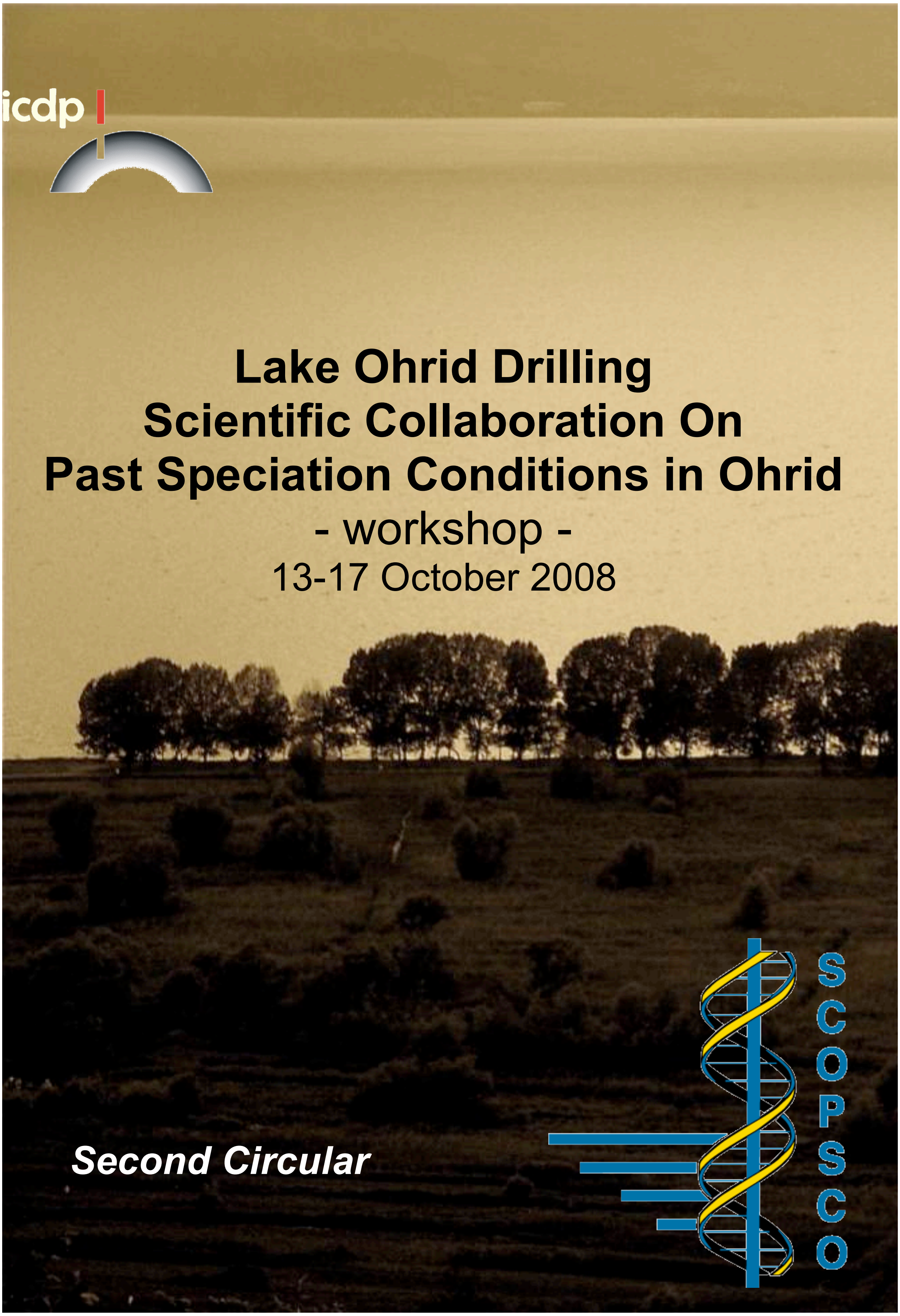

Lake Ohrid Drilling
Scientific Collaboration On Past Speciation Conditions in Ohrid

- workshop -

13-17 October 2008

Second Circular

SCOPSCO

The SCOPSCO Lake Ohrid Drilling ICDP workshop will be held from 13-17 October close to the city of Ohrid in Hotel Klimetica.

Hotel Klimetica situated 4 km to the south of the city of Ohrid, Macedonia. It is located only 100 m far from the beach of the Ohrid Lake under the slope of mountain Galicica and surrounded by pinwood forests. Nearby are the cave church and the monastery St. Stefan. The hotel has been completely renovated in 2006. Every room has own telephone, TV, mini bar, internet access and you have a wonderful view over the lake.

Accommodation incl. full board in Hotel Klimetica will be paid by ICDP funds from 13-17 October 2008. A taxi service will be arranged to and from the airports in Skopje or Ohrid, depending on the dates and times of arrivals and departures. Please let us (Bernd Wagner or Tom Wilke) know your flight dates as soon as possible, if not yet done. Please note that costs for additional stay in Ohrid or Skopje exceeding the period mentioned above cannot be covered by ICDP funds, but we will of course help you to find accommodation. Please also visit : http://www.hotelklimetica.com.mk for further information or for additional reservations if needed.

Program

Monday, 13th October

18.00 Icebreaker Hotel Klimetica, Ohrid

Tuesday, 14th October

Talks and posters

1 General introduction

09.00 Welcome and Introduction
09.10 Bernd Wagner: SCOPSCO – Towards an ICDP project
09.30 Goce Kostoski: History of the Ohrid region and the Hydrobiological Institute
09.50 Tom Wilke: DNA analyses bridging the gap between past and present in ancient lakes
10.10 Shyqyri Aliaj / Andon Grazhdani: Geologic Framework of Ohrid Lake area

10.30 - 10.50 Coffee break

2. Recent biology

10.50 Christian Albrecht: Lake Ohrid biodiversity and endemism - a state of the art overview
11.10 Jurek Sell: *Proasellus* (Crustacea, Isopoda) species group and *Ochridagammarus* (Crustacea, Amphipoda) complex endemic to the Balkan Lake Ohrid: examples of intralacustrine diversification
11.30 Sasho Trajanovski: Endemism, relicts and speciation in Lake Ohrid
11.50 Zoran Spirkovski: Fish speciation in Lake Ohrid

12.10 - 13.30 Lunch

3. Tectonics / Sedimentology

13.30 Klaus Reicherter / Tomas Fernandez-Steger / Nadine Hoffmann: Neotectonics and tectonic morphology of the Lake Ohrid Basin
13.50 Christian Beck: A Multi-proxy study of the Shkodra/Scutari Late Quaternary sedimentation
14.10 Sebastian Krastel /Tilmann Schwenk / Katja Zimmermann: First results from the seismic investigations in Lake Ohrid
14.30 Hendrik Vogel: Cores Lz1120 and Co1202: record of environmental change at Lake Ohrid (Albania, Macedonia)

14.50 Roberto Sulpizio: Tephrostratigraphy and tephrochronology of Lake Ohrid sediments: importance for volcanology and Quaternary sciences
15.10 Marion Matter / Flavio Anselmetti: Carbonate precipitation in the Kalista spring area, northwestern Lake Ohrid

15.30 - 15.50 Coffee break

15.50 Ken Verosub: Paleomagnetism in Lake Ohrid: potential for chronostratigraphic work and paleoenvironmental reconstructions

<u>4. Biological proxies</u>

16.10 Antje Schwalb et al.: Ostracodes from ancient Lake Ohrid sediments as indicators of past environments
16.30 Andy Lotter: Pollen from Lake Ohrid sediments as indicators of past vegetation and climate
16.50 Jane Reed: Diatoms as palaeoclimate indicators in Lake Ohrid
17.10 Jens Holtvoeth: Assessing the potential for a high-resolution multi-molecular biomarker study on Lake Ohrid sediments – initial results from core Lz1120

from 17.30 - 18.30 open discussion and poster presentation

Wednesday, 15th October

09.00 Breakout groups

Breakout groups shall be formed, in order to present the current scientific stage, to discuss potential overlaps of scientific interests, and to define scientific collaboration and responsibilities as well as the specific goals of the deep drilling campaign.

The breakout groups shall focus on the following subjects:

(1) Speciation and Endemism (speaker Tom Wilke)
(2) Seismic / Neotectonics (speaker Sebastian Krastel)
(3) Sedimentology and Volcanology (speaker Bernd Wagner)

The outcome of the discussions within the breakout groups shall be documented by a ca. 1-2 pages worksheet and shall be presented and discussed on thursday morning

10.30 - 10.50 Coffee break

11.00 Breakout groups

12.00 - 13.30 Lunch

13.30 Excursion to Galicica Mountains and Sveti Naum
Excursion by Bus to Sv. Naum, back from Sv. Naum by boat, dinner onboard

Thursday, 14th October

09.00 Presentation of the results and goals defined by the breakout groups

10.30 - 11.00 Coffee break

11.00 Definition of potential coring sites according to the specific goals defined by the breakout groups

12.00 - 13.30 Lunch

13.30 Future steps towards a deep drilling
- logistics and legal issues
- funding (national / international programs)
- schedule for full proposal

15.00 - 15.30 Coffee break

15.30 - ca. 17.00 Plenary discussion

ABSTRACTS

Geologic framework of Ohrid Lake area

S. Aliaj and A. Grazhdani

The Ohrid Lake Area takes place in the internal domain of Albania, characterized by the horst-graben structures formed in an extensional tectonic regime during the Pliocene-Quaternary. From the geologic viewpoint it comprises the eastern part of Mirdita Ophiolite Zone, and the western part of Korabi Zone (Western Macedonian Zone). After the principal Alpine folding and thrusting, the following Cenozoic basins were superposed in this area: the Albanian-Thessalian and Librazhdi marine molasse basins, as well as the Ohrid, Prespa and Devolli lake basins.

In the large area from Qafe-Thana, west of Ohrid Lake, to Prespa lakes, the Upper Triassic-Lower Jurassic limestones of Korabi Zone were thrust on Jurassic ultrabasic ophiolites of Mirdita Zone for more than 50 km.

The structure around the Ohrid and Prespa lakes was intensively affected by normal faulting. At Qafe-Thane structure in horst shape due to normal faulting, the gently west dipping Upper Triassic-Lower Jurassic limestones thrusts on ultrabasic ophiolites. At Qafe-Zvezda, to the south of Prespa e Madhe Lake, the Upper Triasic-Lower Jurassic carbonates were thrust too on the ultrabasic ophiolites.

A horst structure of Upper Triassic-Lower Jurassic carbonates developed eastwards of Ohrid- Korça depression. Small serpentinite diapirs are found along the normal faults cutting the Korabi limestones.

The Albanian-Thessalian Basin, formed on deposits of Korabi and Mirdita Zones, comprises three molasse cycles, namely: i) Middle Eocene (Lutetian), ii) Oligocene (from Middle Oligocene, Stampian) to Lower Miocene (Aquitanian), iii) Burdigalian to Langhian. It is represented by a north-westerly extending syncline fractured by normal faulting.

The Librazhdi Basin, lying mostly over the northern continuation of the Albanian-Thessalian Basin and some parts of Mirdita Zone, comprises the Serravalian and Tortonian molasse deposits. Structurally it comprises an assymetrical syncline with its western flank strongly dipping.

