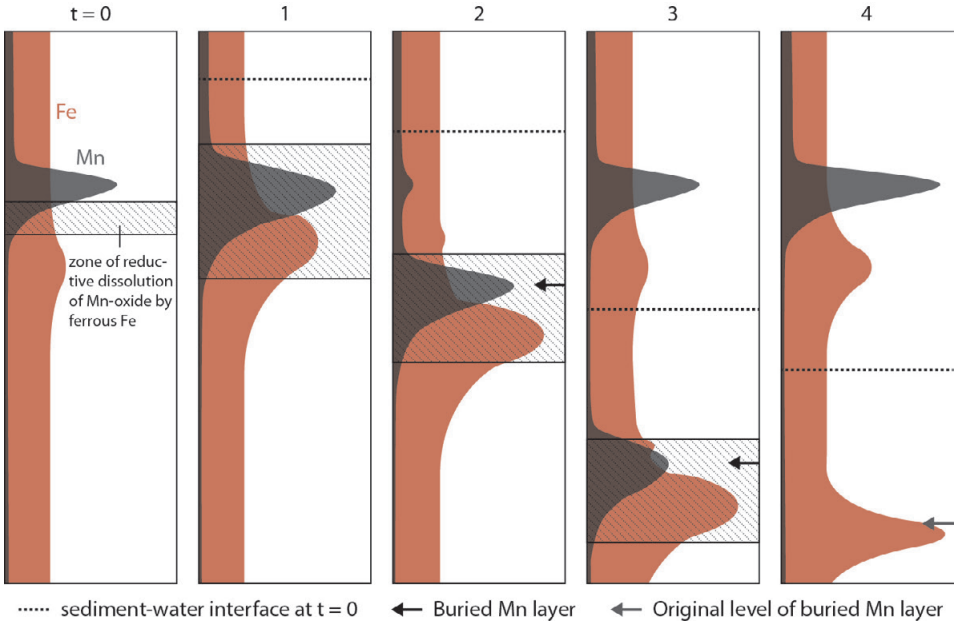

Figure 1. Proposed timeline for the burial and the generation of a new Mn/Fe accumulation in the sediments of Lake Baikal, subjected to a long term cycle. At t=0, Mn- and Fe-oxides have accumulated below the O_2 penetration depth, driven by the reductive dissolution of both metals and their oxidation once oxidising conditions are encountered. The shaded area represents the section where Mn-oxide can be reductively dissolved by Fe(II) and Fe-oxide precipitates. The next step (1) demonstrates the growth of the enrichment while Fe-oxides should accumulate at a faster pace. Through a process which has yet to be understood better (see section 5.1), the dissolution-precipitation dynamic of the Fe/Mn-oxides markedly slow down and the enriched layers get buried within the sediment with on-going sedimentation. Panel 2 shows how an offshoot forms anew underneath the O_2 penetration depth. While the buried enrichment is still dissolving, at a slower pace, Fe-oxide precipitates above the Mn-enriched layer while the more active, upper accumulation is growing further. In the last panel (4), the situation where no reactive Mn is present in the buried accumulation anymore is depicted.

P 13.9

Can lipids help to reconstruct changes in methane availability and methane fluxes in lakes?

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Methane is a major greenhouse gas and lakes are an important but poorly studied source of methane to the atmosphere. Lipids were used before to identify and quantify methane oxidizing bacteria (MOB) (1, 2), giving insight into methane oxidation and production. However, few studies are available that examine how closely the distribution and $\delta^{13}C$ of lipids are related to methane concentrations and fluxes in different lakes. In a multi-lake survey we tried to find a quantitative relationship between lipids, mainly fatty acids, and methane concentrations or fluxes.

Fatty acids (FA) were analyzed in surface sediment samples from eleven Swedish and four Swiss lakes. FA concentrations were examined using gas chromatography with flame ionization , gas chromatography-mass spectrometry (GC-MS) for identification and isotope-ratio mass spectrometry (IRMS) for compound specific $\delta^{13}C$ values. $\delta^{13}C$ analyses indicated that two groups of lipids, C16:1ω9 and C16:1ω11 were depleted in ^{13}C, suggesting that these compounds were at least partly produced by MOB. The relative abundance of C16:1ω9 was related to the methane flux measured at the lake surface and the methane concentration in the bottom water (Fig. 1). This suggests that higher methane content leads to an increased abundance of this fatty acid at least partly produced by MOB. Furthermore, we observe a relationship of the peak area of C16:1ω9 with the ^{13}C depletion of this fatty acid and with the $\delta^{13}C$ value of methane in the sediment.

