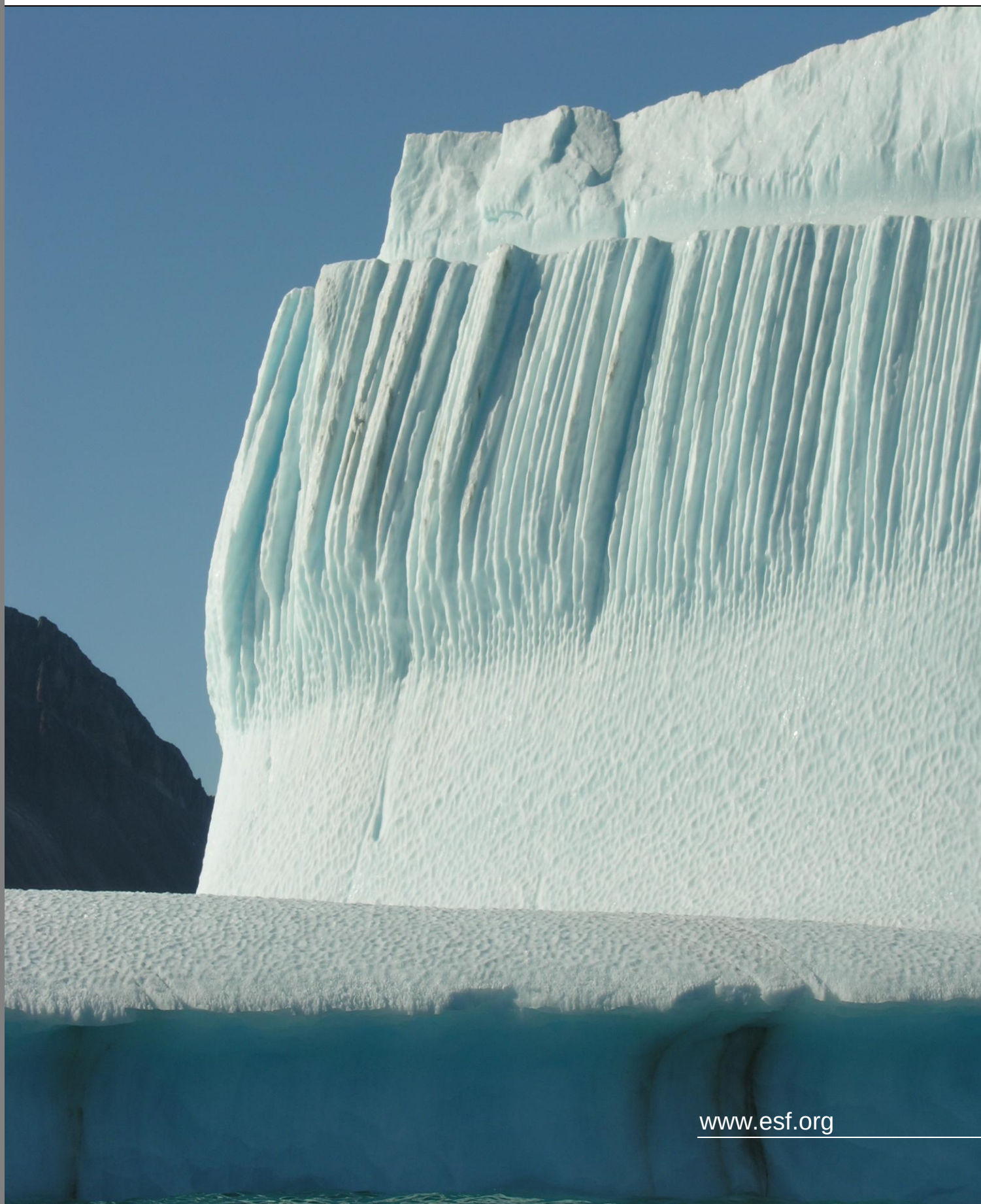
EUROPEAN SCIENCE FOUNDATION
SETTING SCIENCE AGENDAS FOR EUROPE

EUROCORES Programme

EuroCLIMATE

Climate Variability and Past, Present and Future Carbon Cycle

Final Report



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European Science Foundation (ESF)

The European Science Foundation (ESF) was established in 1974 to create a common European platform for cross-border cooperation in all aspects of scientific research.

With its emphasis on a multidisciplinary and pan-European approach, the Foundation provides the leadership necessary to open new frontiers in European science.

Its activities include providing science policy advice (Science Strategy); stimulating co-operation between researchers and organisations to explore new directions (Science Synergy); and the administration of externally funded programmes (Science Management). These take place in the following areas:

Physical and engineering sciences; Medical sciences; Life, earth and environmental sciences; Humanities; Social sciences; Polar; Marine; Space sciences; Radio astronomy frequencies; Nuclear physics.

Headquartered in Strasbourg with offices in Brussels, the ESF's membership comprises 79 national funding agencies, research performing organisations and academies from 30 European countries.

The Foundation's independence allows the ESF to objectively represent the priorities of all these members.

What is a EUROCORES?

The EUROCORES (ESF Collaborative Research) Scheme is an ESF instrument to stimulate collaboration between researchers based in Europe, and to maintain European research at an international competitive level.

The EUROCORES Scheme provides a framework for national research funding agencies (research councils and academies and other funding organisations) to fund collaborative research, in and across all scientific areas.

Participating funding agencies jointly define a research programme, specify the type of proposals to be requested and agree on the peer-review procedure.

The ESF, with funds from the EC Sixth Framework Programme under Contract no. ERAS-CT-2003-980409, provided support for programme coordination and for the networking activities of funded projects while research funding stayed with national funding agencies.

Cover picture: Iceberg LancasterSound. Courtesy of H. Oerter.

Foreword

EUROCLIMATE was an ESF EUROCORES Programme that supported research related to the inter-relationship between global carbon cycle dynamics and climate variability of the past, present and future. EUROCLIMATE included nine international, multidisciplinary Collaborative Research Projects (CRPs). Each of the nine projects has dealt with very different aspects of this complex theme. Some have primarily pursued methodological advances (PaleoSalt, CASIOPEIA, IsoTrace), others focused on reconstructing climate-biosphere and climate-carbon cycle interactions (MERF, DecVeg, Tree14, ChallaCEA, DecLakes, RESOLuTION) at various time and spatial scales. Each of the projects has managed to cover most of the deliverables that were initially set out. New proxies have been developed, the absolute chronology based on tree rings has been extended and coupled to ice-core archives. Most importantly, what we have achieved is that data producers and modellers are becoming close collaborators and that the contacts between the terrestrial and marine scientists have been firmly established.

EUROCLIMATE has also been successfully collaborating with other ESF activities through joint networking activities e.g. special sessions, summer schools, publications, exchange of ideas and plans for the future and has developed close interactions with other major initiatives and programmes within the Earth System Science Partnership (IGBP, WCRP, IHDP and DIVERSITAS). Our programme has developed synergistic relationships with these communities and strong, international scientific efforts.

Some scientific issues such as climate change need to be addressed at a scale which is beyond the scope of national funding levels because its socio-economic implications are global. Next to the EU Framework Programme, EUROCORES is the only alternative for doing research at a European scale. The EUROCORES Scheme is a fantastic instrument that allows scientists to do research at the European level with relatively little administrative burden and a fantastic networking and outreach component. Climate scientists are not only driven by curiosity, but also by concerns about the fate of the Earth. This requires a global approach. The EUROCORES Scheme allows for a bottom-up approach where scientists can propose a programme that they think is important. This is the big difference with regard to the EU Framework Programme where calls are pre-formulated.

Jelle Bijma
Chair of the EUROCLIMATE Scientific Committee

PART 1

Final Report

EUROCLIMATE – A EUROCORES programme on climate variability and the carbon cycle

Origin of the programme

In September 2001, the European Science Foundation (ESF) co-sponsored together with the Hanse Institute for Advanced Study (HWK) an Exploratory Workshop entitled "The ocean carbon cycle and climate change". This workshop was organised by J. Bijma, G. Ganssen and H. Spero and held in Delmenhorst (Germany). This interdisciplinary group of 34 scientists convened during four days in pursuit of the following goals: (1) to discuss scenarios of positive and negative feedback between the global carbon cycle and climate change on different timescales, (2) to better define proxies for recording oceanic carbonate chemistry dynamics and (3) to establish state-of-the-science and directions for the paleoceanography community to explore in the future. In addition, one of the main objectives of this workshop was to establish state-of-the-science and directions for the paleoceanography community to explore in the future. Recommendations to that effect were provided in the workshop report. Another contribution to the future direction in the field evolved during the workshop when the ESF representative indicated that the Standing Committee for Life, Earth and Environmental Sciences (LESC) would encourage submission of outline proposals for potential EUROCORES programmes. During the final two days of the workshop, a small group of participants stayed on to prepare an outline proposal for such a EUROCORES programme which they entitled EUROCLIMATE.

Following this idea, a proposal for a EUROCORES theme was submitted by a small group of scientists (J. Bijma, G.-J. Brummer, E. Jansen, T. Johannessen and N. Shackleton) in spring 2002. The main idea of this outline proposal was to propose a programme to tackle the problem associated with the lack of mechanistic understanding of natural climate variability recorded in paleo-records, which limits the ability to predict (anthropogenic) climate change under global warming. At a preparatory meeting in October 2002, which brought together administrative and scientific representatives of the ESF Member Organisations that had expressed a preliminary interest in this initiative, an intensive discussion took place on the scientific scope and focus of the proposed EUROCORES. Further input was required to finalise the Call for Proposals for the EUROCLIMATE EUROCORES and a second preparatory meeting was convened in Strasbourg in February 2003. A final draft of the Call was circulated to the Member Organisations, and received the support of 13 Member Organisations from 12 countries. The EUROCLIMATE Call for Outline Proposals was launched in July 2003, with a deadline of 31 October 2003. A total of 103 outline proposals were received in response to this call and 35 full proposals were finally scanned by the Review Panel in August 2004. From these proposals, 20 were recommended by the review panel and finally nine were funded by the participating organisations as Collaborative Research Projects including a total of 49 individual projects. The funding of the various projects started as of June 2005 depending on the funding organisations. The first EUROCLIMATE Scientific Committee meeting took place in June 2005 and the final conference in Giens, France was organised in September 2008. Between the letter of intention and the actual start of the programme, three years and three months elapsed. Consequently, the official programme duration has been three years and three months with a total research budget of 6.1 M€ from the participating Funding Organisations and an additional Networking and Dissemination budget provided by the European Commission under the 6th Framework Programme of 472 k€, representing 8 % of the overall budget.

Scope of the programme

EUROCLIMATE was an ESF-EUROCORES Programme that supported research addressing climate variability in the past, present and for the future and particularly its inter-relationship to global carbon cycle dynamics.

The future climate and its variability are expected to be largely different from the present and the recent past. The atmospheric CO_2 concentration is expected to reach levels unequalled over the past millions of years. Temperature is also rising rapidly. The last 150 years of meteorological observations and reconstruction of the last

millennium suggest a rather uniform climate. Reconstructions of paleoclimates extending further back in time reveal a broader climatic diversity. Such reconstructions will help better understand the operation of the climate-carbon system and offer the possibility to test the reliability and robustness of the models used to predict future climate scenarios.

EUROCLIMATE focused both on reconstructing past climates using different well-dated and calibrated proxy records, and on modelling climate and climate variability. It brought together leading European marine, terrestrial and ice-core communities on cross-cutting issues that would advance our understanding of climate variability and the underlying physical, chemical and biological processes involved.

The EUROCLIMATE Programme involved more than 70 European lead scientists and their research teams through nine trans-national collaborative research projects, and provided a unique opportunity for the training of numerous young researchers. EUROCLIMATE fostered pan-European collaborative research and developed close interactions with other major initiatives and programmes within the Earth System Partnership (IGBP, WCRP, IHDP and DIVERSITAS).

Programme activities

Networking and dissemination activities are the key characteristics and the main objectives of the EUROCORES Programme. They are meant to encourage and facilitate scientific collaboration and diffusion across the Collaborative Research Projects (CRPs) within a given domain or, if appropriate, across different domains and programmes. These activities are flexible and can be tailored to the needs of a given programme.

During the course of the EUROCLIMATE programme, five topical workshops and two schools have been organised as well as a final programme wide conference which took place in September 2008. These activities have attracted as many as 70 participants from the different projects and from the different participating countries. These events were crucial in building the EUROCLIMATE scientific community. In addition to these programme conferences, workshop and schools, EUROCLIMATE special sessions have also been organised during the European Geophysical Union annual assembly in 2006, 2007 and 2008. These sessions were a good opportunity to present the EUROCLIMATE research results and achievements to a wider international community.

The aim of these networking activities has not only been to increase the exchange of ideas but also of scientific visitors between the different projects. Through short-term visits and travel grants junior scientists have been encouraged to play an active role in the programme activities strengthening their interactions across the projects and across the different participating countries.

Programme structure and management

The Management Committee (MC) has the overall responsibility for the direction and governance of the EUROCORES Programme within the guidelines of the EUROCORES Scheme. The MC can request expert advice from the EUROCORES Scientific Committee, Review Panel or any other ad-hoc advisory group. Each MC member is responsible for liaison with their funding organisation, including supervision of the funding process for EUROCORES projects within their organisation. This includes: responsiveness to the requests of the coordinators for the confirmation of level of participation and funding, eligibility of applicants according to national regulations, funding decisions for Individual Projects (IPs), etc. Members may attend all meetings of the EUROCORES programme (Review Panel meetings, Science Committee meetings, science meetings) as observers. The EUROCLIMATE programme has been overseen by an MC formed by 12 representatives from each of the 10 national funding agencies, plus three observers from other agencies which initially manifested their interest in the programme (see list on page 104).

The Scientific Committee (SC) of EUROCLIMATE was established once the funding decisions had been finalised confirming the CRPs that would receive grants and their start date. The first meeting of the SC in June 2005

marked the start of the research and networking phase of the programme. The SC members represent the Principal Investigators (PI), Associate Partners (PA) and Project Members of a CRP and are responsible for the communication flow from the Scientific Committee to Principal Investigators, Associated Partners and Project Members. The EUROCLIMATE Scientific Committee was comprised of nine project leaders, one from each CRPs (see list on page 103). Dr. Jelle Bijma from the Alfred-Wegener Institut in Bremerhaven ,Germany, was elected chair of this committee for the whole duration of the project.

The Review Panel (RP) of EUROCLIMATE was established soon after the publication of the call for proposals. It was constituted by the ESF through suggestions from the Management Committee members and the coordinator. The RP members were chosen solely for their scientific contributions to the panel, not as representatives of the interests of their country or funding agency. The RP members had strong scientific backgrounds covering the full scientific spectrum set out in the call for proposals. The panel was convened by the ESF during the peer review process and later on for the evaluation of the progress made by the programme. The submitted full proposals went first through an international peer review and were then further discussed, recommended and prioritised by the RP. The EUROCLIMATE Review Panel was composed of 13 international experts in the field (see list on page 113). The RP members also participated in most programme activities during the course of the programme. Finally, they participated in the final evaluation of the programme.

The final report

In addition to the annual reports provided individually by the participants to their national funding agencies, the ESF conducts the final evaluation of the EUROCORES programme on behalf of the member organisations. The final evaluation concerns the overall achievements of the programme as a whole and as such complements the individual evaluations conducted at the national level. The purpose of the final report is to present the key scientific results of the individual Collaborative Research Projects. Projet leaders are also requested to provide their own feedback on their research and on the programme. Another very important aspect of the final report is to present and evaluate the networking activities which took place between the various projects and to investigate the added value of the programme. The final report report has been evaluated by the Review Panel of the programme.

This report is in two parts. The first part of the report provides the individual project reports from the nine participating Collaborative Research Projects and presents the networking activities which took place during the course of the programme together with the list of publications. The second part of the document is dedicated to the evaluation by the review panel. In this latter section the individual assessments by the review panel members are provided. The review panel also provided suggestions for future activities which could be beneficial to the continuation of the integration efforts undertaken by the EUROCLIMATE community during the programme.

Development, calibration and application of independent salinity proxies (PaleoSalt)

Abstract

Testing climate models for future and past climate change critically depend on our ability to quantitatively reconstruct past climate. Paleosalinity is the single most important oceanographic parameter which currently can still not be quantified from sedimentary records. Nine partners from six different European countries will bring together complementary expertise in a multidisciplinary project to develop accurate and robust salinity proxies by (1) increasing precision, accuracy and applicability of the only currently used salinity proxy (combined d18O-Mg/Ca approach), (2) developing a new approach through compound specific dD combined with UK37 and link the two by using d18O and dD to deconvolve salinity, (3) using ultra-high-resolution elemental and isotopic analysis of biogenic carbonates to trace salinity changes. For all three approaches a mechanistic understanding for proxy relationships will be developed. Only through understanding the processes underlying the actual proxy recording we can develop robust proxy relationships that will hold beyond empirical calibrations under none analogue conditions. Different organisms have been selected (foraminifera, coccolithophorids and bivalves) taking advantage of their specific possibilities. These new proxies will be be verified in key areas where temperature and salinity gradients can be separated and finally applied by investigating the impact of the Mediterranean "salt distil" and Agulhas "salt valve" on North Atlantic convection.

Partners

(CNRS, DFG, FWO, NWO)

Jelle Bijma (project leader)
Alfred-Wegener Institut für Polar- und Meeresforschung, Bremerhaven, DE

Heinrich Arlinghaus
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Stefan Schouten
Nederlands Instituut voor Onderzoek der Zee, Den Burg, NL

Frans Jorissen
Université d'Angers, Angers, FR

Laurent Chauvaud
Université de Bretagne Occidentale, Plouzane, FR

Frank Dehairs
Free University of Brussels, Brussels, BE

Luc André
Musée Royal de l'Afrique Centrale, Tervuren, BE

Collaborative Research Project (CRP)

1. General information

Project Reference Number : **04-ECLIM-FP02**
Acronym / Short Title: **PaleoSalt**
Full Title: **Development, calibration and application of independent salinity proxies**
Project Leader name: **Jelle Bijma**
Project Leader affiliation: **Alfred Wegener Institue for Polar and Marine Research**
Institutional home page (URL): **www.awi-bremerhaven.de**
Project-related home page (URL):
http://www.awi.de/de/forschung/fachbereiche/biowissenschaften/projects/paleosalt/
Reporting period: **20/06/2005 to 30/09/2008**

2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)

IP 1

Principal Investigator (name & affiliation): **Prof. Dr. Jelle Bijma, Alfred Wegener Institue for Polar and Marine Research, Bremerhaven, Germany**

Total Funding amount of the IP: **1 Post-Doc position + 89.5k€**

IP2

Principal Investigator (name & affiliation): **Prof. Dr. Heinrich Arlinghaus, Physikalisches Institut, Westfälische Wilhelms-Universität Münster, Germany**

Total Funding amount of the IP : Personnel: **1 BAT IIa-Stelle +61k€ consumables, 13.4k€ equipment**

IP3

Principal Investigator (name & affiliation): **Dr. Gert-Jan Reichart, University Utrecht, The Netherlands**

Total Funding amount of the IP: **217 k€**

IP4

Principal Investigator (name & affiliation): **Dr. Stefan Schouten, Royal NIOZ, The Netherlands**

Total Funding amount of the IP : **252.6 k€**

IP5

Principal Investigator (name & affiliation): **Prof. Dr. Frank Dehairs, Analytical and Environmental Chemistry, Vrije Universiteit Brussel, Belgium**

Total Funding amount of the IP : **55.5 k€ (FWO-Flanders)**

IP6

Principal Investigator (name & affiliation): **Prof. Luc André, Section de Minéralogie-Pétrographie-géochimie Musée Royal de l'Afrique centrale (M.R.A.C.), Tervuren, Belgium**

Total Funding amount of the IP : **No financial support!**

IP7

Principal Investigator (name & affiliation): **Prof. Dr. Frans JORISSEN, Laboratory of Recent and Fossil Bio-Indicators (BIAF, UPRES EA 2644), Angers University, France**

Total Funding amount of the IP : **39.6 k€**

IP8

Principal Investigator (name & affiliation): **Dr. Laurent Chauvaud, IUEM - LEMAR (UBO/IRD/CNRS UMR 6539), France**

Total Funding amount of the IP : **36.9 k€**

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

WP1: Salinity effects on proxy incorporation in foraminifera. IP: Bijma, AWI (in cooperation with WP3 partners)
The impact of salinity on the incorporation of Mg and Sr has been investigated for benthic and planktonic foraminifera. For both groups a positive relationship between divalent cation incorporation and salinity could be established. It could be demonstrated that the "additional" incorporation of Mg, i.e. independent of temperature, is a direct consequence of increased salinity. This implies that a salinity increase of 2 results in enhanced Mg incorporation equivalent to 1°C temperature increase. In benthic foraminifera, the increased Sr incorporation, is not driven by salinity itself but by the concurrent increase in the saturation state with respect to calcite (Ω). For planktonic foraminifera the Sr data are inconclusive.

WP2: Ultra-high resolution element characterisation and molecular biomarkers fingerprinting in marine biogenic carbonates. IP: Arlinghaus, UMSR
Within this WP we developed:
1) Sample handling for cells and tissues via repeated cryosectioning was developed allowing 3D imaging of single foraminifera with cryo-ToF-SIMS/laser-SNMS (depth resolution: 20-30 µm).
2) A correlation lateral variation of the Ba concentration in a coral core (together with Craig Grove, NIOZ):
- the variations were found and had the expected spacing
- work on expected correlation with luminescent lines in the material still in progress.
3) A SIMS "fingerprint" for an alkenone mixture from *E. hux*. All original molecules in the mixture could be found with SIMS but the relative intensity was shifted compared to the corresponding GC spectrum.
4) A correlation between Mg and organic linings in cross sections of foraminiferal shells.

WP3: Seasonality and habitat controls on benthic foraminiferal salinity proxies. IP: Reichart, UU
WP3 focused on the impact of time and microhabitat on foraminiferal growth rate and shell formation and thus proxy recording. Based on this main objective, the following results were obtained:
1) We determined, in cooperation with partners of WP1, ontogenic and inter-individual variations in Mg incorporation for planktonic foraminifera. Results obtained show a primary/secondary foraminiferal calcite ratio in terms of Mg content that hasn't been reported in literature before. A manuscript describing the ontogenetic effect and inter test variability is in preparation.
2) In close cooperation with partners from WP7, we successfully analyzed the pore water chemistry of core top samples from the Delta of the Rhone River. Trace metal composition of foraminifera samples will be compared to the pore water chemistry in order to find any possible microhabitat effect on the foraminiferal calcite composition.
3) We determined ontogenic and inter-individual variations of trace metal composition in deep benthic foraminiferal calcite. Specimens used (*Cibicides pachyderma*) come from core top samples from the Bay of Biscay, North Atlantic Ocean, collected by partners from WP7.

WP4: Seasonality and habitat controls on planktonic foraminifera - Compound specific dD analysis of alkenones and particulate organic matter. IP: Schouten, NIOZ
To develop dD as a new proxy for paleosalinity, we have grown cultures of *Emiliania huxleyi* and *Gephyrocapsa oceanica* (with partners of WP1) and analysed the long chain alkenones. We found a strong correlation between the fractionation factor $d_{alkenones\text{-}growth\ water}$ and salinity for both *E. huxleyi* and *G. oceanica* although growth rate also had some impact. This suggests that dD of alkenones can be used to reconstruct past salinities. This newly developed proxy was applied to a core from the Aegean Sea covering the S5 sapropel. Our analysis of the δD of alkenones from last interglacial sapropel S5 from the Aegean Sea shows a large decrease in δD of 25 ‰ at the onset of sapropel formation, suggesting a drop in SSS of 6.We have also applied this proxy in a core covering the last 3000 yrs of the Black Sea. Approximately 2700 yrs ago *E. huxleyi* invaded the Black Sea, illustrated by the deposition of a coccolith ooze from this time on. Because *E. huxleyi* has never been observed at salinities below 11, a salinity increase to above 11 has been suggested for that time period. Our results show that the dD values of alkenones gradually decreased over the last

3000 yrs suggesting a decrease in salinity and, therefore, a higher than present day salinity 2700 yrs ago. Relative salinity changes generated from organic walled dinoflagellate cyst (dinocyst) distributions from the same core confirms our SSS reconstruction based on dD of alkenones. This makes it likely that the invasion of the Black Sea by *E. huxleyi* is not caused by an increase in salinity. Our results show that dD of alkenones is a promising new tool for reconstructing past salinities. To reduce uncertainties in SSS estimates, the δD-salinity relationship has to be better constrained with cultures and also be further tested in field studies.

WP5: Salinity effects on proxy incorporation in bivalves. IP: Dehairs, VUB

1) ***Shell barium and Chl-a:*** Ba peaks in bivalve shells do occur in spring when phytoplankton blooms are observed. However, the temporal overlap between shell Ba maxima and Chl-a maxima was not always clear.

2) ***Shell barium and salinity:*** Baseline Ba content, on the contrary, did correlate well with dissolved Ba in the medium, highlighting the potential usefulness of this element as a proxy of estuarine Ba and (site-specific) salinity.

3) ***Shell carbonate $\delta^{13}C$ and salinity:*** Bivalve shell $\delta^{13}C$ relates well with $\delta^{13}C$ of dissolved inorganic carbon, although metabolic C clearly contributes to the shell signal. It was found that the metabolic effect on shell $\delta^{13}C$ could not easily be accounted for to allow reliable $\delta^{13}C_{DIC}$ and salinity reconstructions.

4) ***dD in shell organic matter: a new proxy:*** At this stage only preliminary tasks were completed. These include optimization of extraction protocols for bulk organic matter and specific biochemical compounds from bivalve shells and analysis via GC-MS (for compound identification) and GC-c-MS (only for $d^{13}C$ at this point). The next step will be the determination of dD in specific shell OM compounds to investigate the possible relationship between dD and salinity.

5) ***Correction for the time averaging effect:*** Signal profiles along an accretion axis or a growth axis of e.g. a bivalve shell may show underestimation of signal amplitude due to averaging when sampling by micro-drill or laser. A non parametric model was established enabling to correct for this underestimation.

6) ***Reconstructing an environmental condition via a non-linear multi-proxy approach:*** A spline-model was constructed which uses the information residing in the shell profiles of proxies (elements and isotopes). The first results are promising and a temperature reconstruction with a precision up to 0.45ºC was achieved.

WP6: Temperature-salinity dependent uptake of Mg into biogenic carbonates: constraints from magnesium isotopes. IP: André, MRAC.

1) ***Mg isotopes in sea urchins and starfish skeletons:*** The Mg isotopic composition ($\delta^{26}Mg$) in sea urchins and starfish vary between -2.3 to -2.8‰ and -3.0 to 3.1‰ respectively. Comparison to inorganic calcite precipitated from seawater (-3.5‰) shows that biological processes in echinoderms preferentially incorporate the heavy Mg isotope. The biological influence is larger in sea urchin than in starfish.

2) ***Mg isotope in culture sea urchins:*** Culture experiment performed with sea urchin over a 11°C temperature range for two salinities (36 and 39) show a linear relationship between T and $\delta^{26}Mg$ with a weak salinity dependency. The T dependency of the fractionation factor (-0.03 to -0.02‰/°C) is, however, too low to provide a precise paleothermometer considering the global uncertainty on measured $\delta^{26}Mg$ (0.15‰).

3) ***Mg isotopes in bivalves: $\delta^{26}Mg$ in the different compartments involved in the shell formation of the manila clam:*** Mg isotopic ratios and Mg concentrations were determined in the different compartments involved in the shell formation of the Manila clam . Shell $\delta^{26}Mg$ data show strong and variable enrichments in light Mg isotope and appear to vary according to the salinity contrast between the oceanic (Locmariaquer) and the estuarine site (Le Bono) which is subjected to tidal activity and freshwater input from the Auray river. The Mg isotopic compositions of the shell can be attributed to variations in the extra palleal fluid, which is strongly influenced by the Mg incorporation in the soft tissues (enriched in heavy isotopes). Enrichments in light isotopes of the internal fluids are a consequence of a balance effect due to incorporation of Mg in the intracellular medium. This process which is potentially related to the metabolic activity varies significantly according to salinity variations encountered between the two sites. At the oceanic site, low to moderate metabolic influence is observed contrasting with moderate to high influence at the estuarine site.

WP7: Ecologic constraints on salinity proxies in benthic foraminifera. IP: Jorissen, UA.

The main aim of WP7 was to investigate how the physico-chemical and biological conditions of natural life habitats influence those aspects of the geochemistry that can be used for salinity proxies. In order to achieve this, we combined field observations in areas with a strong salinity gradient and laboratory experiments.

In practice, the contribution to the Paleosalt Project of BIAF Angers had three main components: 1) supplying living deep see foraminiferal faunas to other laboratories, 2) study the impact of salinity on proxy carriers in a field setting, and 3) study the influence of salinity changes on the foraminiferal geochemistry in laboratory experiments. The

following paragraphs explain these points in more detail.
1) We developed a culture protocol to successfully maintain, grow and reproduce the deep sea foraminifer *Bulimina marginata,* over a wide range of temperatures (4-19°C). A key element to success is food quality (a mixture of living green algae and diatoms).
2) The Auray river estuary has a strong salinity gradient (21–32). Six subtidal sampling stations have been selected along the salinity gradient, and the foraminiferal faunas have been studied for 2 contrasting seasons (spring 2006 and winter 2007). Stable isotope measurements show a strong $\delta^{13}C$ gradient from the upper to the lower estuary. This apparent response to salinity is probably caused by a compositional changes of dissolved organic matter used for test construction.
3) Living *Ammonia tepida*, collected in Aiguillon Bay, have been incubated in the laboratory at 3 different salinities (30, 32.4 and 35.7 ‰). The stable isotopic composition as well as trace metal content of the shells will be determined shortly.

WP8: Physiologic controls on salinity proxies in bivalves. IP: Paulet, LEMAR
The aim of WP8 was to understand (1) how trace elements and stable isotopes are incorporated in bivalve shells and (2) how physiological effects alter the environmental signals incorporated in bivalve shells. For this purpose, an euryhalin bivalve, *Ruditapes philippinarum*, living in the Auray River (France) was chosen.

1) An *in situ* monitoring program was set-up along the Auray River: Locmariaquer, located at the mouth of the estuary and Le Bono upstream. Temperature and salinity were recorded at two stations every ten minutes from March 2006 to July 2008.
Every 2 months, water samples were collected in order to characterize the chemical composition of dissolved and particulate orhanic matter (traces elements, $\delta^{18}0_{water}$, $\delta^{13}C_{DIC}$, $\delta^{15}N_{POM}$ and $\delta^{13}C_{POM}$). At Le Bono, salinity was highly variable (between 15 and 34) at various times scales: annual, fortnightly and tidal. On the contrary, at Locmariaquer salinity is nearly stable. At both sites Magnesium, strontium, calcium and barium concentrations, $\delta^{18}0_{water}$ and $\delta^{13}C_{DIC}$ were highly correlated with salinity (the data will also be used by WP7.
2) To develop a sclerochronology for Manila clams, specimens were marked with calcein: Manila clams precipitate one micro-increment per tidal cycle. This result allows to asign a calendar date to each growth increment of *Ruditapes philippinarum* collected at the Bono.
3) *In situ* experiment at high temporal resolution: Seawater and Manila clams were sampled in the subtidal zone by scuba diving every two hours during a 48 hours experiment at the Bono. First results indicate that the osmolarity of seawater equals that in the haemolymph and extra-pallial fluids, except at low tide when osmolarity is higher in the fluids. These results show that *Ruditapes philippinarum* is an osmoconformer. However, when salinity decreases beneath a threshold, the clams seem to close their valves for protection to low salinity. As a consequence Manila clam may not record salinity minima into their shells.
Trace elements analyses of the shells show that the magnesium concentration does not vary at a tidal scale but there is a good relation with strontium. Strontium variations in the shell could be explained by strontium concentration variations in water or by the biomineralization rate. Analyses of traces elements concentrations in *Ruditapes philippinarum*'s fluids (heamolymph and extra-pallial fluids) at a tidal scale are on progress

WP9: Thermo-*haline* controls on past ocean changes: Verification and application of salt proxies. IP: Zahn, UB
Unfortunately, this WP could not be carried out as no funding was made available.

4. What did you not achieve in the CRP and why? (max 1 p.)
Please use the original proposal as reference and explain any deviations from the work plan

WP2:
1) Metal/Ca ratio on foraminifera cultured under controlled conditions have not yet been carried out, as specimens have become available only recently.

WP3:
We have not yet been successful in culturing species of deep benthic foraminifera such as *Cibicidoides sp*., *Uvigerina sp*. and *Globobulimina sp*., mostly because the samples lacked sufficient living individuals. Furthermore, these species reproduce slowly and growth is limited. To minimize time loss we developed protocols that allowed to keep living deep benthic foraminifera stocks in the laboratory.
There is a need to study how environmental parameters (not only the chemistry of the seawater, oxygen levels and food availability) affect the biology of deep benthic foraminifera in the laboratory.

