COMPOUND-SPECIFIC $\delta^{18}O$ ANALYSES OF MONOSACCHARIDES USING GC-PY-IRMS: A NOVEL TOOL IN PALAEOCLIMATE RESEARCH

Michael Zech. *Institute of Soil Science, University of Bayreuth, Germany*
E-mail address: michael_zech@gmx.de

For about 10 years, technical improvements allow the coupling of gas chromatographs with isotope ratio mass spectrometers via online pyrolysis reactors (GC-Py-IRMS). While compound-specific δD analyses e.g. of plant-derived n-alkanes for palaeoclimate studies were readily adopted by the scientific communities, there are only a few studies having applied compound-specific $\delta^{18}O$ analyses, so far. We see large potential for this method especially in palaeoclimate research, because it is well known that not only δD, but also $\delta^{18}O$ of precipitation and of certain chemical compounds of plant (e.g. cellulose) depend on climate parameters.
In order to overcome extraction, purification and hygroscopicity problems of so far applied cellulose methods based on TC/EA $\delta^{18}O$ analyses, we aim at developing a method for compound-specific $\delta^{18}O$ analyses of plant-derived monosaccharides like arabinose, xylose and glucose using GC-Py-IRMS. In our presentation,

- we discuss both technical problems and possible solutions
- and analytical challenges and possible solutions.
- We provide theoretical considerations and experimental results demonstrating that oxygen exchange reactions do neither occur in (hemi-)cellulose monosaccharides from natural archives nor during our analytical workup.
- Furthermore, we present results from an experimental field study demonstrating the absence of oxygen fractionation of (hemi-)cellulose monosaccharides during litter decomposition.
- And finally, we present first results from an application case study.

We conclude that in the near future our method may become a new and valuable tool in palaeoclimate research, which can be applied to a wide range of different climate archives such as tree-rings, lacustrine sediments and loess-palaeosol sequences.

RECONSTRUCTING QUATERNARY VEGETATION HISTORY IN THE CARPATHIAN BASIN, SE EUROPE, USING N-ALKANE BIOMARKERS AS MOLECULAR FOSSILS: PROBLEMS AND POSSIBLE SOLUTIONS, POTENTIAL AND LIMITATIONS

Michael Zech. *Institute of Soil Science, University of Bayreuth, Germany*
E-mail address: michael_zech@gmx.de

Over the recent years there has been increasing fossil charcoal and malacological evidence from loess-palaeosol sequences in the Carpathian (Pannonian) Basin that call into question the traditional paradigm of treeless full glacial palaeoenvironments. In order to contribute to this discussion we focus on plant-derived n-alkanes and evaluate their potential to serve as biomarkers for the reconstruction of vegetation history during the last glacial cycle. Recently published initial results show a strong degradation effect on the alkane pattern hindering the direct application of frequently used alkane ratios like nC31/nC27, which are in literature often used as vegetation proxies (grass vs. tree). In this paper we therefore introduce for the first time an end member model taking into account the different degree of organic matter (OM) degradation in soils/loess. The model is applied to the Crvenka loess-palaeosol sequence on the Balka Loess Plateau (Vojvodina, Serbia) at the confluence of the Danube and Tisa Rivers. The results show grass dominance during the whole last glacial cycle. Some few trees likely contributed to the vegetation cover during glacial periods and during the Holocene, but not during the last interglacial and the Marine Isotope Stage (MIS) 3 interstadial. The reconstructed vegetation history is in agreement with previous malacological and charcoal findings as well as with climate and biome modelling results.