Further investigations will have to be done to confirm the initial correlations. Ultimately we will include surface sediment samples from 29 lakes in Europe in which methane concentration, flux, and isotope data will be measured accompanied by basic limnological parameters. This will allow for determinations of factors responsible for differences in carbon isotopic composition of lipids within the lakes as well as between the numerous studied lake ecosystems.

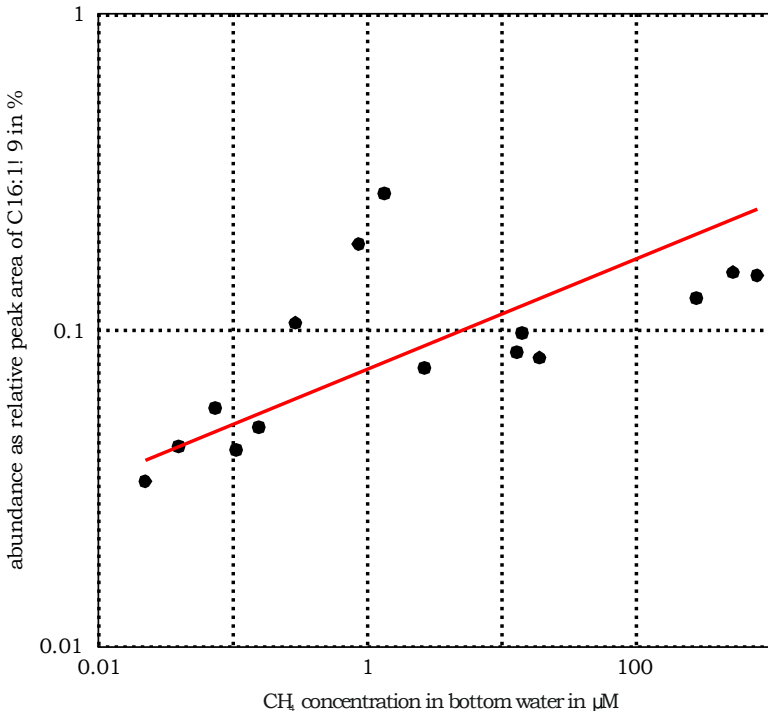

Figure 1: Relationship between the relative abundance of the FA C16:1ω9 and the methane (CH_4) concentrations at the bottom of the lakes.

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P 13.10

Exploring stable isotope composition of Cladocera and Bryozoa using flotsam from lakes

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Chitinous resting stages of certain aquatic invertebrates are easily collected as flotsam from the lake surface and their isotopic composition contains information about the feeding ecology of these organisms. Since the resting stages are well preserved in lake sediments, they can also give insights in changes in the relative importance of food sources over time, when material from sediment cores is analysed.

Here we present stable carbon and nitrogen isotope data of resting stages from water fleas (Cladocera) and moss animals (Bryozoa). The resting stages were collected as flotsam with a hand net from 20 lakes in Sweden, Finland, Germany, the Netherlands, and Switzerland. We analysed ephippia of *Ceriodaphnia, Daphnia*, and *Simocephalus* and statoblasts of *Cristatella mucedo, Lophopus crystallinus, Pectinatella magnifica*, and *Plumatella* to investigate how these taxa differ in their isotopic composition. Furthermore, we compared their isotopic composition to the physiochemical data collected from the lakes to detect which environmental parameters influence the $\delta^{13}C$ and $\delta^{15}N$ of the resting stages. To make the collected material comparable to the chitinous external structures of the resting stages preserved in lake sediments, we removed the easily degradable organic material by manually taking out the eggs from ephippia and statoblasts and treating them with 10% KOH for 2h at room temperature.

N content of Cladocera ephippia was on average 8.7% (mass based), which is significantly lower than the average 12.0% for Bryozoa statoblasts. The C content of ephippia and statoblasts were 47.7 and 46.7%, respectively, which was not significantly different. This could indicate that Cladocera produce resting stages with a lower protein:chitin ratio than Bryozoa.