Numerous Pliocene-Quaternary grabens or half-grabens lake basins formed in the interior of the country due to strong extensional tectonics affected this domain. Since the Pliocene, the Ohrid, Prespa and Devolli lake basins were established in the area under study. Here are distinguished the Pliocene-Quaternary normal fault-controlled Ohrid and Prespa grabens, Korça and Devolli half-grabens.

The Ohrid lake Basin formed during the Pliocene and extended from the Korça plain to north of Ohrid Lake. It comprises two different formations: i) Alarupi coaliferous formation, discordantly and transgressively overlying on Triassic limestones of Korabi Zone, and ii) Çerrava conglomerate formation. Quaternary sediments embodying sands and clays were revealed on Starova plain.

The Prespa lake basins were created during the Pliocene in the area now occupied by the Prespa lakes. Small remnants of Pliocene sediments outcrop on the Prespa lacustrine margins.

The Devolli lake Basin extended from Mirasi village to the Cangonj one, and to the east, it adjoins a normal fault at the foothills of Bilishti. Pliocene deposits dips gently eastwards, overlying the Burdigalian to Langhian sediments of the Albanian-Thessalian Basin. It has three distinctive formations: i) Menkulasi-Suli coaliferous formation, ii) Ziçishti sandy formation, and iii) Dobrenj-Kuçi coal-bearing formation.

The development of horst-graben structures in the Ohrid Lake area, established due to extensional tectonics since the Pliocene, was also influenced by the evaporite diapirism, as in the Peshkopi area, where such phenomena are well evidenced eastwards of Peshkopi depression at Mali i Bardhe and Banjat e Peshkopise evaporate diapir domes, belonging to Kruja Zone.

Lake Ohrid biodiversity and endemism - a state of the art overview

C. Albrecht

Lake Ohrid (Macedonia/Albania) is reknown for its outstanding biodiversity. The last comprehensive review on the lakes biodiversity, however, dates back half a century. There has been considerable progress concerning the knowledge of how many species live in the lake and whether they occur there exclusively. Many taxonomic groups have been studied newly and particularly within the past 5 years within a modern phylogenetic framework. The degree and kind of endemism in the lakes biota has received more focused attention. I summarize the current information on Lake Ohrid biodiversity and endemism using a taxon by taxon approach and suggest future research directions.

Proasellus (Crustacea, Isopoda) species group and *Ochridagammarus* (Crustacea, Amphipoda) complex endemic to the Balkan Lake Ohrid: examples of intralacustrine diversification

J. Sell, A. Wysocka, A. Kilikowska

Phylogenetic relationships and divergence times within the endemic species groups from the relict Lake Ohrid were examined using molecular methods.

Lake Ohrid is inhabited by four isopod species representing the freshwater family Asellidae. Three of them are endemic and belong to the genus *Proasellus* Dudich 1925: *P. remyi* (Monod, 1932), *P. arnautovici* (Remy, 1932) and *P. gjorgjevici* (Karaman, 1933). Taxonomic studies of Karaman led to the description of several morphological forms within *P. remyi*: *remyi*, *acutangulus, nudus* and within *P. gjorgjevici*: *typicus* and *litoralis*. Karaman also recognized a subspecies, *P. arnautovici elongatus*, different from the littoral *P. arnautovici arnautovici*. The morphological forms are connected with different vertical zones of the lake characterized by specific conditions of life and the nature of bottom.

Proasellus species group is composed of two divergent, well-supported reciprocally monophyletic clades. The last common ancestor of all endemic *Proasellus* species from Lake Ohrid was dated at approximately 7 Mya. However, the proper radiation of the two isopod lineages seems to be more recent. In case of *P. remyi* f. *remyi*, *P. remyi* f. *acutangulus* and *P. arnautovici arnautovici* group, the last common ancestor was dated at approximately 1.53 to 1.90 Mya according to different approaches. For *P. gjorgjevici* f. *typicus*, *P. gjorgjevici* f. *litoralis*, *P. remyi* f. *nudus* and *P. arnautovici elongatus* group, this estimate is 2.33 Mya and 2.83 Mya respectively.

The species of the endemic *Ochridagammarus* complex also seem to have characteristic ecological distributions. The species inhabit different zones of the lake along the depth gradient. Genetic variation and evolutionary relationships assessment support monophyly of this complex. The high levels of divergence between intralacustrine species and other representatives of the complex, inhabiting environments outside the lake, suggest divergence time counted in millions of years.

The phylogenetic structures we present, are generally in line with theoretical predictions. There are still some inconsistencies with the hypothesis of adaptive diversification driven by ecologically different environments. Further research is needed to conclusively resolve this issue.

The results of this study provide insight into evolutionary patterns in crustaceans and support the idea of intralacustrine speciation in Lake Ohrid.

Neotectonics and tectonic morphology of the Lake Ohrid Basin

N. Hoffmann, K. Reicherter, T. Fernández-Steeger

Lake Ohrid is located at the Macedonian/Albanian border in the Albanian mountain chain. Lake Ohrid has a length of c. 30 km and a width of c. 15 km. The lake level of 693 m height is surrounded by mountains reaching approx. 1500 m in the W and more than 1750 m in the E. The general extent of the lake has been limited in the east by the horst of the "Dry Mountain" chain and in the west by the "Mokra Mountain" chain. Neotectonic movements along faults that remain active today determine the form of the lake with its simple and relatively straight shorelines. Lake Ohrid is drained presently by the Crni Drim river at the northern end of the basin. It is suggested that the draining already started in the early Pleistocene as evidenced by deeply incised channels (Dumurdzanov et al., 2005).

The Albanian mountain chains are located within the Afro-European Convergence Zone and are an approximately 200 km long and 100 km wide region with dispersed seismicity. More precisely, the orogen formed on the Eurasian Plate, which deforms actively due to NNE-directed convergence with the Adriatic microplate. In contrast to the compressive coastal part of Albania the central and eastern part are subject to extension (Fig.1). Extension in the southern Balkan (Macedonia and parts of Albania) started already in the late Paleogene and lasts to the Present, with a short-termed period of compression between the late Oligocene to middle Miocene. The Neogene stretching period started approximately 6

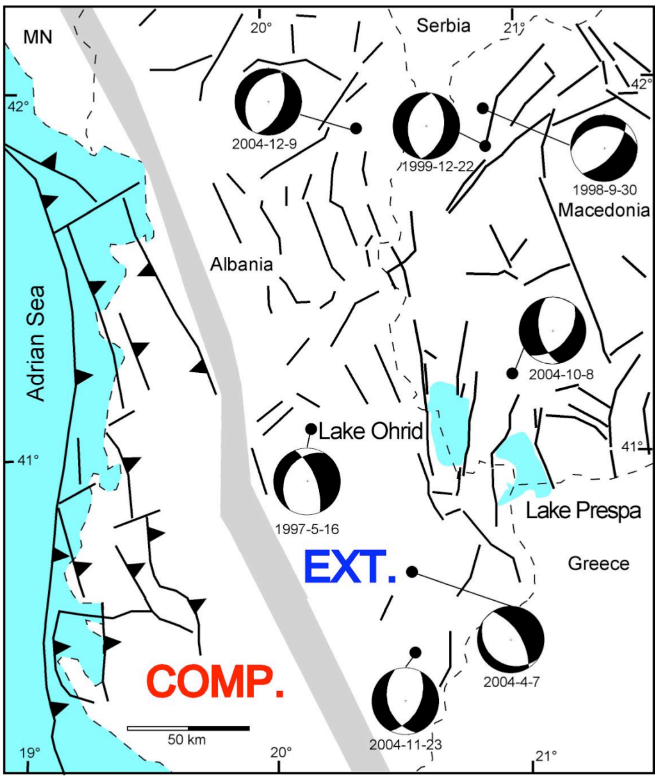

Fig. 1: Geodynamic situation of Lake Ohrid, grey zone separates compressional sector from the extensional sector in the East (modified after Dumurdzanov et al., 2005). Fault plane solutions of seven moderate earthquakes (1998-2004; M_W 4,6-5,4, from http://www.globalcmt.org).

Ma ago due to roll-back of the subducted slab along the northern Hellenic Arc, related with a westward migration of extensional faulting into the area of the Western Macedonian Zone (WMZ, Dumurdzanov et al., 2005). The general geodynamic setting of the Lake Ohrid area can be described with a “basin and range” situation.

The WMZ consists of low- to medium-grade metamorphosed Paleozoic sediments and igneous rocks and an unmetamorphosed Mesozoic sedimentary cover (Triassic, minor Jurassic; striking generally NW-SE). Syn- and postorogenic Oligocene sediments are present only west and south of Lake Ohrid. Later, during the Messinian and Pliocene grabens and half-grabens acted as sediment traps creating a variety of intramontane basins. The initial deposits of Lake Ohrid are known from rare wells, which drilled gravel and sandstones resting unconformably on Paleozoic basement or Triassic carbonates. The approximate thickness of the basal unit is on the order of 130 m (Dumurdzanov et al, 2005). Upsection siltstone, marly limestones, and partly diatomites follow, which are often interbedded with coaly layers. The Pliocene Solnje Formation is made up by 100 m of conglomerate and sandstone layers, deformed by synsedimentary faulting. During the Quaternary above 1200-1500 m altitude glacial deposits developed, in Lake Ohrid lacustrine conditions prevailed. The Pleistocene interval is estimated to be of 50-60 m thickness, mainly consisting of lacustrine and marsh sediments.

Both Hercynian and Alpine orogenies left their imprint on the terrain in the Lake Ohrid watershed. The bedrock in the watershed of Lake Ohrid is constituted by rocks of different lithology of Paleozoic to Cenozoic age (Watzin et al., 2002). Paleozoic metamorphic and magmatic rocks form the country rock of the entire WMZ. Triassic carbonates and clastics are widely exposed to the southeast and northwest of the lake. Especially the carbonates are intensely rugged, broken and karstified. The Ohrid Basin (Fig.2) including the lake in its center is formed in a later phase of the Alpine orogeny. Cenozoic sediments include Pliocene and Quaternary deposits and are particularly exposed to the southwest of the lake. The

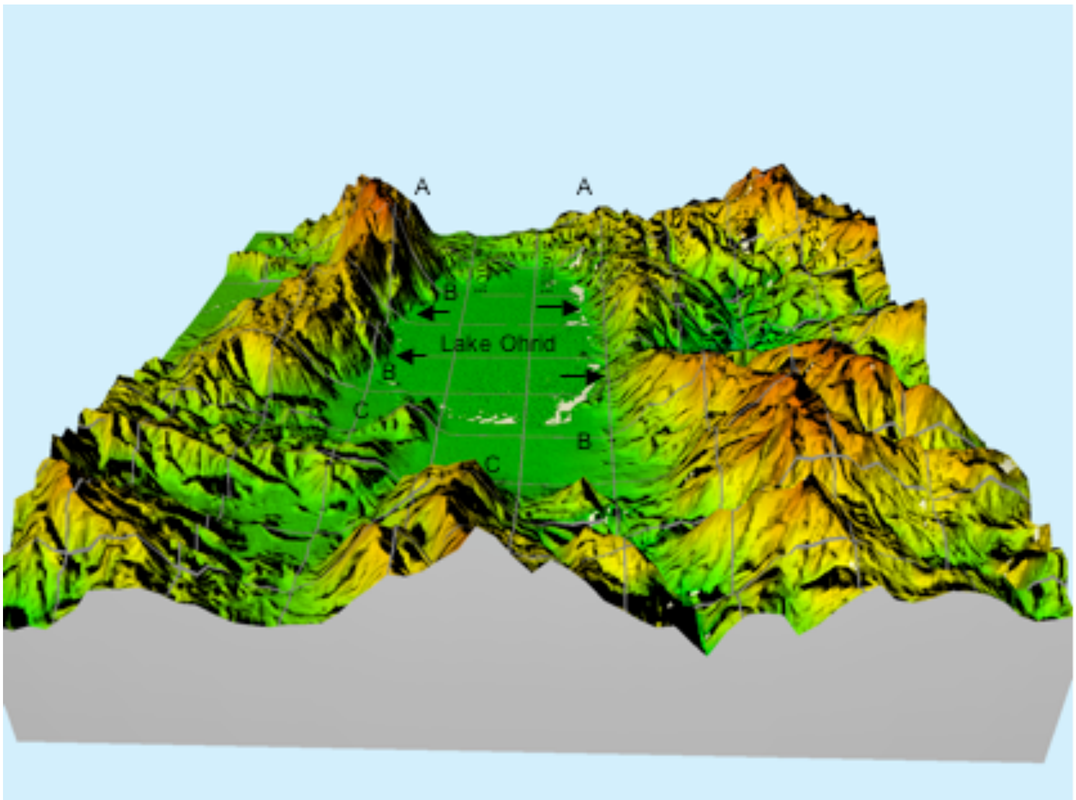

Fig. 2: Topographic situation of Lake Ohrid, view from North, exaggerated (based on SRTM data). Note N-S triangular facets along the lake shore (arrows). A = morphotectonic working area, B = neotectonics and paleoseismology, C = coring area in the dry part of the lake.