WP4:

We were not able yet to analyse the dD of alkenones in high salinity environments or in particulate organic matter due to a lack of alkenones.

WP5:

The methodology for deuterium isotopic analysis in shell organic matter was not finalized. However, the work progressed well and we expect that during the coming 4 to 6 months results will show (or not) how promising dD of specific biochemical compounds in bivalve shells are as salinity proxies. Also further testing is required concerning the non-linear multi-proxy approach for reconstructing environmental conditions.

WP7:

According to the present planning, the isotopic and trace metal measurements will be finished in October 2008. After this, most of the planned research will have been realised. An exception is the envisaged field study of the geochemical variability along 2 Eastern Mediterranean to Atlantic deep-sea transects (at 1000 and 2000 m depth, respectively). An inventory of all available data (our own data plus data from published studies of other research groups) revealed a highly inconsistent pattern, with no visible impact of salinity on the geochemistry of foraminiferal shells. This negative result is probably due to the lack of intercalibration of the various mass spectrometers used by the different research groups, and by the surprising scarcity of data on the stable isotopic composition and the carbonate chemistry of the water masses in which the foraminifera have formed their shells. Without these parameters it becomes virtually impossible to interpret the foraminiferal geochemistry, and to pinpoint the contribution of salinity. In order to fulfill this objective, it would have been necessary to organise a sampling cruise dedicated to this. In view of the allocated budget, such an enterprise was not realistic.

WP8:

Comparative approach of bivalve and foraminifers from the same stations in the Auray river was initially planned. Although that several field campaign was realised by the Angers (Foraminifers) and Brest (Bivalves), and many environmental measures done simultaneously, the results analysis is now limited to species group independently.

One the major reason is the short duration of the program, the three years being meanly devoted to the development of knowledge and methods in each type of organism. The background that has been now accumulated will allow us to begin a comparative approach of foraminifers and bivalves, certainly fruitful.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

- Partner 1 (AWI) is co-proposer, member of the SSC and theme 1 leader of FP7 EPOCA (European Project on Ocean Acidification).
- Partner 1 (AWI) and 2 (UMSR) are PI's in "BIOCALC" (ESF "EuroMinScI") project on biomineralisation and proxies.
- Partner 1 (AWI) and 3 (UU) have proposed a new "EuroCore" programme EurOpA (EuroCore Programme on Ocean Acidification)
- Partner 4 (RNIOZ) has submitted a proposal to continue WP4 work to the Netherlands Organisation for Scientific Research.
- Partner 5 VUB) will continue its research (WP5) over 2008 and 2009 as funded by Belspo (Calmars II). The continuation of the collaboration with IUEM Brest is sought via a bilateral agreement between VUB and IUEM.
- Partner 6 (MRAC) will continue its research (WP6) over 2008 and 2009 as funded by Belspo (Calmars II).
- Partner 8 (IUEM - LEMAR) has two programs in development following paleosalt :
  - Chivas : an ANR (France) program on primary productivity proxies, using the bivale Pecten maximus.
  - ISOBENT : tracing of continental influence in coastal water using flesh and shell of primary consumers (French Program EC2CO)

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Ocean acidification should become a high research priority

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

Partner 1 (AWI):
The biggest advantage of the Eurocore scheme is its networking component which allows cross-fertilisation of the individual research initiatives of the partners and development of new research initiatives

Partner 3 (UU):
Active communication and cooperation with different scientific teams across Europe. This significantly improved our ability to develop new protocols and methodologies needed. Joint publications and the initiation of new research initiatives were facilitated by the frequent meetings.

Partner 4 (NIOZ):
Since the partners work on a common theme it is easy to collaborate with them especially since there is diverse expertise available.

Partner 5 (VUB):
The EUROCORES scheme offers an ideal framework for enhancing international collaboration. The work described above for WP5 was carried out in close co-operation with IUEM, Brest, France (Y.-M. Paulet, L. Chauvaud). While this co-operation was initiated prior to Paleosalt it has gained momentum during PaleoSalt. Paleosalt in particular has catalysed close co-operation and interactions between mutual PhD students (R. Mas; M. Bauwens; V. Beelaerts, C. Poulain). Also the co-operation with IUEM, Brest, France (Y.-M. Paulet, L. Chauvaud), while existing before Paleosalt has gained momentum during PaleoSalt. Paleosalt has catalysed close co-operation and interactions between mutual PhD students (R. Mas; M. Bauwens; V. Beelaerts, C. Poulain).

Partner 6 (MRAC):
The work performed on echinoderms was carried out in close collaboration with the ULB-Biomar laboratory (Ph. Dubois and two PhD students C. Borremans and J. Hermans) and the Royal Institute of Natural Science (Ph. Willenz). The work on Mg isotope in bivalve was carried out in close co-operation with IUEM, Brest, France (Y.-M. Paulet, and C. Poulain PhD student).

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

- The evaluation procedure and especially the negotiations with the national funding agencies could perhaps be speeded up and the commitment of the participation funding agencies should be final.
- The policy of funding by national agencies complicates matters. Though selection by the ESF scientific board warrants quality of the proposal, ESF selected proposals do not necessarily receive the same appreciation or rating from the national agencies. In some countries funding of ESF selected projects remains minimal.
- The huge disparity in the research budgets allocated to the partners of different countries is very frustrating. It is evident that the research groups with a restricted finacial contribution can only have a limited contribution to the project. Such a marginal position is not very stimulating.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Partners 1 & 4:

Schouten, S., Ossebaar, J., Schreiber, K., Kienhuis, M.V.M., Langer, G., Benthien, A., Bijma, J. (2006). The effect of temperature, salinity and growth rate on the stable hydrogen isotopic composition of long chain alkenones produced by Emiliania huxleyi and Gephyrocapsa oceanica. Biogeosciences 3, 113-119.

Partners 1 & 2:

Vering, G., Crone, C., Kathers, P., Bijma, J., Arlinghaus, H. F. (2006). Resonant laser-SNMS of boron for analysis of paleoceanographic samples, Appl.Surf.Sci.,252,7163-7166.

Partners 1 & 3:

Dueñas-Bohórquez, A., Bijma, J., da Rocha, R. Kuroyanagi, A., Reichart, G.-J. (in prep.) Effect of salinity and seawater calcite saturation state on Mg and Sr incorporation in planktonic foraminifera.

Dueñas-Bohórquez, A., Bijma, J., da Rocha, R. Kuroyanagi, A. and Reichart, G.-J. (in prep.) Ontogenic and Inter-individual variations of Mg/Ca ratio of planktonic foraminifera.

Dissard, D., Nehrke, G., Reichart, G.-J. and Bijma, J. (subm.) The impact of salinity on the Mg/Ca and Sr/Ca ratio in the benthic foraminifer *Ammonia tepida*: results from culturing experiments. Biogeosciences Discussions

Dissard, D., Reichart, G.-J. and Bijma, J. (in prep.) Impact of seawater pCO_2 changes on calcification and on Mg/Ca and Sr/Ca in benthic foraminifera calcite *(Ammonia tepida)*: results from culturing experiments.

da Rocha, R., Dueñas-Bohórquez, A., Reichart, G.-J., Bijma. J. (in prep.) The impact of temperature and salinity on the incorporation of Mg in *G. sacculifer.*

da Rocha, R., Dueñas-Bohórquez, A., Reichart, G.-J., Bijma. J. (in prep.) The impact of pH/ CO_3^{2-} on the incorporation of Mg in *G. sacculifer.*

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Partner 1:

Nehrke, G., Reichart, G. J., Van Cappellen, P., Meile, C., Bijma, J. (2007). Dependence of calcite growth rate and Sr partitioning on solution stoichiometry: Non-Kossel crystal growth, Geochimica et Cocmochimica Acta, 71(9), 2240-2249.

Partner 2:

Heinrich F. Arlinghaus, 2008 (in press), Possibilities and limitations of high-resolution mass spectrometry in life sciences, Appl. Surf. Sci.

Partner 3:

de Nooijer, L. J., Reichart, G.-J., A. Dueñas-Bohórquez, M. Wolthers, S.R. Ernst, G.J. van der Zwaan (2007) Copper incorporation in foraminiferal calcite: results from culturing experiments. Biogeosciences, 4, 493–504.

Raitzsch, M., A. Dueñas-Bohórquez, G. J. Reichart and T. Bickert, The effect of calcite saturation state on Mg/Ca in cultured benthic foraminifera *Heterostegina sp.* and *Ammonia tepida.* To be submitted.

Partner 4:

Van der Meer, M.T.J., F. Sangiorgi, M. Baas, H. Brinkhuis, J.S. Sinninghe Damsté & S. Schouten (2008) Molecular isotopic and dinoflagellate evidence for Late Holocene freshening of the Black Sea. Earth Planet. Sci. Lett. 267: 426-434.

Van der Meer, M.T.J., M. Baas, W.I.C. Rijpstra, G. Marino, E.J. Rohling, J.S. Sinninghe Damsté & S. Schouten (2007) Hydrogen isotopic compositions of long-chain alkenones record freshwater flooding of the Eastern

Mediterranean at the onset of sapropel deposition, Earth Planet. Sci. Lett. 262: 594-600.

Partner 5:

Gillikin D.P., A. Lorrain, J. Navez, J.W. Taylor, L. André, E. Keppens, W. Baeyens and F. Dehairs (2005) Strong biological controls on Sr/Ca in aragonitic marine bivalve shells, *Geochemistry, Geophysics, Geosystems*, *G*^{3}, 6, Q05009, doi:10.1029/2004GC000874.

Gillikin D.P., F. De Ridder, H. Ulens, M. Elskens, E. Keppens, W. Baeyens and F. Dehairs (2005) Environmental and biological controls on oxygen and carbon isotopes in the aragonitic bivalve *Saxidomus giganteus*: Implications for paleoclimatic studies, *Paleogeography, Paleoclimatology Paleoecology*, 228, 70-85.

Gillikin D.P, F. Dehairs, W. Baeyens, J. Navez and L. André (2005) Inter- and intra-annual variations of Pb/Ca ratios in clam shells (*Mercenaria mercenaria*): a record of anthropogenic lead pollution? *Marine Pollution Bulletin*, 50, 1530-1540.

Gillikin D.P., F. Dehairs, A. Lorrain, D. Steenmans, W. Baeyens and L. André (2006) Barium uptake into the shells of the common mussel (*Mytilus edulis*) and the potential for estuarine paleo-chemistry reconstruction, *Geochimica et Cosmochimica Acta*, 70, 395-407.

De Ridder, F.; de Brauwere, A.; Pintelon, R.; Schoukens, J. and Dehairs, F. (2006) Identification of the accretion rate for annually resolved archives. *Biogeosciences Discussions*, 3: 321-344.

Gillikin D.P., A. Lorrain, S. Bouillon, P. Willenz and F. Dehairs (2006) $\delta^{13}C$ in *Mytilus edulis* shells: relation to salinity, DIC, phytoplankton and metabolism. *Organic Geochemistry*, 37, 1371-1382.

De Ridder F, de Brauwere A, Pintelon R, Schoukens J, Dehairs F, Baeyens W, & Wilkinson BH (2007) Comment on: Paleoclimatic inference from stable isotope profiles of accretionary biogenic hardparts—a quantitative approach to the evaluation of incomplete data, by Wilkinson, B.H., Ivany, L.C. (2002) Palaeogeogr. Palaeocl. Palaeoecol. 185, 95–114. *Palaeogeography, Palaeoclimatology, Palaeoecology* 248: 473-476.

Gillikin D.P., A. Lorrain, M. Li and F. Dehairs (2007) A large metabolic carbon contribution to the $\delta^{13}C$ record of marine aragonitic bivalve shells, *Geochimica et Cosmochimica Acta*, 71, 2936–2946.

Gillikin, D.P., A. Lorrain, Y.-M. Paulet, L. André and F. Dehairs (2008) Synchronous barium peaks in high-resolution profiles of calcite and aragonite marine bivalve shells, *Geo-Marine Letters*, DOI 10.1007/s00367-008-0111-9.

Beelaerts V., F. De Ridder, N. Schmitz, M. Bauwens, F. Dehairs, J. Schoukens, R. Pintelon (accept) On the elimination of bias averaging-errors in proxy records, *Mathematical Geosciences*.

Partner 6:

F. Planchon, C. Poulain, Y-.M. Paulet and L. André (in prep.) Isotopic evidence for a biological influence on Mg incorporation in the shell of the Manila clam *Ruditapes philippinarum*. JGR.

Partner 7:

Barras, C., Geslin, E., Duplessy, J.C. and Jorissen, F.J. (subm.) Optimisation of laboratory conditions to obtain reproduction and growth of the deep-sea benthic foraminifer *Bulimina marginata*. *Journal of Experimantal Marine Biology and Ecology*.

Barras C., Geslin E., Michel E., Gaultier M., Duplessy J.C., Jorissen F.J. (in prep) Experimental Protocols to Maintain Stable Physico-Chemical Conditions for the Culture of Deep-Sea Benthic Foraminifera. *Journal of Foraminiferal Research*

Partner 8:

Poulain et al., (in prep.) $\delta^{13}C$ and $\delta^{18}0$ variation in clam *Ruditapes philippinarum* shells from two locations along a estuarian salinity gradient (Auray river, France).

Poulain et al., (in prep.) High temporal variation in clam shell strontium concentrations.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

- Partner 1 (AWI) has participated in the documentary "Exploring time" (copy right2007 Twin Cities Public Television), which was broadcasted in the US, Japan, France and Germany.
- Together with 4 other EUROCLIMATE Projects, have partner 1 (AWI) and 3 (UU) of PaleoSalt produced videaoclips of their projects. The clips are available on the ESF homepage (copyright 2008 by ESF and Zcene.

- Partner 1 (AWI) has participated in a podcast.

1 D. Patents and industry collaborations

- Partner 4 (RNIOZ) collaborates with the Netherlands Forensic Institute on hydrogen isotope measurements.

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

1 F. Participation in other conferences

Please list only the most relevant

Partner 1:

- EGU 2006, Vienna, several posters and presentations
- EGU 2007, Vienna, several posters and presentations
- EGU 2008, Vienna, several posters and presentations
- NAC 8: 8th Nederlands Aardwetenschappelijk Congres (Duth Geosciences Congress), 24-25 April 2006, Veldhoven, The Netherlands. Invited oral presentation (Bijma)
- NAC 9: 9th Nederlands Aardwetenschappelijk Congres (Duth Geosciences Congress), 18-19 March 2008, Veldhoven, The Netherlands, as chair of the international advisory board.

Partner 2:

- EGU 2006, Vienna, Patrick Kathers, "Analysis of the Boron Isotope Ratio in foraminiferal Shells with resonant Laser-SNMS" (poster)
- SIMS Europe 2006, Münster, Guido Vering, J. München, C. Crone, H.F. Arlinghaus, "Influence of the Chemical Matrix on the Promary-Ion-Induced Emission of Atomic Boron and gadolinium Neutrals" (poster)
- SIMS XVI 2007, Kanazawa, Japan, H.F., Arlinghaus, "Possibilities and Limitations of High-Resolution Mass Spectrometry in Life Sciences" (invited talk)
- EGU 2008, Vienna, Heinrich F. Arlinghaus, "Novel mass spectrometry techniques for 2D and 3D elemental and molecular imaging" (invited talk)

Partner 3:

- NAC 8: 8th Nederlands Aardwetenschappelijk Congres (Duth Geosciences Congress), 24-25 April 2006, Veldhoven, The Netherlands. Poster: Calibrating benthic foraminiferal Mg incorporation through controlled culturing experiments.
- Biomineralization Workshop, Grenoble, France, October 2006, Poster: Microhabitat vs. ontogenetic effects on Mg incorporation in benthic foraminifera.
- European Geosciences Union, General Assembly, Vienna, Austria, April 2007, Poster: Effect of calcium carbonate saturation state on Mg incorporation in foraminiferal calcite.
- BEHEMOTH Cruise Meeting, June 2007, Angers, France. Presentation: Pore Water Chemistry of the Rhone Delta.
- NAC 9: 9th Nederlands Aardwetenschappelijk Congres (Duth Geosciences Congress), 18-19 March 2008, Veldhoven, The Netherlands. Poster: Effect of calcium carbonate saturation state on Mg incorporation in foraminiferal calcite.
- Derde bijeenkomst van Jonge Onderzoekers in de Paleobiologie (JOP) (Third meeting of Young Scientific Researchers in Paleobiology), 4 April 2008, Naturalis, Leiden, The Netherlands. Presentation: Foraminiferal Salinity Proxies.

Partner 4:

- Van der Meer, M., M. Baas, I. Rijpstra, G. Marino, E. Rohling, J. Sinninghe Damsté & S. Schouten. New proxies for paleosalinity based on stable hydrogen isotopic composition of algal biomarkers. Invited talk at Red Sea workshop, Tübingen, Germany, 25-26 October 2007.
- Van der Meer, M., M. Baas, I. Rijpstra, G. Marino, E. Rohling, J. Sinninghe Damsté & S. Schouten. New proxies for paleosalinity based on stable hydrogen isotopic composition of algal biomarkers. International Meeting on

Organic Geochemistry, Torquay, England, 9-14 September 2007.

- Schouten, S., J.W.H. Weijers, F. Peterse, M.T.J. van der Meer & J.S. Sinninghe Damsté. Development and application of novel organic proxies. Invited talk at Goldschmidt conference, Cologne, Germany, 20-24 August 2007.
- Van der Meer, M.T.J., M. Baas, W.I.C. Rijpstra, G. Marino, E. Rohling, F. Sangiorgi, H. Brinkhuis, J.S. Sinninghe Damsté & S. Schouten. New proxy for paleosalinity based on the stable hydrogen isotopic composition of C37 alkenones. ACS Fall Meeting, Boston, USA, 19-23 August 2007.
- Van der Meer, M.T.J., M. Baas, W.I.C. Rijpstra, G. Marino, E. Rohling, J.S. Sinninghe Damsté & S. Schouten. New proxy for paleosalinity based on the stable hydrogen isotopic composition of C37 alkenones. EGU General Assembly, Vienna, Austria, 15-20 April 2007.
- Van der Meer, M.T.J., S. Schouten, M. Baas, J. Bijma, I. Zondervan, A. Benthien & J. S. Sinninghe Damsté. Stable hydrogen isotopic composition of long chain alkenones: Biological controls and applications. Gordon Research Conference on Organic Geochemistry, Plymouth, New Hampshire, USA, 6-11 August 2006.

Partner 5:

2005

- De Ridder F., R. Pintelon, J. Schoukens, D. P. Gillikin, L. André, W. Baeyens, A. de Brauwere and F. Dehairs, Decoding Nonlinear Growth Rates in Annually Resolved Archives, EGU General Assembly, Vienna, April 2005.
- Gillikin D.P., F. Dehairs, D. Steenmans, A. Lorrain, L. André, J. Navez,W. Baeyens and the CALMARs group, Barium uptake into the shells of the common mussel (*Mytilus edulis*): results from a field and laboratory experiment, EGU General Assembly, Vienna, April 2005.
- Gillikin D.P., A. Lorrain, L. Meng, F. Dehairs, W. Baeyens, E. Keppens and the CALMARs group, Toward a mechanistic understanding of $\delta^{13}C$ in the aragonitic bivalve shells of *Mercenaria mercenaria,* EGU General Assembly, Vienna, April 2005.
- Meert I., D. P. Gillikin, F. Dehairs, A. Ervynck, B. Hillewaert, E. Keppens and the CALMARs group, Environmental conditions of the Belgian coastal area over the past millennium from *Mytilus edulis* shells: preliminary results, EGU General Assembly, Vienna, April 2005.

2006

- André L., H. Arlinghaus, J. Bijma, L. Chauvaud, F. Dehairs, J. Erez, F. Jorissen, G.-J. Reichart, S. Schouten, R. Zahn, Development, calibration and application of independent salinity proxies – PaleoSalt, EGU General Assembly, Vienna, April 2006.
- Bashar B., F. De Ridder, E. Keppens, C. Lazareth, Ph. Willenz, F. Dehairs, L. André and the CALMARS group, Stable Isotopes and Mg/Ca, Sr/Ca Ratios in a Sclerosponge Archive, EGU General Assembly, Vienna, April 2006.
- Bauwens M., Beelaerts V., De Ridder F., Dehairs F. and CALMARs group. 2006. 'Calcereous marine skeletons as recorders of global climate changes'. Paleosalt meeting, Grenoble, France.
- Bauwens M., V. Beerlaerts, F. De Ridder, F. Dehairs, CALMARs group, Calcareous marine skeletons as recorders of global climate changes, EGU General Assembly, Vienna, April 2006.
- Gillikin, D. P., A. Lorrain, S. Bouillon, P. Willenz, & F. Dehairs, 2006. Can the stable carbon isotopic composition of bivalve shells be used as a proxy of $\delta^{13}C$-DIC and provide an indication of estuarine salinity? *GSA Abstracts with Programs* 38(7): 378.
- Gillikin, D. P., A. Lorrain, & F. Dehairs, 2006. A large metabolic carbon contribution to the $\delta^{13}C$ record in marine aragonitic bivalve shells. *Eos Trans. AGU*, 87(52), Fall Meet. Suppl., Abstract PP13D-01
- Gillikin, D. P., I. Meert, & F. Dehairs, 2007. Reconstruction of environmental conditions at the Belgian coastal area over the past 700-800 years using *Mytilus edulis* shells. PAGES workshop: Stable-isotope ratios of shell middens: high-resolution palaeoclimatic and palaeoenvironmental archives. McMaster University, Canada (invited).

2007

- Beelaerts V., De Ridder F., Pintelon R., Schoukens J. and Dehairs F. 2007. 'Time Averaging in solid substrates'. 26th Benelux meeting on Systems and Control, Lommel, Belgium.
- Gillikin, D. P., & F. Dehairs, 2007. Assessing the reproducibility and potential of high resolution trace element profiles in an aragonitic bivalve (*Saxidomus giganteus*) for environmental reconstruction. *Geological Society of America, Abstracts with Programs* 39(1): 100.
- Poulain C., Y.M. Paulet, M. Benoît, F. Dehairs, E. Keppens and P. Claeys, Salinity effect on strontium and magnesium incorporation in clam, *Ruditapes philippinarum*, shells, EGU General Assembly, Vienna, April 2007.

2008

- Bauwens M., V. Beelaerts, F. Servaes, J. Schoukens and F. Dehairs, A non-linear multi-proxy approach for climate reconstruction based on archaeological shells, EGU General Assembly, Vienna, April 2008.

- Bauwens M., V. Beelaerts, K. Barbé, J. Schoukens and F. Dehairs, 2008, Climate reconstruction based on archaeological shells: a non-linear multi-proxy approach, 27th Benelux-meeting on systems and control, Heeze, The Netherlands.
- Beelaerts V., F. De Ridder, M. Bauwens and R. Pintelon, 2008, Identification of a harmonic signal in the presence of additive noise, an unknown timebase distortion, and an averaging effect, 27th Benelux-meeting on systems and control, Heeze, The Netherlands.
- Beelaerts V., De Ridder F., Schmitz N., Bauwens M., Pintelon R., 2008. Identification of a harmonic signal in the presence of additive noise, an unknown time base distortion, and an averaging effect' IMTC, Victoria, Canada.
- Gillikin D.P., A. Lorrain, Y.-M. Paulet, L. André and F. Dehairs, Barium/calcium profiles of calcite and aragonite marine bivalve shells as an environmental proxy, EGU General Assembly, Vienna, April 2008.
- Mas R., Poulain C., Dehairs F., Claeys P. and Keppens E., Stable isotope (C, N) composition of bivalve shell organic matter and salinity, EGU General Assembly, Vienna, April 2008.
- Poulain C., Y.-M. Paulet, L. Chauvaud, C. Bassoulet, K. Pichavant, R. Mas, M. Richard, M. Bohn and A. Lorrain, High frequency variability of clam (*Ruditapes philippinarum*) fluids and shell composition in the Auray River 2008, Physiomar 08, International meeting, Brest, France, September 1-4 2008.
- Servaes F., Bauwens M., Dubois P. and Dehairs F. Proxy incorporation by *Mytilus edulis*: a field survey and *in situ* calibration, EGU General Assembly, Vienna, April 2008.

Partner 6:

- F. Planchon, D. Cardinal, C. Borremans, J. Hermans, P. Dubois and L. André. Mg isotopes fractionation processes in marine calcareous skeletons: methodology developments and preliminary results on echinoderms (sea urchin and starfish), EGU General Assembly, Vienna, Austria, 15-20 April 2007.
- F. Planchon, J. Hermans, C. Borremans, Ph. Dubois, C. Poulain, Y.-M. Paulet, and L. André. Mg isotopes in biocarbonates : new insight into vital effects associated to echinoderms and bivalves calcification. AGU Fall meeting, San Francisco, United-States, December 10-14, 2007.

Partner 7:

- Barras, C., Geslin, E., Duplessy, J.-C., Michel, E. and Jorissen, F., 2006. Reproduction and growth of deep-sea benthic foraminifera: A laboratory study, TMS's Meeting: "Biology and Palaeobiology of Foraminifera and Coccolithophores", Liverpool, UK.
- Barras, C., Geslin, E., Duplessy, J.-C., Michel, E. and Jorissen, F., 2006. Reproduction and growth of deep-sea benthic foraminifera: A laboratory study, ESRF Workshop "Environmental Proxies: From Inorganic Precipitation to Biocrystallisation", Grenoble, France.
- Barras, C., Geslin, E., Gaultier, M., Duplessy, J.-C. and Jorissen, F., 2007. Calcification of the deep-sea benthic foraminifer Bulimina marginata under different laboratory conditions, Terra Nostra: The Oceans in the Earth System, Bremen, Germany, pp. 39. **1st price for the best poster of the congress.**
- Geslin, E., Barras, C., Pucci, F., Leori, E., Duplessy, J.C., Michel, E., Reichart, G.J., Morigi, C., Negri, A. and Jorissen, J., 2006. Laboratory studies on benthic foraminiferal ecology and geochemistry, FORAMS 2006, Natal, Brazil.

Partner 8:

- Poulain C., Y-M. Paulet, M. Benoit, F. Dehairs, E. Keppens and P. Claeys. Salinity effect on strontium and magnesium incorporation in clam, *Ruditapes philippinarum*, shells. European Geosciences Union (EGU), Vienne, Autriche, 15-20 avril 2007.
- Poulain C., Y-M. Paulet, C. Paillard, E. Morize and H. De Pontual. Sclerochronology study on *Ruditapes philippinarum* shell. First International Sclerochronology Conference, St. Petersburg, Florida, USA, 17-21 juillet 2007.
- Planchon F., J. Hermans, C. Borremans, P. Dubois, C. Poulain, Y-M. Paulet and L. André. Magnesium isotopic fractionation in biocarbonates: new insight into vital effects associated to echinoderms and bivalves calcification. AGU Fall meeting, San Francisco, CA, USA, 11-14 décembre 2007.
- Poulain C., Y-M. Paulet, L. Chauvaud, C. Bassoulet, K. Pichavant, F. Dehairs and A. Lorrain. High frequency variability of *Ruditapes philippinarum* fluids and shell composition in the Auray River. European Geosciences Union (EGU), Vienne, Autriche, 14-19 avril 2008 (poster).
- Bauwens M., C. Poulain, V. Beelaerts, F. Servaes, J. Shoukens and F. Dehairs. A non-linear multi-proxy approach

for climate reconstruction based on archaeological shells. European Geosciences Union (EGU), Vienne, Autriche, 14-19 avril 2008 (poster).

- MAS R., C. Poulain, P. Claeys, F. Dehairs and E. Keppens. Stable isotope (C, N) composition of bivalve shell organic matter and salinity. European Geosciences Union (EGU), Vienne, Autriche, 14-19 avril 2008 (poster).
- Poulain C., Y.-M. Paulet, L. Chauvaud, C. Bassoulet, K. Pichavant, R. Mas, M. Richard, M. Bohn and A. Lorrain. High frequency variability of clam (*Ruditapes philippinarum*) fluids and shell composition in the Auray River. Physiomar 08, International meeting, Brest, France, September 1-4 2008 (poster).

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Partner 1:

1) Delphine Dissard. Dipl. Biol. Start: October 2004, end: January 2009, PhD: not yet

2) Régine da Rocha. Dipl. Biol. Start: April 2004, end: Nov. 2008, PhD: not yet

Partner 2:

1) Patrick Kathers, Dipl.-Phys., start: April 2006, end: Juni 2009, PhD: not yet

2) Guido Vering, Dipl.-Phys., start: Oct. 2006, end: March 2008, PhD defense: October 2008 (TITLE: Entwicklung einer Methodik zur Charakterisierung der Zusammensetzung des ionenbeschussinduzierten Sekundärteilchenflusses durch Vergleich der Ausbeuteanteile photoinduzierter Ionenbildungsprozesse)

3) Jan München, Dipl.-Phys., start: Jan 2009, end: June 2009, PhD: not yet

4) Thomas Rietmann, Dipl. Phys., start: Jan 2009, end: June 2009, PhD: not yet

Partner 3:

1) Dueñas-Bohórquez, Dipl. Biol. Start: August 1, 2005, end: July 2009, PhD: not yet

Partner 4:

1) Dr. Marcel van der Meer, Postdoc, Start: 1-2-2006, End: 31-1-2009

Partner 5:
No personnel was funded directly via PaleoSalt. However, other complementary funding provided scholarships for 3 PhD students:

PhD Theses in progress:
1) Mas Remy, Deuterium analysis of bivalve shell organic matter (work in progress)
2) Maité Bauwens, Black-box en white-box models for the reconstruction of paleo-environments using bivalve shells (work in progress)
3) Beelaerts Veerle, The elimination of systematical averaging-errors in measurements of proxy records (work in progress)

Partner 6:
No personnel was funded directly via PaleoSalt. However, other complementary funding provided a post-doc contract:
1) Post-Doc: F. Planchon : Development and application of Mg isotopic systematic to biocarbonates.

Partner 7:
Mrs. Christine Barras – development of experimental protocols for deep-sea foraminifera. Thesis: Paleoceanographical proxies based on cultured eep sea foraminifera under controlled conditions ; calibration of $\delta^{18}O$ in function of temperature. Thesis defence on November 14, 2008.

Via other sources of funding:

1) Dr. Eduardo Leorri (postdoc, January – December 2007) -- study of benthic foraminiferal ecology in the stuarine environments of Auray River (Golfe de Morbihan)
2) Dr. Paula Diz-Ferreiro (postdoc, January – December 2008) -- study of benthic foraminiferal ecology in the stuarine environments of Auary River (Golfe de Morbihan)

Partner 8:

There was no financial support from CNRS in the framework of EUROCLIMATE.

1) Céline Poulain obtained a PhD fellowship for 3 years from the research Ministery. 3x33k€)

Dynamic European climate-vegetation impacts and interactions (DECVEG)

Abstract

Understanding and predicting regional transient terrestrial vegetation responses and feedbacks to climate change are challenges that require development of both models and datasets. Eight research groups will use and improve both dynamic vegetation models (DVMs) and palaeovegetation data in order to study climate-vegetation interactions in Europe. Existing and new general circulation model (GCM) output, inverse modelling of palaeovegetation data, transfer functions and the analogue approach will be used to generate independent sets of palaeoclimatic reconstructions. DVMs will be driven by GCM palaeoclimatic data, and their output compared with palaeoecological datasets. Performance of four DVMs will be compared in both inverse and normal mode. This parallel use of methods, data and models will permit assessment of the robustness of the palaeoclimate and palaeovegetation reconstructions and help identify where further model development is needed. A new series of coupled GCM-DVM simulations will be made. A central aim is to maximise the value of European palaeovegetation datasets in palaeoclimate research. Using DVMs to explore past scenarios will contribute to model development and make them into more effective tools for predicting future ecosystem responses with regard to vegetation diversity, migrational response to climate change, alterations in carbon cycle and hydrology.