EARLY LAST GLACIAL MAXIMUM IN THE KITSCHI-KURUMDU VALLEY, TIEN SHAN, BASED ON ^{10}BE SURFACE EXPOSURE DATING

Roland Zech. *ETH Zurich, Geological Institute, Switzerland*
E-mail address: godotz@gmx.de

Over the last few years, surface exposure dating has turned out to be extremely helpful for establishing new numeric glacial chronologies, particularly in arid high-mountain regions where radiocarbon dating is challenging due to the limited availability of organic material. Here we present 13 new ^{10}Be surface exposure ages from a south-facing Kitschi-Kurumdu Valley, in the At Bashi Range, Tien Shan. Three moraines could be dated to $\sim 14.5 \pm 1.5$ ka, 19 ± 2 and 48 ± 5 ka, respectively, while only morphological evidence documents at least one older, more extensive glacial advance. These results corroborate previous findings that glacial extents in Central Asia during Marine Isotope Stage (MIS) 2 were relatively limited due to very arid conditions. A detailed comparison with existing numeric glacial chronologies from the Tien Shan and Pamir reveals that (i) the local last glacial maximum (LGM) in many regions occurred during MIS 4, with circumstantial evidence for MIS 5 advances, and (ii) post-MIS 4 advances tend to cluster around 55, 48, 35, and 27 to 17 ka. Currently available chronologies are still very sparse, and more detailed stratigraphic and dating studies will be necessary to regionally disentangle the effects of lower temperatures, increased precipitation, and precipitation source (westerlies versus monsoon) for past glacial advances.

GLACIER AND CLIMATE RECONSTRUCTION IN THE LAS LEÑAS VALLEY (35°S), CENTRAL ARGENTINA

Jana Zech. *University of Bern, Switzerland*
E-mail address: jana.zech@gmail.com

We applied ^{10}Be surface exposure dating in the Las Leñas (35°S) Valley, Central Argentina, in order to reconstruct the timing of past glaciation and paleoclimate conditions. The most extensive glacial advance could be dated with one exposure age to 42.3 ka significantly predating the global Last Glacial Maximum (LGM, ~20 ka). The ice extent during the global LGM is documented by one exposure age of 19.2 ka from a remnant of a terminal moraine that did not reach the extent of the early LGM. Prominent lateral moraines further up valley could be dated with two boulders to 17.6 ka. Inner lateral moraines document a glacier readvance at 16.4 ka before final deglaciation. Glacier climate modelling indicate that the glacial advances were triggered by a massive temperature reduction of ~5.9-8°C and a substantial increase in annual mean precipitation of ~60-150% compared to today. These findings, although preliminary because of the limited data set, corroborate previous studies in the arid Central Andes (Valle Rucachoroi ~39°S, Cordon de Doña Rosa ~30°S, Sierra de Quilmes ~26°S), documenting a northward shift and enhanced precipitation of the Westerlies at ~40 ka.

INTEGRATION OF HOLOCENE GLACIER FRONT VARIATIONS INTO THE INTERNATIONAL MONITORING DATABASES

Michael Zemp. *World Glacier Monitoring Service, Switzerland*
E-mail address: michael.zemp@geo.uzh.ch

Glaciers are among the best natural proxies of climatic changes and, as such, a key variable within the international climate observing system. The worldwide monitoring of glaciers has been internationally coordinated for more than a century. Measurements of glacier mass balance are available for the past six decades, regular observations of glacier front variations since the late 19th c. Information on glacier fluctuations before the onset of regular measurements have to be reconstructed from moraines, historical evidence, and a wide range of dating methods. The majority of corresponding data is not available to the scientific community which challenges the reproducibility and direct comparison of the results. Here, we present a first approach towards the standardization of reconstructed Holocene glacier front variations as well as the integration of the data series into the database of the World Glacier Monitoring Service (www.wgms.ch), within the Global Terrestrial Network for Glaciers. The concept for the integration of reconstructed front variations into the WGMS database was jointly elaborated and tested by experts of both fields (natural and historical sciences), based on reconstruction series of 15 glaciers in Europe (western/central Alps and southern Norway) and 9 in the southern Andes. The reconstructed front variation series extend the direct measurements of the 20th c. by two centuries in Norway and by four in the Alps and in South America. The storage of the records within the international glacier databases guarantees the long-term availability of the

data series and increases the visibility of the scientific research which – in historical glaciology – is often the work of a lifetime. The standardized collection of reconstructed front variations allows a direct comparison between different glaciers. It is a first step towards a worldwide compilation and free dissemination of Holocene glacier fluctuation series within the internationally coordinated glacier monitoring.