Pliocene-Quaternary period is characterized by enhanced and progressive uplift in Albania. Most data in the world stress map (Reinecker et al., 2004) point to SW-NE directed extension and normal faulting.

Neotectonics and seismicity

The central mountain chain, especially the intramontane basins of Late Neogene age, form one of the most active seismic zones in Albania/Macedonia with several moderate earthquakes reported during the last few centuries (Muço, 1994, 1998; Muço et al., 2002; Sulstarova et al., 2000; NEIC database, USGS). Major earthquakes occurred during historical times (Ambraseys and Jackson, 1990; Goldsworthy et al., 2002). The last prominent earthquake took place in on 18th February 1911 at 21.35 close to Lake Ohrid Basin, (M 6.7, corresponding to EMS X; 15 km depth, N 40.9°, E 20,8°). No reports of casualties exist.

Hypocenter depths scatter between 10 and 25 km but some deeper earthquakes occur between 25 and 50 km depth. Very rarely intermediate earthquakes around 100 km depth are observed (NEIC database, USGS). Small and moderate earthquakes (< M 5.5) take place predominantly along major fault zones, and are concentrated along the margins of the Lake Ohrid Basin (Aliaj et al., 2004). The Ohrid-Korça Zone is considered to be the region of the highest seismic hazard in the Albanian-Macedonian Corridor based on present-day seismicity (Sulstarova et al., 2003; Aliaj et al., 2004).

Lake Ohrid is situated in a zone controlled largely by extension in the Peshkopia-Korça belt, trending N-S in the eastern part of Albania (Robertson and Shallo, 2000). The so-called Ohrid-Korça Zone comprises the Pliocene-Quaternary normal fault-controlled Ohrid Graben, and Korça and Erseka halfgrabens, which are N-S striking (Aliaj, 2000). Several deformation phases affected the units: a regional foliation developed during the Paleozoic. The Mesozoic phase is characterized by large-scale thrust and folds, whereas during the Cenozoic normal and strike-slip faulting are the main tectonic features, dominantly striking N-S. Active N-S normal faulting with horst and graben structures is seen in the geomorphology and also in earthquake focal mechanisms (Aliaj et al., 2001; Goldsworthy et al., 2002; NEIC, 2006). But also, other sets of morphological lineations are very prominent, these are directed NNE-SSW, NW-SE, and E-W. Lake Ohrid is framed in the W by N-S trending lineations and in the E by sets of N-S and NNE-SSW trending lineations. The origin of the lake formation is unclear, possibly an older tectonic transtensional phase or reactivation led to a pull-apart like opening of the basin, followed by E-W directed extension. A certain influence of basement structures on the present-day fault patterns has been assumed, but not proven. The age of the basin formation and fault activity are not clear. Present-day slip rates of faults estimated by GPS are smaller than 1 to 2 mm/a (Burchfiel et al., 2006), but the uncertainties are larger than the observed movement. GPS data are still not precise enough to discriminate active faulting. Fault scarps in Lake Ohrid area are relatively good preserved (Fig.3), the region can be studied in detail by means of tectonic morphology. Dumurdzanov et al. (2005) found evidence for active faulting is along the western side of Lake Prespa on an E-W trending fault.

In the first two years of the project 3 field campaigns are planned to the Lake Ohrid area. The main aims of the fieldwork are the collection of high-resolution geophysical data, sampling and a paleo-stress analysis. In the following we describe the individual methods and their importance for the project. Specific goals of our project are:

Acquisition and processing of onshore data at Lake Ohrid:

Only a few geophysical data of Lake Ohrid and the surrounding hinterland are available until now. An onshore data acquisition includes shallow subsurface geophysics (structural analysis) and percussion drilling in areas, which were covered by the lake in the past. Onshore percussion coring is applied to study the meanwhile dry parts of the lake in the

North and Northeast and terraces and alluvial fans around Lake Ohrid. The on-shore cores will be described directly in the field. Measurements of physical properties and sedimentological analysis will be carried out in the lab in Aachen. Targets for onshore coring are young, unconsolidated sediments, preferably from fault zones or landslides. Also, the cores will be taken along the radar profiles in order to correlate reflections to sediment properties. Ground penetrating radar (GPR) and OhmMapper (resistivity) are applied to visualize sedimentary structures related to young deformation. High-resolution GPR-profiling provides not only the possibility to trace active normal faults but also to visualize the associated sedimentary hanging wall patterns such as heterogeneous grabens and half-grabens including coarse-grained clastic wedges. Quantitative and qualitative GPR evaluation yields the possibility of estimation of paleomagnitudes and slip rates on active normal faults. GPR was additionally and successfully applied in liquefied sediments and for imaging mass movement bodies and their gliding planes. The radar system of RWTH Aachen allows very quick sampling of data due to a mobile rugged cart (UtilityScan of GSSI) with GPS unit and various antennas, both in 2D and 3D mode. This means we have "online" access to the (unprocessed) data and hence, a good check of the quality/penetration. In the Lake Ohrid and Lake Prespa area several fault and fault zones will be investigated, including landslides, alluvial fans (or hanging deltas) as well as the dried northern part of Lake Ohrid (Fig. 2). The aim is to study sedimentary pattern associated with (seismogenic) faulting and to characterize fault architectures. Ram coring is used to calibrate radar measurements.

Fig. 3: Topographic situation near Ohrid, view from West, arrows indicate two well preserved topographic tectonic scarps.

Field mapping and reconstruction of the sedimentary history of Lake Ohrid:
We will map features such as fan-delta complexes, well-stratified layers, chaotically reflecting layers, slumps and/or slides, sediment wedges, and submerged channels. Major environmental changes will be preserved in the sedimentary record, hence providing important information for studying the link between geological and biological evolution.

Analysis of faults and fault systems and their relation to regional tectonic structures including paleostress analysis: Fault-slip data, obtained from the mountains surrounding Lake Ohrid are used to unravel the paleostress history of the area. The orientation of the principal stress direction through time are calculated by fault-slip data inversion and evaluating overprinting criteria (Fig. 4a). Another scientific objective of the project is to investigate the paleostress fields, which controlled the evolution of Lake Ohrid basin. Therefore, field studies are carried out in the vicinity of the lake, where Paleozoic and Mesozoic rocks crop out. To minor extend younger Neogene to Quaternary sediments are found around the lake, especially in the South. These rocks bear the imprints of several deformation phases that affected the basin system since the Late Cretaceous to present, depending on their age. In the course of the project a detailed structural analysis is performed at key areas in the Lake Ohrid basin where outcrops of lithologies with favourable conservation conditions of kinematic indicators are present (fault-slip data, see Fig. 4b). Subsequently, the orientation of the principal stress direction through time is calculated by fault-slip data inversion to evaluate the distribution of regional paleostress pattern. The displacement vector on fault planes recorded by striae is considered to correspond to the direction and sense of the shear–stress tensor (e.g., Angelier, 1994). Based on this assumption, the deviatoric stress tensor is calculated for each subset using either the Numeric Dynamic Analysis (Spang, 1972) or the Multiple Inverse Method (Yamaji, 2000), which both revealed very good results (e.g., Reicherter et al., 2005). The results are obtained in terms of a reduced stress tensor, consisting of (1) orientations of the three principal stresses s_1, s_2 and s_3 with $s_1 \geq s_2 \geq s_3$ and (2) the ratio of principal stress differences, $\Phi = (s_2 - s_3)/(s_1 - s_3)$ with $1 \geq \Phi \geq 0$. In the case of polyphase tectonics, the chronology of successive events is deduced and the total fault population from each site is qualitatively divided into different subsets, each being consistent with one specific stress regime.

Tectonic geomorphology and paleoseismology:

Quantitative measurements of geomorphic indices (slope gradient, mountain-front sinuosity, valley shape index, stream gradient changes) are used as a reconnaissance tool to identify areas experiencing tectonic deformation. A quantification of the present-day landscape shape is used to characterize the balance between erosion, subsidence, uplift and tectonics in the Lake Ohrid area, including an evaluation of the drainage system, which may record the tectonic evolution. In tectonically active regions the present-day landscape is the product of complex interactions of vertical and horizontal tectonic displacements, uplift or subsidence, deposition and/or erosion, and a significant portion of inherited crustal features that tend to be reactivated during ongoing orogenic/structural processes. Morphotectonics describe the geodynamic and geomorphic implications of such “seismogenic landscapes” in connection with seismotectonics. Tectonic geomorphology includes e.g. the evolution of drainage networks or mountain ranges as slow geomorphic processes, whereas coseismic rupturing and landslides are seen as fast ones. We investigate the tectonic influence on the morphology and drainage pattern, with quantitative measurements of geomorphic indices (slope gradient, mountain-front sinuosity, valley shape index, stream gradient changes). The present-day landscape shape is used to characterize the balance between climate, erosion, subsidence, uplift and tectonics in the Lake Ohrid area. Also an evaluation of the drainage system, which may record the tectonic evolution, will be achieved. The slope gradient index is used to determine changes of slope gradients of streams crossing active and inactive faults. The valley shape in the shoulder areas of the Ohrid Graben adjacent to the border faults is evaluated to image the level of fluvial incision as a response to uplift and tectonic activity. We also built up a GIS for the implementation of all – often heterogeneous – data sets of the working group.

Potential of Lake Ohrid for deep drilling within ICDP:

Seismic data are a precondition for drilling Lake Ohrid within ICDP. Beside structural information they will allow to determine the total sediment thickness of the lake sediments. Site selection for specific objectives in the framework of ICDP (e.g. tectonics, paleoclimatology, paleoseismicity) can only be done on the basis of high-resolution seismic data of high quality.

