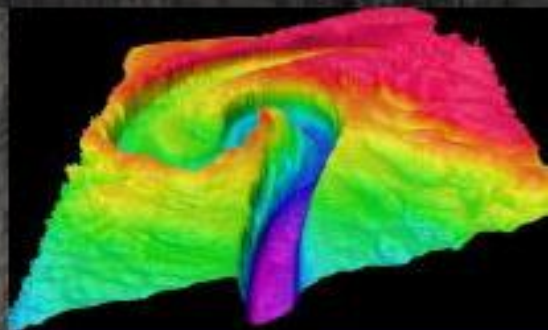




# 5<sup>th</sup> International Limnogeological Congress

August 31<sup>st</sup> – September 3<sup>rd</sup> 2011  
Konstanz, Germany



## Programme and abstracts volume



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Martin Wessels (Institut für Seenforschung, Germany)



## Wednesday August 31<sup>st</sup> 2011

### 08:00 Welcome

### 08:15 Plenary talk

History of sedimentation in Bear Lake, Utah and Idaho, USA, over the last 240,000 years: links to Pacific climate

Walter Dean

### 09:15 Poster Session and Coffee Break

#### Session 1 Paleoenvironmental records from tropical lakes of the Phanerozoic

Tom Johnson & Jim Russell

S1-P01 Late Quaternary stratigraphy and facies model of Chalco Lake, central Mexico.

Beatriz Ortega, Dimitri Herrera, Margarita Caballero, Socorro Lozano, Alejandro Rodriguez

S1-P02 Hydrology and composition of surface sediments in Lake Lonar, central India

Philip Menzel, Nathani Basavaiah, Birgit Gaye, Martin Wiesner, Sushma Prasad, Ambili Anoop, Kannan Deenadayalan, Achim Brauer

S1-P03 The late Holocene (ca. 3000 yr BP) record from lake Santa Maria del Oro, western Mexico: evidence of climatic variability and human impact

Margarita Caballero, Susana Sosa, Socorro Lozano, Beatriz Ortega, Alejandro Rodriguez

S1-P04 Paleoenvironmental interpretation of elemental geochemical proxies of the borehole Jp 585: lacustrine offshore clays of Cypris Formation, Sokolov Basin, Czech Republic

Alice Erlebachová

S1-P05 Characterization of Late Pleistocene and Early Holocene humid phases in SW Saudi Arabia using ostracodes

Isa Behrendt, Anna Pint, Peter Frenzel, Dominik Fleitmann, Albert Matter, Frank Preusser, Thomas Rosenberg, Antje Schwalb

#### Session 2 Limnology and Dynamics of Volcanic Lakes

Dmitri Rouwet & Martin Schmid

S2-P01 Brief Description of Algal Flora Succession in Karymskoye Lake over the Period 1996-2010

Elena Lupikina

S2-P02 Spatial distribution of degassing CO<sub>2</sub> vents inside the Laacher See and bathymetric model of the Laacher See basin

Andreas Goepel, Martin Lonschinski, Nina Kukowski, Georg Büchel

S2-P03 Acquisition of physico-chemical parameters at Monticchio lakes

Marco Nicolosi, Antonio Caracausi, Rocco Favara, Mario Nuccio

S2-P04 Physical-chemical and ecological features of the Paterno sinkhole (Rieti, Lazio, Central Italy): a possible seasonal meromictic lake

Jacopo Cabassi, Franco Tassi, Orlando Vaselli, Matteo Nocentini, Dmitri Rouwet, Massimiliano Marcelli, Marco Quartararo, Roberto Palozzi

S2-P05 Calculating (potential) density of limnic waters of unusual chemical composition

Bertram Boehrer

S2-P06 Past activity of Laguna Caliente crater lake (Poás Volcano, Costa Rica) based on paleolacustrine deposits: a preliminary study

Gino González, Dmitri Rouwet, Gino González, Raúl Mora-Amador, Carlos Ramírez

S2-P07 The disappearance of Irazú crater lake ~ increased volcanic activity of neighboring Turrialba (Costa Rica)?

Dmitri Rouwet, Raúl Mora-Amador, Carlos Ramírez, Gino González

S2-P08 A generalized box model for active crater lakes: a review of mass, chemical and isotope budget analysis

Dmitri Rouwet, Franco Tassi

S2-P09 Carbon dioxide emission from Furnas, Fogo and Sete Cidades volcanic lakes, São Miguel Island, Azores

Gladys Melián, Eleazar Padrón, Zilda França, Victor H. Forjaz, Pedro A. Hernández, Nemesio M. Pérez, Hirochika Sumino

## 10:15 Session 1 Paleoenvironmental records from tropical lakes of the Phanerozoic

Tom Johnson & Jim Russell

**Audimax**

10:15 Late Quaternary Climate of the Indo-Pacific Warm Pool from Large Indonesian Lakes

James Russell, Satria Bijaksana, John King, Bronwen Konecky, Anders Noren, Gerald Tamuntuan, Hendrik Vogel, Nigel Watrus, Satrio Wicaksono

10:35 A 500,000-year paleoclimate record from Lake Malawi, East Africa

Margaret Blome, Andrew Cohen, Matthew Lopez

10:55 Semiprecessional to Precessional Cyclicity in Late Triassic Great Lakes of Central Pangea

Jessica Whiteside, Danielle Grogan, Paul Olsen, Dennis Kent

11:15 TEXing While Driving in Lake Malawi: Are We Staying on the Road?

Thomas Johnson, April Abbott, Josef Werne

11:35 Late holocene lacustrine sedimentation of the Vellayani Lake, Kerala, India

M P Veena, Hema Achyuthan

11:55 Variation in old-carbon age offset and sediment accumulation rates inferred from a high-resolution <sup>14</sup>C chronology for a 25-kyr lake-sediment record from East Africa

Dirk Verschuren, Maarten Blaauw, Bas van Geel, Birgit Plessen, Christian Wolff, Hans van der Plicht

**Session 2 Limnology and Dynamics of Volcanic Lakes (1)**

Dmitri Rouwet & Martin Schmid

**A 701**

10:15 Deep water stratification in Japan's very deep caldera lakes

Bertram Boehrer, Fukuyama Ryuji, Chikita Kazuhisa, Kikukawa Hiroyuki

10:35 A comparative study of six tropical, maar lakes in Eastern Mexico: trophic status, water chemistry and diatom assemblages

Margarita Caballero, Gabriela Vázquez

10:55 The unusual physics of Lake Kivu and its importance for biogeochemical processes and methane exploitation

Martin Schmid, Natacha Pasche, KellyAnn Ross, Alfred Wüest

11:15 The unique geomorphology, geochemistry and archaeal composition of the subaquatic springs that sustain Lake Kivu's stratification

Kelly Ann Ross, Natacha Pasche, Susma Bhattarai, Francisco Vazquez, Helmut Buergermann, Marc De Batist, Flavio S. Anselmetti, Martin Schmid, Alfred Wüest

11:35 Observed anomalous CO<sub>2</sub> emission changes at Taal crater lake, Philippines: a geochemical evidence for a recent volcanic unrest?

Pedro Hernandez, Maricar Arpa, German Padilla, Paolo Reniva, Ericson Bariso, Gladys Melian, Jose Barrancos, David Calvo, Dacil Nolasco, Renato Garduque, Celestino Saquillon, Eleazar Padron, Hirochika Sumino, Nemesio Perez, Renato Solidum

11:55 Chemical and isotopic features of dissolved gases in Albano, Averno and Monticchio volcanic lakes (central-southern Italy): new tools for NyoS-type lake monitoring

Jacopo Cabassi, Franco Tassi, Orlando Vaselli, Jens Fiebig, Matteo Nocentini, Francesco Capeccchiacci, Dmitri Rouwet

**12:15 Lunch**

**13:30 Plenary talk**

Deciphering sediment records from arctic and alpine lakes: the importance of understanding the role of catchment and in-lake processes

N. John Anderson

**14:30 Session 3 Alpine and polar palaeorecords of natural and anthropogenic environmental change (including The sedimentology of high latitude and high altitude lake systems) (1)**

Karin A. Koinig, Jordi Catalan, Jean-Nicolas Haas & Christian Kamenik

**Audimax**

14:30 Climate, nutrients, water chemistry and volcanic eruptions – multiple stressors shape diatom communities in subarctic and alpine regions

Christian Bigler, Laura Cunningham, Anna K. Dadal, Veronika Gälman, Karlyn S. Westover

14:50 Combining aquatic chemistry basics and diatom-based transfer functions: the reconstruction of CO<sub>2</sub> saturation in an alpine lake throughout the Holocene

Jordi Catalan, Sergi Pla-Rabes, Joan Garcia, Lluís Camarero

15:10 Reconstructing seasonal climate signals using chrysophyte cysts

Sergi Pla-Rabes, Jordi Catalan



15:30 High-resolution climate and environmental reconstruction from the last 15.000 years reflected in XRF core scan results on Swiss lake sediments

Adrian Gilli, [Ulrike van Raden](#)

#### **Session 4 General Limnogeology (1)**

Martin Wessels

**A 701**

14:30 Earthquake-related microdeformations of the Lake Van sediments

[Mona Stockhecke](#), Flavio S. Anselmetti, Michael Sturm, Deniz Cukur, Sebastian Krastel

14:50 Geological characteristics of paleolimnological complexes formation in the Ural Mountains

[Andrey Rasskazov](#), Ekaterina Vasilieva, Eugene Gorbatov, Dmitry Bachmanov

15:10 Lake level fluctuations and sedimentological changes during the last ~50 kyrs at the ICDP-site Laguna Potrok Aike, Argentina

[Bernd Zolitschka](#), Christian Ohlendorf, Catalina Gebhardt, Annette Hahn, Pierre Kliem, Christoph Mayr, Stefan Wastegard, PASADO Science Team

**15:45 Pause**

#### **16:00 Session 3 Alpine and polar palaeorecords of natural and anthropogenic environmental change (including The sedimentology of high latitude and high altitude lake systems) (2)**

Karin A. Koinig, Jordi Catalan, Jean-Nicolas Haas & Christian Kamenik

**Audimax**

16:00 Holocene development of a high alpine lake controlled by climate, catchment processes, and seasonality shifts in insolation

[Karin Koinig](#), Elena Ilyashuk, Ruth Drescher-Schneider, Ann Hirt, Andrea Lami, Richard Tessadri, Roland Psenner

16:20 Neolithic lake pollution of Lake Nussbaumersee (Thurgovia, Switzerland) as evidenced by Non-Pollen Palynomorphs

[Jean Nicolas Haas](#), Philippe Hadorn, Albin Hasenfratz, Martina Hillbrand, Bas van Geel

16:40 Past and recent Sedimentation in Lake Baikal as influenced by tectonic activities

[Michael Sturm](#), Elena G. Vologina

17:00 Sediment focusing and wind driven bottom currents in the Finnish lacustrine basins

[Jari Mäkinen](#)

17:20 Holocene erosion patterns in the high altitude Lake Anterne (NW French Alps): a witness of environmental changes, climatic variability and human activities

[Charline Giguët-Covex](#), Fabien Arnaud, Jérôme Poulénard, Jean-Robert Disnar, Pierre Francus, Fernand David, Dirk Enters, Pierre-Jérôme Rey, Emmanuel Malet, Claire Delhon

#### **Session 2 Limnology and Dynamics of Volcanic Lakes (2)**

Dmitri Rouwet & Martin Schmid

**A 701**

16:00 Water structure and circulation dynamics of two maar lakes (Mt Vulture, Italy): geochemical constraints.

Rocco Favara, Mario Nuccio, Marco Nicolosi, [Antonio Caracausi](#), Fausto Grassa, Michele Paternoster

- 16:20 Mantle-derived fluid injection into maar Monticchio lakes, Mt. Vulture volcano (Italy): limnic versus volcanic eruptions?  
Antonio Caracausi, [Mario Nuccio](#)
- 16:40 Geochemical Surveys on Specchio di Venere Lake, Pantelleria Island, South Italy.  
[Giovannella Pecoraino](#), Lorenzo Brusca, Walter D'Alessandro, Manfredi Longo
- 17:00 Fluid circulation at Laguna Caliente (Poás Volcano, Costa Rica) during the 2006-2011 phreatic eruptive cycle: how and how much?  
[Dmitri Rouwet](#), Raúl A. Mora-Amador, Carlos J. Ramírez-Umaña, Gino González
- 17:20 Multi-proxy evidence for late Holocene environmental change at Big Soda Lake, Nevada, Western United States  
Liam Reidy, [Michael R. Rosen](#), Roger Byrne, Lynn Ingram, Scott Starratt, Elmira Wan, David B. Wahl, Marith Reheis
- 17:40 Noble gases in the sediment pore water as proxies for physical transport processes and past environmental conditions in Lake Van?  
Yama Tomonaga, [Matthias S. Brennwald](#), Rolf Kipfer

**18:00 Poster Session and IAL Board Meeting (D430/D431)**

**Session 3 Alpine and polar palaeorecords of natural and anthropogenic environmental change (including The sedimentology of high latitude and high altitude lake systems)**

Karin A. Koinig, Jordi Catalan, Jean-Nicolas Haas & Christian Kamenik

- S3-P01 11 ka of lake dynamics at high latitudes: Evidence for Early Holocene warming in the western Canadian Arctic (Herschel Island)

[Josefine Lenz](#), Michael Fritz, Sebastian Wetterich, Hugues Lantuit, Lutz Schirrmeister, Peter Frenzel

- S3-P02 Response of a subarctic lake system to climate and agriculture during the last two millennia: paleolimnological investigations at Igaliku, South Greenland.

[Charly Massa](#), Vincent Bichet, Bianca Perren, Émilie Gauthier, Olivier Mathieu, Fabrice Monna, Hervé Richard, Christophe Petit

- S3-P03 Variations on Magnetic Parameters During the Last 15500 cal. BP on Sediments from Laguna Potrok Aike (51°57'S, 70°24'W, Argentina)

[María Alicia Irurzun](#), Claudia Gogorza, Ana María Sinito, Daniel Aguilar, Christian Ohlendorf, Bernd Zolitschka

- S3-P04 Diatom-based reconstruction of Late Glacial and Early Holocene lacustrine environment of Burg lake (Pyrenees)

[Carlos A. Rivera Rondón](#), Jordi Catalan

- S3-P05 Microsedimentological investigation of glacial and postglacial sediments from Pingualuit Crater Lake (Ungava, Canada)

[Hervé Guyard](#), Guillaume St-Onge, Pierre Francus, Reinhard Pienitz, Sonja Hausmann

- S3-P06 Siberian 2100 years-long climate chronology based on varved sediments of Shira Lake

[Ivan Kalugin](#), Maria Seliverstova, Andrey Darin, Gennady Tretyakov, Denis Rogozin

S3-P07 Paleoenvironmental record from two high altitude tropical lakes in central Mexico

Estela Cuna, [Margarita Caballero](#), Socorro Lozano, Carolina Ruiz-Fernandez

S3-P08 Magnetic evolution of lake Soppensee

[Jessica Kind](#), Ann Hirt, Ulrike van Raden

S3-P09 Was Medieval Warm Period as warm as today? – climate changes of the last millennium recorded in the Tatra lakes (Carpathians) with additional data from cave ice

[Michał Gąsiorowski](#), Elwira Sienkiewicz, Helena Hercman, Michał Gradziński, Ditta Kicińska

S3-P10 How does the elemental composition of Swiss lake sediments reflect past climate conditions?

[Ulrike van Raden](#), Adrian Gilli, Jessica Kind

S3-P11 Quaternary grain-size distributions of Lake El'gygytgyn, NE Siberia: Statistic analysis and climate dependency

[Alexander Francke](#), Wennrich Volker, Kukkonen Maaret, Martin Melles, Julie Brigham-Grette

**Session 4 General Limnogeology**

Bernd Zolitschka, Martin Wessels, Sebastian Wagner

S4-P01 The role of NAO in Western Europe climate variability during the Late Glacial and Holocene based on Iberian and Azores Island lake cores and climate instrumental data.

[Santiago Giralt](#), Roberto Bao, Manola Brunet, Teresa Buchaca, Vitor Gonçalves, Ignacio Granados, Armand Hernández, Olga Margalef, Pilar Mata, Sergi Pla, Juan José Pueyo, Pedro Raposeiro, Valentí Rull, Alberto Sáez, Ángel Salazar, Javier Sigró, Manuel Toro, Ricardo Trigo, Blas Lorenzo Valero

S4-P02 Spatial and Temporal Variation of Diatoms in the Lower Mountain Fork, Oklahoma

[Nina Desianti](#)

S4-P03 Age-depth modelling based on the multiple dating approach: a case study from Lake Szurpiły, Northeastern Poland

[Małgorzata Kinder](#), Wojciech Tylmann, Natalia Piotrowska, Grzegorz Poreba, Dirk Enters, Christian Ohlendorf, Bernd Zolitschka

S4-P04 Rhone glacier retreat in western Lake Geneva happened during Oldest Dryas with three stages.

[Stephanie Girardclos](#), Anne-Marie Rachoud-Schneider, Julien Fiore, Nicolas Brutsch

S4-P05 Microbialite bioherms, barrier bars and sand tufa in the Wilkins Peak member of the Eocene Green River Formation: Wyoming

[Varner Leggitt](#), Roberto Biaggi

S4-P06 Multidisciplinary palaeolimnological investigations on Late Glacial river-lake-systems – a case study from Northern Germany

Falko Turner, [Anja Schwarz](#), Finn Viehberg, Stephan Veil, Antje Schwalb

S4-P07 Comparison of reflectance spectroscopy methods in visible and visible to near infrared (VNIR) range for paleoclimatic reconstruction of lacustrine offshore clays: Miocene Cypris Formation, Sokolov Basin, Eger Graben, Czech Republic

Karel Martínek, Ondrej Bábek, Jan Hanuš, David Heslop

S4-P08 Biogeochemistry of Lubomirskiidae sponges in Southern Baikal

Natalia Kulikova

**19:00 Evening Talk**

Progress in Global Lake Drilling (GLAD) holds potential for Paleolimnological research

Walter Dean

**Thursday September 1<sup>st</sup> 2011**

**08:15 Plenary talk**

Oxygen and carbon isotopes in lacustrine diatoms: Indicators of regional paleoclimate

Aldo Shemesh

**09:15 Poster Session and Coffee Break**

**Session 5 Isotopes in Biogenic Silica: lake sediment archives (including Stable isotopes of lacustrine organic matter as proxies for nutrient cycling, microbial processes and environmental change)**

Philip Barker, Melanie Leng, Christoph Mayr, Andreas Lücke & Robert Moschen

S5-P01 Critically testing the role of  $\delta^{30}\text{Si}_{\text{diatom}}$  as a novel productivity signal and  $\delta^{18}\text{O}_{\text{diatom}}$  as an indicator of climate variability in temperate lakes: project overview

Andrea Snelling, David Ryves, Melanie Leng, Jonathan Tyler, Philip Barker, Sarah Warrener, Hilary Sloane, Matthew Horstwood

S5-P02 Climate calibration of diatom  $\delta^{18}\text{O}$  records from the varved sediments of Nar Gölü, Central Turkey

Jonathan Dean, Matthew Jones, Melanie Leng, Neil Roberts, Sarah Metcalfe

S5-P03 Geochemical signatures (TOC, TN,  $\delta^{13}\text{C}_{\text{org}}$ ) of glacial Lake Sanabria sedimentary sequence (NW Spain)

Margarita Jambrina, Clemente Recio, Blas Valero-Garcés, Mayte Rico, Ana Moreno, Jose Carlos Vega

S5-P04 Absence of a singular event around 8.2 ka cal. BP in the multi-proxy record of Sacrower See, NE-Germany

Dirk Enters, Thomas Hübener, Susanne Jahns, Eileen Kubitzke, Andreas Lücke, Bernd Zolitschka

S5-P05 Oxygen isotopes from biogenic silica – a comparative study between eight laboratories

Bernhard Chaplign, [Melanie Leng](#), Elizabeth Webb, Anne Alexandre, Justin Dodd, Akira Ijiri, Andreas Lücke, Aldo Shemesh, Andrea Abelmann, Ulrike Herzsuh, Fred Longstaffe, Hanno Meyer, Robert Moschen, Yusuke Okazaki, Nicholas Rees, Zacharias Sharp, Hilary Sloane, Corinne Sonzogni, George Swann, Florence Sylvestre, Jonathan Tyler, Ruth Yam

**S5-P06 An oxygen-isotope record of Holocene variability in the Aleutian Low from Adak, SW Alaska**

Hannah Bailey, [Andrew Henderson](#), Darrell Kaufman, Melanie Leng

**S5-P07 A spineless approach: Tracing past nitrogen pollution in a lake ecosystem using stable nitrogen isotope analysis of chitinous invertebrate remains**

Jos Schilder, Maarten van Hardenbroek, André F. Lotter, [Oliver Heiri](#)

**S5-P08 Quantification of biogenic silica concentration in lake sediments by means of Fourier transform infrared spectroscopy (FTIRS)**

Carsten Meyer-Jacob, Peter Rosén, [Hendrik Vogel](#), Per Persson, Martin Melles, El'gygytgyn Scientific Party

**S5-P09 Decadal scale hydrological and primary organic production changes during the 8.2 ka event: A multi proxy study from Lake Sarup, Denmark**

[Jesper Olsen](#), Bent V Odgaard, Andreas Lücke, Holger Wissel

**S5-P10 Holocene paleoenvironmental changes reflected in organic isotope records from Lake Pupuke (New Zealand)**

Alexander M. Heyng, [Christoph Mayr](#), Andreas Lücke, Holger Wissel, Bernd Striewski

**S5-P11 Relevance of sediment and sedimentation processes in pre-dams of drinking water reservoirs: a project outline**

[Malgorzata Cebula](#), Karsten Rinke, Kurt Friese

**Session 6 Across the Third Pole (Tibetan Plateau)**

Andy Henderson & Gerhard Daut

**S6-P01 Quantitative lake level reconstruction of Lake Issyk-Kul for the last ca. 4000 cal. Years BP: climatic and environmental implications**

[Santiago Giral](#), Alberto Sáez, Núria Cañellas-Boltà, Juan José Pueyo, Armand Hernández, Olga Margalef, Miriam Gómez-Paccard, Juan Cruz Larrasoaña

**S6-P02 Rapid hydrological changes during the late Holocene revealed by stable isotope records of lacustrine carbonates from Lake Sugan, northwest of China**

[Aifeng Zhou](#)

**S6-P03 Linking Indian Ocean Summer Monsoon upwelling events at the Arabian Sea with sedimentary responses of Lake Nam Co, a high altitude lake on the Tibetan Plateau, China.**

[Stefan Doberschütz](#), Gerhard Daut, Torsten Haberzettl, Thomas Kasper, Roland Mäusbacher, Junbo Wang, Volker Wennrich, Liping Zhu

**S6-P04 Trace element and stable isotope analysis of ostracode shells from Southern Tibetan Plateau lakes as hydrochemical indicators**

[Nicole Börner](#), Bart De Baere, Qichao Yang, Klaus Peter Jochum, Antje Schwalb

S6-P05 From the lakeshores of Tibet: shoreline reconstructions of monsoon climate on the Tibetan Plateau

Adam Hudson, Jay Quade

S6-P06 In-situ trace element analysis of ostracod shells of ages up to 17,600 cal a BP from Lake Nam Co, Tibet

Qichao Yang, Klaus Peter Jochum, Brigitte Stoll, Ulrike Weis, Antje Schwalb, Nicole Börner, Peter Frenzel, Denis Scholz, Meinrat Andreae

S6-P07 LGM freshwater event at Nam Co indicates onset of Asian Monsoon

Roman Witt, Ines Muegler, Franziska Guenther, Gerd Gleixner, Roland Maeusbacher, Baiqing Xu, Tandong Yao

S6-P08 Lake system changes of Nam Co (central Tibetan Plateau) during the last 4000 years – multi-proxy results from a sediment core series

Torsten Haberzettl, Thomas Kasper, Peter Frenzel, Anja Schwarz, Stefan Doberschütz, Stephanie Meschner, Antje Schwalb, Marleen Stuhr, Junbo Wang, Birgit Plessen, Gerhard Daut

S6-P09 A 23-kyr stable isotope record from Lake Nam Co, Southern Tibet

Marleen Stuhr, Birgit Plessen, Peter Frenzel, Antje Schwalb

**10:15 Session 5 Isotopes in Biogenic Silica: lake sediment archives (including Stable isotopes of lacustrine organic matter as proxies for nutrient cycling, microbial processes and environmental change)**

Philip Barker, Melanie Leng, Christoph Mayr, Andreas Lücke & Robert Moschen

**Audimax**

10:15 Stable carbon isotopes of invertebrate remains reveal past changes in lake carbon cycling

Maarten van Hardenbroek, Andre Lotter, David Bastviken, Oliver Heiri

10:35 Oxygen isotope fractionation during the life and death of diatoms

Jonathan Tyler, Melanie Leng, Hilary Sloane, Eileen Cox, Rosalind Rickaby

10:55 Advances in the approaches to using the oxygen isotope composition of diatom silica to investigate climate variability with a review of studies in Scandinavia

Melanie Leng, Gunhild Rosqvist

11:15 Understanding the carbon cycle of lakes using the stable isotopes of diatom silica.

Philip Barker, Elizabeth Hurrell, Melanie Leng, Dirk Verschuren, Daniel Conley, Birgit Plessen

11:35 Controls on the magnitude of biogenic silica deposition in lake and reservoir sediments

Patrick Frings, Daniel Conley

11:55 Contribution of allochthonous organic matter to sedimentation and benthic food-webs in Lake Constance: Evidence from stable isotopes

Hans Güde, Norka Fuentes, Dietmar Straile, Martin Wessels

**Session 6 Across the Third Pole (Tibetan Plateau)**

Andy Henderson & Gerhard Daut

**A 701**

10:15 Paleoshorelines of Lake Baikal as indicators of climatic, glacial and tectonic changes during Late Pleistocene

Eduard Osipov

10:35 Multi-proxy analysis of lake sediments at Tangra Yumco (central Tibetan Plateau) – Holocene lake level and climate variability

Iris Möbius, Peter Frenzel, Phillipp Hoelzmann, Sebastian Ferse, Torsten Haberzettl, Birgit Plessen, Antje Schwalb, Claudia Wrozyna

10:55 Alkenone-based Holocene temperature and salinity variations in the Northern Tibetan Plateau

Cheng Zhao, Zhonghui Liu, Zicheng Yu, Yan Zhao, Yuxin He

11:15 Multi-proxy evidence for Holocene lake level history of Lake Nam Co, south-central Tibetan Plateau

Claudia Wrozyna, Peter Frenzel, Antje Schwalb, Ines Mügler, Gerd Gleixner, Gerhard Daut, Roland Mäusbacher

11:35 A high resolution environmental record of Pumoyum Co of Southern Tibet since 19 kyrBP

Liping Zhu, Xinmiao Lu, Mitsugu Nishimura, Yoshimune Morita, Takahiro Watanabe, Toshio Nakamura, Yong Wang

11:55 Understanding changes in moisture origin and transport mechanisms using stable water isotopes along an aridity transect on the Tibetan Plateau

Franziska Guenther, Ines Muegler, Roman Witt, Gerd Gleixner, Shichang Kang, Baiqing Xu, Tandong Yao

**13:00 Midcongress Excursion**

**Friday September 2<sup>nd</sup> 2011**

**08:15 Plenary talk**

Detecting microbes in lake deposits

M. Esther Sanz Montero

**09:15 Poster Session and Coffee Break**

**Session 7 Lake models and carbonates (including Wetlands)**

Elizabeth Gierlowski-Kordesch & David Finkelstein, Daniel Deocampo, Cynthia Liutkus, Gail Ashley & M.A. Fregenal-Martínez

S7-P01 Carbonate Wetlands on Distal Anastomosing River Floodplains

Elizabeth H. Gierlowski-Kordesch, David B. Finkelstein, Jessie Jean Truchan, Kevin D. Kallini

S7-P02 Integrated Macrostratigraphy and Cyclostratigraphy of Eocene Lacustrine Strata, Wilkins Peak Member of the Green River Formation, Western U.S.

Wasinee Aswasereelert, Steven Meyers, Alan Carroll, Shanan Peters, Michael Smith, Kurt Feigl

S7-P03 Lithostratigraphy and geochemistry of Rano Aroi (Easter island, Chile) peatland infill as indicators of long-term a wetland dynamics evolution

Olga Margalef, Santiago Giral, Sergi Pla, Hans Joosten, Núria Cañellas-Boltà, Alberto Sáez, Valentí Rull, Juan José Pueyo

S7-P04 Climatic vs. tectonic control on facies and salinity changes in an Eocene rift lake, Upper Rhine Graben, Central Europe

Edgar Nitsch, Ulrike Wielandt-Schuster, Isabel Rupf, Laurent Beccaletto

S7-P05 Influence of Climate and Tectonics on Progradation of a River Delta in a Mega-Lake System (Upper Triassic, Junggar-Basin, NW-China)

Jianguang Zhang, Jens Hornung, Weihua Bian, Matthias Hinderer, Pujun Wang

### **Session 8 Central and East African Lakes: Climate versus Tectonics**

Jean Jacques Tiercelin & Mathieu Schuster

S8-P01 Stratigraphic framework of the South Basin of Lake Turkana, Kenya from new seismic reflection data and sediment cores

Amy Morrissey, Christopher Scholz

S8-P02 Paleoshorelines as archives of paleolakes evolution: two examples from the Lake Chad (central Africa) and the Lake Turkana (Kenya, EARS) basins.

Mathieu Schuster, Frédéric Bouchette, Philippe Düringer, Jean-François Ghienne, Abderamane Moussa, Alexis Nutz, Claude Roquin, Jean-Jacques Tiercelin

### **Session 9 Biological proxies in Quaternary palaeolimnology: problems and progress**

Jane Reed & Peter Frenzel

S9-P01 Lake ecosystem responses to Late Quaternary environmental change in the SE Pacific from sedimentary pigment and isotopic geochemical data of Raraku Lake (Easter Island, 27°S)

Teresa Buchaca, Juan Jose Pueyo, Núria Cañellas-Boltà, Olga Margalef, Alberto Sáez, Santiago Giral, Jordi Catalan

S9-P02 Palaeoenvironmental Changes in South Baltic Coast Region Recorded in Sediments of Trzebiatów Palaeo-lake

Milena Obremaska, Edyta Zawisza, Bernard Cedro

S9-P03 Late Quaternary climate and environmental change in the American tropics inferred from aquatic bioindicators

Liseth Pérez, Julieta Massafarro, Christine Pailles, Florence Sylvestre, Werner Hollwedel, Gerd-Oltmann Brandorff, Mark Brenner, Burkhard Scharf, Socorro Lozano-García, Antje Schwalb

S9-P04 Mineralogy and Mg, Sr and Na uptake in charophyte gyrogonites from culture experiments. Paleolimnological implications.

Pere Anadón, Rosa Utrilla, Antonio Vázquez, Maite Martin, Fernando Robles, Julio Rodriguez-Lázaro

S9-P05 Holocene Fresh Water Ostracoda from the Black Sea Coast of Turkey

Ceran Sekeryapan, Lisa Doner



S9-P06 Ostracod and chironomid transfer functions for inferring past lakewater conductivity in neotropical aquatic ecosystems

Julieta Massaferro, Liseth Perez, Brenner Mark, Burkhard Scharf, [Antje Schwalb](#)

S9-P07 A 8500-year sedimentary record based on analyses of organic matter, pollen and non-siliceous phytoplankton remains from Lake Bosten, NW China

Dieter Demske, [Philipp Hoelzmann](#), Bernd Wünnemann

S9-P08 Implications of ostracod preservation in Holocene paleoenvironmental reconstruction of Lake La Brava (Argentina)

[Maria Sofia Plastani](#), Cecilia Laprida, Ana María Navas, Blas Valero Garcés, Alicia Irurzún

S9-P09 Lake Ohrid diatoms as palaeoclimate indicators of climate change during the Last Glacial-Interglacial cycle

[Aleksandra Cvetkoska](#), Jane Reed, Zlatko Levkov

S9-P10 Ostracod-based transfer functions in palaeolimnology

[Peter Frenzel](#), Steffen Mischke, Finn A. Viehberg

S9-P11 Combined in-situ trace element, Pb and U isotope analysis of single ostracod shells from Lake Nam Co, Tibet

[Klaus Peter Jochum](#), Denis Scholz, Peter Frenzel, Gerd Gleixner, Franziska Guenther, Antje Schwalb, Brigitte Stoll, Ulrike Weis, Meinrat O. Andreae

S9-P12 Evolution of the limnic system at Middle Danube Plain from Pliocene/Pleistocene boundary till now

[Nadežda Krstić](#)

S9-P13 Palaeocological study of a periodical lake in central Svalbard, Petuniabukta

[Monika Lutynska](#)

S9-P14 Preservation of diatom valves in sediment cores from the Tibetan Plateau

[Kim J. Krahn](#), Anja Schwarz, Peter Frenzel, Antje Schwalb

S9-P15 Microfossils (thecamoebians and Ostracoda) from Holocene sediments in the Akosombo Gorge Area of Volta Lake, Ghana - Perspectives for palaeolimnological studies

[Lailah Gifty Akita](#), Peter Frenzel, Hideshige Takada, Tatsuya Koike, John Ofosu-Anim, Edward Ben Sabi

## 10:15 Session 7 Lake models and carbonates (including Wetlands)

Elizabeth Gierlowski-Kordesch & David Finkelstein, Daniel Deocampo, Cynthia Liutkus, Gail Ashley & M.A. Fregenal-Martínez

**Audimax**

10:15 Vertical and lateral distribution of lacustrine microbial, skeletal, and oncoidal carbonate lithofacies at the parasequence scale in the Miocene Idaho Hot Springs Limestone, USA

[Kevin M Bohacs](#), Timothy M Demko, Kathryn Lamb-Wozniak, Stephen Kaczmarek, Catherine Lash, David M Cleveland, Jason Eleson, Matthew Fabijanic, Orla M. McLaughlin, Stacie L. Gibbins

10:35 Environments and processes of magnesium carbonate precipitation in alkaline playa lakes of British Columbia, Canada, and the Neogene Kozani Basin of northern Greece

Robin Renaut, Michael Stamatakis, R. Bernhart Owen, Brian Jones

10:55 Nanoscale evidence of the microbial role in freshwater ooid formation

Daniel Ariztegui, Muriel Pacton, David Wacey, Matt R. Kilburn, Claire Rollion-Bard, Crisogono Vasconcelos

11:15 Pliocene-Pleistocene palustrine sediments of the Guadix Basin (Betic Cordillera, S. Spain): geologic record of ancient wetlands

Sila Pla-Pueyo, Elizabeth H. Gierlowski-Kordesch, Ian Candy, César Viseras

11:35 Predicting Lacustrine Microbialite Distribution and Facies Associations: the Eocene Green River Formation Analogue

Paul Buchheim, Stanley Awramik

11:55 The Character and Distribution of Lacustrine Microbialites through Time and Space

Stanley Awramik, Paul Buchheim

### **Session 8 Central and East African Lakes: Climate versus Tectonics (1)**

Jean Jacques Tiercelin & Mathieu Schuster

**A 701**

10:15 Tropical to semi-arid lacustrine environments and associated landscapes and ecosystems over the last 45 million years in the Turkana depression of northern Kenya

Jean-Jacques Tiercelin, Peter Thuo, George Muia, Mathieu Schuster

10:35 Examples of sedimentation in the rift lakes of Eastern Africa - Tectonic versus Climatic controls : A comparison between the Eocene - mid Miocene Lake Lokichar and the mid Miocene - Present Lake Turkana in Northern Kenya. Consequences on hydrocarbon prospects

Peter Thuo, George Muia, Jean-Jacques Tiercelin

10:55 The Hominin Sites And Paleolakes Drilling Project: Investigating the environmental context of human origins using high resolution lacustrine records

Andrew Cohen, The HSPDP Science Team

11:15 Early Pleistocene environmental change at Munya Wa Gicheru, Southern Kenya Rift Valley

Bernie Owen, Robin Renaut, Ray Lee

11:35 Palaeoecological information of fish fossils from the Miocene palaeolakes in the East African Rift valley in Kenya

Bettina Reichenbacher, Melanie Altner, Stefan Gehring, Martin Pickford, Brigitte Senut, Nancy Kiptalam, Kiptalam Cheboi

11:55 Lake level fluctuations recorded by hydrothermal deposits: evidence from Lake Bogoria, Kenya Rift Valley

Robin Renaut, Bernie Owen

**12:15 Lunch**

**13:30 Plenary talk**

Quantitative Palaeoenvironmental Reconstructions: Progress and Problems

Steve Juggins

**14:30 Session 9 Biological proxies in Quaternary palaeolimnology: problems and progress (1)**

Jane Reed & Peter Frenzel

**Audimax**

14:30 Ostracods from water bodies in hyperarid Israel and Jordan as habitat and water chemistry indicators

Steffen Mischke, Hanan Ginat, Bety Al-Saqarat, Ahuva Almogi-Labin

14:50 Use of contemporary stable isotope records to determine ecological processes affecting chironomids as paleolimnological indicators

Nina S Reuss, Ladislav Hamerlik, Gaute Velle, Anders Michelsen, Klaus P Brodersen

15:10 Morpho- hydrodynamic conditions along meander bends control the distribution of benthic fauna in a large river (Paraguay River, Argentina-Paraguay).

Martin Blettler, Mario Amsler, Ines Ezcurra

15:30 Reconstruction of the environmental changes in Late Glacial and Holocene in the vicinity of Lake Łukie (SE Poland) using multiproxy analysis.

Izabela Zawiska, Michal Slowinski, Milena Obremska, Krystyna Milecka, Michal Woszczyk, Karina Apolinska

**Session 4 General Limnogeology (2)**

Bernd Zolitschka

**A 701**

14:30 Geochemical records in lacustrine sediments and their interpretation

Georg Schettler, Rolf L. Romer

14:50 Numerical and statistical models for downscaling GCM output to reconstruct lake levels

Sebastian Wagner

15:10 A unique record of centennial- and millennial-scale interaction of climate and vegetation in the Middle Eocene maar lake of Messel, Germany

Olaf K. Lenz, Volker Wilde, Walter Riegel

**15:45 Pause**

**16:00 Session 9 Biological proxies in Quaternary palaeolimnology: problems and progress (2)**

Jane Reed & Peter Frenzel

**Audimax**

16:00 The Mutual Ostracod Temperature Range (MOTR) method: an answer in search of a question?

David J. Horne

- 16:20 European climate change at the end of the last glaciation: chironomid-based temperature reconstruction on a continental scale  
Oliver Heiri, H. John. B. Birks, Stephen J. Brooks, Marjolein Hazekamp, Emiliya Kirilova, Enikő Magyari, Laurent Millet, Morten F. Mortensen, Stéphanie Samartin, Willy Tinner, Monika Toth, Nelleke van Asch, Siim Veski, André F. Lotter
- 16:40 Niche constraints vs. random effects: how much should we trust biological indicators in palaeolimnological reconstructions?  
Francesc Mesquita-Joanes
- 17:00 Quantifying and qualifying salinity response: transfer functions and underlying uncertainty in diatom and ostracod training sets from Turkish salt lakes  
Jane Reed, Francesc Mesquita-Joanes
- 17:20 When less is more: exploring problems, progress and potential with African diatom-based transfer functions  
David Ryves, Keely Mills
- 17:40 Palaeolimnological interpretation of biogenic silica – review based on selected lakes from the Polish Lowlands  
Michal Woszczyk

## Session 8 Central and East African Lakes: Climate versus Tectonics (2)

Jean Jacques Tiercelin & Mathieu Schuster

**A 701**

- 16:00 Middle Miocene to Pleistocene fluvio-lacustrine sedimentary sequences onshore of Lake Albert (Uganda)  
Sybille Roller, Matthias Hinderer, Jens Hornung, Christina Bonanati
- 16:20 Estimating the Age of the Malawi Rift, East Africa, From Scientific Drill Cores and Multichannel Seismic Reflection Data  
Christopher Scholz, Robert Lyons
- 16:40 Climate and environmental history in the lake Victoria basin during the Holocene  
Casim Umba Tolo, Julius B. Lejju
- 17:00 Chad Basin, Lake Mega-Chad and Lake Chad: paleoenvironments of North central Africa/ Sahara since the upper Miocene.  
Mathieu Schuster, Philippe Durringer, Jean-François Ghienne, Claude Roquin, Frédéric Bouchette, Abderamane Moussa
- 17:20 <sup>238</sup>U-<sup>206</sup>Pb dating of early diagenetic calcite crystals from the lacustrine sediments of Bed I and Lower Bed II, Olduvai Gorge, Tanzania  
Elisabeth Rushworth, Jim Marshall, Ian Stanistreet, Randall Parrish
- 17:40 Environmental impacts of large scale degassing (LSD) at Lake Nyos, Cameroon (Central Africa)  
I. Issa, Gregory Z. Tanyileke, N. Sigha, W.Y. Fantong, T. Ohba, M. Kusakabe, Y. Yoshida, J.V. Hell

## 18:15 Guided City Tour and Congress Dinner

## Saturday September 3<sup>rd</sup> 2011

### 08:15 Plenary talk

Between the rock and climate/tectonics: the lake-basin-type approach expanded from conventional source rocks to unconventional resources, biological evolution, and the global carbon cycle

Kevin M Bohacs, Timothy M Demko, Alan R Carroll

### 09:15 Poster Session and Coffee Break

#### Session 10 Phanerozoic lake systems as archives for pre-Quaternary climate and environment

Olaf Lenz, Volker Wilde & Dieter Uhl

S10-P01 Late Jurassic – Early Cretaceous lakes and wetlands of the Cordilleran backbulge depozone, South Dakota (USA)

Michael McGlue, Mark Trees, Andrew Cohen, Erin Abel

S10-P02 Freshwater sponges from Triassic carbonates of Argentina (Cuyana Basin)

Cecilia Andrea Benavente, Adriana Cecilia Mancuso, Nora Graciela Cabaleri

S10-P03 Alluvial-lacustrine record and depositional hiatuses in Atacama Desert during last 10 Ma

Lluís Cabrera, Alberto Sáez, Garcés Miguel, Paul Bogaard, Domingo Gimeno, Arturo Jensen

#### Session 11 Clastic lake sediments as paleoenvironmental archives

Flavio Anselmetti, Adrian Gilli & Stephanie Girardclos

S11-P01 MIR-submersible dives in Lake Geneva: Formation, sedimentation, stability and mass movements of the Rhone delta canyons

Juan Pablo Corella, Stéphanie Girardclos, Flavio S. Anselmetti, Mike Sturm

S11-P02 XRF core scanning and CAT scans as tools for tracking the Holocene flood frequency in Lake Ghirla (Southern Alps, N-Italy)

Stefanie B. Wirth, Lukas Glur, Adrian Gilli, Flavio S. Anselmetti

S11-P03 The geochemical fingerprint of runoff events during the last 70 years in sediments of Lehmühle reservoir (Ore Mountains/ NE Germany).

Frank Jacob, Lucas Kämpf, Peter Dulski, Achim Brauer, Karl-Heinz Feger

S11-P04 Sediment imprint of flood events of different magnitudes in the Lehmühle reservoir (eastern Erzgebirge)

Lucas Kämpf, Peter Dulski, Frank Jacob, Karl-Heinz Feger, Klemt Eckehard, Achim Brauer

#### Session 12 Mediterranean lake- and paleolakerecords - archives of climate and environmental change, tectonic and volcanic activity, and human dispersal (including Karstic Lakes: Depositional models for high resolution archives)

Hendrik Vogel, Luis Gibert, Blas Valero Garcés & Ana Moreno

S12-P01 1200-yr high-resolution terrestrial climate archive from the middle of the Mediterranean: The sedimentary record from Lake “Specchio di Venere” on Pantelleria Island, Italy

Adrian Gilli, Patricia Eugster, Camilla Calò, Jacqueline van Leeuwen, Paul Henne, Elisa Vescovi, Tommaso La Mantia, Salvatore Pasta, Willy Tinner

S12-P02 The varved record of Lake Montcortès (southern Pyrenees, NE Spain): climate variability and human activities in a Mediterranean mountain since the Roman Period

Juan Pablo Corella, Achim Brauer, Blas L. Valero-Garcés, Clara Mangili, Valentí Rull, Teresa Vegas-Vilarrúbia, Mario Morellón

S12-P03 A new, high resolution carbonate isotope record of early to mid Holocene climatic change from the varved sediments of Nar Gölü, central Turkey

Jonathan Dean, Matthew Jones, Melanie Leng, Neil Roberts, Sarah Metcalfe

S12-P04 An increase of  $\delta^{18}\text{O}_{\text{carb}}$  at the beginning of the Holocene –oxygen and carbon isotope data from lake successions from northern Poland

Joanna Miroslaw-Grabowska

S12-P05 The effect of groundwater in sedimentation in karstic lakes: Late Quaternary depositional evolution of Banyoles Lake (Catalonia, NE Spain)

Mario Morellon, Flavio Anselmetti, Blas Valero-Garcés, Daniel Ariztegui, Ana Moreno, Santiago Giralt, Mayte Rico, Fernando Barreiro-Lostres, Maria Rieradevall, Alberto Sáez

S12-P06 Lithostratigraphy of Lake Van sediments over the past 400.000 years

Mona Stockhecke, Flavio S. Anselmetti, Michael Sturm

S12-P07 Climate Variability and Human Impact on Karstic Lake Stymphalia during Late Glacial to Holocene times (NE-Peloponnese, Greece)

Christian Heymann, Lutz Käppel, Oliver Nelle, Kimon Christanis, Helen Zagana, Norbert Nowaczyk, Ingmar Unkel

S12-P08 Recent and fossil ostracodes of Lake Ohrid (Republic of Macedonia/Albania) - Anthropogenic and environmentally driven changes in their spatial distribution

Julia Lorenschat, Burkhard Scharf, Flavio Anselmetti, Trajan Petkovski, Finn Viehberg, Antje Schwalb

S12-P09 High-resolution multi-proxy study in Basa de la Mora sequence (Spanish Central Pyrenees): a Holocene reconstruction of climate, human impact and vegetation cover variability

Ana Moreno, Ana Pérez-Sanz, Penélope González-Sampériz, Ánchel Belmonte, Pol tarrats, María Rieradevall, Graciela Gil-Romera, Carlos Sancho, Blas L. Valero-Garcés

S12-P10 Dynamic of CO<sub>2</sub> emission from Pinatubo crater lake, Philippines

Maricar Arpa, Pedro Hernandez, Paolo Raniva, German Padilla, Gladys Melian, Jose Barrancos, David Calvo, Dacil Nolasco, Celestino Saquillon, Eleazar Padron, Hirochika Sumino, Nemesio Perez, Renato Solidum

S12-P11 Climatic and hydrologic changes in Moroccan Middle-Atlas

Najib El Hamouti

S12-P12 Primary, bacterially induced pseudospherulitic fibrous calcite in the Quaternary lacustrine carbonates of the Farafra Oasis, Western Desert, Egypt: Petrographic and geochemical evidence

Hamdalla Wanas

S12-P13 Diatom response to major Quaternary transitions in Mediterranean ancient lakes: implications for quantitative reconstruction

Jane Reed, Aleksandra Cvetkoska, Graham Wilson, Tim Jones, Ian Lawson, Katy Roucoux, Hendrik Vogel

S12-P14 Late Pleistocene and Holocene lake-level changes at Ioannina, northwest Greece

Timothy Jones, Ian Lawson, Jane Reed, Chronis Tzedakis

### **Session 13 Human impacts on lake systems**

Michael Rosen & Karl-Heinz Feger

S13-P01 Characteristics of the Climate and Environment over the Past 150 Years Recorded in Lacustrine Sediment in Arid Xinjiang, NW China

Jinglu Wu, Long Ma, Abuduwaili Jilili

S13-P02 Origin of shallow lakes in the agricultural region of Khorezm, Uzbekistan and temporal trends in DDT and HCH concentrations from these lakes

Michael R. Rosen, Arica Crootof, Laurel Saito, Bakhriddin Nishonov, Julian A. Scott

S13-P03 Reconstruction of evolutionary processes from resting egg banks of *D. pulicaria* in Lower Lake Constance

Sarah Oexle, Markus Möst, Nora Brede, Martin Wessels, Piet Spaak, Dominik Martin-Creuzburg

S13-P04 Spatial Modeling Approach for the Assessment of Anthropogenic and Climatic Impact on Lake Systems

Ullrich von Bramann, Antje Schwalb, Stephan van Gasselt

S13-P05 New concept for in situ ecotoxicological assessment

Almut Gerhardt

S13-P06 Landuse, the Medieval Warm Period and the Little Ice Age: A multi proxy study from Lake Hampen and Lake Ræv, Denmark

Jesper Olsen, Peter Rasmussen, Kaarina Weckström

### **10:15 Session 10 Phanerozoic lake systems as archives for pre-Quaternary climate and environment**

Olaf Lenz, Volker Wilde & Dieter Uhl

**Audimax**

10:15 Lake deposits of moderate salinity as sensitive indicators of lake level fluctuations: example from the Upper Rotliegend saline lake (Permian, Northeast Germany)

Berit Legler, Joerg W. Schneider, Ute Gebhardt, Dirk Merten, Reinhard Gaupp

10:35 Long-Distance Drainage to Eocene Lakes: A New View of the Green River Formation, Western U.S.

Alan Carroll, Lauren Chetel, Amalia Doebbert, Michael Smith, Steven Davis

10:55 Jurassic lacustrine and palustrine environments in Argentina: a review

Wolfgang Volkheimer, Mirta E. Quattrocchio, Nora Cabaleri, Paula L. Narváez, Laura Scafati, Daniel L. Melendi

11:15 Unexpected high teleost fish diversity in a Late Miocene palaeolake at Venta del Moro (Valencia, Spain)

Bettina Reichenbacher, Plinio Montoya

11:35 A lacustrine diary for Triassic climate change – facies cycles of the Keuper Group, Germany

Edgar Nitsch, Norbert Hauschke

11:55 A prograding delta succession in a mega-lake system: Architecture, depositional cycles, and sequence stratigraphy (Upper Triassic, Junggar-basin, NW-China)

Jens Hornung, Jianguang Zhang, Matthias Hinderer, Weihua Bian, Pujun Wang

### Session 11 Clastic lake sediments as paleoenvironmental archives

Flavio Anselmetti, Adrian Gilli & Stephanie Girardclos

**A 701**

10:15 Numerical Simulation of an Underflow in Perialpine Lake Constance

Magdalena Eder, Martin Wessels, Ulrich Lang

10:35 Flood Alp! - Holocene flood variability in the Alps reconstructed from low- and high-altitude lacustrine records

Lukas Glur

10:55 Reconstruction of summer/autumn flash-floods events over the last millennium from a high-elevation lake sediment sequence (Lake Allos, France)

Bruno Wilhelm, Fabien Arnaud, Pierre Sabatier, Elodie Brisset, Frederic Guiter, Jean-Louis Reyss, Eric Chaumillon, Claire Dehlon, Emmanuel Malet, Charline Giguet-Covex, Jean-Jacques Delannoy

11:15 300 years of underflow record in Lake Bourget: an attempt of quantitative hydrological reconstruction based on spatio-temporal approach

Jean-Philippe Jenny, Fabien Arnaud, Jean-Marcel Dorioz, Charline Giguet Covex, Cécile Pignol, Emmanuel Malet, Jérôme Lazzarotto, Jean-Louis Reyss, Pierre Sabatier

11:35 Discharge variability recorded in the sediments of Grand Lake, a new clastic varve record from eastern Canada

David Fortin, Pierre Francus, Archives Group

**12:15 Lunch**

**13:30 Plenary talk**

Human impacts on lake systems

Michael R. Rosen



**14:30 Session 12 Mediterranean lake- and paleolakerecords - archives of climate and environmental change, tectonic and volcanic activity, and human dispersal (including Karstic Lakes: Depositional models for high resolution archives) (1)**

Hendrik Vogel, Luis Gibert, Blas Valero Garcés & Ana Moreno

**Audimax**

14:30 The Dead Sea Deep Drilling Project (DSDDP): Filling gaps on the shrinking/swelling tale of a lacustrine basin

Daniel Ariztegui, Zvi Ben Abraham, Amotz Agnon, Achim Brauer, Steven Goldstein, Gerald Haug, Emi Ito, Moti Stein, Y. Yasuda, Michael Lazar, Nicolas Waldmann

14:50 Lake Van Drilling Project 'PaleoVan' (ICDP): A long continental record in Eastern Anatolia covering several glacial-interglacial cycles

Flavio Anselmetti, Namik Cagatay, Rolf Kipfer, Sebastian Krastel, Thomas Litt, Michael Sturm, Sefer Örcen, PALEOVAN scientific party

15:10 Lake Van (Turkey) : Geological archives of past high levels, and geomorphological evolution of the lake basin

C. Kuzucuoglu, D. Mouralis, A.-F. Dogu, A. Christol, E. Akköprü, Monique Fort, D. Brunstein, H. Guillou, M. Fontugne, M. Lamothe, J.-L. Reyss, S. Scaillet

15:30 A new 10,000 year pollen record from Lake Kinneret (Israel) – first results

Vera Klinger, Thomas Litt, Norbert Nowaczyk, Mordechai Stein

**Session 4 General Limnogeology (3)**

Sebastian Wagner

**A 701**

14:30 Distribution, morphology, and formation of pockmarks in Lake Constance, Germany

Martin Wessels, Ingeborg Bussmann, Stefan Schloemer, Michael Schlueter, Volker Böder

14:50 River-delta failures in Lake Lucerne (Central Switzerland)

Michael Hilbe, Flavio S. Anselmetti, Raymond S. Eilertsen, Louise Hansen, Sylvia Stegmann, Michael Strasser

15:10 Conditions for the deposition of annually laminated sediments in Lake Suminko, a small meromictic lake in Northern Poland

Wojciech Tylmann, Kamila Szpakowska, Christian Ohlendorf, Michal Woszczyk, Bernd Zolitschka

15:30 Interactions between microbial degradation of sedimentary organic matter and lake hydrodynamics in shallow water bodies - insights from Lake Sarbsko (northern Poland)

Achim Bechtel, Roman Cieslinski, Michal Woszczyk

**15:45 Pause**

**16:00 Session 12 Mediterranean lake- and paleolakerecords - archives of climate and environmental change, tectonic and volcanic activity, and human dispersal (including Karstic Lakes: Depositional models for high resolution archives) (2)**

Hendrik Vogel, Luis Gibert, Blas Valero Garcés & Ana Moreno

**Audimax**

- 16:00 The study of sedimentary records of modern coastal lakes on Thrace and the Black Sea coasts of Turkey  
Ceran Sekeryapan, Lisa Doner
- 16:20 New insights into the climate and depositional history of Lake Iznik sediments during the last 30.000 years BP  
Sven Oliver Franz, Patricia Angelika Roeser, Thomas Litt, Finn Viehberg, Martin Melles, Umut Baris Ülgen, Sena Akçer, Sabine Wulf, Yvonne Hamann
- 16:40 SCOPSCO – Scientific Collaboration On Past Speciation Conditions in Lake Ohrid  
Hendrik Vogel, Bernd Wagner, SCOPSCO Science Team
- 17:00 Chironomid-based environmental reconstructions in Italy and Southern Switzerland using subfossil chironomid assemblages  
Stéphanie Samartin, Oliver Heiri, Willy Tinner
- 17:20 Endogenic sedimentary products in the evaporitic Baza Basin (SE Spain)  
Luis Gibert, Laura Rosell, Monserrat Ingles, Gary Scott
- 17:40 Late Holocene sedimentation in Iberian Range karstic lakes: Facies model, depositional evolution and climatic implications.  
Fernando Barreiro-Lostres, Ana Moreno, Santiago Giral, Pilar Mata, Josu Aranbarri, Blas Valero-Garcés

### Session 13 Human impacts on lake systems

Michael Rosen & Karl-Heinz Feger

**A 701**

- 16:00 Atmospheric trace metal pollution in sediments of London lakes  
Charlotte Hall, Neil Rose, Anson Mackay
- 16:20 Springs as indicators of anthropogenic pollution for geo-environmental monitoring of lakes (by the example of Moscow Region)  
Ekaterina Vasilieva, Andrey Rasskazov
- 16:40 Assessing the human impact on hybrid Daphnia populations across the Alps  
Markus Möst, Aurea Chiaia, Juliane Hollender, Flavio Anselmetti, Piet Spaak
- 17:00 Hydrology of the Cuatro Ciénegas Basin (Mexico) lake system from the Late-Pleistocene to the present: The implications of over extraction of water for industry and the need for conservation.  
Nicholas Felstead, Silvia Gonzalez, Melanie Leng, Thomas Minckley, David Huddart, Sarah Metcalfe
- 17:20 Local to regional scale pollution history of large freshwater lakes from the Swiss Plateau  
Florian Thevenon, Thierry Adatte, Massimo Chiaradia, John Poté
- 17:40 Human impact during seven Millennia in central cores of small lakes in South-west Germany and in littoral cores from Lake Constance  
Manfred Rösch, Elske Fischer, Jutta Lechterbeck, Lucia Wick

**18:00 Farewell**

## Plenary Lecture 1

### **History of sedimentation in Bear Lake, Utah and Idaho, USA, over the last 240,000 years: links to Pacific climate**

Walter Dean

U. S. Geological Survey, MS 980 Federal Center, Denver, Colorado 80225, USA

**Email:** dean@usgs.gov

Bear Lake is a large alkaline lake on a high (ca. 1800 m) plateau on the Utah-Idaho border in the northern Rock Mountains, USA. The Bear Lake region is within the belt of the strongest westerly winds, which transport most of the moisture into the region during the winter. Because of the dominance of winter precipitation, most of the water that enters Bear Lake is from snowmelt, much of which is stored in cavernous carbonate rocks in the Bear River Range to the west of the lake and is released even in the dry summer months, mainly as base flow to the few streams that enter the lake. So, even though it is in a region of high net evaporation, the lake does not dry up.

As a test of the Global Lake Drilling System to 800 m (GLAD800), two 120-m-long cores were collected from Bear Lake, spanning the last two glacial-interglacial cycles. Sediments deposited over the last 240,000 years in Bear Lake are predominantly calcareous silty clay, with calcite as the dominant carbonate mineral. During human historic time the Bear River has bypassed Bear Lake on its way to be the dominant source of water to Great Salt Lake. However, the abundance of siliciclastic sediment indicates that Bear River was connected to Bear Lake during most the last 240,000 years. However, three aragonitic marl intervals were deposited during the Holocene and the last two interglacial intervals, equivalent to oxygen isotope stages (OIS) 5 and 7. During these interglacial periods, Bear River was disconnected from Bear Lake and the lake became more saline. These high carbonate, aragonitic intervals coincide with warm interglacial continental climates, warm Pacific SSTs, increased coastal upwelling under the California Current, and increased organic productivity, all recorded in marine sediments off the western margin of North America. This implies that the subtropical (Hawaiian) high-pressure system that today drives the California Current during the summer had a longer residence time off northern California during interglacials. During the last three glacial interval (OIS 2, 4, and 6), the Aleutian low-pressure system, presently dominant during the winter, had a longer residence time off northern California, producing storms and precipitation that increased the levels of Lake Bonneville and Lake Lahontan in the Great Basin of western United States, and increased the flow of Bear River. On the California margin, the California Current upwelling system was greatly reduced during glacial intervals. Sediments deposited on the margins of North America during glacial intervals indicate that organic productivity was considerably lower than during interglacials. These climatic patterns over the North Pacific are recorded in Bear Lake by river-borne detrital clastic sediments deposited during glacial intervals, and carbonate sediments, dominated by aragonite, deposited during the more arid interglacials.

## Plenary Lecture 2

### **Deciphering sediment records from arctic and alpine lakes: the importance of understanding the role of catchment and in-lake processes**

N. John Anderson

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In the absence of anthropogenic-driven changes, which are a characteristic of much of NW Europe, Central America and SE Asia, Holocene lake sediment records tend to be interpreted in terms of climate, especially temperature, forcing. This paradigm dominates much of the recent literature, particularly that relating to arctic and alpine lakes, where the absence of overt cultural disturbance and limited vegetation development (i.e. no trees) points to climate/temperature as an important driver of limnological change. Clearly, climate exerts considerable control on lake biological structure and functioning at millennial timescales and large spatial scales, for example changes associated with neoglacial cooling and latitudinal/altitudinal gradients. Many of these large scale changes are often the result of indirect climate forcing associated with catchment processes, such as soil development and vegetation immigration (which can lag climate). Lake sediment records, however, also exhibit high temporal resolution, high frequency variability that can be difficult to interpret and/or decipher and which is often dismissed as "local anomalies". However, this problem goes beyond methodological issues associated with temporal scaling: emphasising climate while ignoring in-lake processes tends to over-simplify what might be quite complex interactions and importantly can lead to erroneous inferences with regard to climate dynamics. I will consider the importance of incorporating in-lake processes (trophic dynamics associated with fish immigration; predation and benthic-littoral coupling; thermal stratification, nutrient recycling and bacterial dynamics) and catchment processes (landscape relief, hydrology and erosion; vegetation dynamics and soil development) into the arctic lake-climate paradigm, as well as the interpretation of palaeolimnological "*climate*" records in general. Using examples primarily of Holocene records from lakes in SW Greenland, I will argue that the emphasis on climate as *the* driver of ecological change in arctic and alpine lakes has led to a misinterpretation of recent post-1850 change in these ecosystems.

## Plenary Lecture 3 – Evening Talk

### Progress in Global Lake Drilling (GLAD) holds potential for Paleolimnological research

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Using conventional marine and lacustrine piston coring equipment, maximum core lengths are limited to about 20 m. The marine coring community solved its long-core problem over 30 years ago with drill ships, first the *Glomar Challenger* and then the *JOIDES Resolution*. Probably the most revolutionary invention for obtaining undisturbed Quaternary marine sediments from a drill ship came in 1978 with the hydraulic piston corer. It wasn't until 2000 that the lake coring community solved its long-core problem with the construction of the GLAD800 system capable of handling a total drill string length (water plus sediment) of 800 m. The platform, operated by DOSECC (Drilling, Observation and Sampling of the Earth's Continental Crust) in Salt Lake City, Utah, consists of eight, 6-m international shipping containers. The mining drill rig is modified to handle standard Ocean Drilling Program (ODP) liners and tools, including the hydraulic piston corer. The system was tested in the summer of 2000 in Great Salt Lake, Utah and Bear Lake, Utah and Idaho. Most lake cores obtained by DOSECC, beginning with the cores from Great Salt and Bear Lakes, are stored at LacCore, the National Lake Core Facility at the University of Minnesota. The GLAD800 platform, now named the *R/V Kerry Kelts*, then cored Lake Titicaca, Bolivia in April and May, 2001, obtaining a total of 594 m of core, the longest being 139 m in 232 m of water. In Lake Peten Itza, Guatemala, the *R/V Kerry Kelts* obtained a total of 1327 m of core in up to 150 m of water. To core Lake Malawi in the East African Rift Valley, a Seascore, Ltd., drilling rig was mounted on a 40-m fuel barge equipped with outboard motors for dynamic positioning. Coring four holes to a maximum depth of 380 m in 600 m of water was done using the DOSECC coring tools. The most extreme environment that the DOSECC tools were used was through the ice in Lake El'gygytgyn, or Lake E, in Siberia during the winter of 2008-2009. For the Lake E Drilling Project, the DOSECC tools were melded to a Russian oil rig. Cores of 330 m and 420 m from two sites were shipped to the University of Cologne, Germany for sampling and the archive halves shipped to LacCore. To core even deeper, DOSECC designed the Deep Lake Drilling System (DLDS), which consists of two parts: the main drilling rig and associated equipment, and the barge itself. The drill rig is a modified rotary rig designed for water-well and oil drilling. The platform consists of six 40-foot (12-m) Damen shipping containers, and is 24.4-m long and 7.3 m wide. The barge, like the GLAD800 barge, is modular, which enables easy shipping anywhere in the world. The DLDS platform made its maiden voyage on Lake Van, Turkey, in July and August 2010. There, with the barge anchored in 360 m of water, the longest core collected was 250 m long. The DLDS system then went to the Dead Sea, Israel in November, 2010. Anchored in 300 m of water, the DLDS system collected a 455 m core from the center of the lake. The Lake Van and Dead Sea cores are stored at Bremen University, Germany.

## Plenary Lecture 4

### Oxygen and carbon isotopes in lacustrine diatoms: Indicators of regional paleoclimate

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Lakes serve as one of the best natural archives of past climatic variability on the continents. Their datable sediments typically have accumulated continuously over thousands of years, and a variety of physical, chemical, and biological indicators preserved in lake sediments can be used to reconstruct past climatic change and landscape response. The studies of oxygen isotopes in lake sediments were restricted to the carbonate phase, analyzing authigenic carbonates and calcareous bottom dwellers. However, carbonate material is not available in all lakes. It is absent especially in high altitude and high latitude lakes, in which the geological setting and the precipitation/evaporation ratio do not allow the chemical precipitation of authigenic carbonate. In contrast, lake sediments in these regions often contain biogenic silica. It is composed primarily of diatoms (photosynthetic algae) that deposit internal opal ( $\text{SiO}_2 \cdot n\text{H}_2\text{O}$ ) frustules. Because of light requirements for photosynthesis, silicification occurs only in the uppermost layer of the lake. Thus, diatoms are an ideal recorder of surface temperature and isotopic composition of the surface water. Recent studies demonstrate the potential of measuring the isotopic composition of oxygen in diatom frustules in order to reconstruct past climate changes, both quantitatively and qualitatively. The oxygen isotopic composition of opal depends on ambient water temperature and the lake-water isotopic composition, which is a complex function of the local hydrological setting. The interplay between the local hydrology and diatom isotopic composition will be presented in three key locations: the northern hemisphere, equatorial Africa and the southern hemisphere. The  $\delta^{18}\text{O}_{\text{Si}}$  down-core records will be discussed in terms of regional climate change and its relation to the Younger Dryas cooling. The carbon isotopes of the diatom organic matrix complements the oxygen isotope record and provides information about paleo productivity and nutrient supply/utilization in the lake.

## Plenary Lecture 5

### Detecting microbes in lake deposits

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Among the requirements to sustain life, liquid water with sufficiently high chemical activity is regarded as essential. Assemblages of minerals deposited in ancient lake environments commonly indicate a range of chemical formative conditions that can sustain microbial life. Thus, lacustrine deposits potentially preserve a record of microbial life. Different traces of life (or biosignatures) may be used to identify microorganisms in the rock record. The biosignatures mainly consist of morpho-structural fossils, including cellular remains, biofabrics and stromatolites, organic molecular markers (biomarkers), minerals resulting from microbial activity (biominerals), stable isotopic signatures and other geochemical signatures (trace and rare earth elements). Because the type of biosignatures that can be found is very diverse, the procedures potentially applicable to their study are very broad and include many of the sedimentary, microscopic, mineralogical and geochemical techniques used to analyze rocks. The list of biosignatures is expected to extend in line with the progressive improvements in analytical techniques and the variety of studies being done in modern environments and laboratory, especially to characterize biominerals and biomarkers.

The extent to which lacustrine deposits have preserved microbial biosignatures depend largely on the bio-geochemical factors of the sedimentary environment. For example, chemically reducing conditions are better than oxidizing conditions in promoting the preservation of sedimentary organic matter and favour the precipitation of biominerals such as carbonates, pyrite, apatite, sulphur, etc. The preservation of biosignatures also depends on the mineralogy of the sediments. In general, fossil microbial mats structures are well known from carbonate depositional settings but are more difficult to identify in other environments, for instance in detrital sedimentary systems. A number of key morphological and chemical characteristics have been defined as proxy structures for these rocks. Phyllosilicate in clay-rich sediments enhance the retention of organic compounds by binding and incorporating organic molecules. Silica and, to a lesser extent, carbonates can preserve all type of biosignatures. Encapsulation of microbes and microbial mat features also may take place within phosphate, sulphides and metallic oxides. The preservation potential of traces of life in evaporites is very high due to their high capacity for organic encapsulation and rapid sealing. Although evaporites may be replaced by secondary minerals, biomineral inclusions can be preserved in the resulting pseudomorph. Similarly, bioturbation produced by insects feeding on microbial mats may destroy the original sedimentary structures but provide new structures that have much better preservation potential.

## Plenary lecture 6

### Quantitative Palaeoenvironmental Reconstructions: Progress and Problems

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Palaeolimnological transfer functions provide a powerful tool for quantifying species – environment relationships in modern training sets and for using these relationships to reconstruct environmental conditions from fossil assemblages. This presentation will review recent progress in the development and application of training sets and numerical methods and take a critical look at how these models are being applied. Using real and simulated data I will demonstrate that many examples violate the basic underlying ecological, palaeoecological and statistical assumptions of the transfer function approach, leading to models that lack statistical validity and reconstructions that are problematic and unreliable. I will argue that to make progress palaeolimnologists must (1) take a step back and address fundamental questions such as which environmental variables can we reconstruct, and (2) develop new techniques to address more practical issues around testing the independence and significance of individual reconstructions. I will finish by reviewing a range of numerical analyses that can help with these tasks and outline a framework for their systematic application.



## Plenary lecture 7

### **Between the rock and climate/tectonics: the lake-basin-type approach expanded from conventional source rocks to unconventional resources, biological evolution, and the global carbon cycle**

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The widespread occurrence of only a few distinct lacustrine facies associations and their strong relation to physical, biogenic, and chemical rock property distribution and stratal-stacking patterns highlights the importance of the geological "filter" in determining which modern processes leave preservable stratal records. Each lake-basin type has distinct lithofacies associations that reveal their key controls: hydrologic-state history, drainage-basin provenance lithotypes, and basin shape. These factors influence composition and stability of water chemistry, lake-level-change history, shoreline stability, and wave fetch and effectiveness. Along with biological evolution, they also affect ecosystem structure and trophic-web complexity. Focusing on proximate versus ultimate controls on lake-basin strata facilitates the deconvolution of the many, varied, and sometimes conflicting influences of climate and tectonics.

The lake-basin type model of Carroll and Bohacs (1999) posits the key proximate controls to be rates of potential accommodation change relative to supply of sediment+water. These governing variables are not, however, simple functions of climate and tectonics, but non-linear combinations with other equally important variables such as landscape development, vegetation state and distribution, and catchment lithofacies. Tectonics acts most directly on potential accommodation through structural movement of the basin floor and spillpoint and through landscape development influence on spillpoint height. Climate has the most direct influence through nutrient and sediment supply, floral type and distribution, and water supply.

The lake-basin-type model was originally devised to guide exploration for hydrocarbon source rocks. In the past decade, continuing studies have shown that this approach provides a useful framework for explaining many other aspects of continental depositional environments: siliciclastic and carbonate hydrocarbon reservoirs, fluvial and floodplain character, paleosols, and ichnofossils, as well as the size distribution of lake systems and biological evolution within them. This successful expansion resulted from integration of a wide variety of data types within a process-based framework, along with the substantial progress made in establishing high-resolution chronostratigraphy, through a combination of techniques such as radioisotopic dating, magnetostratigraphy, and astrochronology. The model's integration of all scales of data, from plate-tectonics, through seismic, well-log, outcrop, core, thin-section, and body and trace fossils, to molecular and isotopic geochemistry provides powerful tools for exploration and exploitation of both conventional and unconventional hydrocarbon resources. It also greatly assisted the interpretation of lacustrine sediment cores, biological evolution patterns, and the role of lake strata in global carbon cycles.

## Plenary Lecture 8

### Human impacts on lake systems

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Lakes can provide a detailed history of human impacts on the water use, contaminant inputs, and aquatic health at both local and regional scales. Humans have affected lakes worldwide, directly, or indirectly, for hundreds of years. Dam building that enhances or diminishes river flows, is one of oldest modifications to lake hydrology. The effects of these modifications can be as subtle as changing lake productivity or evaporation rates, to as drastic as creating a reservoir (new lake) or causing lake desiccation. Changes in lake hydrology may also alter lake-groundwater interactions, which can change the water balance and also allow contaminants to enter a lake or groundwater.

Local pollution from nearby industry and farmland can alter lakes and reservoirs directly (or indirectly) and induce changes to fauna and flora caused by the toxicity of metals, pesticides and organic compounds. In addition to local inputs, atmospheric deposition of chemicals such as mercury and acid rain has been detrimental to aquatic biota in lakes. Persistent pollutants have even been carried by birds to Arctic lakes through the food web. Nuclear bomb testing in the 1950's and '60s provides a useful global dating mechanism for sedimentation in lakes, but the impact to aquatic biota at the time, and after the Chernobyl release in 1986, has been poorly studied.

Both urban and rural lakes have been impacted by local and regional runoff that contains nutrients and pesticides. Differences in organic compound concentrations have been found in urban lakes in the United States based on regional product use patterns. For example, Eastern United States urban areas use coal-tar as an asphalt sealant and this has led to large increases in polycyclic aromatic hydrocarbons (PAHs) being carried to lakes in these urban areas. In the Western United States, coal-tar is used much less, and PAH concentrations are lower in these lakes. Chemicals from wastewater treatment plants may also impact lakes. The effect of some compounds such as triclosan is still poorly understood, but recent research has shown that it degrades to dioxins that may be more toxic to aquatic biota than the original compound.

Small lakes may be more easily affected than large lakes by pollutants, simply because the pollutants can make up a larger percentage of the mass in the lake. However, large lakes can also be drastically changed. For example, Lake Erie in the United States was declared "dead" in the 1960's due to excessive algae blooms caused by high phosphorus inputs from farming. The lake has since improved due to regulation and clean-up efforts. Changes in hydrology, however, can impact even the largest lakes. Diversion of water for irrigation from the rivers entering the Aral Sea, located in Uzbekistan and Kazakhstan has reduced the lake to less than twenty percent of its size before diversions began. This has allowed the lake to become more saline and destroyed the regional fishery.

**S1-T01****Late Quaternary Climate of the Indo-Pacific Warm Pool from Large Indonesian Lakes**

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The Indo-Pacific Warm Pool (IPWP) dominates the Earth's atmospheric moisture and heat budgets, and controls globally important climate systems such as the El Niño Southern Oscillation and the Asian monsoons. Indonesia sits at the heart of the IPWP and hosts myriad lakes that record regional precipitation and temperature, yet we have very few Indonesian climate records to evaluate late Quaternary climate variability. We collected new sediment piston cores and airgun seismic reflection data from Lake Towuti, a large tectonic lake in central Sulawesi. Lake Towuti sits at the downstream end of the Malili Lakes (2.5°S, 121°E), a chain of ancient, tectonic, biologically diverse lakes hosted in the East Sulawesi Ophiolite. Towuti's metal-rich sediments record millennial to orbital-scale climate variations during the late Quaternary. Here we present multiproxy analyses of piston cores from Lake Towuti spanning the last ~110 kyr BP. Magnetic susceptibility (MS) profiles in 10 piston cores reveal a distinct sequence of lithologic changes that can be correlated across the entire Towuti basin: Generally low MS from 110 to 70 ka, high MS from 70-60 kyr BP, low MS from 60 to 42 kyr BP, extremely high MS from 42 to 16 kyr BP, and low susceptibility during the Holocene. Geochemical analyses reveal that high susceptibility units are associated with elevated ratios of organic carbon to nitrogen, increased concentrations of inorganic carbonate, enriched  $d^{18}O$  values in authigenic

carbonate, enriched  $d^{13}C$  and  $d^{15}N$  values in organic carbon, and variations in the isotopic composition of terrestrial leaf waxes, indicating that high MS values are associated with dry conditions. This hypothesis is confirmed by XRF analysis of terrestrial runoff indicators, which are low during intervals of high MS.

Our record thus registers a central Indonesian climate history that is an amalgam of the northern and southern tropics, with drier conditions during northern hemisphere cold phases and sea level minima (e.g. MIS 4, between 70 and 60 kyr BP, MIS 2, Heinrich event 1), wetter conditions during interglacials, and a dry/wet early/late Holocene pattern, similar to orbitally-forced monsoon records from the southern hemisphere. The highest amplitude droughts in our record occur during glacial maxima and sea level minima in MIS2 and 4, rather than precession minima in MIS 5, suggesting that greenhouse gas concentrations and exposure of the Sunda Shelf during sea level lowstands exert a stronger influence on IPWP climate than do orbitally-induced insolation changes. Future drilling of Lake Towuti could test this hypothesis over multiple glacial-interglacial cycles.

**S1-T02****A 500,000 year paleoecological record from ostracodes, charcoal, and other paleoclimate indicators from Lake Malawi, East Africa**

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Drill core records from Lake Malawi provide a long and detailed record of climate and limnologic change for the African southern subtropics. Core MAL05-1B (380m-long) was drilled at ~11°S, 34.5°E in central Lake Malawi in 592m water depth. Dates obtained to date suggest a basal age of ~500-600ka, making Core MAL05-1B the longest continuous

lacustrine record of East African paleoclimate. Throughout the length of the core, we collected one cm-thick sub-samples every 16cm (intra-sample time average of ~15 years, time step between samples of ~235 years) for coarse residue analyses of ostracodes, other invertebrates, charcoal and mineralogical/sedimentological indicators of lake level and redox. For ostracodes we collected taxonomic data at the generic level, as well as ostracode abundance and taphonomic condition.

The presence of un-transported ostracodes in Core 1B indicates times when the lake bottom was oxygenated, and thus significantly shallower than at present. Individual ostracode species demonstrate preferences for specific lake environments in terms of salinity or water depth. The assemblage data for the section of core analyzed thus far (231.12 - 351.221 mblf) suggest a transition from a relatively diverse saline/alkaline, littoral assemblage toward the base, to a more *Cypridopsis*-rich assemblage above 272m (~408 ka), indicative of deeper water conditions. These conclusions are supported by other indicators in the core record: from ~338 -347 mblf (~500 - 512 ka) there are abundant littoral indicators such as: ooids, rounded and sorted quartz sand, framboidal pyrite and authigenic siderite (where co-occurring, indicative of anoxic marsh conditions), and the ostracode genera *Limnocythere* and *Ilyocypris*; all indicating an extremely shallow lake environment (and in the case of *Ilyocypris* probably indicative of nearby deltaic inputs). This interpretation is supported by the pollen data and charred particle abundance over the same interval, which suggest an arid, vegetation-poor watershed at this time.

Upon completion of the ostracode assemblage analysis of the entire 1B core, we intend to quantify water chemistry, productivity, and water depth variation through the half million year record using a training set from recently-collected, modern Lake Malawi surface sediments. Using this information we hope to generate a quantitative interpretation of local hydrological change in the Lake Malawi basin,

as well as generate a ~500,000 year record of tropical East African paleoclimate.

### S1-T03

#### Semiprecessional to Precessional Cyclicity in Late Triassic Great Lakes of Central Pangea

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Milankovitch theory predicts a predominant ~21 ky precessional cycle in solar insolation at most latitudes, and at least a component of a ~10 ky cycle in equatorial regions because the convergence of the solstice at perihelion at the equator occurs twice every ~21 ky. As a result, we predict that for tropical lacustrine records, there should be two maxima of precipitation and hence two lake high stands every ~21 ky close to the equator. A component of this "semi-precession" has been shown in African Neogene lacustrine records, but should also apply to those from further back in geologic time.

Late Triassic-Early Jurassic lacustrine basins in the eastern North America formed during the initial fragmentation of Pangea, and lie along a northeast-southwest transect across the paleoequator and the subtropics. During the ~32 my covered by this record, the North American plate drifted northward, transecting zonal climate belts with a paleolatitudinal spread of over 30°. These records are temporally well-constrained by astrochronology, paleomagnetic polarity stratigraphy, and paleomagnetically determined plate positions. Here we report on our analysis of frequency properties of environmental proxies ( $d^{13}C_{TOC}$ , TOC, and depth ranks - facies indicating different degrees of lake depth or desiccation) sampled at 20 cm resolution.

At 8°N paleolatitude, the Lockatong Fm. of the Newark basin in New Jersey records a prominent hierarchy of cycles with periods of ~400, 100, and 20 ky. Of the same age, in the Dan River basin of Virginia, the Cow Branch Fm. lacustrine record at 4°N also preserves these cycle periodicities. However, unlike the Newark basin record, the most prominent cycles are of ~10 to 15 ky duration.

Detailed comparison of the frequency properties of exactly correlative sections of the same length for each basin support our interpretation of the differences between these two records. There is a close correspondence in the ~20 ky period, and a tenuous detection of ~10 ky cyclicity in the Newark basin, whereas there is strong ~10 ky cyclicity in the Dan River basin. In fact, there are nearly twice the number of deeper water units within the Dan River section than in the correlative Newark section. Thus, at the same time the ~20 ky cycles dominated the climate of the Newark basin region, ~10 ky cycles as well as ~20 ky cycles were dominant 4° to the south in the Dan River basin. This supports the hypothesis for ~10 ky period semiprecessional forcing of tropical lakes.