Partners

(AKA, CNRS, DFG, FNRS, FNU, VR)

Richard Bradshaw (project leader)
Geological Survey of Denmark & Greenland, Copenhagen, DK

Martin T. Sykes
University of Lund, Lund, SE

Joël Guiot
CEREGE, Aix-en-Provence, FR

Rachid Cheddadi
Université Montpellier II, Montpellier, FR

Thomas Litt
Universität Bonn, Bonn, DE

Sheila Hicks
University of Oulu, Oulu, FI

Louis François
Université de Liège, Liège, BE

Collaborative Research Project (CRP)
1. General information
Project Reference Number : : **04-ECLIM-FP04** Acronym / Short Title: DECVEG Full Title: Dynamic European Climate-Vegetation Impacts and Interactions Project Leader name: Richard H.W. Bradshaw Project Leader affiliation: Geological Survey of Denmark and Greenland (GEUS) Institutional home page (URL): www.geus.dk Project-related home page (URL): http://www.geus.dk/departments/quaternary-marine-geol/research-themes/decveg-uk.htm Reporting period: 20/06/2005 to 30/09/2008
2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)
IP 1
Principal Investigator (name & affiliation): Martin T. Sykes, Lund University, Sweden
Total Funding amount of the IP : €223630
IP2
Principal Investigator (name & affiliation): Joel Guiot, CEREGE CNRS, France
Total Funding amount of the IP : €96000
IP3
Principal Investigator (name & affiliation): Rachid Cheddadi, Université Montpellier, France
Total Funding amount of the IP: €18000
IP4
Principal Investigator (name & affiliation): Thomas Litt, University of Bonn, Germany
Total Funding amount of the IP : €144000
IP5
Principal Investigator (name & affiliation): Sheila Hicks, University of Oulu, Finland
Total Funding amount of the IP : €142340
IP6
Principal Investigator (name & affiliation): Louis Francois, Université de Liège, Belgium
Total Funding amount of the IP : €220740
IP7
Principal Investigator (name & affiliation): Richard Bradshaw, GEUS, Denmark
Total Funding amount of the IP : €238520

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

DECVEG brought together dynamic vegetation modellers and palaeovegetation data specialists for the first time and the significant achievements included: 1) new palaeoclimatic estimates derived from palaeovegetation data 2) improvements to the vegetation models and palaeoecological databases 3) new insights into the climatic control of vegetation dynamics.

Palaeoclimatic estimation

New palaeoclimatic estimates were derived in three different ways within DECVEG. The most novel and scientifically valuable estimates were obtained from inverting the vegetation models and identifying the combinations of climatic variables that were most likely to have generated the palynologically observed palaeovegetation (Garretta et al. submitted; Haibin et al. 2007). Inverse modeling tended to reconstruct less-cold winters and less-dry climates than earlier statistical methods for the Last Glacial Maximum (LGM). These reconsructions are consistent with other evidence e.g. the absence of an ice cap on northern Eurasia at the LGM because of the lack of precipitation in winter or/and warm summers (Peltier 1994). Temperature and precipitation reconstructions for the entire Holocene based on model inversion using data from Meerfelder Maar, Germany generated new full Holocene palaeotemperature estimates with high internal accuracy.

The second approach to palaeoclimatic reconstruction was to make data-model comparisons in which vegetation models were driven by palaeoclimatic simulations generated in turn by general circulation models (GCMs). Initially equilibrium situations were analysed. Satisfactory data-model comparisons were obtained for the European distribution of *Pinus sylvestris* at the LGM using the CARAIB vegetation model (Cheddadi et al. 2006). This comparison combined evidence from both pollen and plant macrofossil data, which was one aim of DECVEG. In contrast a data-model mismatch was found for European *Fagus* distribution at 6000 years ago (Giesecke et al. 2007). This study was nevertheless an important milestone for data-model comparisons using the past as well as a warning of the pitfalls and potential shortcomings when making future projections. In this case inadequacies were identified in the generalised palaeoclimatic data input to the model and the insensitivity of the pollen data to small, dispersed populations of *Fagus* trees that had established early in the Holocene.

From the work with equilibrium vegetation models, which assume that a vegetation type develops to a climax state, we moved to models that are capable of simulating the vegetation as a function of plant physiological processes in a dynamic system. Data-model comparisons using this type of vegetation model and simulated climatic trends for the last 10000 years showed that much of the past vegetation dynamics in Scandinavia can be explained by general changes in Holocene climate (Miller et al. 2008). Nevertheless all data-model comparisons showed that we still can not fully explain the past species dynamics of important tree species like *Fagus sylvatica* and *Picea abies*. This is especially problematic as these species are of high economic importance and continued efforts are therefore made to improve our ability to model them as well as to improve our understanding of their past dynamics.

Finally palaeoclimatic reconstructions were derived using a refined transfer function approach that describes the climate space occupied by different taxa in probability density functions and can thus be applied to presence/absence information of species derived from both pollen and macrofossil data (Kuhl et al. 2008). Other efforts went into an attempt to reconstruct past changes in continentality in Scandinavia (Giesecke et al. 2008).

Model and data improvements

DECVEG scientists guided the management of the European Pollen Database during the course of the project and helped alter its structure to lay the framework for its long-term development. This was necessary to improve access to the appropriate datasets for the data-model comparisons. Important progress was made in model validation through

the acquisition and development of datasets describing modern vegetation. Modern pollen-trapping datasets were developed and the relationship between pollen accumulation rates and plant biomass was investigated (Giesecke et al. 2007; Giesecke and Fontana 2008; Seppä et al. 2008). A major European pollen surface sample dataset was acquired and is being brought into the public domain. The dynamic vegetation model LPJ-GUESS was developed to output biomass of major species rather than of plant functional types, permitting more sophisticated comparison with pollen accumulation rate data. Significant changes were made to the type of climatic data used to drive the vegetation models, described in the next section.

The climatic control of vegetation dynamics

For the full Holocene data-model comparisons, LPJ-GUESS was driven by long-term climatic trends output from a simplified GCM run at time-slices of 1000 year intervals. Several aspects of vegetation dynamics at the northern limits of trees in Scandinavia were captured by the model runs, but sensitivity studies showed that interannual climatic variability had as much effect on model output as did long-term averages (Miller et al. 2008). One suitable proxy for past interannual temperature variability was shown to be varved lake sediments, particularly those where summer and winter sediment deposition can be separated. Winter temperature has only a partial influence on the thickness of the minerogenic varve component, but its variability may be in tune with the other components of the climate system that control the amount of erosion. The thickness of the organic layer on the other hand seems to be directly related to mid-summer temperature as it represents the temperature limitation on within lake biological productivity (Ojala et al. 2008). These results have important implications for climate reconstructions from biological proxy data, which are generally aimed at reconstructing mean conditions using the modern relationship between mean climate and the abundance of the organism. Projections of future or past plant distributions using statistical vegetation models are also potentially erroneous, yet are widely used. Dynamic vegetation models are better suited to take account of changes in inter-annual variability but require further improvement to capture the processes at species limits more realistically.

Non-DECVEG reference

Peltier WR (1994) Ice age paleotopography. Science 265, 195–201.

4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

The original proposal included a Bulgarian data partner who did not obtain national funding. The French partners' budgets were severely reduced and the German and Belgian partners' budgets were delayed for a year compared with the three Scandinavian budgets. As a consequence the research focus shifted to Scandinavia with limited pan-European cover and a removal of the idea of a Balkan research area to compare with the Scandinavian focus area. Despite these extraordinary administrative complications, most of the proposal aims were fulfilled. Task 8 (driving the vegetation models with pollen-derived palaeoclimate) was judged to be unnecessary as it overlapped with the very successful task 4 (inverse modelling). Task 9 focussed on the models LPJ-GUESS and CARAIB as the models IBIS and ORCHIDEE proved to be unsuitable for the project applications. The GCM output in task 6 was to have been provided by an underfunded French partner, but their role was effectively replaced by collaboration with Prof. Valdes' group at University of Bristol. Prof. Valdes gave us access to relevant GCM output and provided considerable support without funding from DECVEG. His group was supported by the UK QUEST initiative and we were glad to initiate this useful EUROCLIMATE-QUEST collaboration.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

Each partner is continuing with related research using national funds.

Bradshaw (PI) has recently gained funding approval for an ERA-net called FIREMAN within the BIODIVERSA programme. This will build on DECVEG by examining the role of burning as a driver of vegetation change. We will advise on fire management and control in Europe, particularly as a consequence of altered fire risk associated with climatic change.

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Climate change and its consequences for vegetation remain a top research priorities in Europe although the emphasis is shifting towards mitigation of impacts and adaptation issues. EUROCLIMATE was an unusual research programme because so few climate modellers were involved; DECVEG being one of the exceptions. The final meeting illustrated the value of data-model comparisons and this approach could be a useful future theme for research as it embraces both the modelling and data communities.

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

There are clear advantages in European research collaboration and an avoidance of overlapping effort among member states. DECVEG benefited by comparing the Swedish, French and Belgian approaches to climate-driven vegetation modelling that had largely developed independently of each other. The European dimension to the programme justified the major efforts in the management of the European Pollen Database which is developing into an important resource for palaeoclimatic research.

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

EUROCORES projects are an ideal size for effective international research and fill the gap created by the EU move to mega-projects. Apart from the severe problem of co-ordinating the national agencies, the research administration is lean and effective – far more desirable from a researcher's viewpoint than clumsy (but politically expedient) EU administration. The extra networking money (now lost) gave good opportunities for external collaboration. Internal collaboration (within EUROCLIMATE) was less relevant given the wide range of research topics covered.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Cheddadi, R., Vendramin, G.G., Litt, T., Francois, L., Kageyama, M., Lorentz, S., Laurent, J-M., de Beaulieu, J-L., Sadori, L. & Lunt, D. (2006). Imprints of glacial refugia in the modern genetic diversity of Pinus sylvestris. Global Ecology and Biogeography 15, 271-282.

Garreta, V., Miller, P.A., Guiot, J., Hely, C., Brewer, S., Sykes, M.T. & Litt, T. (submitted). Holocene climate and vegetation dynamics reconstructed through inversion of a dynamic model using pollen data. Quaternary Science Reviews.

Giesecke, T., Hickler, T., Kunkel, T., Sykes, M.T. & Bradshaw, R.H.W. (2007). Towards an understanding of the Holocene distribution of Fagus sylvatica L. Journal of Biogeography 34, 118-131.

Laurent, J-M., Francois, L., Bar-Hen, A. & Cheddadi, R. (2007). European bioclimatic affinity groups: data-model comparisons. Global and Planetary Change 61, 28-40.

Miller, P.A., Giesecke, T., Hickler, T., Bradshaw, R.H.W., Smith, B., Seppä, H., Valdes, P.J. & Sykes, M.T. (2008). Exploring climatic and biotic controls on Holocene vegetation change in Fennoscandia. Journal of Ecology 96, 247-259.

Seppä, H., Alenius, T., Muukkonen, P., Giesecke, T., Miller, P.A., Ojala, A.E.K., Calibrated pollen accumulation rates as a basis for quantitative tree biomass reconstructions, The Holocene, submitted (2008).

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Bradshaw, R.H.W. (2008). Detecting human-impact in the pollen record using data-model comparison. Vegetation History and Archaeobotany 17, 597-603.

Brewer, S., Guiot, J. & Torre, F. (2007). Mid-Holocene climate change in Europe: a data-model comparison. Climate of the Past 3, 499-512.

Gebhardt, C., Kuhl, N., Hense, A. & Litt, T. (2007). Reconstruction of Quaternary temperature fields by dynamically consistent smoothing. Climate Dynamics 30, 421-437.

Giesecke, T., Bjune, A.E., Chiverrell, R.C., Seppa, H., Ojala, A.E.K. & Birks, H.J.B. (2008). Exploring Holocene continentality changes in Fennoscandia using present and past tree distributuions. Quaternary Science Reviews 27, 1296-1308.

Giesecke, T. and Fontana, S. (2008). Revisiting pollen accumulation rate estimates from lake sediments. Holocene18, 293–304.

Giesecke, T., Fontana, S.L., Møller, P.F., Bradshaw R.H.W. & Stavngaard, B. (2007). Interannual flowering variability and stand scale dynamics monitored by pollen traps below the canopy. PMP international workshop proceedings. Jūrmala, Latvia 2007.

Haibin, W., Guiot, J., Brewer, S., & Zhengtang, G. (2007). Climatic changes in Eurasia and Africa at the last glacial maximum and mid-Holocene: reconstruction from pollen data using inverse vegetation modelling. *Climate Dynamics*

29, 211-229.

Kuhl, N., Gebhardt, F., Kaspar, F., Hense, A. & Litt, T. (2008). Reconstruction of Quaternary temperature fields and model-data comparison. PAGES News 16, 8-9.

Ojala, A.E.K., Alenius, T., Seppä, H. & Giesecke, T. (2008). Integrating the clastic-organic varve record from Finland with a pollen-based temperature reconstruction to resolve the Holocene seasonal temperature patterns at high latitudes. Holocene 18, 529-538.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

None

1 D. Patents and industry collaborations

None

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

Palaeo-databases: their role in modelling and reconstructing palaeoclimate and understanding palaeoenvironments

Arbois, Aix-en-Provence, France, 7-12 May 2007

1 F. Participation in other conferences

Please list only the most relevant

EGU Vienna 2006, 2007, 2008.

INQUA Cairns, 2007.

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Giesecke, T.	Post-doc, Denmark	4/2005-3/2008
Miller, P.	Post-doc, Sweden	6/2005-5/2008
Garreta,V.	Ph.D., France	5/2006- (still in progress)
Simonis, D.	Ph.D., Germany	5/2006- (still in progress)
Lisitsyna, O.	Ph.D., Finland	10/2005- (still in progress, maternity leave)
Brewer, S.	Post-doc, Belgium	10/2007-9/2008
Laurent, J-M.	Post-doc, Belgium	10/2006-9/2007

Evaluation of the Ca isotope system (d44Ca) in carbonate polymorphs as a new proxy for seawater temperature and secular variations of Ca concentration and fractionation throughout Earth history (CASIOPEIA)

Abstract

We propose the investigation of the thermodynamic and paleo-oceanographic principles of calcium (Ca) isotope fractionation (d44Ca) during biomineralization and inorganic precipitation of calcium carbonate (CaCO3). This is important because recent findings indicate that the Ca isotope system represents a new proxy for the reconstruction of past seawater temperatures and for variations of the Ca seawater concentrations throughout Earth's history. Both aspects are crucial for paleooceanography and -climatology because they interfere with the global carbon cycle influencing the concentration of important greenhouse gases like CO2 throughout time. The concept to validate the Ca isotopes as a paleo-proxy is to test its sensitivity to temperature calibration, the preservation of primary isotope signals, the knowledge of inter-specific differences and of past initial isotope ratios. These requirements will be investigated in laboratory and culturing experiments on inorganically precipitated CaCO3 and on major groups of marine calcifying organisms previously used as proxy archives (foraminifera, bivalves, coccolithophorids). The proposed experimental cross-calibration of the Ca isotope system to temperature sensitive metal to calcium ratios (Mg/Ca, Sr/Ca, Ba/Ca, etc.) and other isotope systems (d18O, d11B, d25Mg, etc.) will be completed by field and down-core experiments offering the unique opportunity to refine their application as paleo-proxies in a multi-proxy approach.

Partners

(DFG, FNU, FWF, NWO)

Anton Eisenhauer (project leader)
Kiel University, Kiel, DE

Adrian Immenhauser
Vrije Universiteit, Amsterdam, NL

Martin Dietzel
Graz University of Technology, Graz, AT

Dirk Frei
Danmarks Og Grönlands Geologiske Undersogelse, Kobenhagen, DK

Collaborative Research Project (CRP)

1. General information

Project Reference Number : **04-ECLIM-FP08**
Acronym / Short Title: **CASIOPEIA**

Full Title: **Evaluation of the Ca Isotope System ($d^{44}Ca$) in Carbonate Polymorphs as a new Proxy for Seawater Temperature and Secular Variations of Ca Concentration and Fractionation throughout Earth History**

Project Leader name: **Anton Eisenhauer**
Project Leader affiliation: **Leibniz-Institut für Meeresforschung, IFM-GEOMAR, Wischhofstr. 1-3, 24148 Kiel, Germany**

Institutional home page (URL): www.ifm-geomar.de
Project-related home page (URL): www.ifm-geomar.de/Casiopeia
Reporting period: 20/06/2005 to 30/09/2008

2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)

IP 1

Principal Investigator (name & affiliation): Anton Eisenhauer, Prof. Dr.
Leibniz-Institut für Meeresforschung, IFM-GEOMAR, Wischhofstr. 1-3, 24148 Kiel, Germany

Total Funding amount of the IP: **401.000.- €**

IP2

Principal Investigator (name & affiliation): Adrian Immenhauser, Prof. Dr.
Vrije Universiteit Amsterdam, Faculty of Earth and Life Sciences, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands. Now: Ruhr-Universität Bochum, Institut for Geologie, Mineralogie and Geophysik, Universitätsstras 150, D-44801 Bochum, Germany

Total Funding amount of the IP : **199.907.- €**

IP3

Principal Investigator (name & affiliation): Martin Dietzel, Prof. Dr.
Institute of Applied Geosciences, Graz University of Technology, Rechbauerstraße 12, 8010 Graz, Austria

Total Funding amount of the IP: **213.728.-€**

IP4

Principal Investigator (name & affiliation): Dirk Frei, Dr.
Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10,
1350 Copenhagen K, Denmark

Total Funding amount of the IP : **174.496,- €**

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:

- new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

1. Eisenhauer Group, Kiel, Germany

(1) Measurement of Mg/Ca ratios on the cultured foraminifera show a strong dependency on salinity and pH. These results are very important for paleoceanographic applications and are now used for salinity and temperature calibrations (see Kisakürek et al., 2008).

(2) Measurement of Ca isotope variations in cultured and free living *A. Islandica* show that they are almost independent on the outside seawater conditions and may hardly be applied as environmental indicators in this archive (see Heinemann et al., 2008).

(3) We could show that Ca-isotope fractionation in *N. Pachyderma* and *G. Sacculifer* can be applied as a paleo-temperature proxy (see Hippler et al., 2007 and Hippler et al. 2006).

(4) The first time ever we could provide a Ca-isotope time-series for the Phanerocoic (see Farkas et al., 2007).

(5) We could decipher Ca-pathways from the seawater to the site of calcification in coccolithophores and corals (Gussone et al., 2006, Langer et al., 2006, Böhm et al., 2006).

(6) First time we could show that there is Sr-isotope fractionation (see Fietzke and Eisenhauer, 2006).

2. Immenhauser Group, Amsterdam, The Netherlands (now: Bochum, Germany)

(1) Growth pattern analyses reveal that growth season and rates are species-dependent. Bivalve shell growth seems to be mainly triggered by food availability. However, also seawater temperature seems to play an important role. Growth stops are prominent and their detection permit an improved time-assignment in (sub-) fossil shells.

(2) Seasonal trends in water chemistry ($\delta^{18}O$, major and trace elements) are related to seasonal trends in salinity. This observation is important, in order to assess whether other factors than seawater chemistry are recorded in the shells.

(3) The oxygen isotope composition of shell calcite and aragonite of M. edulis and A. islandica is likely in isotopic equilibrium with ambient seawater. Thus, we reconfirm that the analysis of oxygen isotope ratios in calibrated bivalve species provides a promising tool for reliable temperature reconstructions.

(4) To date, the study of trace element composition has focused on Mg/Ca-ratios in *M. edulis*. Recent findings indicate that seasonal temperature changes are recorded in the calcite shell layer of *M. edulis* shells. Thus, Mg/Ca can be likely applied as temperature proxy. Studying Mg/Ca-ratios in the youngest shell portion, a strong ontogeny effect has been found, independent of external environmental factors.

3. Dietzel Group, Graz, Austria

(1) A CO_2 diffusion technique was developed and refined to precipitate calcium carbonate minerals at well defined physico-chemical conditions. Refinements were especially done with respect to reproducible experimental conditions as well as to solid and liquid analyses. A great advantage is that this technique can be applied to study the nucleation and precipitation behaviour of carbonate minerals in general (see Bucca et al., 2008).

(2) Experimental results showed that Sr incorporation into calcite is a function of temperature. The significance of this work is that we provided a valid theoretical concept to elucidate mechanisms and kinetics of Sr incorporation into calcite. This is critical as Sr is widely used as a proxy to reconstruct paleo-environments (see Tang et al., 2008a).

(3) For the first time, robust experimental data were presented from our experiments to document a highly significant linear relationship between Ca isotope fractionation and Sr incorporation into calcite. In analogy to Sr incorporation into calcite, a new mechanism to interpret Ca isotope fractionation during inorganic calcite formation was presented (see Tang et al., 2008b)

(4) Stable oxygen isotopic fractionation between calcite and water is used as well-known proxy for seawater temperature in paleoceanography. However, it was not clear whether oxygen isotopic fractionation for inorganically formed calcite is rate-controlled. Based on our experiments we verified a rate-dependence of stable oxygen isotopic fractionation and provided a more reliable "equilibrium" temperature equation of oxygen isotopic fractionation

between calcite and water (Tang et al, 2008c).

4. Frei Group, Copenhagen, Denmark

(1) We have established the first robust experimentally derived dataset describing the variation of Mg/Ca ratios and trace elements concentrations in the alternating calcite and aragonite layers of the bivalves *Mytilus edulis* and *Arctica islandica*, respectively. The data was obtained with very high spatial (and hence temporal) resolution using laser ablation techniques. Monitoring of environmental parameters (e.g., temperature, salinity, chlorophyll-a concentration, and seawater chemistry) during shell growth allow to make tight constraints on the use of shell chemistry as environmental proxies. Shell growth rates obtained in the study are comparable to those found for undisturbed *M. edulis* in natural environments.

(2) The observed variations of the Mg/Ca ratio of the calcite layer in *M. edulis* shells as a function of environmental parameters indicate its potential as a seawater temperature proxy. Although parameters like growth rate and food availability are highly correlated to temperature (and are, based on our dataset, impossible to deconvolute from temperature), the influence of Mg/Ca ratios on temperature is nevertheless highly significant and allowed formulation of an equation that relates shell chemistry of *M. edulis* to seawater temperature. No dependence of seawater chemistry (e.g., salinity or trace metal content) on the Mg/Ca ration in the calcite layer in *M. edulis* shells was found.

(3) The experimentally established relationship between Mg/Ca ratios in *M. Edulis* shells and temperature was appplied to *M. Edulis* shells collected at sites where a high precision long-term monitoring of seawater temperatures exists. The results indicate the validity of the established relationship for the reconstruction of seawater temperatures.

(4) A marked difference between the Mg/Ca ratios of the shell material deposited right after settlement and metamorphosis of the young individuals and the shell material deposited after the first few months of life point to a strong ontogenetic effect on Mg/Ca ratios of *M. Edulis* shells.

(5) The observed variation of the Mg/Ca ratio in the cultivated aragonite shells of *A. islandica* suggest that there is no significant influence of temperature on the Mg/Ca ratios. However, observed variations in Pb concentrations of *A. islandica* shells suggest their potential use as a proxy for Pb seawater concentrations.

4. What did you not achieve in the CRP and why? (max 1 p.)
Please use the original proposal as reference and explain any deviations from the work plan

1. Eisenhauer Group, Kiel, Germany
Our study closely followed the work plan

2. Immenhauser, AmsterdamNetherlands (now: Bochum, Germany)
Our study closely followed the work plan

3. Dietzel Group, Graz, Austria
Throughout the experimental work we focussed on the precipitation of calcite as we found new relationships with respect to element and isotopic fractionation. Subsequently, we rather developed a suitable model to interpret our results than to expand our experiment to the formation of aragonite and various chemical compositions of the solution, like changes in salinity. However, we already have carried out several experiments with respect to aragonite and vaterite formation as well as with respect to NaCl- and $MgCl_2$-rich solutions. Results of ongoing experiments are promising and will be published as soon as possible.

4. Frei Group, Copenhagen, Denmark
One specific aim of our project was to use the experimental data to test the validity of recently developed thermodynamic models describing mineral-fluid partitioning of trace elements. It was anticipated that this could potentially lead to the formulation of thermodynamic expressions that allow the prediction of trace element partitiong behaviour between biogenic and abiogenic calcite/aragonite and seawater. This approach proved to be

unsuccessful because (a) critical input parameters (e.g., cation radii and interatomic potentials to represent the non-Coulombic interactions between ions in fluids) necessary for modelling and atomistic simulations are currently not determined with sufficient reliability; and (b) the lack of suitable techniques for sampling minute amounts of bodyfluids (e.g., hemolymph from *Mytilus edulis*) for subsequent trace element analysis, leading to insufficient datasets for modelling. Moreover, it proved to be disadvantageous that the Copenhagen group, that was heavily relying on experimental data to be produced by the other groups, started well ahead of the other groups (e.g., one year ahead of the Kiel group), thereby heavily inhibiting the interactions between groups necessary for a successful approach to modelling.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

- CASIOPEIA became the impetus for a series of running and planned future activities. Within FP7 the Immenhauser, Dietzel and Eisenhauer Group are now part of a Marie Curie Training program "CALMARO" which was launched in Oct´2008.
- Furthermore the former CASIOPEIA partners are currently preparing a proposal for a scientific working group together using element and isotopic signatures of calcium carbonates as archives for primary environmental conditions and secondary changes (DFG, Germany).
- Inspired by the CASIOPEIA study the Dietzel group now contributed ideas to a project funded by the Competence Network "Water" (BMFT, Austria) dealing with sinter formation in drainage systems.
- Concerning former CASIOPEIA staff Dr. D. Hippler has sent a proposal to NWO MEERVOUD for review.
- Prof. A. Immenhauser has sent a proposal to the German HBFG for review.
- As a direct offspring from CASIOPEIA, the Copenhagen group has submitted proposals to DANCEA and to the Commission for Scientific Research in Greenland for review.

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)
Recommendations of this kind will be launced elsewhere!

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCLIMATE Programme

- A large added value of being part of the EUROCLIMATE program was the interaction of scientists from various European countries within the project.

- Furthermore, the various workshops held where world class experts were invited provided a lot of inspiration for our experiments and projects.

- The direct visibility of our research was greatly enhanced.

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

- Unfortunately, due to national discrepancies and administrative quarrels on the European level there was no simultaneous start of the project. The Danish partner (D. Frei, Copenhagen, Denmark) started first whereas the coordinator project (Eisenhauer, Kiel, Germany) started almost one year later. Thus, in some part hiring and interaction of scientists was not ideal.
- In the beginning ESF hold out a prospect for a second round and additional three years of the EUROCLIMATE project. However, already after the project started we were told that there is no second round.
- Unfortunately, the program manager changed three times throughout the project. The lag of continuity on administration caused various problems in organizing meetings and day-by-day management of the project.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Tang, J., Dietzel M., Köhler S. J., Böhm F., and **Eisenhauer A**. (2008) Sr^{2+}/Ca^{2+} and $^{44}Ca/^{40}Ca$ fractionation during inorganic calcite formation: II. Ca isotopes as an environmental proxy. *GCA* 72, 3733-3745.

Hippler D., Kozdon R., Darling K. F., **Eisenhauer A**., and Nägler T. F. (2007) Calcium isotopic composition of high-latitude proxy carrier Neogloboquadrina pachyderma (sin.),. *Biogeosciences Discussions* **4**, 3301-3330.

Gussone, N., F. Böhm, **A. Eisenhauer**, **M. Dietzel**, A. Heuser, B.M.A.Teichert, J. Reitner, G. Wörheide, W.-Chr. Dullo, (2005) Calcium Isotope Fractionation in Calcite and Aragonite, *Geochim Cosmochim Acta*, 69, 18, 4485–4494.

Hippler D., Kozdon R., Darling K. F., **Eisenhauer A**., and Nägler T. F. (2007) Calcium isotopic composition of high-latitude proxy carrier Neogloboquadrina pachyderma (sin.),. *Biogeosciences Discussions* **4**, 3301-3330.

Klünder M.H., **Hippler D.**, Witbaard R., and **Frei D.** (2008): Laser ablation analysis of bivalve shells – archives of environmental information. *Geological Survey of Denmark and Greenland Bulletin* **15**, 89-92.

Klünder M.H., **Hippler D.**, **Frei D.**, Witbaard R., **Immenhauser A.** and **Eisenhauer A.**: An aquaculture field-based study of environmental and biological controls on the Mg/Ca distribution in *Mytilus edulis* shells: Implications for paleothermometry. For submission to *Geochim. Cosmochim. Acta*.

Klünder M.H., **Hippler D.**, **Frei D.**, Witbaard R., **Immenhauser A.** and **Eisenhauer A.**: Ontogenetic controls on the Mg/Ca distribution in shells of the common blue mussel *Mytilus edulis*. For submission to *Paleogeography, Paleoclimatology, Paleoecology*.

Klünder M.H., **Hippler D.**, **Frei D.**, Witbaard R., **Immenhauser A.** and **Eisenhauer A.**: High-resolution chemical analyses of *Arctica islandica* shells from aquaculture field-based experiments. For submission to *Chemical Geology*.

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

In 2008

Heuser A. and **Eisenhauer A.** (2008) The Calcium Isotope Composition ($\delta^{44/40}Ca$) of NIST SRM 915b and NIST SRM 1486. Geost. Geoanal. Res. 32(3), 27-32.

Amini M., **Eisenhauer A**., Böhm F., Fietzke J., Bach W., Garbe-Schönberg D., Rosner M., Bock B., Lackschewitz C., and Hauff F. (2008) Calcium Isotope ($\delta^{44/40}Ca$) Fractionation along Hydrothermal Pathways, Logatchev Field (Mid-Atlantic Ridge, 14°45' N). Geochem Cosmochem Acta 72, 4107-4122.

Kisakürek B., **Eisenhauer A**., Böhm F., Garbe-Schönberg D., and Erez J. (2008) Controls on shell Mg/Ca and Sr/Ca in cultured planktonic foraminiferan, Globigerinoides ruber (white). *Earth Planet. Sci. Lett.* **273**, 260-269.

Heinemann A., Fietzke J., **Eisenhauer A**., and Zumholz K. (2008) Modification of Ca isotope and trace metal composition of the major matrices involved in shell formation of *Mytilus edulis*. *Geochem. Geopyhs. Geosyst.* **9,** (Q01006, doi: 10.1029/2007GC001777).

Griffith, E.M., A. Paytan, R. Kozdon, **A. Eisenhauer**, A.C. Ravelo, (2008) Influences on the fractionation of calcium

isotopes in planktonic foraminifera, *Earth Planet Sci Lett.*., 268, 124-136.

Rüggeberg, A., J. Fietzke, V. Liebetrau, **A. Eisenhauer**, W.-C. Dullo, A. Freiwald (2008) Stable strontium isotopes ($\delta^{88/86}$Sr) in cold-water corals – a new proxy for reconstruction of intermediate ocean water temperatures, Earth Planet., Sci. Lett., 269, 570–575.

Tang, J., **Dietzel M**., Köhler S. J., Böhm F., and **Eisenhauer A**. (2008) Sr^{2+}/Ca^{2+} and $^{44}Ca/^{40}Ca$ fractionation during inorganic calcite formation: II. Ca isotopes as an environmental proxy. *GCA* 72, 3733-3745.

Fietzke J., V. Liebetrau, D. Günther, K. Gürs, K. Hametner, K. Zumholz, T. H. Hansteen and **A. Eisenhauer** (2008) An alternative data acquisition and evaluation strategy for improved isotope ratio precision using LA-MC-ICP-MS applied to stable and radiogenic strontium isotopes in carbonates, DOI: 10.1039/b717706b, J. Anal. At. Spectrom, 23, 955-961.

J. Tang, S.- J. Köhler, and **M. Dietzel** (2008a) Sr^{2+}/Ca^{2+} and $^{44}Ca/^{40}Ca$ fractionation during inorganic calcite formation: I. Sr incorporation. Geochim. Cosmochim. Acta. 72, 3718-3732

J. Tang, M. Dietzel, A. Leis, and S. Köhler (2008c) Stable isotopic fractionation during inorganic calcite precipitation – Effects of temperature, precipitation rate and pH (*prepared for Geochim. Cosmochim Acta*)

M. Bucca, **M. Dietzel, J. Tang**, A. Leis and S.J. Köhler (2008) Nucleation and crystallization of otavite, witherite calcite, strontianite, hydrozincite, and hydrocerussite by CO_2 membrane diffusion technique. Chem. Geol. (*to be submitted*)

In 2007

D. Hippler, R. Kozdon, K. F. Darling, **A. Eisenhauer**, T. F. Nägler (2007). Calcium isotopic composition of high-latitude proxy carrier *Neogloboquadrina pachyderma* (sin.), *Biogeosciences Discuss.,* 4, 1-3.

Buhl, D**., Immenhauser, A**., Smeulders, G., Kabiri, L., and Richter D. K. (2007) Time series δ^{26}Mg analysis in speleothem calcite: Kinetic versus equilibrium fractionation, comparison with other proxies and implications for palaeoclimate research. *Chem. Geol.,* 244, 715-729.

D. Fleitmann, S. J. Burns, A. Mangini, M. Mudelsee, J. D. Kramers, I. Villa, U. Neff, A. a. Al-Subbary, A. Büttner, **D. Hippler**, A. Matter (2007). Holocene ITCZ and Indian monsoon dynamics recorded in stalagmites from Oman and Yemen (Socotra), *Quat. Sci. Rev.*, 26,170-188.

Hippler D., Kozdon R., Darling K. F., **Eisenhauer A**., and Nägler T. F. (2007) Calcium isotopic composition of high-latitude proxy carrier Neogloboquadrina pachyderma (sin.),. *Biogeosciences Discussions* **4**, 3301-3330.

J. Farkaš, F. Böhm, K. Wallmann, J. Blenkinsop, **A. Eisenhauer**, R. v. Geldern, A. Munnecke, S. Voigt, and Veizer J. (2007) Calcium isotope record of Phanerozoic oceans: Implications for chemical evolution of seawater and its causative mechanisms. *Geochem Cosmochem Acta, 71, 5117-5134,* (10.1016/j.gca.2007.09.004).