$\delta^{15}N$ of Bryozoa statoblasts, especially that of *Cristatella mucedo* was higher than that of Cladocera ephippia in most lakes. Both invertebrate groups are filter feedersand the differences in $\delta^{15}N$ values between invertebrate taxa could reflect a preference for other sizes and species of phytoplankton. The higher $\delta^{15}N$ of Bryozoa could also indicate that they feed mostly on settling particles. These particles are likely to be affected by degradation (microbial remineralisation and excretion of ^{15}N-depleted inorganic nitrogen), resulting in ^{15}N-enriched organic matter (Goedkoop et al., 2006). The higher $\delta^{15}N$ values of bryozoan statoblasts, therefore, suggest that Bryozoa incorporate particles that are more microbially degraded compared with the particles ingested by Cladocera.

Interestingly, $\delta^{13}C$ of *Daphnia* ephippia was generally lower than that of other invertebrates, with values as low as -43.5‰, and significantly negatively correlated to profundal methane concentrations ($r^2 = 0.43$, $p = 0.01$). This was not observed for the other invertebrate taxa and suggests that *Daphnia* incorporates more ^{13}C-depleted methane-derived carbon in lakes with increasing amounts of hypolimnetic methane. These results agree with correlations found between $\delta^{13}C$ of Daphnia ephippia in lake surface sediments and diffusive methane fluxes measured in lakes in Sweden and Siberia (van Hardenbroek et al., in press).

Our results indicate that the $\delta^{13}C$ and $\delta^{15}N$ of their resting stages can be used to extract information about the feeding ecology of Cladocera and Bryozoa. This also suggests that this method can be applied to investigate changes in the diet of these invertebrates over long time scales using resting stages from sediment cores.

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P 13.11

Surface sediments characteristics survey in the Persian Gulf

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Persian Gulf is a semi-closed forearc basin in South of Iran. The length and width of this Gulf respectively are 900 and 300 km. maximum depth is 98 meter on Hormoz straight. The depth is asymmetric in Persian Gulf. North part of gulf is dipper than south part. For this reason sedimentary environment of north part of Gulf is clastic with some coral patch and south part is carbonate. In this research study area is north (Iranian part) of Gulf. 400 surface sediment samples were taken in systematic 15*15 km network. Granulometry, calcimetry and mineralogy (XRD) analysis have been done in Geological survey of Iran. For measuring coarse grains size (sand and granule) vibratory sieve Shaker and for measuring of silt and clay size, using Laser particle sizer was use. Determining percentage of calcite and dolomite was done by autocacimeter and mineralogy analysis was analyzed by Semens XRD diffraktometer.

Results show that the mean of sediments size are between 0.007 to 4.1 mm including clay, silt, sand and granule. Mineralogy of clay minerals shows that main clay minerals contain respectively Chlorite, Palygorskite, Illite, Kaolinite and Montmorillonite. The main non-opaque minerals contains Carbonates, Quartz, Feldspar and small amounts of Chert, Gypsum and The main heavy minerals contains Mica, Amphibole, Pyroxene, Topaz, Garnet, but Epidote, Aragonite, Zircon, Tourmaline and other heavy minerals are found in much smaller amounts. Maximum Carbonate minerals are 83.4 percent contain 74.94% calcite and 8.46% dolomite. Frequency and cumulative curves of grain size for each sample were drowned and Statistical parameters was calculated were then based on the amount of abundance of sediment particles in the range of sediment types,13 spectrum was seen. Statistic parameters of sediment such as standard deviation, kurtosis, skewness is calculated with sediment size program. Based on statistical calculations, sediments in the Iranian part of Persian Gulf has been detected fine-grain, these results prove the latter. So that over 50% of all samples classified are located within the mud confine. Although Sandy sediment particles, are allocated a third of all bed sediments but amplitude of sandy sediments are less than the mud.

Gravel size particles in the samples are all biological and shell fragments. Generally be said that in the Persian Gulf sediments are mainly fine-grain.

Key words: Persian Gulf, Sedimentology, Mineralogy, Sedimentary environments.

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