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Landslide processes and terrain evolution in the Lake Ohrid region

T. Fernández-Steeger

The focus of my interest in the lake Ohrid region is the combination of a “young” mountain area with a highly active neotectonic environment, minor human impact and the potential for mass movements. In Europe environments providing this setting are rare. Only in the High

Tatra region or in parts of the Carpathian arc similar environments may be found. Especially in the Alps, where a lot of research on mass movements is located, the impact of human activity is very large. Additionally past mountain glaciation and its impact on slope generation still cover by far the neotectonic effects.

The tectonic setting of Lake Ohrid provides an interesting setting for landslides and rock falls driven by neotectonic subsidence or probably also uplift. As movements of up to 5.5 mm/yr were proposed e.g. by Lilienberg (1963) for the Galicica, high topographic gradients and steep slopes at major scarps are usual. Mass movements are not only relevant in the context of natural hazards but also regarding their influence on relief generation and subsequently sediment transport. In the case of Lake Ohrid sedimentation rates in the lake might be influenced by periods of high tectonic activity and/or mass movements.

Fig. 1: Landslides in the hills above to the village of Lin in Albania at the W side of the Lake Ohrid.

The morphological setting and the large colluvial fans at the steep eastern flanks of the Ohrid graben indicate that there had to be more active times in terrain evolution as there are today. In a first survey only debris flow generation and smaller rock fall deposits could be found. An exception might be the large structures up in the mountains eastern of Elesec, indicating a collapse of a rock wall not reaching the lake shore. Additionally the area seems to be relevant for the investigation of giant block slides. Many examples that were not recognised from bedrock geologist as gravitational processes interacting with neotectonic processes can be found.

Another area, where more recent complex landslides can be observed, is located in Albania close to the village of Lin (Fig. 1). Here at the contact of Peridotites and Triassic or Cretaceous limestone, large landslides with long run-out distances are located. They seem to be connected to the evolution of the plain W of Lin.

A third possible research area is the plain of Struga and the Drim outlet from the Ohrid basin. Here some sickle shaped structures in the ridges E of the Ohrid airport and close to the narrow outlet give notice of larger landslides. The one at the airport can be observed very well from the main road M4 and can be recognised even in SRTM data. The one at the outlet is steeper. It may be identified by shade analysis or on satellite pictures. As an aspect of outflow control and subsequent influence on the lake level landslide damming of the river Drim might be of interest. The application of terrain data provides additional information about the development of the plain of Struga. Although the 90 m resolution SRTM data show noisy pattern from housing and vegetation, they show that large parts of the plain are actually a gentle sloped fan from the river Sateska (Fig. 2).

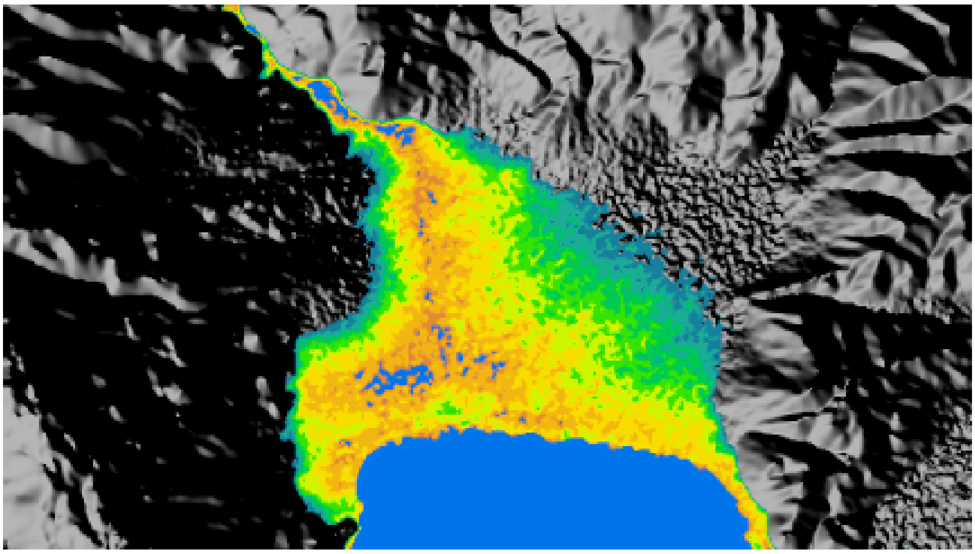

Fig. 2: Terrain model of the plain of Struga showing at the right concentric strcutures from the fan of the Sateska river.

The examples above show the potential for research in the field of landslides and landscape evolution in the Ohrid region. They complement with neotectonic research because many of the processes of mass movements are interfering or triggered of by neotectonic processes like earthquakes and rapid fault generation. They might also contribute to understand the sources and rates of sedimentation at the shores of the lake at least for some areas. Another interesting topic in this context might be the application of high resolution digital elevation models for morphological analysis and subsequent pattern recognition to identify mass movements, neotectonic features and transport path or accumulation of sediments towards the lake (s. appendix). They can also be relevant for further research on hydrology and hydrogeology in this area e.g. recognition of doline structures. Similar investigations from Austria showf very good results for geological environments comparable to the eastern Trias units at the lake (Fig. 3).

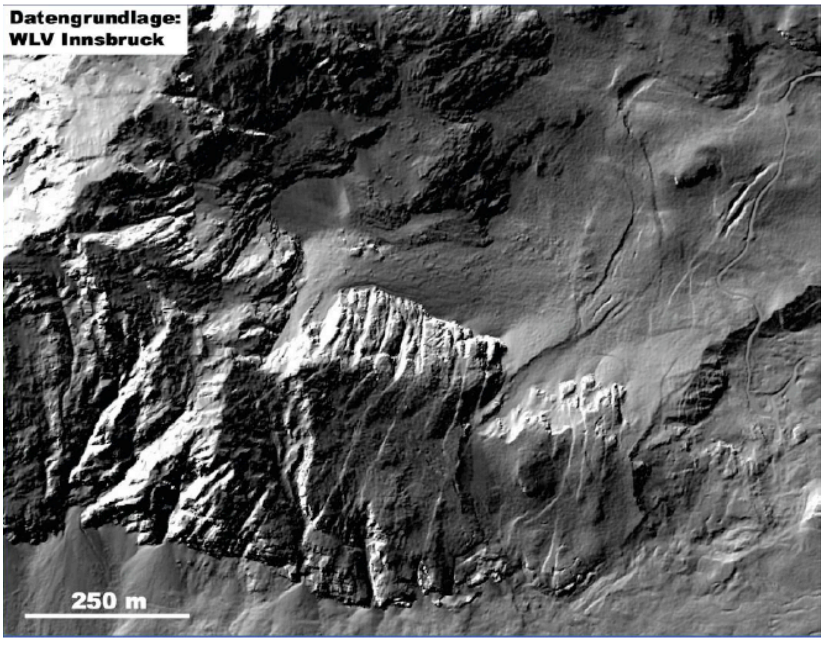

Fig. 3: The Central block in this DEM is gravitational mobilised and fractured while drifting to the east. Additionally a landslide in the center and at the NE margin can be seen (Presentation from Ehret & Rohn, 2008).

Research topics might be:

- Impact of fault generation and neotectonic relief changes on mass movements
- Landslide dams controlling lake outflow and level changes
- Investigation of superposition of long to midterm neotectonic and shortterm geotechnical processes in relief generation and sediment transport
- Onshore scarps and traces of mass movements and their relevance to sub-aquatic landslides in the lake. Alternatively Environments of high sediment provision controlled by landsliding (mainly Albanian side).
- Application of high resolution digital elevation models from LIDAR or SAR data for landslide recognition (also automated) and morphotectonic analysis.

A multi-proxy study of the Shkodra/Scutari Late Quaternary sedimentation

A. van Welden, C. Beck, G. Zanchetta, L. Sadori, M. Giardini, R. Sulpizio, R.N. Drysdale

Lake Shkodra (aka Scutari/Skadar/Skadarsko Jezero) is a large Shallow lake. Several cores taken with an Uwitek device in 2003 enabled to study for the first time se material accumulated recently.

Short gravity cores (1 m long) were studied in order to define the last centuries sedimentation with a particular look on potential perturbation induced by historical seismicity and flood as well as climate events such as Little Ice Age (van Welden et al., 2008a). Chronological framework was defined using radionuclides.

Two long cores (6 ans 8 m long) were also studied in both paleoenvironmental and paleoseismic purposes.

Chronological framework is defined by both ^{14}C AMS dates and the identification of tephras corresponding to known eruptions (Sulpizio et al., in prep). Our multiproxy study, based on magnetic properties, O and C isotopes, and sedimentary fabrics reveals that the sedimentary archive from Shkodra Lake provide a record of hydrological changes linked with climate and solar activity (van Welden et al., 2008b). Sadori et al. (2008a, this workshop) present results of pollen, microcharcoal and plant biomass for the last 5,000 yr.

The Shkodra sediments did not enable to provide a better asset on paleoseismology in the Shkodra District.. A complementary shallow seismic survey should enable to define the potential of Shkodra Lake for long term (last climatic cycle ?) paleoenvironmental studies.

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Core Co1202: a new long record from Lake Ohrid (Albania, Macedonia)

H. Vogel, B. Wagner, G. Zanchetta, R. Sulpizio, S. Schouten, N. Nowaczyk

Lake Ohrid, a transboundary lake situated on the border of Macedonia and Albania in the central-northern Mediterranean with an age of approximately 3-5 Ma, is considered to be the oldest and one of the largest lakes in Europe. With a sediment fill of more than 400 m it provides a unique record in a region responding sensitively to climate change.

Here we present first results from a new sediment record (Co1202) recovered from Lake Ohrid in autumn 2007. The c. 15m long sediment sequence was taken from 145 m water depth in the north-eastern part of the lake, where the sediment succession is widely undisturbed according to a shallow seismic pre-site survey. The identification of nine tephra and cryptotephra layers (OT0702-1 to OT0702-9; Fig. 1) and their geochemical correlation to well known eruptions of Italian volcanoes with known ages as well as seven additional radiocarbon dates (Fig. 1) allowed the establishment of a relatively reliable chronology for core Co1202 (Vogel et al. subm.). According to our age-depth model core Co1202 likely covers the last-glacial interglacial cycle and reaches back to marine isotope stage (MIS) 6 (Fig. 1). The sediment succession is, however, not continuous and comprises an erosional hiatus of approximately 16,000 yrs. Between c. 82,000 and 98,000 yrs. BP.