We therefore conclude that lake level in Late Triassic equatorial Pangea in the Dan River basin followed a 10 ky cyclicity attributable to the control of precipitation by the doubling of the frequency of the climatic precession cycle. Contemporaneous lacustrine records from 4° further north in the Newark basin show much less effect of the ~10 ky cycle and the ~20 ky cycle of "normal" climatic precession is correspondingly stronger.

The development of the paleotemperature proxy, TEX86, has generated a number of papers regarding its application, strengths, and weaknesses in paleolimnology. TEX86 appears to work best in large, tropical lakes, especially those in the East African Rift Valley, and it is least applicable in small lakes where the overprint from terrestrial tetratether compounds invalidates the temperature signal. We now have a TEX86 record of millennial-scale resolution from the Lake Malawi drill core that extends back approximately 500,000 years before present. Temperature swings of glacial-interglacial amplitude are apparent throughout the sequence, but without clear Milankovitch cycles. The age model for the Lake Malawi drill core may be partly responsible for this apparent lack of orbital forcing: there is still considerable uncertainty in the age-depth relationship beyond the radiocarbon time scale ( $\pm 20\%$ ). The TEX86 record also displays intervals of unusually warm or cold temperatures, but these are always associated with high BIT values during megadroughts, when the delivery of terrigenous GDGTs to the drill site was unusually high. We are continuing organic geochemical analyses on specific organic compound groups that provide insight into past rainfall variability in the region, and we are exploring innovative new ways to refine the geochronology in the drill core. While we are encountering bumps in the road, we have not driven into the ditch: the challenges of geochronology and aberrant TEX86 values will be resolved and this long, continuous record of past climate variability in tropical East Africa will become a standard against which other African paleoclimate records will be compared.

## S1-T04

### **TEXing While Driving in Lake Malawi: Are We Staying on the Road?**

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**S1-T05****Late holocene lacustrine sedimentation of the Vellayani Lake, Kerala, India**Veena M P<sup>1</sup>, Hema Achyuthan<sup>2</sup><sup>1</sup> Anna University, Chennai, India**Email:** veenamknair07@gmail.com

Lakes preserve successive sediment deposition that can be used to understand the paleoenvironment of that region over a period of time. Sediment deposition is an important natural process that operates through a chain of actions involving erosion, transportation and finally deposition. The sediments are both carriers and potential sources of natural geochemical constituents derived principally from rock weathering. In this paper we present the texture analysis, geochemistry, organic matter and calcium carbonate study of Vellayani lake sediments, Kerala, to infer the Late Holocene paleoenvironmental change. Vellayani Lake, Kerala, covers nearly 5.5 km and is the second largest freshwater lake in the Kerala State. It is a south west monsoon rain-fed and freshwater lake. The water is extensively used for drinking and irrigation purpose. The topography consists of a hot and wet coastal plain gradually rising in elevation to the high hills and mountains of the Western Ghats. The study area receives an average annual rainfall of 3000 mm/yr from both the southwest and northeast monsoon. The maximum and minimum temperature is 29°C and 18°C. The bedrock in the study area is represented by the Archean rocks and is overlain by Tertiary marine sedimentary sequences. A 145 cm long core recovered from Lake Vellayani, Kerala (N 080° 26' 09" and E 760° 59' 22") reflects the Holocene environmental history from ca. 3025 cal. yr BP (Radiocarbon dated) and the sedimentation rate is ~0.55mm/year. Grain size analysis, major oxide, trace element and REE data reveals distinct down core sediment variations. The retrieved sediment from the core reveals that the coarse sediment unit (50-130 cm) is sandwiched between the fine-grained sediments at the top and lower layers.

High sand content in the sediment core is due to short term aridity. CIA values of the sediments points towards intense chemical weathering process. The A-CN-K diagram reveals high percentage of plagioclase feldspar grains, and the source rocks are the charnockites while the LREE enriched, flat HREE pattern with -ve Eu anomaly points towards felsic rock source for the sediments and Post Archean in origin.

**S1-T06****Variation in old-carbon age offset and sediment accumulation rates inferred from a high-resolution <sup>14</sup>C chronology for a 25-kyr lake-sediment record from East Africa**Dirk Verschuren<sup>1</sup>, Maarten Blaauw<sup>2</sup>, Bas van Geel<sup>3</sup>, Birgit Plessen<sup>4</sup>, Christian Wolff<sup>4</sup>, Hans van der Plicht<sup>5</sup><sup>1</sup> Ghent University, Gent, Belgium<sup>2</sup> Queen's University, Belfast, UK<sup>3</sup> University of Amsterdam, Amsterdam, The Netherlands<sup>4</sup> Helmholtz Centre Potsdam, Potsdam, Germany<sup>5</sup> University of Groningen, Groningen, The Netherlands**Email:** dirk.verschuren@UGent.be

We dated a continuous, ~22-meter long sediment record from Lake Challa (Mt. Kilimanjaro area, Kenya/Tanzania) to produce a solid chronological framework for multi-proxy reconstructions of climate and environmental change in equatorial East Africa over the past 25,000 years. The age model is based on a total of 168 AMS <sup>14</sup>C dates on bulk organic matter, corrected for a variable old-carbon age offset estimated from i) bulk-organic <sup>14</sup>C dates paired with either Pb-derived time markers or <sup>14</sup>C dates on grass charcoal, and ii) wiggle-matching high-density series of bulk-organic <sup>14</sup>C dates. The old-carbon age offset varies through time from ~450 yr during glacial and late-glacial time to ~200 yr during the early and mid-Holocene, and again to ~250 yr today. The screened and corrected <sup>14</sup>C dates were calibrated sequentially, statistically constrained by their stratigraphical order. The dating precision gained with this method partly offsets the uncertainty added by having to subtract a

modeled old-carbon age offset from each bulk-organic  $^{14}\text{C}$  date, particularly in densely dated sections of the sequence. The final smooth-spline age-depth model has 95% age uncertainty ranges varying from ~50 to ~230 yr during the Holocene and from ~250 to ~550 yr in the glacial section of the record. Applying a spline smoothing parameter of 0.60 produced an age-depth curve running through most posterior age distributions of the dated intervals while avoiding too sharp inflections and age reversals. Modest variation in this smoothing parameter scarcely affects sediment age at depth, but significantly affects the inferred magnitude of variation in sediment accumulation rate. The chosen parameter value implies sedimentation-rate variability consistent with varve counting in selected intervals of the core. Finally, to better

understand the origin of the old-carbon age offset in Lake Challa sediments we compared its temporal variation with  $\delta^{13}\text{C}$  values on all C-dated samples and with contiguous high-resolution records of total organic carbon (TOC), the molar carbon to nitrogen (C/N) ratio, and bulk-organic  $\delta^{13}\text{C}$ . The old-carbon age offset in Lake Challa sediments can be attributed to a variable contribution of old terrestrial organic matter eroded from soils, not a true hard-water effect causing phytoplankton algae to assimilate dissolved inorganic carbon (DIC) with reduced  $^{14}\text{C}$  content relative to the atmosphere. The greater age offset during glacial time than during the late-glacial and Holocene is consistent with evidence for reduced vegetation cover inside the crater before ~15,000 years ago.

## S2-T01

### Deep water stratification in Japan's very deep caldera lakes

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From six deep caldera lakes in Japan, namely lakes Ikeda, Towada, Tazawa, Toya, Kuttara and Shikotsu, fine resolution profiles of temperature, electrical conductivity, dissolved oxygen and pH have been measured (Boehrer et al. 2009). The measurements were conducted at the end of the deep circulation period in the time interval end of March to end of May 2005. From single profiles, we could draw conclusions about the circulation

in the previous winter, and give some implication on the general circulation behaviour of the lakes. Two lakes (Lake Ikeda and Lake Towada) showed meromictic features with a clear interface separating the recirculated mixolimnion from the deeper monimolimnion. Lake Tazawa and Lake Toya showed a complete turnover in the winter 2004 / 05.

In Lake Kuttara and Lake Shikotsu, a deep water body remained throughout the winter due to pressure effects on the temperature of maximum density (see e.g. Boehrer and Schultze, 2008). Although these deep waters were never fully recycled into the surface water, they presented themselves as well supplied with oxygen. The incomplete overturn can be inferred from changes in the profiles of oxygen, and conductivity at a depth of 125m. Due to pressure effects, temperatures considerably lower than 4°C were conserved into the summer stratification in Lake Toya, Lake Kuttara and Lake Shikotsu. Typical features of these temperature profiles can be simulated in a simple model by considering local stability and lateral

homogeneity of the lakes. Particularly in Lake Kuttara, the predicted hugging of the temperature of maximum density profile (T<sub>md</sub>) can be confirmed, while Lake Shikotsu shows the predicted isothermal deep water body.

The series of lakes of similar shape and size covered geographical latitudes from 31°N to 43°N, which in particular included the transition from thermobaric stratification to oligomictic circulation. As a consequence the measurements themselves showed the difference of a climate gradient directly. In addition, high accuracy point measurements in the deep waters of these lakes from 1930s (Yoshimura 1936) could be retrieved. Lakes located in the warmer climate were more susceptible to changes than the lakes located in the colder region (Boehrer et al. 2008).

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## S2-T02

### **A comparative study of six tropical, maar lakes in Eastern Mexico: trophic status, water chemistry and diatom assemblages**

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This work was undertaken to study the diatom assemblages in plankton and sediment samples from six tropical maar lakes along a nutrient-depth gradient. The lakes were visited during well established stratification (June), temperature and oxygen depth profiles as well as transparency (Secchi disk visibility) were measured in situ and samples were collected for water chemistry, nutrients, chlorophyll a and phytoplankton analyses. Surface sediment samples were also collected for diatoms and magnetic susceptibility. Monthly water samples (phytoplankton and chlorophyll a) were also collected in the three deepest lakes during a 15 month interval. Cluster analysis and canonical correspondence analysis (CCA) were applied to the matrix constructed with diatom relative abundance in plankton and sediment samples, for the CCA the environmental variables matrix included ion concentration (meq/l) and ion dominance (%).

According to chlorophyll a and transparency a productivity-depth gradient was present in our lakes and the three shallower lakes were the most productive (hypereutrophic). The deeper lakes were eutrophic (1) or mesotrophic (2). Phytoplankton in the eutrophic lake was dominated by cyanobacteria with diatoms accounting for 10% of the cell counts in the average of the monthly data and with a diatom abundance maximum during mixing. In the two mesotrophic lakes phytoplankton was dominated by chlorophyta, diatoms accounted for 20% of the cell counts in the average of the monthly data and the main diatom bloom was during late stratification. Nutrient data showed that phosphorous was particularly high (TP range 350-790 µg/l) and that the two mesotrophic lakes had a low DIN/RP ratio which suggest that during well established stratification they could be nitrogen limited.



However the cluster analysis and the CCA separated the lakes in three groups according to cation dominance, which was the major environmental factor determining diatom distribution between the lakes. The Na<sup>+</sup> dominated lakes (3) had a diatom assemblage where *Achnanthes minutissimum* accounted for over 50% of the diatom counts both in sediment and plankton samples. The Mg<sup>++</sup> dominates lakes (2) had a diatom assemblage with lower *A. minutissimum* abundance (<30%) in association with *Cymbella microcephala*. The Ca<sup>++</sup> dominated lake (1) showed a diatom assemblage where *Navicula arvensis* and small *Stephanodiscus* spp. were most abundant. In these lakes species such as *A. minutissimum* and *C. microcephala*, usually considered as benthic taxa seem to have a true planktonic habitat.

Human impact in these lakes is important, magnetic susceptibility data indicate high erosion rates most likely due to deforestation and agricultural activities and in one of these lakes high Cl<sup>-</sup> levels seem to be related with inflow of waste waters.

## S2-T03

### The unusual physics of Lake Kivu and its importance for biogeochemical processes and methane exploitation

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Lake Kivu, a rift lake situated between the Democratic Republic of the Congo and Rwanda, is one of the most extraordinary lakes in the world. The lake is 485 m deep and has a surface area of 2370 km. Seasonal mixing processes in the top 60 m of the water column are similar to other tropical lakes, with deep mixing occurring during the dry season

and stable stratification during the longer wet season. Below 60 m the lake is permanently stratified, and temperature as well as dissolved salts and gases increase with depth. Its deep water, located below a major chemocline at 260 m depth, is largely decoupled from the surface waters. Residence times of dissolved gases and nutrients in this deep water are on the order of almost 1000 years. Thus, nutrients and gases had time to accumulate below the chemocline to unusually high concentrations of up to 19 mmol L methane, 4 mmol L NH<sub>4</sub>, and 0.2 mmol L PO<sub>4</sub>. In total, the lake contains ~60 km of dissolved methane. This is a highly valuable resource for the bordering countries, and several pilot methane extraction facilities are currently either in operation or in planning. The deep water of the lake is fed by various subaquatic springs. It has been estimated that these springs contribute about one third to the outflow of the lake. They drive a slow but continuous upwelling of the entire water column with a depth-dependent rate of 0.15 to 0.9 m yr. This upwelling is the main source of nutrients for the productive surface layer. The combination of the continuous upwelling and the interannually highly varying seasonal mixing results in a intermittent supply of nutrients and corresponding primary production. Furthermore, the upwelling rate may have increased due to higher precipitation rates after 1960, which may have promoted primary production and subsequent methane formation from the degradation of settling organic matter. The complex interactions between physical and biogeochemical processes need to be taken into account in the design of methane extraction facilities in order to avoid jeopardizing the fragile ecosystem.

## S2-T04

### The unique geomorphology, geochemistry and archaeal composition of the subaquatic springs that sustain Lake Kivu's stratification

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Lake Kivu is situated just south of the equator in the East African rift valley on the border of Rwanda and the Democratic Republic of the Congo. The lake dates back to the mid-Pleistocene epoch, has an area of 2370 km<sup>2</sup>, a volume of 580 km<sup>3</sup>, and a maximum depth of 485 m. Lake Kivu is renowned for its concentration of methane (60 km, STP) and CO<sub>2</sub> (300 km, STP) that have accumulated in its hypolimnion over hundreds of years. The possibility of a lake turnover from the expulsion of these gases is limited by the steep density gradient observed at 260 m depth. This gradient is sustained by salt and CO<sub>2</sub> entering with hydrothermal inputs in the hypolimnion in conjunction with a fresh groundwater input producing a dilute layer above the gradient. The lake has experienced tectonic, volcanic and climatic events culminating to its present day structure. However, the greatest uncertainties pertaining to the future stratification of Lake Kivu are the subaquatic springs that sustain it. Several sources of groundwater have been located in the Northern basin of the lake where geomorphology, geochemistry, and archaeal diversity were characterized to determine their influence on the lake stratification. A high resolution, swath bathymetric map of the Northern basin was produced where a geomorphology associated with tectonic and volcanic activity was determined. Furthermore, simulations of groundwater discharge and precipitation of minerals at the location of the subaquatic springs were conducted. A high concentration of Fe<sup>+</sup> is associated with hydrothermal springs, where the source water may be coming from Kabuno bay that is connected to the Northern basin by a small channel. Additionally, the archaeal analysis of surface sediment revealed a high prevalence of an unidentified group of archaea indicating unique biogeochemical pathways. The implications of these findings

are currently being studied and imply diverse physicochemical and biogeochemical processes at the subaquatic springs in Lake Kivu.

## S2-T05

### Observed anomalous CO<sub>2</sub> emission changes at Taal crater lake, Philippines: a geochemical evidence for a recent volcanic unrest?

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Taal volcano is one of the most active volcanoes in the Philippines and has produced some of its most powerful historical eruptions. Located on the southwestern part of Luzon Island in the Philippines Archipelago, the volcano consists of a 15-22-km prehistoric caldera, occupied by Lake Taal, the active vent complex of Volcano Island and the Crater Lake (TCL), 1.9 km in diameter. Six of 24 known eruptions at Taal since 1572 have caused many fatalities, and several million people live within a 20-km radius of Taal's caldera rim, making the volcano the largest threat to the Philippine population. Typical precursory signals of Taal eruptions are increase in frequency of quakes with occasional felt events accompanied by rumbling sounds, increase in temperature and level of TCL, development of new thermal areas and/or reactivation of old ones and ground swells or inflation. An alarming increase in seismicity, gas emission, deformation and temperature of the TCL, from March 2011 has been interpreted as the result of a new magma intrusion beneath TCL. These signs of growing instability prompted PHIVOLCS to place Alert Level 2 in April. Since 2008, ITER in collaboration with PHIVOLCS and with the

support of the Minister of Science and Education of Spain and the Spanish Aid International Agency (ACECID), has been performing regular CO<sub>2</sub> efflux surveys at the surface of TCL. Measurements have been performed following the accumulation chamber method to determine the scale of total CO<sub>2</sub> emissions at the TCL and to evaluate their temporal and spatial variations in relation with the volcanic-seismic activity at Taal. Together with these measurements, water temperature, pH and conductivity have also been undertaken. Results of CO<sub>2</sub> efflux surveys performed in April 2008, February 2009, March 2010, August 2010, February 2011, and March 2011, showed total diffuse CO<sub>2</sub> outputs of 506 ± 15 t/d; 948 ± 22 t/d; 763 ± 18 t/d; 2716 ± 54 t/d, 1908 ± 68 t/d and 4670 ± 159 t/d, respectively. A clear increasing trend has been observed from February 2011, with an onset on the CO<sub>2</sub> diffuse emission recorded in March 2011. These results reveal significant variations from 2008 to 2011 and do not seem to be masked by external variations, showing a temporal correlation with the onsets of high frequency seismic events recorded by PHIVOLCS at Taal. The increase of stress in the rocks surrounding the reservoir due the movement of magma and inflation of the volcano might explain the recorded seismicity at Taal. These geochemical and geophysical observations support unrest of the volcanic system indicating anomalous gas release from the magma at depth, as is also suggested by other geophysical/ geodetical observations such as water temperature increase from 30.1°C to 31.8°C, water level recede at TCL from 0.36 m to 0.33 m, and a slightly inflation recorded at the Taal Volcano Island by a ground deformation surveys (precise levelling; PHIVOLCS). The above observations suggest subsurface magma movement as the cause for the observed changes in the total output of diffuse CO<sub>2</sub> emission at TCL, and CO<sub>2</sub> efflux surveys appear to be an effective volcanic surveillance tool for Taal volcano.

## S2-T06

### **Chemical and isotopic features of dissolved gases in Albano, Averno and Monticchio**

### **volcanic lakes (central-southern Italy): new tools for Nyos-type lake monitoring**

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Lakes hosted in non-active volcanoes may store large amounts of gases, mainly CO<sub>2</sub> and CH<sub>4</sub>, when these are: i) added from sub-lacustrine vents or ii) generated by microbial activity. Such gas accumulation at depth may be favouring a pronounced vertical thermal, chemical and isotopic stratification of these water bodies. External perturbations (i.e. earthquakes, landslides, heavy rains) able to affect the stability of deep lake strata may trigger massive release of dissolved gases ("limnic eruptions") similar to those occurred at the Cameroon Lakes Monoun and Nyos in 1984 and 1986, respectively. These events can pose a severe hazard if occurring in densely populated areas.

Several lakes are hosted in the central and southern volcanic systems of the Italian Peninsula, although those characterized by chemical and thermal stratification with significant amounts of non-atmospheric dissolved gases at depth are: Albano (Alban Hills), Averno (Phlegrean Fields) and Monticchio Grande and Monticchio Piccolo (Mt. Vulture). The distribution of the dissolved gas composition along the vertical profiles of these lakes is similar, being dominated by N<sub>2</sub> in the oxic epilimnion, whereas CO<sub>2</sub> is the main gas species in the anoxic hypolimnion. The vertical pattern of CH<sub>4</sub> concentration intimately mimics that of CO<sub>2</sub>, both showing significant increases from surface to bottom. The d<sup>13</sup>C-CO<sub>2</sub> values of Monticchio Grande, Monticchio Piccolo and Albano lakes (ranging between -5.8 and -0.4‰ V-PDB) are consistent with those of mantle-derived CO<sub>2</sub>. Conversely, at Averno lake the d<sup>13</sup>C-CO<sub>2</sub> values

are between -13.4 and -8.2‰ V-PDB, supporting the occurrence of prevalent organic CO<sub>2</sub>. The d<sup>13</sup>C-CH<sub>4</sub> and dD-CH<sub>4</sub> values of all the investigated lakes, as low as -67‰ V-PDB and -283‰ V-SMOW, respectively, suggest that the CH<sub>4</sub> production is mainly due to bacterial activity. The d<sup>13</sup>C-CO<sub>2</sub> values progressively increase with depth, whereas the carbon isotopes in methane have an opposite trend. This contrasting carbon isotopic distribution of the two main gaseous species can be related to: 1) CO<sub>2</sub>-CH<sub>4</sub> isotopic exchange; 2) reduction of CO<sub>2</sub> to CH<sub>4</sub> in the anoxic hypolimnion; 3) oxidation of CH<sub>4</sub> to CO<sub>2</sub> in the oxic epilimnion; 4) direct production of CH<sub>4</sub> and CO<sub>2</sub> by bacterial activity.

The morphological features (water volumes of Monticchio Grande, Monticchio Piccolo, Averno and Albano are 3.3x10, 4x10, 6x10 and 450x10 m, respectively) and the relatively low total gas concentrations (max. 19.4 mmol/L at -39 m in Monticchio Piccolo) suggest that the gas reservoirs of these lakes don't currently represent a serious hazard for limnic eruptions. Nevertheless, this study demonstrates that the vertical patterns of the CO<sub>2</sub>/CH<sub>4</sub> ratio and the d<sup>13</sup>C-CO<sub>2</sub> and d<sup>13</sup>C-CH<sub>4</sub> values are important geochemical tracers able to record any change in depth of the oxic and anoxic layers, thus representing new and very promising monitoring tools for evaluating the recharge rate of CO<sub>2</sub>-rich extra-lacustrine fluids.

## S2-T07

### **Water structure and circulation dynamics of two maar lakes (Mt Vulture, Italy): geochemical constraints.**

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Lago Grande and Lago Piccolo of Monticchio, hereafter called LGM and LPM respectively, are two volcanic lakes which occupy maar craters formed during the last activity (~140 ka ago) of Mt Vulture volcano. Previous geochemical studies recognized the gas-rich nature of the LPM waters. In contrast, studies on LGM have so far been mainly focused on palaeoclimatic aspects.

We present the results of physico-chemical investigations we have been carrying out on these lakes since Sept. 2008. CTD profiles have shown the stratified structure of both lakes, their changes over time and a lateral homogeneity of both temperature and composition of the waters. By using the chemical and isotopic composition of the waters, we have found that both lakes are mainly fed by sublacustrine springs and have identified two additional springs at intermediate depths in LPM.

We show that, contrary to what stated in literature, LGM waters cannot directly derive from evaporation of LPM waters, and explain the acquired geochemical data by simultaneous processes of evaporation and groundwater inflow. Furthermore, by means of an energy budget method, we have estimated the extent of evaporation on the basis of in situ acquired meteorological parameters. Moreover, for the first time we have ascertained that, like LPM, the LGM waters are also characterized by large amounts of dissolved gases, mainly CO<sub>2</sub>, CH<sub>4</sub> and atmospheric gases. Waters sampled close to the bottom of LPM show dD (H<sub>2</sub>O) values indicating a meteoric recharge at about 920 m (a.s.l.); they are anoxic and strongly air undersaturated, thus implying they underwent outgassing processes.

CTD profiles and dissolved gases indicate that LPM is permanently stratified (meromictic), whereas LGM has a complete overturn in springtime (monomictic). The trophic state of the lakes has a relevant role. The shallow water of LGM is highly turbid (Secchi-extinction depth < 30 cm), whereas LPM water is clear with high Secchi-depth. This contrast may contribute to the different behaviour in

stratification stability of the two lakes, favouring turnover in the former and gas accumulation in the latter. Also, in spite of the continuous supply of both CH<sub>4</sub> and dissolved carbonates and their relatively transport towards the surface, only part of the produced CH<sub>4</sub> is released into air, as CO<sub>2</sub> degassing at air-water interface is normally prevented by the increase in pH values to above 8.2, caused by chlorophyllian photosynthesis which promotes carbonate precipitation.

The high sensibility of the CTD probes allowed us to evaluate eddy diffusion, estimating both heat and mass transport along water columns. LPM shows a heat flow of 75 mW m<sup>-2</sup> s<sup>-1</sup>, in excess of at least 20 mW m<sup>-2</sup> s<sup>-1</sup> if compared with the expected values. CH<sub>4</sub> is generated by both acetate fermentation and CO<sub>2</sub> reduction. Differently to what reported in literature, the d<sup>13</sup>C (CO<sub>2</sub>) values fall along an essentially inorganic signature and the CO<sub>2</sub>, together with He, is almost all of mantle origin.

## S2-T08

### **Mantle-derived fluid injection into maar Monticchio lakes, Mt. Vulture volcano (Italy): limnic versus volcanic eruptions?**

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Lago Piccolo (LPM) and Lago Grande (LGM) of Monticchio are situated in two explosion craters of Mt. Vulture volcano; they formed ~140 Ka ago during the last explosive volcanic activity when a relatively small volume of erupted magma sprayed out over a large area. Today this area is occupied by towns. Although the two lakes are very close to each other, only LPM is permanently stratified. The major dissolved volatiles are biogenic methane and CO<sub>2</sub> having an isotopic signature in the range of mantle-derived CO<sub>2</sub>. Dissolved helium displays a seasonal change in its isotopic ratio between 6.1 and 5.3 Ra (Ra is atmospheric He/He isotopic ratio), which is

well within the range of values measured in the olivine fluid inclusions (both of mantle xenoliths and dispersed in the pyroclastics) of LPM maar ejecta.

Stratified crater lakes are able to dissolve huge quantities of gases which can suddenly be released as a consequence of a triggering event (i.e. gas supersaturation at depth, flank instabilities, turnover, etc.). Although we cannot expect catastrophic events such as those which occurred at lakes Monoun and Nyos, nevertheless we have estimated that the equivalent volume of gases (CH<sub>4</sub> plus CO<sub>2</sub>) could be released instantaneously following a limnic eruption of the Monticchio lakes. These gases could reach a volume, at atmospheric pressure, of 2.3x10 m for LGM and of 5.8x10 m for LPM, which are equivalent to a lethal gas layer of ~0.6 m and ~3.5 m above the entire surface of the waters of LGM (427,000 m) and of LPM (172,000 m) respectively. Furthermore, taking into account the volcanic activity of Mt. Vulture, characterized by long lasting inter-eruptive periods (up to 350 ka), the continuous supply of mantle derived fluids (i.e., He and CO), the 75 mW ms heat flow from the LPM bottom, which are well above regional values, the estimated 3He/heat ratio of 2.13 x 10 atoms/J and the C/He ratio of 8.3 x 10, which are in the range of sub-continental mantle, and the catastrophic gas bursts that occurred in November 1820, the possibilities of a gas eruption, triggered by crustal accumulation of mantle-derived CO<sub>2</sub>, and/or the resumption of explosive volcanic activity cannot be ruled out. For these reasons we strongly recommend that further investigations be carried out. Therefore, we hope that our results will draw attention to all those crater lakes located in volcanic areas that are apparently no longer active, paying special attention to those situated in areas of tourist interest, where gas risk is probably underestimated or even ignored.

## S2-T09

### **Geochemical Surveys on Specchio di Venere Lake, Pantelleria Island, South Italy.**

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Lake Specchio di Venere (also known as Bagno dell'Acqua) is an endorheic saline lake within a calderic depression on Pantelleria, a quiescent volcanic island in the Sicily Channel, between Tunisia and South Italy. This endorheic basin has been formed through upwelling of the water table, and that it is continuously fed by the thermal springs situated on its shores. The mineralogical characterisation of the bottom sediments shows the almost exclusive presence of neoformation minerals, mainly carbonates, formed in response to the pH gradient between spring- (pH = 6) and lake-waters (pH = 9). The lake continuously receives a contribution from the thermal spring located on its shores.

In the shore of lake, CO<sub>2</sub> fluxes and concentrations were measured with the accumulation chamber method for a total of 136 measurements. Furthermore a vertical profile of main water chemical-physical characteristics (EC, pH and T) and a bathymetric survey have been made.

The total CO<sub>2</sub> output of the anomalous degassing areas was estimated. We have obtained a total output of about 0.349 kg s<sup>-1</sup> over an area of about 0.103 km<sup>2</sup>. Carbon dioxide concentrations in soils ranged from 0.035 (atmospheric value) up to 95 % by volume. The spatial distribution of the sites with anomalous CO<sub>2</sub> concentrations closely resembles those of the sites of anomalous CO<sub>2</sub> fluxes.

Groundwaters of Pantelleria, lake included, are the result of the mixing among sea water, meteoric waters and geothermal waters. Periodical sampling of the surface water, far from the hydrothermal manifestations, revealed variations in the chemical and isotopic compositions due to the annual meteoric recharge - evaporation cycle. On the contrary the waters of the thermal springs feeding the lake revealed a stable

composition. The high concentration in alkali, mainly Na, are the result of notable interactions between waters and Na-rich rocks (Pantelleriti). Nevertheless the large amount of babbling CO<sub>2</sub>, the concentration of C species are very low because of their intense precipitation as carbonates. Lake waters and groundwater flowing in it are originated by the mixing among sea water, rain waters and a local geothermal water.

In May 2006 and in May 2007 the waters of the lake Specchio di Venere were inspected with one vertical profile. Vertical profiles didn't show variation with depth of chemical-physical characteristics and in gas dissolved composition. Such results exclude the presence at that time of any thermal or chemical stratification of the lake. Also the analysis of dissolved gases did not evidence anomalous gas accumulations in the lake waters. The frequent overturning of the water lake, together with morphological (small volume and shallow dept) and chemical (high pH) preclude the dangerous accumulation of CO<sub>2</sub> gas on the lake bottom.

## S2-T10

### **Fluid circulation at Laguna Caliente (Poás Volcano, Costa Rica) during the 2006-2011 phreatic eruptive cycle: how and how much?**

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In March 2006, Poás Volcano resumed phreatic eruptive activity after almost 12 years of quiescence. Until January 2011, 385 eruptions were reported of which 359 phreatic eruptions occurred in 2010. Poás Volcano hosts Laguna Caliente, one of the largest reservoirs of a natural hyper-acidic brine at the Earth surface. This study presents temporal variations of the chemical and isotopic composition of Laguna Caliente water

before and during the ongoing eruptive cycle. These temporal variations though demonstrate that changes in water chemistry do not systematically correlate with the eruptive activity. A combined mass, isotope and Cl balance approach, considering "non-volcanic" factors (i.e. meteoric precipitation, evaporation from the lake surface, seepage) permits to quantify and characterize the "volcanic" input. The temporal variations of the extensive parameter "volcanic" input and its relation with the eruptive activity provides an extra tool during volcanic surveillance of Poás Volcano. A major concern is the quantification of the seepage out of the magmatic-hydrothermal summit system, an unmeasurable subsurface process. The seepage rate can be estimated for short-term quiescent periods showing a lake level drop, resulting in ~50 kg/s of water loss out of the summit system by seepage. Such low seepage rates though do not lead to the observed chemical and isotopic composition of Laguna Caliente water, suggesting that crater lake water recycling is a dominant process at the limit between the lake bottom and the underlying magmatic-hydrothermal system. A basic modeling approach permits to estimate this rapid lake water convection resulting in rates of 125-350 kg/s in and out of the lake system. Calculated residence times vary from 5 months to >3 years, making Laguna Caliente water less sensitive for sudden variations in lake water chemistry due to changes in volcanic activity. Nevertheless, it seems that the phreatic eruptions are accompanied by enhanced lake water recycling or the input of an isotopically light vapour phase.

## S2-T11

### **Multi-proxy evidence for late Holocene environmental change at Big Soda Lake, Nevada, Western United States**

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During the past 130 years paleolimnological research in the Great Basin region of the western United States has produced an extensive record of late Quaternary environmental change. Most of this research has focused on changes in lake level and their implications for understanding climate change in the region. Despite the progress that has been made, relatively few of these studies have focused on high resolution sub-decadal scale records.

The preliminary results of multi-proxy analyses on the upper 4-meters of laminated sediment recovered from Big Soda Lake, a maar lake in the Carson Sink near Fallon, Nevada is presented. Stable isotopes, pollen, diatoms, XRF, XRD, magnetic susceptibility, grain size, and LOI analyses have been employed to produce a 3,000 year record of regional climate change for the study area. Core chronology is provided by <sup>239+240</sup>Pu, <sup>210</sup>Pb, and the first appearance of non-native pollen types, radiocarbon, and several dated tephras.

High resolution d<sup>18</sup>O and XRF data indicate sub-decadal changes in lake level during the Late Holocene and more recently, changes associated with disturbance alongside the lake during the late 19 and early 20 centuries. Oscillations in the oxygen isotopic record during the pre-historic period indicate significant changes in lake water levels. Oxygen isotope data indicate the period between A.D. 1675 and A.D.1725 (i.e. Little Ice Age) was wetter than normal, with higher than average lake level. Oscillations in the d<sup>18</sup>O record for the period that spans the Medieval Climate Anomaly (circa A.D. 900- A.D. 1350) reflect climate conditions that were both wetter and drier than average. Evidence for any major reduction in lake level associated with "mega droughts" that have been reported elsewhere for the western Great Basin region during this time period do not appear to be present in Big Soda Lake.

Preliminary analysis of diatom communities indicates that the lake was first a freshwater lake from 9 m to about 5.4 m depth in the sediment, probably from filling with fresh

groundwater after the maar exploded and became progressively more saline by evaporation. From 5.4 to 4 m depth the lake appears to have been brackish. At about the same interval where the sediments become finely laminated (about 4 m depth), conditions were close to the salinity of the present lake, although finer scale variations in salinity can be seen in the isotopic signature. The presence of occasional blooms of *Chaetoceros muelleri* in the upper 4 m indicates higher productivity and possible freshening of the lake at certain times.

Big Soda Lake is primarily fed by precipitation and groundwater inputs and therefore changes in lake level are related to regional climate shifts. The abrupt change in the oxygen isotopic composition in the recent record marks the introduction of fresh groundwater to the lake after the construction of Lahontan Dam.

## S2-T12

### **Noble gases in the sediment pore water as proxies for physical transport processes and past environmental conditions in Lake Van?**

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Since many decades unconsolidated sediments in lakes and oceans have been proposed as a potential archive for noble-gas records to reconstruct past environmental

conditions in lakes and oceans. In addition, the accumulation of non-atmospheric noble-gas isotopes allows tracing the geochemical origin and transport processes of the pore fluids. For instance, the abundance of terrigenous He isotopes reflects the residence time and transport dynamics of the pore fluids in the sediment. The He/He ratio of terrigenous He can be used to constrain the geochemical origin of the pore fluids. However, methods for reliable noble-gas analysis in sediment pore water have been developed only recently.

Lake Van (Turkey) is one of the largest terminal lakes and the largest soda lake on Earth. The physical conditions of the lake are known to react sensitively to changes in the hydrological cycle and the environmental conditions of the lake catchment. Therefore the noble-gas records in the sediments of Lake Van have a great potential as an archive for palaeoenvironmental research. Also, the basin of Lake Van is situated in a tectonically active region characterized by the presence of major faults and volcanos. The lake is known to accumulate mantle fluids. Noble-gas isotopes are therefore useful to study the origin and transport processes of terrigenous fluids in the sediment pore space and their release into the water body.

In this study we present noble-gas data measured in the pore water of sediment samples collected in Lake Van. On the one hand, data from short cores taken at different sites throughout the lake basin will be discussed. Furthermore, we intend to present first results from the noble-gas samples taken from a 220 m long core during the 2010 ICDP drilling operations of the PALEOVAN project.



**S3-T01****Climate, nutrients, water chemistry and volcanic eruptions - multiple stressors shape diatom communities in subarctic and alpine regions**

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Sedimentary diatom profiles at subdecadal resolution from lakes in Northern Europe (NW Iceland, N Sweden) and the Alps (SE Switzerland) have been analyzed to evaluate the effect of climatic variables in relation to other environmental stressors. Our results indicate that regional setting and site-specific environmental conditions shape the diatom communities, with climate as an important and crucial component.

Lake Silvaplana (SE Switzerland) is a deep, oligotrophic lake where planktonic *Cyclotella* taxa have been dominating the diatom assemblages for most of the last 1000 years. Periods of particularly harsh conditions (i.e., prolonged ice cover and low phosphorus and nitrogen supply) resulted in low planktonic productivity, which was manifested as an increase in the relative abundance of benthic taxa, affecting the ratio of planktonic to benthic diatoms. However, these diatom community changes did not affect the temperature signal derived from a regional diatom-temperature transfer function.

In Baulárvallavatn (NW Iceland), diatom assemblages during the last millennium are dominated by *Aulacoseira*, *Fragilaria* and *Cyclotella* taxa. We found major reorganizations of diatom communities during and after major volcanic eruptions. A regional diatom calibration set yielded higher performance statistics for winter

temperatures, indicating the important role of prevailing regional Ocean circulation patterns.

In northern Swedish lakes (Spåime, Stuur Guossásjavri), diatom assemblages are dominated mainly by *Fragilaria* and *Achnanthes* taxa during the last millennium. Catchment properties in both lakes affect the potential of temperature predictions using regional diatom-temperature calibration sets. For example in Spåime, the hydrological setting (short lake-water turnover time) has a strong effect on the diatom community, whereas the large amount of mire and bog area in Stuur Guossásjavri affects how the temperature signal is imprinted in the lake sediments.

Overall we conclude that geographical location and site-specific properties shape diatom communities, illustrating the importance of both large-scale climatic conditions and small-scale, local and site-specific variables. Even though temperature explains a significant part of the variance in surface diatom data, temperature reconstructions based on diatoms must be considered carefully, and with respect to other local environmental conditions.

**S3-T02****Combining aquatic chemistry basics and diatom-based transfer functions: the reconstruction of CO<sub>2</sub> saturation in an alpine lake throughout the Holocene**

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Among the constraints limiting cross-fertilization between palaeolimnology and current limnological studies, despite that both are dealing with the same ecosystems, is the

scarce overlapping in the variables they effectively measure. Connections are usually established on rather general conceptual bases but achieving a quantitative common playground is difficult. Here we provide an example of how palaeolimnological techniques can be applied to investigate long-term water chemistry dynamics. A diatom sediment record was used to assess the long-term inorganic carbon dynamics in poorly acid-buffered lake.

Using a training set of 115 high-mountain lakes in the Pyrenees, we found that both alkalinity and pH independently explained some of the variability in diatom assemblages. Transfer functions for both variables were developed and applied to a Holocene record from Lake Redon and CO<sub>2</sub> changes calculated. CO<sub>2</sub> saturation broadly followed alkalinity, which in turn was related to summer and autumn air-temperature fluctuations. In general, warmer climate during the ice-free period led to higher supersaturation, due to increased alkalinity, which facilitated retention of CO<sub>2</sub> from respiration, and decreased primary production (assessed by diatom fluxes). Only during the early Holocene, there were periods of extreme undersaturation, corresponding to cold periods of low alkalinity (<20 µeq L), and suggesting carbon limitation of primary production. The winter and spring climate, which determines the ice cover duration, appears to be relevant for CO<sub>2</sub> saturation only during periods when the organic matter content of the sediments was low (<22%). Longer periods of ice cover led to lower lake CO<sub>2</sub> saturation, suggesting that the ice cover influence on internal nutrient loading may regulate lake productivity fluctuations under low allochthonous nutrient and organic matter inputs. Alkalinity ca. 20 µeq L and sediment organic matter ca. 22% appear as critical thresholds in the way lake CO<sub>2</sub> levels respond to climate fluctuations in these lakes.

### S3-T03

#### Reconstructing seasonal climate signals using chrysophyte cysts

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Climate change involves alterations in seasonality as well as shifts in mean annual temperature. Cold temperate lakes show strong seasonality, with winter ice cover and alternating mixing and stratification periods during the ice-free season. These physical changes are ultimately related to seasonal weather variation and also drive annual phytoplankton succession. Therefore, phytoplankton remains in lake sediment records are potentially useful for reconstructing past seasonal climate signals. However, little research has been carried out on the subject. Here we present two lines of evidence demonstrating that chrysophyte stomatocysts can be useful for inferring past climatic seasonality. First, we show that marked seasonal stomatocyst replacement is related to periods of the main physical processes in the lake. Second, using instrumental climate data and microfossils in sediment cores, we show that two main components of stomatocyst variability over the last ~150 years are related to seasonal fluctuations. The first of these components is related to stomatocysts present during summer stratification that respond to general warming trends, particularly in July and August, although we could not reject some influence of atmospheric pollution. The second component, however, relates to stomatocysts typically present in the spring and autumn mixing periods. Numbers of these two stomatocyst types vary inversely in response to variation in spring (April-May) temperatures, which are forcing ice break-up dates. We provide evidence that chrysophyte stomatocysts are an excellent proxy for spring air temperature reconstructions, with little

influence from summer or general annual trends. We also show that with relatively little effort, it is possible to categorise the chrysophyte stomatocyst assemblage of a lake to carry out detailed investigation of the record of seasonal changes preserved within the sediment.

### S3-T04

#### High-resolution climate and environmental reconstruction from the last 15.000 years reflected in XRF core scan results on Swiss lake sediments

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Here we present new sedimentological and climatological results from Lake Soppensee and Baldeggersee, two lakes situated in prealpine Northern Switzerland. Both lakes are excellent high-resolution, continuous recorder of paleoenvironmental changes from the Late Glacial until today.

Climate has a strong influence on sedimentation rates, redox conditions, primary production, and the amount of erosive input to a lake, and this in turn affects the composition of the lake sediment. Specific elements and element ratios often characterize specific mineralogical compositions, lithological properties and redox conditions. Thus, we use X-ray fluorescence (XRF) core scanning for attaining high resolution (1mm) records of the elemental composition in the sediment cores in order to define the sediment's source and to reconstruct the paleo-environment and climate.

Both lakes feature a background sedimentation comprising mainly authigenic carbonates and organic matter. However, the sediments of Baldeggersee also contain a considerable amount of detrital material,

mostly deposited as turbiditic flood layers. The XRF results combined with the flood record and other proxies such as pollen assemblages and magnetic properties create a detailed picture of forcings and feedbacks within the sedimentological records. Elaborate chronologies established by conventional radiocarbon dating on plant macrofossils enable a detailed comparison of both lakes. This comparison illustrates lake system specific sensitivities to climate and environmental change, but also highlights larger scale synchronous shifts such as the deglaciation phase, the development of vegetation and soils in the Swiss midland in the late glacial and early Holocene, the mid-Holocene warm phase, variation in lake levels, early human impact, and the intense phase of modern industrialization.

Our results not only confirm previously published climate reconstructions of Switzerland and Europe, but add new insights about the development and effects of past environmental and climate change reflected in the elemental composition of various lake sediments.

### S3-T05

#### Holocene development of a high alpine lake controlled by climate, catchment processes, and seasonality shifts in insolation

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High alpine lake ecosystems are remarkably sensitive to climate change as even a small increase in temperature shortens the duration of the snow and ice cover of both the lake and

its catchment. We investigated the impact of Holocene climate oscillations in a long sediment core of Schwarzsee ob Sölden, a remote high alpine lake situated well above timberline in the Eastern Alps (2796 m a.s.l.). The multi-proxy analyses include diatoms, chironomids, pigments, pollen, plant macrofossils, geochemistry, and mineralogy. The sediment core covers the entire lake history from the last deglaciation to present. After deglaciation, during a warm and presumably dry climate, the lake was rapidly colonized as seen from the diatom and chironomid record. However, it took over 2000 years, until 8000 years before present (cal. yr BP), for the lake to become more productive as reflected by an increase in organic carbon content, and algal and chironomid remains. This was the onset of a warm but likely more humid period that lasted until ca. 5000 cal. yr BP. The increase in productivity is consistent with a shift from a plankton dominated carbon/nitrogen ratio to a higher C/N ratio that reflected a stronger input of organic matter from terrestrial plants. This increase also triggered the development of anoxic-alkaline bottom water conditions and affected the whole biogeochemistry by causing siderite ( $\text{FeCO}_3$ ) precipitation in this acid, calcium poor lake. Although the catchment had only a scarce and discontinuous soil layer, the development of a slightly more productive soil during favorable climatic conditions significantly affected the lake properties. With the onset of a colder period around 5000 to 4500 cal. yr BP, the C/N ratio decreased again and the lake became less productive and less anoxic. The July air temperature remained low until the 20 century. Recently an increase in temperature and productivity is evident, but not to the previous level observed between 8000 and 5000 cal. yr BP. The modification in summer and spring insolation is responsible for the two major shifts in the system around 8000, and 5000 to 4500 cal. yr BP by affecting water temperature, stratification, and duration of the ice-cover.

### S3-T06

#### Neolithic lake pollution of Lake Nussbaumersee (Thurgovia, Switzerland) as evidenced by Non-Pollen Palynomorphs

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Evidence for prehistorical lake water pollution gains more and more attention due to today's large scale water pollution in some areas of the world. Here we present palaeoecological reconstructions of changes in trophic levels from Lake Nussbaumersee, well known for its extensive presence of pile dwellings during the Neolithic and Bronze Age periods. Analysis of ample amounts of non-pollen palynomorphs (e.g. cyanobacteria, algal cysts, fungal spores) clearly indicates heavy prehistorical lake water pollution. Eutrophication of the lakes took place due to intense agriculture, faeces runoff and human settlement activities, which may also have been responsible for an ecological collapse of the prehistorical village societies. In addition, the results show that recovery of the lake ecosystems and lake water quality occurred within a few decades after abandonment of the settlement areas, as evidenced by the subsequent growth of hydrophytes needing oligotrophic water conditions. This suggests a high level of resilience to eutrophication of lake ecosystems in prehistorical times. Our results are highly relevant for environmental pollution issues today.

## S3-T07

**Past and recent Sedimentation in Lake Baikal as influenced by tectonic activities**Michael Sturm<sup>1</sup>, Elena G. Vologina<sup>2</sup><sup>1</sup> Eawag-ETH, Duebendorf, Switzerland<sup>2</sup> Inst. Earth Crust SB-RAS, Irkutsk, (Russia)**Email:** sturm@eawag.ch

The intracontinental basin of *Lake Baikal*, situated at the Eurasian and Amurian Plate boundary, represents a pull-apart system with deep, asymmetric half-graben basins. Each year the area is hit by an average of 2000 minor to large earthquakes (Atlas of Baikal, 1993).

We report on the influence of tectonic activities on different patterns of sedimentation at three lake sites of Lake Baikal:

- 350 m to 650 m deep *Continent Ridge* within the N-basin
- 5 m deep *Proval Bay* at the northern part of Selenga River Delta
- 1300 m deep basin plain off *Sharyzhalgai* at the southwestern end of the lake

SW-NE striking *Continent Ridge* is situated at the southern end of the N-basin. It is shaped by active faulting processes, which in turn lead to major stratigraphic unconformities within the sediment record by causing significant down-slope mass-movements. Sedimentation at *Continent Ridge* is dominated by pelagic and aeolian particle deposition. Bottom currents or deposition of turbidites do not occur at this site.

*Bay* at the northern part of the Selenga Delta (Selenga River is the lake's largest tributary), was formed by the catastrophic vertical dislocation of a big block of land during the earthquake of 1862 AD. This event moved the boundary of the delta area vastly to northeast and caused flooding of several Buryat settlements by about 1.8-5 m. Construction of

the Irkutsk hydroelectric power station in 1956 raised the water level of the lake by another 1.5 m. Subsequently, sand and turbidite sediments were deposited on top of former subaerial soils. Old lacustrine sediments of a former, shallow and eutrophic lake (Lake Beloe) were observed in recent sediment cores within the subsidized area at the north-east part of Proval Bay.

In August 1912 local newspapers reported the observation of extraordinary water movements at the water surface of the 1300 m deep S-basin, off the settlement of *Sharyzhalgai*. Dead deep-water fish and 'large quantities' of other dead water organisms were observed at the lake surface. It is assumed that aftershocks of a major earthquake in May (M=5.3) triggered the destabilization of gas hydrate and subsequent methane gas release (Radziminovich et al. 2010). Subsequent methane gas eruptions may have caused the sudden upwelling of hypolimnetic water masses and sediment particles towards the water surface. The event has been recorded in recent sediments.

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*This research was supported by Presidium-RAS project 16.17 and EAWAG*

## S3-T08

**Sediment focusing and wind driven bottom currents in the Finnish lacustrine basins**Jari Mäkinen<sup>1</sup><sup>1</sup> Geological Survey of Finland, Kuopio, Finland**Email:** jari.makinen@gtk.fi

One of the most common initial hypotheses concerning lake sediment studies is that the deepest part of the basin represents the sediment focusing area and coring of samples from that area will provide the best picture of the lake sedimentation history. This, however, needs re-evaluation especially in Finnish shallow di- polymictic lakes, with a mean depth of only 6 m.

Sediment morphology was studied in Lake Pyhäjärvi, located in the Pyhäsalmi municipality, using dual frequency echo sounding (24 and 200 kHz) and sediment sampling. Lake Pyhäjärvi is a headwater lake with the following dimensions:  $A = 115$  km,  $D_{\text{mean}} = 6$  m,  $D_{\text{max}} = 27$  m. According to the results, wind driven bottom currents have controlled the sedimentation, generating erosion areas to the deepest part of the lake and producing nodular Fe-Mn precipitations or precipitation aggregates. Shallower areas on the flanks of the deep are accumulation areas with longitudinal, dune-like gyttja formations. This kind of an erosion/sedimentation system has prevailed at least since 5500 BP.

During the last decades, however, there have been changes in the sedimentation dynamics, because some erosion areas have turned into accumulation areas and also the accumulation rates have changed in different parts of the basin. Two time markers have been utilized in the studies of recent sedimentation rates: elevated metal concentrations due to the Pyhäsalmi mine since 1962 and the Chernobyl fallout in 1986. The recent changes in the sedimentation dynamics are suggested to be linked with the lowering of the water level by 1 m in 1937 and/or changes in the strength and direction of the winds.

Deviation from the "normal" sedimentation pattern (i.e. focusing in the deep) was found also in other Finnish lakes, so the question of sediment focusing dynamics should be taken into consideration in coring site selection in the future.

### S3-T09

#### **Holocene erosion patterns in the high altitude Lake Anterne (NW French Alps): a witness of environmental changes, climatic variability and human activities**

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High altitude environments, in NW Alps, are strongly sensitive to erosion processes due to their steep slopes and the high quantity of precipitation. Like lakes act as natural traps of erosion products, lake sediments represent interesting archives of past hydrological activities. However, these environments were occupied by human societies for a long time, which can also have modified past erosion patterns. Indeed, human activities such as deforestation and grazing modify the soil stability and thus favour their erosion. Soil cover represents an interface affected by both human activities and climate, through the vegetation cover. Consequently, the study of soil evolution appears as a key point to trace these factors. However, due to complex interactions between humans, climate and environment, interpretations of sedimentary records remain often ambiguous. We thus propose to investigate these interactions by combining high-resolution quantitative and qualitative reconstructions of erosion, with palynological and archaeological studies. Our interdisciplinary study cover the Holocene period and was applied in the small catchment of Lake Anterne (2063-2472 m asl, NW French Alps).

Lake Anterne sediments are laminated: dark laminas formed by sands and coarse silts alternate with light and fine-grained laminas (fine silts/clays). Sometimes, laminations are interrupted by grain-supported deposits which were associated with floods. The monitoring of sediment transfer, from the catchment to the lake, shown both types of sediment deposits are triggered by rainfall events during summer and autumn. On the contrary to high latitude lakes, the snowmelt few contributes to sediment inputs. This process is probably not rapid enough to generate high stream power in such a small catchment area.

Organic and mineral geochemical analyses were realized on laminated sediments and soils in the catchment to determine their origin (surface or deeper horizons of developed soils, leptosols/rocks). These results, coupled with the assessment of sedimentation rate, flood deposit frequency

and thickness, underline soil and vegetation cover evolution. In particular, we evidence the progressive onset of vegetation and soils (carbonate dissolution and acidification) between 9950 and 7850 cal. BP. Then, a stabilization of soils due to a well-developed vegetation cover is recorded. From 5450 cal. BP, a regressive evolution of soils, with an increase of erosion, is triggered by colder and wetter conditions. This regressive evolution is reinforced by human impacts (deforestation, pastoralism) around 3400 cal. BP and between 2400 and 1800 cal. BP (end of Iron Age-Roman period). Regarding a part of the medieval period (950-750 cal. BP), grazing activities with moderate impacts on erosion, are also recorded. These interpretations are reinforced by paleovegetation data, the presence of archaeological sites, at least during the Roman and Medieval periods and paleoclimatic records.

### S4-T01

#### Earthquake-related microdeformations of the Lake Van sediments

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The Lake Van area is strongly affected by earthquakes that represent major natural hazards in Eastern Anatolia, a tectonically very active region (continental collision zone). Recent moderate earthquakes suggest ongoing subsidence yielding notable strike-slip motion. About 30 earthquakes with

magnitude > 5.0 have occurred in the vicinity of Lake Van since 1900 and two semi-active volcanoes rise in the immediate vicinity of the lake (Nemrut Dag, Süphan Dag). Recurrence rates of strong earthquakes and past seismic activity are recorded in the sediment of Lake Van. A ~400.000 year old and 220 m long sedimentary sequence was recovered within the frame of the International Continental Scientific Drilling Program (ICDP) project PALEOVAN at the Ahlat Ridge site, a sedimentary ridge just of the deep main basin in Lake Van.

Facies analysis of this unique paleoclimate archive revealed that great changes of the depositional conditions occurred and hint to a fascinating evolution of the environment of the Quaternary climate evolution in the Near East.

Moreover, a variety of microdeformations were observed, which are especially apparent in the finely laminated clayey silts. These are interpreted to have been caused by seismic shaking, occur throughout the entire record and consist of i) silt-filled vertical fractures, ii) microfaults with displacements at cm-scale, iii) microfolds, iv) liquefaction structures (mushroom, pseudonodules), iv) disturbed varve laminations and v) mixed layers.

Other none-primary structures are few several cm-thick cemented blocks that often amalgamate different lithotypes. They are independent of lithology and occur in-between undisturbed soft-sediment intervals. As the correlative beds in parallel cores from the adjacent holes show no deformations, it is evident that these blocks are drilling artifacts. From 168 to 189 meters below the lake floor, a 21 m-thick unit of major irregularities and accumulation of deformations (deformed, tilted, overturned, repeated layers, and discrete unconformities) were identified. This deformed unit consists of beds of primary lacustrine and pyroclastic deposits with lithologies as the sediment above. This unit is sealed by a several meter-thick massive dark brown clayey silt, interpreted to be a megaturbidite. The entire unit is visible as acoustically chaotic layer in the seismic sections and can be mapped throughout the Tatvan Basin. This large-scale mega-event deposit is likely related to a seismic trigger mechanism coupled with seiche waves and cyclic water movement.

In order to identify seismic shaking events, microdeformations caused by drilling artifacts need to be excluded. Hence, we classified the deformation horizons by the concurrence of deformations in the correlative beds in one, two, or three adjacent holes, taking advantage of the fact that most sections were triple cored. If deformations occurs at least twice, drilling disturbances are excluded and the deformation event is assigned to seismic shaking related to fault movements or volcanic activity. Ongoing analysis of the earthquake-triggered microfaults or seismites and it's correlation to the earthquake-triggered mass movements observed in the seismic data are used to deduce the first

paleoseismic record documenting reoccurrence rates of past seismic activities for this tectonically active region.

#### S4-T02

##### **Geological characteristics of paleolimnological complexes formation in the Ural Mountains**

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Formation of lacustrine sediments in the Ural Mountains took the whole Phanerozoic. Unevenly cyclic, it was related with the postorogenic development of the Urals.

The paleogeographic reconstruction of Mesozoic lacustrine complexes in the Southern Urals as well as Phanerozoic lacustrine basins in the areas of eastern and western slopes of the Ural Mountains shows that each regional cycle had its own paleogeographic features and mineragenic associations. The most ancient lacustrine complexes in the Southern Urals are related with upper red molasses formation during the final stage of Hercynian geosyncline development. The most strongly pronounced lacustrine cycles are: Late Permian/Early Triassic, Late Triassic, Jurassic, Oligocene, Miocene and Pliocene.

Late Permian/Early Triassic and Late Triassic cycles, with young lacustrine complexes, play the most important role (because of their wide areas and thick sediments) in the Urals.

According to the analysis of paleogeographic and paleoclimatic conditions, subsurface geology of the basins and tectonic features of the region, there is a genetic relationship between lacustrine complexes and such minerals as evaporites, coals, zeolites, placer metals, phosphorites etc.



Thus, along with nonmetallic minerals there is a whole number of ore deposits of lacustrine origin in the Urals. The majority of iron-ore deposits of Early Cretaceous ironstones (the Middle Urals), Cenozoic oolitic ores and part of Oligocene manganese deposits (the Southern Urals) belong to lacustrine complexes. They date to the period of thick residual soils erosion (the Early Cretaceous) with subsequent sedimentation of ores in narrow submeridional graben-like lacustrine structures.

Cenozoic ore-bearing sediments accumulate in alluvial-lacustrine and lagoon-lacustrine deposits of coastal plains. The most part of manganese deposits of the Northern Urals Basin is concentrated in the shelf area of Lower Palaeocene Basin.

The study of post-sedimentation processes plays an important role in analysis of lacustrine rocks formation. It is determined (by lithologic and petrographic methods) that post-sedimentation transformation of rocks at Mesozoic sedimentary complexes of Chelyabinsk and Serovsk Basins considerably changed the composition of primary lacustrine sediments. Their subsequent transformation dates to the early catagenesis phase.

In addition, the relation between lacustrine complexes formation and evolution of fault structures is established. The analysis of correlation between modern lacustrine kettles and tectonic breaches allowed us to work out the geodynamic model of fault sags related with local extension zones in the areas of active displacements interaction. Distinctive morphological features reinforce the importance of sags as indirect indicators of faults kinematics. This relief-forming factor influences the facies distribution and plays an important role in mineral prospecting.

#### S4-T03

##### **Lake level fluctuations and sedimentological changes during the last ~50 kyrs at the ICDP-site Laguna Potrok Aike, Argentina**

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<sup>5</sup> as cited at: [http://www.icdp-online.org/front\\_content.php?idcat=1494](http://www.icdp-online.org/front_content.php?idcat=1494)

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Semiarid conditions are prevailing at Laguna Potrok Aike (52°S, 70°W; 116 m asl; diameter: 3.5 km, water-depth: 100 m) in the steppe of southern Patagonia. Here depositional processes are controlled by the precipitation+runoff-to-evaporation ratio, which is a direct function of climate. Under such climatic regimes lakes undergo distinct hydrological changes from open to terminal lake conditions, especially at glacial/interglacial temporal scales. This variability ranges from a freshwater lake with solutes being eliminated via outflow to a saline lake where dissolved loads tend to build up over time, increase salinity as well as pH and thus lead to precipitation of salts. Such distinct changes are reflected in the chemical composition of sediments. Opposite to open lakes, terminal lakes are characterised by rapid water-depth and shoreline fluctuations, which are accompanied by a higher spatial and temporal variation in lake area. These in turn are the trigger for processes of sediment re-deposition and, sometimes, even desiccation of the lake.

Four seismic surveys and a stratigraphic record based on 51 AMS <sup>14</sup>C dates obtained in the framework of ICDP expedition 5022 (PASADO) provide an ideal database to compare the 106 m composite profile from the lake centre with piston cores from the littoral zone and with outcrops in the catchment area. Based on event correlation using distinct volcanic ash layers with unique geochemical compositions, sediment records can be correlated. This approach allows several firm links to water levels during the past 50 kyrs which provide evidences for lake

level variations in the order of 200 m. Seismic reflection data even points to very low lake levels at Laguna Potrok Aike before ca. 55 kcal BP. This is supported by dune-like structures interpreted from a seismic section in the eastern lake basin, which are unconformably overlain by a series of paleo-shorelines. The latter suggest a rapidly rising lake level that probably was preceded by desiccation. Flooding of the lake basin ended with open lake conditions that seem to have been established only a couple of millennia later.

The Pleistocene to Holocene sediment-facies changes are characterised by three transitions between clastic (outflow lake conditions) and carbonaceous (end lake conditions) depositional systems. During the late Pleistocene (13.2-11.5 kcal BP) calcites are precipitated, whereas at the transition from Late Glacial to the early to mid Holocene (11.5-8.7 kcal BP) clastic sediments regain dominance. Since 8.7 kcal BP intense carbonate precipitation (up to 35% calcite) is recorded that continues until today.

Such geochemical changes are related to hydrological variability which are probably caused (1) by changes in runoff due to permafrost sealing of the ground during the Pleistocene, (2) by varying intensity and position of the southern hemispheric Westerlies and (3) by the Late Glacial and Holocene temperature increase.

#### S4-T04

##### Geochemical records in lacustrine sediments and their interpretation

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Geochemical data are an essential part of palaeolimnological studies. Geochemical signatures of lacustrine sediments document changes in the (1) input of detrital matter of local and/or remote provenance, (2) dissolved

input, (3) deposition of autochthonous materials, and (4) lake-internal processes such as, mixing of the water body, post-depositional mineral dissolution/formation, and microbial mediated reactions. Sediment geochemistry, as determined by the above processes, can be strongly influenced by climate change and - since the Neolithic - by human activity. Lake sediments may show rather constant geochemical signatures over long sedimentation periods, interrupted by rapid permanent or distinct short-term variations associated with changes in palaeoenvironmental conditions.

For instance, (1) sediments from Lake Sihailongwan (SHL, Northeast China) document changes in the strength of the East Asian summer monsoon and influx of dust of remote origin by dry- and wet-deposition, (2) sediments from the Irish karst Lake An Loch Mór record post-glacial sea level rise and aeolian influx, and (3) sediments from the meromictic Lake Pavin (Massif Central, France), which receives substantial dissolved influx by sub-lacustrine springs, comprise hydrogeochemical signatures reflecting changes in local hydrological conditions.

For example (1), sediments document the transition from a transport- towards a reaction-limited weathering regime with the onset of the Late Glacial warming and the Younger Dryas/Holocene transition. The related strengthening of the summer monsoon is associated with temporarily enhanced dissolved influx of PO<sub>4</sub>, Mo(VI), and U(VI) into the lake. The transfer of dissolved Mo(VI) from the lake water to the sediments particularly depends on the redox conditions in the deep water. Short-term climatic deteriorations during the Late Glacial warming, e.g., around 13,000 cal. yrs BP, are sensitively recorded by this trace element.

Lake An Loch Mór (example 2) receives input of sea water and inflow of fresh groundwater from its catchment. The balance between both components is geochemically recorded in the sediments of the lake. Geochemical sediment signatures related to the marine

component show two distinct maxima in the course of the Holocene.

In example (3), inflow of Fe-rich groundwater is positively correlated with rainfall. In lakes receiving siliciclastic input, however, changes in dissolved influx are typically only insensibly recorded in the chemical composition of lake sediments. Thus, the sediments of Lake Pavin represent a rare example of a highly sensitive palaeohydrological archive.

Such astonishing excursions in the geochemical composition of lake sediments are presented for five lakes of various climatic settings. In detail, it is explained how palaeoenvironmental changes induce anomalies in the geochemical signature of lake sediments.

#### S4-T05

##### **Numerical and statistical models for downscaling GCM output to reconstruct lake levels**

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Proxy evidence used for paleoclimatic reconstructions often contains hydrological information on past lake level changes. These changes are typically included in a physical parameter in the lake sediment. To reconstruct lake level changes the physical proxy is linked with empirical and semi-empirical models to changes in meteorological and hydrological variables that drive lake levels.

Lake levels themselves are a residual component resulting in the interplay between precipitation and evaporation and if present, in the variability of direct or indirect inflow and outflow of the lake, respectively. This phenomenon complicates the reconstruction of lake levels, because simultaneous changes in the different hydrological parameters might cancel out each other. This point is also of

specific importance when using statistical and numerical models to reconstruct lake levels.

Results from global circulation models (GCMs) can usually not directly be used for lake level reconstructions, because the horizontal resolution of the GCM is too coarse for the assessment of lake level changes on the local scale. For example, GCMs used for paleoclimte applications still have a horizontal resolution of several hundreds of kilometers, exceeding the size of most lakes by far.

To get more reliable results for the estimation of lake level changes the output of GCMs needs to be downscaled, i.e. the large-scale atmospheric circulation is linked to local scale variables. In this context two main approaches are used to address this point: The first one relates to the establishment of statistical transfer functions linking local lake levels changes and/or their driving components to the large-scale circulation provided by re-analysis data sets and GCMs. A pre-requisite for the application of the statistical downscaling of lake level is the availability of observed hydrological variables at the local scale to link the large-scale circulation with the local scale hydrology of the lake.

The second approach uses another numerical climate model, driven with a higher horizontal and vertical resolution, i.e. a regional climate model (RCM). The resolution of RCMs is in the order of a few 10th of kilometers allowing a better representation of the local-scale processes that drive lake level changes. Especially variables related to the hydrological regime are thought to be better captured by the RCM because many processes driving hydrological changes are operating on small spatial scales, especially during summer when convective processes in the atmosphere become important.

The presentation introduces these two methodological approaches for different lakes and discusses potential advantages and disadvantages for each method for different locations of lakes in South America and Europe. The examples will also be used to demonstrate that these methods can be used to get insights into driving processes that

control lake levels in different periods of the Holocene.

#### S4-T06

##### **A unique record of centennial- and millennial-scale interaction of climate and vegetation in the Middle Eocene maar lake of Messel, Germany**

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The Middle Eocene oil shale of the Messel pit near Darmstadt (State of Hessen, Germany) is worldwide known for an exceptionally well preserved assemblage of fossils. A continuous core proved that the finely laminated oil shale was deposited in a meromictic maar lake which formed 47.8 ± 0.2 Ma ago. The core included a complete reference section of the Middle Eocene lake deposits (Messel Formation) thus representing a unique climate archive for the early Middle Eocene in Central Europe.

The classical "Messel oil shale" is characterized by a continuous succession of finely laminated bituminous claystones. The lamination was caused by annual algal blooms forming light layers that were superimposed on the terrigenous background sedimentation as represented by dark layers. An average sedimentation rate of 0.14 mm/yr has been calculated from the lamination, but there are short-term fluctuations in varve thickness which can be attributed to an "Eocene ENSO".

Palynological analysis of the oil shale, which represents a time interval of ~640 kyr, with a distance of individual samples of 20 cm (about 1400 years/interval), provides an insight into the dynamics of a paratropical climax vegetation during the Middle Eocene greenhouse climate. We were able to show

that short-term fluctuations in the frequency of individual taxa or pollen assemblages reflect periodicities in the range of the Milankovitch frequency band. This implies that orbital control of climate change was sufficient to impose quantitative changes in the composition of the terrestrial vegetation within the range of eccentricity, obliquity as well as long and short precession.

To include the frequency range between fluctuations within the biennial to decadal ENSO-scale band and the Milankovitch frequency band, 10 m of the section were studied in 10 cm intervals (about 700 years). Furthermore, 1 m of the oil shale was examined in 1 cm intervals with a temporal resolution of ~70 years. These time series of ~70 kyr resp. ~7000 years are sufficient to detect any changes in vegetation and climate on the centennial and millennial-scale.

Time series analyses of the pollen data from Messel now provide evidence of climate variability in the sub-Milankovitch frequency band. The major palynomorph elements show periodicities of 200-300 yr, 550-700 yr, ~1200 yr and ~2000 yr comparable, for instance, to De Vriess/Suess (~200 yr), Bond (~1500 yr) and Dansgaard-Oeschger (1470 yr) events of the Quaternary as well as to the millennial-scale variability of ENSO activity in the Holocene (1500/2000 yr). Thus, the recognition of these fluctuations and oscillations in the greenhouse climate of the Middle Eocene are strong evidence that these climate events are not restricted to the Quaternary.

#### S4-T07

##### **Distribution, morphology, and formation of pockmarks in Lake Constance, Germany**

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Pockmarks are well known in the marine environment but almost unreported from limnic systems. In Lake Constance we investigated pockmarks near the mouth of the main tributary, Alpine Rhine River, using sediment cores and hydroacoustics (sidescan sonar, subbottom profiler, horizontal scanning sonar, multibeam echosounder). The maximum dimension of an individual pockmark is about 16 m in diameter and 3-4 m deep, often with a round shape. Most pockmarks are located on top of morphological high points such as sediment waves or shoulders of old channels in front of the Alpine Rhine River. They are collapse structures formed when a reservoir of biogenic methane rapidly empties into the water column. Ebullition of gas very often was observed, indicating that biogenic methane still migrates towards pockmarks.

## S4-T08

### River-delta failures in Lake Lucerne (Central Switzerland)

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River deltas in perialpine lakes are areas of high sediment supply and potentially prone to sediment instabilities. Although large-scale subaquatic landslides are relatively rare, they have the potential to generate tsunami waves and may be a considerable natural hazard. Historical accounts from the 17th century report two events during which tsunami-type

waves caused extensive inundations and severe damage on the shores of the Gersau and Uri basins in Lake Lucerne (Central Switzerland), with wave heights exceeding 5 m and flooding reaching ~800 m inland. While the first event in AD 1601, with largest effects located around the Engelberger Aa delta in Gersau basin, was directly connected to a strong earthquake nearby, no apparent trigger was recorded for the second event in AD 1687, which was focused around the Muota delta in Lake Uri. However, it occurred after a long period with increased precipitation.

Reflection seismic investigations and sampling of the sediments in the affected basins reveal that these events can be linked to large mass-transport deposits that extend from the toes of the deltas over large parts of the basin plains, intercalated between otherwise regularly layered sediments. These event deposits have a similar appearance for both cases and can be divided into two parts, (i) a lower part with chaotic to transparent seismic facies and an irregular upper boundary, composed of diverse sediment types ranging from clayey silt to sand with gravel and coarse plant remains, and (ii) an upper part that is almost seismically transparent with low-amplitude continuous reflections showing a ponding geometry and typically consists of largely homogeneous mud with a graded sandy base. Thicknesses for these units exceed 10 m and 3 m for the lower and upper parts, respectively. Calculated volumes are ~5 x 10<sup>9</sup> m<sup>3</sup> for the Gersau basin event - about 1% of the water volume in the basin - and ~1.5 x 10<sup>9</sup> m<sup>3</sup> for the Lake Uri event.

The geometry of the deposits, their coarse and variable lithologies as well as their enormous volumes suggest that they result from large mass failures in the delta areas. The lower part of the deposits is interpreted as «mass flow» that did not lose coherency during relocation. The upper part likely represents a «megaturbidite», consisting of particles deposited from a suspension cloud. Compared to the estimated sediment delivery to the deltas, the failures involved few (Muota delta) to many centuries (Engelberger Aa delta) of sediment input. Simulations of

tsunami waves generated by the inferred subaquatic slides are able to reproduce the historically documented effects. Further research will investigate factors influencing the susceptibility of deltas to failure (pore-pressure distribution, architecture, sedimentation rate,...), the nature of the trigger mechanisms (seismic vs. aseismic) and assess the «potential» of such failures as natural hazards.

#### S4-T09

##### **Conditions for the deposition of annually laminated sediments in Lake Suminko, a small meromictic lake in Northern Poland**

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A three-year field study was conducted in Lake Suminko, a small kettle lake in Northern Poland, with the main purpose to understand the influences of limnology on the spatial extent of annually laminated sediments within this lake basin. During monthly field campaigns a broad range of physical and chemical parameters of the lake water as well as present sediment fluxes were measured. The spatial extent of laminated sediments was examined by collecting gravity cores from different water depths. Based on accomplished measurements the lake water body is divided into three strata: mixolimnion, chemocline and monimolimnion, each defined by distinct changes along the depth profiles of temperature, electric conductivity and oxygen concentration. Typical for meromictic lakes, the monimolimnion remained constantly anoxic and rich in dissolved solids and nutrients throughout the entire three year monitoring period. The annual course of particle flux at Lake Suminko was closely related to biochemical processes in the euphotic zone. During winter months we observed only very low accumulation rates of

non-carbonaceous matter while during the rest of the year three periods of calcite deposition were recorded (April, July-August, and October-November). They perfectly agree with algal blooms and with maxima of oxygen concentration. We assume that two reasons are responsible for the meromictic character of Lake Suminko: (1) sheltered morphology of the lake basin and (2) biochemical processes related to high lacustrine productivity. These meromictic conditions control the existence of annually laminated sediments within the lake basin, i.e. sediments with well preserved laminations occur only where the lake floor is covered by monimolimnetic waters.

##### Acknowledgements

The research for this study was supported by the Polish Ministry of Science and Education grant (N N306 275635) to W. Tylmann. This is a contribution to the bilateral scientific program "Northern Polish Lake Research" (NORPOLAR), a Polish-German research initiative funded by the Deutsche Forschungsgemeinschaft and the Polish Ministry of Science and Education.

#### S4-T10

##### **Interactions between microbial degradation of sedimentary organic matter and lake hydrodynamics in shallow water bodies - insights from Lake Sarbsko (northern Poland)**

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In the poster we demonstrate spatial and seasonal changes in the pathways of microbial decomposition of organic matter within the surface sediments of Lake Sarbsko, a coastal water body located on the middle Polish Baltic coast. We studied lake waters and bottom sediments at 11 sampling stations throughout the basin and in different seasons between November 2007 and September 2008.

It was established that in this very productive and shallow lake the intensity and pathways of microbial decomposition of organic matter are rather unrelated to bulk sediment composition and only slightly influenced by changes in lake water salinity.

Microbial activity increases in warmer seasons and ceases during winter. In spring bacterial activity is fueled by enhanced influx of highly reactive planktonic organic matter which is decomposed via methanogenesis, reduction of  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$  as well as Fe and Mn oxides.

On the other hand, during summer oxidation processes (mainly oxidation of  $\text{CH}_4$ ) tend to predominate. The change from reduction to oxidation is attributed to wind-induced

vertical mixing of Lake Sarbsko waters and resuspension of bottom deposits.

Degradation of sedimentary organic matter results in appreciable changes in the pH and the concentrations of red-ox sensitive ions in pore waters but has little effect on the chemistry of bottom and surface waters in Lake Sarbsko. However, release of  $\text{PO}_4^{3-}$  from the sediments might be a source of this nutrient in the lake. Internal loading of phosphates in Lake Sarbsko occurs under both oxic/mildly reducing and anoxic conditions. The former was observed in winter and enabled late winter/early spring increase in bioproductivity in the lake.

## S5-T01

### Stable carbon isotopes of invertebrate remains reveal past changes in lake carbon cycling

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Lakes can be important sources of methane, and it is important to study the variations of methane release during past periods of climate change. However, records of methane availability in lakes over time scales longer than a few years are extremely rare. A new method was explored to reconstruct past methane availability in lakes based on the stable carbon isotope composition ( $\delta^{13}\text{C}$ ) of aquatic invertebrate remains. For lake-living invertebrates methane-derived C-depleted

carbon can be an alternative carbon source to plant-derived material and can lead to very depleted  $\delta^{13}\text{C}$  values in invertebrate tissues, including their chitinous remains that preserve well in lake sediments.

In studied lakes in Sweden and Siberia,  $\delta^{13}\text{C}$  values of remains of several invertebrate taxa were negatively correlated with diffusive methane fluxes in surface sediments, suggesting the incorporation of C-depleted methane-derived carbon by these organisms. Strong and significant correlations were observed between diffusive methane fluxes and  $\delta^{13}\text{C}$  of Chironomini and *Daphnia* remains. Similar correlations were also observed within two Swedish lakes, in which surface sediments were obtained along transects with increasing water depth.  $\delta^{13}\text{C}$  values of Chironomini and *Daphnia* were lower in sections of the lake basin in which the sediments had higher methane release rates. These correlations suggest that  $\delta^{13}\text{C}$  in remains of several invertebrates, especially Chironomini and *Daphnia* can be indicative of methane availability in lakes.

In a sediment record from a Siberian thermokarst lake  $\delta^{13}\text{C}$  values of the remains of Chironomini and *Daphnia* showed relatively large negative  $\delta^{13}\text{C}$  shifts in warm periods (between AD 850-1150 and since 1970) compared with  $\delta^{13}\text{C}$  values of bulk sediment and of the remains of predominantly plant-feeding taxa. These results suggest increased methane availability in the studied lake during warm periods and demonstrate the potential to use taxon-specific  $\delta^{13}\text{C}$  analysis of invertebrate remains to study changes in lake carbon cycling.

## S5-T02

### Oxygen isotope fractionation during the life and death of diatoms

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Oxygen isotope analysis of diatom silica ( $\delta^{18}\text{O}_{\text{diatom}}$ ) is rapidly becoming established as a palaeoclimate proxy using lake and marine sediments. In principle, the oxygen isotope ratio of diatom silica is a function of the isotopic composition of ambient water and growth temperature. However, exact controls over  $\delta^{18}\text{O}_{\text{diatom}}$  remain poorly understood, including the fractionation associated with silica biomineralisation during diatom growth, and the effects of diagenetic processes operating post death. Early culture experiments and observations of isotope fractionation from field samples suggest an underlying temperature dependence on silica-water fractionation of  $\sim 0.2\text{‰}/\text{°C}$  during diatom growth (1-3). However, significant  $\delta^{18}\text{O}_{\text{diatom}}$  offsets have been observed between living diatoms and surface sediments which suggest that diagenetic processes also affect the sedimentary signal (4-7). Here, we address

these uncertainties using laboratory cultures of freshwater and marine diatoms. In particular, we assess the thermal dependency of fractionation between diatom species and the influence of additional 'vital' effects. In addition, isotope fractionation associated with experimental condensation of fresh diatom silica is investigated. New results will be presented and discussed with respect to establishing best practice for the laboratory treatment of diatom silica, and for interpreting past climate change from sedimentary  $\delta^{18}\text{O}_{\text{diatom}}$  records.

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## S5-T03

### Advances in the approaches to using the oxygen isotope composition of diatom silica to investigate climate variability with a review of studies in Scandinavia

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Diatom silica are a form of biogenic opal that have oxygen isotope compositions that are being increasingly used in palaeoclimate studies. Frustules are comprised of an inner tetrahedrally bonded silica skeleton with an



outer, hydrous layer. The hydrous layer is freely exchangeable and must be removed prior to oxygen isotope measurement using oxidising reagents and/or high temperatures. Analysis of the oxygen isotope composition of diatom silica requires samples that are almost pure diatomite since extraction techniques will liberate oxygen from all the components in the sediment. There is a generally acceptable protocol involving chemistry, sieving and settling techniques and more recently laminar flow separation. Recent studies of lacustrine diatoms have shown that even a small proportion of contaminant can have a significant influence on the oxygen isotope composition, but where sediment cannot be purified sufficiently, a semi-quantitative assessment of the diatom content can facilitate mass balance techniques. To date we have gathered a body of evidence that show that palaeoclimate data can be gained from the oxygen isotope composition of diatom silica ( $d^{18}O_{\text{diatom}}$ ) in lakes from Scandinavia, especially since diatoms are so abundant and carbonate lakes more rare. The most successful studies have been conducted in areas where the  $d^{18}O_{\text{diatom}}$  registers changes in the oxygen isotope composition of the lake water (rather than temperature) which is then related to other aspects of climate such as precipitation, atmospheric circulation and water balance. We highlight the importance of understanding the present lake hydrology, and the relationship between climate variables and the oxygen isotopic composition of precipitation ( $d^{18}O_p$ ) and lake waters ( $d^{18}O_{\text{lakewater}}$ ) for interpretation of the oxygen isotopic record from the diatom ( $d^{18}O_{\text{diatom}}$ ). Both precipitation reconstructions from northern Sweden and water balance reconstructions from south and central Sweden show that the atmospheric circulation changed from zonal to a more meridional airflow over the Holocene. Superimposed on this Holocene trend are  $d^{18}O_p$  minima resembling intervals of the negative phase of the North Atlantic Oscillation (NAO), thus suggesting that the climate of Northern Europe is strongly influenced by atmospheric

and oceanic circulation changes over the North Atlantic.

## S5-T04

### Understanding the carbon cycle of lakes using the stable isotopes of diatom silica.

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The carbon cycle of a lake can be envisaged as a function of supply and demand. Carbon enters a lake from the catchment, or from atmospheric fixation by photosynthetic organisms within the lake. The carbon is then exported downstream, respired to the atmosphere or locked in sediments. Within a lake the balance between different components is a function of the terrestrial ecosystem, lake productivity and hydrological processes. Tracing these processes and reconstructing them from sediments requires a range of methods and a multiproxy approach. One promising technique is to explore the stable carbon isotopes ( $d^{13}C$ ) of diatom silica. Using a single photosynthetic organism has advantages over using bulk measurements of  $d^{13}C$ , or analysis of higher organisms which are dominated by host effects and food webs.