SIMULATION OF THE HYDRAULIC CHARACTERISTICS OF DILUVIAL FLOODS FROM THE CHUYA AND KURAY GLACIAL-DAMMED LAKES IN THE LATE POSTGLACIAL, ALTAI, RUSSIA

Valery Zemtsov. *Tomsk State University, Russian Federation*
E-mail address: vz@mail.tomsknet.ru

The basic limitation of the previous models was that they simulated only steady water movement, irrespective of was it subcritical, supercritical or mixed. It was certainly not consistent with physical nature of floods as basically unsteady flows. In the latest publications (Rudoy, Zemtsov, 2008, 2010; Carling et al., 2009), another approach has been applied. It took into account unsteady character of water movement after ice dam breaks.
By now, we have collected sufficient experience in application of the digital modeling system HEC-RAS 4.0 for the estimation of hydraulic parameters of unsteady flows generated by breaks of dams of different origins. And it has become possible to simulate different scenarios of dam destruction including both its "instant" collapse, and gradual and often not complete destruction inspired by water flows in intraglacial and subglacial channels and channel networks.
For imitation of diluvial floods generated from the Chuya-Kuray lake system we, for the very first time, have developed the model of unsteady water flow in a framework of the HEC-RAS 4.0 program. As a topographic basis we used a digital elevation model of the Chuya and Kuray depressions and the Chuya River valley up to its confluence with the Katun River valley at the time of about 14-15 thousand years ago in a NASA SRTM-matrixes format.
As a result of modeling, such characteristics of outburst megafloods as water levels, discharges, velocities, energy gradients, and water profiles have been calculated in dynamics. It allowed clarifying the values, earlier received through application of different methods. Moreover, our studies expand understanding the processes of outburst floods forming and movement in a mountain river valley. The peak discharge values of diluvial floods all over the river reach studied exceeded 106 m^3s^{-1}. The peak discharges estimation was not in a scope of the work presented, but they probably could be some bigger (Baker et al., 1993).

THE ROLE OF THE TERRESTRIAL BIOSPHERE IN THE GLACIAL CO_2 PROBLEM AND IMPLILCATIONS FOR FUTURE CARBON-CLIMATE FEEDBACK

Ning Zeng. *University of Maryland, United States*
E-mail address: zeng@atmos.umd.edu

Three decades after the discovery of the lower glacial CO_2 values from ice cores, the mystery remains of the glacial-interglacial CO_2 variations as well as of the associated climate cycles. It is suggested that the terrestrial biosphere may have played a very different role in the glacial CO_2 problem than traditionally assumed, namely, it contains more carbon in the glacial periods than during interglacial maxima. I will discuss the merits and challenges of this hypothesis, emphasizing three aspects: temperature dependence of soil decomposition, CO_2 fertilization, and the fate of glacial burial carbon, all with implication for the future change in the terrestrial carbon storage. I will show results from a model simulation over two glacial-interglacial cycles using a synchronously coupled atmosphere-land-ocean carbon model forced by reconstructed climate change. I found a 547 Gt terrestrial carbon release from glacial maximum to interglacial, resulting in a 60 Gt (about 30 ppmv) increase in the atmospheric CO_2, with the remainder absorbed by the ocean in a scenario in which ocean acts as a passive buffer. This is in contrast to previous estimates of a land uptake at deglaciation. This carbon source originates from glacial burial, continental shelf and other land areas in response to changes in ice cover, sea level, and climate. The input of light isotope enriched terrestrial carbon causes atmospheric $\delta^{13}C$ to drop by about 0.3 permil at deglaciation, followed by rapid rise towards a high interglacial value in response to oceanic warming and regrowth on land. Together with other ocean based mechanisms such as change in ocean temperature, the glacial burial hypothesis may offer a full explanation of the observed 80-100 ppmv atmospheric CO_2 change.