The sediment composition of core Co1202 varies strongly showing two clearly distinguishable lithofacies (Fig. 1). Massive sediments with high amounts of $CaCO_3$, TOC, and low amounts of detrital clastic material as indicated by low Ti and low magnetic susceptibility values correlate well with interglacial stages MIS 5 and the Holocene. Partly laminated sediments, dominated by high amounts of detrital clastic material as indicated by high Ti and magnetic susceptibility values, frequent occurrences of dropstones, and low $CaCO_3$ concentrations, correlate well with glacial stages MIS 6, 4, 3 and 2. In addition to these lithological, geochemical, and magnetic properties, information on changes in past lake

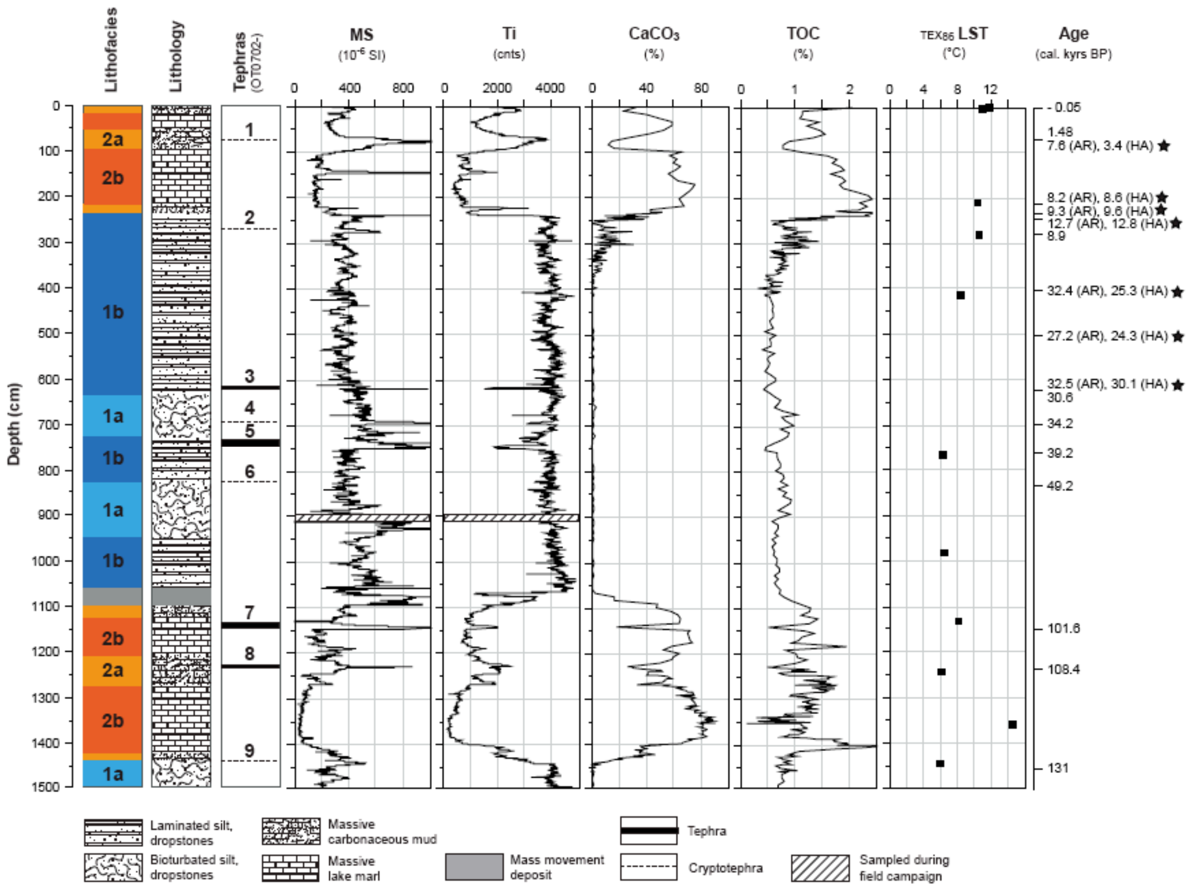

Fig. 1: Major lithofacies, lithology, occurrence of tephras, and selected physical and geochemical properties of core Co1202 from the northeastern part of Lake Ohrid. Test measurements of TEX_{86} reveal a temperature anomaly of ca. 5-6°C between glacial and interglacial periods. The warmest temperature is reconstructed for the Eemian. Ages are based on radiocarbon dating (asterisks) and on tephrostratigraphy.

surface temperature was obtained by application of the recently proposed TEX_{86} paleothermometer (Schouten et al. 2002, Powers et al. 2004). Initial results indicate temperature differences of c. 5-6°C between the last glacial maximum and the Holocene, as well as 2°C warmer temperatures during the Eemian if compared to the Holocene (Fig. 1).

The relatively robust chronology of core Co1202 in combination with the results derived from various inorganic, organic and magnetic properties indicate that core Co1202 comprises an important record to study climatic and environmental changes in the Balkan area over the last glacial-interglacial cycle and back to MIS 6. However, in order to fully understand the impact of climatic change including changes in temperature and hydrology on the ecosytem, additional proxies including e.g., pollen, stable isotopes on authigenic carbonates and ostracods, as well as organic biomarkers need to be investigated in the near future.

High-resolution scanning techniques and a various set of analyses including sedimentological, mineralogical, and geochemical approaches applied on the long cores to be recovered within the scope of the ICDP project will allow to obtain crucial information on the long-term changes mainly triggered by orbital forcing, and on short-term events, such as Dansgaard/Oeschger cycles, Heinrich events, or other abrupt climate shifts, probably triggered by changes in the atmospheric or oceanic circulation patters. The documentation and a better understanding of these long-term trend and short-term events will be a substantial precondition to shed more light (1) on the age and the origin of Lake Ohrid and (2) on potential links between evolutionary processes and environmental/geological events.

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Schouten S, Hopmans EC, Schefuß E, Sinninghe Damsté JS (2002). Distributional varaiations in marine crenarcheotal membrane lipids: a new organic proxy for reconstructing ancient sea water temperatures? Earth Planet Sci Lett 204, 265-274

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Tephrostratigraphy and tephrochronology of lake Ohrid sediments: importance for volcanology and Quaternary sciences

R. Sulpizio

Application of tephrochronology to volcanology, Quaternary science, paleoceanography, and archaeology has an exceedingly high potential in the Mediterranean region, owing to the intense explosive volcanic activity that occurred over the last 200 ka. In the last 30 years, Quaternary tephra layers have been used extensively to develop a high-resolution event stratigraphy for the late Pleistocene and Holocene across the central and eastern Mediterranean. While early work focussed mainly on samples from marine cores, recent work on terrestrial archives (including Italian, Greek and Turkish lakes, and Bulgarian, Greeks and Italian cave sites) has considerably advanced the development of a long, high resolution tephrostratigraphy that will link marine and terrestrial records of Holocene–Pleistocene age across the Mediterranean region and mainland Europe. Nevertheless, there are some areas in the Central Mediterranean in which volcanologic and Quaternary studies are still at the beginning, and the link to the general tephrostratigraphic Mediterranean network is lacking. The Balkan area across Macedonia, Albania and Montenegro is certainly one in which tephrostratigraphic and tephrochronologic studies are in their infancy, although preliminary studies on lacustrine settings appear extremely promising. For these areas both teprhostratigraphic and tephrochronologic studies can offer invaluable stratigraphic supports for sedimentologic, palaeoclimatic, paleoenvironmental, and volcanologic studies.

To date, tephrochronology and tephrostratigraphy of lake Ohrid sediments have encompassed the last ca. 110 ka BP, and the extension of investigation allowed by a very long core (such an ICDP one) it is expected to supply precious information for both volcanology and Quaternary sciences not yet easily available. These include the investigation of volcanic explosive activity down to more than 1-2 Ma with the possible interception of the change from calc-alkaline to alkaline behavior of Italian volcanism, and the link of Balkan area with archives of the Mediterranean area using tens of tephra layers.

Carbonate precipitation in the Kalista spring area, northwestern Lake Ohrid

M. Matter, F. Anselmetti

Half of ancient Lake Ohrid tributaries are springs originating from karstic formations. Most of the surface and subaquatic springs are situated on the eastern shore of the lake, but the spring area investigated here is found south-west of Kalista village, in the south-eastern part of the lake. Subaquatic springs are spread over a 50 m-diameter area at 100 m distance from the shore, at only 5-6 m water depth and underwater made video recordings show ash-like 10-30 cm vertical plumes forming over the springs' outlets. The supposition of these plumes being calcite precipitating when the ion-rich spring water mixes with lake water was investigated in this master thesis. Two moorings with sediment traps were set over deeper zones in the subaquatic spring area from 15 to 29 May 2007. Gravity short cores were recovered in May and September 2007, covering three transects: cores were taken each 100 m towards north and south along the shore, as well as towards the center of the lake, reaching 50 m water depth. Cores were recovered in the spring area as well, partly by divers. Twenty-one gravity short and the trap material were analyzed at EAWAG and ETH in Zurich, Switzerland. Lithotypes were defined based on density and magnetic susceptibility measurement, as well as total organic/inorganic carbon contents and grain size analysis. Calcite crystals found in sediment cores and in sediment trap material were analyzed under the polarization microscope and scanning electron microscope to determinate their morphology and formation origin. The high carbonate accumulation rates and the content of the sediment traps, consisting for a major part in large clusters of authigenic calcite crystals, proves that carbonate precipitates in the spring area. Picocyanobacteria may play a role in this process, as typical holes were found in many crystals and a high cell concentration observed in lake water above the springs. Sedimentation rates calculated on basis of three 14C datings were low, which is not surprising for littoral locations with high erosion potential. The sediment is carbonate silt and shows two distinct stratigraphic units: a bright lower and a dark upper unit, which contains more organic matter. The upper unit is thicker within the spring area and up to 200-300 m and it decreases at more distant locations, indicating a higher sedimentation rate closer to the spring area. These higher rates can be explained by enhanced carbonate precipitation, due either to ion-rich spring water provided by the springs or due to a local nutrient input, increasing biomass production which in turn increases carbonate precipitation. A combination of both factors (i.e. ion-rich water input and local nutrient input) is not excluded. The extent of the spring effect is interpreted to be 200-300 m based on this lithological correlation. This extent is further supported by the authigenic calcite crystal distribution patterns observed: large authigenic crystals and crystals clusters are numerous within the spring area in and this upper stratigraphic unit, whereas they are almost absent in more distant sediment along the shore and in the lower unit. I

Ostracodes from ancient Lake Ohrid sediments as indicators of past environments

A. Schwalb, F.A. Viehberg, B.W. Scharf, and T.K. Petkovski

Ostracodes are one of the few microfossil groups that are preserved over longer timescales in Lake Ohrid sediments. They thus offer a deep-time perspective on patterns of biodiversity and ecosystem response to environmental variability.

Ostracode specimens recovered from sediment core Lz1120, taken at 105 m water depth and spanning the past approximately 40 ka, belong to at least ten species including the benthic Candonidae *Candona neglecta*, *C. trapeziformis*, *C. hadzistei*, *C. holmesi*, *C. ovalis*, *C. depressa*, *C. marginata*, as well as *C.* sp.1, *Cypria* sp. and *Leptocythere* sp., a genus of marine origin. The occurrence of the marine genus *Leptocythere* may possibly hint at a marine origin of the lake. Although ostracodes from Lake Ohrid have been the target of a series of taxonomic investigations since the 1930's, especially because of their high degree of endemism, little is known about their specific ecologies. Collecting was mostly restricted to the littoral regions and there is little information on profundal taxa. Thus, the ecological interpretation of the record from core Lz1120 is mostly restricted to changes in diversity and abundance as a consequence of changes in productivity and preservation.

The general variation in abundance of valves and species diversity tracks the carbonate content of the sediments. Low carbonate contents of less than 1% in Pleistocene sediments suggests that the scarcity of ostracode remains in these sediments may be a result of low carbonate preservation rather than a deficiency in oxygen supply that could have limited the presence of ostracodes at this site because living ostracodes have been found in water depths of up to 120 m. Thus, there is evidence for the presence of ostracodes in the deeper areas of the lake. Local inflows, local hydrology, hydromechanics, or bacterial decomposition, leading to CO_2 production and a pH decrease in the bottom waters may have promoted dissolution of carbonates and ostracodes during the Pleistocene at coring location Lz1120. Distinct fluctuations in ostracode abundances between glacial and interglacial periods have also been observed in other long sequences from, for example, Lake Pamvotis, NW Greece, and Lake Malawi. This suggests that the fluctuating nature of abundances of ostracodes may present an expression of climate change and climate forcing mechanisms.