Here we present a 25,000 year record of  $d^{13}C$  from the sediments of lake Challa a 94-m deep crater lake on the eastern flank of Kilimanjaro at an altitude of 880 masl. The lake is meromictic and supplied by a shallow groundwater system. Sediment samples were cleaned of bulk organic material and carbonates, and sieved to remove silicate minerals leaving pure samples of diatom

frustules. The silica frustules protect organic material from cell wall proteins from oxidation. These will organic inclusions derive from dissolved inorganic carbon from the lake water and should reflect changes in the lake carbon budget through time.

Results are correlated with bulk  $\delta^{13}\text{C}$  measurements and indicators of lake productivity. The data suggest three major phases in the history of the lake's carbon cycle. From 25,000 to 15,000 years BP diatom carbon isotopes and bulk  $\delta^{13}\text{C}$  values were positively correlated, indicating that high diatom productivity, as recorded by high biogenic silica at this time, was depleting the stock of carbon in the lake. From 15,000 to 5500 BP the correlation between diatom carbon isotopes and bulk carbon isotopes breaks down and becomes negative in places, suggesting lower diatom productivity relative to carbon supply to the lake. From 5500 years BP to the present, positive correlations were again found between diatom and bulk carbon isotopes and biogenic silica, indicating an increase in diatom productivity driving internal demand for carbon. Explanations for this tripartite division are provided by hydrological changes shown by the oxygen isotope values from the same diatom samples. These are supported by the palaeoclimatic and palaeoenvironmental context of this sequence.

Understanding the carbon cycle of lakes requires an appreciation of lake productivity and the supply of carbon from the catchment. Diatom carbon isotopes offer a powerful tool in examining long term fluctuations in a lake's carbon budget and how the balance between supply and demand has changed through time.

## S5-T05

### Controls on the magnitude of biogenic silica deposition in lake and reservoir sediments

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Consumption of atmospheric  $\text{CO}_2$  by silicate weathering and diatom control of organic carbon export to the deep ocean provide two key mechanisms coupling the biogeochemical cycles of Si and C. Yet the Si cycle remains poorly understood relative to C, N or P. Within the C and N cycles, lake sediments have been demonstrated to be large net sinks (Cole *et al.* 2007; Harrison *et al.* 2009). Since remains of biogenic silica (BSi) structures formed by the diatoms and other organisms can constitute a large fraction of lake sediments, it is likely Si is also significantly retained in lakes. Whole lake budgets show that Si retention varies widely (Hofmann *et al.* 2002) and on a global scale the magnitude of this sink is poorly known.

We derived estimates of BSi sedimentation from literature reports of BSi fluxes ( $n=100$ ) and available lake Si mass-balances ( $n=20$ ) and developed a dataset relating sedimentation and hydrological, climatological and geographical parameters. A second, larger dataset of surface sediment BSi concentrations ( $n>500$ ) was established from a literature review and existing regional lake-environment training sets. Key structures in the datasets were explored with multivariate statistical techniques, and predictors of BSi fluxes and concentrations identified. Preliminary analyses have demonstrated that percentage Si retention can be modelled as a function of lake morphology, latitude and altitude. Work presented here uses the assembled datasets to derive predictive models for sediment BSi fluxes and concentrations, and produce global estimates of BSi removal in lakes and reservoirs.

Extrapolation of average deposition per unit area derived from Si mass-balances suggests  $\sim 2.7 \text{ Tmol SiO}_2 \text{ yr}^{-1}$  is deposited in lake sediments. This is of comparable magnitude to the total continental export of dissolved silicate ( $6.33 \text{ Tmol yr}^{-1}$ ; Beusen *et al.* 2009). Analogous to C and N storage, we

demonstrate the importance of small water bodies. Regional differences in BSi distribution will be discussed. This analysis suggests that export of Si from terrestrial ecosystems is greater than previously thought (Conley 1997). As our understanding of the global Si cycle becomes more sophisticated, retention in lakes and reservoirs can no longer be neglected.

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## S5-T06

### Contribution of allochthonous organic matter to sedimentation and benthic food-webs in Lake Constance: Evidence from stable isotopes

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In order to evaluate the importance of allochthonous organic sedimentation in the deep oligotrophic Lake Constance a detailed analysis of sedimenting matter collected with sediment traps was performed during the year 2005. In addition to evidence provided from chemical and sedimentological indicators, this evaluation was based mainly on measurements of the stable C-isotope content ( $d^{13}C$ ), because POM of allochthonous origin ( $d^{13}C = -28‰$ ) was sufficiently different from POM of phytoplankton origin ( $d^{13}C = -32$  to  $-33‰$ ) or submersed macrophytes ( $d^{13}C = -14$  to  $-18‰$ ). While autochthonous sedimentation (using the flux of Chlorophyll a as proxy) was on a similar level lakewide,

sedimentation rates of total sedimenting organic matter (sPOM) were significantly higher at areas with riverine depositions. Also the signatures of stable isotopes observed for the two dominant macrobenthic groups (oligochaetes and chironomids) differed considerably at "allochthonous" sites. These sites exhibited also lower densities of microbial biomass but higher microbial activities in sediments compared to "autochthonous" sites. Altogether, the observations suggest that allochthonous carbon supply is at least partly bioavailable and stimulates microbial growth and metabolic activities in lake sediments. Because considerable parts of the lake basin are dominated by allochthonous sedimentation, a more than local significance can be ascribed to the allochthonous impact on benthic communities. Furthermore, the results suggest also that at least a part of this additional allochthonous carbon supply is primarily converted to biogenic methane (which is known to have extremely light  $d^{13}C$  values) that is subsequently made available as food for benthic animals via methane oxidizing bacteria (MOB).

**S6-T01****Paleoshorelines of Lake Baikal as indicators of climatic, glacial and tectonic changes during Late Pleistocene**Eduard Osipov<sup>1</sup><sup>1</sup> Limnological Institute SB RAS, Irkutsk, Russia

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Lake Baikal, the deepest lake of the world, has been influenced by glacier advances and retreats during Pliocene-Quaternary time. Lake sediments record obvious traces of numerous glacial expansions in form of terrigenous clays with ice-rafted detritus material dated from 2.8 Ma ago to the Last Glacial Maximum (MIS 2, about 18-20 C ky BP). Late Pleistocene (MIS 4 to MIS 2) onshore deposits and landforms widely presented in northern and southern Baikal basins have been locally dated by isotopes methods (C, Be). Lake terrace record reflects complex interaction between climatic, glacial and tectonics changes in Baikal watershed. Bathymetric profiling within 0-100 m depth interval at the eastern part of the lake revealed a relatively wide shelf and two lowstand features (underwater terraces) formed due to balance changes in watershed during Late Pleistocene cold stages. However according to quantitative ice reconstruction hydrological balance and level of the lake during full glacial conditions (LGM) was mainly controlled by meltwater supply with level position similar to the present. Two raised shorelines (up to 10 m above modern lake level) mark relative raise of lake level caused by climatic deglaciation (ice melting) combined with post-glacial tectonic (glacio-isostatic rebound) during Late Glacial and Holocene.

**S6-T02****Multi-proxy analysis of lake sediments at Tangra Yumco (central Tibetan Plateau) - Holocene lake level and climate variability**Iris Möbius<sup>1</sup>, Peter Frenzel<sup>1</sup>, Phillipp Hoelzmann<sup>2</sup>, Sebastian Ferse<sup>2</sup>, TorstenHaberzettl<sup>3</sup>, Birgit Plessen<sup>4</sup>, Antje Schwalb<sup>5</sup>, Claudia Wrozyna<sup>6</sup><sup>1</sup> Institut für Geowissenschaften, FSU, Jena, Germany<sup>2</sup> Institut für Geographie, FU Berlin, Berlin, Germany<sup>3</sup> Institut für Geographie, FSU, Jena, Germany<sup>4</sup> GFZ, Potsdam, Germany<sup>5</sup> Institut für Umweltgeologie, TU Braunschweig, Braunschweig, Germany<sup>6</sup> Institut für Erdwissenschaften, Graz, Austria

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Lacustrine sediments from an outcrop located at the northwestern shore of lake Tangra Yumco (central Tibetan Plateau) were investigated using a multi-proxy approach in order to reconstruct hydrological and climatic changes in the region. The section covers the lake history from the Late Last Glacial to the Late Holocene. Twenty-five samples were analyzed for ostracod assemblages, sediment-petrographic parameters as well as stable isotopes and trace elements of ostracod shells. Results allow a subdivision of the section into four units. Unit I, deposited prior to ~10 cal ka BP, is characterized by poorly sorted, coarse, detritus dominated sediments that indicate the occurrence of flooding events probably caused by increased precipitation and meltwater discharge. This led to a lake level rise to at least 40 m above present day level and the Holocene high stand. Between ~10 cal ka BP and ~3.9 cal ka BP (Unit II), the deposition of laminated carbonate and an increase in Mg/Ca ratio suggest deep lacustrine conditions a slowly falling lake level and increasing salinity. Between ~3.9 ka cal BP and ~0.7 cal ka BP (Unit III), further increasing Mg/Ca ratios and peaks in carbonate content and ostracod abundance imply a continued rise in salinity. A decrease in Mg/Ca ratios towards the top of the Unit IV, decreasing oxygen isotope ratios and unsorted coarser sediments characteristic of a shore facies suggest a lake level 13-14 m above present day and the proximal inflow of a river in a persisting dry climate. After ~0.7 cal ka BP, detritus abundance and grain sizes increase, indicating deposition in a shore or deltaic environment before the lake level finally dropped to or below the present level and deposition at the site ceased.

**S6-T03****Alkenone-based Holocene temperature and salinity variations in the Northern Tibetan Plateau**

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The Tibetan Plateau is the highest landscape in the Earth which could significantly influence the large-scale atmospheric circulation of the Asian monsoon and more broader-scale global climate system. As the conjecture place of the Asian monsoon and westerly, the Tibetan Plateau is very sensitive to climatic changes and currently undergoing significant ecological changes. However, there are limited high quality paleoclimate records available to evaluate past climate variations especially temperature changes in the Tibetan Plateau during the Holocene. Here, we present ~20-50-year resolution alkenone-based paired temperature and hydrological records for the past ~9000 years from a freshwater lake in the Qaidam Basin in the northern Tibetan Plateau. Based on the U<sup>K</sup>37 and summer temperature calibration in Chinese Lakes, our U<sup>K</sup>37 record generally represents changes in summer temperature between 11 and 15°C over the past 9100 years, with rejected data around 500 and 4000 yr BP due to the interference of alkenone signals by other organic compounds. From 9100 to 7400 yr BP, our U<sup>K</sup>37 data show a gradually increasing trend from 11 to 15°C with about less than 1.5°C fluctuations at centennial-scale. From 7400 to 6200 yr BP, U<sup>K</sup>37 data show a slightly decreasing trend in summer temperature from 15 to 14°C with negligible fluctuations. Between 6200 and 5500 yr BP, the summer temperature show an abrupt drop from 14 to 10.5°C. After 5500 yr BP, our data show millennial-scale fluctuations in summer temperature between 11 and 16°C. On the other hand, the %C<sub>37:4</sub> based salinity reconstructions show an anti-phased relation with temperature changes in terms of both

climatic trend and variability, which is generally consistent with our previously published lake-level reconstructions based on loss-on-ignition and X-ray fluorescence (XRF) analyses. Contrary to the warm and wet association in monsoonal China, our data suggest an opposite temperature and moisture relation in arid northwestern China, with higher temperature corresponding drier climate, and vice versa. As demonstrated in previous studies, the anti-phased moisture relation between arid northwestern China and monsoonal regions is likely controlled by the increased uplifting air in monsoonal areas and associated stronger subsiding air outside of current monsoon limit during the entire Holocene period.

**S6-T04****Multi-proxy evidence for Holocene lake level history of Lake Nam Co, south-central Tibetan Plateau**

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Lake level records from the Tibetan Plateau (TP) provide substantial information about past changes in effective moisture and hydrological conditions in response to Asian monsoon dynamics. We use selected proxy-based reconstructions (ostracodes species assemblages, stable oxygen and carbon isotopes signatures, *n*-alkanes, compound specific carbon isotopes, sedimentological and geochemical data, pollen) reflecting different climate variables to establish a comprehensive framework of climate changes on the southern TP during the past ~10 ka. This synthesis shows wetter climate than today

associated with rising lake levels after ~10 ka. Between ~7.2 ka and ~5.4 ka increasing  $d^{18}O$  and  $dD$  values indicate a transition to drier conditions due to reduced freshwater input and/or higher evaporation rates. The transition to a long-term aridity trend corresponding to lake level decline around ~5.4 ka is shown by proxies (ostracodes, *n*-alkanes, geochemistry, mineralogy). Contrary, pollen data suggest a wetter interval within this period of increased aridity during the mid-Holocene.

Higher numbers of deep-water ostracode species and a decrease in allochthonous input suggest that climate became again wetter from ~1.4 ka to ~0.8 ka. The last 800 years are relatively stable interrupted by the 'Little Ice Age' associated with drier and/or colder conditions.

The comparison of different paleoenvironmental studies from Lake Nam Co highlights the importance of multidisciplinary approaches for understanding the sensitivity of individual proxies and their interactions in response to paleoclimatic and paleoenvironmental changes.

This is a contribution to the Priority Program 1372 "Tibetan Plateau: Formation-Climate-Ecosystems" of the German Science Foundation.

## S6-T05

### **A high resolution environmental record of Pumoyum Co of Southern Tibet since 19 kyrBP**

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By using a 3.8 m long lake sediments core in the deepest water area of Lake Pumoyum Co of southern Tibet, we pick out enough plant residues from 25 samples equally distributed along the core depth and measure their  $^{14}C$  dating. The sources of plant residues are discussed according to their carbon isotopes and the ages of top section inferred from  $^{210}Pb$  sedimentary rate is used to calibrate the carbon reservoir effect of the core's  $^{14}C$  age. Our results show that the core covered a continue time span since 19 kyrBP. The total organic carbon (TOC), inorganic carbon (IC), grain-size and pollen proxies are utilized to elucidate the sequence of environmental changes. Before 16.4 kyrBP, the lake was in its shallow status with depth of lower than 15 m, the glaciers started to be melted due to rising temperature, but cold and dry climate was still the feature during that period. Climate environment intensively and frequently fluctuated during the period of 16.4-11.8 kyrBP, two cold events around 14.2 kyrBP and 11.8 kyrBP probably the reflections of old dryas and younger dryas. After 11.8 kyrBP, the lake was steadily in its deeper water status. The lake water temperature was always lower because the main supplies consist of nearby glacial melting water. Proxies of lake sediments were not sensitive to warmer conditions due to the cold water influences. By comparing the environmental sequence of Pumoyum Co with other lake sediments-sequences in southern Tibet area, we found that the warmer shifting of climate at the beginning of last deglacial period had more influence to southeastern Tibet area. It reflected that the southwestern monsoon gradually enhanced and moved to the interior of the Plateau. The lakes mainly supplied by glacial melting water were more sensitive to cold events. Within the Holocene, the southwestern monsoon has been exerting the dominant influence to the total southern Tibet areas.

## S6-T06

**Understanding changes in moisture origin and transport mechanisms using stable water isotopes along an aridity transect on the Tibetan Plateau**

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The monsoonal system provides precipitation for the Tibetan Plateau from various water sources holding different isotopic compositions. Sedimentary biomarkers are shown to record these precipitation isotopic compositions and thus are used as an archive to reconstruct regional climate patterns to understand actual and past pattern of air masses and water vapour source.

Calibration studies are the basis for the interpretation of sedimentary paleoclimate records, as they provide local transfer functions for the incorporation of the stable isotope signal in biomarker lipids. These investigations are necessary to relate the

isotopic fractionation of biomarkers, such as n-alkanes, and their water source to climate conditions. So far, most of these calibration studies were taken out in warm and humid systems and thus, are not valid at cool and dry climates on the Tibetan Plateau. Here, we present a novel dataset of collected water samples from different lake systems along a SE-NW aridity transect on the Tibetan Plateau: Nam Co, Tangra Yumco, Taro Co, Kunggyu Co, Lungmu Co and Songmuxa Co.

Our investigation proved that the isotopic signature of <sup>2</sup>H and <sup>18</sup>O of sampled water across the Tibetan Plateau is strongly correlated. Water samples from precipitation and inflows as well as some tap waters are directly in line with the local meteoric water line, while lake water is enriched due to evaporative loss. Two distinct water pools are distinguished by measurements: precipitation water, which supply water for the inflows, and lake water having a clear evaporative signal. The lack of significant changes in d-excess between the sampled lake sites implies that the investigated area is influenced by the same air masses transported over the plateau. As expected we observe a tendency to drier regions along the trajectories. With this understanding of modern stable water isotope variations we are able to provide insight and a basis for the interpretation of past changes in moisture origin and transport mechanisms on the Tibetan Plateau.

## S7-T01

**Vertical and lateral distribution of lacustrine microbial, skeletal, and oncoidal carbonate lithofacies at the parasequence scale in the Miocene Idaho Hot Springs Limestone, USA**

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Lacustrine carbonate lithofacies vary systematically at meter to decameter scales and record paleobathymetry, limnologic conditions, and paleogeographic influences. The Idaho Hot Springs Limestone accumulated during the late Miocene in a series of lakes in extensional basins with volcanic underburden, closely associated with lava flows.

Lithofacies include microbial boundstone (as open-framework bioherms, tightly cemented biostromes, and grain coatings), grainstone with a variety of carbonate and siliciclastic components, wackestone, micrite, and diatomite. Grainstone occurs between and within bioherm complexes.

These lithofacies stack in repeated patterns at the dm to m scale. A typical succession has isolated concave-upward conical arborescent bioherms separated by skeletal-dominated grainstone at base, overlain by upward expanding, increasingly arborescent bioherms with minor surrounding biostromal boundstone, and topped by widely expanded to interlinked arborescent bioherms surrounded by thick involute biostromal boundstone. These parasequence-scale successions are separated by thin bedsets of dominantly horizontal biostromal boundstone with subjacent zones of early diagenetic alteration that we interpret to record lacustrine flooding surfaces.

Lithofacies also vary laterally at the km scale in systematic ways that we mapped over an area of more than 50 km. Lake plain and supralittoral zones are dominated by poorly sorted siliciclastic lithofacies with abundant root, invertebrate, and vertebrate traces. Littoral to proximal sublittoral zones contain poorly sorted siliciclastics, micrite, and wackestone with widely spaced, short (< 33 cm) bioherms. Bioherms are larger, taller (< 242 cm), and more closely spaced towards the medial sublittoral zone, where skeletal-oncoidal grainstone are more common between bioherm complexes. Farther lakeward, into the distal sublittoral zone, bioherms are shorter (< 20 cm), less complex, and more widely spaced. Profundal zone lithofacies include wackestone and micrite, with various admixtures of diatomite.

The distribution and character of diagenetic cements and pore types are strongly influenced by lithofacies and position with parasequence and parasequence set. Microbialites and grainstones have the best preserved primary porosity. Much diagenetic alteration appears to record early subaerial exposure. Microbialites are recrystallized to

varying degrees depending on morphology and location in the stratigraphic column but primary pores are largely preserved. Intra-microbial pores display some post-depositional dissolution and only minor cementation. Grainstones have primary interparticle pores and moldic pores associated with meteoric inversion, which occurs more abundantly near parasequence tops. Blocky meteoric phreatic calcite cements are present in minor amounts with a patchy distribution. Patchy dolomite (replacement and cement), chalcedonic quartz cement, and pedogenic textures also occur.

## S7-T02

### **Environments and processes of magnesium carbonate precipitation in alkaline playa lakes of British Columbia, Canada, and the Neogene Kozani Basin of northern Greece**

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Playa lakes that precipitate pure magnesium carbonate minerals are rare. Most are present in closed drainage basins in semi-arid environments, where the bedrock is rich in ultramafic rocks or dolostones that weather to produce dilute runoff waters with a high initial Mg/Ca ratio. Some of the thickest, most extensive deposits are present in the Late Miocene Kozani Basin, which lies in a NNW-SSE trending graben in Macedonia, northern Greece. The carbonates, which are mainly hydromagnesite and huntite with minor magnesite, are found in the upper part of a thick (~500 m) succession of lacustrine limestones, marlstones, lignites and sandstones. The purest Mg-carbonates form adjacent to the fault-bounded basin margins as white beds and lenses several metres thick; others are mixed with marlstone and



claystone. The deposits are commonly massive or nodular, and locally have been reworked to form bedded clastic carbonates. Thin beds, cyclic laminae and paleosols are preserved in places. Locally associated with the Mg-carbonates are porous tufas and travertines that form bedded deposits and mounds several metres in height and width, composed of aragonite and Mg-calcite. The tufa mounds are commonly aligned along fractures or small faults. Thin stromatolitic beds of aragonite and calcite are also present.

Modern Mg-carbonate playa lakes, located in drainage basins with ultramafic and mafic rocks in northern and central Interior Plateau of British Columbia, give clues to the processes of Mg-carbonate precipitation. At Atlin (59°31'N, 133°41'E, two adjacent small playas contain layers of hydromagnesite with lesser magnesite, minor aragonite and dypingite up to ~ 1 m thick that lie upon glacial and glaciofluvial sediments. The N playa is relict, but Mg-carbonates are actively precipitating in a small spring-fed pond lined with microbial mats in the S playa. Fossil calcite tufa mounds occur in the N playa. Other Mg-carbonates (hydromagnesite and magnesite with minor dolomite and huntite) precipitate annually on the Cariboo Plateau (51°21'N, 121°39'E) from shallow, Ca-poor dilute spring-fed waters that evaporate during summer. Dolomitic palustrine sediments with rootlets and paleosols form fringes around the playas. At both locations, some precipitation appears to be microbially mediated by benthic cyanobacteria. On the Cariboo Plateau, however, suspended crystals of both hydromagnesite and magnesite imply that some crystallization could be occurring in the water column, although this could too be partly biomediated. A downward increase in magnesite abundance might have resulted from early diagenetic alteration of hydromagnesite.

These examples suggest that Mg-rich bedrock, Ca-poor but Mg-rich groundwater inflow from springs and seepage, and low siliciclastic input favour formation of lacustrine Mg-carbonate deposits. Evaporation and bacterial biomediation contribute to precipitation,

while mineralogy is controlled by hydrochemistry and early diagenesis.

### S7-T03

#### Nanoscale evidence of the microbial role in freshwater ooid formation

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Although ooids are generally assumed as resulting from merely physicochemical processes, organomineralization has been recently recognized as a key process for initiating freshwater ooid formation. Field- and laboratory-based experimental results indicate a dominant role of biological processes enhanced by photosynthetic organisms in the early stages of ooid development. However, the precise steps behind these processes remain partially unclear and only a very detailed study at a nanoscale level can shed new light into them.

Coordinated NanoSIMS-SEM and ion microprobe studies make it possible to obtain simultaneous information on the mineralogy, structure, isotopic compositions, and petrographical context of the low Mg calcite cortex in these unique freshwater grains. Our results show that photosynthetic microbes control the formation of the whole cortex and not only enhance precipitation adjoining to the nucleus. More specifically EPS display a close association between amorphous Mg-Si and carbonates linking microbial metabolism to molecular structures. The latter allows to obtain a more detailed view of the role of these organisms during the formation of the carbonate cortex in ooids.

**S7-T04****Pliocene-Pleistocene palustrine sediments of the Guadix Basin (Betic Cordillera, S. Spain): geologic record of ancient wetlands**

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The continental fill of the Guadix Basin (Betic Cordillera, S. Spain) is represented by its three youngest units (from IV to VI) and is Upper Tortonian (Pliocene) to Late Pleistocene in age. Detailed stratigraphic, sedimentologic, and petrographic studies of Units V and VI identifies both siliciclastic and carbonate facies as well as architectural elements resulting in the interpretation of fluvial-palustrine facies in the so-called Axial system, which flowed longitudinally through the basin. It was transversally fed by marginal alluvial fans, draining towards a shallow lake located to the northeast in the neighboring Baza Basin. In the central sector of the Guadix Basin, palustrine siliciclastics are identified in association with palustrine carbonates, coal seams, and other floodplain sediments with some of them showing incipient paleosol development. The paleoenvironment represented by these facies is an ancient analog for modern wetlands.

Unit V comprises mostly fine sediments associated with isolated low-sinuosity channels and rare palustrine carbonate beds with immature paleosol development. It is interpreted as a high accommodation systems tract (HAS), in which the available accommodation space is high in relation to the sediment input. On the other hand, Unit VI, contains in the western and northern zones of the basin vertically-stacked carbonate palustrine sequences. These

successions are interpreted as occurring within a relatively reduced accommodation area receiving sediment from a source area with more carbonates (low accommodation systems tract or LAS).

Two types of laterally-associated architectural elements are interpreted as palustrine in origin in both units: (1) palustrine carbonates (CPm) and (2) palustrine-lacustrine siliciclastic beds (FPb). These palustrine facies appear laterally and vertically related to the floodplain siliciclastic sediments in Unit V. Facies relationships in Unit VI are difficult to assess because of less extensive exposure.

The interpretation of the palustrine deposits in Units V and VI is based on an extensive review of classic examples of palustrine facies from the geologic record together with modern studies. The features described for some sub-environments in the Florida Everglades (USA) and the Recent sedimentation in Las Tablas de Daimiel wetlands (Spain) are strikingly similar to those of the Guadix Basin palustrine facies. The sedimentologic and petrologic features point to a fluctuating base level with seasonal subaerial exposure. Together with the laterally extensive palustrine beds and the lack of deep lacustrine facies in the area, these deposits can be interpreted as marsh wetlands developed during Pliocene and Pleistocene times in the central sector of the Guadix Basin. To confirm this interpretation and refine paleoclimatic reconstructions, stable isotopic analyses (C,O) will be performed on the palustrine carbonates. The research is funded by projects CGL2009-07830/BTE, AHOB-3 and the Working Group RNM-369JA.

**S7-T05****Predicting Lacustrine Microbialite Distribution and Facies Associations: the Eocene Green River Formation Analogue**

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The Green Formation contains one of the most abundant and varied microbialite occurrences in the lacustrine record. They occur in a variety of lake facies, allowing comparison with various paleoenvironmental factors. Microbialites are widely distributed in the Green River Formation; however they are concentrated in near-shore zones. They include stromatolites, oncoids, tufa, and spring-related microbialites. Their stratigraphic occurrence includes all members of the Green River Formation, but appear to be restricted to facies deposited during lake-expansions and flooding or where abundant calcium-rich inflow from rivers or springs predominates.

Facies associations containing microbialites include the classic fluctuating profundal facies association composed of dolomicrite, ooids and flat-pebble conglomerate at the base, followed by 10- 50 cm thick stromatolites, kerogen-rich laminated micrite, and kerogen-poor laminated micrite in sequence. This association may be dependent on low lake-bottom gradients that allow frequent and widespread flooding events. Less common, but certainly important are aggradational facies composed of a stacked 10-30 m thick sequences of oolite and grainstone, stromatolites, wackestone, and finer-grained carbonate mudstones in sequence. This association appears to develop in balanced to over-filled lakes with higher bottom gradients. Less common are isolated bioherms that are 1-3 m high and may be associated with spring inflow. They commonly occur associated with thin lacustrine units in otherwise fluvial sequences. Another facies association is oncoids containing beach pebble, bivalve and gastropod nuclei that occur within fluvial and beach conglomerate in steep near-shore settings. They are typically 3-10 m thick. In many cases they are associated with islands or basin sills within the lake. These facies were deposited during over-filled lake phases.

A careful study of the various occurrences and facies that contain microbialites within the Green River Formation, allow us to make some conclusions about factors that promote microbialite growth and deposition. These

include calcium input (very high), lake type or phase (primarily balanced-filled to over-filled), bottom gradient (controls type of microbialite facies), lake expansions and contractions (produce profundal association), low nutrient input (discourage competitors), low turbidity, shallow water depth, and relatively high energy. These parameters also allow us to predict microbialite distribution and facies associations when exploring for hydrocarbons in deeply buried lacustrine rocks.

## S7-T06

### The Character and Distribution of Lacustrine Microbialites through Time and Space

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Lacustrine microbialites are forming in many lakes today and their record extends back at least 2,720 million years. Stromatolites dominate the lacustrine microbialite record, with thrombolites constituting a minor component in the fossil record, but are relatively common in extant lakes. In any given lake, microbialites are more likely to develop when calcium input is high, the lake is primarily balanced-filled to over-filled, clastic sediment supply is lacking or low, nutrient input is relatively low, turbidity is low, and shallow-water conditions are relatively stable (Buchheim and Awramik, this meeting).

Pre-Phanerozoic lacustrine deposits are few, due to a number of factors, including the reduced likelihood of preserving such epicontinental deposits over long spans of geological time, lakes are geologically short-lived, and lakes are spatially restricted. Also, their recognition is inherently difficult. The Phanerozoic record is better and recognition is facilitated by fossils (animal and plant) diagnostic of a marine or lacustrine setting. The Cenozoic record is best, followed by the Mesozoic and Paleozoic, respectively.

Microbialites can be used to recognize ancient lacustrine deposits regardless of age. They often have two or more characteristics that are more common to lacustrine than marine settings. These characteristics often include: morphological variability within a bioherm or biostrome; macrolamination; moderate to sharp boundaries between laminae; light laminae may be composed fibrous carbonate;

laminae often have high degree of inheritance; bumpy, botryoidal upper surface of the coenoplase; and encrusting habit on clasts, logs, twigs, or other substrates.

The rich and diverse record of lacustrine microbialites provides a valuable archive of the interactions of microbes and sediment within the dynamics of lake basins.

## S8-T01

### **Tropical to semi-arid lacustrine environments and associated landscapes and ecosystems over the last 45 million years in the Turkana depression of northern Kenya**

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The continent-scale East African Rift System is an impressively complex structure considering the large variety of relief and drainage - including fluvial and lake systems - that were created over millions of years by magmatic-, tectonic- and climatically-controlled processes. In the Turkana depression, such processes acting together over different time scales from 100 to 107 years, starting at the Eocene epoch, successively created high-altitude plateaus, axial or plateau-related volcanic edifices and complex horst and graben landscapes, that all acted as topographic barriers over long distances. Dramatic changes in climate, vegetation and hydrology occurred during these last 45 million years, as a consequence of major topographic changes affecting the rift. During the middle-late Cretaceous up to late Eocene, the Turkana depression was marked by a fully

fluvial system of braided type, represented by the Lapur Sandstone, with a possible coeval fluvio-marine setting to the southeast, connecting through the Anza Rift with the Indian Ocean. Climate conditions were considered as semi-arid at that time.

During middle-late Eocene, intense volcanic activity at the northern end of the Turkana depression resulted in the formation of a 3-km high topography made by lava flow accumulation. On the south and west sides of the depression, rifting processes began to create graben landscapes that connected with drainage networks issued from the south. Several lacustrine environments began to develop in this region, as represented by the Lokichar and North Kerio Basins of Eocene? to middle Miocene age. Pollen studies from the oil exploration well Loperot-1, indicate tropical climatic conditions during late Oligocene-early Miocene time with high rainfall conditions and a well-defined dry season. The presence of deep-water lakes with high organic productivity, surrounded by a mosaic environment of semi-deciduous forest and humid woodland, coincides with an abundant fauna represented by reptiles, fishes, and mammals of late Oligocene age.

Active volcanism continued in the northern part of the depression during this period, before shifting to the south in the middle-upper Miocene. During the same period, south-north rift migration led to the end of lacustrine sedimentation in this region. A new single half-graben basin resulted from a new rifting phase during late Miocene-Pliocene

time, corresponding to the present-day northern part of the Lake Turkana Basin. Regional climate change toward aridification resulted in major hydrological changes, particularly for the hydrographic network issuing from the south. The Plio-Pleistocene Lake Turkana was affected by successive lake level fluctuations indicating alternating humid and dry climatic phases. Large variations of lake level and water chemistry directly influenced the behaviour of hominin populations present in this region.

## S8-T02

### **Examples of sedimentation in the rift lakes of Eastern Africa - Tectonic versus Climatic controls : A comparison between the Eocene - mid Miocene Lake Lokichar and the mid Miocene - Present Lake Turkana in Northern Kenya. Consequences on hydrocarbon prospects**

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Extension processes have dominated the evolution of the northern segment of the Kenya Rift from Eocene to Present-day. Several typical N-S half-graben basins have been created during two major phases of extension during Eocene times then mid-Miocene times, each phase being characterized by migration of extension processes from west to east then south to north, resulting in the development of two elongated half-grabens, i.e. the Lokichar Basin of Eocene - mid-Miocene age, and the Turkana Basin of mid-Miocene - Present age.

Sedimentation processes in these two rift basins have been primarily controlled by their typical half-graben morphology as well as by climatic conditions prevailing on each basin during its development, i.e. tropical humid conditions for the Lokichar Basin, and semi-arid conditions for the Turkana Basin. Large

lateral clastic inputs are issued from fault-controlled watersheds, i.e. the major border faults - Lokichar Fault for the Lokichar Basin, Murua Rith-Lapur Fault for the Turkana Basin - characterized by a Precambrian basement-dominated watershed for Lokichar, and a volcanic-dominated watershed for the Turkana Basin. Tropical climate and associated vegetation prevailed in the Lake Lokichar watershed from Eocene to lower Miocene resulting in quartz-rich, well-sorted sand inputs in shallow lake waters and deltaic platforms. In the Turkana Basin, semi-arid conditions induced poorly-sorted, paraconglomerates and sandstones inputs, transported by an ephemeral lateral fluvial network and deposited in shallow depth littoral platforms. The nature of the axial clastic inputs in both lakes were mainly controlled by the fault structure at the watershed as well as by its lithology, issuing well-sorted quartz-rich sands for the Lokichar Basin, and mainly silt and mud from the volcanic-dominated far watershed for the Turkana Basin.

Major differences in basin sedimentation for both the Lokichar and Turkana Basins concern the deep lake basin environment. Thick (100m's), black, organic-rich shales form 2 major sedimentary units deposited in the Lokichar Basin during 2 lake highstand periods in the Eocene and Oligocene. Organic matter resulting from freshwater algal indicates the existence at these times, of a deep freshwater lacustrine environment with well-marked anoxic conditions at depth, which is in line with high rainfall conditions at the watershed. Offshore lake sedimentation in the Turkana Basin was controlled by semi-arid climate conditions, resulting in major inputs of fine-grained sediment with poor organic content from axial and lateral origins. Organic-rich mudstones only occurred in the Turkana Basin during high lake levels that characterized the Plio-Pleistocene period.

Thereby, climate conditions play a major role in rift basin sedimentation by controlling the sorting and petrography of inflowing sediments, as well as influence offshore sedimentation, where organic-rich deposits characterize deep lakes/high lake level

conditions that can be linked to short or longer humid climatic conditions. Precise knowledge of such conditions may greatly help to identify lake basins favourable for hydrocarbon prospects.

### S8-T03

#### **The Hominin Sites And Paleolakes Drilling Project: Investigating the environmental context of human origins using high resolution lacustrine records**

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The Hominin Sites and Paleolakes Drilling Project is an international initiative (43 senior scientists from 10 countries), whose goal is to significantly improve our understanding of the paleoenvironmental context of human origins in Africa through the analysis of new drill cores collected from East African paleolakes. HSPDP plans to obtain continuous paleoenvironmental records through a series of critical intervals in African hominin history from five high-priority coring areas in Ethiopia and Kenya. At each of these sites (N. Awash Basin, Ethiopia-M.-L. Pliocene; Baringo Basin, Kenya-L. Pliocene-E. Pleistocene; W. Turkana Basin, Kenya-E. Pleistocene; Chew Bahir Basin, Ethiopia-M.-L. Pleistocene; and Magadi Basin, Kenya-M.-L. Pleistocene) highly-resolved, continuous lacustrine paleoclimate records will be collected in close proximity to key paleoanthropological sites. These areas include some of the most important fossil hominin and artifact sites in the world, which have directly stimulated much of the current debate about human evolution and environmental dynamics.

The Project's major goals are to:

1) Vastly expand the paleo-data set upon which hypotheses about environmental drivers of human evolution (climatic, tectonic, internal etc.) must be based. We will assemble

high-resolution, quantitative paleoclimate/paleoenvironmental, cosmogenic radionuclide and detrital thermochronology records, allowing us to correlate core records using tephras, paleomagnetism and other dating techniques to nearby outcrop records, hominin and other vertebrate fossils, and artifacts, and infer orographic and exhumation dynamics. Our drilling program involves the collection of ~2400m of new core from nine boreholes in the five study areas. From this we can test important hypotheses linking mammalian (including hominin) evolution to environmental dynamical drivers at the basin-regional scale; and

2) Develop predictive models to simulate environmental change and related ecosystem responses in Africa during critical intervals of human evolution and evaluate these models against our new, high-resolution records. We plan to conduct earth-system modeling experiments within a paleoanthropological framework, to understand climate-orography-hydrology-vegetation coupling. Modeling will investigate global and intermediate-scale climate controls at the broadest scales, then will examine transient phenomena at regional scales relevant to orography, hydrology and vegetation, and finally will model the basin scale geomorphology and hydrology of each study area to evaluate critical resources for hominin survival. We will evaluate the importance of climatic and tectonic thresholds/abrupt changes for hominin environments. These efforts will generate new, testable hypotheses of human evolution/environment dynamics, potentially including feedback between evolving hominin lineages and the African environment.

### S8-T04

#### **Early Pleistocene environmental change at Munya Wa Gicheru, southern Kenya Rift Valley**

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Laterally extensive early Pleistocene sediments are well exposed at Munya Wa Gicheru in the southern Kenya Rift Valley. These deposits rest on obsidian and Limuru Trachytes previously dated at 1.96 Ma and are overlain by phonolites (0.724 Ma). Pumice and ash within the sequence have been dated at 1.65 Ma and 1.71 Ma by earlier researchers. The sediments largely pre-date the better-known Olorgesailie Formation, which lies about 10 km to the south and thus extend our knowledge of Pleistocene palaeoenvironments in the southern Kenya Rift. The deposits are comprised of coarse gravels and sands, laminated and massive diatomites, diatomaceous silts and clays, and non-diatomaceous silts formed mainly in freshwater lakes and wetlands. A composite section (~31 m thick) through these deposits also shows the presence of multiple erosion surfaces, pedogenically altered sediments and large desiccation polygons. Major, minor and trace element data show significant variation through the measured sequence that can be used to subdivide the sequence into several distinct zones. Chemical Index of Alteration data suggests generally less severe weathering took place during the early Pleistocene than occurred during the deposition of the middle Pleistocene Olorgesailie Formation.

Diatom floras are varied and predominantly represent fresh water bodies of varying water depths. The dominant taxa include: *Aulacoseira granulata*, *A. granulata* var. *valida*, *A. granulata* var. *angustissima*, *A. ambigua*, *A. agassizi*, *Stephanodiscus niagarae*, *S. transylvanicus*, *S. carconensis*, *Cyclotella stelligera*, *C. glomerata*, *C. meneghiniana*, *Fragilaria zeilleri*, *Cocconeis placentula*, *Epithemia adnata*, *E. sorex*, *E. argus*, *Synedra ulna* and *Nitzschia Amphibia*. A variety of other *Nitzschia* taxa, *Cymbella* spp. and *Gomphonema* spp. are also common. Saline indicator diatoms (*Rhopalodia gibberula*, *Thalassiosira faurii*, *T. rudolfi*), in contrast with the Olorgesailie Formation, are present but rare. Multiple diatom stages can

be recognized reflecting palaeoenvironmental change, with assemblages that indicate conductivities of generally <6,000  $\mu\text{S cm}$  and pH values of ~7.5-8.5 for the former water bodies that occupied the area. The sedimentology and geochemistry of the deposits also indicates multiple periods of desiccation rather than a continuously existing palaeolake.

## S8-T05

### Palaeoecological information of fish fossils from the Miocene palaeolakes in the East African Rift valley in Kenya

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The Miocene palaeolake deposits in the Tugen Hills in Kenya, within the eastern branch of the East African Rift System, offer a unique, sub-continuous record of fish fossils (Teleostei) from the Middle and Upper Miocene, which is largely unexplored. Precise radiometric age control is available for many of the fossiliferous layers as they appear in lacustrine sediments above or below volcanic rocks and ashes. Nine sedimentary units have been described, they range in age from about 15 Ma to the present without significant interruption (Pickford et al. 2009). The aim of our project is to collect and study fish fossils from selected sites in the Muruyur Formation, Ngorora and Ngerngerwa Formation, Mpesida Member and Lukeino Formation and to provide a preliminary survey on their environmental information. In the talk, we will introduce the project and present some impressions of our Recent field trip in August 2011. Moreover, we will discuss as to whether the exceptional record of fish fossils in the Tugen Hills can be used to better understand the Miocene environmental and climate changes within the East African Rift System.

**S8-T06****Lake level fluctuations recorded by hydrothermal deposits: evidence from Lake Bogoria, Kenya Rift Valley**Robin Renaut<sup>1</sup>, Bernie Owen<sup>2</sup><sup>1</sup> University of Saskatchewan, Saskatoon, Canada<sup>2</sup> Hong Kong Baptist University, Kowloon, Hong Kong**Email:** robin.renaut@usask.ca

Hydrothermal activity is common in many of the lake basins in the East African Rift. Subaerial hot springs discharge from vents along fault-lines that define lake margins; other springs issue from submerged vents on lake floors. In some lake basins hydrothermal inflow accounts for much of the annual recharge, so it is important to detect its former presence in the geological record.

The record of geothermal activity in rift lake basins is sometimes preserved as (i) spring deposits (e.g., travertine, sinter) that are closely associated (or intercalated) with lacustrine sediments, or (ii) areas of hydrothermal alteration that locally modify the lake sediment record. Environmental changes or tectonic movements that affect lake level, lake hydrochemistry and sedimentation can similarly affect thermal springs and their deposits, so the interrelationships among these controls are often complex.

Evidence from Lake Bogoria, a closed saline alkaline lake, illustrates the complex response of thermal springs to changes in lake level. About 200 alkaline hot springs are located along its western and southern shorelines, currently providing ~ 30-35% of the annual inflow. The sedimentary record of the lake marginal springs is discontinuous - spring deposits only form when conditions favour mineral precipitation. At Loburu, travertine at active spring vents lies upon deltaic silts and is encrusted by lacustrine stromatolites. Most of the travertine is relict. Travertine only forms when the lake lies at intermediate levels, leaving no record during high levels when

spring vents become submerged and the waters are diluted, and during low lake levels when their saline waters are Ca-depleted.

The southern basin of Lake Bogoria also provides evidence of the interplay of climate and tectonics on lacustrine and hydrothermal sediment record. When lake level was formerly higher than today and its waters dilute, partly gelatinous silica (opal-A) precipitated around hot spring vents both on the lake-floor and in submerged littoral sediments where it formed cement. In contrast, when lake level lies at intermediate and low levels, as occurs today, silica precipitates only as thin, easily eroded opaline crusts around subaerial vents. The spring deposits are again partly controlled by lake levels.

With falling lake and groundwater levels, some shoreline springs change into steam vents and fumaroles that become acidic where hot gases (e.g. H<sub>2</sub>S) condense at and above the water table. Kaolinite, jarosite, alunite, gypsum, Fe-oxydrides and silica (quartz, opal phases) precipitate as alteration products of lake marginal sediments, locally overprinting spring and lacustrine deposits that formed during earlier phases of higher lake level.

Although mineral deposition at rift springs is often closely tied to lake level, many of the springs do not leave a sedimentary record and their former presence may be overlooked.

**S8-T07****Middle Miocene to Pleistocene fluvio-lacustrine sedimentary sequences onshore of Lake Albert (Uganda)**Sybille Roller<sup>1</sup>, Matthias Hinderer<sup>1</sup>, Jens Hornung<sup>1</sup>, Christina Bonanati<sup>1</sup><sup>1</sup> Institut für Angewandte Geowissenschaften, Darmstadt, Germany**Email:** hinderer@geo.tu-darmstadt.de



Middle Miocene to Pleistocene fluvio-lacustrine sediments are exposed onshore of Lake Albert in hanging wall fault blocks of the Albertine Rift. Biostratigraphic exploration of these successions date back to the 1960ies, however, a modern sedimentological analysis was lacking. We logged in detail more than 400 m of sediments in the Kisegi-Nyabusosi and 83 m in the Kaiso-Tonya area, the latter being of specific interest for ongoing oil exploration. Analysis of lithofacies, architectural elements and cyclicity reveals five evolutionary periods (Roller et al. 2010): (i) a fluvial-dominated period with very massive, uniform and vertically persisting sandy beds and a high fraction of feldspar detritus indicating a rather semiarid climate from ca. 14.5 to 13 Ma. Cyclicity shows an accommodation controlled system. (ii) a lacustrine-dominated period with distal fluvial to lacustrine clayey beds and autocyclic intercalations of coarser material, e.g. crevasse splays between 13 and 6 Ma. The stacking pattern of cycles are still accommodation controlled and lack any preservation potential for base level fall. Iron impregnations and some oolitic beds point to a more humid tropical climate. In period (iii) between ca. 6 and 2 Ma, distal fluvial to lacustrine sedimentation keeps on, but cyclicity shifts towards supply control which is interpreted as lake high stand as well as an increased subsidence of the rift floor. Cyclicity becomes more distinct. Phases (ii) and (iii) correspond to a mega lake covering the entire Albertine Rift and called Lake Obweruka. Period (iv) between ca. 2 and 0.05 Ma shows increasingly fluvial deposits and higher sediment supply which is still accommodated by subsidence. Iron impregnation declines and feldspar reappears both reflecting more arid episodes. Cyclicity and frequency of autocyclic events increase pointing to stronger climatic variability and/or seasonal fluctuations. The youngest deposits (period v) are coarse alluvial gravels unconformably overlying the older synrift sedimentary sequence and called High Plain Alluvium. According to own OSL dating, these deposits can be linked to climatic deterioration of the LGM with increased aridity and stripping of tropical soils. In the Kaiso-Tonya area a mid-Pliocene sedimentary succession (ca. 3.5 to 3.0 Ma) could be

investigated in more detail including chemical, magnetic and mineralogical proxies. Four major transgression and regression cycles within a lacustrine delta sequence could be identified. Clay mineral associations show a predominance of smectite over kaolinite and together with gypsum precipitation high-frequency arid intervals.

Roller, S.; Hornung, J.; Hinderer, M. & Ssemmanda, I. (2010): Middle Miocene to Pleistocene sedimentary record of rift evolution in the southern Albertine Graben (Uganda). *Int. J. Earth Sci.* DOI 10.1007/s00531-010-0560-z

## S8-T08

### **Estimating the Age of the Malawi Rift, East Africa, From Scientific Drill Cores and Multichannel Seismic Reflection Data**

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The Lake Malawi Rift is the dominant extensional feature of the southern part of the western branch of the East African Rift. The lake occupies almost the entire width of the rift valley, and the earliest sediments in the deep part of the lake basin record the onset of late Cenozoic rifting in this part of Africa. Because of the paucity of volcanic material in the western branch as a whole, estimates of the age of rift initiation vary dramatically. In 2005 the Lake Malawi Scientific Drilling Project drilled to nearly 400 m below the lake floor near the center of the basin and recovered a continuous sediment record that extends back more than 500 kYr. By combining age-depth relationships from the scientific drill cores with legacy basin-scale multichannel seismic reflection data from the drill site, we provide new estimates of the age of the lake, and consequently the age of rift initiation in this part of the western branch. An improved age estimate is developed by first depth-converting the seismic data, and then

decompacting the deep section below the base of the drill core. We then propagate the new drill core age-depth model information into the sedimentary section observed on multichannel seismic reflection profiles to estimate the age of the basal sediments in the rift. This approach suggests that the rift may be as young as early-mid-Pliocene in age, considerably younger than most prior estimates.

## S8-T09

### Climate and environmental history in the Lake Victoria basin during the Holocene

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Over the last millennia, particularly in recent past, Lake Victoria has undergone major environmental changes resulting in rapid reduction in its natural resources and significant drop in the water levels. This caused major social, economic and political concern as it threatened the economy of the East African Community and livelihoods of the riparian community. The cause of rapid drop in the lake level remained largely unexplained. Previous studies have linked lake level changes and vegetation history to climatic events, but not at high resolutions. Besides, there has been dearth in scientific information regarding how climate variability and environment in the Lake Victoria basin varied in the past. This paper presents a high resolution multi-proxy palaeoenvironmental data in the form of microfossil pollen, spores and charcoal from Lake Victoria sediments for the last ca. 12000 yr BP. The findings indicate evidence of climatic variations and environmental changes in the lake's basin. The period between ca. 12033 ± 60 to 10691 ± 60 yr. BP was dominated by C4-types of vegetation cover. However, there was onset of forest recovery that continued

uninterrupted between ca. 11843 ± 60 and 11673 ± 60 yr. BP, with increasing diversity in arboreal taxa, and subsequent development of forests under wet-humid climatic conditions in the catchment of the lake prior to ca. 11311 ± 60 yr. BP and thereafter. Broadly, the period ca. 11311 ± 60 to 10715 ± 60 yr. BP was marked by repeated decline and recovery of forest which mirrors with increase and decline in non-arboreal pollen taxa, particularly Poaceae pollen, with low humidity at ca. 11230 ± 60 yr. BP and ca. 10737 ± 60 yr. BP. Fully forested vegetation type, is inferred between ca. 10715 ± 60 to 10691 ± 60 yr. BP, suggesting a humid climatic condition. Charcoal records indicate dry and humid climatic conditions between ca. 4186 ± 40 and 1830 ± 40 yr. BP. A closed vegetation cover was re-established in the lake's basin towards ca. 1320 ± 40 yr. BP and ca. 1247 to 190 ± 40 yr. BP, becoming more humid with a dense forest cover at ca. 458 ± 40 yr. BP. However, from ca. 190 ± 40 to 70 ± 40 yr. BP, δ<sup>13</sup>C values, indicate drastic change of vegetation, from a C3-type to a C4-type, presumably as a result of human-induced forest disturbance.

## S8-T10

### Chad Basin, Lake Mega-Chad and Lake Chad: paleoenvironments of North central Africa/ Sahara since the upper Miocene.

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Lake basins of the East Africa Rift System are intensively studied since several decades, whereas lake basins from central Africa only

received scant attention. Here we present several aspects of the sedimentary archives of Lake Chad basin at selected time slices.

The Chad Basin is an intracratonic sag basin located in North Central Africa. Since the last marine episode at the end of the Eocene, the deposition in the Chad Basin is exclusively continental (fluvial, deltaic, lacustrine and eolian). The Neogene and Quaternary sediments that accumulated in this basin have a maximum thickness of ~500 m and a rough extension over an area of ~500 km in diameter. Lake deposits prevail in the sedimentary record since the Late Miocene.

Miocene-Pliocene: huge surfaces of Neogene deposits, partly covered by the eolian deposits of the Dhourab sand sea and by Quaternary deposits, are exposed in the northern part of the Chad basin. These deposits are famous for their paleontological content (continental vertebrates, early hominids). These deposits are marked by several paleolake recurrences occurring between ~7 to ~3.5 Myrs.

Holocene: the major paleoenvironmental changes in the Sahara during the Holocene are the reactivation of river networks and the expansion of lakes. The hydrologic system of the Lake Mega-Chad is one of the most emblematic features of these changes. The water surface of this huge paleolake exceeds 350000 km<sup>2</sup> (from ~10° to ~18° North, and from ~12° to ~19° East). Around this paleolake, a number of ancient coastal morphostructures have been identified and highlighted, such as deltas, beach ridges, sand spits, wave-cut terraces, or islands. Resulting sedimentary architectures provide informations about paleohydrodynamics and, especially, paleowind regimes.

Modern Lake Chad: Lake Chad is a permanent and shallow freshwater lake that survives at the edge of the Sahara desert, as illustrated by its dramatic modern size decrease (1960ies: ~25000 km<sup>2</sup>; 2000ies: ~1500 km<sup>2</sup>).

Lake Chad reveals to be a very sensitive indicator of climate and environment. Sedimentary deposits in this basin are thus

outstanding archives of paleoenvironments and paleoclimate evolution of north central Africa and Sahara at various time and space scales.

Selected bibliographic references: Bouchette et al., 2010, *Quaternary Research* 73; Düringer et al., 2006, *Naturwissenschaften* 63; Düringer et al., 2007, *Pal. Pal. Pal.* 251; Ghienne et al., 2002, *Quaternary International* 87; Schuster et al., 2000 *C. R. Acad. Sci. Paris* 311; Schuster et al., 2003, *Earth Surf. Proc. and Landforms* 28; Schuster et al., 2005, *Quat. Sci. Reviews* 24; Schuster et al., 2006, *Science* 311; Schuster et al., 2009, *C. R. Geosciences* 341; Sepulchre et al., 2008, *Glob. and Planet. Change* 61.

## S8-T11

### <sup>238</sup>U-<sup>206</sup>Pb dating of early diagenetic calcite crystals from the lacustrine sediments of Bed I and Lower Bed II, Olduvai Gorge, Tanzania

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Olduvai Gorge, Tanzania is one of the world's most important sites for the study of our ancient ancestors, recording significant hominin evolution and cultural change during the Pleistocene.

Lacustrine clays, formed in a saline-alkaline lake between 2 and 1.4Ma, host a variety of different carbonate minerals and, in particular, unusual calcite crystals. Early diagenetic calcite crystals displaying a range of complex internal zonation are present almost ubiquitously throughout the lacustrine sedimentary sequence. They occur dispersed in the clays, within arching sprays of trona pseudomorphs and also as concentrated crystal-rich laminated beds within shallow scours.

The geochronology of the stratigraphic succession has previously been constrained using high precision radiometric dates on the multiple tuff layers interbedded with the sediments. The location thus provides a test-bed for the development of novel geochronological techniques to directly date the sediments.

$^{238}\text{U}$ - $^{206}\text{Pb}$  dating of the zoned calcite crystals from four previously-dated horizons has been investigated using Laser Ablation Multi-collector Inductively Coupled Plasma Mass Spectrometry (LA MC ICP MS), and has consistently produced dates only a little older than those using  $^{40}\text{Ar}/^{39}\text{Ar}$ , with good reproducibility between crystals from the same stratigraphic horizon. In all cases carbonate ages have a 2-6% uncertainty with a mean deviation of  $0.103 \pm 0.053\text{Ma}$  from the known values. On going work to refine the methodology is concentrating on a) inter-element fractionation, b) matrix matching standards to crystals and c) appraisal of the initial uranium disequilibrium, both within the sequence and in modern lake analogues.

Early-diagenetic, authigenic calcite crystals show exciting promise for directly dating ancient saline, alkaline lake sediments which may be useful in other similar hominin sites whose geochronology is less well constrained.

## S8-T12

### Environmental impacts of large scale degassing (LSD) at Lake Nyos, Cameroon (Central Africa)

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Following the sudden release of a huge amount of  $\text{CO}_2$  from Lake Nyos (crater lake lying along the Cameroon Volcanic Line) back in 1986, which claimed the lives of about 1750 people, it was decided to remove the gas, in a controlled manner, using pipes. The degassing system was designed to extract the  $\text{CO}_2$ -TDS rich bottom waters to the surface where the gas phase is released into the atmosphere and the liquid phase "showers" on the lake's surface. Effective degassing of the lake started in January 2001 with one pipe of inner diameter (id) 145 mm. Ten years after, the degassing system was reinforced with two additional pipes of bigger diameter (id 286.5 mm). The large scale degassing (LSD) went operational on March 19th 2011. During the single-pipe degassing period, no remarkable and/or endangering environmental impacts were observed except of the reddish surface waters caused by oxidation of Fe. Measurements of water conductivity, water transparency and  $\text{CO}_2$  concentrations in ambient air were conducted shortly before and barely two weeks after launching the LSD. The results revealed an over 25 % increase in surface water conductivity (135  $\mu\text{S}/\text{cm}$  to 170  $\mu\text{S}/\text{cm}$ ) and water transparency reduced by 95 % (from 2.4 m to 0.1 m on Secchi Disk). Values of  $\text{CO}_2$  concentrations in ambient air of up to 1.1 8%, forty times the atmospheric concentration and more than two times the threshold value (0.5 %) for human exposure, were recorded at the lake's surface, especially within the central basin. Long term exposure to such conditions could be hazardous giving that 1.5 % results in changes in physiological conditions (tachypnea). Changes in the Lake's overall structure aren't visible yet but these preliminary results indicate the need for a close follow up for both scientific and security reasons.

**S9-T01****Ostracods from water bodies in hyperarid Israel and Jordan as habitat and water chemistry indicators**

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The hyperarid region of Israel and Jordan covers a large area where numerous sites of Pleistocene lake sediments suggest that climate conditions were significantly wetter during the Pleistocene. This region experienced a significant increase in aridity in recent decades and the number of existing surface waters is diminishing rapidly. We studied ostracod shells from 43 pond and stream sites in the area to determine their distribution and to infer their ecological preferences especially with respect to general differences in water movement, and in the water's conductivity and ion composition. Twenty ostracod species were identified in total of which 12 taxa occur at three or more sites. Among the rarer species, *Cyprinotus scholiosus* was identified for the first time after two records from Plio- and Pleistocene sites in Yemen and Saudi Arabia. Further, *Paracyprretta amati* was recorded and its ecological preferences discussed for the first time following the description of the species from its type locality in Sudan. *Cypridopsis elongata* is the only typical inhabitant of lotic habitats, strictly preferring freshwater conditions and waters with an alkalinity/Ca ratio around 1 and cations dominated by Ca<sup>+</sup> and anions by HCO<sub>3</sub><sup>-</sup>. In contrast, *Cyprideis torosa*, *Limnocythere inopinata* and *Heterocypris incongruens* apparently prefer waters dominated by Na<sup>+</sup> associated with cations and Cl<sup>-</sup> associated with anions. *Heterocypris salina* and *C. torosa* occur over a wide conductivity (or salinity) range and in waters with alkalinity/Ca ratios around 1 and with significant alkalinity depletion.

*Humphycypris subterranea*, *Ilyocypris* spp. and *H. salina* are the only taxa which do not show any preference with respect to both the cation and anion dominance of the waters. The ecological preferences of the ostracod species from water bodies in the study area are discussed in detail and can be applied as a tool to reconstruct the hydrodynamic and hydrochemical evolution of the former water bodies in the presently hyperarid environment based on ostracod species composition analysis of Pleistocene lake sediments.

**S9-T02****Use of contemporary stable isotope records to determine ecological processes affecting chironomids as paleolimnological indicators**

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A major challenge for modern ecology and palaeolimnology is to merge fundamental knowledge of principal ecological mechanisms into traditional paleolimnological work. It is generally agreed that there is not a simple direct relationship between climate and lake functioning. Quantitative climate reconstructions suffer from confounding effects associated with ecological mechanisms that control the abundance of species that are used in the paleolimnological reconstructions. Head capsules from chironomid larvae have been used in quantitative reconstructions of climate for two decades and have been nominated among the best palaeolimnological indicators. However, there is only limited consistency among temperature reconstructions based on chironomid assemblages. In the present study, integrated analyses of stable carbon and nitrogen isotopes of individual chironomid genera and sediment pigment analyses of contemporary communities from South West Greenland were conducted to increase understanding of the mechanisms controlling the chironomid

composition and abundance. Individual habitats from both freshwater, oligosaline and silty lakes were analyzed covering the major lake types in the area. Detailed information on trophic position of chironomids and their interactions with primary producers are believed to greatly improve the interpretation of paleolimnological studies and thereby generate a stronger tool for estimating current and future changes in lake ecosystems.

### S9-T03

#### **Morpho- hydrodynamic conditions along meander bends control the distribution of benthic fauna in a large river (Paraguay River, Argentina-Paraguay).**

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The Paraguay River is a large South-American river (mean discharge= 4000 m<sup>3</sup> s<sup>-1</sup>, drainage basin area= 1095000 km<sup>2</sup>). It has a meandering channel and drains areas of the tropical Brazilian Shield with Tertiary-Quaternary sediments. Investigations about morphological features and flow characteristics of meanders in large rivers are limited both in number and in detail of measurements because of inherent difficulties involved in obtaining quality data. Changes in morpho- and hydrodynamic conditions directly or indirectly influence benthic invertebrates at the scale of individual organisms or assemblages because they modify the specific food resources and refuge. Considering the above explanation, it is promising to study the links between morphological features and sedimentological characteristics, closely related to hydraulic conditions, and the ecological patterns of benthic invertebrates along meanders. It would be a pioneering contribution on this topic of science.

We have selected two meanders bends of the Paraguay River. One of them is located

downstream of the Bermejo River, a tributary which supplies a huge amount of fine sediments (mainly in suspension) to the Paraguay. These particles in suspension are Precambrian and Paleozoic sediments transported from the Andean headwaters. The other meander is located upstream of this tributary and, consequently, the sediment load is significantly lower and coarser.

The results reveal that at meso-habitat scale (i.e. meander scale) mean bed hydraulic conditions are most intense in the downstream meander (shear stress= 0.18 kg m<sup>-1</sup> s<sup>-2</sup>, mobility number= 0.92) and the concentration of suspended sediments is higher (125 mg l<sup>-1</sup>), leading to low mean density of invertebrates (960 ind. m<sup>-2</sup>). Moreover, the upstream meander presents lower hydraulic stresses (shear stress= 0.04 kg m<sup>-1</sup> s<sup>-2</sup>, mobility number= 0.13) and suspended sediments (56.5 mg l<sup>-1</sup>), prompting larger benthic densities (15600 ind. m<sup>-2</sup>). Besides of the bed hydraulic conditions, the suspended fine sediments would have strong ecological implications. A fraction of these suspended sediment particles cover the interstitial spaces between sand bed grains, i.e. the places where the invertebrates live, impeding their development. At micro-habitat scale (i.e. pool-riffle scale) the density of organisms decreases significantly on the scour hole (pool area) of the upstream meander, where the bed shear stresses are higher, in comparison with the riffle area. Nevertheless, this relation was not clear on the downstream meander. This situation could be attributed to the high sediment input from the Bermejo River, which would reduce the importance of the hydrodynamic role compared with the fine sediment one on the invertebrate densities and composition. This study suggests that benthic invertebrates prefer the benefits from an environment with lower hydrodynamic stress but without fine sediments on the interstitial spaces, providing refuge and probably food.

### S9-T04

#### **Reconstruction of the environmental changes in Late Glacial and Holocene in the vicinity of**

**Lake Lukie (SE Poland) using multiproxy analysis.**

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Lake Lukie is located in the south-east Poland. It is one of the biggest lakes in Leczna-Wlodawa Lake District, the biggest in the Polesie National Park (136,74 ha). It is shallow lake, maximum depth is 4m, with large littoral zone. It is surrounded by peatlands and is strongly overgrowing with water plants.

The main aim of the presented work was the reconstruction of the environmental changes in the vicinity of the lake during Late Glacial and Holocene. The second important goal was to reconstruct the influence of environment on the lake ecosystem (trophy, lake level fluctuations, oxygen conditions, water plant cover).

The multiproxy analysis were conducted in the lake sediments taken from the deepest part of the lake (3,5m). The thickness of the core was 10,5 meters. The bedrock of the Lake Lukie is sand and the oldest sediment, which accumulated during the Older Dryas period, is silt gyttia. Since Allerød alternately sedimented detritus and calcareous detritus gyttia with no trace of lamination.

In the presented multiproxy research the main analysis used for environment change reconstruction was subfossil Cladocera, the other were pollen, plant and animal macrofossils, stable isotopes ( $d^{13}C$  and  $d^{18}O$ ) in carbonates, chemical composition of the sediment. The core was sampled every 10 cm and prepared in the laboratory according to the requirements of each method. In order to

set the time scale for the sediments several  $^{14}C$  AMS data was done.

The results of the multiproxy research allowed to reconstruct climate evolution, plant cover changes, intensity of the erosion and human impact on the environment. It was also possible to reconstruct the influence of mentioned above processes on the ecosystem of the lake. The main factor that influenced environment evolution in the vicinity as well as in the lake itself was climate.

In the cold period of Late Glacial distinctly marked Allerød warming, which influenced plant cover of the Lake Lukie catchment. It also made a great change to the lake environment causing deepening and also development of zooplankton and macrophytes. Younger Dryas cooling caused the decreasing of forest and development of shrubs in the catchment. At that time, similarly as in the Oder Dryas, erosion played great role in the sediment formation. In the lake the cold tolerant species dominated, the biological life and lake trophy decreased.

The results of all analysis also show clearly that Holocene warming was coming gradually and first warmer climate impulses appeared in Younger Dryas. In Preboreal period Cladocera species diversity and frequency was greatest in lake history and they mark optimum condition for zooplankton development. Used resolution of sampling was accurate enough to detect climate fluctuation in the Holocene and allowed to detect PBO episode. Also human impact on the catchment and the lake was marked distinctly in the results of most analysis. It caused plant cover change and the increase of the lake water trophy.

## S9-T05

**The Mutual Ostracod Temperature Range (MOTR) method: an answer in search of a question?**

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The MOTR method uses nonmarine ostracods as proxies for mean January and July air temperatures, relying on correlations of the distributions of living ostracod taxa with modern climate data. It appears to yield valid palaeoclimate estimates, yet it may be argued that ostracods, as aquatic organisms, are not influenced directly by air temperature. An underlying assumption is that although environmental factors such as temperature and solute chemistry are more direct controls, air temperature is nevertheless a major influence on distribution. Perhaps this "answer" can be validated by establishing more precisely what the question is: by examining the biological basis of climatic influence on ostracod distributions. Species may be present in particular locations today because the climate is "right" for them, subject to other conditions being satisfied (e.g., the right water chemistry). From this consideration follows the assumption that species have tracked Quaternary climate change, altering their geographical ranges to stay within their preferred climate regime (or going extinct through failure to do so). A direct influence may be the temperature range to which a species is adapted. In a shallow lake, water temperature corresponds closely to air temperature; in temperate latitudes at least, the temperature of groundwater issuing from springs shows little variation and approximates Mean Annual Air Temperature. The influence is less direct in deeper waters buffered against air temperature fluctuations, such as the hypolimnion of a deep lake. The distribution of a species might be limited by the highest mean summer temperatures tolerated by adults and the minimum winter temperatures that its resting eggs can survive. Such relationships may be different for different species; some have reproductive peaks in different seasons, some overwinter as juvenile or adult instars rather than as eggs. For example, *Tonnacypris glacialis* is a high-latitude northern hemisphere species which extended its range southwards into Europe during Pleistocene cold stages; today it is mostly restricted to latitudes higher than 65N. It has a life-cycle of one generation per year;

overwintering eggs hatch in June/July and instars reach maturity by late August. Its distribution appears to be controlled by requirements for temperatures to remain above freezing for at least two months in summer, in order for it to complete the active part of its life cycle, and to go below freezing in winter. Its southern distribution correlates with a maximum mean July air temperature of +13C (although it is not known whether the latter is physiologically significant). It winters as eggs which not only survive freezing, but will not hatch unless they have actually been frozen, although they apparently do not survive if the temperature drops below -30C.

### S9-T06

#### European climate change at the end of the last glaciation: chironomid-based temperature reconstruction on a continental scale

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In Europe climatic conditions at the end of the last ice age were affected by a number of abrupt temperatures shifts, including the rapid transitions to warmer climate at the beginning of the Lateglacial Interstadial and



the Holocene, and the cooling at the start of the Younger Dryas cold period. The amplitude and spatial pattern of Lateglacial changes in temperature can provide information about forcing factors of these climate shifts and about processes affecting the European climate system during a transition to warmer climate. However, spatially resolved datasets describing temperature change across the European continent during this period at centennial or higher time resolution and based on the same standardized approach are presently not available. We aim to develop such a standardized dataset based on records of past summer temperature reconstructed from fossil chironomid assemblages in lake sediments. A combination of regional calibration datasets provided the basis for a chironomid-based inference model for July air temperature that covers the range of temperatures and chironomid assemblages expected for Europe during the Lateglacial. This model, which is based on modern chironomid assemblages from 274 lakes in Norway and Switzerland and associated observed values of mean July air temperature, was then used to produce temperature records from Estonia, Denmark, Ireland, the UK, Norway, the Netherlands, southeastern France, Western Spain, Northern Italy, Switzerland, and southern Romania. Preliminary results indicate distinct variations in the amplitude of temperature changes across Europe during the Lateglacial, with stronger shifts in July air temperature reconstructed in northern parts than at localities more to the south of the continent. Future work will expand this dataset to include additional sites on the British Isles, Italy, Bulgaria and Scandinavia in order to confirm the observed spatial pattern of Lateglacial temperature changes.

### S9-T07

#### **Niche constraints vs. random effects: how much should we trust biological indicators in palaeolimnological reconstructions?**

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The work of many limnogeologists is reminiscent of that of a detective, searching for signals from preserved biotic remains to unravel complex ecosystem (hi-)stories. These signals are often blurred and confusing and, even when clearer, might lead to misinterpretation or ambiguity, due in part to the complex behaviour of lake biota. Limnetic communities are composed of a plethora of interacting species assembled according to their niche and varying in a dynamic fashion in response to environmental change. Consequently, the application of niche theory allows reconstruction of palaeoenvironments based on species-environment relationships, sometimes with high resolution and confidence. However, recent advances in neutral modelling of biodiversity suggest that random changes in ecological communities alone may produce community patterns that were traditionally explained by species sorting through differential adaptations and biotic interaction effects, challenging classical ecological theory and in this way the use of biological indicators.

The temporal dynamics of palaeoenvironmental bioindicators may be influenced not only by the variables of interest (e.g. salinity, temperature, pH or depth), but also by other factors such as biotic interactions, or may even vary randomly (ecological drift). Limnogeologists must therefore be aware that a substantial proportion of the variation of ecological communities can potentially be explained not only by species niches but also by other sources of variation including random dynamics, dispersal and mass effects... and should be cautious about interpretations based on poor data or a too low number of indicators. Nevertheless, ecological studies show that most aquatic communities are significantly structured by species sorting processes, supporting the use of biological indicators in palaeolimnology. Many examples show the clear effects of environmental spatial heterogeneity in structuring metacommunities, but the influence of temporal changes still needs to be tested in the same way and fully recognised, and here

palaeoecology may provide important advances in ecological theory. In conclusion, to get an accurate picture of past ecosystem status, we need to use a variety of proxies with strong modern limnological datasets, to establish relationships between changes in biological and abiotic indicators, and to develop techniques to define the significance of change over and above that of random variation.

## S9-T08

### **Quantifying and qualifying salinity response: transfer functions and underlying uncertainty in diatom and ostracod training sets from Turkish salt lakes**

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Proxy data for past changes in salinity or conductivity and, by inference, lake level have been instrumental in reconstructing Quaternary climate change from analysis of hydrologically-closed, saline lake sediment sequences. Of the range of biological proxies, diatoms (Bacillariophyceae) and ostracods (Ostracoda) can be a powerful combination. Multiple-indicator transfer functions offer the potential to strengthen quantitative reconstruction. In addition to derivation of individual transfer functions, this study adopted a parallel-sampling approach to determine whether predictable associations of diatoms and ostracods could be defined, testing the degree to which conductivity was an overriding factor in controlling distributions.

Conductivity transfer functions were derived from Turkish lake training sets collected from 59 lakes spanning a gradient from fresh to hypersaline. For logistical reasons, samples were collected in different seasons: summer (July-September, 1996, 1999, 2000), spring 1997 (April, under ice) and in December, 2000, collecting lake edge and centre samples

wherever possible. The resultant transfer functions based on WA with inverse deshrinking for diatoms ( $n=92$ ;  $r^2 = 0.91$ ; jack  $r^2 = 0.79$ ) and classic WA for ostracods ( $n=53$ ;  $r^2 = 0.83$ ; jack  $r^2 = 0.68$ ) are more robust for diatoms, being more diverse and preserved in a greater number of samples, but both demonstrate statistically-significant relationships.

50 paired samples contained both diatoms and ostracods. To match the lower ostracod species richness, the 28 most abundant diatom taxa were selected, and numerical equivalence between the data-sets was achieved by transforming each into 20 class variables based on percentile values, prior to running TWINSpan on the separate data-sets and a combined diatom-ostracod data-set. The lack of comparability in groupings between sites in both cases highlights elements of uncertainty in the data which were not apparent in transfer functions, other than in large estimated tolerance ranges for some taxa. From more detailed exploration of the data, this approach offers an additional means by which to interpret uncertainty in reconstruction which is likely to occur when fossil assemblages are dominated by taxa with wide tolerance ranges.

## S9-T09

### **When less is more: exploring problems, progress and potential with African diatom-based transfer functions**

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Diatoms have had a long history of use for inferring ecologically and climatically-meaningful parameters of water chemistry in Africa, such as pH, conductivity and anion ratio. The development of pan-African training sets within the European Diatom Database

Initiative (EDDI), for example, has enabled many researchers to make quantitative inferences of past conditions from fossil diatom data without the need to create their own laborious, logistically challenging, expensive and time-consuming training sets and models, and have enabled new insights into past environmental and climatic conditions in this important region. Ecological and limnological care needs to be taken however, as uncritical application of (any) models can lead to misleading inferences. Recent research with a crater lake diatom training set from western Uganda, for example, has highlighted some problems and limitations with using such large-scale training sets as a "one-size fits all" approach, even where apparently good analogues can be found within these larger training sets. Here, a smaller, more limnologically appropriate training set can provide "better" (or, rather, more useful) inferences for smaller lakes than larger and apparently more powerful models, with a hybrid model (including carefully selected sites from both training sets) showing most potential, optimising accuracy and utility across a large conductivity gradient. We show, with reference to sediment records from lakes in east Africa, some problems and potential of diatom inference models, and highlight the important role of lake and catchment-specific factors (e.g. lake morphometry, catchment size, and human impact) and taphonomy in modulating the sensitivity of proxies, and lake records, as indicators of environmental change. Transfer functions, as part of a wider framework of ecological and limnological understanding of individual lakes, proxies and taxa, remain useful for providing quantitative inferences, but such reconstructions need corroborating independent proxy data to go beyond the reduction of complex multi-dimensionality of limnological ecosystems and environmental change to a single (sometimes shaky) line.

## S9-T10

### **Palaeolimnological interpretation of biogenic silica - review based on selected lakes from the Polish Lowlands**

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The presentation outlines the possibilities and limitations of the interpretation of biogenic silica ( $\text{SiO}_{2\text{biog}}$ ) contents in lacustrine sediments in the context of reconstruction of past changes in lake ecosystems throughout the Holocene.

The discussion is centered on the following problems:

1. which environmental factors determine the contents of  $\text{SiO}_{2\text{biog}}$  in lake deposits
2. does the  $\text{SiO}_{2\text{biog}}$  preserve local or regional/subregional paleoenvironmental signal and
3. can  $\text{SiO}_{2\text{biog}}$  be used as a tool of correlation of sedimentary records from different lakes

The data discussed in the presentation have been obtained from four lakes located in different parts of the Polish Lowlands (Lake Sarbsko, Lake Ostrowite, Lake Skrzyńka and Lake Gasak).

From the data it emerges that:

1. Studied lakes display individual patterns of stratigraphic variation of  $\text{SiO}_{2\text{biog}}$  which hinders the application of biogenic silica in correlations of sedimentary records in regional/subregional scale
2. Culminations of  $\text{SiO}_{2\text{biog}}$  in the sediments of Lake Gasak correspond with the enhanced contents of terrigenous matter ( $\text{SiO}_{2\text{ter}}$ , K), which indicates that diatom productivity was limited by the delivery of  $\text{H}_4\text{SiO}_4$  or biogenic elements (N and P) to the lake waters. Both, silicic acid and nutrients, are removed from soils owing to surface erosion and are inevitable in the algal life cycle. Silicic acid is secreted by diatoms to produce opal frustules and N/P compounds act as substrates in photosynthesis. The  $\text{H}_4\text{SiO}_4$ -limitation to diatom productivity is inferred from concomitant culminations of  $\text{SiO}_{2\text{biog}}$  and

terrigenous matter in organic matter-rich deposits.

3. Low contents of  $\text{SiO}_{2\text{biog}}$  in the sediments of hardwater Lake Skrzynka were owing to diluting effect of carbonates on biogenic silica or alternatively low availability of nutrients in lake waters caused by sequestration of P by precipitating  $\text{CaCO}_3$ .

4. The unequivocal evidence of dilution effect is provided by a strong negative correlation between  $\text{SiO}_{2\text{biog}}$  and  $\text{SiO}_{2\text{ter}}$  in the Lake Sarbsko sediment core. This covariance

precludes interpretation of biogenic silica as an index of biomass production.

5.  $\text{SiO}_{2\text{biog}}$  can not be regarded as an unambiguous indicator of lake trophic state. In the sediments of Lake Ostrowite the content of  $\text{SiO}_{2\text{biog}}$  increased during oligotrophication (as inferred from subfossil diatoms). In turn in Lake Sarbsko the enhanced accumulation of  $\text{SiO}_{2\text{biog}}$  was accompanied by the growing frequency of eutrophic diatoms.

6. The understanding of  $\text{SiO}_{2\text{biog}}$  strongly benefits from supplementation with other geochemical and paleoecological proxies.

## S10-T01

### Lake deposits of moderate salinity as sensitive indicators of lake level fluctuations: example from the Upper Rotliegend saline lake (Permian, Northeast Germany)

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The Rotliegend saline lake periodically covered wide areas of the Southern Permian Basin in Northwest Europe during the Middle-Late Permian, marking relatively wet climatic phases in a desert environment. The sedimentology, mineralogy and geochemistry of lake deposits was studied to document very high frequency lake level fluctuations and to evaluate their triggers.

Mixed siliciclastic-evaporitic lacustrine deposits are intercalated in terminal fluvial and evaporitic-aeolian deposits. Lacustrine deposits show pronounced cyclicity. Fluvial

silt- and sandstones are frequently intercalated in low-salinity shales, documenting increased run-off. Carbonate and anhydrite contents considerably increase upwards, wave ripples occur in the upper parts and desiccation cracks exist at the top. Lake deposits are overlain by evaporite crusts. Not only the mineralogical composition but also the boron content adsorbed on illite increases upwards. The low to high salinity cycles reflect periodic drying-upward of the lake. Increased precipitation and marine ingressions into the basin resulted in lake formation and extension. Decreased precipitation is followed by shrinkage of the lake and desiccation at its margins. Salinity of lake deposits increased considerably before the areas fell dry, due to concentration of the brine, but halite is not preserved in the study area.

Given the observation that boron contents adsorbed onto illite are distinctively higher in high salinity deposits than in claystones deposited in moderately saline water, boron can be used as a palaeosalinity indicator. However, specific values for calcite or anhydrite precipitation could not be established during the study. Marine ingressions into the saline lake did not result in increased boron content, because salinity

dropped due to dilution of the lake brine by marine water. Sedimentological, mineralogical and geochemical analyses allowed the reconstruction of the depositional conditions in the saline lake and the lake evolution in the Northeast German part of the SPB. The study shows, that lake deposits extending into basin marginal areas during wet periods are pre-eminent indicators for high frequency climatic fluctuations. This high frequency cyclicity is hardly represented in aeolian deposits. Not only varying precipitation but also marine incursions resulted in lake level fluctuations.

### S10-T02

#### **Long-Distance Drainage to Eocene Lakes: A New View of the Green River Formation, Western U.S.**

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Large modern lakes commonly receive river waters that have flowed hundreds of kilometers, connecting them to tectonic, magmatic, climatic, and biotic regimes that can differ markedly from the immediate vicinity of the lakes themselves. However, the geologic record of lake deposits is often interpreted in terms of purely local drainage influence, due in part to inherent difficulties in reconstructing the true watersheds of long-vanished lakes. The advent of geochemical techniques for deriving radiogenic isotopic data from sand grains is rapidly transforming our understanding of sedimentary provenance, however, and could therefore lead to a greatly improved understanding of the drainage networks that were associated with ancient lakes.

The lacustrine Green River Formation is famous both for the rich climatic and

biological records it preserves, and for holding the world's largest known resources of both oil shale and soda ash. Previous paleogeographic reconstructions emphasized drainage from areas near the Eocene lakes, which include basement-cored foreland uplifts, foreland volcanic rocks, and frontal areas of the adjacent Sevier fold and thrust belt. For example, arkose in the Colton Formation in the Uinta basin (Utah) was previously interpreted to derive from a Proterozoic basement-cored uplift in Colorado, and volcanoclastic sandstone in the greater Green River basin (Wyoming) was inferred to have been derived from the adjacent Absaroka volcanic province. However, recent studies employing U-Pb in detrital zircon, <sup>40</sup>Ar/<sup>39</sup>Ar in detrital feldspar, and whole-rock Pb isotopes in sandstone have overturned those earlier hypotheses. Detrital zircon in the Colton Formation includes abundant Jurassic and Cretaceous grains that could not have come from Colorado, and instead appear to record a river that flowed ~1000 km northward from the Mohave region (the "California River"). Several lines of evidence demonstrate that fluvial-deltaic volcanoclastic sandstone in the Greater Green River basin came not from the Absaroka province, but instead from the contemporaneous Challis volcanic field, ~500 km away in central Idaho (via the "Idaho River").