In 2006

J. Fietzke & **A. Eisenhauer** (2006) Determination of Temperature Dependent Stable Strontium Isotope ($^{88}Sr/^{86}Sr$) Fractionation via Bracketing Standard MC-ICP-MS, doi:10.1029/2006GC001243, G-cubed.

Hippler, D., A. Eisenhauer and Thomas F. Nägler (2006) Tropical Atlantic SST history inferred from Ca isotope thermometry over the last 140 ka, Geochim Cosmochim Acta, 70, 90-100.

Böhm F., Gussone N., **Eisenhauer A**., Dullo W.-C., Reynaud S., and Paytan A. (2006) Calcium isotope fractionation in modern scleractinian corals. *Geochem Cosmochem Acta* 70**,** (doi:10.1016/j.gca.2006.06.1546), 4452-4462.

Gussone, N., G. Langer, S. Thoms, **A. Eisenhauer**, U. Riebesell and G. Wefer, (2006), Cellular calcium pathways and isotope fractionation in *Emiliania huxleyi*, Geology, 34, 8, 625-629.

Langer, G. N. Gussone, G. Nehrke, U. Riebesell, **A. Eisenhauer**, H. Kuhnert, B. Rost, S. Trimborn, and Silke Thoms (2006) Coccolith strontium to calcium ratios in *Emiliania huxleyi*: The dependence on seawater strontium and calcium concentrations, Limnol. Oceanogr., 51, 1, 310-320.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

Do not apply!

1 D. Patents and industry collaborations

Do not apply!

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

1 F. Participation in other conferences

Please list only the most relevant

American Geophysical Union in 2005, 2006, 2007

European Geophysical Union in 2007, 2008

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

1. Penpang Reuter: PhD-student, 05-12-05—19.05.06, no
2. Claas Hibenthal: PhD-student, 16-06-06—31-07-08, scheduled 05/09
3. Basak Kisakürek: Post-Doc, 01-04-06—20-09-07,
4. Marius Müller: PhD-student, 01-01-06—14-07-08, scheduled 05/09
5. Dorothee Hippler: Post-Doc 01-05-06—30-04-08.
6. Jianwu Tang: Post-Doc 01-08-05—29-02-2008
7. Maiken Klünder: PhD-student, 01-04-05—31-07-08, scheduled 05/09
8. Thomas Rinder: PhD-student, 25-03-08 – 31-03-09

Dendrochronology, 14C time-sacle and mechanism of rapid climate change during the last deglaciation (TREE14)

Abstract

We propose to create an absolutely dated time frame, of annual resolution and accuracy, for the deglaciation and Late Glacial interval, based on dendrochronologically dated tree-ring chronologies. The extension will come from linking already existing, but floating, Late Glacial pine chronologies to the absolutely dated chronologies of the Hohenheim tree-ring labora-tory, using individual sections already filling the gaps, from undated pine sections already collected, and extensive new fieldwork, predominantly in South-eastern and Southern Europe. High-precision (±25 year) 14C analyses of decadal samples will extend the terrestrial 14C calibration into this crucial time interval, leading to a common time frame for important climate archives, dated by 14C. From the 14C data the fluctuations of the atmospheric 14C level is reconstructed, yielding information of solar variability and ocean ventilation changes. To separate solar, geomag-netic and oceanic forcing we use 10Be data from ice cores and geomagnetic intensity data, obtained in associated and ongoing projects. As 14C and 10Be fluctuations share a common cause (production changes) we can transfer the tree-ring time scale to ice-cores which will improve substantially the potential of ice cores as climate archives. Using well established climate proxies in tree-rings we will provide terrestrial climate information for the deglaciation and Late Glacial period.

Partners

(CNRS, DFG, VR)

Bernd Kromer (project leader)
University of Heidelberg, Heidelberg, DE

Svante Björck
Lund University, Lund, SE

Frédéric Guibal
Institut Méditerranéen d'Ecologie et Paléoécologie, Aix-en-Provence, FR

Barbara Wohlfarth
Stockholm University, Stockholm, SE

Collaborative Research Project (CRP)

1. General information

Project Reference Number : : **04-ECLIM-FP14**
Acronym / Short Title: Tree-14
Full Title: Dendrochronology, ^{14}C time-scale and mechanisms of rapid climate change during the last deglaciation
Project Leader name: Dr. Bernd Kromer
Project Leader affiliation: Heidelberg Academy of Sciences, Institute of Environmental Physics /Univ. Heidelberg, Germany
Institutional home page (URL): www.iup.uni-heidelberg,de
Project-related home page (URL): -
Reporting period: 20/06/2005 to 30/09/2008

2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)

IP 1

Principal Investigator (name & affiliation):
Dr. Bernd Kromer (PI),
Heidelberg Academy of Sciences, Institut für Umweltphysik/Univ. Heidelberg,
Im Neuenheimer Feld 229,
D-69120 Heidelberg

Total Funding amount of the IP : 266.200 €

IP2

Principal Investigator (name & affiliation):
Prof. Svante Björck,
GeoBiosphere Science Centre Lund University,
Sölveg. 12,
SE-223 62 Lund

Total Funding amount of the IP : 45.000 €

IP3

Principal Investigator (name & affiliation):
Dr. Frédéric Guibal
Centre National de la Recherche Scientifique
Institut Méditerranéen d'Ecologie et Paléoécologie Europôle Méditerranéen de l'Arbois
Pavillon Villemin BP 80
F - 13545 Aix en Provence Cedex 04

Total Funding amount of the IP: 28.000 €

IP4

Principal Investigator (name & affiliation):
Prof. Barbara Wohlfarth
Department of Physical Geography & Quaternary Geology
Stockholm University,
SE-106 91 Stockholm

Total Funding amount of the IP : 18.930 €

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

Extension of the absolutely dated tree-ring chronologies covering into the Late Glacial and the deglaciation period

In the project we created an annual time-scale for the Late Glacial in these steps :

(1) The absolutely dated European pine chronology was extended back to 12.593 years BP (1950), i.e. into the first third of Younger Dryas (YD).

(2) Two pine chronologies were built, initially independently, from German pine and Swiss pine, but finally synchronized by ring width into one common chronology. The construction of the chronologies were assisted by numerous ^{14}C dates, both radiometrically and by AMS. Including earlier Swiss Dättnau sections this 1605-ring floating chronology dates to the Bølling/Allerød Late Glacial (LG) phases. From ^{14}C it was evident that the floating LG chronology and the absolutely dated section in YD could even overlap.

(3) More Late Glacial sections were built from subfossil pines found in the Sisteron area, S-France, again pre-dated by ^{14}C

(4) A unique section of Huon pine from Tasmania (SRT 783, M. Barbetti, pers. comm.) could be wiggle-matched by ^{14}C into the YD pine extension. From the ^{14}C sequence of this (one-tree) section a complex pattern o ^{14}C ages in the early YD became apparent, which could be identified in floating Swiss and French pines, and which helped to identify ring-width synchronizations for the Swiss pines in the early part of YD and, most importantly, to the floating LG chronology.

(5) Independently, R. Muscheler (Lund Univ.) found support for the suggestion of a substantial overlap of the tree-ring chronologies, but based on a comparison of ^{10}Be in Greenland ice-cores and the tree-ring based ^{14}C.

As a result we now can announce ring-width links of the previously floating LG chronology to the absolutely dated YD pine, and thus an annual tree-ring scale back to 14237 years BP.

^{14}C calibration

Much of the delay in bridging the tree-ring gap in the early YD was caused by the assumption of a synchronous change in the atmospheric and marine ^{14}C level at the onset of YD, a cornerstone in the sequencing of Late Glacial events. However, our finding outlined above requires a paradigm change, such that the tropical Atlantic and the Greenland ice-sheet registered different (in time) events prior and after the onset of YD, invalidating the Cariaco basin ^{14}C data set for terrestrial ^{14}C calibration in this time interval. Until now the Cariaco data set was the backbone of ^{14}C calibration, and consequently the currently used calibration dataset Intcal04 needs correction.

Solar and THC variability

The complex ^{14}C pattern in late Allerød and especially in the YD, now documented in sub-decadal resolution for the first time in terrestrial archives by our tree-ring based ^{14}C data, is caused by strong variations of the atmospheric ^{14}C level on centennial scales. The ^{14}C signals appear similar, within the confidence interval of the ice-core time scale, to variations in the ^{10}Be flux, which argues strongly for a dominance of a production origin of the signals, i.e. solar variability. Previously, this comparison was not possible, as the ^{14}C fluctuations are attenuated in the marine (Cariaco) ^{14}C record.

Hence, we now can look again into the causes of the YD cool phase, which, at least for the North Atlantic, appear more complex than just a reduction of the thermohaline circulation (THC), because of the evidence of strong solar variability and because of the regional and, most notably, asynchronous signals.

Comparison of ^{10}Be and ^{14}C and time scales of ice cores

We originally proposed to transfer the (annual) tree-ring time scale to the ice-cores, based on the common production anomalies on multi-decadal to centennial scales. As outlined above, it was the ice-core ^{10}Be signal that allowed the LG tree-ring chronology, as constructed in this project, to be adjusted in time. Towards the final phase of our project high resolution ^{10}Be data sets from Antarctic ice cores were completed by J. Beer (Zurich) in an associated project, and more high resolution ^{10}Be data from GRIP will be obtained by R. Muscheler (GeoBiosphere Science Centre Lund University). With the recent link of the LG chronology we now can exploit the initial idea to date ice 'via trees'.

Dendroclimatology

The climate information in the Swiss LG chronology was studied in a PhD thesis (M. Schaub) in the associated project of F.K. Kaiser (see references). For the German sites intensive dendro-ecological and stable isotope analysis was performed. Most interestingly a fire chronology of more than 500 Bølling – Allerød pines from the site Reichwalde in East Germany revealed extremely high fire frequencies of 2-5 years during the first half of the Allerød and a much lower frequencies in the second half of the Allerød. This is explained by enhanced precipitation in second half of the Allerød, also shown up by results of palynological studies and studies of botanical macro-remains on the same sites.

^{14}C activity difference atmosphere-ocean mixed layer

The new finding of an asynchronous ^{14}C pattern around the onset of YD points to a complex sequence of water mass formation and – transport in the tropical North Atlantic (NA) at this interval. Comparison of Δ^{14}C from our tree-ring series and the tropical NA mixed layer, documented in the Cariaco sediments, reveals a very low (ca. 100 yr) difference in ^{14}C ages ca. 150 years prior to the YD signal in Greenland (sic) and a return to even higher than 'normal' (400 yr) reservoir age after the onset of YD in Greenland. A low reservoir age is compatible with reduced ocean upwelling (strong density stratification), and higher gas exchange, whereas the high reservoir ages are best explained by advection of old intermediate water (of Southern Atlantic origin).
We expect more insight from a re-evaluation of high-resolution marine and terrestrial (e.g. glacier) climate and ocean ventilation records of Central and South America.

^{14}C during Heinrich 1

Due to postulated strong changes in the meridional overturning circulation (MOC) in the North Atlantic we expect substantial differences in atmospheric and marine ^{14}C levels for Heinrich events. In the project we re-assessed the larch chronologies of the Revine site in Northern Italy, by new ring-width measurements and more ^{14}C dates. The task is challenging, because of missing rings in larch, and because of the high ^{14}C age, compared to LG. Most of the new ^{14}C dates require extended measurement times, and duplicates to increase the precision. In the new dates we observe a strong reduction in ^{14}C ages between 15k and 14.2k ^{14}C BP, coincident with the 'mystery interval' as coined by W. Broecker. The signal is compatible with a reduction in MOC, as seen e.g. in the Pa/Th ratio in NA sediments, but we need to wait for ^{10}Be series to disentangle production and ventilation effects.

Role of the CRP

In the CRP we combined chronology building at three European tree-ring laboratories with the expertise in ^{14}C dating and ^{14}C wiggle-matching of floating sequences and with the expertise in Late Quaternary geology and Late Glacial climate events. These fields have been collaborating in the past in bilateral projects, but never before like in our project. We now can confidently state that the unique funding scheme and the special chances for networking as offered in the EUROCLIMATE program were fundamental for us to arrive at the success that we now have in hand.

4. What did you not achieve in the CRP and why? (max 1 p.)
Please use the original proposal as reference and explain any deviations from the work plan

We did extensive field work to locate more LG tree-ring series, preferably dating beyond the Bølling interval, where forests emerge in Central Europe. We could extend our collection slightly into early Bølling from new finds in quarries south of Torino, Italy, but we hoped to find subfossil trees of older age in Romania. It is known that SE-Europe was a favorable refuge area of forests during Glacial times and hence we did an intensive search in Romania, based on previous work of the IPs (B.W., IP 4).
In two field trips we collected more than 300 tree sections. They were found to be of the Holocene age, with the notable exception of two pines of 12.5 and 14.5 ka ^{14}C BP.
There is no doubt about the existence of LG and earlier sections and deposits in Romania, yet the present state of mining in the quarries does not require to reach the depths of the pre-Holocene deposits. This situation may change in the near future with increasing demands from the building and road construction sector.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

We will continue and newly establish collaborations with colleagues in the field of Late Quaternary Prehistory in South-Eastern Europe. Fieldwork will be continued in Northern Italy. We continue the collaboration in ^{14}C AMS techniques with the Lund AMS laboratory. The three tree-ring groups of the project will continue to cooperate in cross-dating of new finds.

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

Development of long terrestrial chronologies is a long-term effort, and requires international cooperation, beyond the member states of EU. Hence ESF best suited to initiate and review such activities

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

The strongest impact comes from collaboration on the European level, and here the networking instruments offered by EUROCORES is unique. In addition we observed that the administrative requirements are handled in a highly efficient way, judging from a participant perspective, e.g. compared to FP7

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

Synchronisation among the member funding agencies caused some friction for the research programmes initially.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Muscheler, R., B. Kromer, S. Björck, A. Svensson, M. Friedrich, K. F. Kaiser and J. Southon (2008). "Tree rings and ice cores reveal 14C calibration uncertainties during the Younger Dryas." Nature Geoscience **1**: 263-267

Schaub, M., U. Büntgen, K. F. Kaiser, B. Kromer, S. Talamo, K. K. Andersen and S. O. Rasmussen (2008). "Lateglacial environmental variability from Swiss tree rings." Quarternary Science Reviews **27**: 29-41.

Schaub, M., K. F. Kaiser, B. Kromer and S. Talamo (2005). "Extension of the Swiss Lateglacial tree-ring chronologies." Dendrochronologia: doi:10.1016.

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Lowe, J.J., Rasmussen, S.O., Björck, S., Hoek, W.Z., Steffensen, J.P., Walker, M.J.C., Yu, Z. and the INTIMATE group. 2008: Synchronisation of palaeoenvironmental events in the North Atlantic region during the Last Termination: a revised protocol recommended by the INTIMATE group. Quaternary Science Reviews 28, 6-17.

Kromer, B., B. Wohlfarth, and D. Turk (2007), ESF EUROCLIMATE workshop: Radiocarbon and Ice-Core Chronologies During Glacial and Deglacial Times, Eos Trans. AGU, 88(27), 278.

Bertrand, S., A. Burnett, K. Saunders, J. Striberger, Y. Axfxford, S. Coulter and W. Participants) (2008). "ESF EUROCLIMATE Spring School: Late Quaternary timescales and chronology, Piran, Slovenia, 20-26 April 2008." Pages Newsletter **16**(3): 36-37.

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

The paper of Muscheler et al., 2008 lead to reports in national newspapers and journals

The workshop on Radiocarbon and ice-core chronologies was reported in Kromer, B., B. Wohlfarth, and D. Turk (2007), ESF EUROCLIMATE workshop: Radiocarbon and Ice-Core Chronologies During Glacial and Deglacial Times, Eos Trans. AGU, 88(27), 278.

The spring school in Piran 2008 was reported in Bertrand, S., A. Burnett, K. Saunders, J. Striberger, Y. Axfxford, S. Coulter and W. Participants) (2008). "ESF EUROCLIMATE Spring School: Late Quaternary timescales and chronology, Piran, Slovenia, 20-26 April 2008." Pages Newsletter **16**(3): 36-37.

1 D. Patents and industry collaborations

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

1. Workshop ' Radiocarbon and ice-core chronologies during Glacial and deglacial times', Heidelberg, March 2007' with the RESOLuTION project, co-sponsored by PAGES
2. Spring School: Late Quaternary timescales and chronology, Piran, Slovenia, 20-26 April 2008

1 F. Participation in other conferences

Please list only the most relevant

EGU, Vienna 2007 and 2008

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

M. Friedrich, post-doc, 1.10.2005 - 30.9.2008, part-time extension requested

S. Talamo, post-doc, 1.10.2005 – 30.9.2008, part-time extension requested

New isotopic tracers of the chemistry-climate relationship (ISOTRACE)

Abstract

From a theoretical point of view, climates and chemical states of the Earth's atmosphere should evolve jointly, one influencing the other. But as of today, this complex relationship is largely unexplored. The major obstacle to explore and establish such a relation is that paleoreconstructions of the chemical state of the atmosphere are extremely difficult to establish, simply because so far we have not studied a set of tracers with the required quality. The aim of this project is to make such tracers available through analytical developments. The project proposed here has the main goal of developing new tools to determine past changes in the chemical state of the atmosphere (oxidative capacity) and to provide the first elements from which reconstruction of this very important relationship between climate and chemistry can be derived from natural archives. The central player in our strategy is the oxygen isotopic composition of atmospheric trace compounds, including the rarely measured abundance of the 17O isotope. The oxygen isotopic compositions will be used to trace in time some of the most important oxidation reactions occurring in the atmosphere.

Partners

(CNRS, DFG)

Joël Savarino (project leader)
Université Joseph-Fourier / Grenoble 1, St Martin d'Héres, FR

Carl Brenninkmeijer
Max-Planck Institute for Chemistry, Mainz, DE

Thomas Röckmann
Max-Planck Institute for Nuclear Physics, Heidelberg, DE

Collaborative Research Project (CRP)
1. General information
Project Reference Number : : **04-ECLIM-FP021** Acronym / Short Title: ISOTRACE Full Title: **New isotopic tracers of the chemistry-climate relationship** Project Leader name: *Joel Savarino* Project Leader affiliation: *CNRS* Institutional home page (URL): www-lgge.ujf-grenoble.fr Project-related home page (URL): none Reporting period: 20/06/2005 to 30/09/2008
2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)
IP 1
Principal Investigator (name & affiliation): Joël Savarino – LGGE/CNRS
Total Funding amount of the IP : 75 k€
IP2
Principal Investigator (name & affiliation): Thomas Röckmann – Univ. Utrecht
Total Funding amount of the IP : 0
IP3
Principal Investigator (name & affiliation): Carl Brenninkmeijer – Max Plank Institute
Total Funding amount of the IP: 0

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

Reminder.

From a theoretical point of view, climates and chemical states of the Earth's atmosphere should evolve jointly, one influencing the other. This complex relationship is largely unexplored. The major obstacle to explore and establish such a relation is that paleo-reconstructions of the chemical state of the atmosphere are extremely difficult to establish, simply because so far we have not studied a set of tracers with the required quality. The aim of the ISOTRACE EUROCLIMATE project was to make such tracers available through analytical developments. The project had the main goal of developing new tools to determine past changes in the chemical state of the atmosphere (oxidative capacity) and to provide the first elements from which reconstruction of this very important relationship between climate and chemistry can be derived from natural archives. The central player in our strategy was the oxygen isotopic composition of atmospheric trace compounds, including the rarely measured abundance of the ^{17}O isotope.

Three groups of researcher were originally associated in this project:

- Joël Savarino group from the LGGE/CNRS (France) was in charge of exploring the possibilities given by the oxygen isotopes of nitrate and sulfate
- Thomas Röckmann group from the Max Plank Institute in Heidelberg (Germany), before moving to Utrecht University, to search the openings offered by the stable isotopes of the N_2O molecule
- And finally Carl Brenninkmeijer group from the Max Plank Institute of Mainz (Germany) concentrating his research on the stable isotope of the CO molecule.

These molecules were chosen firstly because they were all displaying a significant oxygen isotope anomaly related more or less with the oxidizing capacity of the atmosphere and secondly because they are well preserved in glaciological archives such as the polar ice cores. Each laboratory had a previous strong experience in dealing with these molecules and workpages where thus built by associating a group with a specific molecules.
The strategy was to let each group develop his analytical techniques to extract the relevant information from the isotopes and finally crossing the results to reconstruct the climate/atmospheric chemistry relationship for future studies.

Well, I have to say upfront that this strategy fell apart just after a year in the program. For reasons outside our reach, the German funding agency delayed by a year the funding of our German colleagues. In the meantime, Thomas Röckmann accepted a professor position at Utrecht University in Netherlands and the DGF refused to transfer the funding to the Netherlands, despite all our efforts to overturn their decision. Details of this failure will be exposed in the next section.

Accordingly, I'm only exposing the work that has been done by the LGGE team. The major achievements are:

- Development of an automated system capable of measuring the full spectrum of nitrate isotope ($^{17}O/^{16}O$, $^{18}O/^{16}O$ and $^{15}N/^{14}N$) on the same sub µmol size samples. To the best of our knowledge this is the only system running in the world.
- Successfully applied to glaciological archives (Antarctic snow, ice and air samples)
- Detail understandings of the source and origin of the nitrate isotopic composition
- Setting up the theoretical framework to interpret the ice signal in term of past oxidation capacity of the atmosphere
- Reveal the role of snowpack photochemistry for the nitrogen oxide budget
- Establish a new isotopic marker to characterize the nature of volcanic events recorded in ice core

All these results are recorded in scientific publications and were exposed at international conferences and workshop (EGU, AGU, ESF).

Because of the funding issue with our German partners, I have to recognize that the LGGE work could have been achieved even without our involvement in a CRP. However, without the CRP grant received through our national funding agency, it would have taken more than the three years of this program to achieve the same scientific results. EUROCLIMATE really boosted our research and finally demonstrated the soundness of our approach.

Beside the scientific results, which I consider nevertheless positive from our perspective, another positive result is that our common frustration about the German funding issue strengthened our wish to collaborate together using a different approach. We have thus submitted a Marie Curie ITN proposal to the EU in 2007 which passed the first review stage but failed in the second round. We have improved this proposal and it is currently under review.

Finally, we found poor interaction with the other CRPs within EUROCLIMATE, mostly because our research was confined at the interface between the atmospheric chemistry and the climate while the other CRPs were essentially focused on pure paleoclimate studies.

4. What did you not achieve in the CRP and why? (max 1 p.)
Please use the original proposal as reference and explain any deviations from the work plan

As mentioned before, all the work of the German partners listed in the original proposal could not be achieved as they never got their funding for reasons exposed in the previous section and in a letter of Thomas Röckmann enclosed with this report. Many emails were exchanged with the different program coordinators (PC), and the German funding agency (DFG) exposing our difficulty but no solution was given to us. Consequently, our German partner abandoned the CRP after two years of the official starting of the program. I should also stress that changing the program coordinator almost every year did not help to solve our funding issue; neither strengthen the cohesion between CRPs.

Meanwhile, the French part of the program was running smoothly since the beginning. Stopping the CRP will have been detrimental to the post doc hired within this program and to the scientific results already obtained.
One of the main goals of the original proposal was to set up a new method to analyze the stable isotopes of nitrate trapped in ice cores. The original plan of drying a strain of water droplets descending from directly from the ice core was quickly abandoned. After few tests, we found out that this system was too unstable and too complicated. In the meantime, a new approach was proposed in the literature. This technique was taken advantage of a particular strain of denitrifying bacteria. After a year of research, we finally succeeded in implementing this method in our lab to study the full spectrum of nitrate stable isotopes (15N, 17O, 18O), with characteristics compatible for ice core analysis. As far as we know, this is currently the only system in the world running.
In the original proposal, plan was made to recover blue ice; an old ice easily accessible from the surface and where unlimited amount of ice can be collected for isotopic studies. Unfortunately, for logistic and weather reasons, such ice could not be recovered during this project. Field work in Antarctica is always unpredictable and subject to cancellation due to the harsh environment prevailing in this part of the world. However, thanks to the large LGGE's glaciological archives available for pilot studies, we were able to conduct our scientific program without restrictions.
The work on nitrate was progressing so well that actually we extended our work to study the sulphate stable isotopes found in snow. This work was not originally listed in our proposal plan but found out to be very complementary to the nitrate study and brought new wealth of information about the climatic impact of volcanoes.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

Due to the turndown of German funding by the DFG, our frustration was high between our colleagues and us. In a common effort to move forward and still develop our collaboration with Thomas Röckmann's group, now installed in the Netherlands, we have submitted last year a proposal for an Initial Training Network, a Marie Curie program of the EU. Despite our failure in 2007, this proposal passed the first round and final reviews were encouraging. We improved the proposal and it is now under review.

This proposal broadens the originally work planned in this CRP and gathers together all the European research groups working on oxygen isotope anomaly.

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

I will advise the panel in charge of the EUROCLIMATE program to open the scientific topics to a broader community in the next call if any. Paleoclimate programs should not be restricted to traditional paleoclimate studies. An effort should be made to really bring together interdisciplinary studies working on the ocean-atmosphere-cryosphere-biosphere interfaces. If the goal of programs like EUROCLIMATE is to open new directions in research, create new knowledge, only interdisciplinary approaches can emulate new ideas, decompartmentalize the scientific approaches and tight together new partners.

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

Despite our difficulties exposed previously, working in an international environment at a European level, with a structure like ESF is really a plus. It brings a framing that usually is not available at a national level. It offers to the participants an opportunity to interact with colleagues from other fields, even if in our case we felt a little bit outside the main core of the EUROCLIMATE participants. Available funds for networking activities are an interesting concept to boost and foster interactions between CRPs.
It was the first program I was in charge of with a European structure. The difference between programs I have managed before and this one really lies in the constant reporting and meetings we had.

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

To avoid the funding issue we faced, the program will be greatly improved if granted programs get their funding directly through the ESF even if ultimately the funds come from the different national agencies. ESF will gain a better control and coordination of the status of the running programs and efficiency will increase. Trusting the national funding agencies with their different administrative rules and bureaucracy is really a handicap. It is amazing at a time where the EU wants to open the borders and build an open space for science that no solution was found to transfer the grant from Germany to the Netherlands. The program would really improve if national funds could be managed by the ESF. For instance, the full program could start only if all state agencies would have transferred their respective funds, putting high pressure on the national agencies to fund the program without delays.

As I stated before, changing the program coordinator so often is not acceptable if we want to keep a dynamic, a long-term record of reporting issues, finding solutions and increasing collaborations and interactions between CRPs. We had three different coordinators in three years duration of the program. This is really not the best way to maintain a program alive. The program coordinator should be appointed for the duration of the program and keep track of the advancement of each CRP.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

none

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Savarino, J., Kaiser, J., Morin, S., Sigman, D. M., and Thiemens, M. H.: Nitrogen and oxygen isotopic constraints on the origin of atmospheric nitrate in coastal Antarctica, Atmospheric Chemistry and Physics, 7, 1925-1945, 2007.

Morin, S., Savarino, J., Bekki, S., Cavender, A., Shepson, P. B., and Bottenheim, J. W.: Major influence of BrO on the NO_x and nitrate budgets in the Arctic spring, inferred from $\Delta^{17}O(NO_3^-)$ measurements during ozone depletion events, Environ. Chem., 4, 238-241, doi:10.1071/EN07003, 2007.

Morin, S., Savarino, J., Bekki, S., Gong, S., and Bottenheim, J. W.: Signature of Arctic surface ozone depletion events in the isotope anomaly ($\Delta^{17}O$) of atmospheric nitrate, Atmos. Chem. Phys., 7, 1451-1469, 2007.

Baroni, M., Thiemens, M. H., Delmas, R. J., and Savarino, J.: Mass-independent sulfur isotopic compositions in stratospheric volcanic eruptions, Science, 315, 84-87, 2007.

Baroni, B., Savarino, J., Cole-Dai, S., Rai, V. K., and Thiemens, M. H.: Anomalous sulfur isotope compositions of volcanic sulfate over the last millennium in Antarctic ice cores, J. Geophys. Res., In press, 2008.

Frey, M. M., Morin, S., Savarino, J., and Martins, J. M. F.: Isotopic constraints on the atmosphere-snow cycling of nitrate above Antarctica, Geophys. Res. Lett., submitted, 2008.

Morin, S., Savarino, J., Frey, M. M., Domine, F., Jacobi, H. W., Kaleschke, L., and Martins, J. M. F.: Comprehensive isotopic composition of atmospheric nitrate in the Atlantic Ocean boundary layer from 65°S to 79°N, J. Geophys. Res., Submitted, 2008.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

Morin, S., and Savarino, J.: Une nouvelle application des isotopes stables de l'oxygène, L'actualité chimique, 303, 14-18, 2006.

Savarino, J.: A new insight into the climatic impact of volcanic explosion: A lesson from the sulfur stable isotopes, Pages News, 13, 19-21, 2005.

Une molécule au centre de la chimie atmosphérique: L'ozone: http://www.futura-sciences.com/fr/comprendre/dossiers/doc/t/chimie/d/lozone-au-coeur-de-la-chimie-atmospherique_771/c3/221/p1/, 2007.

Interviews with Newspapers (Geotimes, New Scientist, La Recherche, Science et Vie)

French short TV coverage : France 24

1 D. Patents and industry collaborations

none

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

none

1 F. Participation in other conferences

Please list only the most relevant

Morin, S., Savarino, J., Gong, S., and Bottenheim, J. W.: Arctic surface ozone meets nitrate isotopes, AGU Fall Meeting, San Francisco, 2005, Fall Meet. Suppl., abstract A13F-05,

Morin, S., Frey, M. M., Grudzieu, A., Martins, J., and Savarino, J.: Isotopic composition of atmospheric nitrate over the Atlantic Ocean, AGU Fall Meeting, San Francisco, 2007.

Morin, S., Savarino, J., Frey, M. M., Domine, F., Martins, J., Bekki, S., and Bottenheim, J.: Isotopic constraints on the budget of atmospheric nitrate in the Arctic, EGU General Assembly, Vienna, Austria, 2008, EGU2008 - A0408.

Baroni, M., Savarino, J., Delmas, R. J., and Thiemens, M. H.: Mass-Independent sulfur isotope fractionation in sulfates of 9 volcanic events of the last 1000 years in Dome Concordia shallow ice-core, ESF Euroconference, Polar Regions and Quaternary Climate, Acquafredda di Maratea, Italy, 2005.

Baroni, M., Savarino, J., Delmas, R., and Thiemens, M. H.: Mass-independent oxygen and sulfur isotopic composition of the Pinatubo and Agung volcanic eruptions as recorded in Dome C snow, EGU General Assembly, Vienna, Austria, 2006.

Frey, M. M., Morin, S., Savarino, J., and Martins, J.: Nitrogen and Triple Oxygen Isotopic Composition of Surface Snow in Antarctica, EGU General Assembly, Vienna (Austria), 2007.

Frey, M. M., Morin, S., Savarino, J., and Martins, J.: Nitrogen and triple oxygen isotopic composition of surface snow in Antarctica, AGU Fall Meeting, San Francisco, 2007.

Savarino, J., Morin, S., Kaiser, J., and Thiemens, M. H.: A year-round isotopic survey of aerosol nitrate from a coastal Antarctic station, AGU Fall Meeting, San Francisco, 2005, Fall Meet. Suppl. abstract A21C-0886.

Savarino, J., Baroni, B., Bekki, S., Delmas, R., and Thiemens, M. H.: Mass-independent sulfur isotopic compositions in stratospheric volcanic eruptions, EGU General Assembly, Vienna (Austria), 2007.

Savarino, J., Morin, S., and Frey, M. M.: Atmospheric nitrate and its isotopic composition, EGU General Assembly, Vienna, Austria, 2008, Sollicited Talk, EGU2008-A-01769.