Future work on ostracodes from Lake Ohrid will include coupled autoecological, systematic and molecular genetic analysis of modern ostracode species from Lake Ohrid and its catchment. This has the potential to further improve (1) ostracodes as environmental indicators, to (2) date speciation events in Lake Ohrid and overall to (3) better understand the origin and evolution of Lake Ohrid and its biological inventory as well as the (4) driving mechanisms for biodiversity of lake systems in the complex region of the Balkans.

Pollen from Lake Ohrid sediments as indicators of past vegetation and climate

A.F. Lotter

The Laboratory of Palaeobotany and Palynology (LPP) of Utrecht University (The Netherlands, http://www.bio.uu.nl/~palaeo/index.html) has a long tradition in studying the role of primary producers (higher plants and algae) as monitors, recorders, drivers, and moderators of climatic and environmental change on different temporal and spatial scales. We use the integration of actualistic (observational, experimental) data and models with palaeo-data to improve the understanding of past and present behavior of biota in relation to exogenous stressors (e.g. climate change, meteorite impacts, human impact) triggering dynamic biotic processes such as extinction, migration, and evolution.

In many cases the biotic response is the basis to qualitatively or quantitatively reconstruct past environmental conditions to assess pre-anthropogenic background values for different aspects of system Earth. Proxies that we use include fossil pollen and spores, plant macrofossils such as leaves, seeds or wood, algae (diatoms, dinoflagellates) as well as molecular markers and stable isotopes. The Laboratory of Palaeobotany and Palynology hosts one of the largest pollen reference collections and is publishing the Northwest European Pollen Flora. Moreover, we have a strong experience in quantitative palaeoecology with applications such as transfer-function based climate reconstruction (Lotter et al., 2000; Finsinger et al., 2007) or palaeoecological hypothesis testing (Lotter et al., 1995; Lotter and Birks, 2003).

Based on our experience with pollen analyses of Quaternary lake Ohrid sediments (Wagner et al., 2008) we want to study the long-term vegetation history of the Balkans to assess the role of this region as important refugium of temperate plants during repeated glacial-interglacial cycles. Studying vegetation history of long sediment cores from lake Ohrid will on the one hand allow to asses the dynamics of changes in biodiversity of terrestrial vegetation in this region. On the other hand, detailed knowledge of the catchment vegetation is of paramount importance to assess biodiversity changes of aquatic biota in lake Ohrid and will also allow reconstructing past climatic variation on centennial to millennial time scales that is an important forcing mechanism for such changes.

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Lotter AF, Birks HJB and Zolitschka B, (1995). Late-glacial pollen and diatom changes in response to two different environmental perturbations: volcanic eruption and Younger Dryas cooling. Journal of Paleolimnology, 14: 23-47.

Wagner B, Lotter AF, Nowacyk N, Reed JM, Schwalb A, Sulpizio R, Valsecchi V, Wessels M & Zanchetta G (2008). A 40,000-year record of environmental change from ancient Lake Ohrid (Albania and Macedonia). Journal of Paleolimnology, DOI 10.1007/s10933-008-9234-2.

Diatoms as palaeoclimate indicators in Lake Ohrid

J.M. Reed

Forming part of the multi-disciplinary pilot studies on Lake Ohrid, diatom results are presented for analysis of the 10.8 m radiocarbon-dated lake sediment sequence (LZ1120) collected from 105 m water depth in the southeastern part of the lake in 2005.

Diatoms are preserved to varying degrees throughout the sequence. In the context of the aims of the workshop, the high quality preservation in the oldest part of the record (*ca.* 38.7-33.8 ka) demonstrates for the first time the potential of diatoms for high resolution palaeoclimate reconstruction within glacial phases. Major shifts in diatom species composition during the Last Glacial and Holocene (e.g. between predominantly epilimnetic and hypolimnetic taxa) are likely to be driven by nutrient availability and thermal stratification, linked to climate change. The dominant taxon is the endemic, planktonic *Cyclotella fottii*, which has the ability to survive throughout glacial-interglacial cycles. Other taxonomically-distinct endemic taxa, such as *Placoneis balcanica*, are only abundant during the Holocene interglacial; there is no evidence for their persistence during glacial phases, but this may be an artefact of preservation. There is a clear need for further research both to improve our understanding of diatom response, and to elucidate patterns of change on a longer, Pleistocene timescale.

Assessing the potential for a high-resolution multi-molecular biomarker study on Lake Ohrid sediments – initial results from core Lz1120

J. Holtvoeth and G. Wolff

Lake Ohrid, one of Europe's oldest lakes, has outstanding potential as a continental climate archive for the past 3-5 million years. Furthermore, it is situated at the interface between Mediterranean and Northern Hemisphere climates, which makes it an ideal location to reconstruct the correlation and the variable predominance of these major climate regimes over the southern Balkan Peninsula. Past climate variations influenced the hydrological cycle of the basin causing significant changes in soil moisture and vegetation cover, terrestrial supply towards the lake and biomass production in the lake's surface waters. These changes are reflected in the amount and the composition of the organic matter (OM) preserved in the lake sediments. Specific organic molecules, or biomarkers, extracted from the sediments allow to reconstruct the varying supply of OM from aquatic and terrestrial sources (aquatic organisms/algae, macrophytes, land plants, bacteria) to the bulk sedimentary OM. Some biomarkers are also sensitive to changes within the terrigenous and aquatic fractions: lignin phenols and specific triterpenoids, for example, determine terrestrial OM derived from either angiosperms or gymnosperms.

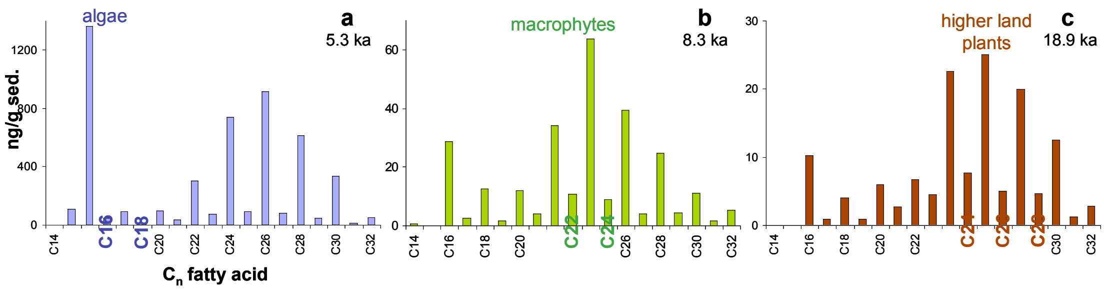

Fig. 1: Fatty acid concentrations of Holocene samples (a, b) and a sample from the last glacial (c). Note the changing predominance of aquatic (C_{16}, C_{18}) and terrestrial (C_{24}-C_{28}) sources with superimposed contribution from macrophytes (aquatic plants; C_{22}, C_{24}) in the sample from 8.3 ka.

We investigated 11 selected samples from Holocene and glacial sections of core Lz1120 to assess the feasibility of a high-resolution biomarker study on Lake Ohrid sediments. The extracted lipids were analysed using gas chromatography-mass spectrometry (GC-MS). Quantified biomarkers include saturated fatty acids, hydroxy-acids, *n*-alkanes, *n*-alcohols, sterols, triterpenoids and various hopanes. Our initial results reveal substantial differences in the proportions of these compound classes as well as highly variable amounts of biomarkers from aquatic and terrestrial sources. Figure 1 illustrates an example of the distribution of fatty acids with source-specific chain lengths in three samples from 5.3, 8.3 and 18.9 ka.

Our initial findings indicate that a high-resolution organic-geochemical study would not only document climate-induced changes within the Lake Ohrid basin. Biomarker-based records of ecosystem variability, especially when combined with stable isotope data, would provide valuable complementary information for further paleoclimatological investigations using micropaleontological or palynological approaches.

Ecosystem response to abrupt climate change – the story told by the MIS 3 sediments of Les Echets, central France

B. Wohlfarth, L. Ampel, M. Blaauw, D. Veres, E. Racivita

We present a high-resolution and independently-dated multi-proxy lake sediment record from Les Echets in southeastern France that displays synchronous changes in independent terrestrial and limnic ecosystem proxies, in concert with rapid climatic fluctuations during the last glacial period. Our results demonstrate that all parts of the terrestrial system responded to the abrupt and dramatic climatic changes associated with Dansgaard/Oeschger and Heinrich events, that regional factors modulated ecosystem response, and that transitions between different ecological states occurred in as little as 40-60 years, illustrating the sensitivity of ecosystems once ecological thresholds are crossed.

Brief summary of motivation for attending the Lake Ohrid Workshop

My motivation to participate in the upcoming workshop is two-fold:

(1) Our recent work with the MIS 3 & 2 sediments of Les Echets demonstrated how sensitive lake ecosystems reacted in the past to abrupt shifts in climate and, that the lake system responded both to regional climate forcing and to local conditions (advance of alpine glaciers).

Veres D, Wohlfarth B, Andrieu-Ponel V, Björck S, de Beaulieu JL, Digerfeldt G, Ponel P, Ampel L, Davies S, Gandouin E, Belmecheri S (2007). Lithostratigraphy of the Les Echets Basin, France: tentative correlations between different core sites. *Boreas*, 36, 326-340.

Wohlfarth B, Veres D, Ampel L, Lacourse T, Blaauw M, Preusser F, Andrieu-Ponel V, Kéravis D, Lallier-Vergès E, Björck S, Davies S, de Beaulieu J.-L, Risberg J, Hormes A, Kasper HU, Possnert G, Reille M, Thouveny N and Zander A (2008). Rapid ecosystem response to abrupt climate changes during the last glacial period in western Europe, 40-16 ka *Geology,* 36/5, 407-410.

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Veres D, Lallier-Vergès E, Wohlfarth B, Lacourse T, Kéravis D, Björck S, Preusser F, Andrieu-Ponel V and Ampel L (2008). Climate-driven changes in lake conditions during late MIS 3 and MIS 2: a high-resolution geochemical record from Les Echets, France. *Boreas* (in press).

Blaauw M, Wohlfarth B, Christen JA, Ampel L, Veres D, Hughen KA, Preusser F, Svensson A: Were last glacial climate events simultaneous between Greenland and Western Europe? *Submitted to XXX*

Ampel L, Wohlfarth B, Risberg J, Veres D, Leng M & Kaislahti P: Diatom community dynamics during abrupt climate change: the response of diatoms to Dansgaard-Oeschger cycles during the last glacial period. *Submitted to Journal of Paleolomnology*.

It would be fantastic to for example further explore the relationship between ecosystem response and abrupt climate shifts by studying a lake sediment record which is situated at greater distance to the North Atlantic. This could provide a link to long vegetation records

from Greece and could help understand how spatially variable the response of ecosystems is to climate shifts in the North Atlantic region.
Moreover, it would be a challenge to apply the same multi-proxy and high resolution approach as done in Les Echets to a different time interval with rapid climate shifts.