The above observations, combined with previously noted regional sedimentary fill patterns of Laramide basins, suggest that the Green River Formation lakes lay at the focal point of a watershed that at least intermittently integrated much of the Laramide tectonic province. The existence of such riverine connections suggests that the lake deposits could hold a much richer record of regional tectonic and magmatic evolution than previously suspected. Moreover, the lake deposits in part appear to represent regionally-averaged records of interactions between climate and topography, rather than single-site climate archives. Finally, regional river courses may help explain the lack of evidence for faunal endemism in what

otherwise appear to have been geographically isolated basins.

## S10-T03

### Jurassic lacustrine and palustrine environments in Argentina: a review

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We compare and correlate Jurassic continental palynofloras of southern and central-western Argentina, to review their environmental and climatic significance and to characterize some time-slices through paleoclimatic multi-proxy mapping, considering lithogenetic, isotopic, palynologic, megafloristic, invertebrate and vertebrate paleodata. The differences between both areas could be related with the sheer size of the Gondwana supercontinent configuration (as expressed by Parrish). In general, the continental interior (Cañadón Asfalto Basin) would be expected to have been dry, with strongly seasonally distributed temperatures, while the western coast of the continent, during the marine transgressions in the Neuquén Basin, would be expected to have been moist. In central Patagonia, early in the Middle Jurassic, and associated with a magmatic arc, after deposition of the volcano-

sedimentary Lonco Trapial Formation, began the sedimentary filling of Jurassic continental depocenters in the Cañadón Asfalto Rift Basin (named Cerro Cóndor, Llanquetrúz and Fossati). Lacustrine and fluvio-deltaic sediments, bearing a continental Middle Jurassic palynoflora, filled the Cerro Cóndor depocenter, while a Late Jurassic palustrine palynoflora characterized the Fossati depocenter. Also, continental and coastal palynomorph assemblages of the back arc Neuquén Basin were considered: a Callovian deltaic swamp palynoflora at Sierra de Chacaico, Callovian continental coastal siltites at Arroyo Picún Leufú locality and a Late Oxfordian coastal saltmarsh palynoflora north of Zapala (Neuquén province). Palynostratigraphic, palynofacial and statistical studies show tendencies in diversity at the species level and in suprageneric groups. A Late Jurassic (Late Oxfordian) time-slice is specially surprising, due to the large regional extension of lithogenetic climatic proxies, which indicate extreme aridity: the thick gypsum and anhydrite deposits of the evaporitic coastal Auquilco Formation, which extend from the southern end of the Sierra de la Vaca Muerta (Neuquén Province) in the south, through western Mendoza and San Juan provinces, crossing to Chile and southern Perú. These evaporites correlate to extended deposits of eolian sandstones on the eastern side of the continent. The eolianites are present between Minas Gerais (Brazil), at the northern end of the Paraná Basin, and the Chaco-Paraná Basin of northeastern and central Argentina. They represent the enormous Botucatu paleodesert and are the register of the largest paleodesert known in the geologic history. Towards the south, in central Patagonia, their time equivalents are palustrine wetland environments with locally hydrophilic palynologic assemblages (trilete spores) of ferns and bryophytes and in some cases with dominance (>80%) of planctonic coccal green freshwater algae (*Botryococcus* spp.). The presence of *Classopollis* spp. and *Ephedripites* sp. indicates a macroenvironment with a certain degree of aridity.

**S10-T04****Unexpected high teleost fish diversity in a Late Miocene palaeolake at Venta del Moro (Valencia, Spain)**Bettina Reichenbacher<sup>1</sup>, Plinio Montoya<sup>2</sup><sup>1</sup> Ludwig-Maximilians-University, Department of Earth and Environmental Sciences, Section Palaeontology & Geobiology, Munich, Germany<sup>2</sup> Universitat de València, Departament de Geologia Àrea de Paleontologia, Burjassot, Spain**Email:** b.reichenbacher@lmu.de

Teleost fishes play a critical role in modern lake ecosystems and their diversity and composition is clearly linked to environmental parameters. Despite their ecological importance, the fossil record of lacustrine fish faunas remains poorly known. Possible explanations for this lack of data may be that lacustrine archives containing fish fossils are rare throughout the world, or that other groups of fossils appeared more promising for scientific analysis. However, previous studies have revealed that fish fossils from palaeolake sediments can contribute considerably to the understanding of environmental change, and, moreover, that fish fossils from palaeolake sediments can reveal a high quality of the ancient taxonomic fish diversity, probably close to the actual palaeodiversity.

Here we report on the fish fauna from the Late Miocene palaeolake at Venta del Moro near Valencia in Spain (Upper Turolian, MN 13, approximately 5.8-6.2 Ma). The reconstruction of the fish fauna is based on the abundant occurrence of exceptionally well preserved otoliths, while skeletal remains are absent. Otoliths have long since been known to allow a precise species identification and most of the otoliths from Venta del Moro could be identified down to species level. More than 35 species are present, they belong to the Cyprinodontidae (> 10 species) and Gobioidae (>10 species), while Cyprinidae and Atherinidae are represented by two species. Moreover, we found the first record of a fossil *Valencia* species, which may be closely related

to the Recent *V. hispanica*, which is an endemic and threatened taxon living near Valencia in Spain.

In all, the fish species diversity from Venta del Moro is clearly higher than all previously known fish records from Miocene palaeolakes. It can be assumed that the Venta del Moro site represented a large, permanent, probably slightly brackish water body, which supported a heterogeneous ecosystem with varying water depths and substrates and different types of prey. The high species diversity in the Venta del Moro palaeolake may have resulted from the prominent changes in climate and palaeogeography in the circum-Mediterranean area that also have produced the immigration of mammalian taxa from Asia and SE Europe. The diversity of this fish fauna is significant for the understanding of the evolution of the lacustrine fish faunas in the circum-Mediterranean area and provides additional information on the climate, environment and palaeogeography of the Late Miocene.

**S10-T05****A lacustrine diary for Triassic climate change - facies cycles of the Keuper Group, Germany**Edgar Nitsch<sup>1</sup>, Norbert Hauschke<sup>2</sup><sup>1</sup> RP Freiburg, LGRB, Freiburg i. Br., Germany<sup>2</sup> Universität Halle, Halle, Germany**Email:** Edgar.Nitsch@rpf.bwl.de

Cyclic climate changes in the Early Mesozoic remain a puzzling and poorly understood feature of the ice-free "warmhouse" mode during the existence of the Pangean supercontinent. Yet there is strong evidence for high-frequency fluctuations in precipitation/runoff to evaporation rates with frequencies of < 10e6 yr in many long lacustrine sedimentary records on different continents. Although often attributed to Milankovich-type changes of orbital parameters and thus global insolation patterns, the coupling mechanisms to

hydrologic changes of closed and semi-closed lacustrine systems remain hypothetical.

Here we present a short review of cyclic and secular changes in climate-sensitive nonmarine facies systems of the Middle to Late Triassic Keuper Group, Central European Basin. These facies systems developed in a structured epicontinental basin, separated from the tropical oceanic gulf of the Tethys Sea by a 60 to 300 km wide mountainous highland. The climatic setting was mainly controlled by high-pressure cells at paleolatitudes of 20° to 35° N and strong seasonality due to the Pangean mega-monsoonal wind system. Sporadic marine incursions during sea-level highstands and tidally influenced estuarine to fluvial deposits in the early Late Ladinian and middle Carnian suppose low topography and altitude of the sediment surface during most of the time. The nonmarine facies systems mainly consisted of a huge terminal mudflat-ephemeral lake complex, hundreds of kilometres across, surrounded by alluvial braidplains up to 200 km wide.

A secular climate shift from arid Late Ladinian (c. 235 Ma) to subhumid Rhaetian (c. 205 Ma) environments is evident from different proxies: plant remains (conifer-dominated to horsetail-fern-pteridosperm-dominated floras), petrography (halite-anhydrite-bearing to quartzose and coal-bearing deposits), paleosols (salic and gypsic vertisols and gypcretes to rooted calcrete, histosols and kaolinite-bearing soil remnants), and oxygen isotopes. This shift to less arid conditions is accompanied by a slight rotation and northward drift of the paleocontinental position of the basin.

On a smaller scale, conspicuous high-frequency facies changes a few metres to decimetres in thickness form a superimposed set of stratigraphic cycles. These cycles do not represent lateral shift of facies belts, since they are not closely related to progradational cycles of the marginal braidplain. They rather represent hydrological changes of the whole lacustrine system, as indicated by alternations of evaporite deposits with fossiliferous fresh-

to brackish-water dolomitic marls. The time scale of these hydrologic cycles is poorly constrained, but biostratigraphic and paleopedologic data point to a set of at least three superimposed frequencies in the scale range of 10e4 to 10e5 yr. However, the error range of Triassic geochronology is yet large enough to allow more than one Milankovich frequency or any alternative in-between for the observed cycle orders.

## S10-T06

### **A prograding delta succession in a mega-lake system: Architecture, depositional cycles, and sequence stratigraphy (Upper Triassic, Junggar-basin, NW-China)**

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Lacustrine deltaic systems differ in several ways from marine ones and classic sequence stratigraphic concepts need to be modified. We aim to point out the linkage of depositional controls and their effect on the rock record. Therefore we figured out a quantitative outcrop analogue study with an exceptionally high-resolution record of a lacustrine delta complex (cm to decimetre) of the Upper Triassic at the southern margin of the Junggar Basin (Xinjiang, China).

Sedimentological logging of lithofacies and architectural elements were combined with GR measurements and 2D mapping. The data are analysed and interpreted in terms of depositional dynamics, cyclicity, stacking pattern, accommodation vs. sediment supply and preservation potential. The sedimentary inventory comprises various types of gravelly channel bodies, sheet like sandy and clayey units, as well as ferrocrete horizons and coal seams organized in four different geosystems: Delta-slope, delta-front, delta-top and distal alluvial plain.



A four-fold hierarchy of depositional cycles from micro- to megascale was identified showing systematic superposition and therefore considered to mirror strong external control. Mostly 2-4 microcycles are stacked to one mesocycle rise and 2 or 3 mesocycles are stacked in a macrocycle rise. Regarding the fall hemicycles, 1-3 (exceptionally 5) microcycles build up a mesocycle fall and 1-4 mesocycles a macrocycle fall. The same pattern is observed for the stacking of mesoscale into macroscale cycles. For the overall megascale four macroscale cycles build a complete overall scale cycle (two for rise and two for fall hemicycles). Here, the overall mega-scale represents a progradational trend and macro-scale cyclicity goes along with a reorganization of the depositional environment.

According to preservation of cycles and regional geodynamic data, tectonic rates did not change markedly in the Upper Triassic (Bian et al., 2010). However, according to pollen and spores data humidity (and its variations) changed over time (Ashraf et al., 2010) and show superpositioned trends. Depositional cycles and reorganization of sedimentary environments go along with that observation, for example, humid phases seem to provide more stable conditions over time, which results in thicker and more pronounced floodplain and sandy crevasse units. Drier phases seem to correlate with more frequent formation of conglomerate filled channels.

In conclusion the sedimentary record supports a strongly linked coupling of climate with

patterns of lake level fluctuations and changes in sediment supply, possibly on a basin-wide scale. This is a unique situation for closed and partly open lake hydrology and makes clear that application of terrestrial sequence stratigraphic concepts (e.g. stratigraphic base level) are more successful in such geosystems (Hornung and Hinderer, 2011, in press).

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### S11-T01

#### Numerical Simulation of an Underflow in Perialpine Lake Constance

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A torrential rain event in the western Alps in August 2005 caused high flood flows in the rivers Alpine Rhine and Bregenzer Ache which are the main tributaries into Lake Constance. The discharge of the Alpine Rhine reached 2200 m<sup>3</sup>/s, which is little below a centennial flood event. Discharge of the Bregenzer Ache was estimated to 1350 m<sup>3</sup>/s which statistically occurs every 100 yr but with a 1000 yr frequency in selected smaller tributaries. The high concentration of suspended solids in the fluvial water increased its density and created an underflow with considerable influence on the lake's hydrodynamics and water quality.

Consequences within the lake were directly registered by a mooring (equipped with thermistor chain, sediment trap, current meter, oxygen sensor). Spatial data of the path and form of suspended matter cloud within the lake were gathered using echo sounder and probe measurements (turbidity, temperature, salinity). An underflow with a temperature of 14°C flew with 1.4 km/h some 20 km into the lake. Several days after the event, the fluvial sediments were detected as increased turbidity at the drinking water outtakes around the lake. We modelled this underflow using the three dimensional hydrodynamic and water quality model ELCOM-CAEDYM. The suspended solids module of the model accounts for the impact of the sediment load on water density. Settling is considered using Stokes Law, and resuspension can also be included. The simulation of the August 2005 flood event and comparison with measured data impressively showed the ability to reproduce the most important effects of the flood flow. Comparative simulations with and without consideration of the coriolis effect indicate an influence of the coriolis force on the flow path of the density current in a lake of this size.

## S11-T02

### **Flood Alp! - Holocene flood variability in the Alps reconstructed from low- and high-altitude lacustrine records**

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Severe floods caused by heavy precipitation represent one of the major natural hazards in the Alpine realm, resulting in enormous financial and social damage. Current climate models predict an intensification of the hydrological cycle and thus even an increase in heavy precipitation in the future due to global warming. In order to assess this flood hazards, intensive scientific efforts are undertaken to gain knowledge about the natural variability in the occurrence of extreme flood events. Lacustrine sediment records allow the reconstruction of flood recurrence-rates in the past, offering time series reaching beyond the relatively short time interval covered by instrumental and historical data. Special focus is put on Holocene time periods with increased air temperatures that could serve as a natural analogue to the present global warming and therefore provide important data input for climate models.

The FloodAlp project aims to reconstruct the Holocene flood history of the Central Alps. We investigate 21 lakes (0.01 to 5.2 km) along a North-South Alpine transect from northeastern Switzerland to northern Italy covering a wide range in altitude (197 to 2065 masl). Modern meteorological data indicate large regional variations in the occurrence of recent flood events. A large number of lakes is required to exclude only locally occurring events from the overall signal (e.g. spatially restricted thunderstorms) and also to generate a statistically significant flood-event data base. In addition, the wide altitude distribution provides essential information on the seasonal occurrence of the floods, as the high-elevation sites are not recording events during the winter due to snow precipitation and ice cover.

In respect to the temporal and spatial flood distribution of the established flood chronology, some well-pronounced features can be observed. Within the northern and

southern flood records, specific periods with enhanced and decreased flood occurrence can be distinguished and correlated among each other. Although there is some regional variation, the overall pattern of the frequency and intensity of flood events match quite well even between both sides of the Alps. Moreover, the flood-frequency records often correlate to various independent climate and solar proxies. This study allows identifying specific time intervals during the Holocene with low and high flood frequency in the entire Alpine realm, providing key contributions for the understanding of the behavior of floods in an alpine environment and the dependency of the flood intensities and frequencies on various forcing mechanisms.

### S11-T03

#### **Reconstruction of summer/autumn flash-floods events over the last millennium from a high-elevation lake sediment sequence (Lake Allos, France)**

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Mountain areas are particularly vulnerable to high extreme flood hazards. One of the main questions in those areas is to know if such events will become more or less frequent in global warming context. Previous lake sediment studies suggest a decoupled flood frequency and intensity in the northern French Alps. Intensity increased while frequency decreased during warmer periods and inversely. The aim of this study was to investigate the Mediterranean climatic

influence from a high-altitude lake sediment sequence of the southern French Alps.

In parallel to a seismic survey, seventeen short cores were extracted from Lake Allos to investigate the main sediment processes. Two distinct basins appeared, fed by two different torrents. Each infill was here studied, characterized and dated independently by the same methods. Lithofacies are common: a silty-clay mud interbedded by graded deposits. From grain size measurement graded layers were associated to turbidite deposits triggered during flood events. Geochemistry data of these deposits allows to define geochemical ratios (Ca/K and Zr/K) that can be used as grain size proxies. Relationship of coarser percentile (Q90), thickness of deposits and geochemical ratios were assessed throughout the sediment sequences. Strong correlations between these proxies allowed us to use high-resolution geochemical ratios i) for a systematic detection of flood deposits and ii) like flood intensity proxy.

To obtain a chronology with low uncertainties, an effort was undertaken to combine different dating methods: short-lived radionuclides, <sup>14</sup>C ages, historical account (floods), heavy metal pollutions and paleomagnetic measurements. Results indicated that the two sequences cover the last 600 and 1400 years respectively for the shallower and upper basins. The evolution of flood frequency and intensity can thus be investigated through periods of relatively cold (the Little Ice Age) and warm (Medieval Period and the last 50 years) climate to better understand the extreme events variability.

At a pluri-centennial scale we record two periods of high flood frequency at 650-800 AD and 1300-1900 AD while the 800-1300 AD and 1900-2009 periods was characterized by low flood frequency. Higher intense floods occurred also during the cold period of the Little Ice Age (1320-1890). Palynological data suggest a continuous human presence since the beginning of the sedimentary record with slight increases during the Medieval Period and over the second part of the Little Ice Age. Contrasted flood frequency and intensity during these both periods suggest a climate-

dominated flood signal. Finally these first results suggest that both frequency and intensity of flood events increased during cold periods in the southern part of the Alps, whereas over the same timescale, the opposite trend was recorded in the northern part for the flood intensity. Investigations of the relationship climate - flood will be also investigated at shorter time-scale.

### S11-T04

#### **300 years of underflow record in Lake Bourget: an attempt of quantitative hydrological reconstruction based on spatio-temporal approach**

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Seismic investigation and sediment analysis have proved their efficiency at reconstructing flood activity and morphology over a long period of time in Lake Bourget (van Rensbergen et al. 1999) (Chapron, Desmet, et al. 2002) (F. Arnaud, Revel, et al. 2005). However seismic investigation still have limit in resolution that could not permit to apprehend thin flood deposits. Investigations from unique sediment core can also hedge the flood inventory i.e. historical flood pathways changed over time and may had not corresponded every time with the core position. In order to reconstruct 1) spatial flood morphologies and 2) exhaustive chronology of flood events over the last 300 years, 35 short sediment cores were collected in the North basin. Core locations were planned

in order to settle a grid that covers a representative area of the flood plain. Dating were performed from radionuclide (<sup>210</sup>Pb, <sup>241</sup>Am, <sup>137</sup>Cs), varves counting and historical events inventory. Stratigraphic markers (turbidites, laminas, floods) and specific sequences of flood were used for correlations. Statistical model was performed to determine 2D-spatial extension of flood deposits. The quantity of detrital material deposited for each flood events have been calculated. Major elements and granulometry were finally measured to characterised flood deposits.

Results alighted difference in flood chronology recorded offshore and near shore the basin. Offshore sediments recorded low frequency/thick deposits whereas shore sediments recorded high frequency/thin deposits of floods. It seems then that it is necessary to take spatiality in account in order to establish a complete flood chronology from sediments. Results also pointed out that bathymetry and flood intensity have a great incidence on flood geometry and then volumes repartition in the basin. Hence volumes of sediment inputs have been calculated for each flood. It enabled to well estimate flood magnitude and then to rebuilt more accurate hydrological intensity and frequency of extreme flood events.

Spatial variability in sediment volumes were compared to major elements repartition. Shore flood sediments (three first kilometres from the inlet) generally showed synchronous positive correlation of major elements (Al, Si, Ti, Fe, Mg, Na, K and P) and negative correlation with Ca. It confirms that phosphorous (P) was mostly particular during major flood events. However, P concentrations are slightly higher offshore than onshore. It could include that flood plume is susceptible to catch and seal P, or that flood undergoes mechanical sorting with respect to P species. Further investigation on P speciation and concentration will be performed at Grenoble synchrotron (ESRF) in order to characterise offshore/near shore P of flood.

**S11-T05****Discharge variability recorded in the sediments of Grand Lake, a new clastic varve record from eastern Canada**

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Grand Lake, Labrador, is the most promising site that was identified after an extensive search for varved lake sediments during the past two years in the Québec-Labrador region of Canada. This search was conducted within the multidisciplinary ARCHIVES project, which has for objective to reconstruct hydrological and climatic variations of the last millennium of this region using tree-ring and varved lake sediments. This deep lake (300 + meters), episodically connected to saltwater tidal Melville Lake, presents exceptional conditions for accumulation and preservation of clastic varved sediments. Firstly, the lake is fed by two very turbid affluent, carrying large amounts of fluvioglacial and marine sediments during peak runoff. Secondly, we hypothesize that the episodic incursion of saltwater into the lake creates a pycnocline and hence meromixis.

Regular laminations found at Grand Lake are

composed of two units. The first unit is made of coarse particles, mostly silt and fine sands, and is sometimes graded. The second unit is made of clay and organic sediments, very similar to clay caps that are found in other clastic varved lakes. The varved nature of Grand Lake sediments was confirmed, so far, by one Cesium-137 profile.

The main affluent of Grand lake, the Naskaupi river, was gauged daily from 1957 to 1970 and from 1978 until now. Although both records comprise missing data and have been recorded at different locations this constitute an exceptional dataset given the relative scarcity of instrumental hydro-climatic in the region. This instrumental discharge record allows us to test if individual varves properties (thickness, structure, grain size, etc.) are related to the river competence and eventually if past river discharge can be inferred from the varves properties.

The annual varve thickness of cores from Grand Lake shows a statistically significant correlation with instrumental discharge measurements of the Naskaupi River. This discharge/thickness relationship supports the hypothesis that it is possible to reconstruct the spring discharge and competence of the Naskaupi River. Large low frequency variability found a network of cores will be discussed in a geomorphological and hydroclimatic context.

**S12-T01****The Dead Sea Deep Drilling Project (DSDDP): Filling gaps on the shrinking/swelling tale of a lacustrine basin**

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Intensive investigations on outcrops and short core sediments in the Dead Sea Basin (DSB) have shown a Late Quaternary history containing a succession of expanding and shrinking lakes during glacial and interglacials intervals, respectively. Sedimentation on this basin located in the lowest continental exposed elevation on Earth has been continuously modulated by regional and global climate and rift tectonics. Hence, its sedimentary infill is comprehensively recording limnological, hydrological and seismic events. Moreover, the sections contain datable material such as primary aragonite that can be used to construct a chronology of the environmental history of lakes and their watershed and compare them to late Quaternary global climate archives. Yet, most of the studies carried out on the Dead Sea lakes during the past decades focused on the marginal terraces that are abandoned when the lake declines. Thus, we moved to drill within the framework of an ICDP (International Continental Scientific Drilling Program) two sets of nearly continuous sedimentary cores at water depth of ~300 m close to the deepest area of today's

Dead Sea and at ~2,5m depth next the shore near Ein Gedi (Israel). These sedimentary cores fill in known (and estimated) gaps in the outcrop sediments and provide a nearly continuous and undisturbed record covering at least the past two glacial-interglacial cycles judging from changes in dominant lithology. The sedimentary record can be divided into two dominant lithologies: salt layers interbedded with laminated muds; and massive and laminated marl interbedded with thin salt layers. Silt and sand (and gravel) levels indicate intervals of extremely low lake level. The results of this study will provide crucial information to better understand the environmental conditions prevailing during human development and migration through the Dead Sea corridor.

\* Complete list of DSDDP scientists @ [www.icdp-online.org](http://www.icdp-online.org)

**S12-T02****Lake Van Drilling Project 'PaleoVan' (ICDP): A long continental record in Eastern Anatolia covering several glacial-interglacial cycles**

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Lake Van is the fourth largest terminal lake in the world (volume 607 km<sup>3</sup>, area 3,570 km<sup>2</sup>, maximum depth 460 m), extending for 130 km WSW-ENE on the Eastern Anatolian High Plateau, Turkey. The hydrologically closed lake tracks climate change with fluctuating lake levels, reflecting changes in the precipitation/evaporation ratio. Currently, lake water is highly alkaline (pH = 9.8) and

saline (21 ppm). Within the sensitive climate region of north-eastern Anatolia, the Lake Van record, partly laminated, represents an excellent continental climate archive between the Black Sea, the Arabian Sea and the Red Sea that covers several glacial-interglacial cycles. Therefore, Lake Van is a key site within the International Continental Scientific Drilling Program (ICDP) for the investigation of the Quaternary climate evolution in the Near East. The ICDP drilling operation was carried out from July 2 to August 23, 2010. DOSECC, as operator of the deep drilling, has built the new Deep Lake Drilling System (DLDS), which was specifically designed for sampling sediments from deep lakes and which made its maiden voyage on Lake Van. The DSDL was operated at water depths of up to 360 m. We recovered a total sediment-core length of over 800 m. Two sites were drilled that reached maximum depths of 140 m (Northern Basin) and 220 m (Ahlat Ridge) below the lake floor, allowing an unprecedented look back in time at the scale of at least three glacial-interglacial cycles. Sediments during interglacial or interstadials are characterized by finely laminated carbonate varves, documenting variable annual particle cycles throughout the lake's history. Sediments deposited during glacials or stadials rather show homogenous to banded lithologies with an increased input of detrital material. The sediments of the very bottom of the Ahlat Ridge site document the initial phase of the lake formation, which was characterized by fresh water conditions. This is reflected by occurrence of fresh-water fauna and by significantly different pore-water chemistry. Several meter thick tephra layers originating from volcanoes surrounding the lake were also recovered, allowing reconstructions of larger volcanic events and related environmental impact. Furthermore, they offer through tephrochronology, radiogenic-isotopes and combined with paleomagnetic analyses the means to date the stratigraphic sections well beyond the range of radiocarbon dating.

## S12-T03

### Lake Van (Turkey) : Geological archives of past high levels, and geomorphological evolution of the lake basin

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The international "ANOVAN" project, devoted to the identification of lake-level variations contained in lake and river terraces extending around Lake Van, studied, not only the relationships of these geomorphological archives with past lake-levels, but also the relationships of past rises and falls of the lake-level with the palaeoclimatology and the palaeohydrology of the continental part of the lake basin.

For this purpose, we studied river, lake and fluvio-lacustrine deposits over the slopes and in the floors of the main tributary valleys of the lake (whether or not associated with terraces), choosing the archives delivering the highest resolution. We also looked for evidences of erosion phases separating distinct phases of lake transgression/regressions. The approach is based on the description, identification, measurement and interpretation of morpho-sedimentary indicators such as sedimentary facies (depositional environments), and on the study of unconformities between the sediment series forming the terraces. A curve of lake-level variations, based on a relative chronostratigraphy, evidences i) several transgressive and regressive phases, ii) erosion and incision periods of low to very low

lake-levels. The comparison with climatic records of the Last Glacial and Late Glacial in the eastern Mediterranean confirms the climatic cause of most phases recorded by the terraces. Out of four high-magnitude level variations (rises and falls) identified, the youngest three occurred indeed during MIS 4 and MIS 2, including the Late Glacial and YD.

A first and higher transgression, which is older than the last Interglacial, reached indeed a = 1755m altitude, i.e. 20m above today's lake threshold at 1735 m. Among others, this finding suggests that other factors (volcanism, tectonism) caused major changes in lake-level. In order to explain the suggested palaeogeographic changes in the lake basin, we study the possible impact of volcanic activity in the area closing the lake. Here, lava flows, pyroclastite flows and tephra falls were thoroughly studied, with focus on the stratigraphic relationships with lake sediments. Field (geomorphology, stratigraphy, tephrostratigraphy) and laboratory (geochemistry, dating) data allow the reconstruction of important volcanic events, and evidence their geomorphological impact on the hydrology of paleolake Van and its basin. Associated with the chronostratigraphy and geomorphological reconstruction, ages obtained by various dating methods ( $^{39}\text{Ar}/^{40}\text{Ar}$  and K-Ar on volcanics,  $^{234}\text{U}/^{230}\text{Th}$  on travertines, OSL and  $^{14}\text{C}$  on lake sediments), suggest that volcanic activity impacted the first and second high-magnitude lake-level variations which occurred before and after the last Interglacial. We will present in this paper the latest chronology provided by OSL ages of lake sediment samples, and by  $^{234}\text{U}-^{230}\text{Th}$  ages of new travertine layers.

## S12-T04

### A new 10,000 year pollen record from Lake Kinneret (Israel) - first results

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Lake Kinneret is situated in the northern part of the Dead Sea Rift in Israel. It is affected by Eastern Mediterranean climate. The lake level at ~212 m below the main sea level has a surface of ~165 m. Lake Kinneret's watershed comprises the Galilee, the Golan Heights, the Hermon Range and the Anti-Lebanon Mountains. Its most important tributary is the Jordan River. The geography of the Lake Kinneret region is characterised by big differences in altitude. Steep slopes elevate up to 560 m above the lake level in the west, north, and east. Mount Hermon (2814 m above mean sea level, amsl) is the highest summit of the Anti-Lebanon Range, and Mount Meron (1208 m amsl), located in the Upper Galilee, encircle Lake Kinneret within a 100 km radius in the northwest. Due to the pattern of average precipitation distinct plant-geographical territories converge in this region, i.e. the Mediterranean and the Irano-Turanian biom after Zohary. Varying ratios of characteristic pollen taxa representing certain plant associations serve as proxy for the reconstruction of paleovegetation, paleoenvironment, and paleoclimate. We present a pollen record analysed from sediment cores obtained during a drilling operation at Lake Kinneret in March 2010. A composite profile of 17.8 m length was established by correlating two parallel cores using magnetic susceptibility data. Our record, which encompasses ~10,000 years, represents a region that is discussed as migration corridor of humans to Europe and, being part of the Fertile Crescent, as the cradle of agriculture in West Asia. Conclusions concerning human impact on vegetation and therefore population density can be drawn by analysing changes of ratios of certain plant taxa such as *Olea europaea* which has been cultivated in this region since the Chalcolithic Period (6,500



BP). These investigations are part of sub-project (B3) within the Collaborative Research Centre SFB 806 (Our Way To Europe), supported by the Deutsche Forschungsgemeinschaft (DFG), and dealing with culture-environment interaction and human mobility in the Late Quaternary.

## S12-T05

### The study of sedimentary records of modern coastal lakes on Thrace and the Black Sea coasts of Turkey

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Study of three lagoonal basins along the Black Sea and Thracian coasts of Turkey allow reconstructions of long term, regional environmental histories, using the following methods. Loss on ignition (LOI) analyses at 1 cm intervals of short and long cores provide stratigraphic cross-correlation and calculations of organic matter, carbonate and mineral weight. At 5 cm intervals, spectrally-inferred chlorophyll-a contents by visible reflectance spectroscopy (Michelutti et al., 2010), estimate algal production. Ostracod analyses are done on sieved sediment samples, at 63 µm using a gentle jet of water and pre-treatment with methanol (Jin et al., 2006). Ostracods are identified to species level and counted using Stereo Microscopes under 80x magnifications, and also photographed under SEM. Trace element analysis (Mg/Ca and Sr/Ca) using ICP-AES (coupled plasma atomic emission spectroscopy) is applied to fully calcified adult specimens of un-noded forms of *Cyprideis torosa* shells (which dominate the uppermost 145 cm of Terkos Lake). <sup>210</sup>Pb and <sup>137</sup>Cs dating of short cores, and AMS <sup>14</sup>C dating of long cores, are used to infer sediment accumulation rates. The results of this work indicate that sediment accumulation rates are 0.58 cm/yr, for the uppermost 30 cm of dam-controlled Terkos and Büyükçekmece lakes,

and 0.11 cm/yr, for the upper 13 cm of Sarikum Lake. AMS <sup>14</sup>C dates (Beta Analytic) on 7 bulk sediment samples from Terkos Long Core 2, indicate a long-term, pre-damming, sediment accumulation rate of 0.15 cm/yr, about 25% of the modern rate and very similar to that of Sarikum Lake. At Buyukcekmece Lake, 7 bulk AMS <sup>14</sup>C dates indicate accumulation rates ranging from 0.08-0.10 cm/yr. The similarity in accumulation rates over several thousands of years preceding the pre-industrial era, suggests similar sediment dynamics in these coastal lagoons. Benthic foraminifers, gastropods, bivalves, single valves of fossil *Glochidia*, and Charophyte seeds are the other biological indicators observed within the sediment archive. According to our observations: 1. Terkos Lake sediments contain records of multiple, sub-millennial scale marine incursion events, over the last 2.8 ka, inferred to be the result of severe storms or tsunami on the Black Sea; 2. sudden decreases in organic matter, carbonate, and increases in algal production and sand amount coincide with the Great Erzincan Earthquake (29 December, 1939), one of four such events in Sarikum Lake sediments along the central Black Sea coast of Turkey; and 3. a large earthquake in AD 447 that affected the entire Sea of Marmara (Leroy et al., 2002) does not appear in the Buyukcekmece Lake sediment record, but there is evidence for a significant hiatus in these deposits, between the development of the dam in AD 1989 and our youngest AMS age of 2400 cal yrs BP. This suggests that Buyukcekmece Lagoon was an environment of net erosion prior to its artificial impoundment.

## S12-T06

### New insights into the climate and depositional history of Lake Iznik sediments during the last 30.000 years BP

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The comparison of multiproxy analysis from several short and long cores, which were drilled in different field campaigns since 2002 in Lake Iznik (NW Turkey), the biggest freshwater lake in the Marmara region, allows us now to reconstruct the regional climate and depositional history. Last long cores from 2009 with a maximum length of 14 m extend the data archive up to the last 30.000 years BP.

A robust age model was generated, based on C-14 dates from plant material, ostracodes shells and bulk sediment, OSL dates, and tephrochronology. It's the first time that tephra layers were found in Lake Iznik sediments. Clearly identifiable tephra layers are on one hand two thin pumice layers from the AP2 eruption of Vesuvius (4.15 ka BP), which is the first noticed occurrence in the Marmara region and on the other hand a 7 cm thick vitric ash layer from the Y2/Cape Riva eruption (approx. 22 ka BP), which were also identified in the Sea of Marmara and the Black Sea. The identification of both tephra layers is based on detailed mineralogical and geochemical investigations.

The new paleoclimate and paleoenvironmental data set covers now the transition from the last glacial period to the Holocene. Terrigenous proxies (magnetic susceptibility, Al, Ti, Fe etc.) indicate high terrigenous input during the last glacial, a gradual decrease in the transition and relative lower input during the Holocene. The opposite behaviour shows the carbonate proxies (TIC, Ca, Sr), which reflect the authigenic carbonate production within the lake. It is a fact, that the carbonate production is dependent on changes in evaporation and temperature. Therefore we believe, that Ca/Ti or Ca/Fe elemental ratios from Lake Iznik sediments

could reflect the precipitation/evaporation changes in this region. These changes seem to be more intense and cyclic during the Holocene than in the last glacial period. These observations are also supported by additional data (mineralogy, isotopes, nutrients, and ostracodes)

## S12-T07

### SCOPSCO - Scientific Collaboration On Past Speciation Conditions in Lake Ohrid

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Lake Ohrid is a transboundary lake with approximately two thirds of its surface area belonging to the Former Yugoslav Republic of Macedonia and about one third belonging to the Republic of Albania. With more than 210 endemic species described, the lake is a unique aquatic ecosystem and a hotspot of biodiversity. This importance was emphasized, when the lake was declared a UNESCO World Heritage Site in 1979, and included as a target area of the International Continental Scientific Drilling Program (ICDP) already in 1993.

Results of the pre-site survey indicate the high sensitivity of Lake Ohrid to climatic and environmental change and thus not only emphasize it as a world class site for paleoclimate research but also as one of the few sites worldwide where the impact of geological/climatic events on the lake's biota can be investigated in detail. The existing records are, however, too short to provide information about the age and origin of the lake and to unravel the mechanisms controlling the evolutionary development leading to the extraordinary high degree of endemism. High-resolution hydroacoustic profiles (INNOMAR SES-96 light and INNOMAR SES-2000 compact) and multichannel seismic

(Mini-GI-Gun) studies demonstrate well the interplay between sedimentation and active tectonics and impressively prove the potential of Lake Ohrid for an ICDP drilling campaign. The maximum sediment thickness is ~680 m in the central basin, where unconformities or erosional features are absent. Thus the complete history of the lake is likely recorded. A deep drilling in Lake Ohrid would help

- to obtain more precise information about the age and origin of the lake,
- to unravel the seismotectonic history of the lake area including effects of major earthquakes and associated mass wasting events,
- to obtain a continuous record containing information on volcanic activities and climate changes in the central northern Mediterranean region, and
- to better understand the impact of major geological/environmental events on general evolutionary patterns and shaping an extraordinary degree of endemic biodiversity as a matter of global significance.

For this purpose, five primary drill sites were selected based on the results obtained from sedimentological studies, tectonic mapping in the catchment and detailed seismic surveys conducted. For the recovery of up to ca. 680 m long sediment sequences at water depths of more than 260 m a newly developed platform operated by DOSECC shall be used. Important milestones concerning the operational and logistical planning of the deep drilling have been accomplished through joint efforts by the coordination team based at University of Cologne, local authorities in Macedonia and Albania, and DOSECC. Shallow drilling operations commenced in summer 2011 and deep drilling operations are scheduled for spring-summer 2012.

## S12-T08

### Chironomid-based environmental reconstructions in Italy and Southern Switzerland using subfossil chironomid assemblages

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South of the European Alps, in Italy and in southern Switzerland few quantitative palaeoclimatic reconstructions are available. Paleoclimatic studies in southern Europe can help to elucidate the main features of regional climatic dynamics, assess the degree of synchronicity with corresponding developments in other parts of Europe and improve our understanding of biotic responses to temperature changes. Here we present Late-Glacial and Holocene chironomid-based summer temperature reconstructions from the Southern Alps, the Po-Plain and the Northern Apennines. Our analyses suggest that midge assemblages responded to climatic events during the past 17'000 years, such as the Bølling warming, the Younger Dryas, the Preboreal Oscillation and the Holocene Thermal Optimum. At Foppe (1470 m a.s.l.) chironomid-reconstructed July air temperature estimates are about 9.9°C during the Oldest Dryas, and 12.2°C during most of the Bølling/Allerød. Lower temperatures of about 10.1°C are inferred during the Younger Dryas. The Holocene starts with an abrupt warming of 4°C, temperatures during the earliest Holocene (~11'600 - 10'000 cal BP) were on average 14°C. Our results imply that early Holocene temperatures were higher in the Southern Alps than in the Northern Alps, as it is still today (+1.5 - 2°C at 1470m a.s.l.) and that today's temperatures were reached at the onset of the Holocene. Paleobotanical evidence shows that afforestation in the lowlands south of the Alps started before the Bølling onset. Our

temperature reconstruction from Origlio (416 m a.s.l.) suggests that a "Pre-Bølling" warming which started around 16'200 cal BP triggered these very early forest expansions. For the first time we can reproduce a chironomid-inferred Holocene temperature reconstruction at two neighboring sites in Southern Europe. The Holocene and Late Glacial temperature reconstructions from Lago Gemini (1349 m a.s.l.) and Lago Verdarolo (1390 m a.s.l.) show prominent common features: low temperatures during the Oldest and Younger Dryas (8.4° - 9.2°C and 8.6° - 10.7°C, respectively), warmer temperatures during the Bølling/Allerød (10.3° - 11.9°C) and a relatively warm early Holocene (13.3° - 14°C). The most notable feature of the Holocene climate is the pronounced middle Holocene Thermal Optimum (HTM) at around 7'000 cal BP, when chironomid-inferred July-air temperatures were 15° - 15.6° C, i.e. up to 0.3° - 0.9°C warmer than at present. Mid-Holocene temperatures were rather stable and on average 13.6° - 14.4°C, late Holocene temperatures were slightly cooler ranging from 12.8° - 13.8°C.

## S12-T09

### Endogenic sedimentary products in the evaporitic Baza Basin (SE Spain)

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The intramountain Baza basin (Betic Range, SE Spain) was isolated from the sea during the Late Miocene. Magnetostratigraphic and paleontological studies indicate that continental sedimentation continued until erosion began in the Middle Pleistocene (~0.6Ma). Surface geology exposes >600m of sediments at the margin, while seismic and gravimetric data indicate an infilling of >2500m in the central area. Facies distribution

shows three lithologic belts evolving towards more evaporitic environments from the basin margin to the depocenter.

The marginal belt is dominated by alluvial lutites and palustrine carbonates. Here, local lignite occurrences are interbedded within the distal facies of alluvial fans. This zone includes isolated diatomitic sediments deposited in non evaporitic lakes and massive gypsum beds (~8m) associated to gypsiferous lakes.

The main deposits in the intermediate belt are carbonates, claystones and gypsum. Native sulfur associated to the gypsum was mined around the town of Benamaurel during the early 20th century.

The central belt of the Baza Basin was dominated by permanent lacustrine conditions, lacking evidence of sub-aerial exposure. The main lithologies are laminated gypsum and massive fine-grain carbonates (mudstones). Beds, commonly 1m thick, of aragonite and dolomite are abundant in this central zone.

Gypsum and carbonates are the usual primary deposits in this basin. Quarries were developed in the massive bioturbated gypsum of the marginal zone while laminated gypsum was quarried in the central areas. Calcite, dolomite and aragonite are common sedimentary products although massive beds of aragonite or dolomite have only been identified in the central zone of the Baza paleolake complex.

Among the clay mineral group, illite, smectite, paragonite, caolinite, chlorite and palygorskite have been identified; from which only palygorskite has a clear primary origin.

**S12-T10****Late Holocene sedimentation in Iberian Range karstic lakes: Facies model, depositional evolution and climatic implications.**

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Numerous small and relatively deep karstic lakes originated during an Upper Pliocene - Pleistocene karstification phase affecting Mesozoic and Triassic limestone formations in the Iberian Range. Their geographic location with Atlantic and Mediterranean influences and the direct correlation with the aquifers makes these lacustrine systems very sensitive to hydrological and environmental variability. The recent depositional subenvironments and the sediment sequences of two lakes in Cuenca province (El Tobar and La Parra) have been analyzed using a multiproxy strategy in order to reconstruct the Late Holocene paleoenvironmental history. Detailed sedimentological descriptions have been complemented with compositional analyses (TOC, TIC, TN), microscopic observations of smear slides and XRF core scanner data. The sequences have been dated with <sup>14</sup>C AMS and <sup>210</sup>Pb techniques.

El Tobar (40°32'N 3°56'E 1200 m a.s.l.; 20 m depth) is the largest lake in the region, and it consists on a shallower monomictic and a deeper meromictic sub-basin with a hypersaline hypolimnion. We obtained six long cores (up to 7.8 m long) and 20 short cores. A basal AMS date in one of the long cores is 2050 ± 30 <sup>14</sup>C yr BP and preliminary <sup>210</sup>Pb dating confirms a very high sedimentation rate. The sequence is finely

laminated, with intervals composed of organic and clastic couplets. The Laguna de la Parra (39°58'N 1°52'E 1000 m a.s.l.; 116 m of diameter and 17,5 m depth) belongs to the Cañada del Hoyo lake complex. The lake is monomictic and freshwater. Two long sediment cores (up to 6.92 m long) and 24 short cores were recovered from the deepest part of the lake. The preliminary chronological model based on nine <sup>14</sup>C AMS dates shows that lacustrine deposition started about 1500 years ago.

Both lake sequences show complex lateral and vertical facies changes illustrating the interaction of depositional, biological and hydrochemical processes. The hydrological and geochemical evolution demonstrates a rapid response of these lacustrine systems to anthropogenic and climate forcing, during last 2000 years while highlights differences due to the particular limnological properties of each lake. We study the relationships of facies distribution and lake level fluctuations through the analyses of three main processes affecting the sedimentary infill: clastic input, endogenic mineral formation and mixing conditions. XRF results help us to reconstruct the depositional environments, particularly, clastic input, endogenic carbonate deposition, redox evolution and organic productivity. The two sequences show a coherent scenario of lower lake levels during early medieval times and increased lake levels during the Little Ice Age. Besides, these two case studies underline the complex interplays and feedbacks of climate variability in the context of variable human landscapes and activities during the last 2000 years and they may enhance our ability to predict the environmental consequences of climate change in Mediterranean climate mountain areas.

**13-T01****Atmospheric trace metal pollution in sediments of London lakes**Charlotte Hall<sup>1</sup>, Neil Rose<sup>1</sup>, Anson Mackay<sup>1</sup><sup>1</sup> University College London, London, United Kingdom**Email:** ucfacjh@ucl.ac.uk

Lake sediments have long been used to reconstruct historical records of metal pollution. Most studies have been carried out in lakes that are remote from industry and transport with no local sources of contamination in order to assess the impact of atmospherically deposited trace metals. In many cases, it has clearly been shown that lake ecosystems have been contaminated by trace elements for at least the last 150 years. However, few studies of atmospheric metal pollution in lakes have been carried out in urban environments. The aims of this study were twofold - to establish how the levels of metal contamination in London lakes have varied between the Industrial Revolution and the present day, and to determine whether atmospheric metal pollution could be isolated from other sources of metal contamination. Determination of the concentrations of metals in lake sediments is also important in a contemporary context as high levels of some metals can be toxic to biota. Therefore if sediments are disturbed harmful metals can be reintroduced into the aquatic ecosystem. Sediment cores were taken from seven lakes across London. Concentrations of trace metals Pb, Zn, Cu, Ni, As and Cd and major elements such as Ti and Al were determined in each of the cores using X-ray fluorescence and organic content was measured by loss-on-ignition. A combination of <sup>210</sup>Pb dating and spheroidal carbonaceous particles were used to date the cores. The results showed that concentrations of metals in London overall were very high, with the peak concentrations generally being found in the 1950s. Pb peaked at 944 µg g<sup>-1</sup> in the Vale of Health Pond and Cu at 708 µg g<sup>-1</sup> in South Norwood Lake. The highest Zn and Ni concentrations (2099 and 262 µg g<sup>-1</sup> respectively) were both found in Wake Valley

Pond. However, the complexity of the urban environment means many different factors can impact upon lake sediments and therefore interpretation of the data is much more complicated. Organic matter and material from the catchment can have an effect on metal concentrations and therefore the data was normalised to allow for these factors. High sediment accumulation rates and possible disturbance at the sites needed to be taken into account when interpreting the chronologies of the cores and calculating metal fluxes. The impact of local industries and run off from nearby roads and buildings may be very important, in addition to pollution from the atmosphere.

**S13-T02****Springs as indicators of anthropogenic pollution for geo-environmental monitoring of lakes (by the example of Moscow Region)**Ekaterina Vasilieva<sup>1</sup>, Andrey Rasskazov<sup>1</sup><sup>1</sup> Peoples' Friendship University of Russia, Moscow, Russian Federation**Email:** e.vassillieva@gmail.com

Anthropogenic pollution of water objects is an important problem in many areas, particularly in Moscow Region. This is the reason why the geo-environmental monitoring of lake basins assumes ever greater importance. To be effective it should include not only water contamination analysis but also a comprehensive study of geological peculiarities of the territory.

Natural indicators of water pollution allow forecasting of environmental degradation of lake systems. Thus, the springs located within lake drainage basin are exceptionally sensitive not only to anthropogenic pollution but also to the decrease of surface and subsurface runoff. Precipitation plays an important role in springs formation as well. In this regard the human impact on air and aeration zone rocks, change qualitative and quantitative characteristics of spring water.

There are more than 2000 lakes in Moscow Region. The most interesting are the glacial-moraine lakes in the northeast of the Region. They were formed in depressions of the Klinsko-Dmitrovskaya ridge as a result of Moscow (Quaternary) Glaciation. Drainage basins of these lakes abound in descending springs.

A number of lakes and springs of the Region were studied during the geoecological surveys of late years: Lesnoe lake (3 springs), Viphanski artificial lake (2 springs) - group I; Torbeevo lake (2 springs), Zagorskoe lake (1 spring) - group II.

The springs of the first group are located in urban areas (Sergiev Posad Town, Hotkovo Town), the other three - in non-urban lands.

The detailed analysis of main anthropogenic factors that impact the lakes basins indicated chemical and bacteriological pollution as well as quantitative change of the spring water.

Analytical results from the spring water monitoring in urban and non-urban areas differ markedly. The first group of the springs is characterized with:

- Water contamination by heavy metals (values of Pb, Cu, Zn, Cd are 1,2 - 1,9 times higher than the maximum allowable concentration (MAC)); oil products (1,1 - 1,4 times higher than the MAC) and nitrate (1,5-2 times higher than the MAC);
- Elevated total dissolved solids (due to CaCO<sub>3</sub>, MgCO<sub>3</sub>);
- Coliform bacteria with value above the (MAC) even in wintertime.
- Considerable seasonal variations of water discharge.
- Inessential water discharge variations throughout the whole period of observation (7 years).

The analysis of the second group of the springs has shown:

- No chemical contamination of water (values of all elements are below the MAC);
- Less bacterial contamination (in comparison with urban area);
- Less seasonal variations of spring water discharge;
- Considerable decrease of overall volume of inflowing water (up to dying-away of the spring) throughout the whole period of observation.

The research showed that a number of anthropogenic factors of different origin cause spring water pollution with heavy metals, oil products and nitrate. High concentration of the same elements can be forecast in the lakes of the Region.

### S13-T03

#### Assessing the human impact on hybrid *Daphnia* populations across the Alps

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Anthropogenic activities can affect the evolution of natural populations and species by altering selective forces. Consequently, humans become themselves an important evolutionary force. Pollution, eutrophication, acidification, and climate warming as well as introduction of species and fisheries are well known examples for such anthropogenically-induced changes. Using resting eggs preserved in lake sediments, combined with identification of human activities stored in the sediment record allows to reconstruct human impacts on the evolutionary history of water flea species over the last decades.

Many water flea species of the genus *Daphnia* (Crustacea) are important planktonic grazers and play a central role in pelagic food webs. Furthermore, daphnids are model organisms

in ecology, ecotoxicology, and evolutionary ecology. They produce resting eggs (ephippia) to outlast unfavourable conditions and facilitate dispersal. A certain fraction of these ephippia eventually sinks down to the lake bottom, gets buried in the sediments and contributes to a resting egg bank in the subsurface that can cover several decades. These egg banks contain both, resting stages as well as hatched animals, and they have successfully been used to reconstruct population structure and dynamics, invasions, and microevolutionary changes for *Daphnia* species. Lake sediments constitute also a useful record for many micropollutants, such as pharmaceuticals, personal care products, and pesticides. Furthermore, sediments also store information about the trophic state of a lake.

In Swiss lakes north of the Alps an invasion of *D. galeata* followed by hybridization with *D. longispina* during a phase of eutrophication was shown by several studies. The historical pattern of populations of the *D. longispina* complex in lakes south of the Alps, however, is unknown. Moreover, the influence of additional factors like micropollutants on past and ongoing population changes on both sides of the Alps has yet not been investigated.

In an interdisciplinary approach, bringing together evolutionary ecologists, environmental chemists, and sedimentologists, we are reconstructing population structure and dynamics in the *Daphnia longispina - galeata* complex south of the Alps. We also identify patterns of pollution and eutrophication across the Alps on the basis of lake sediments, in order to identify factors that drive evolutionary change and invasion patterns in this complex.

### S13-T04

**Hydrology of the Cuatro Ciénegas Basin (Mexico) lake system from the Late-Pleistocene to the present: The implications of over extraction of water for industry and the need for conservation.**

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With over 200 pools, lakes and rivers supporting over 70 species of endemic flora and fauna the Cuatro Ciénegas Basin (CCB), Coahuila, in the desert of NE Mexico is an extremely important and extensively studied area in terms of conservation. Since the early 1900s human water exploitation within the CCB for the purposes of sanitation and drinking has had a considerable influence on the water table and systematics of both the hydrothermal and freshwater springs, pools, lakes and rivers. More recently, the main extraction of water from the CCB has been for irrigation for 3,983 hectares of alfalfa (*Medicago sativa*) in the Ocampo and Durango Basins to the north and west respectively. Here, pollen, stable  $d^{18}O_{LAKWATER}$  and  $d^{18}O_{CARB}$  and  $d^{13}C_{CARB}$  covariance data are presented from a 15m sediment core taken from Poza Tierra Blanca in the CCB; the data were interpreted and divided in several sedimentary units. The CCB is currently functioning as a hydrologically closed system, established around 4 ka BP synchronously with regional drying of the Chihuahuan Desert (Unit 7). Pollen and  $d^{18}O_{CARB}$  and  $d^{13}C_{CARB}$  covariance data suggest Units 1, 3 and 5 also display similar closed hydrology conditions in the CCB, the last of which occurred during an interstadial - 33 ka BP to 23.13 ka BP - before the onset of the LGM. The major difference between these hydrologically closed periods, however, is the human influence throughout the Holocene to the present observed in Unit 7. Previous hydrologically closed regimes seem to have maintained constant water availability through a fine balance between groundwater discharge either exceeding or equalling water loss through evaporation, possibly providing a basis for the floral and faunal endemism observed in the CCB. This over extraction of water, thought to be in the



region of 5.3 x 10m/year compared to 3.5 x 10m/year for inflow, is already leading to the complete drying of some lakes (Laguna Grande) and a large decrease in the CCB water table. Conservative estimates of evaporation in the region of 3.15 x 10m/year in the CCB suggests the modern hydrologic system, like previous hydrologically closed regimes (Units 1, 3 and 5), would be sustainable as inflow exceeds evaporation but the addition of recent alfalfa production suggests water extraction will eventually lead to a complete drying of the CCB system. If the CCB were to become completely dry, this would devastate the local endemic wildlife that has relied on this highly fragile desert ecosystem since at least 56.1 ka BP and possibly as far back as 84.5 ka BP, based on our core data.

### S13-T05

#### Local to regional scale pollution history of large freshwater lakes from the Swiss Plateau

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This study compares the pollutant deposition history from three of the largest freshwater lakes of Western Europe (lakes Geneva, Lucerne, and Constance) over the last centuries, in order to evaluate the impact of the industrialization on freshwater pollution (relative to preindustrial levels) and the present-day risks regarding local development issues. Continuous records of trace elements from contrasting environments (highly polluted to unpolluted sediments) reveal spectacular increases in heavy metal deposition within the Second Industrial Revolution (ca. 1850). Highest levels of metal pollution occurred in Switzerland during the middle of the 20 century due to **industrial (and domestic) wastewater discharges**. The

decomposition of abundant external organic matter inputs further involves the deterioration of the water quality from the large freshwater lakes and anoxic conditions in the 1960s-1970s. Anthropogenic heavy metal inputs subsequently stopped increasing in the 1980s thanks to environmental protection and domestic regulations (implementation of sewage treatment plants). Nevertheless, total phosphorus (P) concentrations were seen to increase during the last decades, probably as a consequence of internal P supplies and warmer climate effect on lake's stratification. In addition to the regional industrial pollution, exceptionally high fluxes of metal occurred i) during the late-nineteenth century nearby Lucerne due to industrial pollution, and ii) between ca. 1960 and 1980 at the Bay of Vidy due to excessive release of wastewaters into this part of Lake Geneva. The Pb isotope composition of the three lakes identifies synchronous changing sources of pollution throughout the last century (e.g., coal burning, wastewater). Finally, we investigate the impact of the anthropogenic pollution and the cultural eutrophication on the composition of microbial community and bacterial activity in freshwater sediments. The results reveal strong interacting effects of sewage treatment plant emissions and redox conditions (eutrophication) on microbial abundance and activities.

### S13-T06

#### Human impact during seven Millennia in central cores of small lakes in South-west Germany and in littoral cores from Lake Constance

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Several research projects of the last years, carried out in the Laboratory of Archaeobotany of the Landesamt für

Denkmalpflege and supported by the DFG are dealing with human impact on vegetation and landscape since the Neolithic and are using profundal cores from small lakes in different landscapes of Southwest Germany. From western Lake Constance region cores from six small lakes were investigated, and 2 littoral cores from upper and lower Lake Constance. From Upper Swabia cores from 2 lakes were investigated, 8 lakes from Northern Black Forest. Key method is high-resolution pollen analysis with sampling in distances between 0.5 and 1 cm without gaps, resulting in a time resolution between less than 10 and 20 years. Good time control by ordinary 20 radiocarbon dates in each profile and partly annual lamination allows a good correlation of the profiles according to time. Pollen, charred particles and the mineral content of central sediments of small lakes are not only the best proxies for environmental change in the lake's catchment caused by man. Man's activity influenced also the lakes themselves by eutrophication, pollution, and input of eroded soil material. This is indicated by changes of the loss-on-ignition, by changes of the sedimentation rate and sediment composition, and by changes of the lake's flora as observed in the pollen and macrofossil record.

**S1-P01****Late Quaternary stratigraphy and facies model of Chalco Lake, central Mexico.**

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Drill cores obtained from Chalco Lake in central Mexico (19°15'N, 98°58'E, 2200 m asl) to a depth of 122 m, potentially contain a ~ 200 kyr record of terrestrial climate history in the northern American tropics. The active tectonic and volcanic setting of Chalco Lake in the Trans-Mexican Volcanic Belt, provides an opportunity to evaluate environmental (volcanic + tectonic vs. climatic) controls on lacustrine sedimentation. The sedimentary sequence is currently under analysis of diatoms, pollen, ostracods, magnetic properties and organic and inorganic geochemistry. The establishment of a time scale is underway, by <sup>39</sup>Ar/<sup>40</sup>Ar and the analysis of paleomagnetic record. The stratigraphical and sedimentological analyses presented here provided the initial recognition of depositional environments. Sedimentary facies were defined on the basis of sedimentological descriptions, microscopic observation of smear slides and compositional analyses. According to compositional criteria, 12 facies were identified and grouped into three main categories according to compositional criteria: 1) detrital and volcanoclastic, 2) biogenic and 3) carbonate-rich facies. The clastic facies includes massive to laminated, silty and clayey sediments composed of clay minerals, feldspars, amphiboles with minor amounts of quartz, opaque minerals and calcite. Organic content is relatively low and comprises diatoms, amorphous organic matter, charcoal and occasional ostracods and phytolites. Diatoms are the most common biological remains in all the clastic facies. Nearly 100 individual volcanoclastic layers of 1-50 cm thickness are present in the sequence. Two facies have been

differentiated: i) massive to graded layers of lapilli, composed of glassy pumice fragments 2-5 cm; and ii) light gray to black massive to poorly laminated ash layers, composed of andesine with subordinate pyroxene, muscovite, quartz and glass. Most of the volcanoclastic deposits correspond to fall-out deposits, some of them of well documented eruptions of the nearby large stratovolcanoes Popocatepetl and Nevado de Toluca. Overall, volcanoclastic layers account for < 3% of the total thickness of the sedimentary sequence. The biogenic facies are massive to finely laminated diatom ooze and ostracod ooze layers. Carbonate-rich facies occurs as finely laminated to massive micritic mud composed of calcite, with minor amounts of dolomite and siderite. The Chalco Lake sequence has been divided into six main sedimentary units, according to their sedimentary facies. Unit 6 (122-108 m depth): finely laminated diatom ooze and micritic mud facies, with some clastic and volcanoclastic facies. Unit 5 (108-90 m): olive brown massive silt with diatoms facies. Unit 4 (90-68 m): reddish brown silt is the dominant facies. Unit 3 (68-40 m): grayish brown silt and gray silty clay facies. Unit 2 (40-7 m): yellowish brown silt facies and ostracod ooze facies. Unit 1 (7 m-surface): mainly of organic-rich silty clay, diatom ooze facies.

**S1-P02****Hydrology and composition of surface sediments in Lake Lonar, central India**

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The DFG funded HIMPAC (Himalaya: Modern and Past Climates) programme aims to reconstruct Holocene Indian Monsoon climate using a multi-proxy and multi-archive

approach. First investigations made on modern lake sediments of Lake Lonar in central India's state Maharashtra, Buldhana District, serve to understand present lake chemistry and sedimentation.

Lake Lonar occupies the floor of an impact crater that formed on the ~ 65 Ma old basalt flows of the Deccan Traps. The modern lake has a maximum depth of about 5 m, is highly alkaline, and hyposaline, grouped in the Na-Cl-CO<sub>3</sub> subtype of saline lakes. The lake level is highly sensitive to precipitation and evaporation; no out-flowing stream is present and only three small streams feed the lake. This leads to lake level and chemistry changes within the year controlled by the Indian monsoon climate. From June to late September the Indian Summer Monsoon supplies the lake with large amounts of fresh water which causes a lake level rise. During winter and spring, there is no noteworthy precipitation and the climate is hot and dry which leads to lower lake levels. Dilution processes during the rainy season lower the salinity and pH value of the lake, especially in the upper part of the water column, thus, developing a distinct stratification with highly saline bottom water. Evaporation in the dry season is accompanied with a rise of salinity and a weakening of stratification supporting complete overturn during spring to early summer.

At present the lake is eutrophic and the waters below 2 m depth are anoxic. The dominant surface sediment of the lake is a soft homogenous mud with no indications of bioturbation or bottom fauna. Fragments of higher plants have been observed frequently within the sediment indicating a strong contribution of terrestrial organic material. Indeed, deposits washed into the lake from the slope of the inner crater rim are the dominant source of sediment in the lake. These lithogenic particles comprise almost equal parts of silt and sand and have mineral compositions plotting into the field of mafic igneous rocks in a CaO+Na<sub>2</sub>O-Al<sub>2</sub>O<sub>3</sub>-K<sub>2</sub>O triangular diagram. The amount of organic carbon within the sediment has a wide range of 0.1 - 6.3 %. The d<sup>13</sup>C of organic matter was used to determine the ratio of terrestrial to

aquatic organic matter by two end member mixing. High d<sup>15</sup>N seems to be related to, both, denitrification in the water column and intensity of organic matter degradation.

## S1-P03

### **The late Holocene (ca. 3000 yr BP) record from Lake Santa Maria Del Oro, Western Mexico: evidence of climatic variability and human impact**

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In the last decades lacustrine records in central Mexico have documented changes in vegetation and lacustrine conditions interpreted in terms of climatic changes and human impact. Most of these changes have been recorded in the high altitude basins of central Mexico or in the eastern lowlands, including the Maya area; few studies have focus on western Mexico. We present pollen, charcoal, diatom and geochemical data from Santa María del Oro, a crater lake on the western Mexico lowlands (750 m asl). This lake lies in a transition zone between the arid climates of northern Mexico and the moister climates of the central highlands, has a tropical sub-humid climate (1250 mm/yr, 21°C) with a short summer rainy season related to the Mexican Monsoon. Two 9 m long sequences were collected: the SMO02 cores, with nine <sup>14</sup>C dates and a basal age of 600 BC and the MOLE cores, with six <sup>14</sup>C dates and a basal age of 2600 BC. Abundant pollen of Teosinte was recovered from ca. 2350 to 100 BC, suggesting early agricultural activity in the area, the first record of maize in the western region of Mesoamerica. Five stages of alternating moister and drier conditions have been identified; the presence of high abundance of *Quercus*, *Eolimna minima*, *Amphora libica*, ostracodes and carbonates during the late Classic period (AD 650-1100)

indicates that this was a time of shallow lake levels and drier conditions. The late Classic has been identified as a time of reduced moisture in other areas of Mesoamerica, where it correlates with a demographic maximum. In SMO it is until the Postclassic that the presence of charcoal particles and *Zea mays* allow to infer important human impact. Since AD 1400 several drought episodes have been identified using Ti concentrations. Low percentages of Ti correlate with the drought episodes and suggest that this element it is a good indicator of runoff. These droughts are in agreement with those recorded by other proxies such as tree rings, historical documents.

### S1-P04

#### **Paleoenvironmental interpretation of elemental geochemical proxies of the borehole Jp 585: lacustrine offshore clays of Cypris Formation, Sokolov Basin, Czech Republic**

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We present geochemical study on the Lower Miocene lacustrine offshore clays of the Cypris Formation in the Sokolov Basin of the Eger Graben aimed at paleoenvironmental reconstruction. The applicability of elemental geochemistry proxies in the interpretation of thick lithologically monotonous, offshore lacustrine successions is tested. Lacustrine deposits of the Cypris Formation cover approximately 20 km<sup>2</sup> and are mainly represented by offshore clays, up to 130 - 180 m thick. This study is based on 94 m of core data from the lower and middle part of the offshore succession. The offshore clays conformably overlie a 29 m thick coal seam with no floral change. Lacustrine clays are mostly laminated, in places with a high organic content (Corg to 2 - 18 %), a low silt admixture, and very rare thin sandy interbeds. Lower Unit 1 (94 - 35 m) is characteristic by low carbonate content and low fluctuation of

other proxies (Ti, Si, Al, K). This may point to hydrologically open permanent lacustrine system. The proxy of lake mineralization (relative proportion of Na and K in exchangeable/water soluble cations) increases continuously in this. Contrarily the upper Unit 2 (0 - 35 m) has a higher carbonate content, with at least 5 distinct Ca-Mg-Fe carbonate beds 5 - 15 cm thick, and elemental proxies fluctuate significantly. Unit 2 is interpreted as deposits of hydrologically closed lacustrine system. Cation exchange capacity of the sediment is much increased in this unit, which could point to neoformation of expandable clay minerals in the sediment. In studied section there is a general trend of decreasing upward proxy of the terrestrial input (Ti), Al/Si ratio is also decreasing upward, which could be due to the increase of authigenic silica (chemogenic or biogenic) in the upper part of the section. Total K/Al ratio is generally increasing upwards, which can be due to decreased leaching of K or other changes in the source area.

### S1-P05

#### **Characterization of Late Pleistocene and Early Holocene humid phases in SW Saudi Arabia using ostracodes**

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The intensity of Late Pleistocene and Holocene humid periods may have played a key role for modern human dispersal across the Arabian

Peninsula. Here we use ostracode assemblages from 51 paleo-lake sediment samples collected from a total of 21 outcrops located in the south western Rub' al Khali at Mundafan (18°33'N, 45°21'E) and Khujaymah (18°33'N, 47°14'E) as paleo-hydrological indicators. Eleven outcrops were of Pleistocene and seven of Holocene age, three were not datable. The ostracode fauna consists of at least 14 species with up to 315 adult specimens per g dry sediment and 2 to 9 species per sample, and mostly 4-5 species. Highest abundances occur in Holocene marls. Four humid phases dating back to about 125 ka, 100 ka, 80 ka, and the early Holocene were identified. All of the species are typical of fresh- to brackish and shallow water (see Meisch, 2000). Each of the four humid phases is characterized by a typical species assemblage (number of samples per humid period given in brackets).

About 125 ka (7) ago *Cyprideis torosa* was the most prominent species. It occurs mainly in marine brackish waters with fluctuating salinity, and is also characteristic of continental water bodies down to water depths of around 30 m. It was followed in abundance by *Darwinula stevensoni*. This species prefers permanent water bodies with salinities up to 15‰ and lives in the littoral zone of lakes as well as in rivers, bogs and springs. Other important ostracodes are *Pseudocandona marchica* which prefers slightly salty coastal and inland waters with salinities up to 4‰, and *Sarscypridopsis aculeata* that prefers salinities between 1 and 6‰. All species suggest a shallow permanent water body with low salinities. *Cyprideis torosa* is again the dominant species of the humid period 100 ka (9) ago. In three samples noded specimen characteristic of low salinities were found. Sieve-pore-analysis from seven specimen of *Cyprideis torosa* indicate low

salinities of <2 Practical Salinity Units, PSU. Shells of *Cyprideis torosa* from older time windows were not suited for sieve-pore-analysis because of strong re-crystallization of shells. Other identified species were *Heterocypris salina* that prefers salty coastal and inland waters but can also occur in freshwater habitats. In addition, *Darwinula stevensoni* and *Limnocythere inopinata* that stand for fresher waters and live mostly in the littoral, shallow water zone, were found in lower abundances. *Limnocythere inopinata* prefers muddy and sandy substrates and tolerates salinities up to 6.7‰. This species suggests the existence of a permanent, shallow water body with possibly running water. The humid period dated to 80 ka (1) is characterized, in comparison to the older humid periods, for the first time, by *Darwinula stevensoni*, as dominant species. Other ostracodes present were *Pseudocandona marchica*, *Pseudocandona* sp. and *Cyprideis torosa* suggesting significantly fresher conditions than before 100 ka and the existence of permanent water bodies. During the early Holocene (24) five species including *Darwinula stevensoni*, *Pseudocandona marchica*, *Heterocypris salina*, *Cypretta* sp., and *Cryptocandona reducta*, were found. *Cypretta* sp. often occurs in shallow and vegetated water and is a typical freshwater ostracode. Overall, this species assemblage suggests small and shallow, permanent and possibly slightly saline environments. Overall, ostracode assemblages support the hypothesis of modern human dispersal during these humid periods, with a maximum in humidity suggested for 100 ka BP.

Meisch, C., 2000. Freshwater Ostracoda of western and central Europe. Süßwasserfauna von Mitteleuropa 8/3, Spektrum Akademischer Verlag, Heidelberg, 522 p.

**S2-P01****Brief Description of Algal Flora Succession in Karymskoye Lake over the Period 1996-2010**Elena Lupikina<sup>1</sup>

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Karymskoye Lake is an ancient freshwater body located inside the caldera of Akademiyi Nauk Volcano of the Karymsky volcanic center which is one of the most active geologic structures in Kamchatka. In January 1996 the lake suffered a phreatomagmatic eruption which rapidly influenced and changed the environment of the lake. The lake showed low mineralization and low temperature with sub-neutral pH prior to the event (average diameter 3.8 km, 50-60 m deep (70 m deep in some places),  $V=4.6 \times 10^9$  m<sup>3</sup>). But the eruption changed the whole lake chemistry significantly into sodium-calcium-sulphate solution with  $\text{pH}=3.1-3.4$ . The water temperature raised about 20-24 °C higher than that prior to the eruption. A few months after the eruption the temperature within the littoral zone of the northern area was as high as 28 °C. Over the period 1996-2003 the ancient autochthonous planktonic algal flora was depressed by hydrochemical factor.

Allogenesis of the water layer over a period of 8 years was showing a distinct allochthonous character with single and rare cyanoprokaryotes delivered from thermal spots of littoral zone.

Evolution of autochthonous component of plankton (Aulacoseira, Cyclotella, and Stephanodiscus) over pre-eruption period was influenced by inhibitive effect generated by lake abiotic conditions. Euglenophyta and Chlorophyta were first settlers in the water layer. Chlorophyta prevailed within depths from 0 to 30-40 m over the period 2001-2003 during all seasons showing large number of cellules varying from 17 to 60-62 million per liter. Benthic clumps evolved locally and were

distributed spasmodically with sub-neutral pH. Prevailing complex was formed by Ulothrix (Chlorophyta) and Pennatae (Bacillariophyta). In the northern part of the lake within new thermal springs local and rapid formation of cyanoprokaryotes (floating and poor-attached) mats is presented. Negative impact from the 1996 submarine blast and continuing inflow of endogenous fluid is one of the reasons for algaebacterial succession usually abnormal for highland lakes.

During post-eruption period of algal flora in Karymskoye Lake we observed two stages. First stage describes depression of autochthonous elements represented by prevailing diatoms (Kurenkov, 1998, 1999, Lupikina 2007). The second stage describes burst of evolution of allochthonous elements accompanied by slow regeneration of autochthonous elements. The later required more than 10 years in order to start regeneration.

**S2-P02****Spatial distribution of degassing CO<sub>2</sub> vents inside the Laacher See and bathymetric model of the Laacher See basin**Andreas Goepel<sup>1</sup>, Martin Lonschinski<sup>1</sup>, Nina Kukowski<sup>1</sup>, Georg Büchel<sup>1</sup>

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The Laacher See volcano explosively erupted about 6.3 km<sup>3</sup> of phonolitic magma during the last eruption, 12,900 a BP (Schminke, 1999). As a result, the Laacher See crater was formed by vent erosion and collapse (Schminke, 1999). Later, the crater was filled by water most likely due to groundwater inflows and rain water. Today the lake level is controlled by a drainage tunnel accomplished by local Benedictine monks in 1844 maintaining the lake level at around 275.3 m (above sea level). As a result the water body of Laacher See covers an area of 3.315 km<sup>2</sup> and volume of 0.108 km<sup>3</sup> with an 8.471 km long shore line.

The bathymetry of the lake basin was measured by an echo sounder GARMIN GPSMap 421s operating a 500 W (Root Mean Square) dual frequency transducer. The transducer has a beam width of 10 degrees at 200 kHz respectively 40 degrees at 50 kHz. Depth data were collected on profiles (total length of 235 km) and calculated to a bathymetric model in a 10 m spaced regular grid.

The aim was to calculate a detailed model of the volcanic, as well as sedimentological structures inside the lake basin. The echosounder signal also reflects rising gas bubbles, primary CO<sub>2</sub> in the Laacher See area. In this way, the method is suitable to localize CO<sub>2</sub> degassing vents, even if the gas is dissolved during uprising and not reaching the lake surface.

The activity of CO<sub>2</sub> degassing is considerable higher in the northern part of the lake, where mofettes (CO<sub>2</sub> degassing vents) are spread in a circular shaped (1.5 km diameter) pattern. Presumably this spatial distribution of the degassing zone is related to the rims of a magma dome under the lake. In the southern part CO<sub>2</sub> degassing vents increasingly occur only in one area, about 30m away from the southern lakeside.

In general the basin is divided into a more shallow (up to 40 m depth) south-western part and the deeper (up to 53 m) north-eastern part. This is consistent to the evolution of the Laacher See eruption that started in the southern part of the basin and finished in the north-eastern part (Schmincke, 1999), while material from the later eruption was deposited over the initial eruption center. Additionally, two crater-like structures were identified. In the south, a structure known as Barschbuckel, possibly the north-eastern part of a crater was observed, and a possible crater structure was identified in the area of the Jägerspitze in the western part of the lake basin. As most conspicuous sedimentological structures a delta of the creek Beller Bach in the south and an alluvial fan in the northern part of the lake become evident. Furthermore, under sea landslides were identified in the north-western part of the lake.

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## S2-P03

### Acquisition of physico-chemical parameters at Monticchio crater lakes

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The geochemical study of lakes requires the use of specific instruments and sampling techniques that make the study of physico-chemical parameters possible, even in deep water (i.e. where there is often high pressure, low/high temperatures and sometimes acidic waters).

We have studied the Monticchio lakes since 2007 (Lago Piccolo and Lago Grande in southern Italy), focusing on the chemistry of the dissolved gases and on major and trace elements of the lake waters. Special attention has been paid to the choice and optimization of the instruments and sampling techniques. An update of the lakes' bathymetry was performed by means of a Garmin 250C Fishfinder coupled with a Garmin V GPS; this allowed us to estimate the partial and total water volumes, which are particularly useful in water balance and dissolved gas budget. The bathymetric map was also used to locate sampling points of interest.

By means of a high resolution multiparametric probe (im71 - Ageotec), temperature, pH and electrical conductivity data were acquired, highlighting both thermal and chemical stratifications along the water column and evidencing lateral water inflows at depth. With the aim of studying processes of mass and energy transfer, specific temperature



profiles were repeated to estimate eddy diffusion along the water column.

Waters were collected using a 2 litre clear polycarbonate water sampler and major and trace elements analyses were performed by means of HPLC and ICP-OES/MS, respectively.

To prevent gas exsolution during sampling, the dissolved gases were sampled by means of two-way stainless-steel samplers equipped with pneumatic valves. Isotope compositions and dissolved abundances of gases were measured in the lab by means of gas chromatography and mass spectrometry respectively, following gas separation in a pressurized extraction line.

We measured both the amount and the isotope signature of the total dissolved inorganic carbon (TDIC), by means of mass spectrometer on carbonate precipitate from the lake waters collected by means of stainless-steel samplers for dissolved gases, equipped with two additional Swagelok valves. (The use of these valves made it possible to extract the sampled water without any pressure being released; they further made it possible to collect the TDIC under the form of Sr CO<sub>3</sub> precipitate by attaching two syringes to them. One of these syringes was previously partially filled with an alkaline solution). Subsequently, we evaluated the carbonate speciation through in situ pH values.

With the aim of performing lake water balance, we estimated the evaporation rate. The latter was estimated by an energy budget method, following the acquisition of meteorological parameters. For this purpose we used a floating meteorological station, also equipped with sensors for water temperature and with a floating evaporimeter.

## S2-P04

### **Physical-chemical and ecological features of the Paterno sinkhole (Rieti, Lazio, Central Italy): a possible seasonal meromictic lake**

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Lake Paterno, located at 430 m a.s.l., not far from the city of Rieti (Lazio, Italy) and between the towns of Cittaducale and Antrodoco, originates from the formation of a sinkhole, a funnel-shaped cavity due to karst phenomena. The lake has an ellipsoidal shape (0.19 × 0.15 km), a surface of about 22.300 m and a maximum depth of 54 m. It is likely fed by underground springs, as testified by the presence of an effluent having a flow rate of 16 L/sec. In hydrogeological terms, the lake belongs to the Velino aquifer hosted within carbonate formations of the northernmost part of the Latium-Abruzzi platform sequences. Plunging from the southern shore, the depth rapidly increases and the bottom has a stepped pattern.

Previous studies carried out in summer 2010 reported an euphotic layer from the surface to the depth of 14-16 m (depending on weather condition) and two clear thermo-clines in the first 8 m, with a sharp temperature drop and no life forms visible by naked eye underneath. The first thermocline (4.5 m deep) is the lower limit of the water layer used by fish and macro-invertebrate populations, while the second one (at 8 m) represents the lower bound of the algal community. Few fish species were detected in summer, whereas in wintertime no fishes were observed. This phenomenon is likely due to the strong reduction of fish activity in the cold season. Fish fauna covers different trophic levels in aquatic systems, so it provides an interesting

and complex ecological object to be associated with physical-chemical descriptors.

In this work we present the results obtained in February 2011, during which the chemical and physical processes controlling the water composition were investigated in order to verify: 1) the occurrence of chemical and/or thermal lake stratification and 2) the presence of non-atmospheric dissolved gases. The results show that the chemical-physical parameters of the lake water remain basically homogenous, although at the lake bottom a slight decrease of dissolved O<sub>2</sub>, accompanied by an increase of the dissolved CO<sub>2</sub> and CH<sub>4</sub> concentrations, was measured. Further water and dissolved gas sampling campaigns are planned in summer 2011 to investigate the evolution of the chemical-physical features along the lake vertical column and their relationships with the external temperature and to assess the origin of dissolved CO<sub>2</sub> and CH<sub>4</sub>. Finally, the geochemical features and processes acting in the Paterno sinkhole may provide helpful insights on the horizontal and vertical fish space use and population dynamics among seasons.

## S2-P05

### Calculating (potential) density of limnic waters of unusual chemical composition

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Small density differences in lakes control vertical circulation, and hence the refreshment with atmospheric oxygen as well as the distribution of solutes. If the vertical circulation is incomplete layers of special chemical milieus can form, which allow reactions that would not take place in a circulated lake. As a consequence, highly accurate density calculations are required. However, this can be a difficult task in volcanic areas. As the composition of solutes varies between lakes, a general formula can only be

of limited accuracy. Lake specific adjustment can solve part of the problem, but still vertical gradients in the composition as well as temporal changes can be found, especially in volcanic lakes.

We present empirical approaches, how lake specific density formulas can be evaluated. A temperature compensation for the electrical conductivity must be implemented, before it can be used for calculating density by quantifying dissolved substances with the bulk measurement of its electrical conductivity. High accuracy measurements of density are used to produce a correlation of density against temperature and electrical conductivity (Boehrer et al. 2009).

A second approach uses partial molal volumes. This approach is based on the knowledge of the composition of the solutes. Hence for each solute its specific contribution to both mass and volume of the solution can be added. Recently a comprehensive list of coefficients of limnic solutes has been published and the accuracy of this approach was assessed (Boehrer et al. 2010). This equation is also made available on the internet [www.ufz.de/webax](http://www.ufz.de/webax). If chemical reactions can impact on the density structure, they can eventually control the circulation pattern, e.g. geochemically meromictic lakes. If a numerical simulation of the stratification (and circulation) of these lakes is attempted, a density calculation based on the actual chemical composition of the solutes can be implemented. The feasibility of this approach has been demonstrated (Moreira et al. 2011).

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## S2-P06

### **Past activity of Laguna Caliente crater lake (Poás Volcano, Costa Rica) based on paleolacustrine deposits: a preliminary study**

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Laguna Caliente, the crater lake at the active volcano Poás (Costa Rica) is characterized by a high temperature (~55°C) and acidity (pH=0). In historical times, strombolian and phreatomagmatic eruptions occurred (1834, 1910, 1953-1955); during the latter magmatic event a dome extruded at the southern sector of Laguna Caliente. Phreatic eruptions are reported since 1832. In March 2006 a new cycle of phreatic eruptions started, summing to over a 1000 phreatic events in 2010. During the history of Laguna Caliente its lake level has been highly variable, and the lake even dried out in several cases (1953-1961, 1989, 1994). The paleolacustrine deposits described in this preliminary study are found at 100 m from Laguna Caliente. Two outcrops are described: one east and one south of Laguna Caliente. In the eastern sector, we could observe a rhythmic sequence of black and grey ashes and white clays, in millimetric to centimetric laminae. The grey ashes are water-charged suggesting they were probably formed by phreatic eruptions. Sedimentary structures such as slumps, loading, convolute bedding, and impact are observed. Juvenile material in at least two laminae probably testify phreatomagmatic events. Organic carbon (3 cm) could be found. In the southern sector, sequences of grey ashes and brown and white

clays are described, and larger parts of organic carbon (10 cm) could be found. At least one phreatomagmatic event is evidenced by juvenile material. In both outcrops, sulphur layers are present in the clay and ash layers, suggesting past occurrence of an acidic crater lake, similar to the present situation. A preliminary reconstruction of the height of the deposits indicates that the past lake level was at least 10 m higher than at present, implying that the past lake had a presumable depth of 50 m. The eruptive spray of recent phreatic eruptions sometimes reach the outcrop in the eastern sector.