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Markus Frey, post doc, started 01/09/2006 end 30/06/2008

Professor Dr. Thomas Röckmann
Institute for Marine and Atmospheric Research Utrecht
Department of Physics and Astronomy
Faculty of the Natural Sciences
Princetonplein 5
3584CC Utrecht
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Phone +31 30 253 3858
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Universiteit Utrecht

To whom it may concern

This is to certify that I have not been able to start the scientific work on the ISOTRACE project (PI Joel Savarino, UJF Grenoble) that was funded as part of the EUROCLIMATE program. Our proposal was ranked 10th in 2004, and suggested for funding, but because of delays in the decision about national funding the funding was not granted by the German funding agency DFG until July 2005. In June 2005, in the meantime, I had accepted a position at Utrecht University in the Netherlands and my research group and laboratory had moved there.
Therefore, when the project was officially about to start, I was not working in Germany anymore, and the DFG refused to transfer the funding to the Netherlands. We tried many routes to get the project started, but there were always formal and legal reasons why this was not possible; the only acceptable solution would have been the official transfer of the funding to Utrecht. Therefore, to my deep regret, I had to cancel my participation in this interesting project.
Sincerely

Prof. Dr. Thomas Röckmann

Utrecht, 2008-06-05

High-resolution reconstruction of Late-Glacial and Holocene climate variability in equatorial East Africa based on laminated lake sediments from Mt. Kilimanjaro (CHALLACEA)

Abstract

Assessing how tropical climate dynamics might drive or amplify climate change in temperate regions is a central issue for understanding natural climate variability and predicting the outcome of its future interaction with anthropogenic climate change. Climate-proxy records from across Africa and Asia testify to the fact that tropical climates during the Holocene have been anything but stable, but the regional synchrony and extra-tropical links of even the stronger, millennium-scale moisture-balance fluctuations remain uncertain because of the lack of continuous, highly-resolved continental archives with good age control. Also contentious is whether reconstructed lake-level changes and oxygen-isotope signatures in tropical glacier ice, cave stalagmites and fossil diatoms mainly reflect variations in rainfall and drought, or of temperature and its effect on evaporation. We propose to answer some of these questions by reconstructing -with excellent time resolution and age control- the complete post-Glacial history of temperature and moisture-balance variation in equatorial East Africa from the continuous and finely laminated sediment record of Lake Challa, a crater lake on the lower East slope of Mt. Kilimanjaro. This reconstruction will significantly advance understanding of tropical climate variability by 1) establishing the detailed patterns and timing of late-Glacial and Holocene moisture-balance fluctuations in continental East Africa; 2) by distinguishing between contributions of temperature change and monsoonal rainfall variation to those moisture-balance fluctuations; and 3) by placing the highly resolved but poorly dated Mt. Kilimanjaro ice-core record of atmospheric chemistry and dust content in an absolute temporal framework.

Partners

(DFG, FNU, FWO, NWO)

Dirk Verschuren (project leader)
University of Gent, Ghent, BE

Daniel Conley
Natural Environment Research Institute, Roskilde, DK

Jaap Sinninghe Damsté
Nederlands Instituut voor Onderzoek der Zee, Den Burg, NL

Bas van Geel
University of Amsterdam, Amsterdam, NL

Marc De Batist
Universiteit Gent, Ghent, BE

Gerald Haug
Geoforschungszentrum Potsdam, Potsdam, DE

Brian Cumming (Associated partner)
Queen's University, Kingston, Ontario, Canada

Daniel Olago (Associated partner)
University of Nairobi, Kenya

Philip Barker (Associated partner)
Lancaster University, UK

Collaborative Research Project (CRP)
1. General information
Project Reference Number : : **04-ECLIM-FP028** Acronym/Short Title: *CHALLACEA (Lake Challa: a Long Archive of Climate in Equatorial Africa)* *Full Title: High-resolution reconstruction of late-Glacial and Holocene climate variability in equatorial East Africa, based on laminated lake sediments from Mt.Kilimanjaro* Project Leader name: *Prof. Dr. Dirk Verschuren* Project Leader affiliation: *Ghent University, Belgium* Institutional home page (URL): *www.Ugent.be* Project-related home page (URL): www.UGent.ecology Reporting period: 20/06/2005 to 30/09/2008
2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)
IP 1
Principal Investigator (name & affiliation): Dirk Verschuren, Ghent University, Belgium
Total Funding amount of the IP : € 219,950 (FWO-Vlaanderen G.0641.05)
IP2
Principal Investigator (name & affiliation): Gerald Haug, GeoForschungsZentrum Potsdam, Germany
Total Funding amount of the IP : € 123,748.40 (DFG HA 2756/7-2)
IP3
Principal Investigator (name & affiliation): Daniel Conley, National Environmental Research Institute (NERI), Roskilde, Denmark
Total Funding amount of the IP: € 35,880 (project no. 21-04-0580)
IP4
Principal Investigator (name & affiliation): Jaap Sinninghe Damsté, Utrecht University and Royal Netherlands Institute for Sea Research (NIOZ), The Netherlands
Total Funding amount of the IP : €101,509 (NWO 855.01.082)
IP5
Principal Investigator (name & affiliation): Bas van Geel, Universiteit van Amsterdam, The Netherlands
Total Funding amount of the IP : € 202,248 (NWO 855.01.083)
IP6
Principal Investigator (name & affiliation): Marc De Batist, Ghent University, Belgium
Total Funding amount of the IP : € 11,200 (FWO-Vlaanderen G.0641.05)
AP1
Principal Investigator (name & affiliation): Brian Cumming, Queen's University, Kingston, Ontario, Canada
Total Funding amount of the IP : n/a
AP2
Principal Investigator (name & affiliation): Philip Barker, Lancaster University, UK
Total Funding amount of the IP : n/a
AP3
Principal Investigator (name & affiliation): Daniel Olago, University of Nairobi, Kenya
Total Funding amount of the IP : n/a

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The most significant achievement of the CHALLACEA project is a continuous, high-resolution reconstruction of climate history in equatorial East Africa spanning the last 25,000 years (i.e. from before the Last Glacial Maximum to the present), with chronological control approaching that of the signature polar ice cores and Asian cave speleothems. No such high-quality climate reconstruction previously existed from this region bordering the western Indian Ocean, which is a critical location for documentation of low-latitude climate dynamics with minimal overprint of climate anomalies originating in high northern and southern latitudes. We found that some millennial-scale climate events of northern origin, such as the Younger Dryas cold episode, did impact strongly on the East African climate as severe drought interrupting the late-Glacial intensified monsoon from ~13 to 11.7 kyr BP (1000s of years ago), but that overall the moisture-balance history of equatorial East Africa over the past 25,000 years mostly responded to long-term variation in equatorial and sub-tropical insolation due to precessional variation in the orbit of Earth around the Sun. Specifically, the region enjoyed high rainfall during the periods >20.5, 16.5-9 and 5-0 kyr BP when peak summer insolation across either northern or southern subtropical Africa strengthened the southeasterly or northeasterly monsoon advecting moist air from the Indian Ocean, respectively; but the region's net moisture balance suffered from peak local solar insolation enhancing evaporation during either the short, southern hemisphere summer dry season (20-16 kyr BP) or the long, northern hemisphere summer dry season (9-5 kyr BP). This moisture-balance reconstruction combines evidence of past lake-level fluctuations inferred from the succession of high- and low lake level phases revealed by reflection-seismic stratigraphy, and of the so-called BIT-index composition of lipid molecules in the cell membrane of certain soil bacteria, that are flushed into the lake by (sub-)surface inflow. This project pioneered the use of this BIT-index in lake sediments as a novel biomarker proxy for relative moisture (or aridity), and stimulated ongoing validation and calibration studies.

Analysis of reflection-seismic signatures in the Lake Challa sediment record beyond 25,000 years ago documented the moisture-balance history of equatorial East Africa over a complete glacial-interglacial cycle. This produced the significant finding that the well-known drought affecting East Africa during the later phase of the Last Glacial Maximum (20.5-16.5 kyr BP) was relatively modest compared to two extreme droughts which occurred at the peak of the Penultimate Glaciation (>130 kyr BP) and in the middle of the Last Interglacial period (115-98 kyr BP). Further, during most of the last glacial period equatorial East Africa enjoyed a relatively wet climate, interrupted only by a handful of short-lived (millennial-scale) droughts that appear largely coeval with Heinrich events 2 to 6, and ending only 20.5 kyr ago in (as said, relatively modest) peak glacial drought. This climate history contrasts sharply with that of western equatorial Africa, where glacial drought commences as early as ~70 kyr ago, because of the greater impact there of the glacial slow-down of Atlantic meridional overturning circulation on the advection of monsoon rainfall onto the continent.

The CHALLACEA project is notable for the large number of paleo-environmental indicators extracted from the Lake Challa sediment record, including mineralogical, sedimentological, (bio)geochemical and biological proxies. Together, these will in time produce coherent and detailed reconstructions of temperature and moisture-balance change, but also of the climate-driven long-term evolution of the lake's aquatic ecosystem, and of the surrounding terrestrial ecosystem. This project focused on application of a variety of standard and more novel moisture-balance indicators (lake-level change deduced from seismic stratigraphy and sedimentology, evaporative concentration deduced from sedimentary carbonate content, rainfall variation deduced from the oxygen-isotope composition of diatoms and authigenic carbonate), permitting a level of cross-validation that is usually elusive. This project is also among the first to study so-called non-pollen palynomorphs (fungal and algal spores, and other remains of micro-organisms preserved in pollen preparations) as indicators of past natural and anthropogenic environments in tropical Africa.

Without the CRP funded through the ESF-EUROCLIMATE programme, a skeletal version of the present CHALLACEA project could potentially have been executed through established collaboration between some of the partners, and bilateral agreements between national/regional funding agencies. However this would not likely have generated the funds necessary for routine sedimentological and geochemical analyses with high temporal resolution (>1000

samples), or the high number (>200) of AMS radiocarbon (^{14}C) dates. Together, these have lifted the resulting reconstructions from the good/solid to the unique/exceptional. Also, without CRP our present results would likely have taken ~6-8 years to achieve, via a succession of smaller projects which together would have commanded a significantly higher total cost.

Besides optimal integration and publication of the diverse project data, which will likely require a few years to complete since several datasets were/are produced in the context of ongoing PhD research, the legacy of the CHALLACEA project will be evident in several new research directions involving a growing number of international collaborators. The excellent chronology and time resolution of the Challa record, and the large number of climate and paleoecological proxies already extracted from it, clearly make it excellent material for application of novel proxies. Two such initiatives are now underway. First, collaborators at Brown University (Providence, USA) together with project partners at the Royal Netherlands Institute for Sea Research (NIOZ; IP3) will conduct analyses of the hydrogen isotopes in leaf waxes as an alternative indicator of regional moisture balance. Secondly, collaborators at the University of Illinois (Urbana-Champaign, USA) will conduct a quantitative and high-resolution analysis of fossil charcoal as proxy for past changes in fire frequency and intensity. Together with carbon isotopic analyses of individual grass pollen grains to separate the contributions of C3 and C4 grass species to African grasslands during episodes of glacial and interglacial time (these grasses differ in their tolerance to drought and low carbon dioxide concentration), this will generate a better understanding of the interplay of environmental controls which govern the long-term dynamics of tropical dryland ecosystems.

Finally, given the demonstrated continuity of late Quaternary sediment deposition in Lake Challa and the exquise detail of the seismic stratigraphy, it is evident that the CHALLACEA project ideally should continue in a follow-up project aiming to produce a high-resolution record of climate history on the East African equator over a complete glacial-interglacial cycle (~140,000 years BP to present). The present CRP consortium will set this process in motion in early 2009 by submitting an outline proposal for deep drilling in Lake Challa to the International Continental Drilling Programme.

4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

All essential components of the project are now completed as planned in the funded proposal, or will be in the near future as the linked PhD projects are finished. The executed work plan differs from the proposed work plan in four aspects.

1) Paleomagnetic analyses were not as extensive as planned, due to loss of magnetic properties of the sediment over major portions of the cored profile; we attribute this to diagenetic processes after sediment deposition. This loss did not handicap our research, however, because the use of the magnetic susceptibility signal as a means to cross-correlate overlapping core sections was taken over by tracing visual fine lamination and by XRF scanning.

2) Validation-calibration analyses of the stable-isotope composition of authigenic calcite and organic matter in the 20th-century portion of the record, for which historical climate data are available. These were originally planned to be executed at the Free University of Brussels, but have been done at the GeoForschungsZentrum Potsdam, taking advantage of more convenient and routine laboratory procedures there.

3) The proposal called for the ^{14}C-based sediment age-depth model to be derived predominantly from dating of terrestrial plant macrofossils. Scarcity of such fossils in major sections of the core necessitated construction of the age-depth model predominantly from dating of bulk organic carbon, which required correction of the obtained ^{14}C ages for a (partial) lake carbon reservoir effect. This did not compromise the result, because parallel dating of bulk and terrestrial organic carbon at ~15 levels, and successful wiggle-match dating of bulk organic ages with three inflections in the ^{14}C calibration curve, allowed estimation of changes through time in the required reservoir correction.

4) Reconstructions of palaeotemperatures for Lake Challa using the TEX_{86} palaeothermometer were not as successful as hoped for. The large amounts of soil organic matter in the lake sediments and the presence of an as yet unknown group of Archaea in the deeper waters of the lake prohibited the reconstruction of absolute temperatures for the last 10 kyr.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

See section 3: Leftover sediment core material from Lake Challa obtained by the CHALLACEA project is being used by international collaborators (funded by the U.S. NSF and NOAA) to study novel paleo-environmental proxies not covered by the original CRP (mostly because they have been developed only very recently).

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

See section 3: A potentially ICDP-funded initiative to obtain a 140,000-yr record of East African climate history could conceivably benefit from a new EUROCORES programme supporting multi-national science projects that exploit cores generated by ICDP projects; this new programme would be broadly equivalent to the existing EuroMARC programme for cores generated by IODP projects.

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

First and foremost the capability, through the size of the consortium and the combined amount of funds awarded, to address relatively major research questions with appropriate detail and rigour within a single project term of 3-4 years. This advantage of scale does not come at the cost of increased bureaucracy, which remains as manageable as in the case of nationally funded projects. Secondly the enhanced willingness of national/regional funding agencies to sponsor local IPs of highly rated CRP proposals at the full amount requested.

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

The EUROCORES programme serves its purpose well, if, as is the case with EUROCLIMATE and EuroDIVERSITY, the research programme is sufficiently broad to generate an adequate number of proposals to submit to external evaluation. In this case the competition is fierce but objective; if a research programme generates too few proposals, it may unduly favour the consortia which proposed that programme, to the detriment of researchers submitting proposals directly to their local funding agencies (which due to its EUROCORES commitments will have less unallocated funds to distribute). Also, the temptation should be resisted to attempt maintaining the momentum present in a EUROCORES community through pursuit of a follow-up EUROCORES programme overlapping substantially in scope with the existing programme. Certainly in the case of EUROCLIMATE where the 9 funded CRPs addressed only a subset of the programme's research objectives, the community of researchers involved is bound to be incomplete in the context of any new research programme with adequate scope and societal relevance.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Verschuren D., J.S. Sinninghe Damsté, J. Moernaut, I. Milne, I. Kristen, M. Blaauw, M. Fagot, G. Haug & CHALLACEA project members [B. van Geel, D. Conley, M. De Batist, D.O. Olago[11], B. Plessen, H. Eggermont, C. Wolff, E. Hurrell, J. Ossebaar, A. Lyaruu, P. Barker, J. van der Plicht, B. F. Cumming, A. Brauer, S.M. Rucina, J.M. Russell, E. Keppens, J. Hus, M. Vuille, R.S. Bradley, M. Leng, J. Mingram, N.R. Nowaczyk]. Half-precessional moisture-balance variation on the East African equator since 25,000 cal yr BP. Submitted to *Nature*.

M. Blaauw is a partner in FP33 RESOLuTION; A. Brauer is a partner in both FP28 CHALLACEA and FP29 DECLAKES.

Blaauw M., Verschuren D., van Geel B., Lyaruu A., Kristen I., Fagot M. & van der Plicht J.. Chronology of late Quaternary lacustrine deposits in Lake Challa (Mt. Kilimanjaro), with an evolving reservoir correction. In preparation for submission to *Quaternary Science Reviews*.

M. Blaauw is a partner in FP33 RESOLuTION.

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Verschuren, D. (2008). Historical lake-level fluctuations of Lake Challa (Kenya-Tanzania) in the context of decreasing rainfall on nearby Mt. Kilimanjaro. *ESF EUROCLIMATE Newsletter*.

Sinninghe Damsté, J.S., Ossebaar J., Schouten S. & Verschuren D. (2008). Altitudinal shifts in the distribution of branched tetraether lipids in soils from Mt. Kilimanjaro (Africa): Implications for the MBT/CBT continental palaeothermometer. *Organic geochemistry* 39, 1072-1076.

Moernaut J., Verschuren D., Charlet F., Kristen I., Fagot M., van der Plicht J. & De Batist M. Seismic-stratigraphic record of Lake Challa (Mt. Kilimanjaro) lake-level fluctuations: climatic stability and change on the East African equator during the last glacial-interglacial cycle. In review, *Geology*.

Sinninghe Damsté, J.S., Ossebaar J., Schouten S. & Verschuren D. Fluxes and distribution of tetraether lipids in an equatorial African lake: Constraints on the application of the TEX86 palaeothermometer and branched tetraether lipids in lacustrine settings. In preparation for submission to *Geochimica et Comochimica Acta*.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

This has been kept at a minimum thus far, to avoid rejection of publication in some journals on the grounds of an unintentional breaching of their press embargo.

The aims and scientific context of the CHALLACEA project are featured in a DVD produced by the production company Zcene (Loosdijk, The Netherlands) for ESF, which describes some of the EUROCLIMATE programme's activities and principal achievements.

1 D. Patents and industry collaborations

None.

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

We have held four project workshops, all of them well-attended:

1) GeoForschungsZentrum Potsdam, Germany (02/09/2005)

2) Amsterdam, The Netherlands (09/2006)

3) University of Nairobi, Kenya (23-24/08/2007)

4) Ghent University, Belgium (2-3/10/2008)

In addition there were annual project meetings involving a more limited number of project partners at the annual meeting of the European Geophysical Union in Vienna, in april of 2006, 2007 and 2008.

The involvement of Maarten Blaauw, contributing partner of FPxx RESOLuTION, to CHALLACEA was implemented in part through a visiting scientist fellowship sponsored by the UGent Research Council.

1 F. Participation in other conferences

Please list only the most relevant

Barker, P., Turner, E., Leng, M., Street-Perrott, F.A. & Verschuren, D. (2007). Carbon from biogenic opal: tracing changes in the carbon cycle using proteins in diatom silica. INQUA congress, Cairns (Australia), 08.2007.

Blaauw, M., Verschuren, D., Lyaruu, A., Fagot, M., van Geel, B. & van der Plicht, H. (2007). A preliminary age model for LGM-to-present lacustrine deposits in Lake Challa, East Africa. ESF-EUROCLIMATE workshop 'Radiocarbon and ice-core chronologies during Glacial and deglacial time', Heidelberg Academy of Sciences, Heidelberg (Germany), 05.03.2007-07.03.2007.

Blaauw M., D. Verschuren, B. van Geel, I. Kristen, A. Lyaruu, J. van der Plicht (2008). High-resolution age-depth modelling of the Lake Challa sediment record, 25,000 kyr BP to present (Mt. Kilimanjaro, Kenya/Tanzania). Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Charlet, F., Verschuren, D., Bessems, I., Olago, D., Muzuka, A. & De Batist, M. (2006). Two glacial-interglacial cycles of lake-level change in equatorial East Africa, documented by high-resolution seismic sequence stratigraphy from Lake Challa (Kenya). Geologica Belgica Meeting, Liège (Belgium), 07.09.2006-08.09.2006.

Charlet, F., Verschuren, D., De Batist, M., Bessems, I., Olago, D. & Muzuka, A. (2005). Two glacial-interglacial cycles of lake-level change in equatorial East Africa documented by high-resolution seismic sequence stratigraphy from Lake Challa (Kenya). Poster, EGU General Assembly, Vienna (Austria), 24.04.2005-29.04.2005.

De Batist, M., Charlet, F., Verschuren, D., Bessems, I., Olago, D., Muzuka, A. & Trauth, M. (2006). Two glacial-interglacial cycles of lake-level change in equatorial East Africa documented by high-resolution seismic sequence stratigraphy from Lake Challa (Kenya). Poster, 17th International Sedimentological Congress, Fukuoka (Japan), 27.08.2006-01.09.2006.

Fagot M., H. Eggermont, D. Verschuren (2008). Zoobenthos community response to climate-driven habitat change in a deep tropical crater lake: the Lake Challa (Kenya/Tanzania) chironomid record, 25,000 ka BP to Present. Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Gelorini, V. for CHALLACEA Project Members (2007). CHALLACEA: Reconstructing full-Glacial to Holocene climate variability and ecosystem dynamics in equatorial East Africa, from laminated lake sediments near Mt. Kilimanjaro. ESF-EUROCLIMATE workshop 'Palaeo-databases: their role in modelling and reconstructing palaeoclimate and understanding palaeoenvironments', Aix-en-Provence (France), 25.03.2007-30.03.2007.

Kristen I., D. Verschuren, G.H. Haug, U. Roehl, N.R. Nowaczyk (2006). Stratigraphy and geochemistry of post-Glacial lacustrine sedimentation (21 ka BP to present) in Lake Challa, East Africa. EGU General Assembly, Vienna (Austria), 02.04.2006-07.04.2006.

Kristen I., C. Wolff, G. Schettler, P. Dulski, R. Naumann, G. Haug, M. Blaauw, D. Verschuren (2008). Lake Challa (Mt. Kilimanjaro) sediments as recorder of present and past seasonality in equatorial East Africa. Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Moernaut J., Verschuren D., Charlet F., Kristen I., Fagot M. van der Plicht J. & De Batist M. (2008). High-resolution seismic stratigraphy as a tool for reconstructing abrupt lake-level changes over the last glacial-interglacial cycle: Lake Challa (Equatorial East Africa). Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Moernaut, J., Verschuren, D., Kristen, I., Fagot, M. & De Batist, M. (2007). Abrupt lake-level changes in Lake Challa (East-Africa) revealed by high-resolution seismic stratigraphy: relationship to global paleoclimatic events during the last glacial-interglacial cycle? 4th International Limnogeology Congress, Barcelona (Spain) 11.07.2007–14.07.2007.

Nelson, D.M., Hu, F.S., Verschuren, D. & Pearson, A. (2008). Estimating C_3- and C_4-grass abundance in the paleorecord: Development and application of SPIRAL (Single Pollen Isotope Ratio AnaLysis). Annual meeting of the Ecological Society of America, 2008.

Sinninghe Damsté J.S., J. Ossebaar, S. Schouten and D. Verschuren (2006). A new palaeoproxy for lake temperatures based on crenarchaeotal lipids: application in Lake Challa, East Africa. EGU General Assembly, Vienna (Austria), 02.04.2006-07.04.2006.

Sinninghe Damsté, J.S., J. Ossebaar, S. Schouten & D. Verschuren (2006). A new palaeoproxy for lake temperatures based on crenarchaeotal lipids. 8th Dutch Earth Science Meeting, Veldhoven (The Netherlands), 24-25.04.2006.

Sinninghe Damsté J.S., J. Ossebaar, S. Schouten & D. Verschuren (2008). Archaeal and bacterial membrane lipids in lake sediments as indicators of thermal and precipitation history in equatorial Africa. Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Sinninghe Damsté J.S., J. Ossebaar, S. Schouten & D. Verschuren (2008). The BIT index in lake sediments as an indicator of precipitation in equatorial Africa. Gordon conference on Organic Geochemistry. Plymouth (NH, USA), 3-7.08.2008.

Sinninghe Damsté, J.S., J. Ossebaar, R. van Houten, M. van der Meer, S. Schouten & D. Verschuren (2007). Organic proxy records from Lake Challa (Mt. Kilimanjaro area) reveal continental climate change in tropical Africa since the last Glacial. EGU General Assembly, Vienna (Austria), 15–20.04.2007.

Sinninghe Damsté, J.S, J. Ossebaar, R. van Houten, M. van der Meer, S. Schouten, B. Plessen, C. Wolff, G.H. Haug & D. Verschuren (2007). Continental climate change in tropical Africa since the last glacial: organic proxy records from the Mt. Kilimanjaro area. 23rd Intern. Meeting on Organic Geochemistry, Torquay (UK), 9–14.09.2007.

Turner, E., Barker, P., Leng, M. & Verschuren, D. (2008). A 25,000 year record of carbon and oxygen isotope variation in diatoms from Lake Challa, Kilimanjaro. JESIUM (Joint European Stable Isotope Users Meeting), Giens (France), 31.08.08 - 05.09.08.

Turner, E., Barker, P., Leng, M. & Verschuren, D. (2008). Diatoms and stable isotopes from Lake Challa, Mount Kilimanjaro. Research in Progress Meeting, The Geological Society Geochemistry Group, London (UK), 03.03.2008.

Turner, E., Barker, P., Leng, M. & Verschuren, D. (2008). A 25,000 year record of carbon isotope variation from biogenic silica. Isotopes in Biogenic Silica research meeting, Oxford (UK), 16.05.2008.

Turner. E., Barker. P., Leng, M. & Verschuren, D. (2007). Diatoms and stable isotopes from Lake Challa, Mount Kilimanjaro. British Diatom Meeting, Derbyshire (UK), 26-28.10.2007.

Van Geel B., A. Lyaruu, A. Aptroot & D. Verschuren (2008). Climate change and the fungal record in the sediments of Lake Challa. Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Verschuren, D. (2008). Age-depth models for tropical lakes. ESF EUROCLIMATE Spring School on 'Late Quaternary Timescales and Chronology', Pirana (Slovenia), 20.04.2008-26.04.2008.

Verschuren, D., Haug, G., Sinninghe-Damste, J., van Geel, B., Conley, D., De Batist, M., Kristen, I., Fagot, M., Lyaruu, A., Milne, I., Hus, J., Keppens, E., van der Plicht, J., Hus, J., Nowaczyk, N.R., Mingram, J., Brauer, A., Cumming, B.F. & Russell, J.M. (2006). CHALLACEA: High-resolution, multi-proxy climate reconstruction for equatorial East Africa (21 ka BP to present) from laminated lake sediments near Mt. Kilimanjaro. Poster, EGU General Assembly, Vienna (Austria), 02.04.2006-07.04.2006.

Verschuren, D., Sinninghe Damste, J.S., Haug, G., Kristen, I., Moernaut, J., Milne, I., Wolff, C., Fagot, M., van Geel, B., Blaauw, M. & CHALLACEA partners (2008). A 25,000 years climate record from the East African equator: Half-precessional climate forcing and the history of temperature and hydrological change. EGU General Assembly, Vienna (Austria), 13.04.2008-18.04.2008 .

Verschuren, D., Sinninghe Damste, J.S., Moernaut, J., Milne, I. & CHALLACEA partners (2008). Half-precessional climate forcing, megadroughts, and high-latitude influences on the moisture-balance history of equatorial East Africa. International conference 'Climate Change, from the Geologic Past to the Uncertain Future' in honor of André Berger, Louvain-la-Neuve (Belgium), 20-24.05.2008.

Verschuren D., J.S. Sinninghe Damsté, J. Moernaut, I. Milne, I. Kristen, M. Fagot, G. Haug**,** M. Blaauw & CHALLACEA project members (2008). Half-precessional climate forcing of Indian Ocean monsoon dynamics on the East African equator. Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Wolff C., G. Haug, B. Plessen, I. Kristen, D. Verschuren & CHALLACEA Participants (2008). Lake Challa (Kenya/Tanzania) sediments – a varved climate archive of environmental variability in equatorial East Africa of the last 25,000 years. Final EUROCLIMATE Conference, Giens (France), 29-30.09.2008.

Wolff, C., Haug, G., Plessen, B., Verschuren, D. & CHALLACEA Participants (2008). Lake Challa (Kenya/Tanzania) sediments: archive of climate and environmental variability in equatorial East Africa. EGU General Assembly, Vienna (Austria), 13.04.2008-18.04.2008.

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Maureen Fagot, Ghent University, Belgium: biological analyst, 2005-2007

Anna Lyaruu, Universiteit van Amsterdam, The Netherlands: biological analyst, 2005-2007

Iris Kristen, GeoForschungsZentrum Potsdam, Germany: PhD student, 2006-2008

Jort Ossebaar, University of Utrecht, the Netherlands, geochemical technician, 2005-2007.

Decadal Holocene and Late-Glacial variability of the oxygen isotopic compositionin precipitation over Europe reconstructed from deep-lake sediments (DECLAKES)

Abstract

DecLakes will provide six well-dated high-resolution records of the oxygen-isotope composition of past precipitation derived from ostracods in the profundal lake sediments from the Northern, Western and Southern margin of the Alps and from North-eastern Poland. The wide spatial distribution will allow to decipher in particular regional variations of past climate variability. A network of highly experienced research groups of which each will apply their specific knowledge in isotope analyses, sedimentology and palaeoecology to all sediment cores guarantees a high degree of comparability of the individual data sets in terms of dating, analytical standards and data quality. These data sets will be used for data-modelcomparison applying a hierarchy of models equipped with the explicit modelling of water stable isotopes. The study concentrates on three time windows: (1) the last 1000 years, (2) the period around the prominent cold phase at 8,200 BP, and, (3) the Lateglacial with a special focus on the rapid high-amplitude changes. The expected outcome of the project will be a spatial view of decadal to centennial climate variability in Europe which will be used to better understand prevailing forcing mechanisms.

Partners

(CNRS, DFG, FWF, CICYT)

Ulrich von Grafenstein (project leader)
Laboratoire des Sciences du Climat et de l'Environnement, Gif sur Yvette, FR

Nils Andersen
University of Kiel, Kiel, DE

Angel Baltanás
Universidad Autónoma de Madrid, Madrid, ES

Achim Brauer
Geoforschungszentrum Potsdam, Potsdam, DE

Dan Danielopol
Österreiche Akademie der Wissenschaften, Mondsee, AT

Collaborative Research Project (CRP)
1. General information
Project Reference Number : : **04-ECLIM-FP029** Acronym / Short Title: **DecLakes** Full Title: **Decadal Holocene and Late-glacial Variability of the Oxygen Isotopic Composition in Precipitation over Europe Reconstructed from Deep-lake Sediments** Project Leader name: **Ulrich von Grafenstein** Project Leader affiliation: *LSCE, URM CEA-CNRS-USQV, Gif-sur-Yvette, France* Institutional home page (URL): www.lsce.ipsl.fr Project-related home page (URL): http://declakes.von-grafenstein.com/ Reporting period: 20/06/2005 to 30/09/2008
2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)
IP 1
Principal Investigator (name & affiliation): Ulrich von Grafenstein, LSCE
IP2
Principal Investigator (name & affiliation): Nils Andersen, Leibniz-Labor Kiel
IP3
Principal Investigator (name & affiliation): Achim Brauer, GFZ-Potsdam
IP4
Principal Investigator (name & affiliation): Dan Danielopol, ÖAW, Mondsee
IP5
Principal Investigator (name & affiliation): Angel Baltanas, Univ. Autonoma Madrid

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

DecLakes allowed to obtain new stable isotope records from three lakes (Mondsee, Austria; Lago d'Iseo, Italy; Jezioro Hancza, Poland) and to increase the temporal resolution of existing records from two other lakes (Lac d'Annecy, France; Ammersee, Germany). Although important steps of the project are still in progress, the available results (Lac d'Annecy, Ammersee, Mondsee) already allow concluding that, during the last 1500 years, the oxygen isotopic composition of meteoric precipitation ($\delta^{18}O_P$) varied in concert along a ca. 700 km long transect parallel to the northern European Alps. Comparison with homogenized air temperatures over the observation period (the last 200 years) in addition confirms that $\delta^{18}O_P$ is an excellent proxy for the mean annual air temperatures.

The isotope-based Central European temperatures for the last 1500 yaers significantly differ from those derived from tree-ring time series, which, for the last 1000 years indicate lower than present temperatures with suppressed multi-decadal and centennial amplitudes and a dramatic increase only for the last 150 years. In our records, temperatures as high as the reference period (1960-1990 AD) are reached or exceeded several times during the Little Ice Age (for example between 1500 and 1530 AD). During the Medieval Warm Period (before 1300 AD) temperatures vary around or slightly above those of the reference period and frequently exceed even the last decadal mean. The reason for this discrepancies between tree-ring and isotope based reconstructions might be that tree-rings react preferentially to warm season temperatures, whereas our $\delta^{18}O_P$ records reflect pluri-annual temperature means. In addition, the statistical treatment applied to tree-ring width series in order to remove tree growth trends, tend to also reduce possible climatic trends with similar slopes. Our results risk altering significantly the understanding of natural climate variations in Europe for the youngest pre-industrial millennium, with consequences regarding appropriate forcing scenarios and model sensitivities. Obviously, our results will be taken up to argue against greenhouse gas induced warming. Our results therefore need very strict scientific quality control (with respect to chronology and quantification) and careful wording, which unfortunately is considerably delaying the publication.

For the last deglaciation (15000 to 10000 years BP) the new records show excellent agreement to the Greenland ice core records concerning the frequent centennial events, and the chronological position and relative amplitudes of the shifts bracketing the YD cold event. However, the mean levels and longer term trends of the individual records differ considerably, thus confirming a picture already indicated by the comparison of the Ammersee and the Central Greenland isotope records. We are still working on detailing the record from Lac d'Annecy, but the available data (Ammersee, Mondsee, and the low resolution record from Lac d'Annecy) already allow to conclude that during the Bølling/Allerød warm phase an additional North/South gradient built up with significantly warmer temperatures over Southern Europe, which lasted until about 10 000 years BP, when present day gradients were established.

New highly resolved results for the Mid-Holocene time-stream, selected to characterize decadal climate variability during a period which in average was most probably warmer than the last 1000 years, for the moment only come from the new Mondsee record. However, our results give an excellent confirmation of the timing and amplitude of the 8.2k cold event in Central Europe.