(2) Work with Lateglacial lake sediments in Romania suggests that Romania and the Balkan region acted as a refuge for trees during the Last Glacial Maximum. However we never found lake sediments covering the LGM or earlier time intervals (except for the Eemian) and could therefore not test this hypothesis. The location of Lake Ohrid seems perfect to address such a question.

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The last 5000 years of environmental history at Shkodra Lake

L. Sadori, G. Zanchetta, M. Giardini, A. van Welden

Lake Shkodra (also named Shkoder or Scutari, aka Skadar, Skadarsko jezero) is a very large (45 km long, 15 km wide) and shallow (mean depth ca. 5 m) karstic lake of sub-elliptical shape, occupying a depression of tectonic origin. It is located at the Albania/Montenegro border, separated from the sea in the southwest coast from the Adriatic Sea by the steep slopes of the Tarabosa and Rumia mountains. This mountain zone is only 10 to 15 km wide, but has peaks up to 1600 m.

A number of cores from the Albanian part of the lake have been the subject of paleosismological studies (van Welden et al., 2008a) and have been recently used (Sadori et al., 2008; van Welden et al., 2008a) for palaeolimnological analyses.

Three parallel overlapping cores down to the depth of 7.26 m have been used to investigate the potential of this lake for paleoclimatological studies. Several proxies were utilised to reconstruct the environmental evolution of the lake and its catchment (e.g. stable isotopes, pollen and microcharcoal). A preliminary age model supported by three ^{14}C ages and four well-known tephra layers suggests an age of ca. 5000 years for the record, indicatiing that a high sedimentation rate occurred. This fact could result in a very detailed paleoclimate reconstruction for the region.

First data on stable isotopes obtained on the bulk carbonate indicates that this proxy was very sensitive to local hydrological changes, which, with the aid of tephra layers, can be correlated to climatic oscillations recorded in other archives of the central Mediterranean basin. Preliminary pollen data show few changes, not in the floristic assemblage, but either in the plant biomass or in the sedimentation rate. Arboreal plants are dominant all over the considered time period, slightly decreasing towards the top. The more widespread taxa are deciduous oaks and pine, but several other Mediterranean, mesophilous, and termophilous taxa show continuous curves. From a floristic point of view no important changes are found. Fires are almost absent. No clear evidence of cultivation is found.

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Newcastle University - Summary of proposed research

T. Wagner

Integrated biogeoscience and paleoclimate research at Newcastle University focuses on geochemistry, with a long-standing reputation in organic and petroleum geochemistry, marine paleoenvironmental research including molecular proxy development, water management and hydrologic modelling (see www.ceg.ncl.ac.uk and www.ncl.ac.uk/environment/ for more details). Strategic developments over the last years have complemented our profile, now also covering inorganic/isotope geochemistry (Simon Poulton), ultra-high resolution paleoclimate reconstructions of lake sediments (Takeshi Nakagawa), soil sciences (David Manning), and clay mineralogy (Claire Fialips). Our geochemical and paleoclimate research is closely embedded into an international network with partners at Durham, Norwich-UEA, NIOZ, WHOI, Bremen, and Cologne, to name a few.

Contributions to this work programme will specifically come from IFM-GEOMAR, Kiel (Sascha Floegel, leading top 3 `Integrated modelling`), UEA (Nikolai Pedentchouk, C and H isotopes of biomarkers), and Durham (D. Gröcke, black carbon isotopic analysis). Close collaboration with other groups involved on the Lake Ohrid Drilling initiative is anticipated.

Our proposed work programme aims to make strategic contributions to four interrelated areas:
(1) multi-proxy, high-resolution records of climatically driven changes in vegetation and carbon burial,
(2) molecular evidence for microbial-mediated methane cycling,
(3) iron cycling and redox change, and
(3) advanced modelling integrating hydrological, biogeochemical and climate processes.

(1) <u>Palaeohydrology and associated changes in vegetation and carbon burial</u>
To investigate changes in the hydrological cycle and to provide an integrated inventory of geochemical properties used for assessing the supply of different types of organic matter to the lake, with a focus on soil organic matter (SOM), we propose to generate complementary molecular records of

- lignin/wax/cellulose using a combination of ^{13}C-labelled TMAH thermochemolysis, analytical flash pyrolysis (Py-GC/MS) and solid state ^{13}C NMR. Py-GC/MS and solid state ^{13}C NMR can be used to identify land plant inputs (e.g. Abbott et al., 1998) and to assess the relative contributions of lignin, demethylated lignin, fatty acid methyl esters (waxes), methylated carbohydrate derivatives (cellulose) and non-lignin phenolics including tannins (Mason et al., submitted) as well as the degradation state and reactivity of the OM (Vane et al., 2001a/b).
- soil-specific microbial markers, bacteriohopanepolyols, BHPs (e.g. Cooke et al. 2008 a/b; Farrimond et al. 1989, 2000; Talbot et al. 2001, 2003).
- black carbon extraction and isotopic analysis (Bird & Gröcke 1997; Lopez Chapel et al. 2005, 2006; Hammes et al. 2007)
- gymnosperm/angiosperm markers (e.g. Schouten et al. 2007) and leaf wax lipids,
- anoxia/euxinia markers (Sinninghe Damste et al. 2001, 2003; Wagner et al., 2004)
- compound-specific stable isotopic carbon and hydrogen isotopic signatures of aquatic and higher plant organic compounds (Andersen et al., 2001, Chikaraishi et al., 2003, Hou et al., 2007, Pedentchouk et al., 2008).

These geochemical/isotopic records will be complemented by detailed palynological records (e.g. providing independent and highly diagnostic information on the development of the vegetation structure and climate conditions. Combined with bulk geochemical and isotopic analyses and novel thermal analysis techniques (thermal analysis-isotope ratio mass spectrometry, TG-IRMS; Lopez-Capel et al. 2005, 2006) the palyological and geochemical programme aims to provide an integrated view on supply and fate of organic matter and to reconstruct climate trends including short-term perturbations in the past.

(2) <u>Microbial-induced methane cycling</u>

Hopanoids are good candidates to trace specific microbial-induced aerobic and anaerobic processes. Many different bacteria synthesize BHPs (e.g. Farrimond et al. 1998) and hopanoids in sediments are believed to derive mainly from bacteria in the water column and surrounding environment (e.g. Farrimond et al. 2000). We propose to specifically explore microbial-mediated cycling of methane and its history in the lake. In particular the process of aerobic microbial oxidation has received little attention to date but possibly plays a more important role in carbon cycling and oxygen availability in aquatic systems than commonly considered. As highly specific molecular tracers for aerobic microbial oxidation of methane we use compounds generated by methane-oxidising bacteria (aminobacteriohopanepentol and other related compounds, BHPs). Recently we analysed these compounds in sediments from the Congo fan down to one million years (at about 100 m depth), which pushes direct evidence for aerobic microbial oxidation of methane far back into the geological past; previous studies suggesting a similar mechanism were limited to the last 45 ka.

(3) <u>Iron cycling and redox change</u>

Iron (Fe), along with N and P, are essential micro-nutrients driving primary productivity in aquatic systems. Fe availability in aquatic systems, amongst others, is controlled by oxygenation levels closely linking cycling of nutrients and other elements, in particular carbon, to redox conditions. Developing high resolution inorganic records, focussing on C-S-Fe-P systematic and trace metal abundances and ratios, in tandem with the organic geochemical evidence will identify changes in redox, and will help relating these changes to climate across a range of time scales. Of specific interest are periods when Lake Ohrid turned into low-oxic, anoxic or even sulfidic (euxinic) conditions, with enhanced burial of organic carbon in the sediments. A recently developed Fe speciation technique (Poulton, et al. 2004; Maerz et al. 2008) has been shown to be highly diagnostic along with other redox indicators (both inorganic and organic) to distinguish euxinic, anoxic non-sulfidic, and oxic water column conditions.

(4) <u>Integrated modelling</u>

To investigate the history of large scale climatic conditions of Lake Ohrid we propose the use of an AGCM (Global Atmospheric General Circulation Model) to simulate various time slices during the Quaternary. Being a key area between the Mediterranean and central European region, special emphasis will be put on the links between the atmospheric circulation and the associated hydrological and nutrient cycles. We would aim to investigate the effect of regional scale changes in climate, vegetation and soil conditions of the catchment area on historical nutrient inputs to the lake, considering both groundwater and surface water mediated transport. These studies will integrate GCM outputs with catchment scale hydrological and nutrient modelling based on the SHETRAN physically-based catchment flow and transport modelling system (Ewen et al., 2000) including nutrient transport components (Birkinshaw and Ewen, 2000; Nasr et al., 2003), with a simplified model to extend these interpretive simulations over long historical time-periods. A similar approach was developed and used previously in the context of radiological safety risk assessments (Parkin et al., 1996; Parkin et al., 1999; Parkin and Brock, 2000).

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LETTERS OF MOTIVATION

K. Zimmermann

Since June 2008 I am working within the SCOPSCO project as a PhD student at IFM-Geomar in Kiel. My major task is the processing and interpretation of the seismic data set collected on Lake Ohrid in September 2007 and June 2008. Based on the seismic data we want to reconstruct the sedimentary history of Lake Ohrid, analyze the tectonic geomorphology and paleo-seismology, and select locations as potential future ICDP-sites. This work is funded by DFG until May 2010.

During an expedition in June 2008 we collected 31 profiles within 8 days that covered the entire lake. We used a Mini-GI-Gun (2*0.25l) that was triggered every 7.5 -8.5 seconds in harmonic mode while the vessel moved with approximately 3 knots along the profile. Compressed air was provided by 2 Bauer Mariner 320 Compressors as they are used for scuba-diving. Data was recorded by a 100 m streamer with 16 channels.

At the moment I am processing the new data set first with special focus on profiles crossing the central part of Lake Ohrid because we consider this basin as promising locations for ICDP sites. The seismic data show thick undisturbed, well stratified sediments in some parts of the basin. The maximal sediment thickness reaches ~720 ms TWT corresponding to ~570 m using an average sound velocity of 1600 m/s. The lower part of the seismic image, however, is characterized by weak reflections and interference with multiples. Therefore a main task will be to suppress multiples and gain weak reflections in the deep part of the Lake.

Beside the thick sediments within the central part of Lake Ohrid the seismic data also show several other interesting features such as faults, channels in the northern part as well as slide deposits more dominant in the southern part of the Lake. Foreset structures in the shallower part indicate major lake level fluctuations but we do not find indications that Lake Ohrid fell dry for a longer period of time since its formation.

T. Schwenk

I was part of the seismic team doing the pre-site surveys on the Lake Ohrid in September 2007 and June 2008. During these surveys, a Mini/Micro GI Gun and a 100 m long 16-channel streamer were used to collect multichannel seismic data on a dense spaced grid covering the whole lake. These data are used to characterize the sedimentary deposits down to the basement in order to find suitable locations for scientific drillings. Results of these surveys will be presented on the workshop by Sebastian Krastel. First I would like to take part on the workshop to continue the discussions about the results of the multichannel pre-site survey data. I am hoping to bring in my experience of seismic interpretation to search for the best scientific drilling sites. Additionally, I find the whole project very exciting and would like to continue my work within this international community. I am looking forward to a fruitful meeting.