## S2-P07

### **The disappearance of Irazú crater lake ~ increased volcanic activity of neighboring Turrialba (Costa Rica)?**

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On 9 April 2010, the Irazú crater disappeared after a five year period of steady lake level drop. Coincidentally, the neighboring volcano Turrialba increased its activity since 2005, escalating to a major phreatic eruption on 5 January 2010. It is unclear if both features are related, though the timing of both events is striking. The 690 m wide-150 m deep Irazú crater generally hosts an emerald green lake with a slightly acidic pH (6.2-6.5) and a Cl-poor Ca-SO<sub>4</sub> composition of the water with a temperature similar to the ambient temperature at the high elevation of the crater area (~3,000 m a.s.l.).

Previous fumarolic activity in the crater and bubble degassing at the lake has not been observed since 2008, while boiling point fumarolic degassing occurs only at the highly altered northern outer flank of Irazú. Considering that the evaporation from the lake surface and the input of a volcanic fluid

are practically nihil, the volume of the lake is only controlled by the meteoric precipitation and the seepage at the lake bottom. Hydrologically speaking, the Irazú crater lake seems to be the main meteoric recharge reservoir for the flank hydrothermal system (fumaroles and numerous thermal springs). From April 2007 to its disappearance in April 2010 the lake level dropped by about 7.3 m, or an average rate of water loss of ~0.1 kg/s (meteoric water influx - seepage outflux). Enhanced seepage can result from an increased permeability at the lake bottom induced by (1) an increased seismic activity along faults within the volcanic edifice, (2) an enhanced vapor loss from the flank fumaroles, (3) the loss of the sealing capacity of clays at the lake bottom, or (4) another external factor. The three former scenarios are improbable.

Turrialba volcano considerably increased its degassing regime from boiling temperature fumaroles degassing (2007-2009) to massive plume degassing ( $\text{SO}_2$  flux of 1,000-2,000 t/d) in 2010. This extra loss of water mass at the Irazú-Turrialba volcanic complex in recent years probably affected the hydrology of both volcano-hydrothermal systems: the overpressurized Turrialba volcano might have induced a regime of underpressure at Irazú, leading to the observed crater lake disappearance. In terms of volcanic risk mitigation, the recent disappearance of the Irazú crater lake could mechanically weaken the northern flank of the volcano which eventually leads to flank failure or collapse, even during periods of apparent volcanic quiescence. This dynamics was demonstrated in recent (October 2010) and past avalanches (1963-1965 eruption) on the Irazú flank. Larger such events in the future could lead to flank failure which could affect the bridge on Highway 32, ~20 km NW of Irazú volcano, the major connection between the Caribbean and Pacific coasts. This study aims to demonstrate that, even with the highly active neighboring volcano Turrialba, the Irazú crater lake poses an indirect volcanic risk which deserves to be studied in more detail.

## S2-P08

### A generalized box model for active crater lakes: a review of mass, chemical and isotope budget analysis

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In the past, the variations in chemical contents ( $\text{SO}_4$ , Cl, cations and their ratios) of crater lake water have not systematically demonstrated a relationship with the eruptive activity. Intensive parameters (i.e., concentrations, temperature, pH, salinity) should be converted into extensive parameters (i.e., fluxes, changes with time of mass and solutes) taking into account all the internal and external chemical-physical factors affecting the crater lake system. This study presents a generalized box model approach which can be useful in the geochemical monitoring of active crater lakes, highly dynamic natural systems. The mass budget of a lake is based on observations of physical variations during a certain period of time: lake volume (level, surface area), lake water temperature, meteoric precipitation, air humidity, wind velocity, input of spring water, and overflow of the lake. This first approach leads to the quantification of the in- and output fluxes contributing to the actual crater lake volume. Estimating the input flux of the "volcanic" fluid ( $Q_f$  - kg/s) -an unmeasurable subsurface parameter- and tracing its variations with time is the major focus during crater lake monitoring. Expanding the mass budget into an isotope and chemical budget of the lake, the box model helps to qualitatively characterize the involved fluids. The (calculated) Cl content and dD ratio of the rising "volcanic" fluid rules out its origin. The accuracy of the box model approach strongly depends on the error of the single detection methods. With a glance towards continuous monitoring of crater lakes, the present work provides tips which make it able to better

calculate  $Q_f$  in the future. We recommend a real-time detection of meteoric parameters (precipitation, ambient temperature, wind speed and direction, air humidity), of lake level variations by pressure gauging, and in-situ measurements of lake water temperature, pH and salinity as the first steps towards continuous monitoring of active crater lakes.

## S2-P09

### **Carbon dioxide emission from Furnas, Fogo and Sete Cidades volcanic lakes, São Miguel Island, Azores**

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Carbon dioxide emission monitoring of volcanic lakes is becoming a useful tool for volcanic surveillance (e.g. observed 2007 CO<sub>2</sub> emission changes at Kelud crater lake, Indonesia; and 2010-2011 CO<sub>2</sub> emission changes at Taal crater lake, Philippines). The goal of this study is to evaluate the spatial distribution and the CO<sub>2</sub> emission rates from Furnas, Fogo and Sete Cidades volcanic lakes which fill calderas of active composite volcanoes where pre-historical and historical eruptions (between 1439-44 A.D. and 1630 A.D.) ranging from Strombolian to Subplinian/Plinian had occurred. In order to evaluate the CO<sub>2</sub> emission of the three major volcanic lakes at São Miguel Island (Azores), hundreds of CO<sub>2</sub> efflux measurements were performed at the surface environment of each volcanic lake on May 2011 using a floating device to the accumulation chamber and a IR sensor with an accuracy of approximately 5%. The observed CO<sub>2</sub> efflux values ranged from non-detectable levels to (i) 14,0 g·m<sup>-2</sup>·d at

Furnas volcanic lake (1,93 Km) and (ii) 3,8 g·m<sup>-2</sup>·d at Fogo volcanic lake (1,59 Km), while CO<sub>2</sub> efflux measurements at Sete Cidades volcanic lake (4,69 Km) are still in progress at the time of the abstract submission. Most of the Furnas volcanic lake showed CO<sub>2</sub> efflux values below the detection limit (<0,5 g·m<sup>-2</sup>·d), and the relatively observed higher values were detected in the northern sector of the volcanic lake. Similar low emission rate values were observed at Fogo volcanic lake where the relatively higher values were detected in the southeastern sector of the lake and close to the site of the 1563 eruption. To quantify the CO<sub>2</sub> emission from each volcanic lake, CO<sub>2</sub> efflux maps were constructed using conditional sequential Gaussian simulations (SGS) provided by the GSLIB program (Deutsch and Journel, 1998; Cardellini et al., 2003). Estimates CO<sub>2</sub> emission from Furnas and Fogo volcanic lakes were 33 ± 11 Kg·d and 161 ± 14 Kg·d, respectively. Therefore, the normalized CO<sub>2</sub> emission rate were 0,02 and 0,10 t·m<sup>-2</sup>·d from Furnas and Fogo volcanic lakes; respectively. These observed normalized CO<sub>2</sub> emission rates are really low and suggest an extremely poor contribution of deep-seated CO<sub>2</sub> degassing through Furnas and Fogo volcanic lakes. Therefore, the observed CO<sub>2</sub> emission will be essentially derived from organic matter decomposition, which is compatible with the eutrophication process underway in numerous lakes from the Azores archipelago (Cruz et al., 2006). After considering the estimated global CO<sub>2</sub> emission from volcanic lakes is 117 ± 19 Mt·yr (Pérez et al., 2011), the CO<sub>2</sub> emission from the three major volcanic lakes at São Miguel Island will account < 0,0001% of the global CO<sub>2</sub> emission from volcanic lakes. In spite of this low CO<sub>2</sub> emission rate, monitoring this geochemical parameter on volcanic lakes at São Miguel Island should be taken into account to help on the volcano monitoring in the Azores.

## S3-P01

**11 ka of lake dynamics at high latitudes: Evidence for Early Holocene warming in the western Canadian Arctic (Herschel Island)**

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Lake sediments on Herschel Island (69°36' N; 139°03' W) were analysed in order to reconstruct late Quaternary landscape dynamics in the western Canadian Arctic.

The permafrost-affected island is situated 60 km east of the Yukon-Alaskan border and 3 km off the modern coastline of the Yukon Territory, and is of outstanding scientific importance since it is part of a push moraine at the former margin of the Laurentide Ice Sheet. Previous studies focused on its geology, permafrost processes and coastal erosion but palaeoenvironmental records are relatively rare from this remote region. This study concentrates on 11,000 years of environmental dynamics of Lake Herschel, which is the northernmost terrestrial climate archive of the Yukon Territory.

To analyse the 728 cm long sediment core and its pore water, a multidisciplinary approach was applied covering sedimentology, stable isotope geochemistry, geochronology, invertebrate paleoecology and hydrochemistry to obtain a comprehensive view on the palaeoenvironmental conditions.

The generally clayey-silt sized sediments were interbedded by organic-bearing sandy layers. A mixed assemblage of freshwater and brackish-marine faunal communities of molluscs (*Pisidia* sp.), ostracods (e.g. *Limnocytherina sanctiipatricii*, *Sarsicytheridea bradii*) and foraminifera (e.g. *Haynesina*

*orbiculare*) was found in various depths of the sediment core. Pore waters were characterised by high electrical conductivity continuously increasing with depth. This indicates constant brackish water conditions through time due to dissolution of salt from the ice-thrusted marine deposits of the underlying source sediments. Results from biogeochemical analyses point towards distinctive stratigraphic and lithologic units. Accordingly, the onset of Lake Herschel was presumably caused by thaw subsidence by about 10,300 cal. years BP. Thus, the lake onset mirrors a warmer-than-modern phase during the Early Holocene and reflects an environmental response of ice-rich permafrost to an arctic-wide climate stage known as the Holocene Thermal Maximum. An event by about 3,000 cal. years BP points towards disturbance in sedimentation on a local scale: Mass wasting processes from the lake shore or a hiatus due to drainage could have caused changes of the continuous sedimentation.

The post-glacial environmental history is recorded by the lake sediments on Herschel Island. The palaeoecological data obtained so far prove an extraordinary brackish environment controlled by marine catchment deposits. Ongoing analysis of molluscs, ostracods and foraminifera will be used to highlight Lateglacial to Holocene lake and environmental dynamics.

## S3-P02

**Response of a subarctic lake system to climate and agriculture during the last two millenia: paleolimnological investigations at Igaliku, South Greenland.**

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A multiproxy high-resolution record from Lake Igaliku, South Greenland, was generated to evaluate the environmental response to both Norse (986- ca.1450 AD) and modern (post-1920 AD) agricultural disturbance, and its paleoclimatic context. Our study includes a reconstruction of past changes in vegetation (pollen), soil erosion (sediment yield) and lake biology (diatoms). Soon after the Norse arrival, the reduction of wood cover and the introduction of grazing mammals led to a rapid increase in soil erosion, 2 fold higher than the natural background. From 1320 AD, about one century before the end of the Norse occupation, the grazing pressure decreased and the vegetation began recovering. The soil erosion level consequently decreased to natural values. While the response to Norse agriculture is characterized by marked changes in soil erosion rate and linked geochemical proxies (C:N ratio, titanium content, C and N isotopes ratios), only slight changes in the diatom flora were observed. On the contrary the environmental response to the last 3 decades of modern sheep farming, which implicates tillage and the use of nitrogen fertilizers for fodder production, is marked by drastic changes in both sedimentological parameters and diatom assemblages with a sharp increase in sediment yield, 6 fold higher than the pre-anthropological background. Indeed, the lake environment of the last 30 years is unmatched by any of the late Holocene. These results contradict the notion that the Greenland Norse caused the widespread destruction of their pastoral landscape. It rather suggests that in response to the worsening climate condition, the Norse adapted their practices quite early in the history of the medieval occupation of Greenland.

### S3-P03

#### **Variations on Magnetic Parameters During the Last 15500 cal. BP on Sediments from Laguna Potrok Aike (51°57'S, 70°24'W, Argentina)**

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Lake sediments are excellent archives of paleoenvironmental information as they provide continuous and high-resolution records. They are good recorders of magnetic parameters which are often used as proxies of paleoclimate, because every change in the catchment area (rainfall and drought periods, temperature changes, differences in sedimentation rates) is reflected in variations of these parameters.

In this work, we studied three piston cores collected from the centre of Laguna Potrok Aike, located in southern Santa Cruz, Argentina. It is a maar lake, permanently water-filled lacustrine system in the Patagonian steppe, with a current water depth of around 100m. There is no stratification of the lake because of the strong winds. The cores (PTA02/3, PTA03/12 and PTA03/13) form a composite core for the past 15500cal BP.

The following measurements were performed on sub-samples of 8cc: magnetic susceptibility (specific, and volumetric, k); isothermal remanent magnetisation reaching the saturation (SIRM); back-field in growing steps until canceling the magnetic remanence; anhysteretic remanent magnetisation (ARM<sub>100mT</sub>), with a direct field of 0.5mT and a peak alternating field of 100mT. Associated parameters also were calculated: S-ratio (IRM<sub>300mT</sub>/SIRM), %soft IRM ((SIRM-IRM<sub>40mT</sub>)/SIRM),

coercitivity remanence (BCR), frequency-dependence magnetic susceptibility (F-factor), anhysteretic susceptibility (k<sub>ah</sub>) and interparametric ratios (ARM<sub>100mT</sub>/SIRM, k<sub>ah</sub>/k, ARM<sub>100mT</sub>/k).

According with the rock magnetic studies, the main magnetic carrier in the sediments is magnetite. The magnetic grain size is between 4 and 16 µm, with strong variations in the last 2000 yrs. The general behaviour indicates a change from coarser to finer magnetic grain size.

During dry periods, B<sub>CR</sub> show high values while %soft IRM show low values, indicating the presence of a low percentage of antiferromagnetic minerals, suggesting an eolian sediment source in these periods. B<sub>CR</sub> vs %soft IRM indicate the presence of four distinctive groups of sub-samples differentiated by the percentage of magnetite and correlated with sedimentological changes.

Relationships between magnetic and chemical parameters can be used to suggest related sedimentological, hydrological and climatic fluctuations. The results from previous studies suggest high lake levels from 15500 to 13200cal BP, a dry period around 11600cal BP and periods of moister environment at the beginning of the Holocene. There is an important change in the sedimentation rate, from 1 - 2mm/yr to 6 - 8mm/yr, between 8700 and 7800cal BP. This period coincide with drier conditions between 8700 and 6000cal BP, and then an increase of available moisture when the sedimentation rate become 1.8mm/yr. Periodic changes among low and high lake levels were identified for the last 1500cal BP with a particular high lake level between 500 and 150cal BP attributed to the "Little Ice Age (LIA)".

### S3-P04

#### **Diatom-based reconstruction of Late Glacial and Early Holocene lacustrine environment of Burg lake (Pyrenees)**

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The Pyrenees hold a large number of mountain lakes with great potential for the reconstruction of past climate fluctuations and their consequences using sedimentary records. Climate affects lacustrine environment both directly (e.g, physical processes) and indirectly through the interaction with the lake catchment (e.g. water chemistry). The diatom communities in the lakes adjust to those changes. Consequently, the diatom record from these systems store a large amount of information about past climate related variability. Here, we explore to what extent multivariate reconstructions from a common diatom record can be performed.

Transfer functions for several environmental variables were developed based on a survey of 82 mountain lakes of the Pyrenees. The environmental gradients surveyed included the main bedrock types, altitudinal range and lake morphologies. The variables selected were those explaining relatively independent variability in the distribution of diatoms among lakes and covered major chemical conditions, water transparency and nutrients.

A diatom record covering Late Glacial and Early Holocene was studied from Burg lake (42°30'N, 1°19'W, 1900 m.a.s.l.). The core was thirteen meters long and was sliced every centimetre; the bottom of the core was dated at 16,400 yr BP. We analysed the section corresponding to 5,000-16,000 yr BP because the lake becomes a wetland with high peat accumulation at about 5,000 yr BP.

Here we present the diatom-based reconstruction of the changes in the lacustrine conditions (pH, transparency, trophic state) throughout that period and try to disentangle those related to ontogenetic changes from those attributable to climatic fluctuations



based on knowledge of current limnological process in the Pyrenees.

### S3-P05

#### Microsedimentological investigation of glacial and postglacial sediments from Pingualuit Crater Lake (Ungava, Canada)

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The Pingualuit Crater was formed by a meteoritic impact ca. 1.4 million years ago in northernmost Ungava (Canada). The Pingualuit Crater Lake (modern water depth = 246 m) likely subsisted as a subglacial lake during the last glacial period, as recently suggested by hydraulic potential modeling (Guyard et al., *subm*). Here we present sedimentological microfacies and microstructures of a 9 m-long sediment core retrieved in the deep basin of the lake using backscattered electron images and microphotographs from thin sections, as well as radiographic and CAT-Scan images. Micromorphology of grains was also investigated using a SEM. Four distinct facies were characterized: sediments deposited by ice shedding in a subglacial and lacustrine environment (Facies IV), proglacial sediments (Facies III), a mass wasting deposit (MWD, Facies II) and postglacial sediments (Facies I).

Recognized microstructures in facies IV, containing subangular striated grains, consist of fluid escape features, galaxy and comet structures, pressure shadows and crushed grains, revealing high-energy conditions and rotational deformations associated with high sediment discharge due to the melting of the

overlying ice-sheet. The facies above (Facies III) consists of finely laminated meltout silts (<1-2 mm) containing a few dropstones and subangular striated grains and is associated with proglacial conditions in a more distal environment. The laminations are normally graded and highly inclined and deformed at the base of the sequence, while they become horizontal at the top, reflecting a gradual transition from a high discharge to a lower energy environment. Rotational and injection structures were also observed. The postglacial period (Facies I) is associated with the onset of organic sedimentation and much lower energetic environment, due to the final retreat of the overlying ice sheet. Postglacial sediments are also characterized by post-depositional deformation (sand injection, micro folds etc...) due to the above MWD (Facies II). This MWD is characterized by an erosive base, pressure shadows, large folds and cross laminations and could have been triggered by seismic activity or by slope instabilities associated with rapid lake discharges.

### S3-P06

#### Siberian 2100 years-long climate chronology based on varved sediments of Shira Lake

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The first sediment cores from meromictic Shira Lake (N54°30', E90°12') located in semi-arid zone of Southern Siberia were earlier collected in shallow part (Phedorin, 2009). New core has been taken at water depth 24 m in plane central basin for paleoclimate study. The uppermost undisturbed layers (22 cm) are sampled by box-corer for detail analysis of

time interval corresponding to instrumental period. 140 cm-long sediment column is composed by layered black muds of organic-clay-carbonate matter. There are also 5 light carbonate macrolayers of 5-15 cm in thickness through the core. Water content, carbon and sulfur as well as rock forming element content are different in black and light muds. Such minerals as calcite, monohydrocalcite, Mg-calcite, dolomite, quartz, feldspar, micas, and chlorite are determined by X-ray diffractometry.

To construct depth-age model  $^{137}\text{Cs}$  and  $^{210}\text{Pb}$  were measured in upper part subsampled by 5 mm step. Coincidence between isotope dating and counting of individual layers corroborated annual origin of them. Thermodynamic modeling of water-sediment multisystem showed that white carbonate component within annual couple is corresponded to cold (winter) conditions with ice-cover, and black organic one - to warm season. Light carbonate macrolayers formed during periods of low standing and increase water salinity every 400-600 yrs.

Then varves were counted for the complete core, and age of bottom is estimated as 2450 yrs BP. Average thickness of varves is 0.6 mm. Three radiocarbon dates (Lab. Poznan, Poland) showed the same result on the assumption of 1200 years reservoir effect for each measurement.

Elements distributions downcore were measured by x-ray fluorescence analysis on synchrotron radiation (XRF SR) in Institute of Nuclear Physics, Novosibirsk. Records of 20 elements were obtained by scanning step 0.1-0.2 mm. After calibration of geochemical time series by metadata, the equations for annual temperature and signal of salinity were estimated using multiple regression methods. Shira temperature profile is similar to other Siberian reconstructions of paleoclimate.

### S3-P07

#### Paleoenvironmental record from two high altitude tropical lakes in central Mexico

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High altitude tropical lakes El Sol and La Luna are located inside the crater of the Nevado de Toluca volcano (4,200 m.a.s.l.) in central Mexico. These lakes, the only high altitude lakes in Mexico, are shallow (<15m) with low mineralization ( $\text{EC} < 100 \mu\text{S}/\text{cm}$ ) and therefore considered to be sensitive ecosystems to environmental change and human impact. The comparison of the diatoms that characterize each lake can help in the understanding of the environmental and anthropogenic changes that might have affected these lakes. The present study describes the diatom distribution along short sedimentary sequences from each lake, Chrysophycean stomatocysts, palynomorphs, pollen, carbon particles and magnetic susceptibility analyses were also performed in these sequences. The sediment cores were dated with  $^{14}\text{C}$  and  $^{210}\text{Pb}$ , giving an age range of 600 yr for El Sol and 400 yr for La Luna. In El Sol 61 diatom taxa were present the most abundant: *Cavinula pseudocustifomis*, *Aulacoseira distans* and *Achnanthes levanderi*. In La Luna 50 diatom taxa were identified, the most abundant: *Cymbella aff. gracilis*, *Navicula sp. (NTA)* and *Pinnularia microstaurum*. The main species indicate low mineralization and oligotrophy. Differences in species composition are due probably to the higher pH at El Sol compared with La Luna, along the sedimentary sequence changes in diatom assemblages probably indicate that both systems are changing and in the

case of lake El Sol giving warning signals of eutrophication (appearance of *Fragillaria* spp. and *Cyclotella stelligera*). Between AD 1500-1900 there are signals of a temperature increase, with evidence of forest fires and a reduction in water level (*Pinus* pollen decrease, carbon particles increase and diatom assemblage change).

### S3-P08

#### Magnetic evolution of lake Soppensee

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In the present study, we test magnetic properties of lacustrine sediments as high resolution proxy for climate changes. It is well known that the magnetic response of iron oxides such as magnetite/maghemite or hematite can be indicative of redox-conditions and detrital input, as well as of inorganic or biological processes during mineral formation. To decipher the feedback of the climate on the magnetic properties in sediments, a diagnostic approach, combining rock magnetic tools and ferromagnetic resonance spectroscopy (FMR) was applied to a 6.5 m piston core from the Soppensee. Based on the magnetic bulk susceptibility, which is a measure for the magnetic content, the sediment core can be subdivided into six units A to F. Using the age model of Hajdas et al., (2011), the oldest unit F can be assigned to the late Pleistocene Würm deglaciation, unit E to the Bøling/Allerød (B/A), Younger Dryas (YD), and the units D, C, B, and A to the Holocene. In unit F the magnetic carriers are hematite and magnetite. These two phases were identified by their Curie temperatures and magnetic saturation behaviors. The pronounced occurrence of coarse grain hematite indicates detrital input. The decrease of hematite, i.e. decrease in detrital input, toward the end of the deglaciation can be related to the change from an open to a

closed lake system. In unit E hematite is absent and the magnetic remanence is carried by magnetite. Apart from this ferromagnetic phase siderite and vivianite were found by X-ray diffraction (Fischer et al., 1996). These mineral phases suggest post-oxic, non-sulfidic conditions. Variations in grain size and concentration of magnetite within unit E points to varying conditions in the depositional environment, most likely due to changes in vegetation during the B/A-warm and YD-cold period. Unit D, assigned to the onset of the Holocene warm period, the FMR data indicate single-domain magnetite of uniform grain size in chain-like configurations. Such properties provide clear evidence for biologically-controlled magnetite formed by magnetotactic bacteria (MTB). The subdivision of the Holocene (units D to A) is based on the variation of the MTB production and their preservation as magnetofossils and they can be linked to the TOC content of the sediments (Fischer et al., 1996). Early Holocene (unit E) with TOC<5% and mid-Holocene with TOC=20% exhibit the lowest and highest production of biogenic magnetite. Anthropogenic activities since 1.5 kyr cal BP, such as deforestation and agriculture, lead to highly eutrophic conditions. The poor preservation of MTB under such conditions is documented in the units B and A.

The magnetic evolution preserved in the sediment column of the Soppensee clearly demonstrates that magnetic records have strong potential to contribute to high resolution climate reconstructions.

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**S3-P09****Was Medieval Warm Period as warm as today? - climate changes of the last millennium recorded in the Tatra lakes (Carpathians) with additional data from cave ice**

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We studied sediment sequences from several lakes located in the Tatra Mountains (Carpathians) with special emphasis to cladoceran and diatom records. The lakes represent all main type of the Tatra basins: from small dystrophic forest lakes to deep tarns located in glacier cirques above current tree line. Although, zoo- and phytoplankton were specific in each type of lakes, every record points to existence two warm periods during the last millennium and separating them a cold period. Age-depth models based on radiocarbon and lead <sup>210</sup>Pb dates recognize them as the Medieval Warm Period (MWP) and the 20<sup>th</sup> century (relatively warm periods) and the Little Ice Age (LIA, colder period), respectively. In general, zoo- and phytoplankton flourish during warm periods and benthic forms, mainly related to rocky and sandy bottom, predominated during the LIA. This regularity was disturbed by an artificial introduction of fishes into several tarns and very effective selective predation on larger plankton form, mainly daphnias and *Eurycercus spp.* However, the records from the lakes remaining fishless show a higher development of plankton during the MWP than today. Artificial acidification is the next process overlapping climate effect on the lakes. The lower pH during the final decades

of the 20 century was lethal to some water organisms while attracting others.

Climatic variation during the last millennium is confirmed by data from a cave ice profile in the Lodowa Cave in Ciemniak. There, two generations of a cave ice are separated by unconformity representing a melting episode. The younger generation of ice was dated on the LIA. The distinctive erosion boundary recorded a significant period of ablation which preceded the LIA probably during the MWP. The older generation of ice is supposed to have originated during cold stage between the Atlantic period and the MWP. The ice volume in the cave was substantially smaller before the LIA than it is today, despite the clear tendency to melt which has been recognized since 20s of the last century. It suggests even more intensive melting during the MWP.

**S3-P10****How does the elemental composition of Swiss lake sediments reflect past climate conditions?**

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As part of an interdisciplinary multi-proxy study, we conducted a high-resolution XRF core scan analysis on lacustrine sediments from Lake Soppensee (Central Switzerland) covering the last 16.000 years to answer the question of how the elemental composition of lake sediments reflects past climate conditions.

Climate has a strong influence on sedimentation rates, redox conditions, primary production, and the amount of erosive input of a lake, and this in turn affects the composition of the lake sediment. Since specific elements and element ratios often characterize specific lithological properties,

XRF analysis helps to define the sediment's source and gives hints to reconstruct the paleo-environment and -climate.

At Soppensee, the sediment deposited at the end of the last glaciation mainly consists of detrital material, which strongly decreases just at the onset of the Bölling/Alleröd (B/A). With the beginning of the B/A first authigenic calcite precipitation starts due to higher temperatures and developing primary production. Siderite deposition during the Late Glacial coincides with a period of summer anoxia most probably caused by additional organic matter input from the catchment, as well as longer phases of stratification due to reduced wind exposure caused by the increased vegetation cover.

At the end of the YD, first formation of calcitic varves starts, which indicates rising primary production at the lake surface, and anoxic conditions at the sediment surface due to decomposition of organic material and poor mixing of the hypolimnion. Varves become darker, discontinuous and eventually faint at around 5500 cal y BP. Changes in the vegetation cover due to warmer temperatures lead to more organic matter produced within the epilimnion and also transported into the lake, which then decays at the lake bottom. This rotting process leads to pH changes in the hypolimnion, which supposedly circumvents the build-up of calcite varves. In addition, these more acidic and reducing conditions result in an rapid increase of ferromagnetic minerals as well as increased mobility of metal ions.

First human activity in the catchment and first local settlements may be seen in the sediment at about 5500 and 3500 yr cal BP. The Middle Ages (about 1500-500 y cal BP) coincide with massive changes in the sediment due to deforestation in the catchment and around the lake. The lack of forest presumably enabled mixing of the lake water due to winds and increased soil erosion supplied additional nutrients to the lake. The topmost part of the lake sediment is strongly influenced by

anthropogenic eutrophication of the lake due to intense agriculture in the catchment.

On the same sediment core material, paleomagnetic properties were determined, which support our interpretation and completes the reconstruction of the paleoenvironment from Lake Soppensee.

### S3-P11

#### Quaternary grain-size distributions of Lake El'gygytyn, NE Siberia: Statistic analysis and climate dependency

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The Crater Lake El'gygytyn, located at the Anadyr-plateau of central Chukotka in the northeastern part of Siberia, was formed by a meteorite impact about 3.58 Ma ago (Layer 2000). The results of a seismic survey indicate a thickness of hemi-pelagic sediments of approximately 320 m (Niessen et al. 2007). In 2009, an ICDP founded deep drilling campaign was carried out in order to obtain a long and continuous sediment sequence and to drill into the impact breccia. The sediment-breccia boundary was achieved at 315 mblf (meters below lake floor), and drilling was continued until 517 mblf (Melles et al. 2011). In this poster, we present the grain-size data of pilot core Lz1024 and deep drilling core 5011-1 from Lake El'gygytyn covering the past 2.6 Ma (0 to 123 mblf). Taken a mean sedimentation rate of approximately 50mm/ka during the Quaternary (Melles 2011), the temporal resolution of the grain-size data can be calculated to ca. 1.6 ka. Although thicker mass movement deposits (MMD) were excluded from the sampling, thinner MMD may occur within the analyzed profile. The according samples were initially identified by core descriptions. To identify

characteristic grain-size distributions over time as well as of MMDs, we apply multivariate statistic methods. The interpretation of the calculated statistics reveals the most important processes triggering the grain-size distribution, as changes in the activity of the hydrological cycle, which can be traced back to regional and global climate variations on a glacial-interglacial time scale. Conforming to previous studies at Lake El'gygytyn (Asikainen et al. 2007), warm periods are characterized by coarser sediments whereas finer ones occurred during cold periods. In detail, the thickness of the active layer, the availability of non-frozen water and the duration of perennial lake-ice cover play an important role on the grain-size distribution. Furthermore, a recent study of the modern sedimentological setting (Wennrich et al., in prep.) imply that the poly-modal grain-size pattern in the lake center is mainly triggered by different strengths of a wind-induced current pattern in the lake during the ice-free period. Assuming that this is also valid for the sedimentation during the Quaternary, variations in the poly-modal grain-size distribution can be used as indicator for the activity of the in-lake current system, and thus for the existence of a perennial ice-coverage at Lake El'gygytyn over the last 2.6 Ma.

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#### S4-P01

##### **The role of NAO in Western Europe climate variability during the Late Glacial and Holocene based on Iberian and Azores Island lake cores and climate instrumental data.**

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The North Atlantic Oscillation (NAO) climate mode controls, to a large extent, the winter climate of SW Europe. The dominant role played by the NAO on climatic and environmental variables has a direct impact on terrestrial ecosystems and in the distribution development and phenology of many species, which could be related to the variability on the length of the growing season, moisture balance and climate seasonality. NAO also has a strong and direct influence on lacustrine ecosystems through many ways. Despite the importance of this climate phenomenon for SW Europe, only some historical reconstructions based on documentary evidences and tree rings covering the last 1500 years and few millennial scale reconstructions using terrestrial sedimentary records of the NAO fluctuations have been carried out. The first attempts of NAO millennial-scale studies using terrestrial sedimentary archives for the Iberian Peninsula are currently in progress. Surprisingly, few multiproxy reconstructions of the NAO evolution have been conducted in the Azores islands, albeit being located at the center of the southern extreme of the dipole that characterizes it.

The objective of the PaleoNAO research project (<http://www.ija.csic.es/~sgiralt/paleonao/>) is to achieve a high-resolution spatial and temporal reconstruction of the NAO at multiannual-decadal resolution for the last 1000 years and at millennial time-scale for the last 15000 years in the SW Europe and Azores Islands from the multiproxy characterization of lacustrine sediments. The research team includes sedimentologists, geochemists,

limnologists, ecologists, palynologists and climatologists. The objective of the PaleoNAO project includes the following milestones:

- Geomorphological characterization of the lake catchments from the Iberian Central Range and from São Miguel island (Azores Islands, Portugal).
- Multiproxy high-resolution characterization of the sedimentary cores.
- Paleolimnological and paleoclimate reconstruction at two temporal scale windows: last 1000 years, and Lateglacial and Holocene periods.
- Identification and isolation of the NAO climate signal from the other ones in each temporal scale window and studied locality.
- Development of long and high-quality instrumental temperature and precipitation records (both regional and single sites timeseries) for the Iberian Central Range and Azores Islands, along with a compilation of the NAO Indices.
- Assessments of intraannual, interannual, decadal and interdecadal relationships between NAO and the surface climate of Central Iberia and Azores.
- Exploratory relationships analysis between multiproxies from the sedimentary cores and Central Iberia and Azores instrumental climate timeseries.
- Characterization of the NAO climate signal transmission from the atmosphere to the lake sediments for the last 1000 years.
- Comparison of the reconstructed NAO climate signals in order to characterize the spatial-temporal evolution of this atmospheric anomaly.

#### S4-P02

##### **Spatial and Temporal Variation of Diatoms in the Lower Mountain Fork, Oklahoma**

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The lower Mountain Fork, downstream of Broken Bow Reservoir, is the southern-most USA occurrence of the nuisance/invasive diatom *Didymosphenia geminata* (Didymo). We began monitoring Didymo and the other epilithic diatoms in the lower Mountain Fork in June 2009, first sampling upstream-downstream sites and then continuing temporal monitoring at two Didymo sites. Diatom assemblages showed both spatial and seasonal changes; for example, the dissimilarity of assemblages increased with increasing downstream distance. Numerically dominant taxa were *Achnanthydium rivulare*, *Achnanthydium minutissimum*, *Aulacoseria granulata*, *Cocconeis placentula*, *Encyonema silesiacum* and *Gomphonema* sp. A. Didymo persisted when visible mats were absent - such as after a large spring flood. When mats were not apparent, scrubbing larger rocks across a transect was better at finding Didymo than collecting and processing a few small stones. Characterizing the seasonal and spatial pattern of Didymo and documenting the associated diatom assemblages will help with identifying and monitoring potential Didymo sites in Oklahoma and neighboring states.

#### S4-P03

##### **Age-depth modelling based on the multiple dating approach: a case study from Lake Szurpily, Northeastern Poland**

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Annually laminated (varved) lake sediments are important natural archives allowing high-resolution reconstructions of climatic and environmental change. A key issue is to

establish a reliable absolute time-scale with the support of an independent verification of the varve chronology, usually accomplished by applying several radiometric dating methods.

The present study describes age-depth modelling based on long lacustrine sediment cores collected in 2007 from Lake Szurpily (Northeastern Poland). Parallel overlapping cores were used to construct a composite sediment profile with a total length of 12.39 m. The sediment sequence is dominated by annually laminated carbonaceous and organic-carbonaceous gyttja, in some sections disturbed by graded turbidites and massive sand layers. Due to this discontinuous character of the varve record, additional dating methods other than varve counting were required.

The goal of this study is to use the multiple dating approach as the basis for the age-depth modelling. Therefore the sediment profile was sub-sampled for thin sections, <sup>210</sup>Pb, <sup>137</sup>Cs and <sup>14</sup>C dating. Varve counting and thickness measurements including microanalysis and digital imagery were carried out microscopically on thin sections. The counting error was determined by replicate varve counts. For the uppermost sediments covering approximately the last 120 years <sup>210</sup>Pb and <sup>137</sup>Cs dating were applied. Altogether 21 terrestrial plant macrofossils were selected for AMS <sup>14</sup>C-dating to provide an independent verification of varve ages of the entire sediment profile. The presented continuous age-depth model extends back to the Late Glacial. It is based on a combination of varve chronology and multi-method radiometric dating and was calculated using BACON software.

##### Acknowledgements

The research for this study was supported by the Polish Ministry of Science and Higher Education grants to M. Kinder (N N306 009337) and to N. Piotrowska (N N306 291639). This is a contribution to the bilateral scientific program "Northern Polish Lake Research" (NORPOLAR), a Polish-German research initiative funded by the Deutsche



Forschungsgemeinschaft and the Polish Ministry of Science and Higher Education.

#### S4-P04

##### **Rhone glacier retreat in western Lake Geneva happened during Oldest Dryas with three stages.**

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Western Lake Geneva contains sediments mostly deposited during the last deglaciation and constitutes an important geological archive to understand past glacial and lacustrine processes. During the Last Glacial Maximum, the Rhone glacier was one of the main Alpine glaciers and filled the Rhone valley down to the foreland basin, covering the Geneva area with more than 800-m-thick ice flowing towards the South-West. Knowledge on the timing of this large ice mass deglaciation is still scarce.

Seismic reflection data -acquired with a 1 in airgun and a pinger source- and geotechnical drillings were performed in spring 2009 within a public project of the State of Geneva to build a bridge or a tunnel across the lake. This mandate combined to detailed palynological and sedimentological analysis reveal new insights in the history of Lake Geneva formation.

Seismic reflection data images the bedrock lake basin (U0) as well as infill units (U1-14) with glacial-, glaciolacustrine- and lacustrine facies. In the West, bedrock is topped by up to 30 m of sediment, whereas in the centre and eastern part of the lake, 70- to 110-m-thick units fill the basin. The deepest infill unit (U1) is interpreted as glacial sediments left during an older glacial cycle. This unit is covered by U6b and U7a units which consist of melt-out till deposited at the beginning of Oldest Dryas biochronozone. The compaction values of U6b

indicate a new Rhone glacier stage during the beginning of unit U7a near 'Le Reposoir' location. Later, when the glacier retreated again, the ice mass melted asymmetrically, first in the central and eastern part of the lake basin while it was still lying on the Molasse 'ramp' in the West (U7a). During the next sequence (U8-12), glacio-lacustrine sediment deposited with variable facies including gravels of alpine origin and lets mousue to the recurrent presence of icebergs over the lake (ice-rafted debris). Units U8 to U10 are sismostratigraphically preceding push-moraines and erosion surfaces due to the Coppet and Nyon stages/readvances, respectively. It shows that during the upper Oldest Dryas the Rhone glacier ice front was still covering large parts of the Lake Geneva basin and that the Petit-Lac infill consists mostly of sediment older than 15'000 yrs.

This project is financed by the Fondation Ernest Boninchi, the Fondation Ernest et Lucie Schmidheiny, the Swiss Civilian Service and partly by the SNF grant 200021-121666/1. Thanks to De Cerenville Geotechnique and the State of Geneva for access to drillings and geotechnical data.

#### S4-P05

##### **Microbialite bioherms, barrier bars and sand tufa in the Wilkins Peak Member of the Eocene Green River Formation: Wyoming**

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Localized clusters of microbialite bioherms, stromatolites, barrier bars and sand tufa spires (clusters up to 50 m wide), occur at the local base of the Wilkins Peak Member of the Green River Formation near the town of La Barge, Wyoming. In this area, Wilkins Peak oil shale represents a significant transgression of Eocene Lake Gosiute over the fluvial Cathedral Bluffs Member of the Wasatch Formation. In general, the localized microbialites and barrier

bars are embedded within Wilkins Peak oil shale and are associated with the Wilkins Peak "layered tuff".

Six outcrops in Steed and Spur Canyons illustrate the vertical succession of three localized facies (from bottom to top): 1) vertically oriented sand tufa structures up to 3 m thick, 2) overlain by a 2-3 m thick barrier bar sequence composed of crossbedded microbial carbonate fragments, 3) microbialite bioherms or spring mound deposits up to 1.5 m thick. The sand tufa is considered strong evidence of vertical groundwater flow directly below the carbonate spring mounds and stromatolites.

Two outcrops at Little Mesa illustrate a similar vertical succession of localized facies but lack the vertical sand tufa structures and are embedded in kerogen-poor wackestone (instead of oil shale). At Little Mesa, the carbonate barrier bars are associated with overlying stromatolites and caddisfly-dominated microbial carbonate bioherms. The Little Mesa outcrops are 12 km northwest of the Spur Canyon outcrops and represent a more nearshore paleoenvironment (evidenced by the occurrence of caddisfly fossils and the lack of oil shale at Little Mesa).

The Steed Canyon, Spur Canyon and Little Mesa outcrops record evidence of a 12 km long and 50 m wide accumulation of linear barrier bars and microbialites that paralleled the margin of Lake Gosiute during deposition of late Wilkins Peak sediments.

It is clear that carbonate precipitation was greatest at nearshore locations where calcium-rich freshwater refraction springs discharged into the more saline/alkaline Lake Gosiute. The occurrence of lake margin refraction springs, increased rates of carbonate precipitation and wave action gave rise to barrier bars that accumulated parallel to the western shoreline of Lake Gosiute (and directly above the refraction springs). Later, microbial carbonates (stromatolites, caddisfly-dominated microbial carbonate bioherms and spring mounds) developed along the path of the buried barrier bars due to vertical movement of calcium-rich groundwater from

the porous barrier bars into the overlying saline/alkaline lake.

## S4-P06

### Multidisciplinary palaeolimnological investigations on Late Glacial river-lake-systems - a case study from Northern Germany

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The last Glacial to Holocene transition has already often been subject of palaeolimnological research. However, multidisciplinary investigations focused on various organism groups are still few. Here we present records of Diatoms, Ostracods and Chlorophyceae (Genus *Pediastrum*) from Late Glacial to Early Holocene lacustrine sediments, which accumulated in residual channel lakes of river *Jeetzel* - an *Elbe* tributary - in Northern Germany.

As analyses on different organism groups are integrated in a wider palaeoenvironmental and geoarchaeological survey, individual and combined organismic records can be asked to reflect diverse environmental factors like climatic shifts, trophic changes or water level fluctuations. Ostracods and *Pediastrum* algae are shown to be sensitive to temperature shifts, new approaches intend to estimate temperature fluctuations qualitatively and quantitatively. Diatoms seem to reflect disturbances or flood events during the Allerød interstadial and the Allerød-Younger Dryas transition. During the Younger Dryas-Holocene transition organism groups reacted with different intensity and different lags of time to changing environmental conditions.

Altogether our investigations represent an example how combination of various biotic proxies enlarges available information on former ecosystems. The palaeoecological reconstructions also are of archaeological interest as they contribute to understand the frequent occurrences of Late Glacial hunter-gatherers that are documented by one of the largest known settlement areas of the Late Palaeolithic.

#### S4-P07

##### **Comparison of reflectance spectroscopy methods in visible and visible to near infrared (VNIR) range for paleoclimatic reconstruction of lacustrine offshore clays: Miocene Cypris Formation, Sokolov Basin, Eger Graben, Czech Republic**

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We present reflectance spectroscopy study on the Lower Miocene lacustrine offshore clays of the Cypris Formation in the Sokolov Basin of the Eger Graben focused on paleoenvironmental and paleoclimatic reconstruction. The applicability of reflectance spectroscopy methods in the interpretation of thick lithologically monotonous, offshore lacustrine successions is tested. Lacustrine deposits of the Cypris Formation cover approximately 20 km and are mainly represented by offshore clays, up to 130 - 180 m thick. This study is based on 75 m of Dp-333-09 core data from the lower and middle part of the offshore succession. Lacustrine clays are mostly laminated, in places with a high organic content (Corg to 2 - 18 %), a low silt admixture, and very rare thin sandy interbeds. 10 cm sampling was used for this study. Mineral grains also include

volcanogenic material from nearby volcanics and volcanoclastics.

Visible range spectroscopy (400 - 700 nm) is fast, simple and powerful tool for distinction of coaly clay, algal clay and sulphide rich clay. Formula for determination of different organic admixture - coaly and algal material is proposed. But different proportions of quartz, clay and carbonates do not affect spectra sufficiently to distinguish siltstone-marlstone-carbonate lithologies. DRS-Unmixer software was used for determining endmembers of mixed spectra. This approach is very useful for time series analysis - the spectra are clear, revealing distinct cycles, compared to elemental geochemical proxies or gamma ray or resistivity data which show much noisy spectra.

Spectral analysis of VNIR range (350 - 2500 nm) validated by X-Ray diffractometry mineralogical and XRF and ICP-MS geochemical data enabled to propose mineral indexes to determine significant occurrence of smectite, zeolite and carbonate group minerals. The section is dominated by quartz-kaolinite-illite association, but the spectral analysis revealed prominent cycles with (from bottom to top) smectite-zeolite-dolomite minerals, which reflects decreasing upwards lake level probably due to climatic oscillations. The meter-scale cycles are possibly in the Milankovitch band, but the interpretation of periodic signatures must await refinement of the chronostratigraphic constraints.

#### S4-P08

##### **Biogeochemistry of Lubomirskiidae sponges in Southern Baikal**

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Encrusting lubomirskiid sponges are common in the shallows of Baikal, and they generally dominate benthic communities of the stony littoral zone. Hence, they take part in destruction of the stone substratum, extraction and incorporation of a wide range of chemical elements into biological processes.

To analyze the elemental composition of the sponges we used the specimens representing the dominant and subdominant species of encrusting sponges of the family Lubomirskiidae Rezvoj, 1936: *Baikalospongia intermedia* (Dybowski, 1880); *Baikalospongia bacillifera* (Dybowski, 1880); *Lubomirskia incrustans* Efremova, 2004. After preparation they were analyzed by a Agilent 7500ce mass spectrometer (Agilent Technologies) with a quadrupole mass analyzer. Basal spongin layer and mineral particles from the sponge body were examined by EPMA analysis using a Superprobe JXA-8200 analyzer (JEOL Ltd, Japan).

Besides silicium that is an essential element in Baikal sponges, the macro-elemental composition of *L. incrustans* is dominated by P(1400 mcg/g dry weight) > Al(520) > Fe(500) > Ca(420) > S(400) > Mg(270) > K(270) > Na(240), and *B. intermedia* and *B. bacillifera* - P(2700) > S(710) > Fe(570) > K(530) > Mg(430) > Ca(380-170) > Al(370) > Na(260). Among microelements of the sponges Cu > Zn > Mn > Ti > Ba > Br are dominant.

The sponges accumulate chemical elements that are deficient or undetectable in the water. Stony substratum is a potential source of the chemical elements. Raster electron microscopic examination revealed aggregations of mineral particles on the inner side of the basal layer of the sponge and destruction of the stone surface at the contact with the basal layer. The contents of many elements in the basal layer exceed their concentration in the sponge body. According to EPMA data, there is an area at the border line stony substratum - basal sponge layer extending from the surface 30-50 µm deep with minimal concentration of silicium, which is intensively consumed by the sponges and is mostly accumulated in their skeletons. Moreover, we registered decrease in the contents of calcium, aluminum and iron hardly absorbed by the sponges. In contrast, higher concentrations of silicium, potassium, sodium and lower concentrations of calcium, iron and aluminum were found in remote parts of the mineral grain showing signs of disintegration. Mineral particles with well-defined signs of decomposition were seen in all parts of the sponge. As the particles disintegrate, they supply some accessible chemical compounds that may be easily absorbed from the solution by the sponge cells and symbionts.

Supported by SB RAS Integratsiya Project 49.

### S5-P01

#### Critically testing the role of $d^{30}\text{Si}_{\text{diatom}}$ as a novel productivity signal and $d^{18}\text{O}_{\text{diatom}}$ as an indicator of climate variability in temperate lakes: project overview

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Due to the close connection between the Si and C cycles, silicon isotopic analysis of sedimentary diatom silica ( $d^{30}\text{Si}_{\text{diatom}}$ ) potentially offers an alternative, and possibly less problematic, means to trace past primary productivity in lakes, particularly alongside independent evidence for climate and hydrological variability derived from diatom silica oxygen isotopes ( $d^{18}\text{O}_{\text{diatom}}$ ) measured on the same cleaned sample.

Understanding the lacustrine Si cycle, and its  $d^{30}\text{Si}_{\text{diatom}}$  fingerprint, requires detailed case studies of well-chosen and representative sites. We give an overview here of a project aimed at addressing these issues by sub-monthly monitoring of Si cycling in conjunction with  $d^{30}\text{Si}_{\text{diatom}}$ ,  $d^{18}\text{O}_{\text{diatom}}$ ,  $d^{18}\text{O}_{\text{water}}$  and  $d^{30}\text{Si}$  of dissolved silica at Rostherne Mere, Cheshire (53°20'N, 2°24'W), a deep (30m), freshwater, monomictic and eutrophic lake.

Sampling began in February 2010 and will continue over an 18-month period covering two spring (diatom bloom) cycles. We aim to test the following hypotheses:

- 1) Dissolved Si concentration (DSi) in Rostherne Mere is dominated by internal recycling (during overturn) and diatom productivity (during spring, and to a lesser extent, autumn);
- 2)  $d^{30}\text{Si}$  of sedimenting biogenic silica (BSi) and of dissolved silica ( $d^{30}\text{Si}_{\text{DSi}}$ ) is directly proportional to silicic acid uptake within the water column;
- 3)  $d^{30}\text{Si}$  and  $d^{18}\text{O}$  of sedimentary and seston BSi faithfully records  $d^{30}\text{Si}$  and  $d^{18}\text{O}$  of the water column, independent of diatom silica dissolution and maturation effects.

Diatom silica samples consist of pelagic open tube traps (retrieved every 3 months), automatic sequencing traps (0.05 m; 12 bottles collecting every 2-4 weeks) and surface sediments collected over the course of the project. Water samples for analyses of DSi,  $d^{18}\text{O}_{\text{water}}$  and  $d^{30}\text{Si}_{\text{DSi}}$  have been collected every

2-4 weeks from the open water (with profiles every 2-3 months), the main inflow (in phase with sediment trapping), and in fringing Phragmites reed beds.

Trap and sediment samples will be assessed for diatom species composition, abundance, biovolume, BiSi content, preservation and particulate organic C. Purified BiSi (for  $d^{30}\text{Si}_{\text{diatom}}$  and  $d^{18}\text{O}_{\text{diatom}}$ ), DSi and  $d^{30}\text{Si}_{\text{DSi}}$  will be analysed at NIGL. We also plan to analyse reed phytoliths for  $d^{30}\text{Si}$ .

Initial findings show clear seasonality of algal biomass production from the sequencing and open traps, and in the  $d^{18}\text{O}_{\text{water}}$  of lake and inflow. Qualitative inspection of  $\text{H}_2\text{O}_2$ -cleaned trap material suggests little mineral contamination, good preservation of diatoms and low species diversity of predominantly planktonic taxa.

This project addresses fundamental questions concerning  $d^{30}\text{Si}$  biogeochemistry and will provide an important step towards understanding the environmental significance of  $d^{30}\text{Si}_{\text{diatom}}$  in lake sediments. It will establish the potential for this proxy as a productivity tracer in aquatic systems, and provide insight into nutrient recycling.

## S5-P02

### Climate calibration of diatom $d^{18}\text{O}$ records from the varved sediments of Nar Gölü, Central Turkey

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There is increased interest in reconstructing changes in climate seasonality through the Holocene in the Eastern Mediterranean, especially following Stevens et al.'s (2006, QR,

66, 494) proposal of a shift during the mid Holocene from winter- to spring-dominated precipitation in NW Iran. On the other hand, similar isotope records from Eski Acigol in Turkey (Roberts et al., 2001, *The Holocene*, 11, 721) were interpreted as indicating a shift at this time from wet to dry conditions. Therefore, there is debate about the nature of the Mid Holocene Transition and there is a need for a robust reconstruction of seasonality changes. This reconstruction could be achieved by analysing hosts of  $d^{18}O$  that record lake conditions at different times of the year. However, in order to do this accurately, we need to better understand the controls on these hosts by comparing values from the recent past to instrumental records.

The varved sediments of Nar Gölü allow high resolution, precisely dated records to be acquired (Jones et al., 2005, *JoPI*, 34, 391; Jones et al., 2006, *Geology*, 34, 361; England et al., 2008, *The Holocene*, 18, 1229; Woodbridge and Roberts, 2010, *JoPI*, 44, 855) and monitoring by water sampling and sediment traps since 1998 means the modern isotope hydrology of the lake, as well as the timing of sedimentation, is well understood. A climate-isotope proxy comparison has already been carried out on the carbonates for the past 80 years, and this indicated that summer temperatures and evaporation are the dominant controls on  $d^{18}O_{\text{carbonate}}$  (Jones et al., 2005).

Initial data confirm that  $d^{18}O$ , the difference between the diatom and carbonate records, shows significant changes over the past 80 years.  $d^{18}O_{\text{diatom}}$  and  $d^{18}O_{\text{carbonate}}$  are precipitated at different times of the year - in the spring/autumn and summer respectively. Therefore, it may be possible to compare the oxygen isotope values from the diatoms and carbonates to investigate changes in seasonality (Leng et al., 2001, *JoPI*, 25, 343). To better understand the controls on  $d^{18}O_{\text{diatom}}$  at Nar and to test this hypothesis,  $d^{18}O_{\text{diatom}}$  is calibrated with the instrumental record. This will inform future work on a new core retrieved from Nar Gölü, which aims to reconstruct seasonality through the Mid

Holocene Transition and test the hypothesis of Stevens et al. (2006) by combining  $d^{18}O_{\text{diatom}}$  and  $d^{18}O_{\text{carbonate}}$  data.

## S5-P03

### Geochemical signatures (TOC, TN, $d^{13}C_{\text{org}}$ ) of glacial Lake Sanabria sedimentary sequence (NW Spain)

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Sanabria lake (42°07'30"N, 06°43'00"W; 1000 m a.s.l., NW Iberian Peninsula) is the largest glacial lake in Spain. A long (up to 9 m) core and a short (60 cm) gravity core from the deepest basin ( $Z_{\text{max}} = 50$  m) have been selected for a combined sedimentological, geochemical (XRF-core scanner) and organic geochemistry (TOC, TN and  $d^{13}C$  in bulk organic matter) study. The chronology is constrained by 13 AMS  $^{14}C$  dates and  $^{210}Pb/^{137}Cs$  techniques. The compositions of the water-column particulate organic matter (POM), land plants, and aquatic macrophytes have been characterized during an annual cycle.  $d^{13}C$  values of bulk organic matter range from -28.3‰ to -14.‰. Atomic TOC/TN ratios (8-17, average 14) indicate a mixture of algal and terrestrial sources.

Seven sedimentary units have been defined in the sequence. Proglacial sediments (Unit 7, >26 - 14.3 Kyr BP) have typically high  $d^{13}C$  (-14.7‰). Organic matter-rich silts deposited in a glaciolacustrine environment (Unit 6, 14.3 - 13.1 Kyr BP) show decreasing  $d^{13}C$  values (-24.8‰ to -26.5‰) and higher TOC reflecting an increase in organic productivity coherent with more humid and warmer climate. An increase in clastic input, higher TOC/TN, and a small positive  $d^{13}C$  excursion occurred during deposition of Unit 5 (13.1 - 12.2 Kyr BP).

Holocene sediments (Unit 4 to 1) are fine-grained, organic-rich silts with intercalated sandy layers. The transition to the Holocene (12.2 - 10.1 Kyr BP) shows both increasing organic productivity (higher TOC, lower TOC/TN and higher  $d^{13}C$ ) and increased clastic delivery to the lake (higher Fe, Ti and magnetic susceptibility MS) while these trends are the opposite during the Early Holocene (10.1 - 8.5 Kyr BP). Most of the Holocene sediments (Unit 3, 8.5 - 1.5 Kyr BP) show low  $d^{13}C$  and constant TOC/TN with intercalations of clastic layers characterized by high values of MS and Si, Al, K, Ti and Fe content that generally correlate with more negative  $d^{13}C$ . These events are indicative of higher fluvial input and, likely, more humid conditions and nutrient supply to the lake. During the last 1.5 Kyr (Unit 2, 1.5 Kyr BP - 1959 AD), two of such  $d^{13}C$  negative excursions (1.5 - 1.4, 1.3 - 1.1 Kyr BP) occur. However, the catastrophic flood caused by the breach of the Vega de Tera reservoir (1959 AD) is characterized by a positive  $d^{13}C$  values. Since 1959 (Unit 1, 1959 AD - 2000 AD) a significant negative  $d^{13}C$  trend represents a large change in the lake, likely associated to increased productivity and human impact.

Both the modern environment survey and the geochemical signatures of the Holocene sediments suggest that higher organic productivity and more negative  $d^{13}C$  occur during periods of stronger nutrient input. The close relationships among rainfall, NAO dynamics and lake productivity at this particular site suggest that organic chemical records could serve as precipitation proxies allowing the reconstruction of rainfall variability during the last millennia.

#### S5-P04

##### **Absence of a singular event around 8.2 ka cal. BP in the multi-proxy record of Sacrower See, NE-Germany**

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The so-called "8.2 event" which has first been observed in Greenland ice-cores is regarded as the most prominent climatic fluctuation that occurred during the early Holocene. It is thought to be triggered by a freshwater inflow into the North Atlantic disrupting the thermohaline circulation and leading to cold and wet conditions in northern Europe. However, the exact timing, magnitude and spatial extent of this event as well as the environmental responses are still under investigation. We applied a high-resolution multi-proxy approach including stable isotopes, geochemistry, pollen and diatom analyses to a well-dated lacustrine sediment sequence in order to reconstruct the environmental conditions during this time period for Sacrower See, NE-Germany. We hypothesized that a strong cold phase is directly reflected in oxygen isotope values of lacustrine carbonates, in a higher abundance of diatoms adapted to colder water temperatures, in a decrease in thermophilous tree taxa and in a higher input of minerogenic matter into the lake. In addition, we expected a partial re-dissolution of lacustrine carbonates due to prolonged anoxic conditions with low pH values in the hypolimnion caused by an extended ice-cover of the lake. Such conditions would also lead to enhanced mobilization of nutrients and thus to eutrophication despite of colder temperatures.

However, our analyses suggest that no exceptional environmental changes are recorded at our study site as expected for the "8.2 event". XRF scanning reveals only a minor input of Ti and K between 8150 and 8200 cal. BP. Unlike the Younger Dryas event, where a considerable decrease of Ca occurs in Sacrower See despite more eutrophic

conditions, no such prominent decrease was detected in the early Holocene. The carbon isotope composition of organic matter as a potential indicator of lacustrine productivity shows increasing values starting already around 8400 cal. BP and several negative oscillations of short duration occur in the following centuries. Carbonate oxygen isotopes also reveal an early period of change around 8400 cal. BP but miss to document a distinct pattern that could be related to the "8.2 event". Pollen analyses give no conclusive indication of a decline in thermophilous tree species such as *Tilia*, *Quercus* or *Ulmus*. Diatom analyses support the assumption of an increase of cold water adapted species, but only on a low level. Additional signals come from the decrease of planktonic diatoms and a slight increase of diatom-inferred TP values. Results from diatom analyses assist the hypothesis that the "8.2 event" occurred in two short phases. These results are in contrast to other paleoenvironmental reconstructions from central and northern Europe and might be explained by a higher degree of environmental stability of the lake system and the surrounding landscape at Sacrower See in relation to the relatively short cold spell or to the more continental location.

## S5-P05

### Oxygen isotopes from biogenic silica - a comparative study between eight laboratories

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Several techniques have been introduced in the last decades for the dehydration and release of O<sub>2</sub> from biogenic silica for oxygen-isotope analysis. However, only one silica standard is universally available: a quartz standard (NBS28) held and distributed by the IAEA, Vienna. Hence, there is a significant need for biogenic silica reference materials. This paper compares the existing methods for the dehydration and release of O<sub>2</sub> from biogenic silica and aims to characterise additional possible reference materials. For this purpose, an inter-laboratory comparison for the determination of d<sup>18</sup>O values of biogenic silica was organized between eight participating laboratories. Six potential standard materials were analysed repeatedly against NBS28. The standards cover a wide range of d<sup>18</sup>O values (+23 to +43‰) and include diatoms (marine, lacustrine), phytoliths and synthetically-produced hydrous silica.

To characterise the proposed standards, X-ray fluorescence (XRF) spectrometry, X-ray diffraction (XRD) and nuclear magnetic resonance (NMR) analyses as well as imaging by Scanning Electron Microscopy (SEM). The participating laboratories used their specific analytical methods for determination of d<sup>18</sup>O values: the Alfred Wegener Institute (AWI, Germany) uses inert gas flow dehydration



(iGFD) with Helium (HFD). The NERC Isotope Geosciences Laboratory (NERC, UK) and the University of New Mexico (UNM, USA) employ Stepwise Fluorination (SWF). Three laboratories - Weizmann Institute of Science (WIS, Israel), the University of Western Ontario (UWO, Canada) and the Centre Européen de Recherche et d'Enseignement des Géosciences de l'Environnement (CEREGE, France) - use controlled isotope exchange (CIE) while the Japan Agency for Marine-Earth Science and Technology (JAMSTEC, Japan) and the Forschungszentrum Jülich (FZJ, Germany) use the inductive high-temperature carbon reduction method (iHTR).

Four of the proposed standards have SiO<sub>2</sub> contents of >97%, as determined using XRF and an amorphous SiO<sub>2</sub> structure verified by XRD analysis. Despite the different analytical methods utilized, the overall precision for all standards lies between 0.3 and 0.9‰ (1s) and show reasonable agreement while the internal reproducibility for individual laboratories ranges predominantly between 0.2 and 0.3‰. The mean d<sup>18</sup>O values obtained by one CIE laboratory (CEREGE) except for one standard were all outliers - a methodological correction for this bias has been proposed. The results from one iHTR laboratory (JAMSTEC) showed a lower standard deviation when a two-point calibration was utilized. We suggest that four standards are suitable for use as oxygen-isotope reference materials for biogenic silica. Future study of oxygen isotopes in biogenic silica should state the biogenic standard used (type of silica, d<sup>18</sup>O value and analytical precision). This will improve international standardization in the reporting of d<sup>18</sup>O values of biogenic silica.

## S5-P06

### **An oxygen-isotope record of Holocene variability in the Aleutian Low from Adak, SW Alaska**

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To comprehend the modern climate system, determine the extent to which its current change is aberrant, and to predict its future course, all require an understanding of the natural variability of climate. The Aleutian Islands in the Alaskan Peninsula offer an unparalleled opportunity to investigate climate dynamics in the North Pacific. The most prominent feature of the ocean-atmospheric circulation in this region is the Aleutian Low pressure system, linked to variations in surface air temperature, moisture patterns, and storm trajectories in the North Pacific. To reconstruct the behaviour and test for low-frequency changes in the Aleutian Low, stable isotope ratios of the water molecule provide an excellent means of tracing climate-related processes within the hydrological cycle and lake-sediment archives. The lack of lacustrine carbonate material suitable for d<sup>18</sup>O analysis in Alaska often hampers the establishment of such records in this climatologically sensitive region. Here we present the first record of climate utilising the d<sup>18</sup>O of biogenic silica (d<sup>18</sup>O<sub>diatom</sub>) from this remote region of the North Pacific. This study presents evidence from multi-proxy analyses on the Holocene sediments of Ashley Lake on Adak, a small island in the western Aleutians, with climate inferences from our oxygen isotope record (d<sup>18</sup>O<sub>diatom</sub>) supported by changes in biogenic silica abundance (BSi) and diatom assemblages from the same core. In southern Alaska, d<sup>18</sup>O<sub>diatom</sub> reflects the d<sup>18</sup>O of lake water, in turn controlled by the d<sup>18</sup>O of precipitation (d<sup>18</sup>O<sub>p</sub>) rather than evaporation. d<sup>18</sup>O<sub>p</sub> is strongly influenced by moisture sources and its seasonality, consequently we believe the d<sup>18</sup>O<sub>diatom</sub> record from Ashley Lake reflects the changes in atmospheric circulation and seasonality of precipitation associated with the Aleutian Low, and indicate widespread variability in North Pacific atmospheric circulation during the Holocene.

## S5-P07

**A spineless approach: Tracing past nitrogen pollution in a lake ecosystem using stable nitrogen isotope analysis of chitinous invertebrate remains**

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In palaeolimnology stable nitrogen isotope ratios ( $d^{15}N$ ) are measured on bulk sediment organic matter in order to track changes in the nitrogen source of a lake. Organic matter in bulk sediment represents production by organisms in the lake food web as well as allochthonous organic material.  $d^{15}N$  has rarely been measured in chitinous fossils of aquatic organism groups such as chironomids (non-biting midges) or cladocerans (water fleas), even though this would potentially allow for the disentanglement of autochthonous and allochthonous contributions to sediment organic matter  $d^{15}N$ . In an experiment with larvae of the chironomid midge *Chironomus riparius* we found that  $d^{15}N$  of both soft tissue and fossilizing head capsules faithfully reflect the  $d^{15}N$  of their food source. A field study showed that there is considerable variability in  $d^{15}N$  of living cladocerans and chironomids in Lake De Waay (the Netherlands). This variability was apparent within taxa, between taxa and between seasons. Moreover, analysis of samples of subfossil remains showed spatial (i.e. within lake) variability in  $d^{15}N$  although repeated sampling of fossils from core-tops retrieved at the same location resulted in consistent results. A downcore record of  $d^{15}N$  in fossil cladoceran and chironomid remains was produced from Lake De Waay and

compared to bulk organic matter  $d^{15}N$ . The results suggest that trends in bulk sediment organic matter  $d^{15}N$  follow general patterns in nitrogen pollution in The Netherlands. More importantly, the  $d^{15}N$  of fossil remains of cladocerans and chironomids shows similar trends, yet with an amplitude three to four times larger than recorded in  $d^{15}N$  of bulk sediment organic matter. Our results show that  $d^{15}N$  of chitinous remains of chironomids and cladocerans can be used to reconstruct past changes in nitrogen source in Lake De Waay, and possibly in similar lakes.

## S5-P08

**Quantification of biogenic silica concentration in lake sediments by means of Fourier transform infrared spectroscopy (FTIRS)**

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Fourier transform infrared spectroscopy (FTIRS) can be used for the fast and cost-efficient quantification of biogenic silica (BSi) concentrations in lacustrine sediments (Vogel et al. 2008; Rosén et al. 2010). IR-measurements in the mid-infrared region provide a variety of information on organic as well as minerogenic constituents and require only a small amount of sample material (0.01 g dry weight). Partial least squares regression (PLSR) is utilized to quantitatively estimate the BSi concentration from the FTIR spectra, since a direct evaluation based on peak heights or areas is hindered due to the multitude of components in sediments causing spectral overlaps. In this study, FTIRS analysis have

been conducted on sediments of the 317 m long and 3.6 Ma old sediment succession of Lake El'gygytgyn in NE Siberia which has been recovered during the ICDP El'gygytgyn Drilling Project in 2009. The resulting FTIRS calibration model for BSi based on 132 sediment samples covering the entire sediment record yielded a good statistical performance ( $R = 0.92$ ). The most important spectral ranges for the developed model correspond well with FTIR spectra of pure BSi. These results highlight the potential of the technique as an analytical tool for the quantitative estimation of BSi in lacustrine sediment successions. The calibration model has then been applied in high-resolution (2.5 mm) to a sediment sequence from Lake El'gygytgyn covering the marine isotope stage (MIS) 11 interglacial about 400 ka BP. The inferred BSi values for MIS 11 show a strong correlation with other globally distributed paleoclimate records suggesting a strong productivity response to climate change in Lake El'gygytgyn. The concentration of BSi in the sediment record is considerably higher during MIS 11 than during any other period of the past 450 ka indicating unusually high productivity. We assume high productivity at Lake El'gygytgyn during MIS 11 to be strongly controlled by higher temperature causing warm surface waters, prolonged ice-free conditions and high nutrient levels.

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## S5-P09

### Decadal scale hydrological and primary organic production changes during the 8.2 ka event: A multi proxy study from Lake Sarup, Denmark

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Hydrological and nutrient dynamics during the 8.2 kyr cooling event in a wiggle-matched radiocarbon dated annually laminated sediment section (8700-8000 cal BP) from Lake Sarup (55 °N) using a multiple proxy approach. Sediment accumulation and multiple biological proxies indicated a lake level increase during 8359-8225 BP, followed by an abrupt lake level decrease during the 8.2 kyr event. Thus, the climate anomaly started some 100 years before the cooling event. A lake level increase during this period is supported by a higher load of inorganic and organic allochthonous sedimentation. It is still debated whether lake levels generally increased or decreased during the period around 8.2 ka and here stable isotope analysis ( $d^{13}C_{carb}$  and  $d^{18}O_{carb}$ ) on authigenic carbonates are presented and used to infer changes in the hydrological balance of Lake Sarup during the 8.2 ka event. The  $d^{13}C_{carb}$  and  $d^{18}O_{carb}$  values are strongly correlated suggesting that Lake Sarup exhibited hydrologically closed conditions throughout the interval represented by the stratigraphic record. The variation of  $d^{18}O_{carb}$  of a closed-basin lake is principally controlled by hydrologic balance and vapor exchange and much less by temperature. Also  $d^{13}C_{org}$ ,  $d^{15}N_{org}$  and C/N ratios on organic matter are presented and used to infer changes in primary production, origin of organic matter and nutrient status of the lake. Further initial results on lake water  $d^{18}O_{cell}$  derived from the oxygen isotopic

composition of cellulose will be presented. Because the isotopic fractionation between the lake water oxygen isotopic composition  $d^{18}O_{lw}$  and the oxygen isotopic composition of aquatic cellulose ( $d^{18}O_{cell}$ ) is independent of temperature,  $d^{18}O_{cell}$  may be used in combination with  $d^{18}O_{carb}$  to estimate past water temperatures. Here we present the first attempt of reconstructing temperature using  $d^{18}O_{cell}$  and  $d^{18}O_{carb}$  from Lake Sarup.

### S5-P10

#### Holocene paleoenvironmental changes reflected in organic isotope records from Lake Pupuke (New Zealand)

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Lake Pupuke (36°47.25'S, 175°46.25'E) is situated in a maar crater in the Auckland Volcanic Field (New Zealand) that was formed 140,000 years ago. Organic matter stable isotope approaches were applied on a sediment core of 590 cm length from the deepest part of the lake spanning the last 7000 years. The warm monomictic and holomictic lake has a small catchment (110 ha) and a maximum depth of 58 m. The sedimentary organic matter as well as modern samples of potential organic matter sources were analysed for organic carbon (TOC) and nitrogen (TN) content and organic carbon ( $d^{13}C_{OM}$ ) and nitrogen ( $d^{15}N$ ) isotope

composition. Isotope analyses were also carried out on the green alga *Botryococcus* that were isolated from selected samples. A geochemical fingerprint approach shows that contributions of allochthonous organic matter were negligible for most of the sediment record. TOC/TN ratios higher than generally expected for lacustrine algae, thus, are mainly attributed to N-limiting conditions. Long-term variability of carbon isotope composition of bulk sediments during the last 7000 years are interpreted as variations in epilimnetic primary productivity and microbial processes. The periods between 6600 and 5300 cal yr BP and around 2800 and 1600 cal yr BP were characterized by a predominance of epilimnetic carbon assimilation and export of  $^{13}C$  depleted OM through sedimentation. Microbial methanogenesis and methane oxidation were dominant processes from 5300 to 3600 cal yr BP, when both  $d^{13}C$  values of bulk organic matter and *Botryococcus* show more negative  $d^{13}C$ -values. Around 6500 cal yr BP a prominent shift to more enduringly positive  $d^{15}N$  values marks a fundamental change in lake internal nutrient cycling as the result of denitrification in the water column resulting from intensified anoxia in the hypolimnion. A contemporary negative excursion in  $d^{13}C_{OM}$  is interpreted as a pulse of intensified microbial methanogenesis in the course of this transition. The youngest interval from 1600 cal yr BP until present-day is first characterised by enhanced methanogenesis indicated by rapidly dropping  $d^{13}C_{OM}$  and thereafter by eutrophication due to anthropogenic disturbances indicated by subsequently increasing  $d^{13}C_{OM}$  values. Comparison with regional storm frequency reconstructions indicate that changes in the wind-induced mixing conditions of the lake could play a significant role in the observed changes of the lacustrine carbon and nitrogen cycle.

### S5-P11

#### Relevance of sediment and sedimentation processes in pre-dams of drinking water reservoirs: a project outline

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Pre-dams have been used in water management mainly for eutrophication control and particle removal. Recently it appeared that they play also an important role for the carbon budget of catchments,

particularly carbon burial in the sediments and the dynamics of dissolved organic carbon (DOC). For our study we chose the Rappbode reservoir system, the largest drinking water reservoir in Germany, located in the eastern Harz Mountains. The following research aspects are in the centre of our interest: 1) quantifying nutrient elimination, particle removal and carbon storage in pre-dams of drinking water reservoirs; 2) assessment of the sources of carbon in pre-dams.

### S6-P01

#### Quantitative lake level reconstruction of Lake Issyk-Kul for the last ca. 4000 cal. years BP: climatic and environmental implications

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A multi-proxy characterization (XRF core scanner, XRD, bulk elemental composition and stable isotopes on bulk organic matter) of the core c142a (42°34'31.2" N - 77°20'03" E, 150 m of water depth, 150 cm long) from the intramontane and high altitude Lake Issyk-Kul (Rep. of Kyrgyzstan, Central Asia) allowed us to characterize the environmental and climatic evolution of this area for the last 3800 cal. years BP.

The recovered sediments are made up of a finely laminated dark and light muds and silty muds. These laminae are composed by a

mixture of organic matter, carbonates (monohydrocalcite, calcite and high-magnesium calcite), clays (illite and chlorite), coarse terrigenous (amphiboles, quartz, microcline and albite) minerals and diagenetic aggregates of pyrite. The chronological framework was built with 7 AMS radiocarbon dates.

Redundancy (RDA) analysis of the mineralogical and XRF core scanner datasets was used to gain insight about the provenance of the chemical elements. The first eigenvector of the Principal Component (PCA) analysis of the XRF core scanner allowed us to qualitatively reconstruct the lake level oscillations for the last ca. 4000 cal. years BP. The linear model between the available instrumental lake level and the lake level reconstruction for the 1927 - 1990 AD period permitted to convert the qualitative reconstruction into a quantitative one.

Furthermore, bulk total nitrogen (TN) and carbon (TC), and bulk stable isotope composition ( $d^{15}N$  and  $d^{13}C$ ) of this organic matter allowed us to qualitatively characterize changes in the lake water mixing conditions and in the primary productivity for these 3800 cal. years BP.

The C/N molar ratio (between 5 and 11.5) indicates that phytoplankton has been the main primary producer in Lake Issyk-Kul. On a long-term scale, the lake level remained stable up to ca. 3000 cal. years BP when it started to steadily decrease, which led to a progressive rise of the lake primary productivity (increase of TN and of TC) and an increase of the lake stratification period (progressive  $d^{15}N$  decrease from 5‰ to 0‰). On a centennial temporal scale, the Lake Issyk-Kul water level was characterized by a number of abrupt lake level oscillations, possibly linked to solar activity changes. The Medieval Warm Period (950 - 1250 years AD) was marked by relative low-lake levels whereas the Little Ice Age (1550 - 1850 years AD) was characterized by high lake water levels at the beginning and end of this period of time, which led to the highest primary productivity of the last 3800 cal years BP. The climatic evolution of Lake Issyk-Kul agrees with the main climatic framework proposed by Chen et al. 2010. QSR, 29:1055-1068. The lake level and the primary productivity of the last 100 years have been marked by a pronounced decrease, possibly due to intensive use of water from the surrounding ice caps for irrigation purposes.

### S6-P02

#### Rapid hydrological changes during the late Holocene revealed by stable isotope records of lacustrine carbonates from Lake sugan, northwest of China

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High resolution records in late Holocene have many effective proxies such as ice core, tree ring and cave deposit in west of China. However, lake sediment record is scarce because of its weak chronology. Furthermore, the comparison of different climate records from the Tibetan Plateau is complicated due to the uncertainties arising from poorly constrained chronologies in the region where

terrestrial plant remained are usually not available for radiocarbon dating.

Lake sugan, a closed lake, located in northern edge of Tibetan plateau, with 2700 year varved chronology result. A high-resolution proxy record of precipitation and evaporation variabilities, with modern hydrological isotope process, through the past 2700 yr from  $d^{18}O$  analysis was obtained to examine hydrological and climatic change in the west arid China. Stable isotope and multiple proxies show aridification trend during the past 2700 years with rapid wetter intervals shifts (A.D. 1200-1230 and A.D. 1550-1840) between dry periods. The hydrological evolution in the Sugan Lake catchment during the last 2700 years reconstructed by carbonate stable isotope analysis is in broad agreement with previous palaeo-moisture data derived from other sites in arid Northwest China (ANC). But was distinctly different from that in monsoonal China, implying an "out-of-phase" relationship between moisture evolution in these two regions during the past 2700 years.

### S6-P03

#### Linking Indian Ocean Summer Monsoon upwelling events at the Arabian Sea with sedimentary responses of Lake Nam Co, a high altitude lake on the Tibetan Plateau, China.

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This study focuses on Late Glacial and Holocene paleo-monsoon dynamics on the Central Tibetan Plateau. In addition, a possible connection of post-glacial upwelling events at

the Arabian Sea and a response of a Tibetan Lake at a high altitude is discussed.

A lacustrine record, covering the last ~23.7 ka, was retrieved from Lake Nam Co (~4.700 m above sea level), the second largest and highest saline lake in China. Since Nam Co has no outflow, the water balance of this terminal lake is mainly controlled by precipitation, evaporation and glacier meltwater inflow, making it a perfect study site for paleo-monsoon driven changes of lake sedimentation.

A multi-proxy approach was applied to the recovered sediments from Lake Nam Co. 30 AMS <sup>14</sup>C ages were used to establish a chronology for our record, coupled with paleo-magnetic measurements for ensuring accurate age determinations. A high resolution analysis of sediments by means of ICP-OES was conducted for the whole sequence. Al and Ti were used to reconstruct influx of clastic material from the catchment, while Ca, Mg and Sr reflect a changing water balance. Total organic carbon was used as a proxy for lake productivity.

From ~23.7 to ~13.3 ka cal BP, only minor oscillations of geochemical properties are visible, indicating stable conditions of the sedimentary regime. After ~13.3 ka cal BP the system changes. Strong monsoonal pulses are reported from the Arabian Sea and dated to 13.5 ka cal BP, 13.0 ka cal BP and 13.0 - 12.5 ka cal BP (SIROCKO ET AL. 1993, OVERPECK ET AL. 1996). A ~13.3 ka cal BP event is clearly visible within our sequence, allowing the connection of monsoonal pulses at the Arabian Sea and a sedimentary response of Lake Nam Co, interpreted as a hydrological signal of a freshwater pulse, coupled with enhanced fluvial transport of clastic material. All geochemical proxies indicate a first distinct monsoonal pulse with higher precipitation and meltwater discharge at ~13.3 ka cal BP.

At around 9.7 ka cal BP, the same pattern of sedimentary response similar to the ~13.3 ka cal BP event is displayed by all proxies. Therefore, a second strong monsoonal pulse reaching Lake Nam Co is a likely cause for the

observed changes. Again, a distinct lake level rise due to increased precipitation and fluvial inflow can be assumed. Records from the Arabian Sea display an abrupt increase in monsoon intensity from 10.0 to 9.5 ka cal BP (OVERPECK ET AL. 1996), ~9.9 ka cal BP and ~8.8 ka cal BP (SIROCKO ET AL. 1993), pointing again to a connection of the Arabian Sea and the Tibetan Plateau.

OVERPECK, J., ANDERSON, D., TRUMBORE S. & W. PRELL (1996): The southwest Indian Monsoon over the last 18000 years. *Climate Dynamics* 12, 213-225.

SIROCKO, F., SARNTHEIN, M., ERLLENKEUSER, H., LANGE, H., ARNOLD, M. & J. C. DUPLESSY (1993): Century-scale events in monsoonal climate over the past 24,000 years. *Nature* 364, 322 - 324.

## S6-P04

### Trace element and stable isotope analysis of ostracode shells from Southern Tibetan Plateau lakes as hydrochemical indicators

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Large lake systems such as lakes Nam Co and Tangra Yum Co, Southern Tibetan Plateau, are particularly suited for trace element analyses because the broad range and low-noise signature of stable isotope data from bulk sediment and ostracode shells promises that trace element data from these lakes will also provide robust hydrological information. A multi-technique inter-laboratory comparison using laser ablation ICP-MS, flow-through dissolution ICP-MS and conventional dissolution ICP-MS the trace element analysis in ostracode shells should improve our understanding of shell calcification and, as a

result, our prospects for hydrochemical reconstruction of lake water evolution.