The CRP allowed impressing progress in dating the new and existing records, by bundling the sedimentological expertise from the GFZ-Potsdam group with that of the AMS-^{14}C group from Kiel. The quality of the records could be improved by significant contributions from the involved micropalaeontologist and ostracod biologist. They could develop new methods to identify juvenile instars of common candonids to the species level. However, the most important impact of the CRP to the project was the multiplication of laboratory capacity. It took more than 15 years to achieve less data from Ammersee by one group, but only three years for the DecLakes consortium to finish a completely new record (Mondsee) from scratch.

4. What did you not achieve in the CRP and why? (max 1 p.)

Please use the original proposal as reference and explain any deviations from the work plan

Despite a careful site selection and excellent sedimentary resolution, the sediment core for Lago d'Iseo turned out to be problematic concerning the quantitative reconstruction of $\delta^{18}O$. The ostracod assemblages found in many of the samples is a mixture of 'in-situ' fauna and valves transported from shallow water. Their isotopes are biased towards lower values for oxygen (due to the warmer calcification temperatures in shallow water) and towards higher for carbon (due to the stronger carbon sequestration in the productive epilimnion). We could not overcome this problem by selecting exclusive deep-lake fauna, because the species found living in 100 m also occupy the shallow water zones. We therefore decided to re-sample Lago d'Iseo in a follow-up project and to put the remaining DecLakes resources into the successful search for a new coring site, where the morphological conditions preclude contamination by shallow water fauna, but still warrant high sedimentation rates and hypolimnic low temperature conditions.

The progress with condensing the existing records from Ammersee and Annecy was hampered by the lack of technical staff in LSCE and by the important, larger than expected, implication of the co-ordinator in the other sites. New core material for the last millennium, which was necessary to obtain fresh materiel for a varve-based chronology, has been obtained from Ammersee. Ostracod related laboratory work on this material and on existing material from Lac d'Annecy, covering the last 1000 years is almost finished.

A general problem was the asynchronous funding (more than one year delay between official onset of the funding period in France and Austria), compared to Spain and Germany. In consequence, the main personal for a crucial part (dating by lamina counting) could join the group only after the field work was already very much developed. It is also one of the reasons for the delay of this report.

During the project, the co-ordinator had to take a 7 month time-out for health reasons (August 2006 to February 2007), which also contributed to some delay in reporting and publication activities.

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

Other than many national funding programmes, EUROCORES in general, and EuroCLIMATE specially, encourage real interdisciplinary projects with international participation. National projects with important participations from atmospheric sciences, geosciences, and biology very often suffer from rejection by reviewing panels dominated by one of the disciplines.

At least for DecLakes, EUROCORES funding by the national agencies allowed taking advantage of the subtle differences in funding preferences of the agencies to re-balance the overall project budget.

EUROCORES networking activities largely increase the communication and stimulate collaboration between the different CRPs.

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

As already mentioned above, the project suffered from asynchronous start of funding. Better co-ordination and communication between the participating agencies would have helped to overcome this problem. We also would have liked to have a stronger role of the ESF in the communication between CRP-partners and their national agencies. The role of the co-ordinator is rather limited in this case.

The EuroCLIMATE call mentioned a minimum funding period of 5 years, which was restricted to the initial 3-period

during the project runtime. Because of the rather labour intensive data production part of the project, we counted on the second funding round for the exploitation and data analyses.

Although the final EuroCLIMATE conference was certainly a big success, a meeting of as much as possible EuroCLIMATE participants, with a detailed presentation of the CRPs within the first year of the funding period would certainly have stimulated cross CRP interaction.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Danielopol, D.L., Baltanás, A., Namiotko, T., Geiger, W., Pichler, M., Reina, M., Roidmayr, G. 2008. Developmental trajectories in geographically separated populations of non-marine ostracods: morphometric applications for palaeoecological studies. *Senckenbergiana lethaea*, **88**: 183-193.

Danielopol, D.L., Gross, M., Piller, W.E., Baltanás, A. 2008. Ostracods of the Paratethys Sea and Lake Pannon – Perspectives for renewal of cooperative projects. *Senckenbergiana lethaea*, **88**: 141-145.

Lauterbach, S., Brauer, A., Plesse, B, Zamelczyk, K., Namiotko, T., Hüls, M., Andersen, N., von Grafenstein, U., Danielopol, D.L. and DecLakes participants, in press. Multiproxy evidence for Lateglacial to mid-Holocene environmental and climatic changes in Northeastern Poland. *Boreas*.

Danielopol, D.L., Namiotko, T., Lauterbach, S., Brauer, A., Andersen, N., Hüls, M., Baltanás, A., von Grafenstein, U.. *Candona neglecta* Sars (Ostracoda, Candonidae) - Shape variability of valves at a deep site of lake Mondsee (Austria) during the Lateglacial and the Holocene. To be submitted to *International Review of Hydrobiology.*

Namiotko, T. Danielopol, D.L., Pichler, M., von Grafenstein, U. in press. *Fabaeformiscandona harmsworthi* (Scott, 1899) – an Arctic ostracod species (ostracoda) in Late Glacial and Early Holocene sediments of lake Mondsee (Austria). *Crustaceana*.

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

1 D. Patents and industry collaborations

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

DecLakes internal networking strategy was

- to have at least one three-days meeting per year,
- to maintain a public and member-restricted web-page,
- in addition to an FTP-site for data exchange.

Meetings were held in Mondsee, Austria (February 2005), Chambéry, France (March 2006), Potsdam, Germany (May 2007), and Matalascañas, Spain (June 2008). At least two persons of each group actively participated in each meeting. Those meetings were very constructive, with excellent presentations and complete update of all partners concerning the new results. The exchange was also fostered by several bi-lateral visits, mainly to finish the first manuscripts.

The four field campaigns (Mondsee, June 2005; Jezioro Hancza, September 2005; Lago d'Iseo/Sebino, October 2005; Lago d'Iseo/Sebino, April 2006) were at least as important for networking as the scientific meetings, not only by providing 'ready-to-use' samples and field experience for all partners, but also through intensive and lively discussion.

The use of the FTP-site for data exchange was satisfying, but could have been ameliorated by installing a common

database adopted to the very heterogeneous data.

1 F. Participation in other conferences

Please list only the most relevant

Marc Desmet, Jérôme Nomade, Aurélie Leroux, Urich von Grafenstein & Membres DECLAKES, 2005 : Carottages de grands lacs Européens: Sédimentologie et chronologie des remplissages, reconstitutions décennales des températures depuis le Tardiglaciaire. 10ème Congrès Français de Sédimentologie, Presqu'île de Giens

von Grafenstein, U., Leroux, A., Nomade, J., Andersen, N., Desmet, M., Erlenkeuser, H., Belmecheri, S., Reyss, J.-L. and DecLakes Participants, 2006 : A new 600-years long oxygen-isotope record from Lac d'Annecy (France) exhibiting sub- to multidecadal temperature variability in Europe. *General Assembly of European Geosciences Union 2006, Vienna. Geophysical Research Abstracts,* 8: 08645

Namiotko, T., Danielopol, D.L., Baltanás, A., von Grafenstein, U., Brauer, A., DecLakes Participants. 2006. Late-Glacial and Holocene ostracod sequences from lacustrine sediments of lake Mondsee (Austria). *General Assembly of European Geosciences Union 2006, Vienna. Geophysical Research Abstracts*, 8: 06076.

Namiotko, T., Pichler, M., Danielopol, D.L., Roidmayr, G. 2006. Eine arktische Ostracodenart (Crustacea: Ostracoda) im Spät Glacial und frühen Holozän Sediment des Mondsees. In: *SIL-Austria Treffen. Programm, Abstracts,*. Universität Innsbruck, Innsbruck.

Danielopol, D.L., Baltanás, A., Namiotko, T., Geiger, W., Pichler, M., Reina, M., Roidmayr, G. 2007. Developmental trajectories of the carapace shape and size in geographically separated populations of *Candona candida* (O.F. Muller) and *Candona neglecta* Sars (Crustacea, Ostracoda) – the interest for palaeoecological studies. In: Lord, A., Franz, C. (eds) *19th International Senckenberg Conference – 6th European Ostracodologist's Meeting, Abstract Volume*: 26. Senckenberg Forschngsinstitut und Naturmuseum, Frankfurt/Main.

Lauterbach, S. Andersen, N. Milecka, K., Namiotko, T., Zamelczyk, K., Brauer, A. 2007. A multi-proxy record of climate change at the Lateglacial / early Holocene transition from Lake Hańcza, Northeastern Poland. In: Röhling, H.-G., Breitkreuz, Ch., Duda, Th., Stackebrandt, W., Witkowski, A., Uhlmann, O. (eds) *Geo-Pomerania 2007 – Geology cross-bordering the Western and Eastern European Platform. Joint-Meeting of DGG (Deutsche Gesellschaft für Geowissenschaften) and PTG (Polskie Towarzystwo Geologiczne* Szczecin, 2007. *Schriftenreihe der Deutschen Gesellschaft fur Geowissenschaften*, 53: 163.

Namiotko, T., Danielopol, D.L., DecLakes Participants 2007. Ostracod succession in Post-glacial lacustrine sediments of lake Mondsee (Austria). In: Krzymińska, J. (ed.) *Abstracts of 6th Polish Micropalaeontological Workshop MIKRO-2007*: 51. Polish Geological Institute, Gdańsk.

Namiotko, T., Pichler, M., Danielopol, D.L. 2007. *Fabaeformiscandona harmsworthi* (Scott, 1899) – an Arctic ostracod species (Ostracoda) in Late Glacial and Early Holocene sediments of lake Mondsee (Austria). In: Lord, A., Franz, C. (eds) *19th International Senckenberg Conference – 6th European Ostracodologist's Meeting, Abstract Volume*: 67. Senckenberg Forschngsinstitut und Naturmuseum, Frankfurt/Main.

Namiotko, T., Pichler, M., Danielopol, D.L., Roidmayr, G., DecLakes Team. 2007. An Arctic ostracod species (Crustacea: Ostracoda) in Late Glacial and Early Holocene sediments of lake Mondsee (Austria). *General Assembly of European Geosciences Union 2007, Vienna. Geophysical Research Abstracts*, 9: 01372.

Pichler, M., Namiotko, T., Danielopol, D.L., Picot, L., von Grafenstein, U., Roidmayr, G., Stracke A. 2007. The phylogenetical and biogeographical history of the *Fabaeformiscandona caudata* (Kaufm.) lineage (Ostracoda, Candonidae). In: Lord, A., Franz, C. (eds) *19th International Senckenberg Conference – 6th European Ostracodologist's Meeting, Abstract Volume*: 27. Senckenberg Forschngsinstitut und Naturmuseum, Frankfurt/Main.

Swierczynski T.**,** Lauterbach S., Brauer A., and DecLakes Participants. 2008. Detrital layers as a sedimentary record of

historical flood events - A case study from Lake Mondsee (Upper Austria). *General Assembly of European Geosciences Union 2008, Vienna. Geophysical Research Abstracts*, 10: 07966.

Lauterbach S. , Brauer A., Dulski P., Plessen B., K. Zamelczyk,, Milecka K., Andersen N., Hüls M., and DecLakes Participants. 2008. Multi-proxy evidence for delayed early Holocene warming in Northeastern Poland from Lake Hancza sediments General *Assembly of European Geosciences Union 2008, Vienna. Geophysical Research Abstracts*, 10: 02776

von Grafenstein U., Belmecheri S., Andersen N., and DecLakes Participants. 2008. Stable isotope records from deep lakes Sebino (Italy) and Ohrid (Albania/Macedonia). *ESF MedCLIVAR meeting on "Oxygen isotopes as tracers of Mediterranean climate variability"*. June 2008, Pisa

Danielopol, D.L., Baltanás, A., Andersen, N., Brauer, A., Geiger, W., Erlenkeuser, H., Hüls, M., Lauterbach, S., Namiotko, T., Piccin, A., Pichler, M., Montserrat, R., Roidmayr, G., von Grafenstein, U. 2008. The usage of the ostracod *Candona candida* (O.F. Müller) as companion to *Candona neglecta* Sars for ecostratigraphy of deep-lake sediments in Europe. In: *EuroCLIMATE: Climate variability and past, present and future carbon cycle. Book of Abstracts, Final EuroCLIMATE Conference*: 17-18. European Science Foundation, Giens.

Namiotko, T. Danielopol, D.L., Pichler, M., von Grafenstein, U., Roidmayr, G., Stracke, A., DecLakes Participants 2008. Arctic and psychrophilic ostracod species (Ostracoda) in Lateglacial and Early Holocene sediments of lake Mondsee (Austria). In: *EuroCLIMATE: Climate variability and past, present and future carbon cycle. Book of Abstracts, Final EuroCLIMATE Conference*: 55-56. European Science Foundation, Giens.

von Grafenstein, U. 2008. Stable Isotope Records from Lake Sediments as Quantitative Palaeoclimate Proxies. NICE (Network of Ice sheet and Climate Evolution) autumn school, Poznan, Poland, October 6th- 10th , 2008

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

PI Danielopol, ÖAW, Mondsee (Austrian Science Fund, FWF –Project I35-B06)

- Doz. Dr. Tadeusz Namiotko (Univ of Gdansk, Department of Genetics, Gdansk), post-doc & junior investigator 2005 (05.07-0.4.09), 2006 (01.07-30.09), 2007 (01.07-30.09), 2008 (15.07-30.09)
- Mrs. Gertraud Roidmayr (Mondsee) technical assistant, 1.04.2005-31.07.2005 (halftime) and 1.08.2005-31.12. 2007 (fulltime)

PI Brauer, GFZ-Potsdam (Deutsche Forschungsgemeinschaft, DFG, BR2208/2-2)

- Dipl.-Geol. Stefan Lauterbach, PhD-student, 15/07/2006 – 14/07/2009, defence planned for December 2009

PI von Grafenstein, LSCE, UMR 12572 CEA-CNRS-UVSQ, CNRS-INSU

- Pierre-Alain Danis, Post-Doctoral fellow, April 2006-March 2008

PI Baltanas, UAM Madrid

- Walter Geiger (Ph D), research contract. 1.3.2006 to 28.2.2007.
- Montserrat Reina (Graduate), technical assistant. 1.3.2006 to 31.10. 2007.

PI Andersen, Leibniz-Labor für Altersbestimmung und Isotopenforschung (DFG, An554/1-1,2)

- Dr. rer. nat. Helmut Erlenkeuser, scientist, 1.10.2006 to 15.1.2007

Rapid climatic and environmental shifts during oxygen isotope stages (OIS) 2 and 3 - linking high-resolution terrestrial, ice core and marine archives (RESOLuTION)

Abstract

Understanding the complex palaeoenvironmental behaviour associated with the rapid centennial- to millennial-scale climate instabilities (Dansgaard-Oeschger oscillations; Heinrich events) during the last glacial period, is one of the major issues in paleoclimate research at present. These dramatic changes, seen in ice-core and marine archives, have rarely been recognized on land. The scarcity of terrestrial records, which allow documenting these instabilities as well as large dating uncertainties prevent detailed, time-synchronous correlations between land, ocean and ice core archives, which are necessary if the roles played by the different parts of Earth's environmental system are to be understood. RESOLuTION will address these issues by linking high-resolution, multi-proxy marine, terrestrial and ice-core records through detailed geochronology and time-synchronous tephra horizons. It will explore the impact of abrupt climatic changes on Paleolithic populations in Europe and perform transient simulations with a coupled atmosphere-ocean-vegetation model to simulate realistic Dansgaard-Oeschger stadial-interstadial changes. RESOLuTION will finally propose a scenario which could explain a possibly different timing and impact of Dansgaard-Oeschger climate variability on the Atlantic Ocean and the adjacent European regions and will thus contribute significantly to the discussion on underlying mechanisms of sub-orbital climate variability.

Partners

(CNRS, FNU, NWO, VR)

Barbara Wohlfarth (project leader)
Stockholm University, Stockholm, SE

Sjoerd J.P. Bohncke
Vrije Universiteit Amsterdam, Amsterdam, NL

Francesco d'Errico
Université Bordeaux I, Talence, FR

Sigfus Johnsen
University of Copenhagen, Copenhagen, DK

Hans Renssen
Vrije Universiteit Amsterdam, Amsterdam, NL

Maria Fernanda Sanchez Goñi
Université de Bordeaux 1, Talence, FR

Stefan Wastegard
Stockholm University, Stockholm, SE

Karin Helmens
Stockholm University, Stockholm, SE

Tine Rasmussen
University of Tromsø, Tromsø, NO

Collaborative Research Project (CRP)
1. General information
Project Reference Number : : **04-ECLIM-FP33** Acronym / Short Title: RESOLuTION Full Title: **Rapid climatic and environmental shifts during Oxygen Isotope Stages (OIS) 2 and 3 – linking high-resolution terrestrial, ice core and marine archives** Project Leader name: ***Barbara Wohlfarth*** Project Leader affiliation: ***Stockholm University*** Institutional home page (URL): www.geo.su.se Project-related home page (URL): http://www.geo.vu.nl/~cmeerb/RESOLuTIONwebsite/Resolution-webpage.html Reporting period: 01/01/2005 to 18/09/2008
2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)
IP1
Principal Investigator (name & affiliation): Karin Helmens, Stockholm University
Total Funding amount of the IP : 0 **(IP1did not receive any funding from the Swedish Research Council)**
IP2
Principal Investigator (name & affiliation): Sjoerd Bohncke, VU University Amsterdam
Total Funding amount of the IP : 166 k€
IP3
Principal Investigator (name & affiliation): Barbara Wohlfarth, Stockholm University
Total Funding amount of the IP: 172 k€
AP4
Principal Investigator (name & affiliation): Tine L Rasmussen, Tromsø University
Total Funding amount of the IP : 0 **(AP4 did not receive any funding from the Norwegian Research Council)**
IP5
Principal Investigator (name & affiliation): Maria Fernanda Sánchez-Goñi, UniversitéBordeaux 1
Total Funding amount of the IP : 95 k€ **(IP5 received much less money than the 149 k€ applied for)**
IP6
Principal Investigator (name & affiliation): Sigfus Johnsen, Copenhagen University
Total Funding amount of the IP : 200 k€
IP7
Principal Investigator (name & affiliation): Stefan Wastegård, Stockholm University
Total Funding amount of the IP : 70 k€
IP8
Principal Investigator (name & affiliation): Francesco d'Errico, Université Bordeaux 1
Total Funding amount of the IP : 41.8 k€ **(IP8 received much less money than the 86 k€ applied for)**
IP9
Principal Investigator (name & affiliation): Hans Renssen, VU University Amsterdam
Total Funding amount of the IP : 178 k€

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

1. Most important achievements

Terrestrial records (WP 1.1, 1.2, 1.3)

Terrestrial records included in RESOLuTION were the site Sokli in northern Finland, Nochten and Reichwalde in Germany and Les Echets in south-central France. Nochten and Reichwalde had to be excluded from further analyses within the project because the extensive dating exercise showed that they were much older than OIS 3. Instead focus was placed on detailed high-resolution multi-proxy analyses of the lacustrine sequence at Sokli.

The investigations of the Sokli sequence indicate ice-free and warm conditions during the early part of Stage 3. Aquatic fossils show warming to present-day summer temperatures during at least part of the ice-free interval. The inferred terrestrial vegetation was remarkably similar to the present-day shrub tundra in northern Fennoscandia. It is suggested that the early Stage 3 interstadial interval recorded at Sokli probably correlates to the prominent Interstadial (IS) 14 at ~53 ka in the Greenland ice core record. In agreement with the proxy-based reconstructions, the first experiments of the climate model simulation for average Stage 3 interstadial conditions (IP 6 'Modelling') suggest high mean July temperatures for the sector northeast of the Scandinavian Ice Sheet. In the model, warm summer conditions are the combined result of enhanced July insolation compared to present and northwesterly winds advecting cool, but very dry air from the ice sheet. The combination of high insolation and dry air leads to a strong sensible heat flux and relatively warm conditions near the surface.

The multi-proxy and high-resolution study of the Les Echets lake sediment sequence in France provides the first detailed and continuous terrestrial record in Europe for the later part of OIS 3. Dansgaard-Oeschger climate variability had a dramatic impact on the lake and its surrounding and the proxy parameters show that the lacustrine and terrestrial systems responded in tandem to rapid climate variability. Diatom inferred summer temperature reconstructions moreover suggest that summer temperatures changed only slightly between DO-interstadials and stadials, while changes in winter and spring temperatures seem to have been much more pronounced. These latter findings support modeling experiments.

Marine records (WP 2.1, 2.2)

Here we only report results from WP 2.2, since WP 2.1 was an associated partner and did not receive any project financing.

Work package 2.1, focused on the multiproxy study of four high resolution marine records from the North Atlantic subtropical and mid-latitudes distributed between 36°N and 45°N, has provided an array of terrestrial (pollen and microcharcoal) and marine (foraminifers, dinocysts, sedimentological and geochemical tracers) climatic data allowing us to establish a direct correlation between eastern North Atlantic oceanic and western European environmental changes in response to the millennial-scale climatic variability (D-O events) of Marine Isotopic Stage (MIS) 2 and 3. These data have shown that:

a) the D-O events in the Mediterranean region were modulated by precession while at latitudes northern than 40°N, D-O events appears to be influenced by obliquity. The contrasting climatic scenario that we have identified during MIS2 and 3 has been compared with Greenland temperatures and with the global methane concentration curve showing that the variations in the Mediterranean climate parallel those of the methane record. On the basis of this similarity we have proposed that a common mechanism, changes in the intensity of monsoon, would control both the amplitude of methane emissions and that of the Mediterranean climate (particular wet winters and dry summers) during the last glacial period.

b) fire regime in both Mediterranean and Atlantic regions were primarily controlled by the amount of the

available biomass

c) two major climatic phases during the large episodes of iceberg discharges in the North Atlantic between 40 and 15 kyr (Heinrich events 1, 2 and 4): the first phase was characterised by a cold and humid climate in the western European margin and the second one by cooler and dryer conditions. We have proposed that the shifts between the first and the second phase were possibly related with changes in the predominant mode of the North Atlantic Oscillation which is the atmospheric mechanism which controls at present the wintertime in western Europe.

Greenland ice cores (WP 3)

The NGRIP ice core was sampled in great detail to find tephra particles. 134 ice core samples have been sub-sampled around the Z2 ash layer (GIS 14-16, GS 15-16) in the NGRIP ice core, and 227 new sub-samples covering GS 2, 11-15 and GI 1, 11-14 are currently under investigation. The sampling plan was based on volcanic events observed in the chemical records (ECM, DEP, SO_4, Ca, etc.). 134 samples were cut, centrifuged and mounted on SEM stubs. The samples were scanned using a SEM in order to identify samples with ash particles. Samples where ash was found will be prepared for microprobe analysis. This project has been delayed almost a year due to a serious injury suffered by our PhD student Inger Seierstad.

Other investigators have worked on tephra layers in the GRIP and the NGRIP ice cores locating several layers in the RESOLuTION time frame of investigation. Some of these layers have also been found in North Atlantic marine sediments providing an absolute link between the timing of atmospheric and oceanic climatic transitions.

The NGRIP core has been dated by counting annual layers back to 60 ka BP, thus providing the project with an independent absolute and highly accurate time scale. Furthermore, this work has been used to improve the dating of the EPICA deep ice cores in Antarctica.

Linking the records (WP 4)

We identified new tephra horizons in ice-cores and marine cores covering OIS 3 and are thus able to successfully correlate ice core and marine records along synchronous time intervals. However since no tephra could be found in the terrestrial records, they have to be correlated to marine and ice cores based on independent chronologies. For Sokli the establishment of a precise ^{14}C chronology was not possible, because the sediments were likely deposited during an early interval of OIS 3. For Les Echets we established a precise chronology and age model, based on numerous ^{14}C and IRSL dates, which can be used to correlate to marine and ice core sequences.

Climate-human interactions (WP 5)

The team working on climate human interaction (WP5) has applied with success novel predictive tools (Eco-Cultural Niche Modeling) to understand the impact of rapid scale climatic variability on human adaptation. In particular they have applied a biodiversity tool (GARP) to the archaeological record and modelled the human range during the Last Glacial Maximum (LGM).

They have also modelled the LGM distributions of reindeer and red deer, two main prey species of this time period, quantified and described their responses to climatic variability, and evaluated their respective role in shaping cultural identities. The team used the same approach to investigate Neanderthal extinction and demonstrated that this crucial population event was mainly determined by competition with modern humans rather than by climate change. These achievements have stimulated new research directions that will allow the members of this WP to tackle other human-environment interactions during the Paleolithic period in Europe and Africa.

Modelling (WP 6)

We performed, for the first time, transient simulations of a Dansgaard-Oeschger event using a coupled 3-dimensional coupled atmosphere-ocean-vegetation model. In these experiments we prescribed realistic boundary conditions, such as variations in orbital parameters, ice sheet extent and altitude, atmospheric greenhouse gas levels, atmospheric dust concentrations and melt-water discharges. Moreover, we also performed an extensive sensitivity experiments to

delineate the separate effects of these forcings.

Using the transient simulations, we performed a novel, detailed analysis of the day-to-day variability over a D-O onset, in order to study the change in characteristics of the summer season (e.g. length, peak warmth, growing season). This is relevant for our understanding of the response of biota to rapid climate change.

2. Could the same results have been achieved without involvement in the CPR?

Certainly not.

First of all, our group was composed of a variety of specialists covering topics such as marine cores, terrestrial records, ice cores, prehistory and modelling. This led to a very fruitful collaboration between different members of the ice core, marine, terrestrial and modelling community and made it possible to establish new links between tephra specialists and scientists representing the modelling and proxy data community. Moreover, our workshops attracted the attention of other specialists, and made it possible to also involve the speleothem community and a wider modelling community.

Secondly, when we realized that the sites Nochten and Reichwalde were too old for our project, the postdoc could easily switch topic and instead focus on work at the site Sokli. The involvement in Sokli would not have been possible otherwise.

Thirdly, the results obtained by WP 5 would not have been possible using traditional analytical approaches and without close interactions between archaeological members of WP5 and the others project teams, especially since no CNRS post-doc was provided to WP5. By demonstrating the efficacy of this approach this post-doc (W. Banks) obtained an NSF grant that has allowed him to further pursue this research in France.

Fourth, an important collaboration in this CRP has been the discussion and the ongoing application on our marine records of the new Greenland ice core chronology GICC05 developed by WP 3 (Ice cores led by Sigfus Johnsen). Unfortunately, the collaboration established with Stefan Wastegård (WP 4) to identify tephra and microtephra layers in our mid-latitude marine sequences has not been successfully due to the lack of volcanic particles in this region. In contrast, our data and discussions have been essential to WP5 on climate-human interactions (led by Francesco d'Errico) as a part of our data have been used to set up the climatic conditions of the Last Glacial Maximum, D-O and Heinrich events in the palaeoclimatic models involved in the GARP

3. Other achievements besides scientific results

A new thematic workshop "Quantitative climate reconstruction for Stage 3 based on multi-proxy evidence from Sokli (northern Finland)" was organized in Helsinki, November 15-16, 2007. Funding: NEPAL ("Nordic Network of Palaeoclimatology"), NordForsk.

Two workshops organized by one of our PI's (F. d'Errico) and one of our post-docs (W. Banks) in the framework of an ESF OMLL program served to form a bridge between two ESF programs (OMLL and EUROCLIMATE) in that they significantly contributed to the development of tools to model the impact of climate change on Paleolithic human and large mammal populations.

By demonstrating the efficacy of the approach applied in WP 4, W. Banks obtained an NSF grant that has allowed him to further pursue this research in France.

The achievements of WP 2.2 led to a strong involvement of the WP2.2 team in the QUEST-DESIRE project, a British-French collaborative project aiming to understand the variability of greenhouse gas concentrations at orbital and sub orbital time scales. Within this project we have developed a new initiative, the QUEST working group on abrupt climate changes (http://researchpages.net/QUESTD-O/) which assembles all researchers working on high resolution pollen records and reconstructing vegetation changes during Dansgaard-Oeschger (D-O) events. The first workshop, was organised by Sandy Harrison (U. Bristol), Maria Fernanda Sanchez Goni and William Fletcher (EPHE, U. Bordeaux 1) and the subsequent working group primarily aims to achieve: (i) The compilation of a database of global pollen records of D-O variability and the application of biomisation techniques required for quantitative evaluation of vegetation changes worldwide. (ii) A synthesis volume for Quaternary Science Reviews, summarising the current-state of knowledge of the vegetation response to short-term variability during Stages 4, 3 and 2 on a regional basis.

4. What did you not achieve in the CRP and why? (max 1 p.)
Please use the original proposal as reference and explain any deviations from the work plan

In two of our sites (Sokli, Les Echets) we could not find any tephra layers. Correlations to ice cores and marine records were therefore based on radiocarbon and OSL chronologies. One site (Nochten/Reichwalde) proved to be much older than anticipated and was thus no longer included in the project. Instead multi-proxy analyses were directed at a detailed investigation of the Sokli site, which had not received funding.
The most important deviation from the work plan is that tephra analyses in NGRIP are still ongoing (PhD student is on sick leave) and that we had limited or no success in the establishment of a tephrochronology framework for the terrestrial sequences. Hence we were not able to precisely link marine, ice-core and terrestrial sequences, based on tephra layers.

The model-data comparison for selected D-O event has not yet been achieved. However, it is important to note that the PhD project in WP6 (Climate modelling) is continued for one more year. In this remaining year, the model results will be compared to the proxy data compiled in the other work packages.

Collaboration was hampered and several of the aims outlined in the proposal could not be achieved because not all projects were funded as applied for in the application. This was the absolutely most important constraint for a successful work!

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

- 3-month work visit of C. Van Meerbeeck to Dr. J. Flückiger (ETH Zürich), resulting in joint model experiments and a joint publication.

- 4-year PhD project: "Quantifying the role of permafrost in climate change by means of numerical modelling and evaluation using present-day process measurement data and the geological archive", funded by the Netherlands Organization for Scientific Research (NWO). Project leader: H. Renssen.

- Postdoctoral position for Stefan Engels (PhD student) at Stockholm University to work with the Sokli site in Finland.

- 2-year funding to B. Wohlfarth by the Swedish Nuclear Waste Management Company to assemble OIS 3 data sets for Scandinavia.

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

- Many more high-resolution, multi-proxy analyses of long terrestrial sequences are needed to better understand the spatial variability and impact of rapid climate changes.
- Radiocarbon dating techniques need to be refined and explored more when dating such old sediments. OSL/IRSL dating of lacustrine sediments needs much more research before this technique can be fully employed.
- The application of modelling methods for better understanding climate-environment-human interactions should be explored further
- We recommend the development of a research programme on the response of biota to rapid climate change, including the effect of changes in seasonality.

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

- The fantastic opportunity to organize a research programme with scientists from different European countries

without the bureaucratic procedures involved in an EU project.

- Discussions with top specialists working with a variety of natural archives (lakes, stalagmites, marine, ice) and modeling. The RESOLuTION project has been an excellent possibility to meet colleagues with the same research interest in a relaxed atmosphere.
- Scholars from France, The Netherland, Norway, Germany, Denmark and Sweden collaborated in the research conducted in the framework of our CRP, co-authored research papers which stemmed from it, and attended the networking activities we organized. This has played a crucial role in structuring a community of European scientists interested in OIS 3-2 climate and human-climate interactions from various perspectives and helped to establish standards and protocols concerning the analysis, handling and interpretation of relevant paleoclimatic and archeological data.
- The integration of PhD and postdoctoral students in our yearly workshops helped them create new and own research networks. Moreover they had the possibility to meet scientists in a relaxed atmosphere
- The possibility to organize cross CPR workshops, summer schools and other meetings

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

- It was extremely unfortunate that not all projects within our CPR received funding, that some projects received much less funding than applied for, that some funding agencies were very slow with allocating the money and cut funding as they liked.
- The different national funding agencies should follow the evaluations of the project as made by the external reviewers, instead of implementing their own policies (which differ greatly between the different countries involved in the programme). IP 1.1 was evaluated very positively and should have got funding from the Swedish Research Council. The research carried out in IP 1.1 was instead funded by the Swedish and Finnish Nuclear Waste Management Companies (SKB and Posiva) and resulted in a large amount of publications in high standard international journals.
- We find it is **absolutely crucial** for the successful collaboration within a CRP, which had obtained very high evaluation scores, that all individual projects should have the same duration, that funding should be accordingly and that individual countries do not impose their own policies upon projects.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products

Please include only those resulting from the **joint work of two or more** CRPs (if any)

Banks, W.E., **d'Errico, F**.. Dibble, H.L., Krishtalka, L., West, D., Olszewski, D.I., Peterson, A.T., Anderson, D.G., Gilliam, J.C., Montet-White, A., Crucifix, M., Marean, C.W., **Sánchez-Goñi, M.-F.**, **Wohlfarth, B.**, **Vanhaeren, M.** (2006). Eco-Cultural Niche Modeling: New Tools for Reconstructing the Geography and Ecology of Past Human Populations, *Palaeoanthropology*, 68-83.