S.O. Franz

One of my research topics are paleoclimate and paleoenvironment reconstructions using inorganic geochemical and sedimentological methods. I investigated Quaternary to Tertiary marine sediments (Franz, 1999; Franz & Tiedemann, 2002; Gruetzner et al., 2002; Yokokawa and Franz, 2002), but also lake sediments from Recent to Tertiary age (Franz et al., 2004). Current research areas include Germany (Lake Enspel, Lake Stoesschen, Lake Kunkskopf) and Turkey (Lake Iznik, Lake Van). The study location of Lake Iznik has recently been investigated by a German-Turkish research initiative, which I coordinated in 2002 and 2005. The sedimentary record has been surveyed by deep and shallow seismic (Niessen and Franz, 2006). At key locations short cores were retrieved and studied using a multiproxy approach. The results and the state of the art are summarized in Franz et al. (2006). More recently, extended cores (>5 m) have been taken in 2005. They are already dated by the radiocarbon method and first results clearly document climate signals (Franz et al., 2007). First results of my work on Lake Van sediments are published in Litt et al. (submitted to QSR).

My motivation to join the scientific group of Lake Ohrid is my strong interest in environmental and climate changes in the Mediterranean region and the lake's high potential to record these changes up to the Tertiary. I would like to bring in my experiences, which I gained in the Eastern Mediterranean area (Lake Iznik, Lake Van), into the scientific group of Lake Ohrid. To reconstruct the paleoclimate and paleoenvironment I am using inorganic geochemistry (XRF scanning, XRF on discrete samples, CNS analysis), mineralogy (XRD), sedimentological (e.g., grain size analyses, smear slide description) and dating methods (e.g., Pb-210, Cs-137, C-14). All these techniques, except the C-14 dating, are available in the laboratory of the Steinmann Institute, Section Geology, in Bonn. I am looking forward to collaborate with other scientific groups, which are also interested to work on this research topic.

H. Cremer

As a presumably new project member for the subject 'diatom paleoecology and biodeiversity' I am particularly interested to meet the other members of the current ICDP research group for the SCOPSCO project. This would provide a superb opportunity to receive information about the goals and current state of the SCOPSCO project and the interests of the single subgroups and researchers in the team.

K. Verosub

I am interested in conducting paleomagnetic and environmental magnetic studies of cores from Lake Ohrid. The paleomagnetic studies would contribute significantly to the development of a chronological framework for the cores by providing a magnetostratigraphic correlation to the Magnetic Polarity Time Scale. In addition, variations in the geomagnetic paleointensity recorded by the cores could provide a chonostratigraphy for the past 1 million years with a resolution of a few thousand years. Variations in environmental magnetic parameters would contribute to an understanding of changes in paleoenvironmental and paleoclimatic conditions at Lake Ohrid over the past 2.5 million years.

I have previously been involved in magnetic studies for several projects that are analogous to the proposed coring of Lake Ohrid, including the Pleistocene to Eocene record of climate change in Antarctica, as part of the Cape Roberts Project, and the Quaternary record of glacial/interglacial cycles on the Chinese loess plateau and the South China Sea. I am currently studying the mid-Quaternary to Holocene environmental magnetic records of cores from the Cariaco Basin in the Caribbean Sea, from the Ross Sea in Antarctica and from the Adriatic Sea. I am also working on magnetic studies of lacustrine sequences from various lakes in the western and central United States. My paleomagnetic laboratory is one of the best-equipped in North America and has been designated by NSF as a national facility for paleomagnetic and environmental magnetic studies.

M. Urbat

Environmental magnetic methodology provides a high resolution tool to understand facies, paleoenvironments and depositional processes in lacustrine sediments. A multi-parameter rock magnetic approach is suggested to decipher primary depositional versus post-depositional alteration of magnetic minerals including iron oxides and iron sulfides as a consequence of mostly (bio-)geochemical processes in the sediment column. A continuous sampling of the core or respective sections at about every 10 cm (depending on sed. rate) is suggested as to obtain a record which potentially reflects gradual (low temp. diagenetic) as well abrupt changes (amount and quality of organic matter input) in the depositional environment. Methods applied will be mostly non-destructive (af, dc fields only) and correlation with non-magnetic parameters (geochemistry, sedimentology) ideally from the same specimen will be highly welcome. Paleomagnetic data as to date the sediment column (Magnetostratigraphy, secular variation) could be provided.
The paleomagnetic laboratory in Cologne is equipped with a 2G Enterprises DC-SQUID magnetometer Model 755R featuring in-line AF-demagnetization (up to 160 mT), ARM (anhysteretic remanent magnetization) as well IRM units (Isothermal rem. Mag. Up to 2.5T). The SQUID magnetometer is designed to measure discrete samples (around 8cc). Magnetic susceptibilities including AMS (anisotropy of magn. Susc.) are measured on a Kappabridge susceptibility meter which is equipped with a respective high and low temperature apparatus (-194 to 700°C). Additional measurements (Curie balance, MPMS, VSM) are intended, however, respective equipment is presently not available in Cologne.

I. Delusina

I am interested in conducting pollen studies of cores from Lake Ohrid. I was trained as a palynologist in Russia and have now developed my own research program in the United States. I am particularly interested in using palynology to study rapid climate change in lakes and nearshore marine environments. In Russia, I studied Late-Glacial/Holocene pollen records from Lake Ladoga and records from the Eemian (Stage 5) to the present from the Baltic Sea. In the United States, I have worked on the late Glacial/Holocene transition as recorded in Lake Superior and on lacustrine sediments from the Great Basin. I am currently using pollen to study rapid climate change across the same transition in the Cariaco Basin of the Caribbean Sea and vegetation changes associated with development of peat deposits in the Sacramento-San Joaquin Delta of California.

LIST OF PARTICIPANTS

Emirjeta Adhami
Polytechnic University of Tirana
Institute of Energy, Water and Environm.
Tirana
Albania
thadhami@icc-al.org

Christian Albrecht
Justus Liebig University Giessen
Animal Ecology and Systematics
Heinrich-Buff-Ring 26 - 32 (IFZ)
35392 Giessen
christian.albrecht@allzool.bio.uni-giessen.de

Shyqyri Aliaj
Polytechnic University of Tirana
Geological Faculty
Tirana
Albania
aliaj@sizmo.edu.al

Fulvio Anselmetti
Eawag aquatic research
Überlandstrese 133
8600 Dübendorf
Switzerland
flavio.anselmetti@eawag.ch

Christian Beck
LGCA UMR CNRS 5025
University of Savoie
7337 Le Bourget du Lac
France
christian.beck@univ-savoie.fr

Holger Cremer
TNO Built Environment and Geosciences,
Geological Survey of the Netherlands
P.O. Box 80015
3508 TA Utrecht
Netherlands
holger.cremer@tno.nl

Tomás M. Fernandez-Steeger
RWTH Aachen University,
Lochnerstrasse 4-20
52064 Aachen
Germany
fernandez-steeger@rwth-aachen.de

Sven Oliver Franz
University of Bonn
Steinmann Institute, Section Geology
Nussallee 8
53115 Bonn
Germany
s.franz@uni-bonn.de

Andon Grazhdani
Polytechnic University of Tirana
Geological Faculty
Tirana
Albania
grazhdani2003@yahoo.com

Nadine Hoffmann
RWTH Aachen University,
Lochnerstrasse 4-20
52064 Aachen
Germany

Jens Holtvoeth
Liverpool University
4 Brownlow Street
Liverpool, L69 3GP, Merseyside
UK
J.Holtvoeth@liv.ac.uk

Dusica Ilik-Boeva
Hydrobiological Institute
Naum Ohridski 50
6000 Ohrid
Republic of Macedonia
dusicaib@hio.edu.mk

Goce Kostoski
Hydrobiological Institute
Naum Ohridski 50
6000 Ohrid
Republic of Macedonia
gocekos@hio.edu.mk

Sebastian Krastel-Gudegast
IFM-GEOMAR
Wischhofstr. 1-3
D-24248 Kiel
Germany
skrastel@ifm-geomar.de

Andy Lotter
Instutue of Environmental Biology
Utrecht University
Budapestlaan 4
3584 Utrecht
The Netherlands
a.f.lotter@uu.nl

Marion Matter
Eawag aquatic research
Rue d'Italie59
1800 Vevey, Switzerland
marion.matter@gmail.com

Trajce Naumovski
Hydrobiological Institute
Naum Ohridski 50
6000 Ohrid
Republic of Macedonia

Dennis L. Nielson
DOSECC
675 S. Arapeen Dr., Suite 201
Salt lake City, Utah USA
dnielson@dosecc.org

Trajan Petkovski
Macedonian Museum of Natural History
Briselska 12
1000 Skopje, Macedonia
bioeco@unet.com.mk

Jane M. Reed
University of Hull
Inst. Dept of Geography
Add. Cottingham Road, Hull HU6 7RX,
East Yorkshire
UK
J.M.Reed@hull.ac.uk

Klaus Reicherter
RWTH Aachen University
Lochnerstr. 4-20
52056 Aachen
Germany
k.reicherter@nug.rwth-aachen.de

Laura Sadori
University of Sapienza
P. le Aldo Moro 5
I-00185 Rome
Italy
laura.sadori@uniroma1.it

Mitat Sanxhaku
Polytechnic University of Tirana
Institute of Energy, Water and Environm.
Tirana
Albania
SOKELA@albaniaonline.net

Antje Schwalb
TU Braunschweig
Pockelsstraße 3
D-38106 Braunschweig
Germany
antje.schwalb@tu-braunschweig.de

Timann Schwenk
MARUM, University of Bremen
Klagenfurter Str.
28359 Bremen
Germany
tschwenk@uni-bremen.de

Jurek Sell
University of Gdansk
Kladki 24, 80-822 Gdansk
Poland
sell@biotech.ug.gda.pl

Zoran Spirkovski
Hydrobiological Institute
Naum Ohridski 50
6000 Ohrid
Republic of Macedonia
zoranspi@hio.edu.mk

Roberto Sulpizio
University of Bari
Department Geomineralogy
via Orabona 4, I-70125
Italy
r.sulpizio@geomin.uniba.it

Sasho Trajanoski
Hydrobiological Institute
Naum Ohridski 50
6000 Ohrid
Republic of Macedonia
trajsa@hio.edu.mk

Hendrik Vogel
University of Cologne
Zülpicher Str 49a
D-50674 Cologne
Germany
vogelh@uni-koeln.de

Bernd Wagner
University of Cologne
Zülpicher Str 49a
D-50674 Cologne
Germany
wagnerb@uni-koeln.de

Thomas Wagner
School of Civil Engineering and Geosci.
University of Newcastle
Newcastle upon Tyne
NE1 7RU, United Kingdom
thomas.wagner@ncl.ac.uk

Thomas Wilke
Justus Liebig University Giessen
Animal Ecology and Systematics
Heinrich-Buff-Ring 26 - 32 (IFZ)
35392 Giessen
Tom.Wilke@allzool.bio.uni-giessen.de

Barbara Wohlfarth
University of Stockholm
Dept of Geology and Geochemistry
SE-10691 Stockholm
Barbara@geo.su.se

Gianni Zanchetta
Dipartimento di Scienze della Terra
via S. Maria 53
56126, Pisa
Italy
zanchetta@dst.unipi.it

Katja Zimmermann
IFM-GEOMAR
Wischhofstr. 1-3
D-24248 Kiel
Germany
kzimmermann@ifm-geomar.de