The LA-ICP-MS method provides the advantage that (1) single shells can be analyzed, (2) a variety of elements can be measured, and (3) the heterogeneity of individual shells can be resolved. The flow-through analysis technique allows to chemically separate mineral phases of different solubility such as, in particular, original shell calcite from overgrowth calcite. This is necessary because variations in trace element composition have been identified to be in the order of a magnitude range, likely associated with original and altered shell calcite.

Analyses will be carried out on single specimen of recent and fossil ostracode shells from Nam Co and Tangra Yum Co sediments. In conjunction with the ion composition of the host waters, further hydrological reconstructions will be derived. This includes Mg/Ca and Sr/Ca ratios in ostracode shells that provide information about past water temperature and salinity resulting from changes in precipitation vs. evaporation ratios and monsoonal activity. We plan to advance salinity reconstructions using flow-through dissolution ICP-MS to overcome limitations caused by aragonite overgrowth and diagenetic alteration, and to exploit Mn/Ca, Fe/Ca and U/Ca ratios as redox as well as Ba/Ca ratios as productivity indicators. Different species will be analysed in order to test for inter-species differences and to find the best suited species for the reconstruction of specific habitats.

## S6-P05

### **From the lakeshores of Tibet: shoreline reconstructions of monsoon climate on the Tibetan Plateau**

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The contorted, structurally-controlled topography of the central Tibetan Plateau creates hundreds of natural depressions spanning eight degrees of latitude and fifteen degrees of longitude, a few hundred of which are large enough to contain closed-basin lakes. Currently these lakes range in size from less than 1 km up to >2000 km, with the largest lakes found in the southernmost basins with significant glacial melt-water contributing to their watersheds. Satellite imagery shows that, regardless of size, these lakes exhibit evidence of extensive paleoshorelines which enclose lake areas up to 9 times the size of the modern lakes. As lake area in internally drained basins is ultimately related to precipitation amount, especially in arid environments such as the Tibetan Plateau, these closed-basin lakes represent a potential monsoon precipitation 'proxy' dataset with a large spatial footprint. Preliminary radiocarbon dating of shoreline tufa from paleoshorelines of Ngangla Ring Tso, a large closed-basin lake in the western Tibetan Plateau, suggest lake level change is consistent with other reconstructions of Indian Summer Monsoon intensity. Ngangla Ring Tso reaches its early Holocene highstand between 9-10 ka BP, and has subsequent lower highstands centered on 7.5 and 5.2 ka BP. No shorelines have been dated less than 4.5 ka BP, which we suggest is because they are currently below the modern lake level.

Regional GIS analysis of lake highstands in over 170 closed basin lakes on the plateau, including Ngangla Ring Tso, suggest that the monsoon intensified differently depending on region. Conroy and Overpeck (in press) identified two distinct regions of monsoon precipitation on the plateau, correlated with the Indian Summer Monsoon in the west and more East Asian Monsoon in the east. Paleolake area analysis suggests that in the eastern central plateau lakes expanded only ~2x modern while in the western plateau lakes expanded between 4-6x greater than modern on average. This differing lake level pattern indicates that the regions of monsoon precipitation defined by Conroy and Overpeck (in press) do not change in the past and the Indian Summer Monsoon intensifies more



relative to the East Asian Summer Monsoon during insolation maxima in Tibet.

## S6-P06

### In-situ trace element analysis of ostracod shells of ages up to 17,600 cal a BP from Lake Nam Co, Tibet

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-Ostracods have been widely used as indicators for past climate change studies. Trace element analysis in ostracod shells provides important information for palaeolimnological and palaeoceanographical reconstructions.

-Laser ablation ICP-MS is a very promising microanalytical technique for in-situ trace element analysis of single ostracod shells. Many trace element concentrations can be determined simultaneously. The elemental distribution within a single shell can be measured by using a small spot size of 12 µm.

-In our study, we focused on the top 4 m section of the 11 m long sediment core NC08/01 drilled in the lake Nam Co on the central Tibetan Plateau. This section corresponds to an age interval from 270 to 17600 cal a BP. 72 valves of ostracods, belonging to three taxa, were picked and analyzed. We determined the concentrations of 30 trace elements in the shells using LA-ICP-MS. The results show that different shells with the same age have similar element abundances, especially for Sr, Y, Ba, U, and the rare earth elements. Element abundances may therefore be used as proxies for past

environmental conditions. At the same depth, the trace element compositions in the shells of *Leuocytherella sinensis* are similar to those of *Leuocythere dorsotuberosa*. For the *Leuocythere dorsotuberosa* f. *postilirata* samples, the concentrations of some elements (such as Fe, Ti, Rb) are higher than those in other taxa, which may be due to biological effects for different ostracod taxa.

-The trace element contents in the shells collected from different depths show significant differences. For example, the shells show uniform and high Sr content (about 10,000 µg/g) within the age interval from 270 to 1000 cal a BP, low Sr content (about 1500 µg/g) from 2400 to 10,000 cal a BP and highly variable abundances with pronounced peak values between 10,000 and 17,600 cal a BP. This variation may be related to past climate changes in the Nam Co area, which were reported in previous studies, and contribute information about paleoenvironmental conditions in this area: a potential explanation for the observed trace element signals is high variability of precipitation between 17,600 and 10,000 cal a BP in the area. After that, from 10,000 to 2400 cal a BP, large contribution of monsoonal precipitation and melt water input may have caused low Sr abundance in the lake. During the last 1000 a, a relatively dry period with decreased precipitation and water input may have induced lake shrinkage and high abundances of trace elements (e.g., Sr) in the ostracods. Our results agree with recent U and Pb isotope data derived from ostracods of ages up to 7000 cal a BP from Nam Co (Jochum et al., this congress).

## S6-P07

### LGM freshwater event at Nam Co indicates onset of Asian Monsoon

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The Tibetan Plateau acts as a major driver of the Asian monsoon intensity and responds sensitive to climate changes. The monsoonal activity on the Plateau is of particular importance for the water availability of millions of people living in neighboring countries. To reconstruct past environmental changes, we focused on lacustrine sediments of the second largest lake on the south central Tibetan Plateau, Nam Co. The 11 m sediment core NC 08/01 was taken in the southeastern part of the Nam Co from a water depth of 93 m. The sediments date back to 23000 a BP and thus, stored climate information almost from the Last Glacial Maximum (LGM). In order to give evidence on first periods of the south asian monsoon initiation, we determine the amount and the compound specific hydrogen isotopic content of aquatic n-alkanes between 21 and 23 ka BP. Within the LGM the lowest amounts of terrestrial and aquatic n-alkanes (mean amount: 550 ng/μl) compared to Holocene (mean amount: 21000 ng/μl) imply cold and dry conditions and enriched dD values (mean value: - 123‰) implicate a lake level-lowstand due to a higher glacier extent. With an abrupt change of environmental conditions between 21.1-21.3 ka BP by high sedimentation rates (0.5 cm/a), increased n-alkane amounts (mean amount: 700 ng/μl) and decreased dD values (mean value: - 170‰) a freshwater input was indicated. Due to these results we suggest that the final Holocene warming was initiated by several earlier freshwater events like this one.

## S6-P08

### Lake system changes of Nam Co (central Tibetan Plateau) during the last 4000 years - multi-proxy results from a sediment core series

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Nam Co is the second largest lake (area 1962 km) on the Tibetan Plateau. It is situated at 30°30'-30°56' N and 90°16'-91°03' E at an altitude of 4718 m asl. The hydrologically closed brackish lake (salinity 1.3‰) has a maximum depth of about 100 m.

Five 68 to 115 cm long gravity cores and one piston core from 93 m water depth in the central part of Nam Co were for palaeoenvironmental analyses. Our age model using <sup>210</sup>Pb and <sup>137</sup>Cs analyses as well as eleven AMS C-ages is supported by excellent agreement between secular variations determined on one of the cores to geomagnetic field models. Our palaeoenvironmental analysis is based on sedimentology, geochemistry, and micropalaeontology (ostracods and diatoms).

High summer-monsoonal activity was detected in our record between approximately 4000 and 1950 cal yr BP as well as between 1480 and 1200 cal yr BP. Lower monsoon activity prevails in between the two intervals and thereafter. This pattern shows a good correlation to the variability of the Indian Ocean Summer Monsoon (IOSM) as recorded in a peat bog ~1000 km NE of Nam Co. This is the first time that such a supra regional homogenous monsoon activity is shown on the Tibetan Plateau and beyond. Finally, our data show a significant lake level rise after the Little Ice Age (LIA) in Nam Co. This is suggested to be linked to glacier melting in consequence of rising temperatures after the LIA.

## S6-P09

### A 23-kyr stable isotope record from Lake Nam Co, Southern Tibet

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The stable oxygen and carbon isotope signatures of calcitic ostracode valves and bulk sediment from the 11 m long core NC 08/01 from Lake Nam Co, Southern Tibetan Plateau (30°30'-35°N, 90°16'-91°03'E; 4719 m a.s.l., 93m water depth at drilling site), reflect climatic and environmental variability since 23 cal. kyr BP. Isotope values of shells from *Leucocytherella sinensis* as well as *?L. dorsotuberosa* (*f. typica*), *?L. dorsotuberosa f. postilirata*, two morphotypes of the same species, show about 2‰ and 4‰ lower  $\delta^{13}\text{C}$  values, respectively, than those for bulk sediment isotopes. Ostracode  $\delta^{18}\text{O}$  values are about 2‰ higher than bulk sediment values. The  $\delta^{13}\text{C}$  vs.  $\delta^{18}\text{O}$  diagram shows a clear evaporation line for the sediment, typical of large closed lakes such as Nam Co.

*L. sinensis* shows a trend from high  $\delta^{18}\text{O}$ , indicating dry conditions, to lower values

between 12.5 and 5 cal. kyr BP back to higher values characterized by a wide range of  $\delta^{13}\text{C}$  values. During the Late Glacial, *L. sinensis* and bulk sediment values show a shift to lower  $\delta^{18}\text{O}$  values that may be indicative of the Younger Dryas. Three extreme negative shifts in the stable isotope compositions of bulk sediment before and after the Younger Dryas could have resulted from melt water events. After 8 cal. kyr BP,  $\delta^{18}\text{O}$  values show a positive trend while the  $\delta^{13}\text{C}$  values remain relatively constant, suggesting a shift from a moister to a drier climate.

The offset in  $\delta^{13}\text{C}$  between ostracodes species shows differences in epifaunal (*L. sinensis*) vs. infaunal (*?Leucocythere* species) microhabitats with the latter assimilating methane with low  $\delta^{13}\text{C}$  values produced by anaerobic bacteria living in the sediment

The offset in  $\delta^{18}\text{O}$  between ostracodes and bulk sediment probably reflects the temperature difference between surface (bulk sediment) and bottom (ostracodes) waters.

Because of the similarities with the bulk sediment values and its relatively high abundance, *L. sinensis* seems to be the best-suited species for stable isotope analysis and paleoclimatological interpretations.

## S7-P01

### Carbonate Wetlands on Distal Anastomosing River Floodplains

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Wetlands form on distal anastomosing river floodplains that exist below the spring line of fluvial fan complexes. Carbonate wetlands on such perennial siliciclastic river floodplains are hypothesized to form under two conditions: (1) an influx of Ca-rich waters from a limestone- and dolostone-rich watershed and (2) long-term isolation areas from siliciclastic influx allowing carbonate precipitation.

To test the hypothesis that carbonate wetlands generally form within anastomosing river systems with carbonate provenance, a database of these perennial river systems in the geologic record was compiled to examine

carbonate lake to wetland deposits on anastomosing floodplains and the composition of source rocks. Overall, 178 river deposits from the geologic record were examined, but only 136 contained enough pertinent data to be compiled into the database. Of these, 57 were found to be ancient anastomosing river systems associated with carbonate wetlands. These entries also had carbonate-rich watersheds. Anastomosing river systems without carbonate lake deposits added up to 66 entries, but these had little to no carbonates exposed in the source area.

Hydrodynamic features and geomorphology promote the existence of isolated areas on an anastomosing floodplain for the precipitation of carbonate. Concave-upward interchannel flood basin areas mostly receive dissolved and suspended load during floods, because of relatively high levee systems in an aggradational system. Bedload only enters these areas mostly as crevasse splays. Anastomosed river channels are in general stable over long periods and the preservational potential of interchannel lake, marsh, and wetland areas are high. In order to test whether dissolved and suspended load or groundwater input is important for the accumulation of carbonate in these anastomosing river wetlands, a sedimentation model was constructed using Pennsylvanian freshwater limestones in southeastern Ohio within the Appalachian coal basin. The volume of floodplain limestone bodies (Upper Pittsburgh, Fishpot, Swickley, Benwood/Arnold, Uniontown, and Waynesburg Limestones) within the Stewart Quadrangle of Athens County were derived from detailed geologic mapping of the quadrangle. Using modern discharge rates of present-day rivers in Ohio as well as average groundwater velocities in the area, sedimentation rates were calculated. The modeling results show that the only way for thick wetland limestones to accumulate quickly enough on a geologic short-lived floodplain is through overland flow.

Carbonate wetlands can form on anastomosing river floodplains because of isolated flood basins and the presence of carbonate-rich source areas. Overland

transport of suspended and dissolved Ca-rich load, not groundwater, allows the accumulation of thick carbonate lake, marsh, and wetland deposits.

## S7-P02

### **Integrated Macrostratigraphy and Cyclostratigraphy of Eocene Lacustrine Strata, Wilkins Peak Member of the Green River Formation, Western U.S.**

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The Wilkins Peak Member of the Eocene Green River Formation contains repetitive sedimentary facies that have been previously interpreted to reflect orbitally-influenced climate change, based on spectral analyses of Fischer Assay oil yield. Such studies have relied exclusively on one-dimensional analysis of cyclicity at single localities, but preservation of Wilkins Peak Member depositional cycles varies dramatically across the Bridger Basin, Wyoming. This study therefore employs macrostratigraphic time series derived from lithofacies associations observed at multiple localities to gain a basin wide perspective of rhythmic deposition. This novel approach minimizes the influence of local variation, by directly incorporating lateral variability into a basin-scale analysis of temporal changes in sedimentation. Wilkins Peak lithologies are grouped into three distinct facies associations: alluvial, marginal lacustrine, and basinal lacustrine. Dated tuff horizons, major oil shale beds, and member contacts are used to erect a high-resolution chronostratigraphic cross-section comprising 12 separate localities distributed north-south across the Bridger basin. The macrostratigraphic time series indicate a strongly reciprocal relationship between carbonate-rich lacustrine facies, and dominantly siliclastic alluvial facies. Spectral analyses of the macrostratigraphic data

identify significant periods (= 90% significance level) that are in close agreement with predicted orbital periodicities, with a particularly strong ~100 k.y. cycle that is expressed in all facies associations, but numerous non-Milankovitch periods are also recognized. Thus, while orbital influence is strongly supported by our analysis, the power spectra also document substantial taphonomic distortion, as well as the potential for high-frequency autocyclic processes. Based on the new results, we interpret that depositional controls on the recurrence of nine prominent alluvial bedsets were strongly influenced by short-eccentricity variability, and more generally, their deposition played a major role in secular basin evolution. Specifically, this study demonstrates that eccentricity cycles in the Wilkins Peak Member are not primarily recorded through fluctuations of Lake Gosiute water level, as previously interpreted. Instead, they are recorded by the alternation of siliciclastic alluvial and carbonate-rich lacustrine strata, necessitating a strong response of fluvial deposition to orbital-insolation changes. We introduce a new model for the formation of these 100 k.y. paced alluvial bedsets, and also propose that hydrologic controls on lake level fluctuations at the finer-scale (< 100 k.y.) had a strong impact on lacustrine deposition, during the absence of alluvial deposition. This study provides a new quantitative approach that should be broadly applicable to evaluate potential orbital signals preserved in the stratigraphic record.

### S7-P03

#### **Lithostratigraphy and geochemistry of Rano Aroi (Easter island, Chile) peatland infill as indicators of long-term a wetland dynamics evolution**

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Rano Aroi is a freshwater peatland located in a small, steep-sided basin in an ancient volcano crater near the highest summit of Easter island (Rapa Nui, 27°09'N 109°27'E. The fen is fed by discharging groundwater and precipitation. The local vegetation is dominated by *Scirpus californicus*, *Polygonum acuminatum*, *Asplenium polyodon* var. *squamulosum*, *Vittaria elongata* and *Cyclosorus interruptus*. We present the results of a multiproxy study of two cores from the centre (ARO 06 01) and edge (ARO 08 02) of Rano Aroi basin, respectively, involving lithostratigraphy, elemental geochemistry, XRF core scanning, and the analysis of stable isotopes and macrofossils. The age model based on 26 AMS radiocarbon dates and sedimentary architecture show that Rano Aroi has been a wetland since MIS 4 (70 ky BP).

Three sedimentary facies have been distinguished. A fine-grained organic mud with high Ti-Fe concentrations, which is present frequently in the central part of the mire, might originate from an open water body. This facies is associated with high Total Nitrogen (TN) and abundant remains of Curculionidae and Oribatidae. The second facies is a granulated muddy well-decomposed peat with less terrigenous material. The third facies consists of reddish peat composed of coarse plant remains. The latter facies is associated with high C/N ratios and might have originated from the rapid burial of fresh peat mats. Such peat mats preferentially developed as grounded mats at the margins of the mire and might have become buoyant during periods with high water tables. Apparently, Rano Aroi has been a suitable place for the development of extensive floating peat mats in the past. The presence of such mats might explain anomalous radiocarbon ages on ARO 06 01, similar to the chronological discrepancies found by Flenley (1993) and Peteet et al. (2003) in sediments of Rano Aroi.

Small fragments of *Scirpus californicus* rhizomes at a depth of 6 m depth in the ARO 06 01 core illustrate that *S. californicus* has been present at the island from approximately 45 ky BP onward. Its expansion coincides with an increase in abundance of Curculionidae and Oribatidae associated to palustrine sedge vegetation.

Changes in South Pacific Ocean circulation during the Late Pleistocene have likely been relevant for the environmental history of Rano Aroi. Next to such climate forcing, however, stochastic processes like the establishment of colonizer species (notably *S. californicus*) will have induced irreversible changes in the hydrologically closed and isolated system of Rano Aroi. The interplay between these factors and the changes in the available space for sedimentation will have determined the evolution and the present stratigraphical architecture of the Rano Aroi sedimentary infill.

#### S7-P04

##### **Climatic vs. tectonic control on facies and salinity changes in an Eocene rift lake, Upper Rhine Graben, Central Europe**

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The Upper Rhine Graben (URG) is a complex rift and wrench basin about 300 km long, 35 to 50 km wide and filled with up to 3500 m of Eocene to Quaternary sediments. In its early rifting stage, normal and transtensional block faulting created an elongated, land-locked rift valley possibly hundreds of metres deep.

Middle to Late Eocene lacustrine and saline deposits cover an area of c. 7500 km<sup>2</sup> of the central and southern segment of the URG. Thicknesses vary from a few metres of condensed palustrine limestone on tectonic highs to more than 1000 m of halite-bearing

marls in the Wittelsheim depocentre. Lithofacies associations include bedded halite-bituminous marl alternations with salic paleosols (central halite zone), laminated marls with poor freshwater fauna, partly with intercalated vertic, calcic or gypsic paleosol horizons (Lymnaea marl facies zone), poorly bedded marls with vertic paleosols and subordinate sandstone beds (Pechelbronn facies), and palustrine, partly rooted or brecciated limestone with pisolites and freshwater gastropods (Melania limestone marginal facies). Due to post-Eocene uplift of parts of the basin margins, lake shore deposits are rarely preserved. Where they are, lacustrine sediments with pedogenic horizons pass over to cyclic deposits of channelized alluvial conglomerates, sandstones and rooted overbank mudstones. This alluvial facies belt is typically only a few kilometres wide and rapidly replaced by block conglomerates of steeply sloped fan-delta deposits close to the rift margins (conglomerate zone).

There is a first-order change in the position of facies boundaries in the Eocene succession, indicating rapid transgressive drowning of the internal parts of the basin in the Lutetian and successive progradation of fluviolacustrine environments during the Priabonian. Paleosol facies and fossil content do not show significant changes in the overall climate regime over this transgressive-regressive cycle, spanning almost 10 Ma. Thus, we attribute this first-order cycle trend mainly to early syn-rift tectonics creating accommodation space and its subsequent autocyclic fill-up.

In any of these facies there is evidence for high-frequency cyclic variations in lake level and salinity, e. g. by alternations of halite deposits and fossiliferous freshwater marls, recurring pedogenic overprint on laminated hypolimnion deposits, and subaqueous green clay intercalations within successions of palustrine carbonates. They suggest rapid lake level oscillations between deep freshwater lake phases and intense droughts, reducing the open-water surface to a small and shallow salt lake in the deepest parts of the Graben. The time scale of these oscillations is poorly constrained. According to the maturity of the

paleosols, time intervals seem to represent cycles well within the Milankovich frequency band, i. e., 10e4 to 10e5 yr, and thus suggest a climatic control on these small-scale cycles.

## S7-P05

### **Influence of Climate and Tectonics on Progradation of a River Delta in a Mega-Lake System (Upper Triassic, Junggar-Basin, NW-China)**

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Sedimentary sequences in the central Asian Junggar basin provide a continuous continental record of climatic and tectonic parameters during the Mesozoic. The basin kept its paleolatitude over the whole time span, which makes it a natural laboratory for investigation of how geodynamic processes interplay with climate and how evolution adapts to those changes. We present a quantitative outcrop analogue study with an exceptionally high-resolution record of a fluvial delta complex (cm to decimetre) of the Upper Triassic at the southern margin of the Junggar Basin (Haojiagou section, Xinjiang, China). Sedimentological logging of lithofacies and architectural elements were combined with GR measurements and 2D mapping. The data are analysed and interpreted in terms of depositional dynamics, cyclicity, stacking pattern, accommodation vs. sediment supply and preservation potential.

The sedimentary inventory comprises various types of gravely channel bodies, sheet like sandy and clayey units, as well as ferrocrete horizons and coal seams organized in four

different geosystems: Delta-slope, delta-front, delta-top and distal alluvial plain. A four-fold cycle hierarchy was identified, which shows systematic superposition of cycles and therefore considered to represent an external control of depositional environments, sediment supply and accommodation space. According to preservation of cycles and regional geodynamic data, tectonic rates did not change markedly in the Upper Triassic (Bian et al., 2010). However, according to pollen and spores data humidity (and its variations) changed over time and show superpositioned trends. Depositional cycles and reorganization of sedimentary environments go along with that observation, for example, a more humid phase coincides with less variance over time, which results in thicker and more pronounced floodplain and sandy crevasse units. Drier phases seem to correlate with more frequent formation of conglomerate filled channels. In conclusion the sedimentary record supports a strongly linked coupling of climate with patterns of lake level fluctuations and changes in sediment supply, possibly on a basin-wide scale. This is a unique situation for closed and partly open lake hydrology and makes clear that only adopted or terrestrial sequence stratigraphic concepts (e.g. stratigraphic base level) can be applied in such geosystems (Hornung et al., In Press).

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**S8-P01****Stratigraphic framework of the South Basin of Lake Turkana, Kenya from new seismic reflection data and sediment cores**Amy Morrissey<sup>1</sup>, Christopher Scholz<sup>2</sup><sup>1</sup> Syracuse University, Syracuse, United States**Email:** amorriss@syr.edu

Lake Turkana is the largest rift valley lake in the eastern branch of the East African Rift system and measures 250 km in length with maximum and mean depths of 120 and 30 m, respectively. It is a mildly saline (2500 ppm) and alkaline (pH = 9.2), hydrologically-closed lake located in a desert environment between 2° and 5° N. This study focuses on the southernmost of the 3 main bathymetric basins that comprise the lake.

The South Basin's sedimentary environment is unique from the lake's northern basins as it has minimal sedimentary influence from the Omo River, the lake's main water source (~90% of inflow). The South Basin's detrital sediment sources are mainly small drainages that only intermittently deliver sediment to the lake during the region's brief rainy season. The rainy season at this latitude is associated with the migration of the Intertropical Convergence Zone. Because most of the lake's watershed in the Ethiopian highlands is at the NE extreme of the ITCZ migration path, even slight path variations can lead to reduced input to the lake. Additionally, rainfall over the lake itself may be reduced during times of reduced solar insolation and reduction in ITCZ convection. Because of this high vulnerability to climate forcing, Lake Turkana's hydrologic record is not to be likely in phase with lakes outside of Ethiopia and the Kenyan Rift.

Whereas deep-water sediments consist of hemipelagic muds, westward prograding delta deposits are observed in both high-resolution CHIRP and airgun seismic data, primarily near the eastern shore (flexural margin) of the southernmost half-graben. At least 3 time-correlative sets of deltas or reworked

shoreline deposits are observed in the geophysical data along the eastern shore at depths of approximately 26.6, 32.3, and 39.0 m below the modern lake surface. No evidence for similar deltas is observed on the western shore, where major normal faults, with kilometer-scale offset create a steeper shoreline. Other sediment sources in the South Basin include aeolian sediments, authigenic carbonate, autochthonous organic matter, tephra and other volcanoclastic sediments derived from regional volcanic systems.

Seismic data also show multiple occurrences of onlap and erosional truncation in the upper 100m of the sediment column. The presence of sharp contacts and desiccation surfaces in cores, along with associated sediment geochemical data acquired from various locations throughout South Basin suggest extreme lake level fluctuations over the past 10,000 yr or more. A rapid decrease (5%) in organic carbon is contemporaneous with a rapid increase (~2.5%) in inorganic carbon at a sub-bottom depth of ~7m in core 46P that was acquired along the eastern shore. Cores that sample a thickened seismic sequence thought to be composed of only of mid-late Holocene material do not show these dramatic changes.

**S8-P02****Paleoshorelines as archives of paleolakes evolution: two examples from the Lake Chad (central Africa) and the Lake Turkana (Kenya, EARS) basins.**Mathieu Schuster<sup>1</sup>, Frédéric Bouchette<sup>2</sup>, Philippe Durringer<sup>1</sup>, Jean-François Ghienne<sup>1</sup>, Abderamane Moussa<sup>3</sup>, Alexis Nutz<sup>1</sup>, Claude Roquin<sup>1</sup>, Jean-Jacques Tiercelin<sup>4</sup><sup>1</sup> Institut de Physique du Globe de Strasbourg, UMR 7516, CNRS & Université de Strasbourg/EOST, 67084 Strasbourg, France<sup>2</sup> Géosciences-Montpellier CNRS / Université Montpellier II, 34095 Montpellier, France<sup>3</sup> Université de Ndjamena, Ndjamena, Tchad<sup>4</sup> CNRS, UMR 6118 Géosciences Rennes, Université de Rennes 1, 35042 Rennes, France**Email:** mschuster@unistra.fr



Modern and ancient shoreline variations are well-known from the marine domain, but have received less attention in lake domains. Shorelines are the result of various processes (erosion, bypass and deposition) that are related to sedimentary inputs (mainly from rivers), to the redistribution within the basin (waves, storms, alongshore drift) and to base-level variations (regression/ transgression). These processes are linked to the climate (e.g., precipitation, wind regime) and to the geology (e.g., 3D-shape of the lake basin, tectonic, lithologies of the drainage basin and coastlines). Shorelines are snapshots of lakes spatial extension and hydrodynamics.

Two large lakes/ paleolakes basins, where prominent fossil morphosedimentary shoreline features are preserved, are considered here.

-Lake Chad Basin: Lake Mega-Chad is a fascinating large paleolake that existed during the Holocene African Humid Period. In this lake basin, numerous ancient shoreline features have been identified and highlighted: deltas, beach ridges, sand spits, wave-cut terraces and islands. Resulting sedimentary architectures provide informations about the extension of this paleolake (>350000 km), about its paleohydrodynamics and, especially, about prevailing paleowind regimes over this area.

-Lake Turkana Basin: This is the largest lake of the eastern branch of the East African Rift System. Its modern coastline is outlined by well-developed beach-ridges, sand spits and deltas. Various ancient (Pliocene-Quaternary) shoreline markers are also evidenced from both the sedimentary record (outcrop study) and the surrounding geomorphology (remote sensing) in this half graben basin. Vertebrates fauna and hominid remains from this area appear to be closely linked to these paleoshorelines.

Some other examples illustrate the ubiquity and the significance of ancient/ modern shoreline features in lake systems (e.g., Lake Albert, Lake Saint-Jean, Oligocene Rhine graben Lake, Lake Bonneville, Aral Sea, Lake Khiargas,...).

Identifying paleoshorelines in the geological record provides direct and concrete evidences for the extension and dynamic of ancient water bodies. Paleoshorelines are thus of major importance for the reconstruction of the geological evolution of lake basins, as well as for all studies concerned by past landscapes, ecosystems and climates.

Selected bibliographic references: Bouchette et al., 2010, *Quaternary Research* 73; Schuster et al., 2005, *Quaternary Science Reviews* 24; Tiercelin et al., 2010, *Journal of African Earth Sciences* 58.

## S9-P01

### Lake ecosystem responses to Late Quaternary environmental change in the SE Pacific from sedimentary pigment and isotopic geochemical data of Raraku Lake (Easter Island, 27°S)

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A multi-proxy paleoecological approach was developed to determine lake responses to Glacial and Holocene climate changes in the SE Pacific. Photosynthetic pigments,  $\delta^{13}\text{C}$  and  $\delta^{15}\text{N}$  in sediments, were analysed in a composite core of 19 m depth for the last 34 cal kyr BP from Lake Raraku. Marker pigments analysed show a diverse assemblage.

Increased productivity between 17.3 and 12.5 cal kyr BP, indicated by the ubiquitous  $\beta,\beta$ -carotene, may have been related to increased precipitation and runoff to the lake resulting in higher nutrient supply. Cyanobacteria, chlorophytes and phototrophic bacteria were particularly well represented from ca. 32.6 to 11.6 cal kyr BP. The series of high Zeax/Echin ratio's concomitant with the presence of Oscillatoriaceae (oscillaxanthin) point to the relative dominance of Chroococcaceae and Oscillatoriaceae versus Nostocaceae until ca. 17.3 cal kyr BP. Brown strains of Chlorobiaceae (isorenieratene) dominated along that time interval. After ca. 17.3 cal kyr BP, green strains of Chlorobiaceae (chlorobactene) appeared followed by Chromatiaceae (okenone) and high contributions of filamentous cyanobacteria and chlorophytes. The presence of phototrophic bacteria indicates oxygen depletion either beneath the uppermost living layer of the benthic cyanobacterial mat, or somewhere in the water column possibly associated with stratification. The transition to Holocene was characterized by an increase in algal development ca. 10.2 cal kyr BP, with high contributions of planktonic groups (alloxanthin; Cryptophyta) and diatoms (diatoxanthin) followed by a drop of all groups. With some exceptional episodes and the uppermost part of the record, there was a near absence of pigments along the Holocene. High values of  $\delta^{15}\text{N}$  during earlier and mid-Holocene were indicative of denitrification processes (isotopically light  $\text{N}_2$  degassing at neutral pH) and anoxic conditions, which is consistent with the development of a swamp partially favored by the infilling process of the lacustrine basin. Results were discussed in terms of how catchment factors interact with in-lake processes to determine lake ecosystem evolution.

## S9-P02

### Palaeoenvironmental Changes in South Baltic Coast Region Recorded in Sediments of Trzebiatów Palaeo-lake

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Research area is located within limits of the Trzebiatów Coast and northern slope of Gryfice Plain. Predominant geomorphological form is wide and flat coastal melt water valley where the Rega and the Blotnica rivers run. The lowest part of the valley is located on the altitude 0.3 m a s l. Directly to the south of the valley spread there is moraine plateau. Sediment cores were taken in this area in summer 2008. The main aim of our research was reconstruction of palaeoenvironmental changes in region and also we would like to test finding record of Littorine Transgression in this area. Reconstruction of past environment was made on the basis of multi-proxy analysis like: lithology, radiocarbon data, pollen, plant macrofossil, Cladocera, Diatomae and Ostracods. On this poster we present the results of lithology, radiocarbon data, pollen and Cladocera analysis. Palynological record and radiocarbon data suggest that the bottom layer were accumulated in Late Glacial period (Allerød). Analysis of species composition of Cladocera show that in the first part of Late Glacial (Allerød -subphase Ia) there were good conditions for development of zooplankton. Trophic of the lake was probably formed at the level of oligo/mesotrophy. At the end of this phase (subphase Ic) Cladocera species composition changed. The decreasing of number of Cladocera species and frequency of individuals are probably connected with climate conditions.

Pollen analysis and <sup>14</sup>C dating provide that in studied profile is hiatus coincided with the Younger Dryas and the early Holocene. The lithology showed that these layers were removed and replaced by maritime deposits (sand-sea). Sea-water made an irruption, washed the sediments, which were

accumulated earlier. This event was caused by first stage of Littorine Transgression.

Next phase of accumulation "in situ" occurred since the Atlantic Period. Cladocera analysis revealed that sedimentation (except the time of transgression) proceeded in freshwater environment. Over the time the influence of sea transgression and saline intrusion decline. The habitat conditions in the lake were mostly depending on the climate but also from occasionally seep seawater into lake during the storm. The diagrams presented include only core part of sediments which were accumulated till Subboral Period, since overlaying layer was fluvial and didn't contain pollen and Cladocera microfossils.

### S9-P03

#### Late Quaternary climate and environmental change in the American tropics inferred from aquatic bioindicators

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The northern Neotropics are rich in aquatic ecosystems. Few lakes in the region, however, contain pre-Holocene sediments. Lakes Petén Itzá, Guatemala and Chalco, central México are exceptions, and have yielded long, continuous sediment records (>200 ka) that contribute to our understanding of late Pleistocene climate and environmental changes in the Neotropics. We developed

paleoenvironmental transfer functions for the northern lowland Neotropics using limnological and bioindicator autecological data from 63 aquatic ecosystems on the Yucatán Peninsula and in surrounding areas. Here we present training sets that incorporate limnological measures and data on chironomids, diatoms and microcrustaceans (Cladocera, Copepoda and Ostracoda). Sixty-six chironomid morphospecies, 288 diatom species, 51 cladoceran species, 6 calanoid copepod and 29 ostracode species were identified in surface sediments collected across altitudinal (from 1560 to 1 masl) and precipitation (from >3200 to ~450 mm yr) gradients, from the highlands of southern Guatemala to the lowlands of the northern Yucatán Peninsula. We used multivariate statistics to link extant biotic assemblages quantitatively to water depth, altitude and environmental variables (temperature, dissolved oxygen, pH, conductivity, water chemical composition,  $d^{18}O_{SMOW}$ ,  $d^{13}C_{DIC}$  and total organic carbon in surface sediments). Canonical Correspondence Analyses (CCA) indicate that altitude, conductivity (water ionic strength), and lake productivity are the main environmental factors that influence bioindicator distribution in regional aquatic ecosystems. We applied ostracode-derived transfer functions (WA-PLS and BC) to fossil ostracode assemblages from Lago Petén Itzá core PI-6 to infer late Quaternary climate and environmental change in the northern lowlands of Guatemala. Results suggest a cold and wet Last Glacial Maximum (~24-19 ka BP) and alternating dry-wet conditions during the deglacial-early Holocene (19-10 ka BP), in agreement with inferences based on core sedimentology. We recently developed a chironomid-based transfer function for the study area, but due to the scarcity of chironomid remains in deep-water long core PI-6, future analysis will apply the transfer function to long cores taken in shallower water. A new training set is being developed for central México, where modern autecological information for most aquatic bioindicators is still lacking. Ostracode assemblages in late Pleistocene sediments of long cores from Lake Chalco are now being analyzed. We hope to soon apply transfer

functions to these quantitative counts to infer past fluctuations in lake level and water chemical composition. Our objective is to use multiple bioindicators to provide reliable reconstructions of past climate and environmental conditions in the American tropics.

### S9-P04

#### Mineralogy and Mg, Sr and Na uptake in charophyte gyrogonites from culture experiments. Paleolimnological implications.

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Charophytes are aquatic non-marine green algae which include taxa that live in brackish waters. The ensheathing cells of the female reproductive organ or oogonium of some taxa are able to calcify, producing the so called gyrogonite which may be fossilized. The interest of the geochemical studies on the gyrogonites is because the calcification process happens in few weeks during summer while the incrustation of the charophyte stems, when it occurs, usually takes place along several months of the growing season (spring to fall). Gyrogonites therefore may provide precise indications of summer limnic conditions. Three *Chara* species (*C. vulgaris*, *C. hispida* and *C. globularis*) and *Lamprothamnium papulosum* have been grown under controlled conditions of water chemistry, temperature (T) and light period (12h/12h) in laboratory aquaria to examine the mineralogical composition and Mg, Sr and Na uptake features of the gyrogonite calcite. Four types of water at 18, 20, 25 and 28°C were used for the cultures. The conductivity ranged from 0.8 mS/cm to 47 mS/cm; molar Mg/Ca<sub>w</sub>: 0.40 -11, Sr/Ca<sub>w</sub>: 0.0030 - 0.0070 and Na/Ca<sub>w</sub>: 0.60 - 26.3. The carbonate from the

gyrogonites was analyzed by XR diffraction and ICP-OMS. The mineralogy of gyrogonites for the three *Chara* species varies from low magnesian calcite (LMC, 1.7-4% Mg mol) to high magnesian calcite (HMC, 4.3-26% Mg mol) and to a mixture of HMC and aragonite. At low water conductivity, temperature is the main factor controlling the Mg content in the calcite; at higher T values HMC is formed in *C. hispida* and *C. globularis* gyrogonites. At moderate conductivity (5.5 mS/cm) the gyrogonites from *C. hispida* and *C. globularis* mostly consist of a mixture of HMC and aragonite; the latter increases with the water T, reaching 48-53% at 25-28°C in both species. The gyrogonites from *L. papulosum*, which formed at 22 and 47 mS/cm, are made of HMC or a mixture of HMC and aragonite. Our data suggest that Mg/Ca and T of the water are not the unique factors that control the mineralogy of the obtained gyrogonites. The results for the trace-element analyses in monomineralic gyrogonites indicate that the Mg/Ca in the calcite gyrogonite is directly related to the Mg/Ca and T of the water but there is a species-specific control at low Mg/Ca<sub>w</sub> and some influence of the conductivity. In contrast, Sr/Ca<sub>gyr</sub> is not related with the Sr/Ca and conductivity of the water, although Sr uptake is species-specific controlled. On the other hand, the Na/Ca from gyrogonites is directly related to the water conductivity. There is no noticeable species-specific control of the Na/Ca<sub>w</sub> and T in the Na uptake except for Na/Ca<sub>w</sub> for *C. hispida*.

Acknowledgements: The research was supported by CGL2008-00594/BTE.

### S9-P05

#### Holocene Fresh Water Ostracoda from the Black Sea Coast of Turkey

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Although diatoms are an excellent proxy for long term climate and environmental change studies, they are not well preserved in some Black Sea coastal basins. Here, we provide results of mid/late Holocene fresh water ostracoda analyses from coastal modern lake basins located along the Black Sea coast in Turkey. While neither diatoms nor Cladocera are abundant in the sediments, Podocopian (fresh water ostracods) ostracods preserved well, but with discontinuous occurrences during the mid/late Holocene. A large, brackish water diatom species, *Campylodiscus clypeus* (Ehrenb.) is observed at some sediment depths within a long core from Terkos Lake. Un-noded forms of *Cyprideis torosa*, along with other Podocopian ostracods, are common in surface sediment samples and cores collected between 2005-2008 from the modern lake basins we studied. Our ostracod data include species level and individual valve (or carapaces) level of information. Ostracod assemblages are identified to the species level. Male/female and adult juvenile ratios of *Cyprideis torosa* are also calculated.

### S9-P06

#### Ostracod and chironomid transfer functions for inferring past lakewater conductivity in neotropical aquatic ecosystems

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Chironomids (Insecta: Chironomidae) and ostracodes (Crustacea: Ostracoda) are two of the most abundant, diverse and environmentally sensitive groups of organisms in northern neotropical aquatic ecosystems. This study shows the potential of using different organisms (ostracods, chironomids) as environmental indicators for quantitative reconstructions.

We identified 66 chironomid morphospecies and 29 non-marine ostracode taxa on the Yucatan Peninsula and in surrounding areas. Lack of limnological and autecological data for these lacustrine organisms, however, had precluded their use in neotropical paleoenvironmental studies. We developed a training set with 63 waterbodies containing environmental data and information on species tolerances and optima. Multivariate canonical analysis indicated that lake water conductivity controls ostracode assemblages and was one of the three significant variables (conduct, TOC and HCO<sub>3</sub>) explaining chironomid distribution. Next, we developed chironomid- and ostracode-based transfer functions using Weighted Average Partial Least Squares (WA-PLS) regression and a leave-one-out cross validation method to infer past water conductivity in lakes. Conductivity ranged from 127 to 5,960  $\mu\text{S cm}^{-1}$ . The chironomid-based transfer function based on a five-component WA-PLS regression provided a coefficient of determination ( $r^2_{\text{jack}}$ ) of 0.66 and a root mean square error of prediction (RMSEP<sub>jack</sub>) of 686.7  $\mu\text{S cm}^{-1}$ . The two-component WA-PLS model based on ostracode data displayed better predicting performance ( $r^2_{\text{jack}}=0.79$ , RMSEP<sub>jack</sub> = 159.18  $\mu\text{S cm}^{-1}$ ). Our results indicate that both taxonomic groups can provide accurate quantitative estimates of past environmental changes. Transfer functions will be applied to samples from long cores taken on the Yucatán Peninsula and in surrounding areas to infer late Quaternary environmental conditions.

### S9-P07

#### A 8500-year sedimentary record based on analyses of organic matter, pollen and non-siliceous phytoplankton remains from Lake Bosten, NW China

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Bosten Lake is situated in a climatically sensitive region of central Asia neighbouring both the southern piedmont of the Tian Shan and the Taklimakan desert. Sediment analyses of TIC, TOC, TC,  $d^{13}C_{TOC}$ ,  $TN_{TOC}$ ,  $C_{TOC}/N_{TOC}$  and palynomorphs (pollen, phytoplankton remains including blue-green algae) from a 9 m core provide proxy data of limnic and climatic changes. Both approaches combined reveal a sequence of lake phases and a detailed palaeoenvironmental record since 8500 cal BP.

Arboreal pollen types (*Picea*, *Betula*, *Juniperus*) indicate a wide distribution of mountain forests until c. 4200 cal BP, though subject to stepwise reductions. The regional vegetation around the lake was dominated by Chenopodiaceae, *Ephedra*, *Artemisia* and Poaceae indicating generally arid conditions, with moister intervals around 8300, 6400-5700, 5400-5000 and 2500 cal BP. Algae assemblages include *Gloeotrichia* type (Cyanobacteria), *Botryococcus*, *Pediastrum* spp. and *Coelastrum* spp. (Chlorophyceae) as well as *Cosmarium* and Zygnemataceae (Zygnematophyceae). Their compositional variation may explain changes in trophic status (nutrient input), inflow and water temperature. Numerically delineated algae assemblage zones reflect the limnic development.

Generally low  $C_{TOC}/N_{TOC}$  ratios point to the predominantly limnic origin of organic matter in the sediment, and therefore the  $d^{13}C_{TOC}$  values point to changes in carbon discrimination within the lake rather than variations in allochthonous matter derived from C3 or C4 land plants. Correspondingly the palynological record does not show major vegetation shifts during long intervals. Additionally, the correlation of less negative  $d^{13}C_{TOC}$  with higher  $TN_{TOC}$ , TIC, and TOC values as well as high concentrations of algal remains reflect changes within the lake's carbon and nutrient budget.

High abundances of fungal chlamydozooids in the basal aeolian sand suggest soil formation around 8500 cal BP, prior to the initial shallow lake phase. Intensified inflow activities caused the lake level to rise considerably until 7000 cal BP, while maximum water depths were reached c. 5400 cal BP. Spreading swamp vegetation corresponds to mesotrophic and warm limnic conditions until 4000 cal BP. The water depth remained relatively high associated with weak but continuous inflow activities and still favourable moisture availability in the mountains. Subsequently with decreasing water depths enhanced variability in phytoplankton assemblages and increased  $C_{TOC}/N_{TOC}$  ratios indicate a rising influence of temporarily strong inflow at the coring site. This change corresponds to cooler N-hemisphere climate conditions linked to weakened moisture transport by the westerlies. The record of chlamydozooids after 4000 cal BP evidences increased soil erosion in the catchment area, possibly also human impact. Widespread swamp vegetation reflects water depth minima at 3500-2500 and 2000-1400 cal BP, and thereafter our data point to stronger inflow and higher lake levels.

## S9-P08

### Implications of ostracod preservation in Holocene paleoenvironmental reconstruction of Lake La Brava (Argentina)

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The Pampean plain (Argentina) is a flat and low area with an altitude between 80-400 masl extending to the south up to 40°S and sprinkled with several thousand shallow lakes called *lagunas*. Two factors make the

Pampean plain an important site for reconstructing past environmental changes. First, moisture is mostly controlled by the subtropical low-level jet associated to the South America Monsoonal System (SAMS), and represents the austral border of the subtropics, a very sensitive area to past atmospheric circulation changes. Second, *lagunas* represent sedimentary archives of subtropical mid-latitudes of South America where the reconstruction of Holocene environmental variability have been hampered by the paucity of complete and well-dated paleoclimate archives. Hence, the paleoenvironmental analyses of the sedimentary record of the *lagunas* allow to reconstruct regional climate variability and past activity of the SAMS. The *lagunas* tend to be alkaline lakes that preserve biogenic carbonate, potentially allowing the reconstruction of past changes in moisture balance by analyzing ostracod assemblages recovered from sediment cores. La Brava (37°52'S - 57°58'W; 69 masl) is a bicarbonate-sodium oligohaline laguna (4.5 km; 4.8 m depth). Ostracod, geochemical and sedimentological analyses were performed in core Br4 (551 cm) in order to reconstruct paleoenvironmental and paleohydrological conditions since the Mid Holocene. Surprisingly, up to one third of the samples lack ostracods. In fertile samples, five species were recorded. *Limnocythere* sp. aff. *staplina*, a highly eurytopic species, is by far the most abundant and sometimes the only species recorded, providing more than 90% of shells. As a consequence, ostracods of core Br4 are taxonomically monotonous, and diversity is extremely low, allowing inferring at best salinities lower than 4‰ and alkaline waters. Thus, classical paleoecological approach fails to allow a precise reconstruction of the paleohydrological state and evolution of the lake. However, if the pattern of ostracod distribution is considered together with geochemical proxies, the presence/absence of ostracods can be interpreted as a signal of conditions that allow/preclude the preservation of biogenic carbonate, and thus more paleoenvironmental information can be obtained. Abundance of ostracod valves tracks TIC and Ca content. Decomposition of organic

matter and a decrease in the pH related to the establishment of eutrophic environments could have promoted the dissolution of ostracod valves. Relations between TOC and TS confirm this hypothesis. We can infer that La Brava experienced significant environmental changes in the last 4700 years. Varying environmental conditions were related to alternating phases of moderate productivity and well oxygenated bottom waters, and phases of high productivity and oxygen depletion, which drive the calcite record promoting dissolution/preservation of calcite and therefore of ostracods.

### S9-P09

#### Lake Ohrid diatoms as palaeoclimate indicators of climate change during the Last Glacial-Interglacial cycle

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Lake Ohrid with its presumed Tertiary age is probably the oldest lake on European territory. Thus, the palaeolimnological records held in its sediments are important archives of Quaternary climate change. This study presents the results of a diatom based palaeoanalysis carried out on a 14.5 m long sequence (core Co1202), which spans the last ca. 135 ka of lacustrine history. This gave the opportunity to test diatom community shifts and to identify trends in morphological change of the dominant taxa, across two glacial-interglacial transitions and during the Last Glacial. The results again acknowledge diatoms as sensitive indicators of climate change and the advantage in their use as palaeoclimate proxies. The evidence of temperature or other climate changes is clearly marked by the glacial-interglacial shifts of diatom communities dominated by the endemic *Cyclotella fottii* and the *Cyclotella ocellata* complex, respectively. There is exact

correlation with previously established geochemical proxies marking the onset of the Last Interglacial in Lake Ohrid after ca.130 ka. During the Last Glacial, the most important result is that diatoms showed stronger evidence of warming during MIS 3 rather than other productivity related proxies, marked through the peak of *Cyclotella ocellata* between ca. 33.9-39.3 ka, and its onset by an increase in non-planktonic taxa after ca. 59 ka. After ca. 6.9 ka there is a possible evidence of nutrient enrichment of the lake indicated by the first appearance of *Stephanodiscus transilvanicus* in the sediment record. In the post-Medieval period (last 2 ka of the sequence), the presence of the more thermophilic taxa, and also the peak of benthic and facultative planktonic taxa, indicates that although the sequence is again dominated by *C. fottii*, this is not a return to cold glacial conditions. Although, diatom preservation in Lake Ohrid sediments showed to be highly dependant on climate characteristics, the future development of a site-specific diatom dissolution index and absolute diatom analysis would be useful in testing different factors influencing diatom preservation in the lake. Comparing changes in morphology of the most abundant diatom taxa with the tephra record, with the aim to assess the influence of Italian volcanic activities from the Quaternary period, a possible effect over the valve morphology of *C. fottii* after the deposition of a tephra layer at 822 cm depth was revealed. Taxonomically, *C. fottii* showed variation in valve size classes between the glacial and interglacial periods (although possibly linked to preservation potential rather than ecological response) and *Cyclotella ocellata* showed large variation in core Co1202 which resulted with establishment of 22 different morphotypes, with a clear shift in types between successive interglacials. Two hypotheses are raised to explain this variation. The first is that environmental and climate changes are the main factors driving the variability and the second is that evolutionary processes rather than climate have provoked the response. However, future genetic, spatial and high resolution temporal studies are necessary to test these hypotheses.

## S9-P10

### Ostracod-based transfer functions in palaeolimnology

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Ostracods are among the most important proxies from Quaternary lake sediments. Major methods of their use in palaeolimnology are indicator species, ecological tolerance data, ecological groups, as well as shell chemistry approaches. Transfer functions were applied relatively sparsely; an increasing use started within the last decade about. Environmental parameters reconstructed so far include salinity, water temperature, and water depth. Despite its great potential for quantitative reconstruction of palaeoenvironmental data, the time consuming set up of high quality modern training sets and the problem of application to non-modern analogue systems create barriers for a wider use. We present examples for ostracod-based transfer functions showing both pitfalls and problems as well as new perspectives.

## S9-P11

### Combined in-situ trace element, Pb and U isotope analysis of single ostracod shells from Lake Nam Co, Tibet

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Ostracods represent a useful biological archive for Quaternary environmental and climate change. In particular, ostracod shells deposited in lake sediments of the Tibetan Plateau are suitable samples to study the large-scale atmospheric circulation of the monsoon over Asia.

We have developed a new laser ablation-ICP-mass spectrometry (LA-ICP-MS) technique for combined in-situ trace element, Pb and U isotope analysis of single ostracod shells. High spatial resolution is achieved by using small spot sizes of 12 - 100 µm. We analyzed very small (ca. 0.5 mm) and thin (about 0.05 mm) shells from eight different levels of a Holocene lake sediment core from Nam Co, Central Tibetan Plateau, deposited within the last 7700 a BP. 34 major and trace element concentrations could be determined by electron probe microanalysis (EPMA) and LA-ICP-MS in single ostracod shells with a precision of about 5 - 10 %. In-situ measurements of (<sup>234</sup>U/<sup>238</sup>U) and <sup>208</sup>Pb/<sup>206</sup>Pb, <sup>207</sup>Pb/<sup>206</sup>Pb yielded a precision (RSD) of about 2 % for U = 10 - 20 µg g and 0.2 % for Pb = 10 - 40 µg g.

Whereas CaO contents for ostracods from the eight levels are uniform (about 56.1 %), MgO, Sr, Ba and Pb show significant variations. The uranium content is relatively high (about 10 - 20 µg g). Normalized REE patterns are similar to those of the upper continental crust. Our results show identical isotope ratios within uncertainty for ostracods from the same core depth indicating that they reflect the isotope composition of the lake water. Influence of vital effects may, hence, be negligible or stable. (<sup>234</sup>U/<sup>238</sup>U) and <sup>208</sup>Pb/<sup>206</sup>Pb are correlated and show significant variability with age: Ostracods from the upper core section with an age of 100 - 500 and ~ 2500 a BP show uniform isotope ratios (1.42 ± 0.01 and 2.134 ± 0.003, respectively). The older samples, which were deposited between 4500 - 7000 a BP, show lower and more variable isotope

ratios. These results are in agreement with geochemical and mineralogical investigations of the sediments and suggest that the isotope ratios of the ostracod shells reflect past climate variability: reduced precipitation and runoff, low lake water volume and maximum salinity since ca. 800 a BP, humid conditions and a positive precipitation/evaporation balance between 5400 and 7200 a BP. The lowest ratios ((<sup>234</sup>U/<sup>238</sup>U) = 1.13, <sup>208</sup>Pb/<sup>206</sup>Pb = 2.112) are observed in a 6000 a old ostracod shell, where a high intensity of monsoonal precipitation, associated with elevated lake levels in Tibet, is recorded.

## S9-P12

### Evolution of the limnic system at Middle Danube Plain from Pliocene/Pleistocene boundary till now

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At the approach of Ice Age existing Pliocene lakes spread and new ones appear. The palynomorphs indicate pulsating change of climate.

Older part of the Ice Age, cold and arid, is hardly preserved, nor on hills neither in lowlands. In the Middle Danube Plain it was washed out by subsequent pluvial period, except from horsts, loess covered. Some deeper parts is difficult to distinguish firmly and to date the loess and loessoides (Klichevac Formation). There terrestrial snails are rare, often absent and palynomorphs destroyed by oxygenisation.

In warm and humid Mid-Pleistocene the lake again spread far, having very low content of salt (1,5-2.0‰ S), but one short arid phase with *Scordiscia scordisca* indicated a closed lake according to the higher water mineralization.

Upper Pleistocene in the lowlands was characterised by tundra landscape, well preserved on all plateau till now in western

and eastern Europe at the same latitude. In Middle Danube Plain numerous ponds were divided by dry narrow rungs. Some ponds were large enough to house *Candona rawsoni* dwelling today thermo-karst waters in Siberia, shallower ones contain many of *Planorbis* and its relatives. Numerous terrestrial snails were washed down from grass-rungs with rare shrubs. Trees were seldom corroborated by *Clausilidae* mostly situated northerly, close to the large sand area. Few star-dunes reach to the south along strongest wind direction.

Holocene is preserved along rivers. On oldest Begej riverbed (in Koštanc forest) the strata of re-deposited pedolithe was noticed, and, in an ancient side chanel, the age of pedolithe obtained was  $9.750 \pm 180$  years BP. Along Danube, at the foothill of Fruška Gora, Holocene deposits reach 27 m bellow surface due to ice-corks in cold winters prohibiting normal river-flow, Danube break left-side. *Secale* (ray) and other cereals pollen grains were found at 17 m, and *Zea* (maize) at 2 m of depth. The praeboreal palynospectrum appear at 18,13 m of depth.

Recent subsiding appear in some restricted areas in many places where listric faults were active. Best example is "Morovic" area where larger (Sava) and smaller rivers (Drina, Bosut) often change its direction according to the subsidence speed. The age of early Holocene, still relatively cold, for this lake corroborate *Candona bimucronata* and some Neolithic tools. Recent ostracode communities differ enough. Sand dunes of Deliblato are also recent, brought to the SE corner of the Plain by the wind "koshava".

Great and relatively rapid chngement is now supported by the Man. Some 100 years ago the xerofile *Dreissena polymorpha* re-conquest Middle Danube Plain. A terrenstrial *Helicella obvia* appear in historical time, along with the bird turtledove flocks coming from the south till Middle Danube Plain.

## S9-P13

### Palaeocological study of a periodical lake in central Svalbard, Petuniabukta

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Small tundra lakes located within the system of raised marine terraces on the eastern coast of Petuniabukta (the northern tip of Billefjorden, Central Spitsbergen) were investigated with the aim to reconstruct environmental changes in the central Spitsbergen over the last few centuries. 11 cores (monoliths), 15-36cm thick, were recovered in July and August 2009 from the lakes located on the southern side of the Ebbaleva.

#### The poster first results of the analysis of subfossil diatoms.

Diatoms were classified according to their ecological requirements after Denys (1992) and Van Damm et al. (1994).

A total of 70 taxa were identified. 29 of these occurred in the abundance greater than 1%. Nevertheless, the preservation of the frustules was bad. Broken and corroded frustules are to be found in most of the samples.

Diatoms were found only in the upper part of core (from the top down to 19 cm below the lake bottom), while they were lacking completely in the bottom section of the profile. Moreover, in the samples taken at depths of 6cm and 10-12cm below the lake bottom diatom abundance was very low.

In most of the samples only single diatom frustules and siliceous algae were found possibly due to strong dissolution of opaline silica.

Diatom analyses in the core showed that in the subfossil assemblages a diverse mixture of

both planktonic and benthic taxa occurred. With respect to habitat, planktonic forms dominated over benthic in the samples from a depth of 18cm, 10 and 8cm. Among the predominant planktonic species were: *Puncticolata radiosa*, *Cyclotella cyclopuncta*, *C. atomus*, and *C. rossii*.

Generally the diatom flora in the above samples was composed of mesotrophic brackish-fresh species, which require salinity <0.9% (Van Damm et al. 1994).

At a level of 5 cm below the core top a distinct change in the diatom assemblages was observed. Some species started to decrease (e.g. *Puncticolata radiosa*, *Cyclotella cyclopuncta*, *C. atomus*, and *C. rossii*), and the others, which were sparse or even not present at all in the lower part of the profile, increased. The diatom flora in this zone is dominated by brackish-fresh benthic forms (e.g. *Sellaphora bacillum*, *Diploneis pseudovalis*, *Pinnularia viridis*, *Denticula tenuis*) indicative for more eutrophic and slightly alkaline waters.

For the moment it is difficult to explain what is the reason for selective preservation of diatoms in the different sections of core. Preliminary conclusion is that it could be due to unfavorable environmental conditions (pH) in the lake waters and/or postsedimentary dissolution of biogenic opal in alkaline pore waters.

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## S9-P14

### Preservation of diatom valves in sediment cores from the Tibetan Plateau

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Diatoms are exposed to both chemical and physical processes that promote poor preservation in lakes. This is an important source of errors in quantitative and qualitative reconstruction. Numerous studies have analyzed factors of diatom dissolution and breakage and the main results are summarized here. Preservation in sediment cores from two lakes (Nam Co, Npen Co) on the southeastern Tibetan Plateau was examined. Five distinct stages of preservation for the diatom *Cyclotella ocellata* and the diatom concentration were identified (stage 1: valves intact; stage 2: mantle of valves partly dissolved; stage 3: mantle of valves completely dissolved; stage 4: only central area of valves remained; stage 5: valves broken). The impact of dissolution on diatoms is evident in both cores although it is greater in the core from Nam Co. Percentage abundances of preservation stages clearly show that in the Nam Co sediment core there were significant fewer intact valves of *C. ocellata* and partial dissolution was more frequent. Major changes in the proportions of preservation stages were found in this lake with values of intact valves ranging from less than 1 to over 40 % and breakage occurred over 30 % more often. In the Npen Co sediment core proportions changed only slightly and intact valves were the most abundant ones. The poorer preservation in Nam Co, compared to Npen Co, could be due to higher salinity and pH value. We suggest establishing criteria in order to select suitable lakes for diatom analysis.

## S9-P15

**Microfossils (thecamoebians and Ostracoda) from Holocene sediments in the Akosombo Gorge Area of Volta Lake, Ghana - Perspectives for palaeolimnological studies**

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Microfossils are important proxies of past and modern environments. Although microfossils such as thecamoebians and Ostracoda have been studied extensively from other parts of the world, the knowledge on these groups in West Africa is very limited. Thecamoebians are a diverse group of testate rhizopods present in a variety of lacustrine and terrestrial habitats. Ostracoda are small bivalved crustaceans (mostly 0.5 - 2.0 mm) abundant in nearly all non-marine and marine habitats, but also found in semi-terrestrial environment. In Ghana, due to lacking taxonomical data, ecological studies either ignored Ostracoda or treated them as a group only so far. There are no thecamoebian studies from Ghana up to date.

The tropical Volta Lake in Ghana is by its surface area of 8,500 km<sup>2</sup> the largest man-made lake of the world. The length of the lake is about 400 km and it runs in north-south direction. The deepest portions of the lake are about 90 m, which has an average depth of about 30 m and a shoreline of about 5,500 km. The lake was established in May 1964 as a result of the construction of a hydroelectric dam on the River Volta at Akosombo. Volta Lake is divided into eight segments referred to as strata, based mainly on prevailing

meteorological, physico-chemical, hydrological and ecological consideration.

So far, benthic studies in Volta Lake were restricted to macro-benthos from shallow waters (phytal habitats of the littoral zone); Ostracoda (limited to adult stages of larger species) were identified as a group only. The only taxa of Ostracoda in Volta Lake reported before are *Acocypris* sp., *Chrissia* spp., *Cypricerus* sp., *Stenocypris* sp., *Strandesia* sp., and a cypridinid species.

The present study was carried out to provide some baseline information on microfossils in Lake Volta, Ghana, for future palaeolimnological investigations in Western Africa. Bottom sediment was collected from a depth of 23.0 m at Akosombo Gorge Area (Strata II) of Volta Lake (Latitude 6° 14' 4.7" and Longitude 0° 5' 7.6") on 13th September 2011. The sediment was a black mud. During the time of sampling, environmental parameters recorded were: air temperature = 30.7 OC, surface water temperature = 28.8 OC, pH = 7.56, conductivity = 59.6 µScm<sup>-1</sup>.

We found two groups of microfossils in relatively high diversity and abundance: Thecamoebians and Ostracoda: Thecamoebians: *Diffflugia corona* (Wallich, 1864), *Diffflugia oblonga* (Ehrenberg, 1832), *Diffflugia tricuspis* (Carter, 1865), *Diffflugia urceolata* (Carter, 1864).

Ostracoda: *Afrocythere rostrata* Klie, 1935, *Alicenula serricaudata* (Klie, 1935), *Cypria?* sp., *Cypridopsis?* sp.

All of these taxa were found in lakes before, many in large rivers also. The ecological preferences of the thecamoebians reflect the measured pH and sediment with high organic content. They indicate an elevated trophic level for the lake system.

Our results proof the presence of smaller microfossils in Volta Lake useful for palaeolimnological investigations.

**S10-P01****Late Jurassic - Early Cretaceous lakes and wetlands of the Cordilleran backbulge depozone, South Dakota (USA)**

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Lithostratigraphic and geochemical datasets developed from Late Jurassic - Early Cretaceous outcrops in the Black Hills of western South Dakota (USA) provide new information on continental deposystems and ecosystems in the distal backbulge of the Cordilleran foreland basin. Interfingering Late Jurassic strata in the study area record a transition from aeolian to wetland depositional environments, which show some similarity to late Quaternary deposits in the seasonally-flooded savannas of the Brazilian Pantanal. Wetlands deposits of the upper Morrison Fm are associated with both shallow groundwater-dominated ponds (massive mudstones and charophyte wackestones) and larger, deeper lakes (marls and fissile mudrocks with lacustrine turbidites) fed by surface water. The Sevier foreland appears to be broadly overfilled in the Late Jurassic, but relatively high effective precipitation and local tectonics may account for the presence of permanent lake systems in the study area. Eastward forebulge migration appears to have substantially altered patterns of topographic closure in the Early Cretaceous. Siliciclastic fluvial and floodplain units of the Chilson and Fuson Members sandwich the Minnewaste Member, a < 20 m thick freshwater carbonate unit that early researchers interpreted as a large lake. Detailed measured sections, microfacies and oxygen and carbon isotopes of Minnewaste strata reveal a much different depositional history however, characterized by an alkaline, hydrologically-diffuse environment strongly influenced by spring discharge and frequent sub-aerial exposure. Sedimentation rates and paleohydrology are

consistent with a regional reduction in sediment supply and an underfilled Sevier foreland during the Early Cretaceous. Enigmatic, widespread spring discharge in the Sevier system suggests that local structural elements may play a key role in the development of lentic ecosystems in backbulge basins.

**S10-P02****Freshwater sponges from Triassic carbonates of Argentina (Cuyana Basin)**

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Freshwater sponges are scarce in the fossil record globally. There exists a unique report of spiculites from the Permo-Carboniferous, and the rest from the Jurassic period. This gap in the sponge record has been related to the effects of the Permo-Triassic extinction. Thus, the present finding of freshwater sponges from a Triassic succession in Argentina (South America) constitutes the first occurrence known from a Triassic freshwater environment in Gondwanaland, giving a useful indication of paleoenvironmental and paleolimnologic conditions.

The sponge remains are found in the upper section of Cerro Puntudo Formation (Anisian, Triassic). The succession consists mainly of microbial carbonates that probably correspond to spring deposits that developed on an alluvial plain near a lake margin. An oncolitic boundstone facies is interpreted as small shallow lake (pond) deposits. This is in contrast with previous reports in which freshwater sponges are reported from the shales of Jurassic alkaline lacustrine sequences and silica cherts.

The sponge remains of the Cerro Puntudo area are observed in the oncoidal facies as

spicules, mainly megascleres with minor microscleres. The megascleres range in size from 1.6 to 4.2 mm in length, are fusiform, straight or slightly curved, and can present spines. Microscleres measure 0.4 mm long, with spines and a preserved central canal. They are found associated with charophyte algae (gyrogonites) and cyanobacteria (filaments) in a micritic and siliciclastic silt-grain matrix. Gyrogonites are found commonly as the nuclei of oncolites and cyanobacterial filaments are present within cortices, while the spicules are dispersed in the matrix.

The finding of Porifera representatives is the first from a freshwater environment of the Triassic period globally, what allows reducing the gap in the sponge register from the Permo-Carboniferous to the Triassic. The presence of sponges in this oncolitic facies gives an interpretation of oxic shallow conditions with clear waters, perhaps associated with groundwater springs feeding into small carbonate-rich Cerro Puntudo paleolakes.

### S10-P03

#### Alluvial-lacustrine record and depositional hiatuses in Atacama Desert during last 10 Ma

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The Atacama Desert has existed for approximately 15 million of years. This hyperarid region has a major geologic interest because its evolution has been controlled by major tectonic and climatic forces: (1) the uplift of Central Andes with its Atlantic rain shadow effect; (2) the temperature and intensity of the cold water current in the neighbor Pacific Ocean, flowing northward from southern latitudes and reinforced during

glacial stages. Late Cenozoic climatic studies of Atacama region have been focused basically on establish the age of the onset of its hyperarid conditions.

The Quillagua Basin (19°35'-22°40'S) is a north-south elongated basin that stretches between the Coastal Range and the Western Cordillera. From late Miocene to recent times this basin was internally drained, leading to the accumulation of nearly 200 meters of alluvial sediments, which include three lacustrine units and volcanic tephra layers. Alluvial deposits correspond to red mudstones and fine sandstones sourced from the Western Cordillera that alternate with minor sandstone and gravel contributions from the south corresponding to paleo-Loa River transported deposits. From bottom to top, the lacustrine units encompass gypsum-anhydrite deposits (Hilaricos Fm), diatomites, marls, silty limestones, gravelly sandstones and minor tufa deposits (Quillagua Fm), and halite (Soledad Fm). The lacustrine facies in the Quillagua Fm deposits are organized in 2 major cycles of lacustrine expansion and retraction (4th-order cycles) and each of them is arranged in ~20 transgressive - regressive lacustrine cycles of 5th-order.

Only the lower and mid intervals of the stratigraphic sequence had been previously dated by K/Ar on biotites, yielding an age of 6.0 and 5.8 Ma for the Hilaricos and Quillagua Fms respectively. In this study, a total of 15 tephra layers from the basin center and eastern margin have been dated by the <sup>40</sup>Ar/<sup>39</sup>Ar method. Analyses have been carried out on non-reworked crystals of biotites and sanidine. The results yielded numerical ages that cluster into three distinct groups: around 8.76 Ma (Hilaricos Fm.), from 5.05 to 5.50 Ma (Quillagua Fm.) and at a Late Pleistocene age (Soledad Fm.). This new radiometric data combined with magnetostratigraphy from Quillagua and Calama basins (Atacama Desert) indicate that major depositional hiatuses in the central parts of the Atacama basins were coeval to Upper Miocene and Lower Pliocene Patagonian and Antarctic glaciations that enhanced the intensity of Humboldt Current. On the other hand, sedimentation stages

developed during less arid conditions related with interglacial episodes, with warmer temperatures in the surrounding ocean. The early Pliocene high frequency cyclicity recorded in the Quillagua lacustrine facies is

attributed to eccentricity and precession orbital forcing.

## S11-P01

### **MIR-submersible dives in Lake Geneva: Formation, sedimentation, stability and mass movements of the Rhone delta canyons**

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The 'Elemo' scientific program (<http://www.elemo.ch>) coordinated at the Swiss Federal Institute of Technology in Lausanne (EPFL) includes more than 15 research teams from Swiss, French, British, Russian and American public institutions. The goal of the program is a better understanding of the subaquatic processes in Lake Geneva, including geological and physical properties of the Rhone Delta as well as the microbiology and micropollutant dynamics. From June to August 2011 two MIR submersibles will explore the deepest parts of the lake at depths over 300 meters.

The 'Elemo' workpackage 'The canyons of the Rhone delta' focuses on the proximal Rhone delta area. This part of the lake is characterized by a complex underwater morphology with a slope deeply incised by canyons. The sediments of this delta system consist of channel and levee deposits

punctuated by turbidite sequences. A recent multibeam bathymetric survey of the sub-lacustrine Rhone delta greatly improved our knowledge of underwater structures and raised new questions of their possible origin and relationship to mass-movement processes (Sastre et al., 2010):

- What controls the location and shape of canyons?
- How old are the canyon beds?
- How fast do they develop and migrate?
- How old and stable are canyon walls?
- How are Rhone river-floods expressed in canyons?
- How do slope instabilities contribute to the underwater morphology of the lake?

MIR-submersible surveys in the canyons of the Rhone delta will include in-situ observations of sediment structures such as ripples, dunes, scars etc., recorded by video, and sediment sampling in canyon beds and walls. These sedimentological and geomorphological data, complemented by regular core sampling from research vessels, will give us significant information about particle distribution, sediment physical properties, ages of levees/channels and sedimentation rates.

We thank the ELEMOS Scientific Program for their financial support.

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Sastre, V. et al., 2010. Morphology and recent history of the Rhone River Delta in Lake Geneva (Switzerland). *Swiss Journal of Geosciences*, 103: 33-42.

**S11-P02****XRF core scanning and CAT scans as tools for tracking the Holocene flood frequency in Lake Ghirla (Southern Alps, N-Italy)**

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XRF core scanning and CAT scans (computed axial tomography) are two non-destructive and fast tools providing continuous and high-resolution records of lacustrine sediments to track past climatic and environmental changes. While XRF core scanning reflects variations in the elemental distribution, computer tomography mainly illustrates density variations. In addition, the 3-dimensional information included in CAT scans provides knowledge on internal sediment structures and deformations, which is especially useful if slump deposits need to be identified.

Both methods are applied to the Holocene sediment record of Lake Ghirla in northern Italy (lake area 0.28 km<sup>2</sup>; max. water depth 14 m). Sediment cores from Lake Ghirla were retrieved in the framework of the FloodAlp project investigating frequency and intensity of heavy precipitation events in the Alps through the Holocene. Lake Ghirla becomes detritally infilled by flood-triggered turbidite deposits, as revealed by the lake-shore morphology that is dominated by large delta structures and by its flat basin floor seen on reflection seismic data. The catchment area consists of Permian granites with a minor part of Mesozoic dolomites. XRF core scanning was realised with an AAVATECH instrument (Netherlands) at 1 mm resolution; CAT scans were performed with a medicinal instrument (Siemens) at 0.6 mm resolution.

Flood layers are clearly detected by high abundances of detrital elements such as Ca, Sr and Zr in the XRF data and by high density values in the CAT scans. In addition, flood

layers could also be visually mapped for the time period between 4 and 13 kyr. However, sediments younger than 4 kyr are bioturbated and no clear flood layers can be visually identified. Therefore, CAT scans and XRF data are applied to expand the flood record to the present. This Holocene flood record, established by layer counting, XRF data and CAT scans, shows a strong positive correlation to the non-sea-salt K and sea-salt Na concentrations in the GISP2 ice core [1] and to the storminess pattern in the NE United States reconstructed from 13 lake records [2]. In contrast, a clear anti-correlation to the Holocene record of the East Asian summer monsoon is observed [3]. The onset of the bioturbated section at 4 kyr might indicate enhanced lake-water mixing induced by stronger winds, temporally coinciding with a decrease in insolation relative to the earlier part of the Holocene. These results from Lake Ghirla add to the observations on the distribution of northern hemispheric precipitation and thus will contribute to the understanding of the involved circulation patterns and forcing factors.

[1] Mayewski et al. (2004) *Quat. Res.*, 62, 243-255.

[2] Noren et al. (2002) *Nature*, 419, 821-824.

[3] Maher (2008) *The Holocene*, 18, 861-866.

**S11-P03****The geochemical fingerprint of runoff events during the last 70 years in sediments of Lehmühle reservoir (Ore Mountains/ NE Germany).**

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Sediment cores from the Lehmühle reservoir (Ore Mts., Saxony, NE Germany) were used to reconstruct the sedimentation pattern as a



result of major flood events since dam construction in 1931. Altogether 19 flood layers with a thickness between 0.8 and 6.8 mm were detected by a combination of thin section analysis and Micro X-ray fluorescence ( $\mu$ -XRF) scanning techniques. The  $^{137}\text{Cs}$ -based detrital layer chronology was further synchronized with a hydrological dataset from the reservoir management and historical archives (cf. Kämpf et al., 2011). Together with high resolution  $\mu$ -XRF data and sequential geochemical analysis (Jacob et al., 2009) typical geochemical element compositions were identified for each flood. The main results of our study were as follows: (a) the best chemical fingerprint of flood layers was identified to be the index element titanium followed by potassium, (b) even thin detrital layers cause peaks in the  $\mu$ -XRF data of Ti and K, (c) the geochemical composition of winter/spring-floods are characterised by a wide range and lower XRF signals of these two indicator elements (in summer flood layers there was a more narrow range and higher values), (d) only the geochemistry of summer floods correlates with the intensity and duration of floods as recorded in hydrological time series and, (e) a clear relation between the thickness of flood layers as a result of clastic material input and the maximum discharge and duration of the various events could not be observed.

#### References:

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Kämpf, L., A. Brauer, P. Dulksi, K.H. Feger, F. Jacob, E. Klemm, K. Speth (2011): Sediment imprint of the severe 2002 summer flood in the Lehmühle reservoir, eastern Erzgebirge (Germany), Quaternary Science Journal (submitted, in revision).

**S11-P04**

#### Sediment imprint of flood events of different magnitudes in the Lehmühle reservoir (eastern Erzgebirge)

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A series of 18 short cores has been obtained from the Lehmühle reservoir in eastern Erzgebirge (Germany) in order to investigate the effects of the severe flood event in August 2002 on sedimentation by combining microfacies and high resolution  $\mu$ -XRF scanning techniques. A distinct graded detrital layer, unique for the entire record, appears in almost the entire reservoir basin, ranging in thickness from 33 mm at proximal sites close to the river inflow to 5 mm at distal sites. The total sediment influx during this event was estimated to approximately 2,400 tons.

In addition to the exceptional 2002 flood layer, 22 thinner detrital layers were detected in the sediment cores, most of them at the deepest core locations close to the main dam. A chronology of detrital layers was established by  $^{137}\text{Cs}$  dating of three core sequences and was transferred to other cores by correlation based on three lithological markers. The comparison with instrumental data reveals that 62 % of the flood events over the last three decades with a mean daily discharge  $> 7.5 \text{ m}^3\text{s}^{-1}$  of the main inflowing stream (recurrence: 1.5 years) resulted in deposition of a detrital layer in the reservoir basin. The sediment transport into and within the reservoir is modified in comparison to natural lakes: (1) detrital sediment is partly trapped in an open pre-dam, separating the main basin from the river inflow, (2) sedimentation within the main basin is influenced by strong water level fluctuations  $> 15$  meters.

## S12-P01

**1200-yr high-resolution terrestrial climate archive from the middle of the Mediterranean: The sedimentary record from Lake "Specchio di Venere" on Pantelleria Island, Italy**

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The special location of Lake "Specchio di Venere" on Pantelleria Island in the Sicily Channel (Mediterranean Sea) between Tunisia and Sicily offers a unique terrestrial archive recording atmospheric changes, which are otherwise difficult to decipher in the marine records from this area. The lake is an endorheic saline basin with a maximum depth of 12.5 m. As the water input depends on rainfall, precipitation variations influence changes of the lake's water chemistry.

In summer 2008, Lake Venere was cored with a modified Livingstone corer revealing a composite sedimentary sequence of 10.29 m length. Two radiocarbon dates form a preliminary age model indicating a very high sedimentation rate ~80 cm/100 years. Therefore, the recovered sequence allows the analysis of the last 1,200 years in high resolution.

The sedimentology of the core alternates between intervals with carbonate laminations, and sections rich in organic matter with variable amount of detrital influence. The carbonate was likely precipitated during dry climatic periods, when the ratio evaporation/precipitation was high.

Carbonate content is especially high in the lower part of the core between 800 and 950 years AD. The carbonate content stays low for about 3 centuries, before several intervals of intermediate carbonate content separated by nearly carbonate free sediment occur. In the last 130 years, the carbonate content increases.

The carbonate curve closely follows the general European climate evolution of the last millennium. Intervals rich in carbonate in the lower part of the Venere core coincide with the medieval warm period (WMP), whereas during the little ice age (LIA) (1250 - 1850 years AD) little or no carbonates were deposited. Pollen analysis suggests vegetation responded to the climatic changes we inferred from litho-stratigraphical properties. During the period 800-1050 AD, drought and disturbance-adapted, evergreen-broadleaved trees (e.g. *Olea*, *Q. ilex*), shrubs (e.g. *Pistacia*), and heliophilous herbs (e.g. *Artemisia*) dominated the vegetation of the island, and conifers were moderately abundant (on average 20-30% of the pollen sum). Afterwards conifers (*Pinus pinaster*) expanded, while *Olea*, *Q.ilex*, and open environments declined. From 1800-2000 AD *Quercus ilex* and *Olea* re-expanded and conifers became less abundant. Today dense *Pinus pinaster* forests are restricted to higher altitudes of the island, where moisture is more abundant. The pronounced negative correlation between evergreen broadleaved and conifers is also registered at decadal scales, with rather strong and abrupt oscillations during and after the LIA period. However, vegetational changes were certainly co-determined by land-use, which was quite intense in the past, as also shown by widespread stone-terrace constructions for crop cultivation. This initial analysis shows the potential of the Lake Venere sedimentary record as a valuable climatic and environmental archive for the Central Mediterranean.

**S12-P02****The varved record of Lake Montcortès (southern Pyrenees, NE Spain): climate variability and human activities in a Mediterranean mountain since the Roman Period**

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The sedimentary sequence of karstic Montcortès Lake (Southern Pyrenees, NE Spain) constitutes the first continuous, annually-resolved record in northern Spain spanning the last 3500 cal yrs BP. The permanent anoxia in the hypolimnion, the development of algal blooms in spring and the strong seasonality of Mediterranean climate have favored the formation and preservation of biogenic varves composed of couplets of calcite and organic layers punctuated by grey detrital layers. A high-resolution sedimentological microfacies study carried out in sediment cores retrieved from the deep areas (30 m deep) has enabled the reconstruction of the paleolimnological evolution and the human-climate interactions during the last 1.5 ka. The robust age model is based on absolute varve chronology supported by 4 radiocarbon dates and 210Pb dating.

The variable allocthonous detrital input into the lake, the calcite layers thickness and the internal varve texture variations identified

warmer and relatively more arid conditions between AD 580-660 and AD 1000-1322 synchronously to some phases of the Dark Ages Cold Period (DACP) and the Medieval Climate Anomaly (MCA) respectively, and colder temperatures between AD 1322-1817 during the Little Ice Age (LIA). An abrupt increase in sedimentation rate is parallel to higher human occupation and an increase of farming activities during the High Middle Ages (10-13th centuries) and the 19th century.