Banks, W. E., **d'Errico, F.**, Townsend Peterson A. Masa Kageyama M., Sima A., **Sanchez-Goni, M.-F** (under revision). Neanderthal Extinction by Competitive Exclusion, *PlosOne.*

d'Errico F., **Sánchez-Goñi, M.F.**, **Vanhaeren, M. 2006**. L'impact de la variabilité climatique rapide des OIS3-2 sur le peuplement de l'Europe. In : Bard, E. (Ed.), *L'homme face au climat*. Paris : Odile Jacob, pp. 265-282.

Sepulchre, P., Ramstein, G., Kageyama, M., **Vanhaeren, M.**, Krinner, G., **Sánchez Goñi, M.F.** & **d'Errico, F.** (2007). Neanderthal extinction delayed by an abrupt climatic change. *Earth and Planetary Change Letters*258: 283:292.

1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Ampel, L., **Wohlfarth, B**., **Risberg, J.**, **Veres, D.** (2008): Paleolimnological response to millennial and centennial scale climate variability during MIS 3 and 2 as suggested by the diatom record in Les Echets, France. *Quaternary Science Reviews,* 27, 1493-1504.

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*.

Andersen, K.K., **Svensson, A**., Rasmussen, S.O., Steffensen, J.P., **Johnsen, S.J.**, Bigler, M., Röthlisberger, R., Ruth, U., Siggaard-Andersen, M.-L., Dahl-Jensen, D., Vinther, B.M. and Clausen, H.B. 2006. The Greenland Ice Core Chronology 2005, 15-42 ka. Part 1: constructing the time scale. *Quaternary Science Reviews*, 25 (23-24), 3246-3257.

Banks, W.E., **d'Errico, F**., Peterson, A.T., **Vanhaeren, M.**, Kageyama, M., Sepulchre, P., Ramstein, G., Jost, A., Lunt, D. (2007). Human ecological niches and ranges during the LGM in Europe derived from an application of eco-cultural niche modelling, *Journal of Archaeological Science* 35, 2, 481-491.

Banks, W., **d'Errico, F**., Peterson, T. A., Masa Kageyama, M., Colombeau, G. (in press). Reconstructing ecological niches and geographic distributions of caribou (*Rangifer tarandus*) and red deer (*Cervus elaphus*) during the Last Glacial Maximum. *Quaternary Science Review*.

Blaauw, M., **Wohlfarth, B.**, Christen, J. A., **Ampel, L.**, **Veres, D.**, Hughen, K. A., **Preusser, F., Svensson, A**.: Were last glacial climate events simultaneous between Greenland and Western Europe? Submitted to *Climate of the Past.*

Bohncke, S. J. P., **Bos, J. A. A.**, **Engels, S.**, Heiri, O. and Kasse, C. (2008) Rapid climatic events as recorded in Middle Weichselian thermokarst lake sediments. *Quaternary Science Reviews,* 27, 162-174

Bos, J. A. A., **Helmens, K. F**., **Bohncke, S. J. P.**, Seppä, H., Birks, H. J. B. (*in revision).* Flora, vegetation and climate near Sokli, north-eastern Fennoscandia, during the Weichselian Middle Pleniglacial. *Boreas*, submitted.

Daniau, A.-L., Sánchez Goñi , M.F. & Duprat, J. Last glacial fire regime variability in western France inferred from microcharcoal preserved in core MD04-2845, Bay of Biscay. *Quaternary Research* (in revision).

Daniau, A.-L., **Sanchez Goñi, M.-F.,** Beaufort L., Laggoun-Défarge F., Loutre, M.-F. & **Duprat J.** (2007). Dansgaard-Oeschger climatic variability revealed by fire emissions in southwestern Iberia. *Quaternary Science Reviews*26: 1369-1383.

Davies, S. M., Wastegård, S., **Rasmussen, T. L.**, **Svensson, A.**, **Johnsen, S. J.**, Steffensen, J. P. Andersen, K. K. (2008): Identification of the Fugloyarbanki tephra in the NGRIP ice-core: a key tie-point for marine and ice-core sequences

during the last glacial period. *Journal of Quaternary Science 23,* 409-414.

EPICA community members (2006), One-to-one coupling of glacial climate variability in Greeland and Antartctica, *Nature*, Vol. 444, p. 195-198, doi10.1038/nature05301 (……**S. J. Johnsen**….)

Engels S., **Bohncke, S. J. P**., **Bos, J. A. A.**, Brooks, S. J., Heiri, O., **Helmens, K. F.** (2008) Chironomid-based palaeotemperature estimates for northeast Finland during Oxygen Isotope Stage 3. *Journal of Paleolimnology 40 (1), 49-61*.

Engels S., **Bohncke, S. J. P.**, Heiri, O., Nyman, M. (2008) Intraregional variability in chironomid-inferred temperature estimates and the influence of river inundations on lacustrine chironomid assemblages. *Journal of Paleolimnology,* 40 (1), 129-142.

Engels, S., **Bohncke, S. J. P.**, **Heiri, O.**, Schaber, K., Sirocko, F. (2008) The lacustrine sediment record of Oberwinkler Maar (Eifel, Germany): chironomid-based inferences of environmental changes during Oxygen Isotope Stage-3. *Boreas* 37, 414-425.

Fletcher, W.F. & **Sánchez Goñi, M.F.** (in press). Orbital- and sub-orbital-scale climate impacts on vegetation of the western Mediterranean basin over the last 48,000 years. *Quaternary Research* doi:10.1016/j.yqres.2008.07.002

Helmens, K.F., **Bos, J.A.A**., **Engels, S**., **Van Meerbeeck, C**., **Bohncke, S.J.P.**, **Renssen, H.**, Heiri, O., Brooks, S. J., Seppä, H., Birks, H. J. B., **Wohlfarth, B.** (2007): Present-day temperatures in northern Scandinavia during the Last Glaciation. *Geology*, 35, 987-990.

Helmens, K.F., **Risberg, J.**, Jansson, K.N., Weckström, J., Berntsson, A., Kaislahti Tillman, P., Johansson, P.W. and **S. Wastegård** (*in revision*). Early MIS 3 glacial lake evolution, ice-marginal retreat pattern and climate at Sokli (northeastern Fennoscandia). *Quaternary Science Reviews*.

Huber, C., Leuenberger, M., Spahni, R., Flückiger, J., Schwander, J., Stocker, T.F., **Johnsen, S.**, Landais, A. and Jouzel, J. 2006. Isotope calibrated Greenland temperature record over Marine Isotope Stage 3 and its relation to CH_4. *Earth and Planetary Science Letters*, **243**(3-4), 504-519.

Naughton, F., Sánchez Goñi , M.F., Kageyama, M., Bard, E., **Duprat, J**. , Cortijo, E., Desprat, S., **Malaizé, B.**, Joly, C., Rostek, F. & Turon, J-L. Wet to dry climatic trend in north western Iberia within Heinrich events. *Earth and Planetary Science Letters* (in revision).

Naughton, F., **Sanchez Goñi, M.F.,** Desprat, S., **Turon, J-L.**, **Duprat, J., Malaizé, B.**, Joli, C., Cortijo, E., Drago, T., & Freitas, M.C. (2007). Present-day and past (last 25 000 years) marine pollen signal off western Iberia. *Marine Micropaleontology*62: 91-114.

Rasmussen, S.O., **Seierstad, I.K**., Andersen, K.K., Bigler, M., Dahl-Jensen, D. and **Johnsen, S.J.** (2006): Synchronization of the NGRIP, GRIP, and GISP2 ice cores across MIS 2 and palaeoclimatic implications. *Quaternary Science Reviews*, 25, 3246-3257.

Rasmussen, T.L., Thomsen, E., 2004. The role of the North Atlantic Drift in the millennial timescale glacial climate fluctuations. *Palaeogeogr., Palaeoclim.,Palaeoecol*. 210, 101-116.

Rasmussen, T.L., Thomsen, E., Ślubowska, M.A., **Jessen, S.**, Solheim, A., Koç, N. (2007). Paleoceanographic evolution of the SW Svalbard margin (76°N) since 20,000 ^{14}C yr BP. *Quaternary Research*, 67, 100-114.

Rasmussen, T.L., Thomsen, E., 2008. Warm Atlantic surface Water inflow to the Nordic seas 34-10 calibrated ka B.P. *Paleoceanography*, 23, PA1201, doi:10.1029/2007PA001453.

Roche, D.M., T.M. Dokken, H. Goosse, **H. Renssen**, S.L. Weber, (2007): Climate of the Last Glacial Maximum: sensitivity studies and model-data comparison with the LOVECLIM coupled model. *Climate of the Past* 3, 205-224.

Roche, D.M., **H. Renssen,** S.L. Weber, H. Goosse, Could meltwater pulses have been sneaked unnoticed into the deep ocean during the last glacial? (2007) *Geophysical Research Letters* 34, L24708, doi:24710.21029/22007GL032064.

Sánchez Goñi, M.F., Landais, A., **Fletcher, W., Naughton, F.,** Desprat, S. & **Duprat, J.** (2008). Contrasting impacts of Dansgaard-Oeschger events over a western European latitudinal transect modulated by orbital parameters. *Quaternary Science Reviews* 27: 1136-1151.

Siggaard-Andersen, M., Hansson, M., Fischer, H., Bigler, M., Roethlisberger, R., Goto-Azuma, K., Steffensen, J., Ruth, U., Andersen, K.K., Clausen, H.B., Jonsell, U., Walløe Hansen, A. and **Johnsen, S.J**. 2006. A continuous IC glaciochemical

record of the last glacial period from NGRIP ice core. *Geophysical Research Abstracts*, 8, 07796.

Svensson, A., Andersen, K.K., Bigler, M., Clausen, H.B., Dahl-Jensen, D., **Davies, S.M**., **Johnsen, S.J.**, Muscheler, R., Rasmussen, S.O., Röthlisberger, R., Steffensen, J.P. and Vinther, B.M. 2006. The Greenland Ice Core Chronology 2005, 15-42 ka. Part 2: comparison to other records. *Quaternary Science Reviews*, 25 **(**23-24), 3258-3267.

Svensson, A., Andersen, K.K., Bigler, M., Clausen, H.B., Dahl-Jensen, D., **Davies, S.M., Johnsen, S.J**., Muscheler, R., Parrenin, F., Rasmussen, S.O., Röthlisberger, R., **Seierstad, I**., Steffensen, J.P. and Vinther, B.M. Submitted to Climate of the Past, November 2007. A 60,000 year Greenland stratigraphic ice core chronology.).

Van Meerbeeck, C., **H. Renssen,** D.M. Roche, How did Marine Isotope 3 and Last Glacial Maximum climates differ? Perspectives from equilibrium simulations. *Climate of the Past* (submitted).

Veres, D., **Davies, S.M**., **Wohlfarth, B., Preusser, F.**, **Wastegård, S.**, **Ampel, L.**, Hormes, A., Possnert, G., Raynal, J.-P. & Vernet, G., (2008): Age, origin and significance of a new middle MIS 3 tephra horizon identified within a long-core sequence from Les Echets, France. *Boreas 37,* 434-443*.*

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

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).

Wastegård, S., **Rasmussen, T.L**, Kuijpers, A., Nielsen, T., & van Weering, T.C.E. (2006): Composition and origin of ash zones from Marine Isotope Stages 3 and 2 in the North Atlantic. *Quaternary Science Reviews 25,* 2409-2419*.*

Wohlfarth, B., **Veres, D.**, **Ampel, L.**, Lacourse, T., **Blaauw, M.**, **Preusser, F**., **Andrieu-Ponel, V.**, Kéravis, D., Lallier-Vergès, E., Björck, S., **Davies, S.M.,** de Beaulieu, J.-L., **Risberg, J.**, Hormes, A., Kasper, H.U., 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.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

Interview H. Renssen in Dutch monthly popular science magazine *Natuurwetenschap & Techniek* on "The origin of the Younger Dryas", April 2008.
Interview H. Renssen in Dutch Daily Newspaper *Trouw* on "The next ice age", 10 March 2008.
Interview H. Renssen in Dutch Radio programme *Hoe?Zo! Radio* on "Climate reconstructions covering the last deglaciation", 7 November 2007.
Interview H. Renssen in Dutch Radio programme *Hoe?Zo! Radio* on "The next ice age", 8 October 2007.
Interview S. J. Johnsen in Icelandic TV Station 2 on climate instability, August 2005.

1 D. Patents and industry collaborations

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

- Annual CRP workshops:

  2005 France, 2006 Sweden, 2007 The Netherland, 2008 France

- Annual CRP meetings at EGU General Assembly in Vienna
- Joint sampling of sediments for tephra layers

1 F. Participation in other conferences

Please list only the most relevant

The list below only contains a small part of those conferences where RESOLuTION members presented their research. This list is by no means complete!

2005 (Participation, Oral Presentations, Posters, Abstracts)

EGU General Assembly, Vienna 2005

Bohncke J. P., d'Errico F., Helmens, K., Johnsen, S., Rasmussen T. L , Renssen H., Saanchez Goni M. F. Wastegard S. Wohlfarth B. 2005. Rapid climatic and environmental shifts during OIS 2 and 3 – linking high-resolution terrestrial, ice core and marine archives, presentation of a recent ESF Eurocore project. *European Geosciences Union 2005*, Geophysical Research Abstracts, Vol. 7, 03697.

Academy Colloquium Early Holocene Climate Oscillations-Causes and Consequences. April 2005 KNAW Amsterdam (Wastegård)

INTIMATE Workshop 2005 on Iceland (Wastegård, Davies).

d'Errico F., Sanchez Goni M. Vanhaeren M. 2005. The Impact of the D/O Climatic Variability on Upper Paleolithic Populations. *Exploring the potential of Eco-cultural Niche Modeling for reconstructing the geography of past human population*s. ESF/NSF international workshop, Les Eyzies 22-26th of September 2005.

SCOTAV International Field Workshop and Tephrochronology and Volcanism, Dawson City, Canada, 2005

Carlsberg Dating Conference, Copenhagen, 15-18/8 2005 (poster presentation I. Seierstad).

Nordic Branch meeting, International Glaciological Society, Copenhagen, 3-5/11 2005 (I. Seierstad).

Geofysikdag, Dansk Geofysisk Forening, Niels Bohr Insitute, 11/11 2005 (I. Seierstad).

2006 (Participation, Oral Presentations, Posters, Abstracts)

EGU General Assembly, Vienna 2006 (C. Van Meerbeeck & H. Renssen, Maria Fernanda Sanchez Goni, Daniel Veres, Linda Ampel, Barbara Wohlfarth, Sigfús J. Johnsen, Inger Seierstad)

Daniau, A.-L., Sánchez Goñi M. F., d'Errico, F., European Geosciences Union (EGU) General Assembly, Vienna, Austria, Avril 2006. Oral presentation: Fire and climatic variability during the last 140,000 years in South Western Iberia.

Fletcher, W., Sanchez Goñi M. F., Sierro, F.J., Cacho, I., European Geosciences Union (EGU) General Assembly, Vienna, Austria, Avril 2006. Oral presentation: Vegetation response to rapid climatic variability in the Alboran Sea region (W. Mediterranean) during the last 30 kyr.

AGU fall meeting, San Francisco, USA, 2006 (H.Renssen)

Dutch Climate Variability Symposium, Royal Netherlands Academy of Sciences, Amsterdam, The Netherlands, 10 October 2006 (C. Van Meerbeeck & H. Renssen)

Rapid climate change, International Science Conference, Birmingham UK, 24-27 October 2006 (H. Renssen)

Volcanism in the Arctic System, Magnitude, Geochronology, and Climate Impacts

Workshop held in Iceland 29-30 April 2006. (S.J.Johnsen, I. Seierstad)

Banks, W. E., and Francesco d'Errico 2006 Eco-Cultural Niche Modeling of European Human Populations during the Last Glacial Maximum. Paper presented at the 2006 Paleoanthropology Meetings, April 24–26, San Juan, Puerto Rico.

Banks, W. E., Anta Montet-White, A. Townsend Petereson, Francesco d'Errico, Marian Vanhaeren 2005. Eco-Cultural Niche Modeling Applied to the Solutrean: A Feasibility Study. Paper presented at the OMLL-NSF International Symposium on Eco-Cultural Niche Modeling: Exploring the Potential of Eco-Cultural Niche Modeling for Reconstructing the Geography of Past Human Populations, Sept. 22–26, Les Eyzies, France.

Carlsberg Dating Conference, Copenhagen, Denmark 2006 (Wastegård, Wohlfarth, Johnsen, and many others)

Workshop in Marine Paleoproductivity, Tromsø-Hammerfest, March 26-29, 2006.

George P.L. Walker symposium on Advances in Volcanology, Reykholt, Iceland, 12–17 June 2006

2007 (Participation, Oral Presentations, Posters, Abstracts)

EGU General Assembly, Vienna 2007 (C. Van Meerbeeck & H. Renssen, Maria Fernanda Sanchez Goni, Daniel Veres, Linda Ampel, Barbara Wohlfarth)

Naughton, F., Sanchez Goñi, M.F., J. Duprat, E. Cortijo, B. Malaizé, C. Joly, E. Bard, F. Rostek, J-L. Turon. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 2007. Oral presentation: Complex pattern of Heinrich events in mid-latitudes of the North-east Atlantic explained by oceanic and atmospheric mechanisms.

AGU fall meeting, San Francisco, USA 2007 (B Wohlfarth, TL Rasmussen and many others)

Rasmussen, T.L., Thomsen, E., Ślubowska-Woldengen, M., Jessen, S.P., Solheim, A., Koç, N., 2007. Water masses and brine formation on the southwestern Svalbard margin (76°N) during the last 20,000 ^{14}C years. AGU Fall Meeting, San Francisco, 10-14 Dec. 2007.

Snowball, I., Nilsson, A., Rasmussen, T., 2007. Late Quaternary Geomagnetic Excursions at High Northern Latitudes in Marine Sediments: Reproducing Results for the Wrong Reasons? AGU Fall Meeting, San Francisco, 10-14 Dec. 2007.

Rasmussen, T.L., Thomsen, E., Ślubowska-Woldengen, M., Jessen, S.P., Solheim, A., Koç, N. The interplay of Atlantic Water, polar water and meltwater on the southwestern Svalbard margin (76°N) during the last 20,000 ^{14}C yr. 20th Nordic Winter Meeting, Stavanger Jan. 8-10, 2007. NGF Abstracts and Proceedings of the Geological Society of Norway, 1, p.78.

Jessen, S.P., Rasmussen, T.L., Nielsen, T., Solheim, A. A stacked magnetic susceptibility chronology for the W. Svalbard margin (0-23 ka BP). International Conference on Arctic Margins (ICAM V), Tromsø 3-7 September, 2007.

International workshop on Past, Present and Future Climate Dynamics, Feedback Mechanisms, and Land – Atmosphere Interactions, Helsinki, Finland, 22-23 October 2007 (H.Renssen)

International workshop on Arctic natural climate change. University of Tromsø, Norway, 12-14 November 2007 (H.Renssen)

IUGG 24th General Assembly, Perugia, Italy, July 2-16, 2007. (H. Renssen)

d'Errico, F., Vanhaeren M. 2007. Archaeological evidence for migrations and cultural interaction in the Middle and Upper Palaeolithic. *Migrations* OMLL-ESF Workshop, Porquerolles, 5-7 septembre 2007.

Banks, W. E., 2007 Eco-Cultural Niche Modeling: Evaluating Prehistoric Human-Environment Interactions. Paper presented at the University of Cambridge, Department of Anthropology, October 19, Cambridge, United Kingdom.

Banks, W. E., F. d'Errico, A. T. Peterson, M. Vanhaeren, M. Kageyama, P. Sepulchre, G. Ramstein, A. Jost, D. Lunt. 2007 How Environmental Conditions of the Last Glacial Maximum Affected Human Ranges. Poster presented at the Colloque de Restitution du Programme ECLIPSE II, October 15-16, Paris.

Banks, W. E., 2007 Eco-Cultural Niche Modeling: Synchronic and Diachronic Evaluations of Prehistoric Human-Environment Interaction. Paper presented at the European Science Foundation EUROCLIMATE meeting: Radiocarbon and Ice-Core Chronologies during Glacial and Deglacial Times, March 5-7, Heidelberg, Germany.

Banks, W. E., 2007 Eco-Cultural Niche Modeling: Synchronic and Diachronic Evaluations of Prehistoric Human-Environment Interaction. Paper presented at the Modelling Hominid Dispersals workshop, March 2, Montreal, Canada.

Helmens, et al. (2007). Ice free and warm conditions in the central area of the Scandinavian glaciations during MIS 3. 17th INQUA, Cairns, Australia.

Bos et al. 2007. Abrupt climatic events during OIS3 recorded in terrestrial sediments in NW Europe: multi-proxy approach. 17th INQUA, Cairns, Australia.

Carlsberg Dating Conference, Copenhagen, Denmark 2007

INQUA, International Union for Quaternary Research, Cairns, Australia, 2007

Sanchez Goñi, M.F., Landais, A., Naughton, F., Fletcher, W., Desprat S., Cortijo, E., Bard' E.& F. Rostek, XVII INQUA Congress, Cairns (Australia), July 2007. Oral presentation: Contrasting impacts of Dansgaard-Oeschger oscillations over a western European latitudinal transect (36°N-45°N).

Naughton, F., Sanchez Goñi, M. F., Turon, J-L., Duprat, J., Cortijo, E., Malaizé, B., Joli, C., Bard, E. and Rostek, F. 9th International Conference on Paleoceanography (ICP9), Shanghai (China), September 2007. Poster: Wet to dry climatic trend in north western Iberia within Heinrich events. STUDENT POSTER AWARD

2008 (Participation, Oral Presentations, Posters, Abstracts)

9th Netherlands Earth Sciences Conference, Veldhoven, The Netherlands, 18-19 March 2008 (C. Van Meerbeeck & H. Renssen)

EGU General Assembly, Vienna 2008 (C. Van Meerbeeck & H. Renssen, Maria Fernanda Sanchez Goni)d'Errico F., Sanchez Goni M.-F., Vanhaeren, M. 2008. Expectations of the impact of climatic variability of OIS3-2 on human demography and cultural diversity in Europe. Table Ronde Internationale ESF-OMLL *Us and Them. Modeling past genetic, linguistic, and cultural boundaries*. Université Bordeaux 1, Haut Carré 15-17 Mai 2008.

Sanchez Goñi, M.F., Landais, A., Fletcher, W., Naughton, F., Desprat S. & Duprat, J., European Geosciences Union (EGU) General Assembly, Vienna, Austria, Avril 2008. Oral presentation: Contrasting impacts of Dansgaard-Oeschger events over a western European latitudinal transect: Implications for the location of main sources of glacial CH_4.

Jessen, S.P., Rasmussen, T.L., 2008. Millenial scale climate change during Marine Isotope Stage (MIS) 3 and 2 - Preliminary results from the West Svalbard Slope. Geophysical Research Abstracts, 10. EGU General Assembly, Vienna, Austria 13-18 April, 2008.

Banks, W. E., F. d'Errico, A.T. Peterson, M. Kageyama, M.F. Sanchez-Goni. 2008 Assessing the climatic hypothesis for Neanderthal extinction using Eco-Cultural Niche Modeling. Paper presented at the Sixth World Archaeology Congress, June 29–July 4, Dublin, Ireland.

Banks, W. E., 2008 Possible relationships between cultural boundaries and large mammal ecological niches during the LGM. Paper presented at the OMLL (ESF-funded) networking meeting "Us and Them: Modeling past genetic, linguistic, and cultural boundaries", May 15–17, Talence, France.

Helmens et al. (2008). Weichselian vegetation dynamics in the central area of the Scandinavian glaciations recorded in a long sediment sequence from Sokli (N-Finland). 33rd IGC Oslo, Norway.

Fletcher, W.J. & Sanchez Goñi, M.F., 12th International Palynological Congress, Bonn (Germany), September 2008. Oral presentation: Western Mediterranean forest response to climatic variability during the last climatic cycle.

Penaud, A., Eynaud, F., Turon, J.-L., 12th International Palynological Congress, Bonn (Germany), September 2008. Oral presentation: Climatic and paleohydrological interactions between the Mediterranean Sea and the Atlantic Ocean during the Last Glacial cycle.

QRA 6th International Postgraduate Symposium, Aug. 21.-24, 2007, Copenhagen I. Seierstad).

WAIS Divide science meeting, Oct. 3.-5. 2007, Lake Tahoe, USA. Preparation for field work in Antarctica.

NEEM steering committee meeting, Copenhagen, Nov. 6.7, 2007.

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme

Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

Cedric Van Meerbeeck, PhD student, start date: 18 July 2005, end date: 19 July 2009. PhD not yet achieved (planned in 2009)

Dr Stefan Engels, PhD 2008

Daniel Veres, PhD 2007 (financed 2007)

Linda Ampel, PhD defense planned for November 2008 (financed 2005-2006)

Dr. Johanna Bos, post Doc. Starting date 18.05 2005, end date 18.05 2009.

William Banks, CNRS Post-Doc sept. 1 2005- Aug. 31 2006; CNRS contract oct. 1 2006 – Jan 31 2007; CNRS contract March 1 2007 to Apr. 30 2007.

Guillaume Colombeau, PhD student, CNRS contract 1 Jan 2006-30 March 2006

Annika Berntsson, laboratory assistant (now PhD student), ca 3 months in total, 2007-2008

Inger Seierstad PhD student (2005 – ongoing)

William J. Fletcher, CNRS Post-doctoral position 15/11/05 to 15/11/06

Quaternary marine ecosystem response to fertilization: Mediterranean sapropel events and implications for marine carbon uptake (MERF)

Abstract

Within the Late Quaternary record of the Eastern Mediterranean basin, sapropel horizons indicating periodic anoxia have long been recognised. Recent research has shown that these form in response to natural fertilization of the Mediterranean Sea and occur every 23,000 years, suggesting that the forcing mechanism is a precessional modulation of monsoon strength. The mechanisms of ecological change and propagation of nutrients through the surface ocean ecosystem remain poorly constrained. This limits our ability to use anoxic events to predict likely analogue situations as a result of present day climate change and eutrophication. A new multi-proxy approach will be implemented to reconstruct both, the extent of the response in marine productivity and the supporting nutrient fluxes to climate change. Further, we aim to monitor changes in the carbon system by analysing the key Mediterranean calcifying marine phytoplankton, coccolithophorids. To quantify the change in trophic conditions in the past, we will refine our proxies using a unique combination of culture samples, sediment trap material, core top sediments, and sub-recent sediments (to evaluate diagenetic overprinting). These refined proxies will then be applied to time intervals corresponding to three defined phases of enhanced fertility over the last 200 kyr (sapropels 1, 5, and 6).

Partners

(CNRS, DFG, NWO)

Patrizia Ziveri (project leader)
Vrije Universiteit Amsterdam, Amsterdam, NL

Kay-Christian Emeis
University of Hamburg, Hamburg, DE

Heather Stoll
Universidad de Oviedo, Oviedo, ES

Luc Beaufort
Université Aix-Marseille III, Aix-en-Provence, FR

Ian Probert
Université de Caen, Caen, FR

Antoni Rosell-Mele
Universitat Autonoma de Barcelona, Bellaterra, ES

Cesare Corselli
Milano-Bicocca University, Milano, IT

Maria Triantaphyllou
University of Athens, GR

Collaborative Research Project (CRP)
1. General information
Project Reference Number : : **04-ECLIM-FP35** Acronym / Short Title: **MERF** Full Title: **QUATERNARY MARINE ECOSYSTEM RESPONSE TO FERTILIZATION: MEDITERRANEAN SAPROPEL EVENTS AND IMPLICATIONS FOR MARINE CARBON UPTAKE** Project Leader name: **PATRIZIA ZIVERI** Project Leader affiliation: **VRIJE UNIVERSITEIT AMSTERDAM** Institutional home page (URL): **www.vu.nl** Project-related home page (URL): **www.gpi.uni-kiel.de/~sm/Meier/MERF.html** Reporting period: 20/06/2005 to 30/09/2008
2. Individual Projects (IPs) and Associated Partners (APs) of the Collaborative Research Project (CRP)
IP 1
Principal Investigator (name & affiliation): **Patrizia Ziveri, Vrije Universiteit Amsterdam, Netherlands**
Total Funding amount of the IP : 223.907
IP2
Principal Investigator (name & affiliation): **Kay-Christian Emeis, University of Hamburg, Germany.**
Total Funding amount of the IP : 105.450
IP3
Principal Investigator (name & affiliation): **Luc Beaufort, Université Aix-Marseille III, Aix-en-Provence, France.**
Total Funding amount of the IP: 46.088
IP4
Principal Investigator (name & affiliation): **Ian Probert, Université de Caen, Caen, France**
Total Funding amount of the IP : 93.572
AP1
Principal Investigator (name & affiliation): **Heather Stoll, Universidad de Oviedo, Oviedo, Spain.**
AP2
Principal Investigator (name & affiliation): **Cesare Corselli, Milano-Bicocca University, Milano, Italy.**
AP3
Principal Investigator (name & affiliation): **Maria Triantaphyllou, University of Athens, Greece.**
AP4
Principal Investigator (name & affiliation): **Antoni Rosell-Mele, Universitat Autonoma de Barcelona, Bellaterra, Spain**

3. What are the achievements of the Collaborative Research Project (CRP) (max 2 p.)

Please provide a brief overview of the most important achievements of the CRP, including

- Information on how and if the same results could have been achieved without the involvement in the CRP
- any other achievement beside the scientific results such as:
  - new directions, new ideas, new questions, new formulations, new topics for research, new thematic workshops which came out of this CRP etc

The ESF-project MERF aims to detect the impact of changes in fertilization on marine productivity and carbonate response in the present and during times of natural Quaternary fertilization in the Mediterranean Sea. This enclosed Sea is presently characterized by low primary production but in the recent past changes in nutrient fluxes were occurring, modulated by monsoon cycles. A suite of new proxy indicators derived largely from inorganic chemistry of primary producing coccolithophorids (dominant calcareous phytoplankton group in the Mediterranean Sea), $\delta^{15}N$ and organic compounds, and C:P ratios in sediments were used to characterize the modern Mediterranean and during the Quaternary productivity change. The type of sampling approach we have used included culture experiments, plankton community, sinking particles in sediment traps, surface sediments and core material.

The principal new productivity proxy is based on the Sr/Ca ratio of coccolith calcite. Recent culture and field studies suggest that the Sr/Ca ratio has potential as an indicator of nutrient-stimulated coccolithophorid growth rates. In the MERF project we have applied a combined new techniques allowing the separation of quasi-monospecific coccolith assemblages, enabling detailed work on minor and trace elements of individual coccolith species. In addition, we used a new technique for geochemical analysis using Secondary Ion Mass Spectrometry ion probe analysis on single, individually picked coccoliths. Our results show that the coccolith Sr/Ca ratios in the Mediterranean sediment trap samples, surface sediments and spanning the most recent sapropel S1 are lower than the ones found in previous sediment trap studies or recent sediments from the Sargasso Sea, Bay of Bengal and Arabian Sea. In fact we have registered the lowest coccolith Sr/Ca ratios ever recorded. This would not only confirm the present day nutrient starving marine ecosystem conditions in the basin but also that the productivity was not so much higher during sapropel 1 deposition. In sediment trap samples, the amplitude of seasonal variation in the Sr/Ca ratio is small. This could reflect significant attenuation of seasonal productivity variations due to long residence of coccoliths in the water column because of low export efficiency.

We compared the coccolithophorid calcite $\delta^{18}O$ and alkenone-temperature signature ($U^{k'}_{37}$ -index) from the same organism (*Emiliania huxleyi*). Paired measurements of alkenone $U^{k'}_{37}$ and calcite $\delta^{18}O$ are uniquely suited to deconvolve the temperature and salinity effects on the $\delta^{18}O$ signal and provide separate temperature and salinity records. Interestingly we could quantitatively trace the increase in primary productivity during the most recent sapropel 1 (S1). This increase mimics the change in $\delta^{18}O$ of sea water (calculated by *E. huxleyi* $\delta^{18}O$ and $U^{k'}_{37}$ temperature), thus suggesting that freshwater input was a major mechanism of nutrient delivery. However, an increase during sapropel formation in the relative abundance of *Florisphaera profunda*, a deep-dwelling species, indicates that deep photic zone productivity was increased, probably due to the release of nutrients from the anoxic sediments that were mixed into the deeper photic zone. Anoxic sediments are missing in the Western Mediterranean (only organic reach layers), which may explain the different trend observed there. In the overall S1 productivity data set from the eastern Mediterranean we could detect an increase in production, not as a eutrophic modern region but rather under the influence of very moderate production. In contrast, in the western Mediterranean, coccolith Sr/Ca-derived productivity didn't change during the organic rich layer (quasi-equivalent to the eastern Med S1 layer). This suggests that the formation of this layer in the western Mediterranean is mainly controlled by bottom water circulation but not production.