RECONSTRUCTING PAST FIRE REGIMES THROUGH LEVOGLUCOSAN DETERMINATION IN THE NORTH EEMIAN (NEEM) GREENLAND ICE CORE

Piero Zennaro. *Institute for the Dynamics of Environmental Proces, Italy*
E-mail address: piero@unive.it

Polar ice cores are precious environmental archives that document the major changes in past atmospheric composition in terms of ionic species, dust, trace elements and organic compounds from the Late Pleistocene to the present. Ice core analyses provide advantages in relation to other paleoclimatic proxies. The chemical properties of compounds remain unchanged and stored in the Artic ice matrix. The excellent time resolution of NEEM ice core, due to high accumulation rates, results in precise dating. Identifying past biomass burning requires the evaluation of specific molecular markers. Levoglucosan (1,6-anhydro-α-D-glucopyranose) is an organic compound which is only released during the pyrolysis of cellulose and is thus a unique marker of cellulose combustion emission. This marker represents the main combustion product present in the fine emission fraction from wood burning and is delivered in amounts between 40 and 1200 mg from 1 kg of biomass fuels. Due to high atmospheric concentrations, levoglucosan can be detected even at regional to global distances from emission sources. Ice core levoglucosan analysis allows the estimation of past biomass combustion including forest fires and agricultural waste burning. Here, we present the levoglucosan flux in samples covering the last 120 kyr from the NEEM ice core. We analize and synthesize organic biomarker data relative to the present and previous interglacial period. Samples were collected within the framework of the European project Past4Future (www.past4future.eu). Levoglucosan was directly determined through High-Performance Liquid Chromatography at the picogram per milliliter level and quantified using a triple quadrupole mass analyzer as a detector. The collected data are useful to determine the possible impact of anthropogenic combustion-derived aerosols on the climate system due to the advent of the first agricultural settlements.

PALEOMONSOON ROUTE RECONSTRUCTION ALONG A W–E TRANSECT IN THE CHINESE LOESS PLATEAU USING THE ANISOTROPY OF MAGNETIC SUSCEPTIBILITY: SUMMER MONSOON MODEL

Rui Zhang. *Northwest University, China*
E-mail address: ruizhanggeo@gmail.com

The anisotropy of magnetic susceptibility (AMS) was investigated in three Chinese Loess Plateau sedimentary sections along a W–E transect (400 km). The loess-paleosol sequences in our study represent the most recent 130 kyr interval. The measured AMS was compared to expected theoretically derived magnetic fabrics occurring in strong and weak current airflow conditions. The major and minor AMS ellipsoid axis orientations were used to evaluate the paleowind direction along the transect. Previously published models assumed that cold and dry winter monsoons bringing dust from northwestern desert areas were responsible for the magnetic fabric formation of loess sequences. In our new interpretation, the stronger summer monsoons from the southeast played the major role in magnetic fabric orientation in the studied west and central parts of the Chinese Loess Plateau. Although the material was brought to the area by the winter monsoon, the AMS was generated during the rainy summer monsoon when the sedimentary particles including magnetite were rearranged, settled, and fixed. We reconstruct the summer paleomonsoon routes for the last 130 kyr. These winds prevail from SE to NW but appear to be affected by regional topographic factors. In the western section, the corridor between the north and south Liupan Mountains disturbed the summer monsoon route, shifting it from SE to SEE.

ORBITAL AND MILLENNIAL SCALE PERIODICITY OF EASTERN ASIAN MONSOON VARIATION DURING THE PAST 110KA RECORDED BY XIASHU LOESS, EASTERN CHINA

Maoheng Zhang. *Nanjing Normal University, China*
E-mail address: zhangmaoheng@njnu.edu.cn