The sedimentary record of Lake Montcortès documents the hydrological impact of recent climate fluctuations (DACP, MCA, LIA and 20th century warming) and the significant impact of farming activities in the area. The consistent pattern of higher temperatures and aridity during reconstructed persistent positive NAO phases (MCA) and colder and relatively more humid conditions synchronous to sunspot minima periods within the LIA suggest a link between regional patterns of climate variability, solar activity and North Atlantic dynamics during the last millennium.

We thank DAAD Project (D/07/13363) and 'ELEMO' research program (subproject 101) for their financial support.

**S12-P03****A new, high resolution carbonate isotope record of early to mid Holocene climatic change from the varved sediments of Nar Gölü, central Turkey**

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There is active debate about the relationship between past climate variations and cultural change in the Eastern Mediterranean, a region of great importance for human cultural evolution. However, there are no continuous,

sensitive and well-dated records that can resolve sub-centennial climate events, which may have been crucial in forcing societal change (Staubwasser and Weiss, 2006, QR, 66, 372). In addition, although a number of isotope records from lakes in the Mediterranean region have been published in the last decade and regional patterns have been identified (Roberts et al., 2008, QSR, 27, 2426), the correct way to interpret the records is debated. This has led to differing interpretations of Holocene climate in the region, particularly conditions before and after the Mid Holocene Transition, with similar isotope records interpreted as showing changes from wet to dry (Eski Acigol, Turkey - Roberts et al., 2001, The Holocene, 11, 721) and from dry to wet with an associated change in rainfall seasonality (Mirabad, Iran - Stevens et al., 2006, QR, 66, 494).

A core spanning the late glacial and Holocene has been retrieved from Nar Gölü, a crater lake in Cappadocia, central Turkey. Previous studies on a shorter sequence from Nar Gölü showed the site's potential for the production of high resolution, well-dated records from its varved sediments (Jones et al., 2005, JoPI, 34, 391; Jones et al., 2006, Geology, 34, 361; England et al., 2008, The Holocene, 18, 1229; Woodbridge and Roberts, 2010, JoPI, 44, 855). Monitoring by water sampling and sediment traps since 1998 means the modern isotope hydrology of the lake, as well as the timing of sedimentation, is well understood. Carbonate  $d^{18}O$  from the past 80 years has been calibrated with the meteorological record, indicating that summer temperatures and evaporation are the dominant controls (Jones et al., 2005).

Preliminary oxygen isotope analysis of the carbonates and organics has been carried out on the whole core at a resolution of ~160 years. In addition, oxygen isotope analysis on the carbonates at a 40 year resolution through the last glacial-interglacial transition and mid Holocene has produced one of the highest resolution records to date from the region for this time period. High levels of climate variability during the early Holocene and a

transition in the mid Holocene from wet to dry conditions are apparent, matching other records from the region (e.g. Roberts et al., 2001; Eastwood et al., 2007, JQS, 22, 327). The varved sedimentary record from Nar Gölü and the sensitivity of the site to climate change make it a key location in furthering understanding of regional palaeoclimate and human-environment interactions.

## S12-P04

### An increase of $d^{18}O_{carb}$ at the beginning of the Holocene - oxygen and carbon isotope data from lake successions from northern Poland

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The results of oxygen and carbon stable isotope investigations of the Late Glacial/Holocene lacustrine sediments from northern Poland (Skaliska palaeolake) are presented. Stable isotope analyses were done for authigenic carbonates from two profiles: W1 - Piotrowo-Lawniki and W2 - Sakiely Male, containing carbonate silts on the bottom, then calcareous detritus gyttja and at the top - organic silts and peat. The values of  $d^{18}O$  change from ca. - 8.9 to - 4.5‰, and  $d^{13}C$  values oscillate between - 4.2 and + 0.1‰. Such a large range of isotopic data reflects changing conditions in the lake during accumulation of deposits (different water level, water temperature, bioproduction).

The palaeolake originated during the final phase of the Younger Dryas. The Late Glacial deposits are characterized by  $d^{18}O$  values of ca. -6.5‰ and  $d^{13}C$  of ca. -1‰. These isotopic values might be associated with input of dispersed detrital carbonates from the adjacent areas. At the final time of the Younger Dryas a rise or a fluctuation in  $d^{18}O$  values occurs in this palaeolake. It could be likely caused by short-time shallowing (ice-cover, blocked inflow?).

At the transitional time between the Late Glacial and the Holocene,  $d^{18}\text{O}$  systematically decreases below  $-8\text{‰}$ . The lowering of the  $d^{18}\text{O}$  values reflects a substantial change in the isotopic composition of the lake water caused by inflow of water enriched in light oxygen isotopes. It could be through the inflow of meltwater. At that time, a trend of  $d^{13}\text{C}$  is similar to  $d^{18}\text{O}$ .

During the Preboreal period, initially both of the  $d^{18}\text{O}$  and the  $d^{13}\text{C}$  values systematically decrease and reach a minimum ( $-8.4\text{‰}$  for  $d^{18}\text{O}$  and ca.  $-3\text{‰}$  for  $d^{13}\text{C}$ ). Then an increase of above  $2\text{‰}$  in  $d^{18}\text{O}$  and of ca.  $1\text{‰}$  in  $d^{13}\text{C}$  values and re-drop in oxygen isotopic values occur. These varying trends in  $d^{18}\text{O}$  record are likely connected with changing circulation of air mass causing the fluctuations both of rainfall and isotope composition of water.

## S12-P05

### The effect of groundwater in sedimentation in karstic lakes: Late Quaternary depositional evolution of Banyoles Lake (Catalonia, NE Spain)

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Lake Banyoles ( $42^{\circ}08'\text{N}$ ,  $2^{\circ}45'\text{E}$ ; 175 m a.s.l.) is the largest and deepest (46.4 m) lake of karstic-tectonic origin in the Iberian Peninsula. Its location, close to the boundary between the Eurosiberian and Mediterranean bioclimatic regimes makes this area very sensitive to hydrological and environmental fluctuations. Previous research carried out in the Plio-Quaternary deposits of the

surrounding areas (Banyoles-Besalú paleolake) has demonstrated the potential of the lake as an archive of environmental changes in the Western Mediterranean region. The lake basin is characterized by a complex bathymetry that results from its karstic origin encompassing eleven sub-circularly shaped depressions fed by individual groundwater springs.

In the frame of the ongoing projects GLOBALKARST and BanBu, involving geoscientists from several European institutions, this sedimentary basin has been explored using both seismic and multicoring techniques. High-resolution seismic surveys conducted with a 3.5 kHz pinger and multi-beam CHIRP profilers provide a quasi three-dimensional image of the sedimentary fill and enable reconstruction of the main depositional phases during the late Quaternary. Multi-proxy analysis of long percussion piston-cores recovered in the Northern and Southern platforms of the lake, including sedimentary facies, Geotek-MSCL, XRF-core scanner and other compositional and biological proxies have demonstrated large hydrological fluctuations in the system over the last millennia. Establishing a robust chronology by  $^{137}\text{Cs}/^{210}\text{Pb}$  and AMS  $^{14}\text{C}$  dating is in progress.

Preliminary results are consistent with previous limnological research carried out in the lake and demonstrate different sedimentation rates and patterns in the two main sub-basins. These results emphasize the peculiarities in the depositional processes that are highly influenced by groundwater input and karstic processes. According to previous limnological research carried out in Lake Banyoles (Colomer et al., 2002; Serra et al., 2002 and 2005), the groundwater flow in the deepest and largest depressions leads to periodic fluidification of the sediments and their subsequent transport by turbidite currents sweeping over the southern platform. These fluidification events occur during periods of higher groundwater discharge caused by high precipitation periods in the catchment (Soler et al., 2007 and 2009) and are likely responsible of the deposition of

homogeneous layers in the southern platform. We evaluate the number, thickness and age of the homogeneous layers on the southern platform as a proxy to estimate frequency and intensity of high rainfall events. Preliminary data show a good correlation with limnological and meteorological data and strengthen the potential of the Banyoles sequence as a paleohydrological and palaeoenvironmental record.

## S12-P06

### Lithostratigraphy of Lake Van sediments over the past 400.000 years

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Within the frame of the International Continental Scientific Drilling Program (ICDP) project PALEOVAN, a partly laminated sediment record from Lake Van, a closed lake situated in a climatically sensitive semiarid and tectonically active region in Eastern Anatolia, has been drilled in summer 2010. At two sites, Ahlat Ridge (AR) and Northern Basin (NB), sedimentary records of 220 and 140 m were recovered, respectively. Preliminary results from 1) core-catcher analysis during drilling operations in the onshore laboratory and from 2) facies analysis during the first sampling party in spring 2011 at the IODP core repository in Bremen document the sedimentological and geochemical succession. The composite profile from the Ahlat Ridge, is composed of seven parallel holes and is in total 218.5 m long including 29 gaps of total 19.7 m. The sedimentary record consists of cm- to m-thick beds of lacustrine (62% of AR) and pyroclastic (9% of AR) deposits. Interbedding of alternating cm-thick beds of lacustrine and pyroclastic deposits are defined as intercalations (18% of AR). Most spectacular are numerous beds containing hundred to thousands of fine sub-mm laminae

(15% of AR) which are interpreted as varves (in analogy to the modern depositional environment). In general, the laminated and non-laminated lacustrine clayey silt, is composed of clay minerals and carbonate. On the basis of macroscopic sediment descriptions, six lacustrine (L) lithotypes are defined within the sedimentary succession: L1) laminated clayey silt, Lf) faint laminated clayey silt, Lmo) mottled clayey silt, Lb) banded clayey silt, Lm) massive clayey silt, and Lg) graded clayey silt. Each lithotype appeared in various colors and the color changed drastically during oxidation. However, prominent sediment colors are brown, grey, crème, greenish and red tones. Eye-catching single red and green laminae are observed within the laminated clayey silt. Microscopically, mainly autochthonous carbonates are observed next to vitric glass and amorphous organic material. Well-preserved centric and elongated diatom frustules appear in particular below 190 mcbf. Additional to the lacustrine and pyroclastic deposits, the lowermost sediment is composed of gravel and is overlain by sand deposits that contain fresh-water gastropods (*Bithynia*). Apart of the undisturbed bedding and lamination, irregular stratification and deformation structures such as disturbed laminations, microfolds and microfaults were observed frequently. The sharp and great downcore lithologic variability is indicative of a highly and rapidly changing depositional conditions forced by lake-level and other climate-driven changes and by tectonic events over the past 400.000 years. The basal Ahlat Ridge sequences reflect the early transgressive state of the lake's history, and its evolution from an open to a closed system, i.e. from fresh to saline water, because the site reached acoustic' basement, which to its lithology (indicative for a beach-like environment) and hard nature, could not be penetrated further. Upcore, glacial (banded to massive) and interglacial/interstadial periods (laminated) are interpreted from the lithological succession. Argon-argon dating, magnetostratigraphy and orbital tuning will be used to establish an age model. Complementing the age model, with varve

counting enables us to study signals at decadal to annual resolution. Standardized sample sets (every 20 cm) for ongoing multiproxy analysis will give detailed insight into paleoclimatological and paleoenvironmental conditions. This unique paleoclimate archive hints to a fascinating evolution of the environment and has ideal prerequisites for the investigation of the Quaternary climate evolution in the Near East.

### S12-P07

#### Climate Variability and Human Impact on Karstic Lake Stymphalia during Late Glacial to Holocene times (NE-Peloponnese, Greece)

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Known from the ancient Heracles myth of the Zeus' son slaying the Stymphalian birds, the mountainous region of Stymphalia (22°27'E/37°51'N, 600 m above sea level) is an ideal site to study the environmental history of the area by combining the climate archive of lake sediments with the historical and archaeological record of the nearby ancient settlement of Stymphalos. Above all, we aim to distinguish the natural versus human-induced environmental change and compare the results to other areas in the Peloponnese and the Eastern Mediterranean region.

Lake Stymphalia is the only natural perennial lake on the Northern Peloponnese today, which provides a continuous sedimentary

record of the entire Holocene and a large part of the Last Glacial. As a large and quite reliable water reservoir, Lake Stymphalia and its surrounding karst springs played an important role for the water supply of the region from ancient time until today. However, due to climate fluctuations, the water supply can change significantly, challenging the water management of the people living in the area.

The climatic and environmental variability of the ancient Arcadian region, as it is documented in the lacustrine sediment core STY-1, is connected with human development in the karst polje of Stymphalia. Historical sources and archaeological findings indicate settlement activity since at least the 5th century BC at Stymphalos. Hence, the spatiotemporal patterns of land use and water management and the effect of climate on the environmental development of the region are reconstructed.

Here we present geochemical analyses of the uppermost part of a lake sediment core (STY-1), recording the changes in climate and water supply during the Holocene and the Late Glacial. The chronology is based on several C dates combined to a Bayesian age-depth model. Using XRF elemental analysis, we compare the influx of terrestrial material (indicated by K and Rb) to the carbonate precipitation in the lake (indicated by Ca and Sr). The Rb/Sr ratio as a proxy for changes between dry/warm and wet/cold conditions indicate pronounced wet phases around 6800, 4000-3700-4000, 3500-3000 and 500-200 cal BP.

### S12-P08

#### Recent and fossil ostracodes of Lake Ohrid (Republic of Macedonia/Albania) - Anthropogenic and environmentally driven changes in their spatial distribution

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Oligothropic ancient Lake Ohrid, with a maximum water depth of 289 m, is located in a tectonically active graben system at an altitude of 693 m.a.s.l. and is characterized by a high degree in endemism. Because knowledge of ecological preferences of ostracode species, small bivalved crustaceans, is poor and accurate taxonomy is essential for interpreting subfossil ostracode assemblages from sediment cores, we perform autecological and taxonomic analyses of recent ostracodes in Lake Ohrid and its catchment. To test if eutrophication has an impact on ostracode species assemblages we have taken short cores from presumably polluted (nearby the cities of Struga, ST09, and Ohrid, OH09) and pristine sites (near Sveti Naum, SV09). The cores were <sup>210</sup>Pb and <sup>137</sup>Cs dated, geochemically analysed and sampled for ostracodes.

Initial results from our survey of living ostracodes based on 200 samples from Lake Ohrid provided 34 species belonging to 13 genera: *Candona*, *Fabaeformiscandona*, *Candonopsis*, *Cypria*, *Cyclocypris*, *Ilyocypris*, *Eucypris*, *Prionocypris*, *Dolerocypris*, *Leptocythere*, *Paralimnocythere*, *Cytherissa*, and *Darwinula*. The most prominent species was *Cypria lacustris* that occurred in all water depths ranging from the littoral down to 280 m. The most common group were the Candonidae representing about 52% of all species. Even in 280 m water depth five living ostracode species were found. In the catchment of Lake Ohrid 21 species were discovered of which 14 also occurred in the lake itself.

We identified a total of 27 ostracode species in the short cores (17 in ST09, 25 in OH09 and 14 in SV09) out of which ten species were not yet found in our recent sediment samples. Dominant species in ST09 and SV09 was *Candona trapeziformis* and in OH09 *Candona hadzistei*. Higher ostracode diversity and abundances occurred near the cities of Struga and Ohrid than near Sveti Naum.

## S12-P09

### High-resolution multi-proxy study in Basa de la Mora sequence (Spanish Central Pyrenees): a Holocene reconstruction of climate, human impact and vegetation cover variability

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La Basa de la Mora is a small lake of glacier origin located at 1914 m asl in the Cotiella massif in the Central Pyrenees. A frontal moraine dams the lake in the southeastern margin. Cretaceous limestones dominate the catchment area but the bottom of the lake is constituted by impermeable material from Triassic formations. The lake is shallow (2-3 meters depth) and relatively small (6 ha surface area) but it is permanent. The main input of water and detrital sediments comes from several creeks particularly active during the snow melting season. The vegetation surrounding the lake is composed mainly by both alpine grassland and *Pinus uncinata* forest. The local vegetation varies from evergreen oak formations at southern slopes to mixed *Pinus sylvestris*/deciduous taxa forest at northern slopes.



A 12 m long core was recovered from the distal area of the lake using the UWITEC platform and analysed for its sedimentological and geochemical properties and for its palynological and chironomid content. The age model is based on 13 AMS  $^{14}\text{C}$  dates providing evidences of a continuous sedimentary sequence for last 10.500 years. The sediments consist on banded to massive carbonatic silts with low organic content (mostly of terrestrial origin) and abundant detrital particles (quartz, clay minerals). Three main depositional environments are defined:

(1) a deeper lake with sedimentation dominated by clastic particles supplied by active creeks from 10.500 to 5800 years BP;

(2) a shallow lake, with precipitation of endogenic carbonates associated to the development of the palustrine area from 5800 to 800 years BP and

(3) a return to deeper conditions and intensification of the exogenic sedimentation for the last 800 years.

This succession is supported by preliminary palynological data showing *Betula* as main arboreal taxon during the Early Holocene, that decreases abruptly at 5800 years ago confirming an aridity trend. The increase in *Artemisia* and *Juniperus* towards the top of the sequence (last 800 years) indicates a stronger influence of human activities in the region. Chironomid record also shows the same three zones defined by changes in their total densities and in taxa composition.

This new Pyrenean sequence is coherent with previously studied sequences in the Iberian Peninsula where a transition from a generally more humid Early Holocene to a drier Middle Holocene was established. The elevated sedimentation rates attained throughout the Holocene in Basa de la Mora lake (117cm/kyr) arise the opportunity to differentiate abrupt climate changes, such as the 8.2 or 4.2 kyr events, that appear as dry and cold periods in this region with a vegetation characterized by *Pinus* in the first case and a great decrease in

all arboreal taxa in the latter. Further analyses increasing the resolution and improving the chronology will reconstruct with a high detail the climate and anthropogenic changes that took place in this area during the Holocene.

## S12-P10

### Dynamic of CO<sub>2</sub> emission from Pinatubo crater lake, Philippines

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We report herein the first surveys related to diffuse CO<sub>2</sub> emissions from Pinatubo Crater Lake (PCL), Philippines. The Mount Pinatubo volcanic complex is located on the island of Luzon, 90 km northwest of Manila in the Philippine Islands. The 1991 eruption, one of the world's largest of the 20th century, was the second-largest of the past century, venting about 5 km of magma and producing voluminous pyroclastic flows, forming a small, 2.5-km-wide summit caldera whose floor which is now covered by a lake. Caldera formation lowered the height of the summit from 1745 to 1486 m. During the last years, several studies have focused on CO<sub>2</sub> emission from volcanic lakes. After the gas disasters at lakes Monoun (1984) and Nyos (1986), both in Cameroon, the accumulation of CO<sub>2</sub> in these lakes has been well known by the scientific community. This led to the recognition that volcanic lakes are hazardous. Since a large amount of magmatic gases is dissolved in the water, CO<sub>2</sub> degassing from volcanic lakes, which occurs by bubbles (convective/advection degassing) or by diffusion through the water/air interface, should be a process to be taken into account.

Since 2008, ITER in collaboration with PHIVOLCS and with the support of the Minister of Science and Education of Spain and the Spanish Aid International Agency (ACECID), has been performing regular CO<sub>2</sub> efflux surveys at the surface environment of PCL. Measurements have been performed following the accumulation chamber method to determine the scale of total CO<sub>2</sub> emissions at the PCL and to evaluate their temporal and spatial variations in relation with the volcanic-seismic activity. At each survey, about 100-150 measuring points are selected at the surface of PCL to obtain an even distribution of the sampling points over the area of study. The GPS positioning of each measurement point is always recorded with a resolution  $\pm 5$  m. Together with these measurements, water temperature, pH and conductivity have also been undertaken. In general, relatively high diffuse CO emissions values were measured if are compared to other volcanic lakes. Surface anomalies at PCL have shown changes in both location and magnitude during this study. Results of CO<sub>2</sub> efflux surveys performed in March 2008, February 2009, March and November 2010, and March 2011, showed total diffuse CO<sub>2</sub> outputs of  $711 \pm 17$  t/d,  $928 \pm 19$  t/d,  $1014 \pm 16$  t/d,  $375 \pm 13$  t/d and  $468 \pm 18$  t/d, respectively. These results do not show significant variations during the period of study and do not seem to be masked by external variations. However, to perform regular diffuse CO<sub>2</sub> emission surveys at PCL will be important for detecting possible changes in the activity of the volcano and to contribute to the volcanic surveillance program at Pinatubo volcano.

### S12-P11

#### Climatic and hydrologic changes in Moroccan Middle-Atlas

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This study deals with climatic and hydrologic changes in Moroccan Middle-Atlas. Four cores have been sampled in Tigalmamine site and dated by 14C. Diatoms from this site show new data for some species of *Cyclotella* genera and give valuable informations concerning the hydroclimatic changes.

At Tigalmamine, from 18Ka BP. to present-day, a succession of three species related to hydroclimatic changes have been found: *Cyclotella* sp. aff. *comensis* type 1 and *Cyclotella* sp. aff. *comensis* type 3 characterizing a wet and cold conditions from 18 to 7 ka B.P., the type 3 is likely to be associated with severe climatic conditions about 18-16 (?) Ka B.P., 10.3-10 Ka B.P., and 8-7 Ka B.P. *Cyclotella azizensis*, which became dominant from 10-9 Ka B.P. to present-day time, shows a more wet and warm conditions, particularly between 7 ka B.P. and present-day.

The study of diatoms is used as a tool to determine the water level fluctuations. We conclude that wet and warm conditions during the Late glacial (16 à 10 Ka B.P.), at about 9 Ka B.P., and finally at 7 Ka B.P. 100 to 400 yrs climatic crisis are recorded at Tigalmamine site and seem to occur every 2000-3000 yrs. Each crisis is framed by 50 yrs severe arid episodes.

### S12-P12

#### Primary, bacterially induced pseudospherulitic fibrous calcite in the Quaternary lacustrine carbonates of the Farafra Oasis, Western Desert, Egypt: Petrographic and geochemical evidence

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The pseudospherulitic fibrous calcite (PFC) has been found as a major constituent of the Quaternary lacustrine massive limestone

layers in the Farafra Oasis, Western Desert, Egypt. The massive limestone layers vary in thicknesses between 2 and 5 cm. They form a rhythmic cyclic succession with thin massive mudstone beds that possess thicknesses range from 5 to 10 cm. This cyclic succession represents mudflat-shallow lacustrine facies association, which occurs within a depositional sequence consisting of distal alluvial-floodplain and palustrine facies associations.

The PFC is composed mainly of single calcite crystals with intracrystalline fibrous microfabric marked by fibers radiated from the center of the individual crystals. The PFC occurs as loosely packed 300 to 500  $\mu\text{m}$ -sized crystals exhibiting poorly developed faces, which usually results in a rounded to sub-rounded morphology of the crystals. The individual PFC crystals also show spherulitic to lobate growth forms, and clumps of ellipsoid to sub-globular bodies. Under cathodoluminescence, each PFC crystal exhibits an alternation of dull non-luminescent and bright orange luminescent irregular zones that do not reflect euhedral crystal faces. Chemically, the PFC is of low-Mg calcite type that has low concentration of Na (0.11-0.20%) and Sr (70-110ppm). It also has slightly negative values of  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  (-0.51 to -2.19‰ and -4.65 to -5.96‰, respectively). The matrix between the individual PFC crystals is mainly honeycomb-like smectite that has little projections of palygorskite fibers. A combination of CL, SEM and microprobe analyses revealed that the PFC crystals are free of mineral inclusions or relics.

The PFC is postulated to be of a primary precipitate. This assumption relies on: (i) the PFC does not represent Microcodium structures, root-calcification, globulites of speleothem, calcite spherulites of laminar calcretes, and calcitization of precursor dolomite or aragonite, (ii) the homogenous compositional and textural characters of the recognized calcite mineral, (iii) the occurrence of the studied PFC-bearing carbonate layers in between impermeable massive mudstones, which tend to act as physical barriers

impeding fluid flow and retarding diagenetic processes during burial, (iv) the occurrence of the early formed-clay minerals in the PFC that would provide an adequate medium, in terms of diffusion transport, to the fibrous growth in calcite, and retard compaction during burial, preserving original primary texture of the PFC. A role of bacterial contribution in the PFC crystallization is assumed in the view of its internal microfabric characteristics (irregular and lobate internal growth patterns), and morphological features (subglobular to spherical appearance), in addition to its possessing to slightly negative values of  $\delta^{13}\text{C}$ . The trace-elemental concentrations (Na, Sr and Mn), and oxygen stable isotopic measurements ( $\delta^{18}\text{O}$ ) in the PFC reflect its deposition in a well-oxygenated fresh water. In conclusion, the PFC is interpreted as a primary precipitate induced by bacterial activity (cyanobacteria) in a hydrologically-open, short-lived freshwater lake with base-level fluctuation.

### S12-P13

#### Diatom response to major Quaternary transitions in Mediterranean ancient lakes: implications for quantitative reconstruction

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The ancient, karstic, tectonic lakes of Ohrid (Albania/Macedonia; a graben) and Ioannina (NW Greece; the base level of a major aquifer) are located ca. 350 km apart at 693 m and 470 m a.s.l., respectively. Reflecting the growing awareness of these lakes for global climate reconstruction, preliminary diatom analysis of two complete sequences from Ohrid (LZ1120; ca. 39.5 ka and Co1201; 135 ka) and of the last

three Terminations in Ioannina (I-284; >200 ka) demonstrates a very clear diatom response to climate change. Both lakes are dominated by *Cyclotella* taxa, including various *C. ocellata* morphotypes, and small *Fragilariales*. The character of diatom response varies both between lakes and, in the case of Ioannina, over time, however. This has important implications for the assumption that taxa exhibit a linear response to climate. Interpretation of past climate variability requires an understanding of the individual lake and its changing response thresholds over time.

### S12-P14

#### Late Pleistocene and Holocene lake-level changes at Ioannina, northwest Greece

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A reconstruction of lake-level changes since the Last Glacial Maximum (21,000 years ago) at Ioannina, northwest Greece, is presented. The research addresses outstanding palaeoenvironmental questions in the eastern Mediterranean, including determining the impact of abrupt (centennial-scale) climatic

events. Lake-level variability in closed basins is indicative of climatic change as it is largely a consequence of the balance between precipitation and evaporation. A robust multi-core, multi-proxy methodology was adopted, with diatom analysis proving to be a particularly useful lake-level indicator. The reconstruction reveals shallow waters during the Last Glacial Maximum, implying aridity in the region. Lake-level deepening during the Lateglacial Interstadial suggests a wetter climate, and contemporaneous pollen evidence indicates that this coincided with warming. The Younger Dryas event caused a lowering of lake-levels along with a set-back in the spread of thermophilous vegetation in the region, and this is the first convincing evidence for the impact of this event in northwest Greece. The lake deepened rapidly at the onset of the Holocene, with deepest lake-levels being achieved around 9.0 cal kyr BP. Long-term shallowing commenced around 7.0 cal kyr BP. There is little evidence that abrupt climatic events such as the 8.2 ka event and 4.2 ka events were significant enough to influence lake-levels at Ioannina, and orographic precipitation in the area may have been a significant buffer against shallowing. The impact of human activity in the area is recorded in the Ioannina sediments across the last 5,000 years. The reconstruction prior to human interference is in general agreement with a nearby reconstruction from Lake Xinias, central Greece, indicating that climatic change is the dominant driver of the observed trends.

### S13-P01

#### Characteristics of the Climate and Environment over the Past 150 Years Recorded in Lacustrine Sediment in Arid Xinjiang, NW China

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Lake Chaiwopu, Xinjiang, NW China, is a closed-basin, shallow lake that responds rapidly to changes in the ratio of precipitation to evaporation (P/E). A sediment core recovered from the Lake was analyzed for grain size, organic matter content,  $d^{13}C$  of organic matter and magnetic susceptibility to reveal the history of changes in the regional climate and environment over the past 150 years. Based on modern observations, the content of organic matter in the sediments is interpreted to reflect the regional precipitation and the organic  $d^{13}C$  is inferred to reflect air temperature. Ordinal sample optimal cluster analysis was used to divide the element-content sequence of sediment core into several stages characterizing the pattern of changes in the climate and environment. The data indicate that the lake displayed high levels and the climate was slightly cold and wet 1860 ~1910AD. From 1910 to 1950AD, grain size, geochemical indicators, organic matter content and magnetic susceptibility all showed significant fluctuations, and organic  $d^{13}C$  continuously become heavier, suggesting the variability of the lake environment and the instability of the regional climate. Around 1920AD, grain size displayed a sudden shift, and organic  $d^{13}C$ , loss on ignition and element contents exhibited obvious variations, implying the occurrence of abrupt changes in the climate and environment. During the past 50 years, magnetic susceptibility was high, and heavy metal and total phosphorus contents were enriched in the lake sediments, denoting the impact of human activities on the environment of the lake region. Changes in the organic matter content and organic  $d^{13}C$  are consistent with variations in the observed temperature and precipitation, indicating the combined effect of the recent climate changes and human activities on the lake environment.

### S13-P02

**Origin of shallow lakes in the agricultural region of Khorezm, Uzbekistan and temporal trends in DDT and HCH concentrations from these lakes**

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The Khorezm province in Uzbekistan is an agricultural area within the Aral Sea Basin, where human impacts on the Amu Darya River have affected aquatic ecosystems. The landscape is dotted with small lakes in natural depressions that receive irrigation runoff, inflow of Amu Darya river water via canals, and groundwater. The origin of these lakes is important because if they are natural, they may persist if the hydrologic regime is changed by removing excess irrigation water inputs to the lakes. However, if the lakes were formed by human activity, they may desiccate if irrigation excess is no longer available, causing associated aquatic ecosystems to be extirpated as well as posing dust hazards to nearby communities. To assess the origin of these lakes, 0.5 to 1 meter length cores were taken in 13 lakes throughout the province. Only 1 of the 13 lakes had fine-grained sediments (mud) deeper than 60 cm from the top of lake bed. Unlike cores from the other lakes, the core from this lake did not penetrate to a sand layer, rather organic carbon content of samples at the bottom of the core were less than half that of samples above, indicating the bottom of the mud was likely within 5 cm beyond the end of the core. All cores changed relatively abruptly from mud to eolian and alluvial sand, with organic carbon content changing from > 5% organic carbon in the mud to generally < 2% organic carbon in the sand. Age dating models using <sup>137</sup>Cs and <sup>210</sup>Pb measurements indicate that all sampled lakes are <100 years old and that some lakes have experienced intermittent mixing and desiccation. While some lakes in the region may be naturally occurring, evidence from this study indicates that the majority of lakes formed from human modification of the landscape to

accommodate agricultural activities. Therefore, if less water is used for agriculture, these lakes could shrink or desiccate completely.

Sediment cores were also analyzed for the pesticides p,p'-DDT (p,p'-dichlorodiphenyltrichloroethane) and lindane (gamma-hexachlorocyclohexane; gamma-HCH), which were widely used in the region during Soviet occupation of Uzbekistan with application rates of up to 2 kg/ha by aerial spraying before 1983. Although DDD concentrations (an anoxic pathway degradation product of the parent p,p'-DDT compound) in surface sediment from the 13 lakes statistically correlate with greater amounts of agriculture surrounding the lakes, the concentrations are low. The sum of DDT ( $\Sigma\text{DDT} = \text{DDD} + \text{DDE} + \text{DDT}$ ) and sum of HCH ( $\Sigma\text{HCH} = \text{alpha-HCH} + \text{gamma-HCH}$ ) over time show peak concentrations generally  $< 8 \mu\text{g/Kg}$  for  $\Sigma\text{DDT}$  and  $< 4 \mu\text{g/Kg}$  for  $\Sigma\text{HCH}$  in the 1960s, although some lakes show later peaks, and some show no peaks. Consensus-based probable effect concentration for DDT and gamma-HCH are 62.9 and 4.99  $\mu\text{g/Kg}$  dry weight, respectively, indicating that these lakes are below these guidelines, even at observed peak concentrations.

### S13-P03

#### Reconstruction of evolutionary processes from resting egg banks of *D. pulicaria* in Lower Lake Constance

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Lake sediments often were used to reconstruct environmental changes in many lakes in Europe and world wide. Severe ecological changes induced by human impact provoke new selective pressures which, in addition to natural ones, act on freshwater

organisms. Resting eggs buried in the sediment can be used as genetic archives of the occurring species. Utilization of these egg banks allows the reconstruction of historically occurring genotypes in the habitat, thus revealing adaptations of species due to ecological changes. In this study, the consequences of eutrophication and re-oligotrophication on the genetic constitution of *Daphnia pulicaria* populations in Lower Lake Constance have been investigated. *D. pulicaria* invaded Lower Lake Constance in the early 1970s during maximum eutrophication. Resting eggs were isolated from sediment layers of different ages to compare genotypes of progeny of past populations. Colonization and migration patterns were analysed by changes in allele frequency of six microsatellites in DNA samples extracted from resting eggs. By reconstructing the population dynamics over the last 40 years, i.e. during the change from eutrophic to oligotrophic conditions, we found multiple invasion patterns. These enriched the gene pool of the early founding populations and led to a range of different genotypes. Changes in the genetic constitution suggest that *D. pulicaria* populations have been subjected to strong anthropogenically induced ecological changes in Lower Lake Constance within the last 40 years.

### S13-P04

#### Spatial Modeling Approach for the Assessment of Anthropogenic and Climatic Impact on Lake Systems

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The characterization of species-ecological niches is an important asset for the identification of variables, such as

temperature, precipitation, chemical properties and others, that influence the species-potential distribution. In this particular research field a number of stand-alone tools such as GARP or MaxEnt are employed to model subaerial species potential distribution as a function of environmental variables. However, in order to describe and parameterize species distribution in a subaquatic system, a three-dimensional approach is needed to account for variables such as water temperature, pH-value, conductivity and others as a function of location and waterdepth. In addition, time-dependent boundary conditions such as local currents and swell must be considered within their time-dependent framework. The complexity and interrelationships between variables required to describe a subaquatic system demand for integrated software solutions which are capable of administrating and analyzing spatial datasets based on a variety of datamodels. We here provide a conceptual approach for establishing one possible 3-dimensional, subaquatic model framework with workflows combining the predictive power of the maximum-entropy method with the capabilities of a commercial GIS software suite.

### Index Terms

Species distribution modeling, Anthropogenic Influences, Climatic Influences Maximum Entropy Method, Ecology, Geoinformation Systems

Ecological applications in research fields such as invasive species management, sustainable nature conservation and the impact assessment of climatic and anthropogenic influences on an ecosystem require the prediction of geographic distributions of species based on environmental boundary conditions at a number of sample sites [1]. Several methods such as the maximum entropy approach, realized in the software "MaxEnt", the "Genetic Algorithm for Rule-set Production", realized in the software "GARP" and the DOMAIN software package which delivers a suitability index by computing the minimum distance in environmental space to presence records are commonly employed to perform static modeling tasks [2]. Distribution

modeling of occurrences of certain species within a well-defined geospatial context is of utmost importance in order to characterize and quantify habitats and their ecological boundary conditions. With the focus on anthropogenic and climatic influences on lake systems, species-distribution modeling and the identification of boundary conditions become increasingly important with respect to paleoclimate and the paleoecology of a lake. Current GI-systems and static modeling methods are well suited to predict a species distribution within a 2-dimensional, subaerial domain. In order to describe a subaquatic ecosystem such as a lake, a 3-dimensional approach is needed in order to address changing environmental conditions also as a function of water depth.. One approach to describe a subaquatic ecosystem is to divide the ecosystem using lateral slices at given depth for which environmental conditions can be measured and interpolated. Such slices are modeled semi-independently and the predicted distribution can be merged after integration.

We here present a discussion of problems and a conceptual approach to model the potential species distribution using the maximum entropy method in conjunction with a commercial GIS suite. For generalized data we present and discuss a methodological framework and requirements regarding data acquisition.

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**S13-P05****New concept for *in situ* ecotoxicological assessment**Almut Gerhardt<sup>1</sup><sup>1</sup> LimCo International, Konstanz, Germany**Email:** almutg@web.de

Lake Constance receives a cocktail of different pollutants via small streams running through agricultural areas, transporting pesticides. Up to now, ecotoxicological assessment is not required for monitoring according to the EU Waterframework Directive and the Swiss law. This presentation proposes a stepwise approach to assess and evaluate pesticide stress in water bodies on the basis of a) existing biomonitoring data and b) additional ecotoxicological testing with field collected indicator species from reference sites. Biomonitoring data are used to calculate the SPEAR index (SPECies At Risk) in order to select potential problem sites. Problem sites are further investigated by *in situ* ecotoxicity tests with gammarids. During the exposures, survival, feeding rate and locomotory behaviour are monitored either manually or automatically with the Multispecies Freshwater Biomonitor. At the same time, chemical samplers are exposed. The first results of this ongoing InterReg IV project will be presented.

**S13-P06****Landuse, the Medieval Warm Period and the Little Ice Age: A multi proxy study from Lake Hampen and Lake Ræv, Denmark**Jesper Olsen<sup>1</sup>, Peter Rasmussen<sup>2</sup>, Kaarina Weckström<sup>2</sup><sup>1</sup> Queen's University Belfast, Belfast, United Kingdom<sup>2</sup> Geological Survey of Denmark and Greenland, Copenhagen, Denmark**Email:** j.olsen@qub.ac.uk

Nutrient-poor, low-productive (oligotrophic) soft-water lakes in the Atlantic areas of West and North-West Europe - the so-called Lobelia lakes - are of high conservation value as their low nutrient status favours a particular submerged macrophyte flora with isoetids, which are becoming increasingly rare or threatened due to nutrient enrichment (eutrophication) associated with landuse changes and urbanisation.

Here we report on two Lobelia lakes located in sandy soil from the western Jutland, Denmark just west of the main stationary line of the ice. Using pollen, diatom analysis, geochemistry and stable isotopes ( $d^{13}C$  and  $d^{15}N$ ) past variation in land use, organic primary productivity and hydrological changes are inferred. The timing of the anthropogenic impact is surprisingly late and is not noticeable before 1920 AD. It appears that sandy soils of central and western Jylland have been less intensively used for crop cultivation in the past and hence lakes located in such settings are less affected. Our data show that climate exerts a notable influence on the groundwater-fed lake and its biota implying that the physical, chemical and biological status of the lake has changed naturally in the past. In particular the Medieval Warm Period appears dry whereas the Little Ice Age appears as a period with higher effective humidity. We also report on attempt of using the oxygen isotopic composition of aquatic cellulose to infer changes in paleo hydrology.



## Lake deposits of the Early Triassic Buntsandstein in Central Germany: Type localities of oolites and stromatolites.

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### Introduction

The Central European Basin (also Germanic Basin) is the type locality of the Triassic. Here, the system was named and defined as a stratigraphic unit by ALBERTI in the year 1834. The given name is based on the tripartite succession of Buntsandstein, Muschelkalk and Keuper (today supergroup of the Germanic Triassic), which covers wide areas of southern and central Germany. The Buntsandstein group consists mostly of fluvial, aeolian and lacustrine sediments, deposited in terrigenous environments. Only the Upper Buntsandstein of the eastern and central basin is partly characterised by restricted shallow-marine to Sabkha environments. The Muschelkalk group was deposited during several marine incursions from the Tethyan sea. Most sediments of the Muschelkalk group are represented by shallow marine limestones (ramp carbonates) and evaporites. The Keuper group comprises most of the Triassic time scale and shows a broad variety of terrigenous and marine environments. As a whole, the supergroup of the Germanic Triassic represents one of the major continental basins during the Triassic, situated near the centre of Pangea but close to the Tethyan sea (fig. 1).

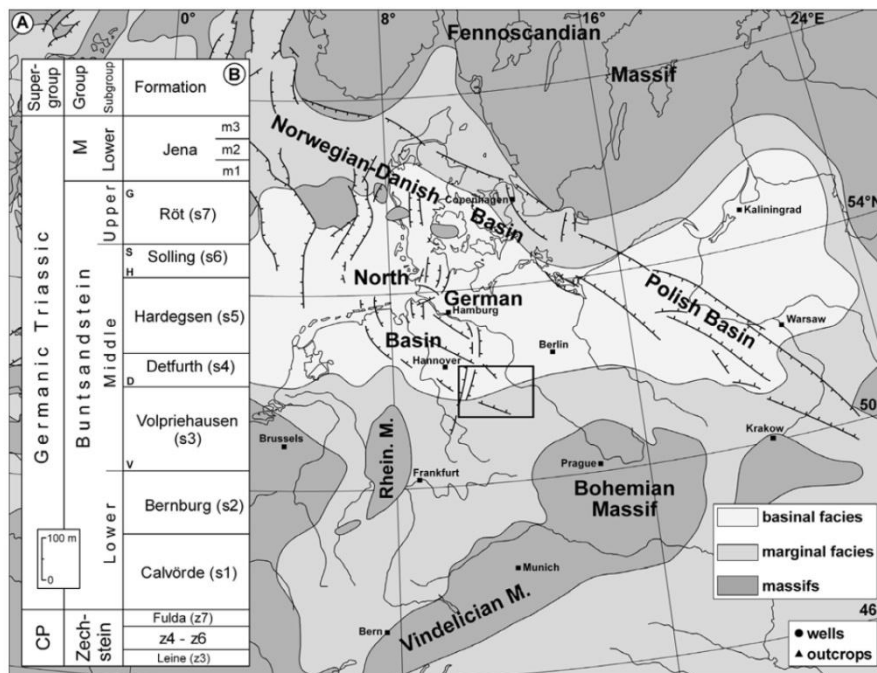


Fig. 1: Early Triassic paleogeography of the Central European basin and stratigraphy of the Buntsandstein group (BACHMANN et al. 2009)

The position of the basin between 20 and 30° latitude caused an arid climate, probably strongly modified by an intensive monsoon (e.g. PARRISH 1993). Some features of the basin-fill make the Germanic Triassic interesting for sedimentological studies. Especially the huge extension (500 x 1000 km) of cyclic mudflat deposits in the Buntsandstein and Keuper groups are difficult to explain from a sedimentological point of view, because transport of sediments in such a flat basin can not be

compared with recent mudflats which show only limited extent. But major problems arise also from the very uniform facies and thickness trends of Muschelkalk and Buntsandstein deposits (“layercake geometry”) for reconstructions of the sedimentary environments and are subject of intensive discussion. Some of these questions will be addressed during this excursion. The Triassic of the Germanic Basin is also interesting concerning evolution and preservation of life. Some continental series of the Buntsandstein, although deposited in lakes or rivers, contain neither fossils (like plant remains, molluscs or vertebrates) nor other traces of life like bioturbation or rootlet beds. Ostracods and chonchostracans are the only exception, thus providing the base of biostratigraphy (KOZUR & SEIDEL 1983). Plants, bivalves, gastropods and reptiles re-appear in the Middle Buntsandstein but remain rare. It could be assumed that the extinction event at the Permian-Triassic boundary affected the fauna for some million years (WEIDLICH 2007) or, alternatively that strong fluctuations of environmental conditions prevented the establishment of a permanent fauna (PAUL 2010). The abundance of stromatolites and giant oolites in fresh water deposits points to sedimentation very similar to Precambrian lakes, most probably caused by the lack in cyanobacteria-consuming biota (WEIDLICH 2007).

Especially the Lower Buntsandstein is characterized by deposits of a large shallow fresh-water to brackish lake which occupied the basin centre of the Central European Basin. But, also the Middle Buntsandstein, which is in general coarser and contains more fluvial deposits, shows a broad variety of lacustrine sediments, deposited either in temporary lakes at the floodplain or in bigger endorheic, partly restricted lakes in the basin centre. Acritarchs, which were found in the eastern Basin (Poland), indicate even limited access to the sea (BECKER 2005).

The focus of the excursion is on the Lower Buntsandstein lake. Some typical outcrops are visited, where KALKOWSKY (1903) firstly described and defined stromatolites, and where BRÜCKMANN (1721) used the term “Oolithi” for the first time. Famous outcrops of near-shore to pelagic lacustrine deposits are supplemented by deep well core material of a younger Middle Buntsandstein lake.

## **The Buntsandstein of the Central European basin**

### **Paleogeography**

During the late Permian, the Central European basin was several times flooded by the Arctic ocean via a graben system within the future North Sea area. Sea-level changes and hyperarid climate led to the deposition of thick evaporites. Step by step, the basin was filled up with salt and close to the Permian-Triassic boundary, when accommodation space was exhausted, a large salt pan (inland-sabkha) with low sedimentation rates extended over most of central Europe. At the basin margins, slowly growing alluvial fans developed which gradually passed to salty mudflats (HUG 2004). These mudflats are characterized by structureless sandy mudstones (“Bröckelschiefer”) and occupied a belt more than 100 km wide. Climate change to more precipitation and uplift of the hinterland caused the transition to fluvial and aeolian deposition close to the Permian-Triassic boundary. This boundary was fixed in several boreholes and outcrops on the base of magnetostratigraphy, but is devoid of fossils. The basin was closed, so that an endorheic lake evolved in the subsiding centre of the basin (Fig. 1). Basin margins were fringed by short alluvial fans merging to braid plains of ephemeral streams. Deposits of the early Buntsandstein rivers cover most of southern Germany. A north-directed fluvial trunk system left behind rather uniform deposits of cross-bedded sandstones. The homogeneous facies of stacked braided river sediments and increased thickness in a N-S striking area of increased subsidence (Hessian sub-basin) indicate the persistence of this fluvial transport system.

The facies of central and northern Germany is much more diversified: The more distal parts of the sand plains were occupied by aeolian dunes and small seasonal lakes (MAAß et al. 2011). The margins of the main lake are characterized by a broad variety of beach- and shoreface sands, deltas and mud flat deposits (VOIGT & GAUPP 2000, FENSTERER & VOIGT 2010). Further to the basin centre, ooid-shoals evolved and where mixed with the sands transported from the south. Strong fluctuations of the shoreline are expressed in rapid vertical and lateral facies changes. A similar facies transition is expressed in the Polish part of the basin and in the Netherlands (PALERMO et al. 2008).

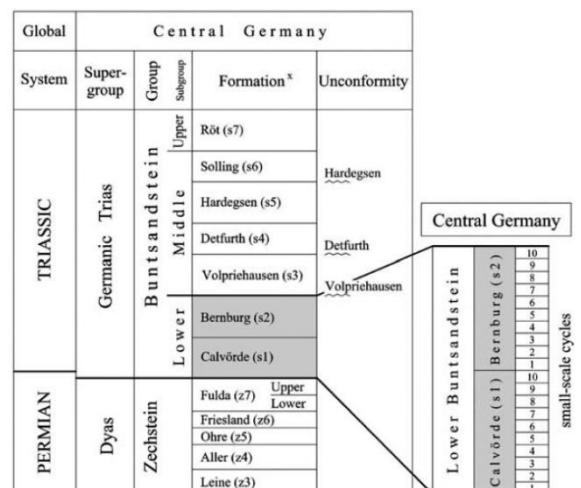
Both deposits of the central lake and fluvial sediments of the basin margins often show a characteristic cyclicity (e.g. SCHULZE 1969, GELUK & RÖHLING 1997), which was recently attributed to base-level changes by different authors (e.g. BECKER 2005, PALERMO et al. 2008). GELUK & RÖHLING 1997 and MENNING et al. 2005 postulated orbital cycles as a driving force for the observed cyclicity. Especially the eccentricity with a periodicity of 100.000 years is believed to be the main control on solar-induced cycles expressed in the succession. In this model, precipitation intensity triggered river discharge and evaporation and thus has controlled the amount of river load and lake level fluctuations.

The Buntsandstein was deposited in an epicontinental sag basin of moderate subsidence within the land mass of Pangea. The cycles can be correlated over vast areas as it was proven by GELUK & RÖHLING (1999) and BECKER (2005). Thickness changes and some synsedimentary shallow unconformities are attributed to mild tectonics (intraplate stresses) and initial diapirism of Zechstein salt. The main structures within the basin are two N-S striking areas with reduced subsidence: The Eichsfeld-Altmark swell (HERRMANN 1956, PAUL & KLARR 1987, RÖHLING 1991, PAUL 1993) in the central basin and the Hunte swell in the western basin (TRUSHEIM 1961, WOLBURG 1962). As most of the clastic material was trapped in the adjacent subbasins, these swell areas were the preferred places for oolite and stromatolite formation during the Early Triassic (PAUL 1982).

**Stratigraphy of the Buntsandstein group**

The early Triassic Buntsandstein group of Germany is bounded by the Upper Permian Zechstein group, mainly composed of evaporites and the overlying Muschelkalk group of marine limestones. The Buntsandstein group is divided into three subgroups, characterized by predominantly lacustrine deposits and fine-grained fluvial deposits in the Lower Buntsandstein, fluvial deposits of the Middle Buntsandstein and a fluvial to marine-evaporitic succession of the Upper Buntsandstein. The thickness of the Buntsandstein group increases from a few hundred metres of the fluvially dominated succession of southern Germany to more than 1300 m in the Hessian trough and more than 1500 m in the Glückstadtgraben close to the North sea basin.

Fig. 2: Lithostratigraphy of the Lower Buntsandstein. The Lower Buntsandstein is subdivided in two formations each comprising ten fining upward cycles, traceable throughout the basin (SZURLIES 2003).



### The Lower Buntsandstein

The Lower Buntsandstein is divided into two lithostratigraphic units: Calvörde and Bernburg formations (Fig. 2). Both of them contain several clayey-upward cycles; the Calvörde Formation consists of ten fining-upward cycles, whereas in the Bernburg Formation up to 14 cycles can be observed in the basin center. Towards the margins and internal swells the uppermost cycles are often missing due to erosion beneath the overlying Volpriehausen Formation (Volpriehausen unconformity) of the Middle Buntsandstein. The fining-upward cycles can easily be recognised in the  $\gamma$ -ray logs. In the basin centre, the base of the Bernburg formation is traditionally placed at a major oolite bed; the “Hauptrogensteinzone”, but detailed investigations of SCHÜLER (1976), PAUL & KLARR (1987) and Röhling (1993) proved that the maximum deposition of ooids was not contemporaneous through the basin. So, the main oolite bed occurs at the base of the 1<sup>th</sup> cycle of the Bernburg Formation in the eastern basin, while 50 km apart, in Lower Saxony, maximum thickness of oolites occurs in the 2<sup>th</sup> and 3<sup>rd</sup> cycle (fig. 3).

Biostratigraphic subdivision is based on conchostracans. SEIDEL & KOZUR (1983), KOZUR 1999 established a biostratigraphic scale for the Buntsandstein of 10 assemblage zones. Some of the conchostracans occur also in other places, thus allowing the correlation with the international scale (KOZUR 1999, KOZUR & BACHMANN 2008). SZURLIES (1999, 2003) was able to date the Buntsandstein throughout the basin on the base of magnetostratigraphy. This correlation confirmed biostratigraphic data and also the precision of basin-wide lithostratigraphic correlation (fig. 4). On the base of the combined data-set, it was concluded that the observed cyclicity represents basin-wide simultaneous changes of deposition (SZURLIES et al. 2003). Nevertheless, formation of oolites occurs at shoals of limited extent and formation of beds traceable over hundreds of kilometres requires migration of facies belts, as does the covering of a fluvial sand plain with river deposits. This would suggest that migration of facies belts occurred faster than precision of stratigraphic dating.

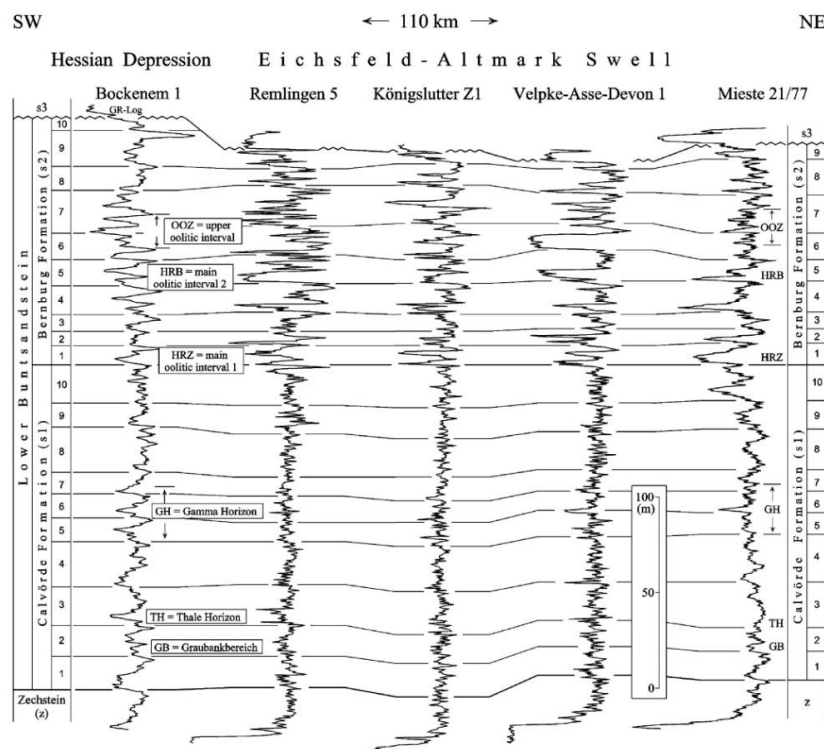


Fig. 3: Correlation of Lower Buntsandstein cycles across the Eichsfeld-Altmark swell shows a sharp boundary between the clay- and sand-dominated Calvörde Formation and the oolite-rich Bernburg Formation (SZURLIES 2003). Individual cycles of the Calvörde formation are better defined east and west of the paleohigh.

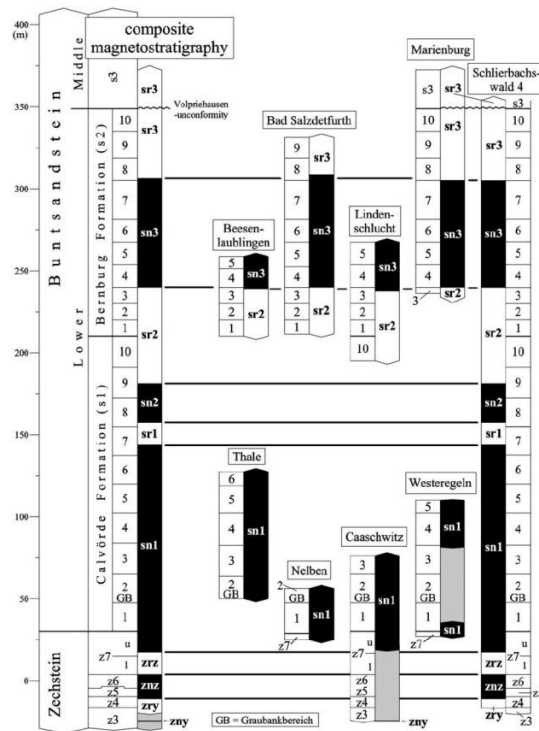


Fig. 4: Composite magnetostratigraphy of the Lower Buntsandstein in the Central European basin. Note that lithostratigraphic boundaries seem to be isochronous in different sections (SZURLIES 2003).

**Depositional model of the Lower Buntsandstein**

On the base of boreholes and surface outcrops, VOIGT & GAUPP (2001) established a simple sedimentary model for the deposition of sandstones, oolites and claystones in the south-eastern basin (fig. 5), which was affirmed and refined for the Netherlands by Palermo et al. (2008), see fig. 6).

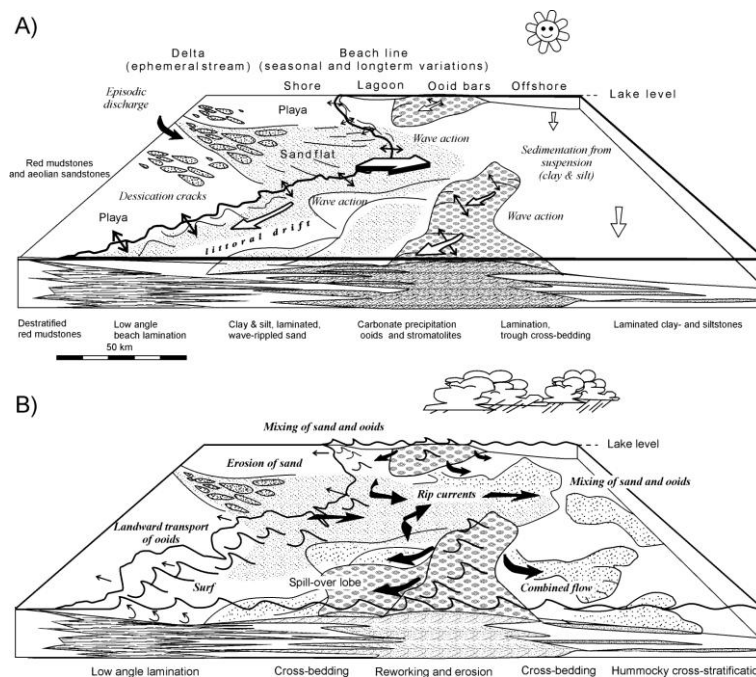


Fig. 5: Depositional model of the Early Buntsandstein lake margin (modified from VOIGT & GAUPP 2000). A) During fair weather conditions, ooids were produced at detached shoals, clastic input occurred from rivers entering the lake from the southern basin margin. B) During stormy weather, ooids were transported into deeper basin parts and mixed with sand.

Both models presuppose that the formation of oolites requires the absence of terrigenous input and assume formation of shallow oolite bars (shoals) offshore. Wide distribution of the pure oolite facies

was induced by the migration of shoals according to changing lake level or by autocyclic processes (exhaustion of depositional space by ooid formation). The widespread mixed facies of sandy oolites was attributed to spill-over lobes as a result of storm redeposition. The model of VOIGT & GAUPP (2001) was created only for times when deposition of ooids occurred. PALERMO et al. (2008) considered that the oolite horizons are traceable over hundreds of kilometres and are always separated by thick units of clay and sand without any ooids, indicating that formation of ooid shoals was limited to certain conditions. So, a second model for lake-level lowstands was developed. Destratified clay- and siltstones with abundant anhydrite nodules and roots are considered as desiccated mudflats which spread over older lake deposits. The remaining lake in the basin centre was characterized by enhanced terrigenous input and thus carbonate precipitation declined. The interpretation of sands replacing the ooid shoals in some cycles is different in both models: while VOIGT & GAUPP (2001) assume a delta-like depositional system connected to the rivers flowing into the lake, PALERMO et al. (2008) suggested the formation of flat isolated sand shoals off the coast as a substitute of oolite bars.

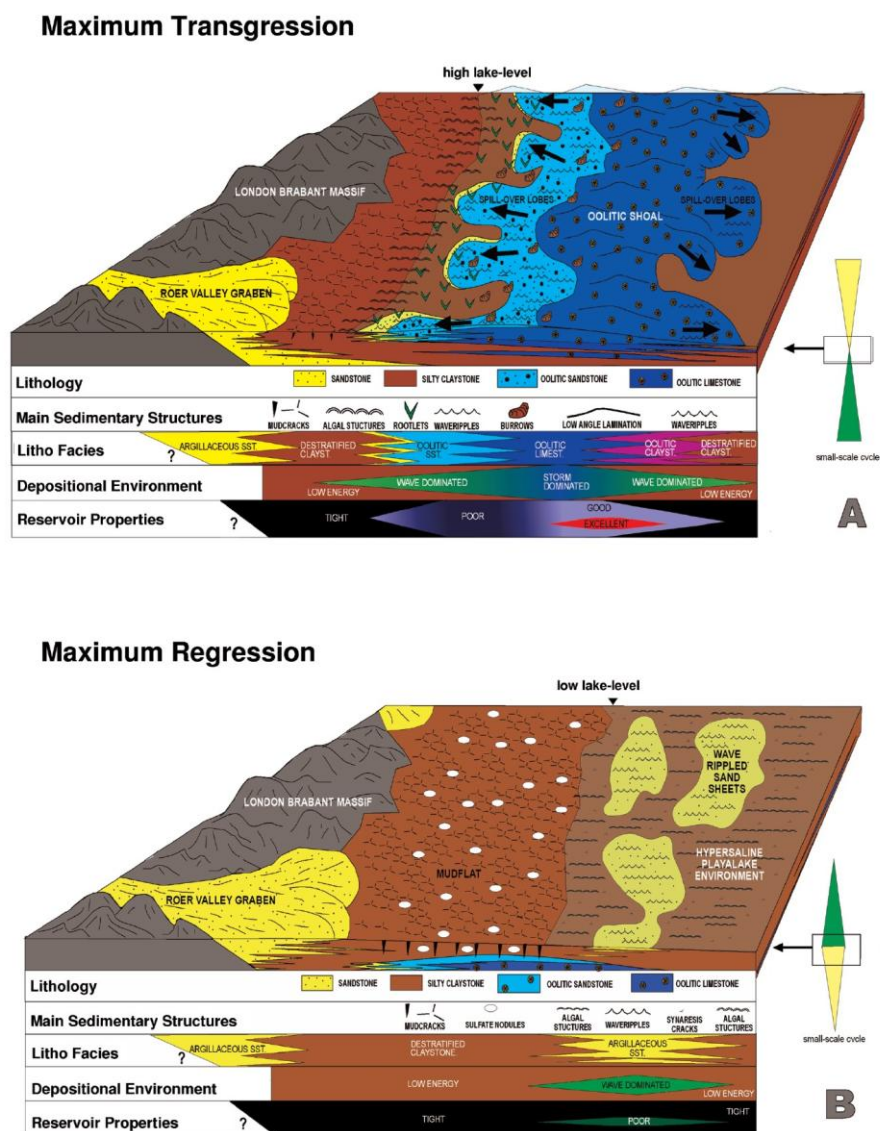


Fig. 6: Refined depositional model of Palermo et al. (2008): Oolite deposition during transgressive phases was followed by a breakdown of the carbonate factory due to enhanced terrigenous input. Extended mudflats formed during periods of low precipitation. Ooid shoals were replaced by sand shoals.

### The Middle Buntsandstein

The Middle Buntsandstein is divided into four formations: Volpriehausen, Detfurth, Hardegsen and Solling formations, each starting with a basal sandstone or conglomerate, tens of metres thick, which passes gradually in a succession of claystones and sandstones. Most of the basal sandstones are of fluvial or aeolian origin. The sandstone-claystone successions are interpreted to represent the same depositional system. While basin margin deposits consist of stacked braided river channels, the amount of flood-plains fines increases continuously towards the central basin. Falling base-level resulted in river incision and ended finally with formation of peneplains and a disconformity close to the basin margin. Slowly increasing base-level led to channel-dominated successions due to frequent erosion of inter-channel facies (e.g. BECKER 2005). A rapid rise of base-level supported preservation of floodplain deposits and caused the observed clay and silt-rich deposits in the upper parts of formations.

According to the position of the excursion area close to the basin centre, deposits of the Middle Buntsandstein in the excursion area contain therefore also units which were deposited on flood plains. Floodplains are topographically lower than river levees and so temporary shallow lakes could develop after floods. Although the Middle Buntsandstein of Poland contains also oolitic horizons and point to a similar endorheic lake system like in the German Lower Buntsandstein (BECKER 2005), most lake deposits of the excursion area are characterised by these flood-plain lakes. Typically, they are represented by red claystones with some sandstone intercalations, often rippled or bioturbated.

Additionally, grey to greengreen, and dark grey coloured units are intercalated in the predominantly red sandstone units in the Middle Buntsandstein succession of the Central European basin and the adjacent Hessian Subbasin. They occur especially in the Volpriehausen and Solling formations. Typical thickness of these clay- and siltstones with a varying content of thin (mm to few cm) sandstone layers is between 5-20 m. Lateral extension of these units varies strongly according to stratigraphic position. Some of these lacustrine horizons occupied much of the whole Lower Saxony (about 48,000 km<sup>2</sup>). As these clay-dominated horizons have a natural high  $\gamma$ -radiation, they provide good regional markers in the  $\gamma$ -ray logs. Some of the claystones contain high amounts of uranium, arsenic and heavy metals like lead, copper and zinc, leading in the sixties to some exploration efforts.

The deposits are interpreted to be deposited in shallow, in maximum some tens of metres deep lakes with stable stratification of the water column. Reducing conditions are reflected by the high metal contents and the good preservation of plant debris. Both lake types will be presented during this excursion: Red claystones of a small flood-plain lake are exposed at the base of the Middle Buntsandstein in Großwangen (stop 5); core material of an extended perennial lake of the Solling formation will be shown and discussed in Königslutter (stop 4).

### Sedimentology of Buntsandstein oolites

The oolites of the Lower Buntsandstein of Germany were investigated by KALKOWSKY (1908), VOSS (1928), DORN (1953), USDOWSKI (1963), RICHTER (1983) and PAUL et al (2011). Ooids occur both in pure oolitic limestones as in a varying mixture with quartz sand. They form single layers of some centimetres thickness or up to ten metres thick units. These packages are intercalated in red sandy claystones which make up more than 50% of the whole lake succession. Oolitic limestones are limited to the central basin and are most abundant in a broad belt, some tens of kilometres off the lake's shore line.

Ooids have normally small cores consisting of quartz-grains, mica or ostracod shells. Size varies strongly; Diameters of 0.2 to 3.5 mm are most abundant, but sizes up to 12 mm are not uncommon

in some regions (stop 3). RICHTER (1983) concluded a primary composition of high-Mg calcite, because he observed randomly distributed idiomorphic dolomite crystals in the calcitic ooids. Primary structures of the ooids are seldom preserved; often they are recrystallised or even dolomitised. Both concentric layers of calcite and radial orientation of calcite crystals across the whole ooid occur. Outer layers of the biggest ooids have an irregular structure close to the observed crinkly surface of stromatolitic crusts. In thin-sections, the coatings of such ooids consist of columnar stacked dark and light laminae divided by deep furrows. The outer surface of these “cerebroid” ooids (CAROZZI 1962) is very similar to blackberries. PAUL & PERYT (2000) assume quick precipitation, probably under the influence of cyanobacteria. Some of these spherical carbonate grains can be classified as oncoids.

### Sedimentology of Buntsandstein stromatolites

Dome-like structures in the succession of the Lower Buntsandstein of northern Germany were first described and named as stromatolites and stromatoids by KALKOWSKY (1908) who also already assumed a biogenic origin of these structures. Further investigations of the stromatolites from the type locality go back to PERYT (1975), PAUL & PERYT (2000) and PAUL et al. (2011).

The stromatolites are distributed in a limited area close to the basin centre and in the surroundings of the Eichsfeld swell (fig. 7).

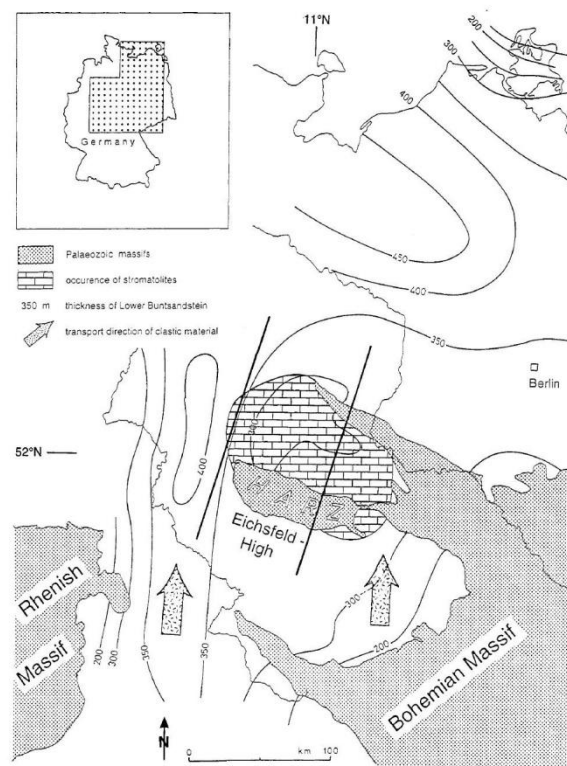


Fig. 7: Occurrence of stromatolites in the Lower Buntsandstein of the central basin is restricted to an intrabasinal paleohigh, the Eichsfeld swell (PAUL 1982). Oolitic limestones reach their highest thickness in the same area, which is explained to be the result of clastic sediment trapping in the surrounding lows. The uplift of Palaeozoic massifs occurred after deposition of the Lower Buntsandstein, during Late Cretaceous.

They are always closely associated with oolites. Often they start as thin algal mats on top of rippled oolite beds or start to grow on giant cerebroid ooids. In large outcrops (stop 3), it can be observed that single oolite beds are covered by closely spaced domal stromatolites of the same size. They form horizons traceable over more than 700 m (PAUL et al. 2011). Domal growth forms prevail, but stromatolitic crusts and centimetre-high branching columns also occur. Input of terrigenous material,



mostly clay, terminated stromatolite growth, while shedding of ooids interrupted it only temporary (PAUL & PERYT 2000). This proves, that migrating ooid bars and ooid ripples co-existed with stromatolites. Internal structure is characterised by various growth structures of and interstices, filled with quartz, ooids and broken stromatolitic crusts. Internal growth structures were described by PAUL & PERYT (2000). They distinguished between domal/laminar – and columnar/digital forms. Microstructures were differentiated by the same authors as spongy-fenestrate and fan-like fabrics. Organic material is not preserved; diagenesis was accompanied by strong recrystallisation. According to the considerable size of stromatolites and the strong relationship to oolites, PAUL et al. (2011) compare the depositional system with recent alkaline lake deposits in eastern Africa and the marginal marine stromatolites of the Shark bay, Western Australia. They conclude a subtidal environment of an alkaline lake, protected from terrigenous input.

### Excursion

Stop 1: Clay pit Beesenlaublingen.

**Location:** The large (700 x 300 m) abandoned clay pit is situated between the river Saale and the regional road B6 near between the small towns of Alsleben and Könnern. It can be reached easily from the highway BAB 14, exit Plötzkau. The best way to enter the large pit is to follow the Saale-bicyclepath stream-up from the village of Zweihausen.

Coordinates of the pit centre: 51°41'48"N, 11°42'16"E

**Geological setting:** North of the Harz mountains, mesozoic rocks reach a wide extension, especially Triassic and Cretaceous formations occupy large areas. The area between the two basement-uplifts of the Harz and the Flechtingen High is called the Subhercynian basin, although it represents only a part of the late Paleozoic to Mesozoic Central European Basin, which was separated during late Cretaceous inversion tectonics. The basement surface below the Subhercynian basin is deepest near the thrust basement of the Harz (up to 4000 m), where a Late Cretaceous foreland basin developed, and shallows to the north (basement surface in depths of 500-1000 m). Salt-injected folds and some gentle diapirs bring older sediments to the surface. The Beesenlaublingen outcrop belongs to an uplifted area east of the Harz mountains.

**Stratigraphy:** The pit exposes the top of the Calvörde formation and the first six cycles of the Bernburg formation (fig. 8). These cycles are expressed as units starting with sandstones or oolites with few clay intercalations gradually passing into flaserbedded claystones of varying sand content. The tops of these sandstone-dominated units often show desiccation cracks. To the top of one cycle, clay-content increases, before the next cycle starts with a sudden increase of sand-content.

Sandy claystones of the Calvörde formation form the base of the succession. Their structureless appearance and the occurrence of small anhydrite concretions and strongly dissolved gypsum indicate deposition on a saline mudflat.

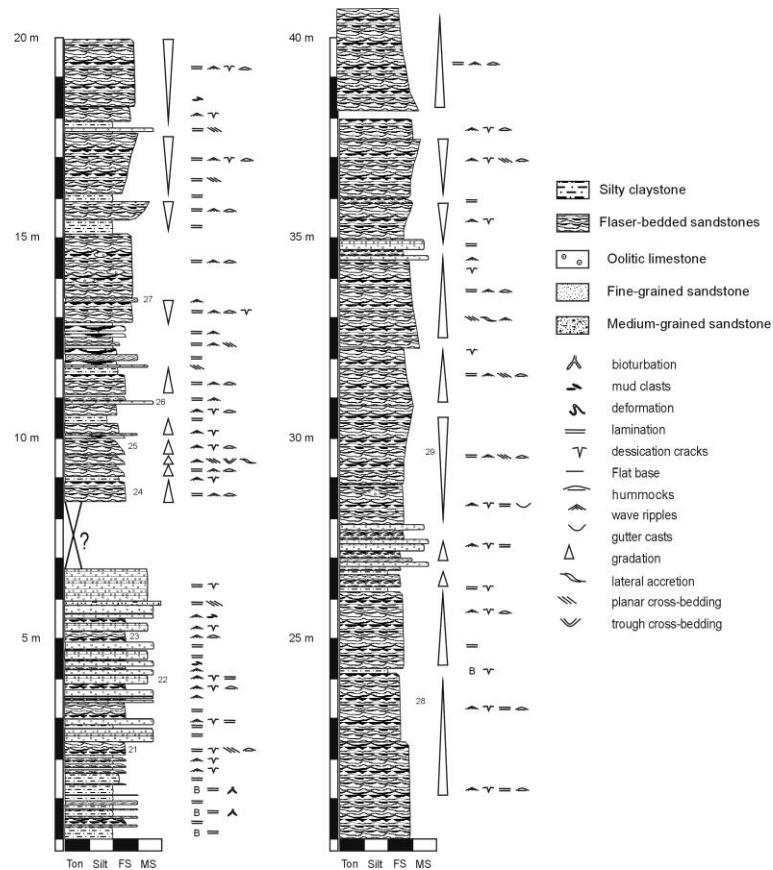


Fig. 8: The more than 40 m thick succession of the Beesenlaublingen clay pit exposes lacustrine deposits of the Bernburg formation. Rippled sandstone-claystone units represent the most abundant facies type. Oolites are represented at the base of two cycles.

The basal Bernburg formation starts with the “Hauptrogenstein”, an about 4 m thick unit which is dominated by oolitic limestones following above. The higher parts of the succession consist of rippled or flaser-bedded sandstone-claystone units. They start typically with cross-bedded to laminated sandstones, which may pass vertically into oolitic limestones or a mixed sandy oolite facies. Magnetostratigraphy (SZURLIES 2003) and biostratigraphy (KOZUR 1999) provide evidence for an early Gandarian age, although endemic species of conchostracans (as the only fossils) and long periods of normal polarity in the early Triassic make a correlation with the international chronostratigraphic scale difficult.

**Sedimentology:** The about 50 m thick succession and the large area of the pit give the opportunity to observe a variety of sedimentary structures. The most abundant feature is represented by ripple marks. Oscillation ripples are abundant at the top of oolite beds, they occur at the top of sandstone units and form meters thick uniform successions of flaser-bedded sandstone-claystone units. This can be interpreted to represent a very shallow lake facies, where temporary input of sand in a shallow water body was followed by moderate wave action. We assume a delta-like environment above wave base, but the existence of extended sand shoals as proposed by PALERMO et al. (2008), is also likely. Desiccation cracks occur preferentially on top of oolite beds and in sandy units at the base of cycles. They give evidence for temporary lake level lowstands. Small gutter casts and hummocks (indicating combined flows of directed currents and waves) occur frequently in the higher parts of the succession. Pocket-like structures, up to ten centimetres deep penetrate red laminated claystones in some horizons close to the base of the Bernburg formation. They are filled with loosely packed green ooids. We assume biogenic origin or current action by small wind-induced eddies (scour-and-

fill structures, pot casts). Deformation structures are restricted to single units: Some ball and pillow structures point to density inversion during rapid sedimentation; folds and brecciated units could either be caused by slumping or (more probably) by dissolution and precipitation of salt. A striking feature is the complete absence of bioturbation and trace fossils on bedding planes. This allows the preservation of very fine bedding structures like small ripples and lamination.

**Interpretation:** The large pit is the best exposure of lake deposits of the Lower Buntsandstein in Germany. It shows perfectly the internal architecture of lake deposits and the organisation of oolite bodies. Formation of oolites is restricted to single horizons at the base of the  $\gamma$ -ray cycles. They are interpreted to represent transgressions of the lake, preventing progradation of clastics and thus allowing the establishment of ooid shoals (PALERMO et al. 2008). The absence of any traces of life (with the exception of conchostracans and cyanobacteria) needs explanation. PAUL (2010) assumed strong fluctuations of lake chemistry as the main reason, but also slow recovery of global fauna after the Permian/Triassic extinction event must be taken in consideration in our opinion. Another reason could also be the isolated position of the endorheic lake in the arid climate belt of Pangaea far from other lakes. Together with the lack in flying animals which could act as carrier of larva and fish eggs this would prevent faunal exchange between early Triassic lake systems.

**Issues to discuss:** An open question is the lack of evaporites in the deposits of the Lower Buntsandstein. All published models propose an endorheic lake in the basin centre. Together with the position of the Central European basin in the arid trade wind belt this would result inevitably in the precipitation of gypsum or salt in some areas of the lake. In fact, no massive evaporites are known. There is only poor evidence for evaporite precipitation like some small marks of lenticular gypsum in some sandstones or strong dolomitisation of ooids which could be explained by the enrichment of magnesium in the course of calcium sulphate precipitation. Two ideas can be discussed: 1) The evaporites could be hidden in the deepest (and in a depth of 10 km inaccessible) parts of the Central European Basin near Hamburg, or 2) The basin was not closed and had an outflow to the global ocean. The latter is supported by the findings of marine acritarchs in the Lower Buntsandstein of Poland.

## **Stop 2: Old quarry between Benzingerode and Heimbürg**

**Location:** The old quarry is situated between the villages of Heimbürg and Benzingerode close to the Harz mountains (fig. 9). It can be reached from the road B6n (exit Heimbürg). After 4 km on the road B6 towards Wernigerode, in the centre of the village Benzingerode, close to the church a small road (Ziegeleistraße) leads to the left (eastward). The road must be followed for approximately 1 km to a small junction, where an unpaved forest road leads to the Harz mountains in the south. The outcrop, a trench-like quarry is situated in a conspicuous bush-covered hill, approximately 300 m from the junction.

Coordinates of the stromatolite: 51°49'32"N, 10°53'11"E

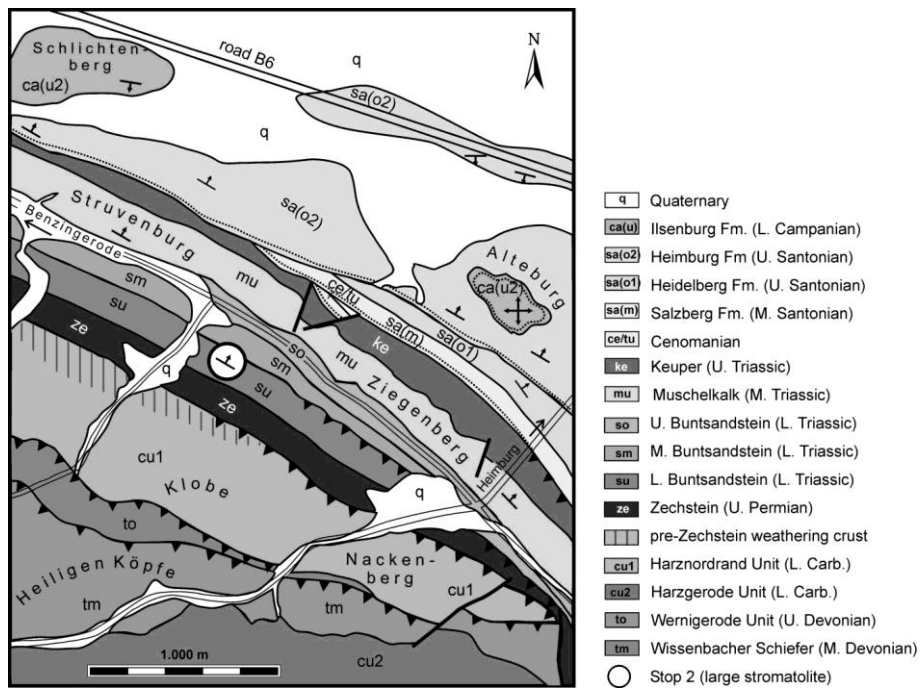


Fig. 9: At the northern margin of the uplifted basement block of the Harz, oolites of the Lower Buntsandstein were quarried. Between the villages of Benzingerode and Heimburg, the biggest known stromatolite of the Lower Buntsandstein is exposed.

**Geological situation:** The northern margin of the Harz mountains is characterised by a 2-3 km thick upturned succession of Permian to Cretaceous deposits. Nearly the complete basin-fill of the Central European basin is exposed here. The reason is intraplate deformation in the course of Africa-Europe convergence (about 15 km shortening in Central Europe) during late Cretaceous which led to the uplift of basement blocks, folding and thrusting of the basinfill. The Harz mountains represent one of the most prominent basement uplifts. According to geometry of the structure and results of fission track data, the vertical displacement at the northern border is in the order of 10-12 km and occurred in the timespan of only 20 million years.

**Stratigraphy:** In the narrow trenches, accompanying the northern margins of the Harz over tens of kilometres, oolites ("Rogenstein") of the Lower Buntsandstein (Bernburg Formation) have been quarried since early medieval ages. The "Rogenstein" was used as a preferred building stone and is present both in Romanic churches and monasteries of the 10<sup>th</sup> - 12<sup>th</sup> century (Gernrode, Wöltingerode, Drübeck) and in profane buildings of the villages. They belong to the first cycle of the Bernburg formation (Hauptrogenstein) as the oolites in the Beesenlaublingen quarry visited before. While the oolitic limestones were completely removed from the quarry, the 2.5 m thick, compact stromatolite remained as it was not usable for building purposes.