In the MERF project we also monitored the response of coccolith calcification to fertilization and the possible implication for carbon burial. We were able to show that coccolithophore species react differently to fertilization events in the modern Mediterranean Sea than to longer periods of increased productivity during sapropel formation in the Quaternary. A sediment trap study from the Gulf of Lions has shown that coccolithophore production is dominated by *E. huxleyi*. This species reaches highest fluxes in the traps during times of highest chlorophyll concentration in the water column, i.e. during late winter to early spring (January to April). During this time the coccoliths are also larger and better calcified than during the rest of the year. This is in accordance with the culturing experiments that have shown that coccoliths formed at higher growth rates are generally better calcified.

When regarding extended periods of organic carbon accumulation during sapropel S1 deposition in the Eastern Mediterranean (~9000 to 5000 years BP), a different pattern is observed. A comparison of cores on a W-E transect through the Mediterranean has shown that *E. huxleyi* weight and size decreases in the Eastern Mediterranean, whereas it slightly increases in time equivalent series of the Western Mediterranean. Despite generally higher levels of productivity in the eastern Mediterranean, which should lead to a size and weight increase in *E. huxleyi* according to sediment trap and culture observations, we observed a size and weight decrease instead. This may be explained by different fertilization mechanisms.
The examination of laminated sediments from the S5 sapropel in the Eastern Mediterranean has shown that the variability in assemblages (*F. profunda* vs. *E. huxleyi*), and size and weight of *E. huxleyi* between dark and light laminae within the sapropel is at the same level as between the non-sapropelic and sapropelic sediments. This indicates that the formation of sapropels was probably not a process in which the Mediterranean Sea was permanently in a high fertilization state, but which was a lot more variable, probably even on an interannual to seasonal scale.

The recent (oligotrophic) Mediterranean N-cycle was compared to former times when change in nutrient fluxes is expected (during sapropels) with emphasis on the use of the stable isotope ratio $^{14}N/^{15}N$, indicative for sources and availability of nutrients in the photic zone. To complicate matters, early diagenesis also has an impact on the $\delta^{15}N$ of the sedimentary record. To estimate these alterations we used an index of organic matter degradation (Degradation Index, DI) that is calculated from the relative abundance of 14 amino acids. Interestingly, the ^{15}N data give evidence (after normalization by the DI) that the isotopic signature of the source nitrogen (assimilated in the photic zone) was the same during several highly productive sapropel intervals (S1, S5, S6) and in the modern setting of the Eastern Mediterranean Sea. This implies that nitrogen cycling possibly was not that fundamentally different during sapropel deposition in comparison to the present day; that it was different has been postulated in numerous previous studies. Differences in $\delta^{15}N$ and organic carbon contents could be mainly attributed to preservational effects.
Present day C to P ratios in Mediterranean deep sea sediments range from 15 to 40, mainly between 20 and 35. This obvious deviation from the Redfield ratio of 106:1 in primary produced organic matter results from the following reasons: (i) the P analysed is bulk material, including organic and mineral phases (i) under oxic water and sediment conditions, C is remineralized while P is adsorbed onto Fe-oxides. Mediterranean sapropels are characterized by enormously enhanced C:P ratios of 60 to 110 in the examined S1 sapropels and peaks with C:P>600 in the S5 sapropel. The obvious difference to the recent situation is witness of a completely different system of nutrient cycling during anoxic sapropel deposition. Increase in C:P ratios is mainly caused by the preferential preservation of C, due to water column and sediment anoxia. P concentrations in sapropels are barely elevated over non-sapropel background sediments; we believe that the sapropel sediments do not report the original composition of primary produced organic matter. This discrepancy is caused by release of phosphorous under oxygen-deficient conditions at the sea floor. Release and assimilation (after convection into the photic zone) of phosphate originally released from the anoxic sediment-water-interface during sapropel times may be one reason for the elevated productivity that must have occurred during sapropel deposition.

A second topic not directly related to fertilization became apparent during our investigations. Calcification in *E. huxleyi* seems to be also strongly related to the carbonate saturation state. A long-term decrease in lith weight of *E. huxleyi* is superimposed on the annual variability observed in the sediment trap series in the Gulf of Lions. This decrease is paralleled by a decrease of carbonate ions, probably due to the increase of CO_2 uptake from the atmosphere.

In surface sediments from the Mediterranean Sea the effect of elevated levels of carbonate ion concentration can be observed. Whereas weight distributions within *E. huxleyi* are very homogenous in the Western Mediterranean Sea, a lot more variability can be observed in the Eastern Medietrranean. This can be explained by the carbonate saturation levels, which are generally higher in the Eastern Mediterranean. Therefore the observed change in size and weight during sapropel formation is most probably also due to changes in the carbonate saturation state of the Eastern Mediterranean.

The various groups working in the project have enormous respective abilities to perform a range of important and related analyses. However without the CRP network structure, these efforts would have been a lot more disparate and far less coordinated. As a result of the CRP, this work was coordinated in a central and directive fashion, facilitating overall greater productivity, output, and impact.

4. What did you not achieve in the CRP and why? (max 1 p.)
Please use the original proposal as reference and explain any deviations from the work plan

The main deviation and delay from the original proposal was the exclusion (at least as work packages) of the two Spanish teams. This was caused by a lack of financial support from the Spanish government. This should be avoided in the future, and all European governments that sign on as participatory to a European CRP should be equally willing, capable, and responsive to actually deliver required support in a timely fashion. I sincerely hope that this situation can be rectified in the near future.

The different work packages started at different times, as well as the postdoc and PhD positions, which also caused delays to the beginning of initial project activities. Consequently, we are now in a phase of rapidly producing manuscripts for publication.

It would be useful to have a similar report as this next year, but only for publication listing to update the record of production.

5. Are there any follow-up activities related to the CRP and the EUROCORES Programme? (max 1 p.)

5. A. Please give details of any new research project (i.e. within FP7, COST Action, etc) or any spin-off company that was developed as a result of the collaboration of the CRP and the EUROCORES Programme (short-term strategies- next 2/3 years)

I participated in the development and submission of a team proposal to the ESF EUROCORES program on ocean acidification, also including the Mediterranean region.

5. B. Please give recommendations for future developments of the area and research priorities to ESF and to Funding Agencies (long-term strategies-next 5/10 years)

In my opinion future development should include anthropogenic marine environmental issues and paleo studies. Modern environmental threats are reasonably clear due to observed impacts in a variety of ways. However, further paleo-studies are required to place these into a longer-term and pre-anthropogenic perspective. Only this way will human influences on the modern oceans be fully appreciated and understood, with policy-oriented implications toward resource protection and use. Furthermore, climatic changes and consequences in the marine environment (including ocean acidification) are critical to understand more fully in this sense, with far greater reading of the past records to give us a sense of scale and perspective.

6. Your feedback on the EUROCORES Programme (max 1 p.)

6.A. What, in your view, is the added value of being part of a EUROCORES Programme

In my view this program successfully facilitated a fruitful and productive collaboration toward a broad-scale environmental issue. It brought together various research lines and efforts that would have otherwise been much more discrete and separate from one another. Consequently, collaborations have been enhanced, expanded, and improved, and much future success and impact will ultimately be able to be credited to what has begun here in a more formalized fashion.

6.B. Give any critical and constructive comments on the EUROCORES Programme and its procedures

As described above, requiring all governments that agree to participate to actually deliver financially would be a significant improvement and step forward. In our case, Spain was disappointing in this respect, however I am sure that in other cases not all governments were collectively of equal reliability this way.

Appendix 1. List of Products of the CRP

1 A. Joint publications and products
Please include only those resulting from the **joint work of two or more** CRPs (if any)

Auliaherliaty, L., Stoll, H.M., Ziveri, P., Malinverno, E., Triantaphyllou, M., Stavrakakis, S., and Lykousis, V. Coccolith Sr/Ca ratios in the Eastern Mediterranean: production versus export processes. Subm. to *Marine Micropaleontology.*

Beaufort, L., Probert, I., and Buchet, N., (2007) Effects of acidification and primary production on coccolith weight: Implications for carbonate transfer from the surface to the deep ocean, *Geochemistry Geophysics Geosystems*, 8, Q08011, doi:210.1029/2006GC001493, 2007.

Malinverno, E., Triantaphyllou, M.V., Ziveri, P., Stavrakakis, S., and Lykousis, V., Seasonal and spatial variability of coccolithophore export production at the south-western margin of Crete (eastern Mediterranean). Subm. to *Marine Micropaleontology*.

Malinverno, E., Prahl, F. G., Popp, B. N., **Ziveri, P.** (2008) Alkenone abundance and its relationship to the Coccolithophore Assemblage in Gulf of California, *Deep-Sea Research Part I*, 55 (9): p.1118-1130.

Triantaphyllou, M.V., Antonarakou, A., Kouli, K., Dimiza, M., Kontakiotis, G., **Ziveri, P.**, Mortyn, G., Lykousis, V., Dermitzakis, M.D., 2007. Plankton ecostratigraphy and pollen assemblage zones over the last 14 000 years in SE Aegean Sea (core NS-14). *Bulletin of the Geological Society of Greece* XXXX: 209-224.

Triantaphyllou, M.V., Ziveri, P., Gogou, A., Marino, G. , Lykousis, V., Bouloubassi, I., **Emeis, K.-C.**, Kouli, K., Dimiza, M., **Rosell-Melé, A.**, Papanikolaou, M., Katsouras, G., Nunez, N. Late Glacial-Holocene climate variability at the south-eastern margin of the Aegean Sea. Submitted to *Marine Geology.*

Publications to be submitted in 2008-2009

Auliaherliaty, L., Prins, M.A., **Mobius, J., Meier, S., Emeis, K., Beaufort, L. and Ziveri, P.** Spatial distribution of Late Holocene fluvial and aeolian origin sediments in the Eastern Mediterranean Sea: a possible link with marine productivity. *Marine Geology.*

Auliaherliaty, L., Ziveri, P., and Stoll, H. Eastern Mediterranean sapropel 1 (S1) dynamics from coccolith chemistry. *Paleoceanography*.

Meier K.J.S., Beaufort L., Schneider A., **Ziveri P.** Influence of carbonate saturation on coccolithophore morphometry and calcification in the Mediterranean Sea. *Biogeosciences*.

Meier K.J.S., Beaufort L., Kucera M., Schulz H., **Ziveri P.** Productivity and carbonate saturation induced variability in coccolithophore morphometry and carbonate production during sapropel S1 formation. *Marine Micropalaeontology.*

Meier K.J.S., Beaufort L., Emeis K.-C., Ziveri P. Fast coccolithophore productivity and carbonate production changes during sapropel S5 formation. *Paleoceanography*.

Meier K.J.S., Beaufort L., Heussner S., Goyet C., **Ziveri P.** Decrease in coccolithophore carbonate production as a response to rapid anthropogenic CO_2 uptake in the Mediterranean Sea. *Science*.

Conferences, abstracts:
Auliaherliaty, L., Ziveri, P., and Stoll, H.M., 2008. Eastern Mediterranean sapropel 1 (S1) dynamics from coccolith chemistry. International Nannoplankton Association 12th Meeting Abstracts, Vol 12, 12th International Nannoplankton Association (INA) Meeting Lyon, France.

Auliaherliaty, L., Stoll, H.M., Ziveri, P., Malinverno, E., Triantaphyllou, M., Stavrakakis, S., Lykousis, V., 2008. Coccolith Sr/Ca ratios in the Eastern Mediterranean: production versus export processes. Geophysical Research Abstracts, Vol. 10, EGU General Assembly Vienna, Austria.

Auliaherliaty, L., Prins, M.A., and Ziveri, P., 2007. Late Holocene aeolian dust and coccolith stable isotope records from the Mediterranean Sea: does aerosol fertilization affect biological productivity? Geophysical Research Abstracts, Vol. 9, 03556, EGU General Assembly Vienna, Austria.

Auliaherliaty, L., Ziveri, P., Troelstra, S.R., Prins, M.A., Stoll, H.M., and Emeis, K.-C., 2006. Phytoplankton response to marine fertilisation during sapropel formation in the eastern Mediterranean Sea. Geophysical Research Abstracts, Vol. 8, 00693, EGU General Assembly Vienna, Austria.

Katsouras, G., Gogou, A., Emeis,K-C., Bouloubassi, I., Ziveri, P., Triantaphyllou, M.V., Möbius, J., Lianou, V., Lykousis, V., 2007. High-Resolution Paleoclimatic Records In The Eastern Mediterranean (Aegean Sea) During The Last 20 Kyrs: A Biogeochemical Approach. 9th International Conference on Paleoceanography, 3-7 September 2007, Shanghai, China, Book of Abstracts, p.190.

Kontakiotis, G., Antonarakou, A., Mortyn, P.G., Triantaphyllou, M.V., Bouloubassi, I., Ziveri, P., Lykousis, V., Dermitzakis, M.D., 2008. Temperature and water column conditions linked to sapropel S1 formation in the Aegean Sea: planktonic foraminiferal, Mg/Ca, and Uk'37 evidence. EGU General Assembly, Vienna, Austria.

Malinverno, E.; Triantaphyllou , M.; Stavrakakis , S.; Ziveri , P.; Lykousis, V., 2007. Coccolithophore export production and flux at the south-western margin of Crete (Eastern Mediterranean). EGU General Assembly, Vienna, Austria.

Meier K.J.S., Möbius J., Beaufort L., Emeis K.-C., Ziveri P. 2008. The laminated sapropel S5 from ODP core 971C - deciphering the seasonal productivity signal during sapropel formation. TMS joint foram and nanno meeting, Tübingen, Germany.

Meier K.J.S., Beaufort L., Emeis K.-C. Ziveri P. 2007. Coccolithophore morphometry and calcification during the sapropel S1 time interval in the Mediterranean Sea. TMS joint foram and nanno meeting, Angers, France.

Meier K.J.S., Beaufort L., Heussner,S., Emeis K.-C., Ziveri P. 2007. Coccolithophore response to changes in the carbonate system of the Mediterranean Sea. ICP IX, Shanghai, Japan.

Meier K.J.S., Beaufort L. 2006. A seven year coccolith carbonate flux record from the NW Mediterranean Sea. EGU, Vienna, Austria.

Meier K.J.S., Beaufort L., Heussner S. 2006. Seasonal and interannual dynamics of coccolith carbonate production in the Gulf of Lions (NW Mediterranean Sea). INA11, Lincoln, USA.

Triantaphyllou , M.V., Ziveri , P., Lianou, V., Mortyn , G., Lykousis , V., Dermitzakis , M.D., 2008. Sea water $\delta^{18}O$ variability surrounding sapropel S1 deposition in the Aegean Sea. EGU General Assembly, Vienna, Austria.

Triantaphyllou, M.V., Antonarakou, A., Kontakiotis, G., Dimiza, M ., Ziveri, P., Mortyn, G., Lianou, V., Lykousis, V., Dermitzakis, M.D., 2007. Calcareous nannofossil and planktonic foraminiferal assemblages and paleoecological reconstruction of sapropel S1 in SE Aegean Sea. EGU General Assembly, Vienna, Austria.

Triantaphyllou, M., Antonarakou , A., Lourens, L., Ziveri, P., Tsolakis, E., Tsaila-Monopolis, S., Theodorou, G., Dermitzakis, M., Kontakiotis, G., Konstantinidou, E., Athanasiou, M., 2008.
Calcareous plankton events and climate variability during late Zanclean in the eastern mediterranean (Pissouri basin, Cyprus), 33th International Geological Conference (IGC), Oslo, Norway.

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Lianou, V., Ziveri, P., Mortyn, P.G., Lykousis, V., 2008. Comparing late glacial – Holocene plankton ecozones and pollen assemblage zones in the south – eastern Aegean Sea: evidence for climatic variability (E. Mediterranean), "Climate Extremes During Recent Millenia and their Impact on Mediterranean Societies", Symposium organized by MedCLIVAR, ESF, PAGES, Mariolopoulos-Karaginis Foundation, NKUOA, Academy of Science, Athens, Greece.

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1 B. Publications and products of individual projects

Please include only those resulting from research carried out **within the CRP (both joint and individual)**

Ziveri, P., Thoms, S., Langer, G., Geisen, M., Universal carbonate ion effect on stable oxygen isotope ratios in unicellular planktonic calcifying organisms, *Geochmica Cosmochimica Acta*, in review.

Publications to be submitted in 2008:

Möbius, J., Lahajnar, N. and Emeis, K-C.: Diagenesis controls nitrogen isotope fractionation in Holocene sapropels and recent sediments from the Eastern Mediterranean Sea.

Koppelmann, R., Böttger-Schnack, R., Möbius, J. and Weikert, H.: Trophic level of zooplankton size classes and key taxa in the eastern Mediterranean based on stable isotope measurements.

Conferences, abstracts:

Möbius, J. & Emeis, K-C. (2006): The $\delta^{15}N$ distribution in Quarternary sapropels and Recent sediments of the Eastern Mediterranean Sea: A nutrient or a diagenetic signal? *EGU General Assembly, Vienna*

Möbius, J. & Emeis, K-C. (2007): Amino acid preservation and $\delta^{15}N$ in surface sediments and sedimentcores from the Eastern Mediterranean Sea. *EGU General Assembly, Vienna*

Möbius, J. & Emeis, K-C. (2007): Linked Amino acid preservation and $\delta^{15}N$ in surface sediments and S1 sapropel timeslice in sedimentcores from the Eastern Mediterranean Sea. *GV-Conference, Bremen*

Möbius, J. & Emeis, K-C. (2008): Diagenesis controls nitrogen isotope fractionation in Holocene sapropels and recent sediments from the Eastern Mediterranean Sea. *JESIUM 2008*

Möbius, J., Emeis, K.-C. (2008) δ15N distribution in recent Mediterranean surface sediments and during sapropel S1 timeslice: Interpretations. 33th International Geological Conference (IGC), Oslo, Norwey.

Ziveri , P.; Langer , G.; Thoms , S.; Probert , I.; Rost , B. (2007) Establishing the link between $\delta^{18}O$ vital effect and cell physiology in planktonic calcifying organisms (coccolithophores and foraminifera). 9th International Conference in Paleoceanography, Shanghai, China.

1 C. General outreach

Radio interviews, TV coverage, Newspaper articles etc.

I organized a networking activities including 3 EUROCLIMATE projects and worls specialist on Atmospheric CO_2, ocean acidification, and ecological changes in planktonic calcifying organisms. During the first day a public lecture series on ocean acidification and climate change was organized. This took place in a tri-lingual format at the Cosmo Caixa Science Museum in Barcelona, and attracted a significant level of public interest and attendance. This event also attracted the media and several newspaper articles were published as a result.

The MERF CPR was also included in the ESF EUROCLIMATE documentary.

1 D. Patents and industry collaborations

1 E. Networking within the CRP

Networking with other CRPs is in Part 3 (completed by ESF)

1 F. Participation in other conferences

Please list only the most relevant

Appendix 2. Scientific & technical personnel involved in the CRP

Personnel directly funded by the EUROCORES Programme
Please supply only the missing information stating name, position, contract start/end dates and in case of students say if they achieved a PhD

At the VU Amsterdam, Suzan Verdegaal was employ as a lab technician for 6 months at 10% and Lia Auliaerlaty as a junior researcher (PhD) from September 2006 to March 2009. Her contract will be possibly prolonged to terminate her PhD thesis.

Networking activities of the programme

EUROCORES Programmes comprise a networking and dissemination component which primarily aims at strengthening internal programme coherence and external programme visibility. Networking with the aim of programme coherence would seek to develop synergies between the funded projects, and can address programme aspects that the highly competitive selection process has left uncovered. This may include forging links with other promising research networks. Activities with the aim of programme visibility promote the contributions of the field to wider areas of participating disciplines or to spread it beyond core countries. The benefits of interdisciplinary and international collaborative research would become visible in such activities. The EUROCORES networking and dissemination components can include workshops, conferences, summer schools, strategy and infrastructure meetings, mutual research visits, and dissemination support (e.g.: conference attendance, joint publications). Considering that EUROCORES programmes privilege the funding of innovative, emerging and/or as yet under-connected research, the overall objective of these activities is to strengthen the field in question (capacity building) and to discover new research horizons (perspective creation).

Topical workshops, schools and conferences

Type of meeting (conference, school, workshop, etc.)	*Title of event*	*Start date of meeting*	*End date of meeting*	*Place of meeting*	*No of partici pants*	*Other comments (session at EGU, linkage to conferences, co-funding)*
Conference	Final EUROCLIMATE Conference	28/09/2008	29/09/2008	Giens, France	67	
Symposium	JESIUM 2008	31/08/2008	05/09/2008	Giens, France	5	Session at a larger conference
Conference	EGU 2008	13/04/2008	18/04/2008	Vienna, Austria	17	Sessions at EGU
Workshop	GIFT 2008 Workshop for Teachers	13/04/2008	16/04/2008	Vienna, Austria	62	Part of Annual workshops at EGU, co-funding
School	Summer School on Late Quaternary Timescales and Chronology	20/04/2008	26/04/2008	Piran, Slovenia	15	
Workshop	EUROCLIMATE Workshop on Atmospheric CO2 ocean acidification, and ecological changes in planktonic calcifying organisms	26/09/2007	28/09/2007	Barcelona, Spain	45	
School	STRAT Summer School on African Paleoperspectives	20/08/2008	21/08/2008	Nairobi, Kenya	27	
Workshop	Palaeo-databases	7/05/2007	12/5/2007	Aix-en-Provence	24	
Conference	EGU 2007	15/04/2007	20/04/2007	Vienna, Austria	24	
Workshop	Radiocarbon and Ice-Core Chronologies During Glacial and Deglacial times	5/03/2007	7/03/2007	Heidelberg, Germany	34	
Workshop	Environmental Proxies (ESf/EUROCLIMATE-EuroMinScI/ESRF)Workshop	30/10/2006	31/10/2006	Grenoble, France	19	
Conference	EGU 2006	2/04/2006	7/04/2006	Vienna, Austria	24	

Short-term visits

Title of Visit	*Start date of Visit*	*End date of visit*	*Grant recipient (name)*	*Home institute (including city and country)*	*Host (name)*	*Hosting institute (including city and country)*
BioCalc	06/08/2007	17/08/2007	Gernot Nehrke	Alfred Wegener Institute for Polar and Marine research, germany	Jean-Pierre Cuif (EUROMINSCI programme	Orsay, Paris

Dissemination travel grants

Grant recipient	*Conference visited*	*Start date of travel*	*End date of travel*	*Place of conference*
Claire Jones	12th International Palynological Conference	29/08/2008	05/09/2008	Bonn, Germany
Jürgen Möbius	33rd International Geological Congress	11/08/2008	14/08/2008	Oslo, Norway
Richard Tol	EGU 2008	13/4/2008	15/04/2008	Vienna, Austria
Carol Turley	EGU 2008	14/04/2008	16/04/2008	Vienna, Austria
Joel Gattuso	EGU 2008	13/04/2008	18/04/2008	Vienna, Austria
Vincent Garreta	EGU 2008	13/042008	18/04/2008	Vienna, Austria
Judith Piontek	ESSP Open Science Conference	9/11/2006	12/11/2006	Beijing, China
Maria Fernanda Sanchez Goni	XV11 Inqua Symposium	28/07/2007	3/08/2007	Cairns, Australia
Thomas Giesecke	XV11 Inqua Symposium	23/07/2007	3/08/2007	Cairns, Australia
Samuel Morin	AGU Fall meeting 2007	9/12/2007	17/12/2007	San Francisco, USA

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Gillikin D.P., A. Lorrain, J. Navez, J.W. Taylor, L. André, E. Keppens, W. Baeyens and F. Dehairs (2005) Strong biological controls on Sr/Ca in aragonitic marine bivalve shells, *Geochemistry, Geophysics, Geosystems*, *G*^{3}, 6, Q05009, doi:10.1029/2004GC000874.

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- **Nederlandse organisatie voor wetenschappelijk onderzoek (NWO), The Netherlands**

PART 2

Final Report Assessement

Individual Evaluations

Each review panel member has been invited to provide an assessment of the programme has a whole. The purpose of the Final Evaluation is to make up the overall picture and present the key results of the programme. It was stressed to the review panel members that the evaluation concerns the overall achievements of the programme and as such complements the reporting of individual projects conducted by the national funding agencies. The main evaluation criteria and guidelines have been proposed. Only one evaluation has been received and is provided in the next pages.

1. Evaluation of the programme on the basis of its scientific achievements

Provide an objective assessment of the EUROCLIMATE programme on the basis of the scientific achievements highlighted by the Project Leaders in their report and presentation.

Comment on the level of scientific cooperation, the degree of integration across disciplines and the European added value of the collaborations within the EUROCLIMATE programme.

Based on your scientific assessment, would you say that the EUROCLIMATE Programme set new directions in its field of research and broke new grounds?

2. Evaluation of the programme on the basis of networking, training and dissemination

Provide an objective assessment of the merits of the EUROCLIMATE programme based on the networking, training and dissemination activities developed during the project duration.

Comment on the usefulness and impact of these activities on the EUROCLIMATE programme and the relevant field of research.

3. Recommendations to ESF and funding agencies

Based on the evaluation of the EUROCLIMATE program, provide suggestions for the future developments of the EUROCORES Programme, in particular regarding sub-area that was not covered within EUROCLIMATE or new directions which have emerged.

Recommendations for the future of the scientific field as a whole (mid to long term vision to develop research agendas and for ESF priorities for future programmes.

Your feedback on the EUROCORES programme and type of activities proposed within the programme.

1. Evaluation of the programme on the basis of its scientific achievements

The scope of the Euroclimate programme was large, in that it was addressing research on climate variability, particularly of the past, and its relationship to global carbon cycle dynamics, in the context of increasing methodological understanding of the palaeo-record. As only 9 CRPs were funded, and in some cases not all elements of a CRP were funded by the respective national bodies, the achievements of the programme need to be seen within the constrained opportunity that was available.

Within this circumscribed envelope the individual CRP's produced fair to excellent achievements, generally meeting their initial objectives in large measure. Again, within individual CRPs, there was a good level of scientific co-operation, adding value to the sub-projects within CRPs in most cases. There was little sign of interaction between CRPs, but the mechanism of CRP selection meant that projects with natural interactions were not rated more highly and it can be argued, as some PIs did in their final reports, that such highly developed programmes are more the remit of European Frameworks than Eurocores.

Below I give a few words about the significant achievements of individual CRPs.

1. Palaeosalt
Palaeosalt's aim was to improve understanding of current salinity proxies, develop new ones and apply these to understand salinity changes in the past. This was pursued in a very process-oriented fashion, with an advance of understanding, and discovery of where further advances were required following the CRP. However, the field still needs a synthesis of the state of the science of salinity proxies, and the CRP seemed to only apply their findings on a regional, or even local, basis. In summary, a useful project, but the final report did not suggest that definitive tool was now available.

2. DECVEG
DECVEG aimed to development and test dynamic vegetation models for use in climate modelling. By its nature this was a project requiring the integration of palaeovegetation specialists and modellers and it appears to have been very successful in producing synergy between these groups. Its main constraints were lack of funding of some of the original partners, but this was well compensated for by additional collaboration outside the original consortium.

3. CASIOPEIA
The aim of this project was to develop new proxies for seawater temperature from Ca isotopes, and link these to existing metal to calcium and isotope proxies. Many of the isotopic and process understanding aims were successful. However, one problem was the lack of modelling interaction between the projects, largely due to stepped start dates across different countries, and the reversal of the optimal pattern due to funding issues beyond the CRP's control.

4. TREE14
The aim of this project was to create an absolutely dated timeframe stretching back towards the Late Glacial, using tree rings. The CRP was unsuccessful in creating a database in SE Europe, however a European pine database extending back to 12,500 BP has raised some potentially important issues over the previous use of a carbon-14 calibration dataset from the Cariaco Basin, and over the complexity of the history of the Younger Dryas climate event.

5. ISOTRACE
This project aimed to explore past history of oxidation within the atmosphere, particularly through

interpretation of the O-17 isotopic record. It has achieved this through study of three species containing nitrogen in the atmosphere, achieving significant progress in methodological understanding. However, as only one of the three partners in the CRP was funded by national agencies, development of an internationally cooperative project stalled.

6. CHALLACEA
This project aimed to develop a high resolution reconstruction of temperature and moisture variability of tropical climate back to the early Holocene from lake cores in east Africa. The project exceeded its aim, through producing an exciting record back to 25000 BP, with potential for going further back into the previous glacial period in the future. Their analysis allowed them to understand Holocene and Late Glacial climate change through its wide range of proxy indicators. Some elements originally proposed were unsuccessful, but this project is one of the more successful of the Euroclimate CRPs.

7. RESOLuTION
This project aimed to develop understanding of abrupt climate change during the last glacial period and its impacts on human evolution, through a number of means from developing synchronicity between high resolution records to modelling experiments. The project could not develop this intercomparison for as many records as originally proposed because of non-overlapping records, but also the lack of tephra in some of the useful records. However, overall this project has advanced our understanding of Dansgaard-Oeschger events and has shown support for the view of the interactions between homo sapiens and Neanderthals leading to the latter's extinction, rather than climate change.

8. MERF
This project aimed to understand the impact of sapropel events in the Mediterranean and how these were related to ocean productivity, and so marine carbon uptake. This project achieved good methodological understanding of the productivity proxies, how these varied geographically, and their impacts on the nitrogen cycle of the Mediterranean. It was clear from their results that sapropels were more complex in terms of their productivity patterns temporally than previously supposed.

9. DecLakes
This project aims to achieve decadal to centennial scale resolution of the rainfall patterns across Europe during three time windows since the peak of the last glaciation. Despite some problems with one of the chosen lake cores, the project was very successful in developing a more detailed view of climate variation across Europe during its three chosen periods. Some interesting differences with the tree ring record were found for the most recent of these periods that may be influential if proven correct.

Please, rate the EUROCLIMATE programme as appropriate:

0: cannot evaluate 1: weak 2: average
✓3: good 4: excellent

2. Evaluation of the programme on the basis of networking, training and dissemination

The Euroclimate programme had a good number of workshops and conference sessions. There was an excellent collection of publications (but why nothing in the overall list or many CRP lists for 2009? I would have thought there would be more relevant publications at the end of the programme than after its first year or two.). It was surprising that there was no model-data intercomparison workshop across the project, when a number of CRPs had this type of science in their original aims and it promises new ways of thinking about data for those groups not yet doing so.

In terms of dissemination and internal CRP networking this varied substantially across the programme, from nothing (where only one PI was finally funded within an entire CRP!), to very extensive. Some CRPs

had extensive involvement with the media (e.g Palaeosalt, RESOLuTION) but many had none. In general networking within the CRPs was good, with visits and workshops being common. There was very active attendance at conferences and so very good exposure of the work of Euroclimate within the scientific community. Overall, the impression is of scientifically very successful projects that tended to miss the opportunity to move their science outside of conventional circles.

There was a good level of training, through the holding of CRP and programme-wide workshops, and the employment of postgraduate students, and research fellows. However, funding constraints meant that many projects funded only parts of PhD posts. Many PhD students enjoyed Euroclimate funding for 12 months only. While this may be a feasible means of training postgraduate students in some countries, in others it is not. For consistent identification by the student with particular programmes it is far better for funding to last throughout the student's study.

Please, rate the EUROCLIMATE programme as appropriate:

0: can not evaluate 1: weak ✓ 2: average
3: good 4: excellent

3. Recommendations to ESF and funding agencies

I have some administrative comments and some scientific ones. Firstly, the administrative comments:

1. Many projects were disadvantaged, sometimes significantly, by the lack of coordination between different countries' funding agencies. Some IPs weren't funded from particular countries for many projects; some had funding delayed while others in a particular CRP did not, so there was a lack of phasing within a CRP that had, in some cases, major impact on the type of work that was possible. These financial and timing issues need urgent attention because they downgrade the value of the research that can be achieved by the ESF system.

2. The general level of administration was viewed very favourably compared to EU Framework programmes. This is a very positive aspect of ESF funding.

3. The size and scope of CRPs was also viewed very favourably compared to EU Framework programmes. The ESF style of funding offers something that is uncommon, but valued, within Europe.

4. There were relatively few Associated Partners from countries outside the funding frame. This is not necessarily a bad thing, but can limit opportunities for networking.

Secondly, the scientific comments:

1. There is still a lot to learn in the area of climate variability, and what the past can tell us about the future. This programme has contributed across a wide range of fields. However, future programmes might make more impact with a more tightly focused objective. This could be in terms of understanding a time period or climate event, or it could be a particular tool or approach. Some national agencies have been moving funding in this direction in recent years.

2. As an example of a new area, without the rise of anthropogenic CO_2 emissions the world would be heading towards a new glacial period. However, much concentration has been given to climate change during deglaciation or the peak of the last glaciation. How does the climate decline naturally towards glaciation, and what might be the interaction between this and the current direction of climate change, would be an interesting topic.

3. In methodological terms, the most exciting projects had elements of model-data intercomparison. A future climate-related programme would be strengthened if this interaction of technologies lay at its heart. This may well apply to rather different fields as well.

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