Fig. 10: The dome-shaped stromatolite of the Benzingerode quarry reaches a size of more than 2.5 m.

**Sedimentology:** This is the biggest stromatolite ever reported from the Lower Buntsandstein of Germany. Nevertheless it was never investigated in detail and was only mentioned by PAUL & PERYT (2000) in a scientific paper. The stromatolite shows a dome-shaped appearance with the characteristic brain-like, crinkled surface on top. PAUL & PERYT assume that solution due to changing lake chemistry played a major role during formation of these surfaces.

The internal structure is characterized by several growing phases, marked by thin layers of red claystones and even some intercalations of oolites. Although the base of the stromatolite is not exposed, it seems to consist of several smaller stromatolites (LHD-type) which were overgrown and merged to one giant stromatolite cupola. Thin sections prove strong recrystallisation but still show micritic layering of biofilms. The domal structure is composed of several centimetre-thick units, second-order fabric shows branched columns, separated by micritic limestone and silt-sized quartz grains.

### Stop 3: Abandoned quarry Heeseberg near Jerxheim

**Location:** Jerxheim will be reached after 35 km from the medieval town of Wenigerode via the road B 244. Before entering the village, a small road leads to the Heeseberg, (view point, restaurant). A parking site is situated at the restaurant. The better of two outcrops will be reached after 15 min walk along a marked path ("Geologie-Natur-Erlebnispfad"). The abandoned quarry represents the point 6 of the education path. The former quarry-wall is protected (Geotop) and represents the best outcrop of the stromatolitic facies of the Lower Buntsandstein in Germany (RÖBER et al. 2006a, b).

**Coordinates:** 52°05'01"N, 10°51'27"E

**Geological situation:** North of the Harz mountains, the North-German lowlands extend over more than 250 km to the shores of the North sea and the Baltic sea. Only few smooth hills not higher than hundred metres interrupt the plains. They are formed mostly by gentle domes and diapirs caused by Upper Permian salt or by anticlines and thrusts developed during late Cretaceous deformation of the Central European Basin. The Heeseberg, situated near Jerxheim is one of these structures and belongs to a major thrust system which probably represents a re-activated and inverted normal fault.

Thrusting was supported by separation of the sedimentary cover from the underlying basement by thick Permian salt. Together with the Asse fault zone, the Heeseberg structure forms a 50 km long structure that was produced during late Cretaceous basin inversion. During thrusting, Lower Buntsandstein deposits were transported from a depth of about 2000 m to the surface.

**Stratigraphy:** The Heeseberg section exposes a more than 7 m thick succession of oolites and stromatolites, overlain by red claystones with intercalated calcareous sandstones (fig. 11). It represents the main oolite horizon of the Bernburg Formation, but in contrast to the outcrops visited before, the maximum of oolite thickness is reached one cycle higher and correlates not directly with the "Hauptrogenstein" of the foreland of the Harz mountains.

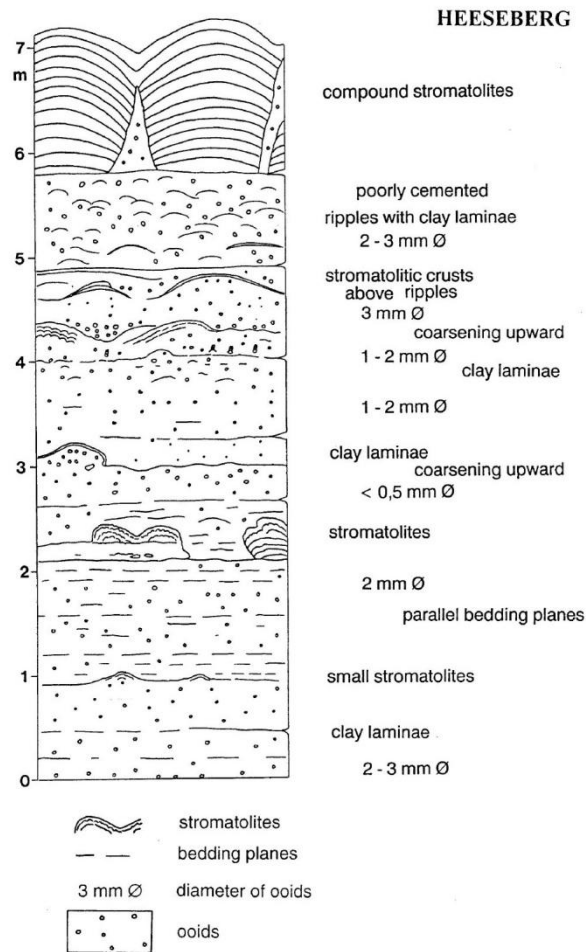


Fig. 11: The Heeseberg quarry is situated on top of the Eichsfeldswell and exposes a section of more than 5 m of pure oolites with some stromatolite layers (PAUL & PERYT 2000).

**Sedimentology:** A detailed study on the sedimentology of the Lower Buntsandstein was carried out by PAUL & KLARR (1987) at the core of the borehole Remlingen 5. This borehole is situated about 10 km to the west of this outcrop and recovered the whole succession of the Lower Buntsandstein. The Heeseberg succession was investigated by PAUL & PERYT (2000), to exemplify the relationship of ooid-formation and stromatolite growth.

The section consists of horizontally stratified oolites with only few thin clay intercalations. Oolites are often graded. Single units are separated by thin algal mats (stromatolitic crusts) or clay lamina. Most of these surfaces are traceable across the whole outcrop. The most conspicuous feature are a number of stromatolites, arranged in two horizons, but also occurring as small dome-like structures in the oolite beds between these two marker beds. The biggest stromatolites occur in the uppermost

horizon, they reach a height of about 1.2 m. The occurrence of oolites and stromatolites ends abruptly with the sudden transition to the overlying clastic succession of red claystones and sandstones.

**Interpretation:** Oolites and stromatolites are closely related in this section, while the appearance of claystones terminates both stromatolites to growth and ooid formation. This is interpreted to result from poisoning of the carbonate factory by terrigenous input during lake-level fall (PAUL et al. 2011). Stromatolites are best developed in two single horizons and are associated with the biggest (mostly cerebroid) ooids. PAUL & PERYT (2000) assume an intertidal growth of stromatolites, which is supported by the undisturbed forms of the domal shapes. This assumption would suggest a transport of ooids from the top of the oolite shoal, situated in some distance. Persistent wave action can be excluded on the base of some observation: 1) ooid units are covered by thin stromatolithic crusts; 2) stromatolites grow initially on undisturbed ooid layers, directly from the light-exposed surface of cerebroid ooids; 3) Intraclasts of cemented ooid grainstones form occasionally the substratum for stromatolite growth, thus pointing to early cementation in a quiet environment.

#### **Stop 4: Information Centre Geopark Braunschweiger Land – Ostfalen (Femo) in Königslutter**

**Location:** The Geopark Braunschweiger Land Land-Ostfalen was established to protect and to explain the geological sites of the northern foreland of the Harz mountains. Main attractions are beautiful outcrops of the basin fill of the North German Basin comprising a nearly complete succession from Permian to recent and the numerous findings of late Jurassic to Lower Cretaceous dinosaurs, shown in some museums (Münchehagen, Braunschweig, Hannover). The information centre is situated in the well-preserved medieval town of Königslutter, where some German emperors had temporary their residence during the 12<sup>th</sup> - 13<sup>th</sup> century. The grave of emperor Lothar III. († 1135) is located in the Kaiserdom.

**Coordinates:** 52°15'08"N, 10°49'02"E

**Stratigraphy:** The presented cores belong to the uppermost unit of the Middle Buntsandstein, the Solling formation. PAUL & KLARR (1987) described the core of the borehole Remlingen 5 and interpreted facies to represent lake deposition. PAUL & SIGGELKOW (2004) investigated sedimentology and paleontology of the lake deposits in southern Lower Saxony and published a summary concerning stratigraphy, correlation and interpretation. The main horizon of lake deposits is traditionally named as "Graue Tonsteinschichten" (Grey claystone beds). The thickness of these beds fluctuates between 5 and 10 m. They follow above calcareous grey sandstones of only 1-2 m thickness. At the top, the "Graue Tonsteinschichten" are overlain by red claystones with intercalations of sandy siltstones of about 12 m thickness with abundant mud clasts and dessication cracks, interpreted to represent a mud flat (PAUL & KLARR 1987). The Solling formation ends with a unit of thick cross-bedded sandstone (about 17 m), representing a braid plain prograding into the playa.

**Sedimentology:** The basal sandstones below the "Graue Tonsteinschichten" are structure-less apart from some clay drapes. To the top, mud clasts and water escape structures occur. Laminated grey claystones are the main facies type of the "Graue Tonsteinschichten". These claystones have a varying carbonate content of 15-30% (calcite and iron-rich dolomite) and contain framboidal pyrite and galenite. High amounts of uranium (100-700 ppm) and other heavy metals are a typical feature of this unit. Total organic carbon was determined to be in the order of only 0.15-0.69%. The whole section contains thin streaks of silt and fine sand, often graded. Gamma-ray logs indicate a clayey upward succession. Some of the thicker sand and silt units are cross-bedded. Bioturbation is absent.

No fossils benthic fossils occur. The traces of life are limited to spores and pollen and fine plant debris. Additionally, some marine acritarchs and prasinophytes occur.

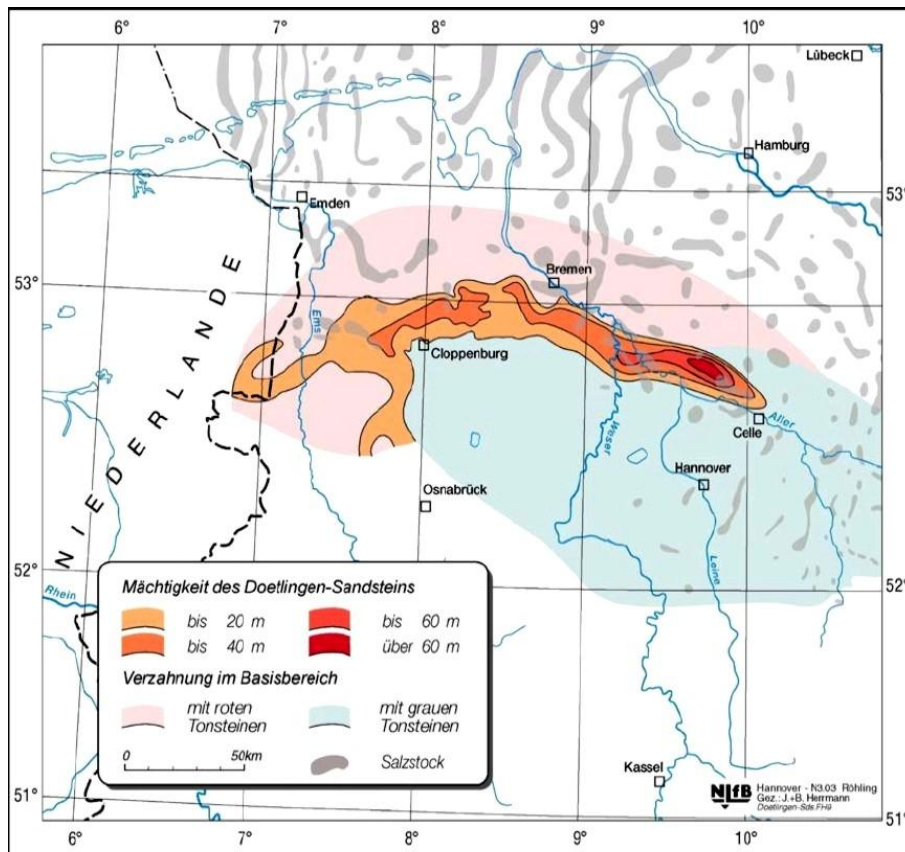


Fig. 12: Lake deposits of the Middle Buntsandstein (Solling Formation) are widely distributed in the subground of Lower Saxony. A sandstone belt divides grey claystones of a meromictic lake from red clay- and sandstones of a more oxygenated facies in the north (RÖHLING & SCHULZ 2000).

**Interpretation:** The grey claystones with varying sand content form a conspicuous horizon within the stratigraphy of northwest Germany and extent over tens of kilometres. PAUL & SIGGELKOW (2004) interpreted a shallow, meromictic lake with a stable stratification caused by increased salinity of bottom waters. The limited thickness of the grey claystone unit indicates only a short existence of the lake. The authors estimate duration of lake sedimentation to be in the order of 10,000 to 50,000 years with a sedimentation rate of 0.1 to 1 mm/y. The extension of the lake was probably twice the size of the recent lake Tschad. Schulz & Röhling (2000) investigated the regional distribution of the Grey claystones at the base of the Solling Formation. They determined the northern boundary of these lake deposits in the middle of northern Lower Saxony where they interfinger with a narrow sandstone belt, the Dötlingen sandstone (fig. 12). Röhling (1986, 1988) and Schulz & Röhling (2000) interpreted it as a sand shoal. North of it, red oxygenated clays prevail, interpreted to represent the oxygenated, high energy lake facies.

### Stop 5: Old quarries west of Großwangen

**Location:** Large abandoned quarries extent along the Unstrut river west of the village Großwangen. Here, dolomitic sandstones and red claystones of the Lower Buntsandstein are exposed which are overlain by sandstones of the Middle Buntsandstein. Wangen is situated near the town of Nebra and is famous for a spectacular archaeological site; the 4000 years old Sky Disc of Nebra was found here. Großwangen will be reached from the road B 250 from Querfurt and a local road leading from Nebra



to the small village of Wangen. The sandstone quarries are situated immediately west of the village and can be reached by a path following the quarry walls.

**Coordinates:** 51°16'02"N, 11°32'14"E

**Geological situation:** South of the Harz mountains which represent an uplifted basement block of Paleozoic folded and metamorphosed sediments, a large syncline is developed in the overlying succession of about 2000 m thick Upper Permian to Triassic deposits (Thuringian syncline). Großwangen is situated in the northern part of this structure. The Buntsandstein dips with a few degrees towards the northeast reflecting two substructures of the northern Thuringian syncline, the Bibra anticline and the Querfurt syncline. The Lower Buntsandstein of this area shows the transition from the lake facies (indicated by ooid beds) to the southern sandplains (fig. 13).

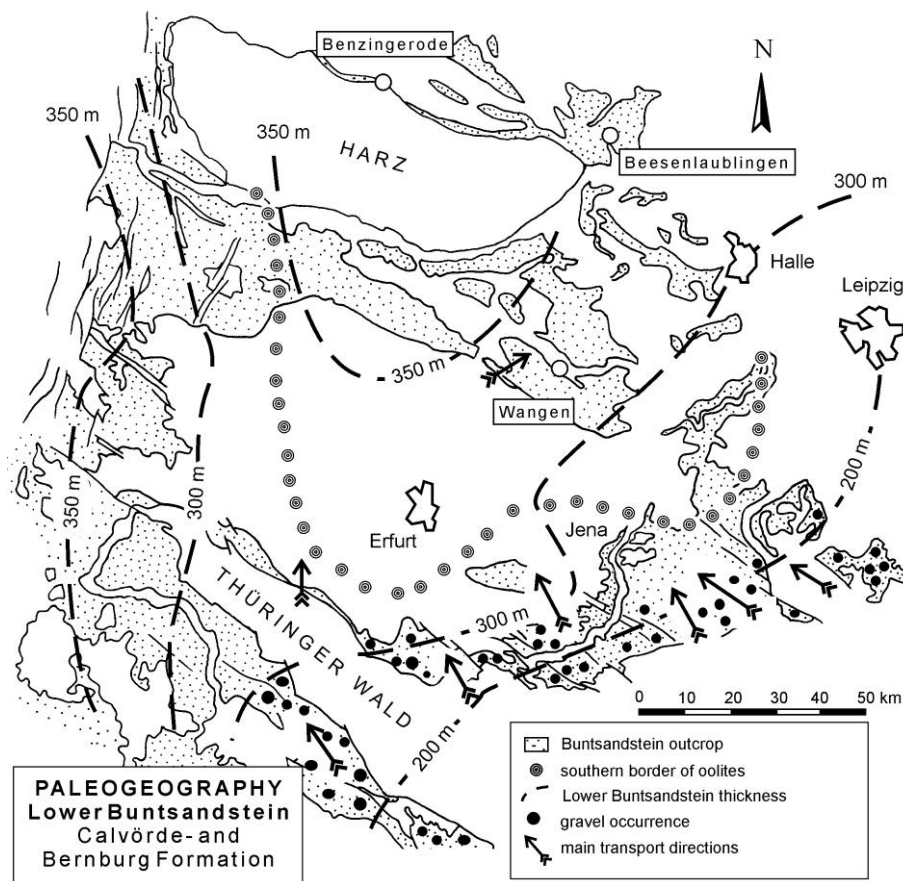


Fig. 13: The lake margin of the Lower Buntsandstein forms a bight towards the south, which can be mapped in the Thuringian syncline between the Harz mountains and the Thüringer Wald, reflected both from the southern boundary of oolite beds as by thickness distribution. (modified from VOIGT & GAUPP 2000).

**Stratigraphy:** The about 15 m thick whitish to light-grey sandstones at the quarry base belong to the uppermost part of the Lower Buntsandstein, the Bernburg formation (fig. 14). Correlations on the base of the gamma logs according to RADZINSKI (1995) point to cycle 8 of the Bernburg formation. The sandstones are overlain by 2.5 m thick red claystones with some rippled sandstone beds which still belong to the Bernburg formation. The following medium- to coarse-grained, reddish sandstones (30 m) represent the base of the Volpriehausen formation, the first unit of the Middle Buntsandstein. The upper cycles of the Bernburg Formation were probably eroded.

A conspicuous feature of the succession is the existence of synsedimentary normal faults at the base of the Middle Buntsandstein. In the visited outcrop, they form a small (2 m deep) graben structure.

This is the only place in Germany where synsedimentary extensional tectonics are obvious in outcrop although a short-term change of intraplate stresses is also indicated by significant changes in thickness deduced from seismic sections and log correlations (BOIGK 1959, WOLBURG 1962, HERMANN 1961). The resulting gentle unconformity, traceable at the Eichsfeld-Altmark and the Hunte swell, is called the Volpriehausen Unconformity (“V-Diskordanz”).

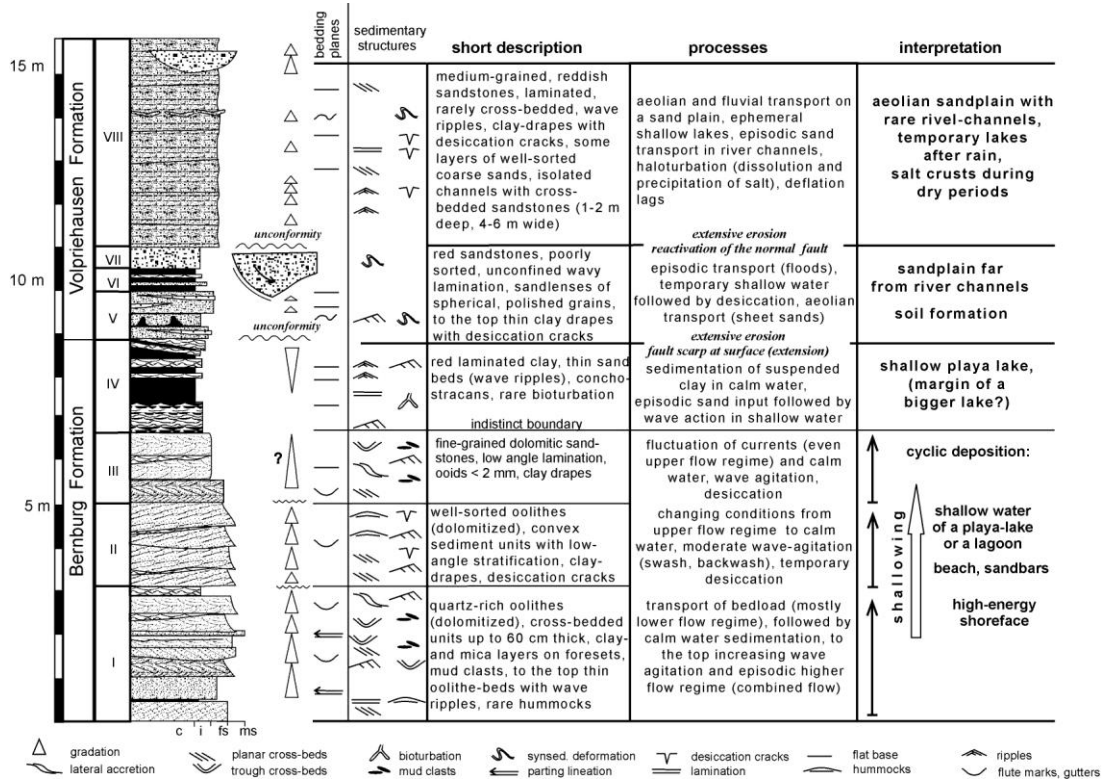


Fig. 14: The Wangen section exposes the transition from Lower Buntsandstein (Bernburg formation) to the Vopriehausen Formation of the Middle Buntsandstein (modified from VOIGT & GAUPP 2000). As the Dolomitic Sandstone represents the 8th cycle of the Bernburg Formation according to correlations of RADZINSKI (1995), major erosion is assumed. Synsedimentary faults are observed near the boundary of formations.

**Sedimentology:** The dolomitic sandstones of the Bernburg formation form a conspicuous horizon traceable over a vast area from the northern foreland of the Harz mountains to the northern part of the Thuringian syncline between Halle and the Kyffhäuser mountains (50 km across). The unit is composed of light-grey, well-sorted sandstones with few intercalations of green claystones (fig. 15). Thin-sections show that sandstones contain quartz, up to 20% feldspar and a varying quantity of ooids. In some distinct layers ooids even prevail. Grains are cemented by dolomite; the original calcite of ooids is also completely replaced by blocky dolomite cement. Ghost structures of the primary coatings are marked by brownish (organic?) inclusions. Sedimentary structures are dominated by cross-bedding, low angle bedding and lamination. Oscillation ripples occur frequently especially on top of single units. Transport directions vary significantly and indicate strongly fluctuating current directions. Most of the sedimentary units are grouped to convex bodies with a flat base, followed by draping clay-sandstone units of some cm thickness. Erosion of current ripples occurred frequently and gave way to the formation of reactivation surfaces.

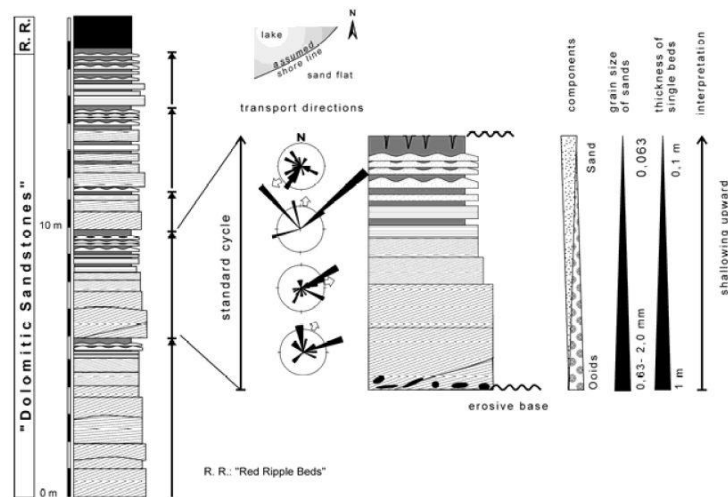


Fig. 15: Units of cross-bedded and low-angle stratified sands, followed by sand- and claystones with wave-ripples are a characteristic feature of the light-grey dolomitic sandstones of the Wangen section. To the top, thickness of units decreases. Similar sandstones are distributed along the southeastern margin of the Lower Buntsandstein lake, but occurrence in different cycles of the Bernburg Formation point to significant shifts of the coast line (modified from VOIGT & GAUPP 2000).

The dolomitic sandstones are covered by a red claystone unit with intercalated sandsheets. Claystones are laminated and contain conchostracans. Sandstone beds reach a few centimetres thickness and show flat bases, but rippled surfaces (symmetric wave-ripples). They are followed by the basal sandstone of the Volpriehausen formation: a 30 m thick unit of red, green and white sandstones, poorly sorted, with thin clay drapes and lenses of coarse, well-rounded coarse sands. At the base they contain some small quartz granules (up to 5 mm) and some units of green to wine-red claystones with a lot of desiccation cracks in every horizon. Most of the sandstones are horizontally bedded, but in some horizons, saucer-shaped structures of more than 1 m size and other deformation structures can be observed. A fluvial channel is visible in the outcrop, about 10 above the base of the Volpriehausen formation.

**Interpretation:** The basal unit represents the uppermost part of the Bernburg formation and is interpreted to be deposited at the margin of the Buntsandstein lake (VOIGT & GAUPP 2000). Mixing of ooids and sand indicates an allochthonous facies belt in the transition from carbonatic lake deposits (deposited from sands) to a terrigenous facies belt (delta or shore). According to the observed sedimentary structures, this facies type is interpreted to represent a lake margin facies characterized by breaking waves producing low angle beach lamination and strong wind-induced along shore currents (VOIGT & GAUPP 2000). The high thickness of these deposits in a NE-SW-striking belt indicates a long term fixed position of the coast line during the deposition of the higher Bernburg formation. Similar deposits occur in the Lower Bernburg Formation of eastern Thuringia (FENSTERER & VOIGT 2010), indicating basin-ward shoreline migration of about 50 km. In the Großwangen outcrop, the transition to red claystone and sandstone deposition marks the final destruction of the carbonate factory of the Lower Buntsandstein lake system in this part of the basin.

The red-coloured claystone-sandstone unit is characteristic for a small lake or a lagoon dominated by temporary clastic river input, which was reworked by wave action. Progradation of a river mouth is indicated by the increasing thickness of sandstone beds and decreasing amount of clay in the succession.

The following sandstones of the Volpriehausen formation are characteristic of sandplains dominated by aeolian processes and temporary lakes. They are dissected by only few fluvial channels. Tepee

structures and destratified mudstones indicate a salty mud flat influenced by frequent precipitation and dissolution of salt both in the subsurface and on the surface of the sandflat. The existence of salt crusts is indicated by irregular distribution of sand patches in some units. Lakes existed temporarily, but millimetre-thin layers of green clay, dissected by desiccation cracks indicate limited size and rapid drying.

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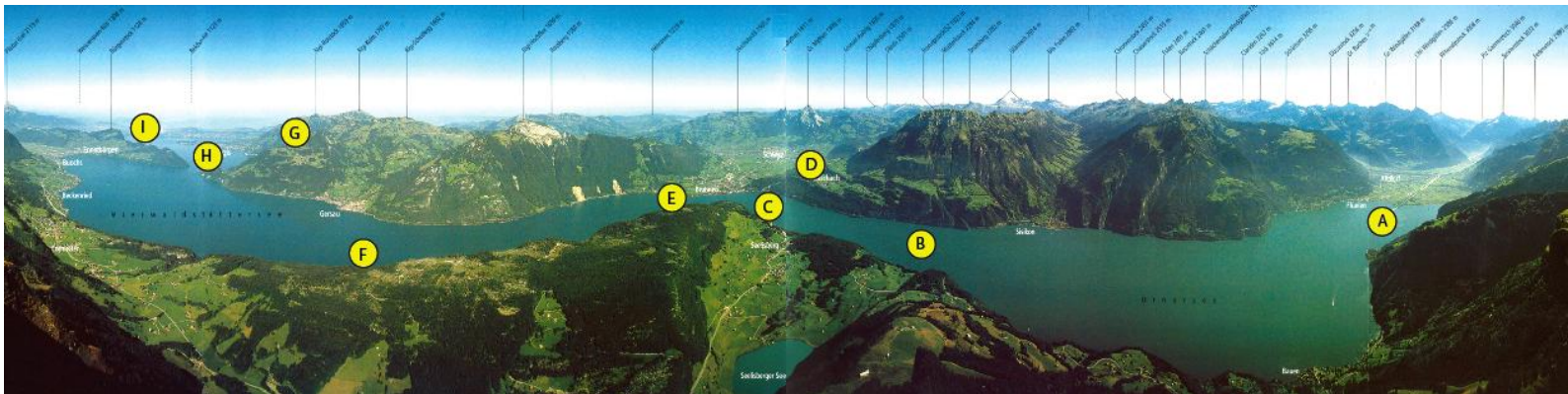
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## Cruising Lake Lucerne from inflow to outflow: Exploring Alpine geology, glaciations, natural hazards and human- environment interactions

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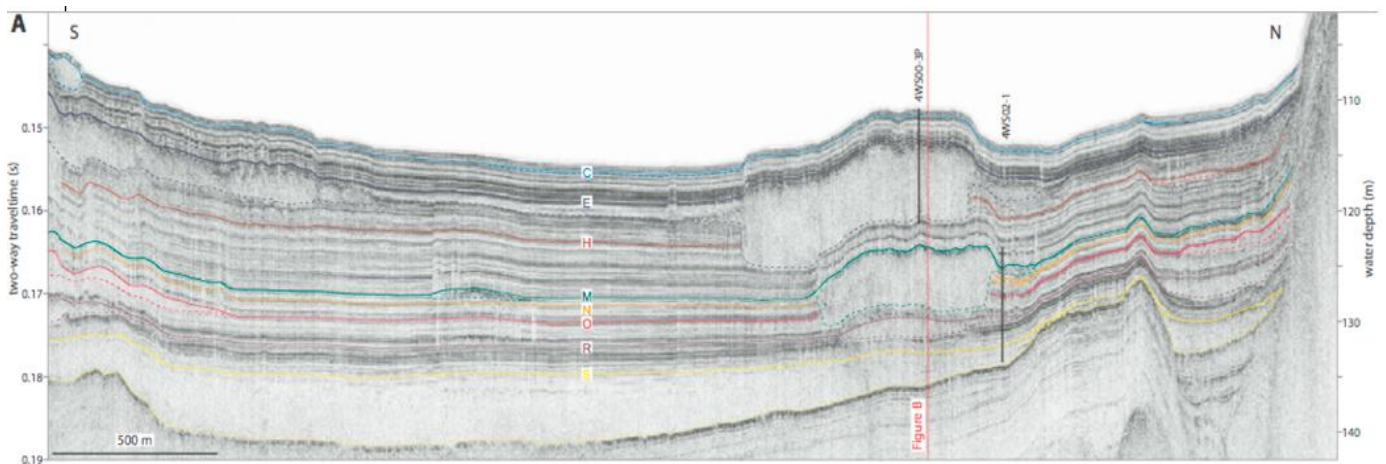
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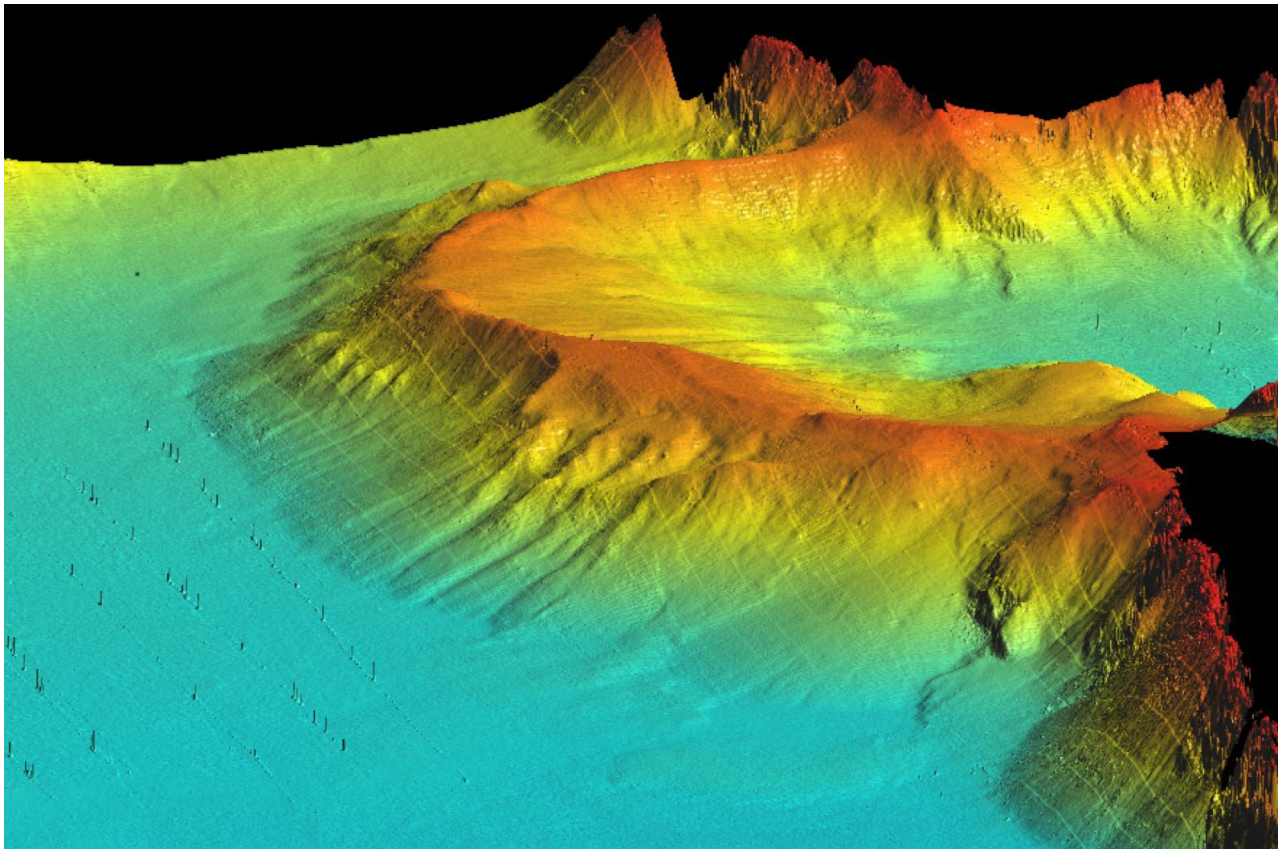
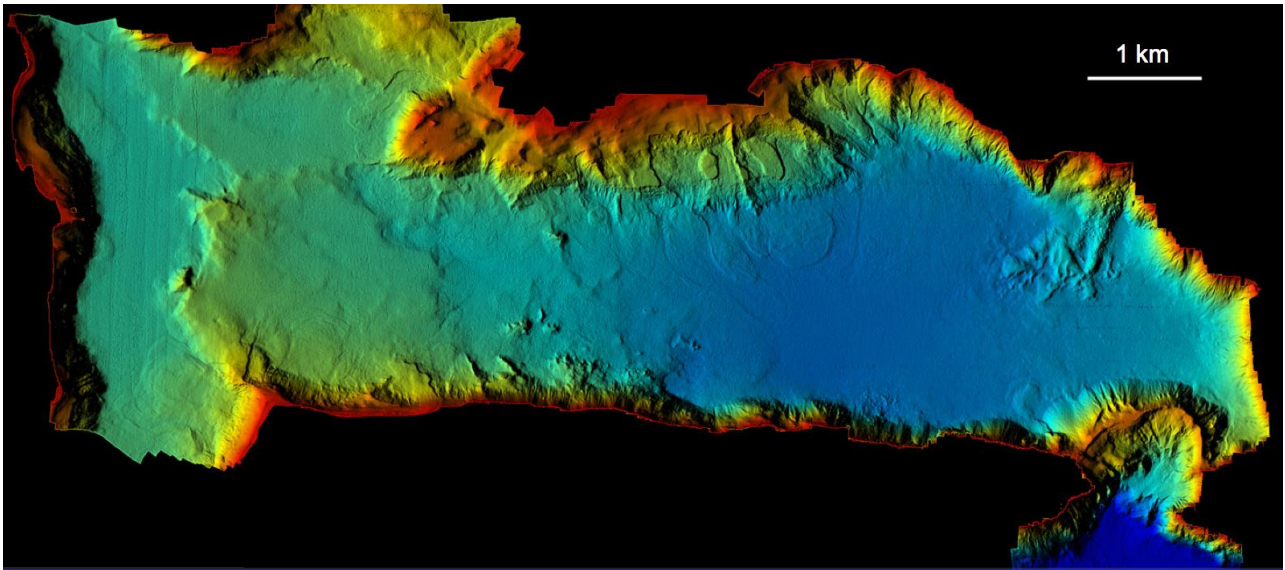
Overview of Lake Lucerne with indicated stops

**Itinerary:** Konstanz - (train) - Flüelen - Boat on Lake Lucerne - Lucerne - (train) - Konstanz.

This one-day field trip along Lake Lucerne will take us onboard a ship from the main inflow to the outflow of this perialpine fjord-type lake. Traces of alpine geology, glaciations and natural hazards (mass movements, earthquakes, tsunamis) in and around the lake will be explored. Results from lake sediment studies will be presented embedded in the landscape history. The scenic lake setting also hosts numerous historic events and places, which highlight the complex human-environment interactions in a scenic alpine setting.



Seismic reflection profile showing intercalated earthquake-triggered mass-movement deposits and undisturbed lacustrine sediments (from Schnellmann et al., 2006).



High-resolution bathymetry of Vitznau Basin and Chrützttrichter with traces of subaquatic slides, rockfalls, moraines ('Nase' moraien shown in 3D below).





and even into bedrock composed of of Jurassic limestone. The broad channel was later filled with fluvial and brackish sediments of the Brackish Molasse. Youngest preserved sediments in the Molasse Basin belong to the terrestrial Upper Freshwater Molasse.

The sedimentary succession (Fig. 2) is well-exposed along a geological trail starting in Sipplingen, a small medieval town located at the northwestern shoreline of Lake Constance near Überlingen. The trail is partly steep and narrow, and climbs ca. 270 m in elevation.

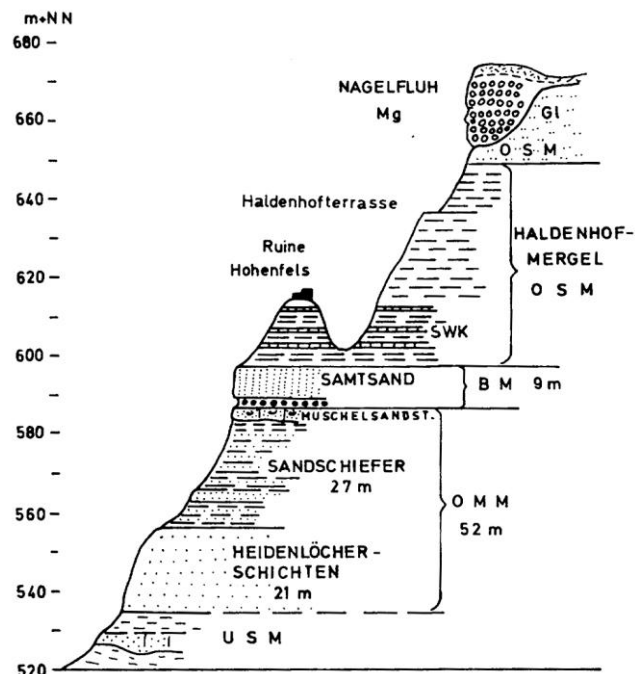


Fig. 2: Lithostratigraphical profile of the Molasse deposits in the northwestern Lake Constance area near Überlingen (from Schreiner 2008, simplified from Haus 1951).

Since the oldest marine period, the *Lower Marine Molasse (UMM)*, never reached as far north, the succession starts here with weakly cemented sandstones and variegated clay- and mudstones of the *Lower Freshwater Molasse (USM)* providing insight into a first terrestrial phase of the basin evolution. At that time, large fluvial systems drained the rising Alps and reached far north and interfered with smaller local rivers from the north. The climate at that time is considered to be monsoon-like, subtropical-humid, as indicated by fossil findings of crocodiles, turtles, rhinos, palm trees, cypresses etc. This depositional phase covered a time period roughly between 31-21 Ma (late Oligocene, early Miocene).

The following deposits are already part of the *Upper Marine Molasse (OMM)*, the terrestrial-to-marine transition is not visible along the trail. The fluvial plain of the USM was flooded at ca. 21 Ma and greenish-grey, glauconitic sandstones formed in a shallow marine environment. Fossil remains, especially shark teeth, are commonly found in these sandstones. A partly steep bedrock-cliff formed in places along the northern shoreline as indicated by abundant borings of shells into Jurassic bedrock. Higher up, the succession becomes finer grained and marly indicating less turbulent and possibly deeper water.

During the retreat of the sea around 17 Ma, an extensive and broad channel was cut into the former deposits of OMM and USM, in some places even into Jurassic bedrock. The estuarine channel („Graupensandrinne“) was filled with fluvial (east) and brackish (west) deposits of the *Brackish Molasse (BM)*. A basal pebble horizon comprising of alpine gravels and reworked local calcrete is succeeded by fine grained sandstones.

The final retreat of the OMM-Sea after ca. 17 Ma reestablished a fluvial plain in the basin, the *Upper Freshwater Molasse (OSM)*. Sediment in the northern part of the basin is generally derived from the east

containing mostly quartz and higher amounts of mica. Along the trail, a faintly laminated succession of clay- and siltstones, fine-grained sandstones and freshwater limestones can be observed. These sediments formed in an swampy fluvial landscape; fossil findings include remains of elephants (mastodon) and saber-toothed tigers.

Cenozoic volcanic rocks are widely distributed in Southwest-Germany and well-known in the Upper Rhein-Graben (Kaiserstuhl) and in the Swabian Jura (Urach). The volcanic rocks considered here are part of the *Hegau volcanic field* of Miocene age, situated west of Lake Constance (Fig. 1). The volcanic rocks, comprising of cover-tuff (i.e., relicts of pyroclastic debris) and remnants of former volcanic vents, interfinger with the deposits of the OSM. While some volcanic horizons lie within the OSM and are thus coeval with middle Miocene Molasse deposition, volcanic vents are always younger than (i.e., cutting through) the youngest OSM deposits. The ages of the basalts and phonolites are around 10-8 Ma (Weiskirchner 1972). Since these volcanic vents are more resistant to weathering than the surrounding deposits of the OSM, they give distinction to the landscape of the Hegau with a number of characteristic pinnacles (e.g., Hohentwiel near Singen).

Quaternary deposits and landforms are widespread and most often related to the last glacial period (e.g., Schreiner 1992). During the Last Glacial Maximum, the entire area was covered by ice of the Rhine Glacier. Sediments are dominated by till and melt-water gravels, which formed in a glacial outwash plain; landforms comprise moraines and drumlin fields. The basin of Lake Constance was also formed during the Last Glaciation.

However, there is also a variety of much older glacial and glacialfluvial rocks at higher elevation. Glacialfluvial gravel deposits („Deckenschotter“) of mid-Pleistocene age are exposed along the crestline above Sipplingen on top of the Molasse succession at an elevation of ca. 650 m, i.e., 250 m above the present-day valley bottom. The sandstones of the OSM had been incised by melt-water river channels, which were filled with poorly sorted gravels.

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## Excursion to the Bodensee-Untersee (Lower Lake Constance)

**Manfred Rösch**

Landesamt für Denkmalpflege

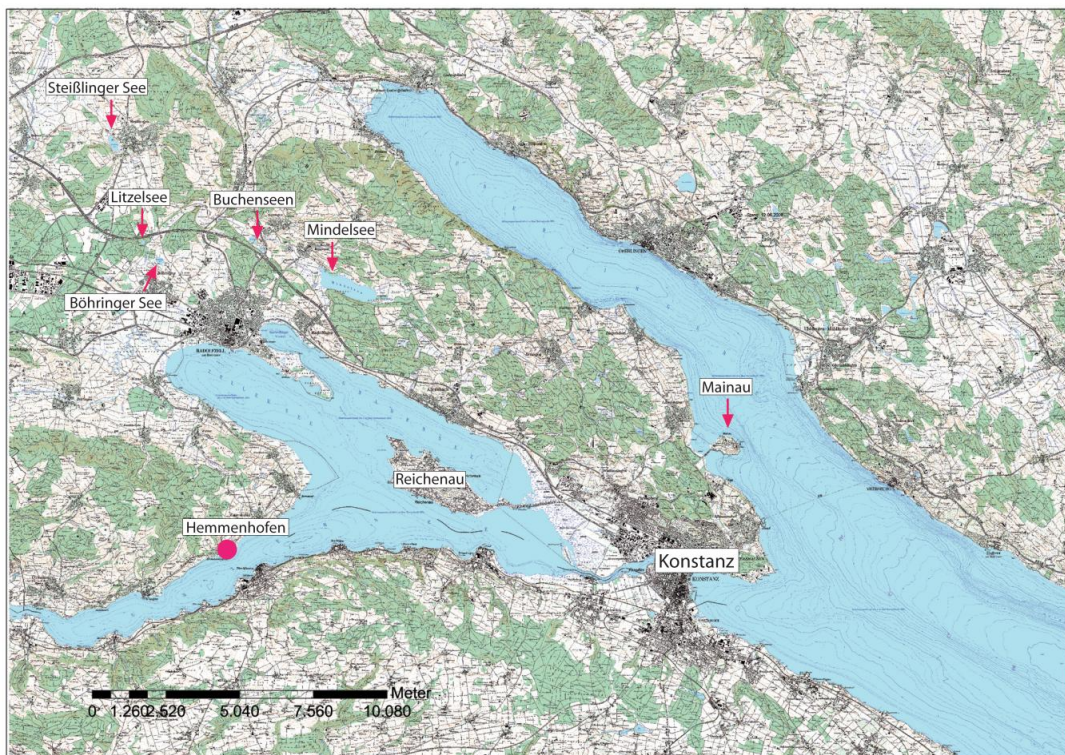
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Guide compiled by M. Rösch, T. Märkle, J. Lechterbeck



Base: Topographische Karte 1:25000 © Landesamt für Geoinformation und Landentwicklung

### Mid conference excursion, 1<sup>st</sup> September 2011, start 12:15

Island of Mainau

Mindelsee

Mettnau

Reichenau

### Post-congress field trip, 4<sup>th</sup> September 2011

Reichenau

Mindelsee

Buchensee

Böhlinger See

Litzelsee

Steißlinger See

Rheinfall

Hemmenhofen

### The Lower Lake Constance

The Lower Lake Constance area was formed during the last glaciation by the Rhine glacier. It is particularly rich in small lakes and mires which today form excellent palaeoecological archives. The laboratory for archaeobotany analysed these archives for the last decades. The lower Lake Constance is therefore the region in Europe with the best palynological research status.

Besides its natural archives, the region is also rich in cultural heritage, beginning with the pile dwellings which surround the lake shore, the churches of the Middle Ages on the Reichenau, the Bernadotte park on the Mainau to name only a few.

The excursions will lead to some of the most interesting sites, both palaeoecological and cultural.

### Landuse in the Neolithic and Bronze Age at lower Lake Constance

Between 2004 and 2011 the laboratory for archaeobotany ran a research program which aimed at evaluating land use strategies during Neolithic and Bronze Age in the Lake Constance area. During the course of this project a number of small lakes have been cored and analysed, some of them for the first time.

The project allowed new insights into the prehistoric land use dynamics. Some of the sites will be visited in course of the field trips.

General data of the small lakes in the hinterland of Lake Constance

Name	easting	northing	surface area (ha)	max. depth (m)	lake type	altitude asl	today's use
Steisslinger See	3493784	5295569	11.2	20.40	Ice-dammed lake/ Dead ice hole	446	swimming, angling
Buchensee 1	3498521	5292300	2.77	12.50	Dead ice hole	433	swimming, angling
Buchensee 2	3498643	5292179	1.21	12.00	Dead ice hole	433	angling, swimming
Buchensee 3	3498855	5291976	1.17	2.50	Dead ice hole	433	---
Litzelsee	3494800	5292188	1.25	8.30	Dead ice hole	407	angling
Böhringer See	3495373	5291557	5.36	8.70	Dead ice hole	405	swimming, angling
Mindelsee	3501785	5290646	101.10	13.50	Tongue basin	406	fishing, angling

### Mid conference excursion, 1<sup>st</sup> September 2011, start 12:15

#### Mainau

The Mainau was mentioned first 1242 as "Maienowe". It has an area of 45 ha and is thus the third biggest island in the Lake Constance. The island consists of tertiary molasse sandstone and lies between 395 and 425 m asl. It belongs to the town of Constance and is owned by the noble family of Bernadotte. The family is one of the main attractions of the island. They maintain an extensive park and garden which practically covers the whole of the island. Important buildings are the castle (begun in 1739), the "Schloßkirche" (begun in 1732) and the "Gärtnerturn".

To get access to the island, an admission fee has to be paid.

At the south shore of the Mainau prehistoric settlement traces were found already in 1862. A pile dwelling was discovered in 1930 and is dated to 3000 B.C.

The laboratory of archaeobotany took a core off the southern shore of Mainau to analyse it for pollen and eventually catch the settlement signal in the record. The pollen diagram (app. 1) was dated by 9 radiocarbon dates. It shows settlement activities not only at the time of the evidenced pile dwelling but from around 6000 B.P. to 2000 B.P. in varying intensities. The shift from the Neolithic to the Bronze Age economy can be observed very well: whereas human impact in the Neolithic is shown mostly by the increase of shrub vegetation, in the Bronze Age indicators for open spaces, meadows and grass land as well as cereals increase. This is the beginning of an agriculture with large open spaces which were kept open for a longer period of time – in fact the birth of our cultural landscape today.

### **Mindelsee**

The Mindelsee is a glacier tongue lake on the Bodanrück and has an area of 115 ha. It is 2200 m long and 570 m broad and stretches northwest-southeast. In the extent and wet areas around the lake peat accumulated after the ice age which was cut before the lake was declared nature reserve in 1932.

Today it is a very rich and variate area which offers natural habitats for numerous plants and animals.

The Mindelsee pollen profile (app.2) shows human impact already in the Neolithic though no Neolithic settlements are known. Earliest settlement traces come from the Bronze Age – a pile dwelling is known from the south shore.

### **Mettnau**

The Mettnau is a peninsula of 3,5km length and 800m width which juts out into the Untersee of Lake Constance. It is a nature reserve since 1926 and hosts a wide variety of fauna and flora. The amphibious plants in the southwest part of the area represent a floristic peculiarity and include species like *Litorella uniflora*, *Ranunculus reptans* and the endemic *Myosotis rehsteineri*, a plant almost exclusively growing at the shores of Lake Constance. The Mettnau is also characterized by a rich bird life with 90 breeding species in the timespan between 1982 and 2002, among them water rail, black-necked grebe and great reed warbler. Next to the NABU-centre is a branch of the ornithological station, where songbirds during their migration period in autumn are caught and ringed. Since the hundred year flood of 1999 some rare butterflies are missing but other invertebrates like ground beetles or spiders still occur. Different bat species are represented in the area, remarkable in particular is the endangered Nathusius's pipistrelle, whose nursery roosts in summer are about 1000km up to the north.

### **Reichenau**

In 724, the itinerant bishop Pirmin founded a Benedictine monastery on the island. As a direct imperial monastery, it developed into a spiritual centre of the Occident from the 8th to the 11th century. Teachers of distinction taught at the famous monastic school, from which outstanding personalities (theologians, politicians, scientists, poets and musicians) emanated. Furthermore, the monastic library, the "Reichenauer Malschule" (painting school for wall and book illustrations) and the art of goldsmiths were famous. After the golden years of the Carolingian-Ottonian epoch, the monastery increasingly lost importance in the late Middle Ages and the spiritual and economic decay began. In 1540, the monastery was converted into a priory and it was dissolved by Pope Benedict XIV in 1757. On 30th November 2000, the "Monastic Island of Reichenau" in Lake Constance was admitted to the list of UNESCO World Cultural Heritage Sites as a

cultural landscape giving an outstanding testimony to the religious and cultural role of a great Benedictine Monastery in the Middle Ages.

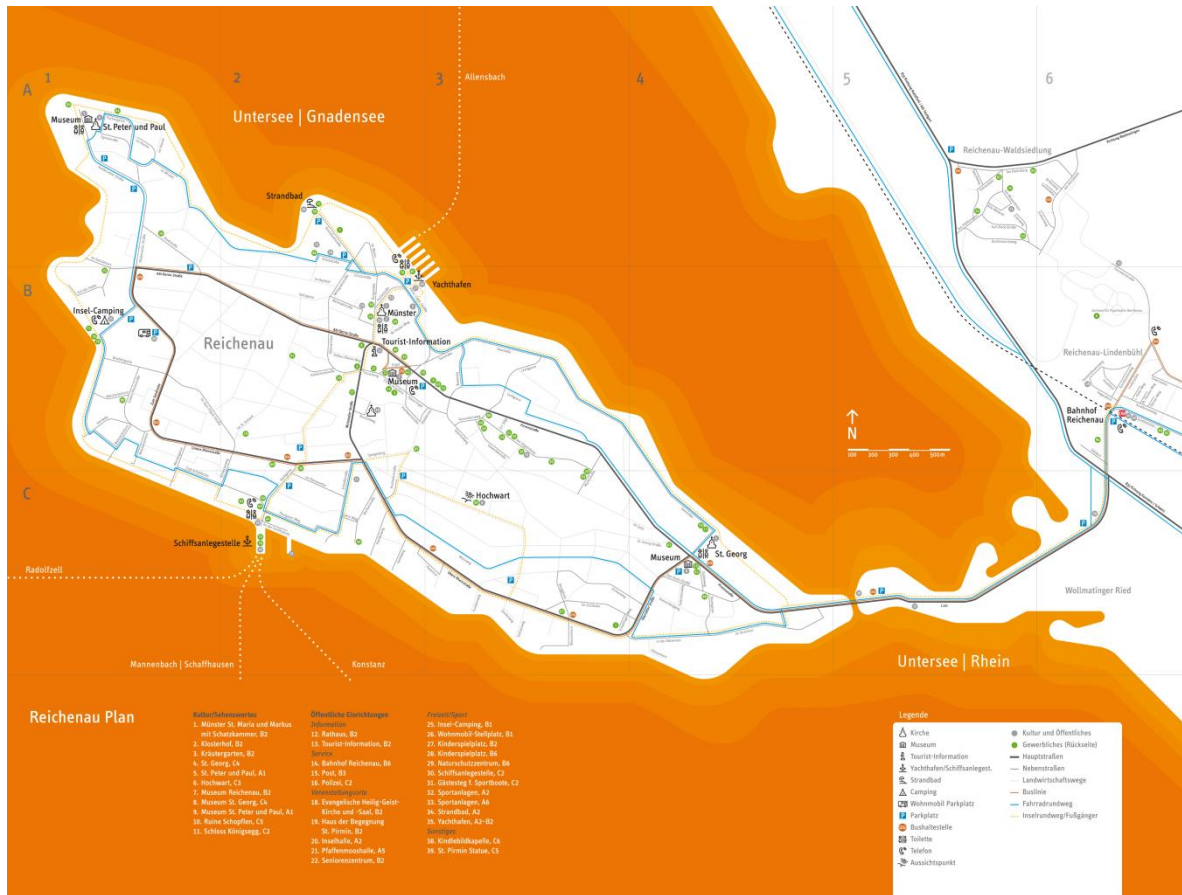


fig. 2: Map of the island of Reichenau

The well-preserved churches of the island offer clear examples of the monastic architecture from the 9th to 11th century, the carefully renovated wall paintings show Reichenau as an artistic centre of great importance for European art history of the 10th and 11th centuries. The monastic era has strongly characterised the image of the island, its countryside as well as its economic structure in a way that is perceptible to the present day.

© [www.reichenau.de](http://www.reichenau.de)

**Post-congress field trip, 4<sup>th</sup> September 2011**

**Reichenau**

see mid congress field trip

**Mindelsee**

see mid congress field trip

### Buchenseen, Böhringer See and Litzelsee

The Buchenseen, the Böhringer- and Litzelsee are a set of small lakes which formed from dead ice after the last glaciation. They were sampled for pollen analysis and detailed diagrams (app. 3, 4, 5) were made in the course of a project trying to show the differences between Neolithic and Bronze Age land use. To achieve a good time control, the datation of the three profiles is based on about 50 radiocarbon dates.

### Steisslinger See

Lake Steisslingen is situated in the western part of the Alpine Foreland (8.9°E 47.8°N). The foreland basin's bedrock is built of Jurassic limestone underlying the Tertiary basin sediments.

The lake is 600 m long and 200 m wide. It has a funnel like morphology with a maximum depth of 20.5 m (fig. 3). The lake is meromictic: under a depth of 15 m there is no exchange of water. Because of that, large parts of the sediments are annually laminated. The lake has no surfacial inflow and is solely fed by submerged springs originating in marine molasse sandstone. The incoming water is very rich in calcium carbonate and sulfate.

Lake Steisslingen was subject to an interdisciplinary research project between 1992 and 2000. More than 40 probative drillings, eight littoral, four sublittoral, and five profundal cores up to 8m length were cored. A detailed chronological model was established by varve-counting that is cross-dated by a series of radiocarbon dates. Sedimentation starts with glacio-lacustrine sands and clays of the Oldest Dryas. During the Bølling/Allerød the amount of organic material increased and lamination commenced. These layers, interpreted as organic varves, are characterised by two seasonal layers: a thin dark layer containing organic material, diatom valves, pyrite framboids, and various detritic material, followed by a relatively thicker, light-coloured, and mainly calcitic layer. The profundal sediments were analysed by high resolution pollen analysis (app. 6). This allowed to combine a detailed record of vegetation change with a detailed and accurate time model.

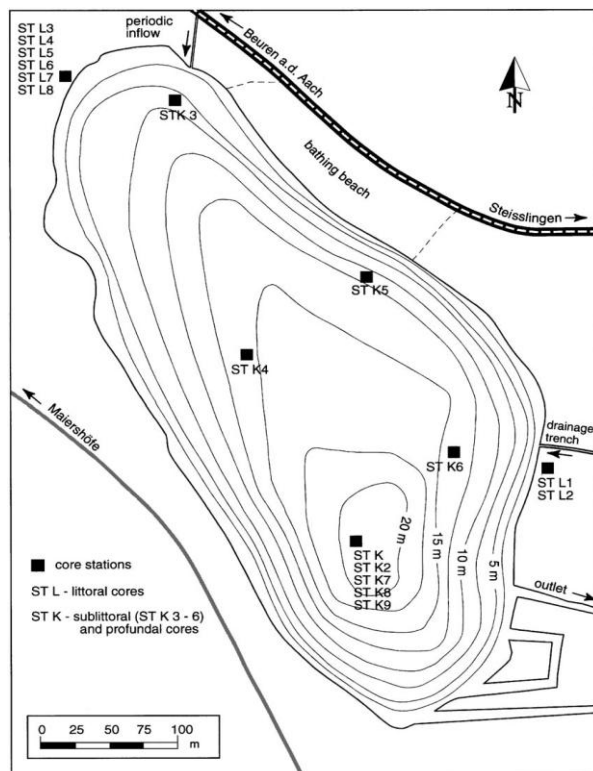


fig 3: Bathymetric map of Lake Steißlingen

### Rheinfall bei Schaffhausen

The Rhine Falls (*Rheinfall* in German) are the largest plain waterfalls in Europe. The falls are located on the Upper Rhine between the municipalities of Neuhausen am Rheinfall and Laufen-Uhwiesen, near the town of Schaffhausen in northern Switzerland, between the cantons of Schaffhausen and Zürich. They are 150 m wide and 23 m high. In the winter months, the average water flow is 250 m<sup>3</sup>/s, while in the summer, the average water flow is 700 m<sup>3</sup>/s. The highest flow ever measured was 1,250 m<sup>3</sup>/s in 1965; and the lowest, 95 m<sup>3</sup>/s in 1921.

The falls cannot be climbed by fish, except by eels that are able to worm their way up over the rocks.

The Rhine Falls were formed in the last ice age, approximately 14,000 to 17,000 years ago, by erosion-resistant rocks narrowing the riverbed. The first glacial advances created today's landforms approximately 500,000 years ago. Up to the end of the Riss stadial approximately 132,000 years ago, the Rhine flowed westwards from Schaffhausen past Klettgau. This earlier riverbed later filled up with gravel.

About 132,000 years ago the course of the river changed southwards at Schaffhausen and formed a new channel, which also filled up with gravel. Part of the Rhine today includes this ancient riverbed.

During the Würm glaciation, the Rhine was pushed far to the south to its present course, over a hard Late Jurassic limestone bed. As the river flowed over both the hard limestone and the easily-eroded gravel from previous glaciations, the current waterfall formed about 14,000 to 17,000 years ago. The Rheinfallfelsen, a large rock, is the remnant of the original limestone cliff flanking the former channel. The rock has eroded very little over the years because relatively little sediment comes down the Rhine from Lake Constance.

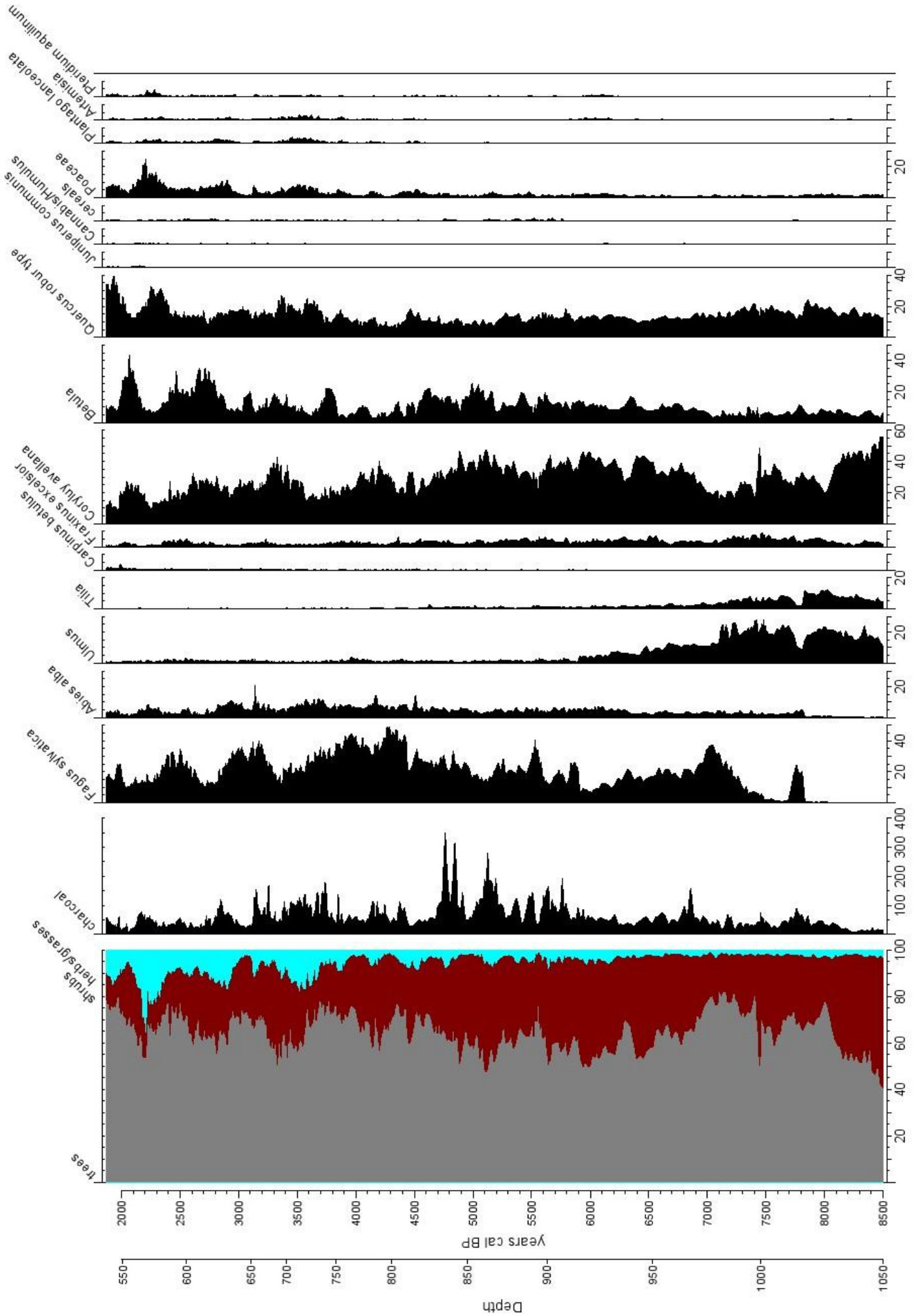
### Hemmenhofen, Landesamt für Denkmalpflege

At Hemmenhofen, on the shore of Lake Constance, the division of the department for the protection of archaeological sites and monuments within the State Cultural Heritage Department of Baden-Württemberg maintains two units, the archaeobotany branch (Labor für Archäobotanik) and the wetland archaeology branch (Fachgebiet Feuchtbodenarchäologie) (Abt. 8, Ref. 84 and 85). The personnel is housed in a workplace with laboratories, in which four researchers (a botanist, two archaeologists and a dendrochronologist), one excavation technician, one scientific diver, one draughtsperson and four technical assistants look after the Baden-Wuerttemberg pile dwellings and associated sites and the botanical remains of archaeological sites respectively. External financing of temporary projects (e.g. by Deutsche Forschungsgemeinschaft) increases the budget for personal costs, and thus the number of employees.

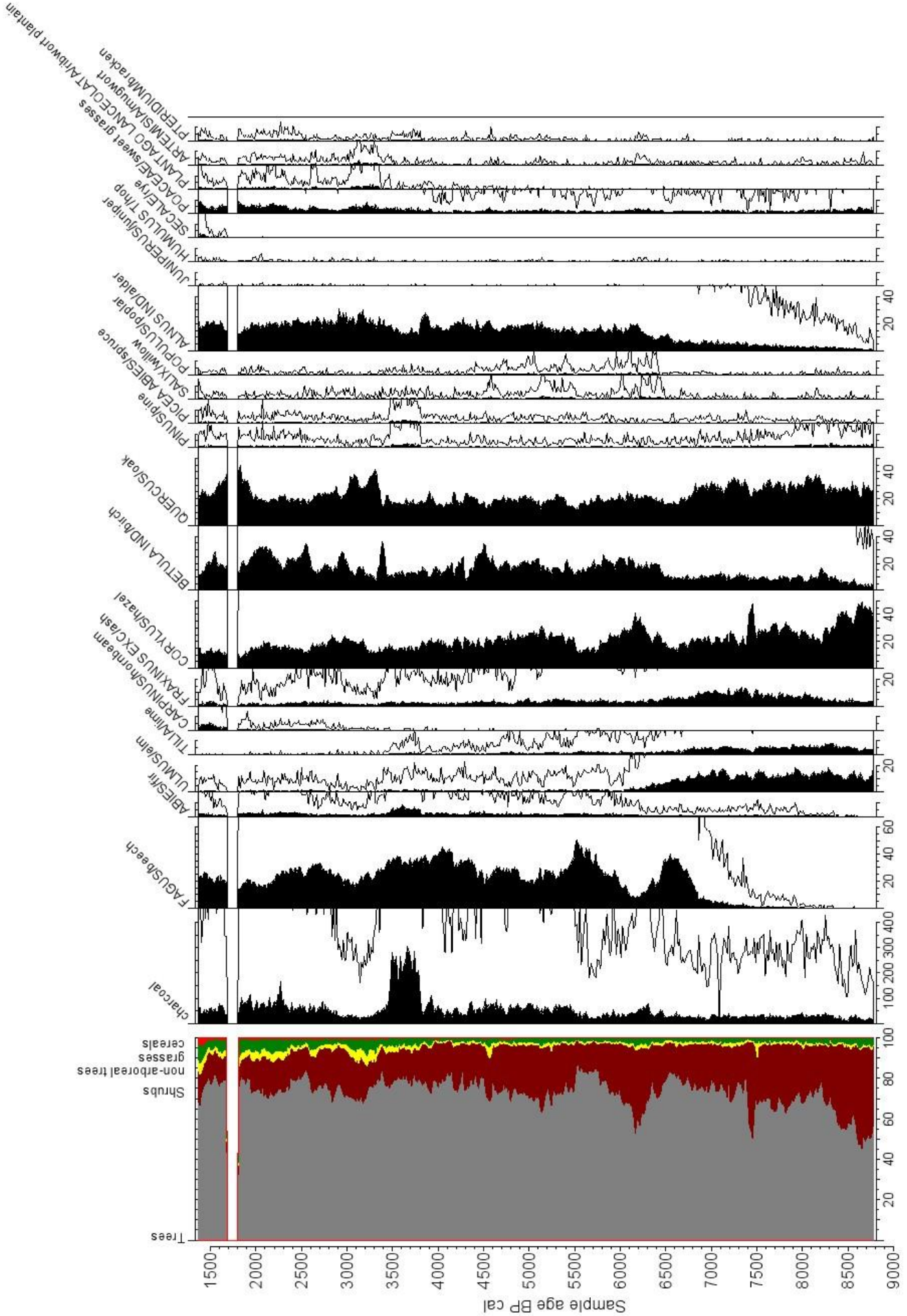
### UNESCO World Heritage: the pile dwelling sites

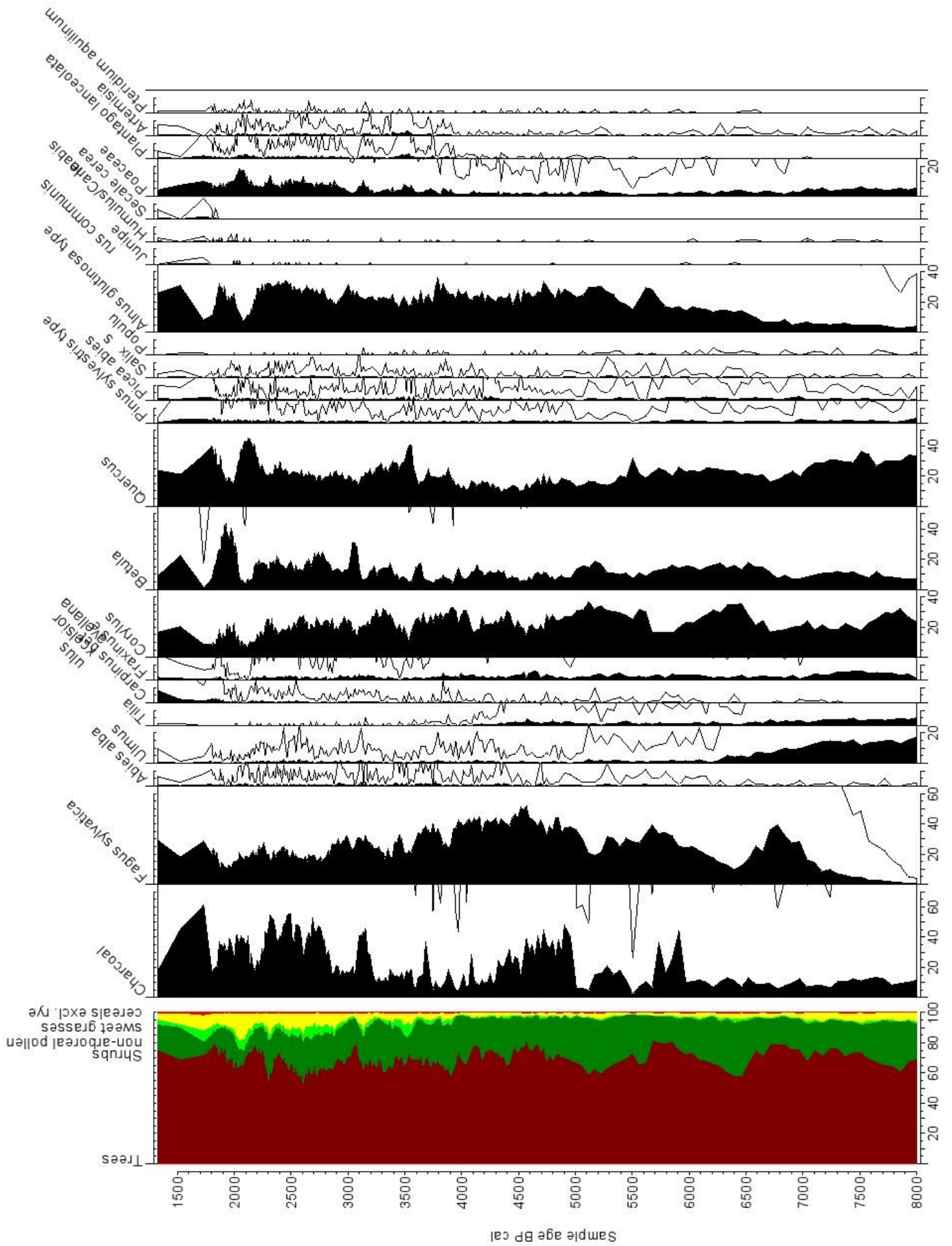
On the 27.06.2011 a series of 111 out of the 937 known archaeological pile-dwelling sites in six countries around the Alpine and sub-alpine regions of Europe was declared as World Heritage. 9 of them are located at Lake Constance. The series is composed of the remains of prehistoric settlements dating from 5,000 to 500 BC which are situated under water, on lake shores, along rivers or in wetlands. The exceptional conservation conditions for organic materials provided by the waterlogged sites, combined with extensive under-water archaeological investigations and research in many fields of natural science, such as archaeobotany and archaeozoology, over the past decades, has combined to present an outstanding detailed perception of the world of early agrarian societies in Europe.

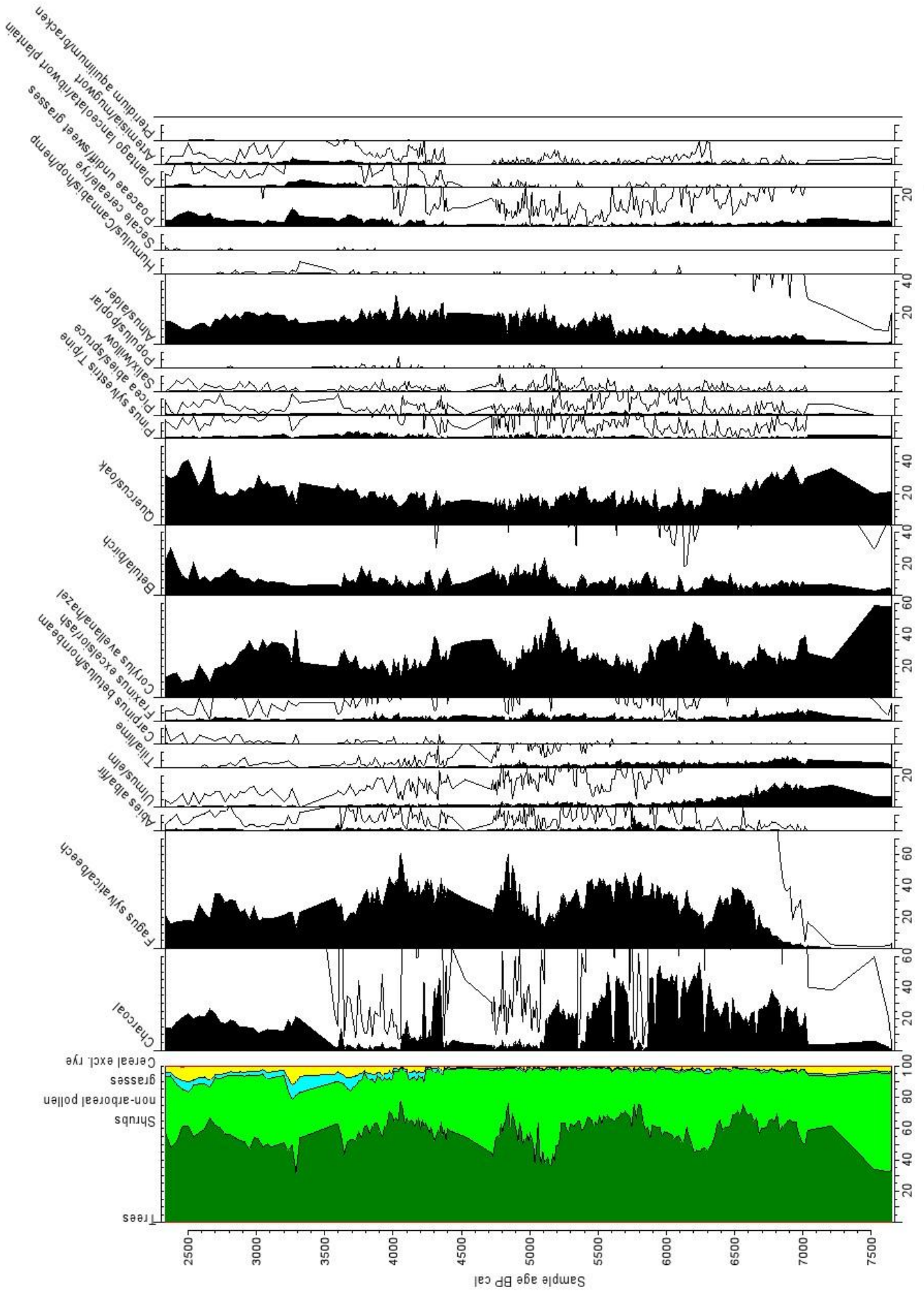




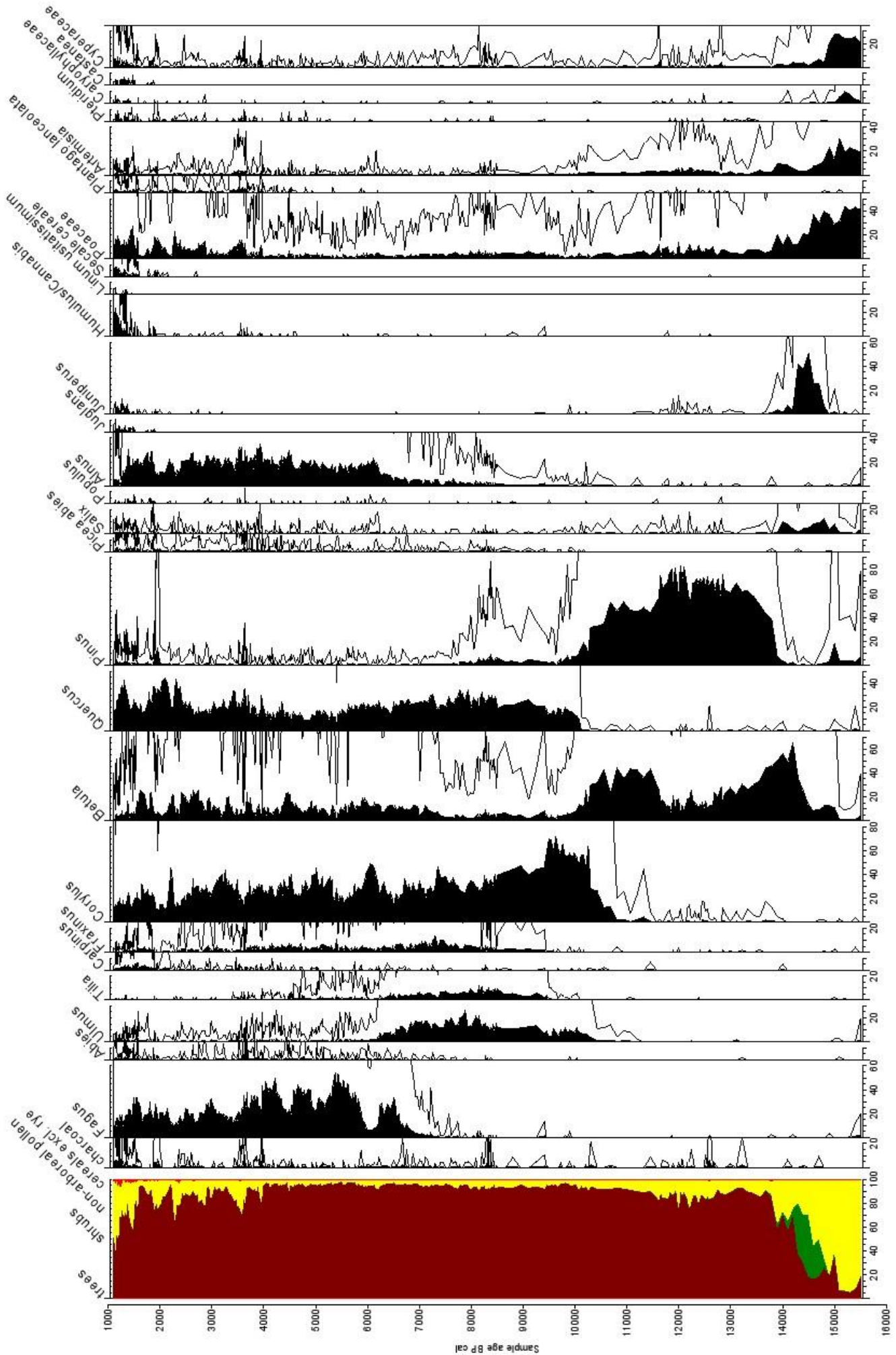








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