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08/20/2012

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ESF Short visit grant - Final report

I attended the Urbino Summer School in Paleoclimatolgy 2012. It took place in Urbino, Italy in the time from July 11th – July 31st (the short visit grant was only requested for July 11th – July 19th).

Over three weeks, the Summer School integrated lectures, seminars, poster sessions, fieldwork and open discussions covering many fields in paleoclimatology. The focus was set on paleoclimate proxies and modeling as well as future climate prospects. These topics were conveyed by an ensemble of highly regarded researches from around the world, who were either presenting insights into their most recent or current projects or were giving an overview over the state of the art in certain fields in their lectures. Seminars were used by the participants to apply their newly gained or deepened knowledge, while discussions offered the opportunity to open a dialogue between students and lectures and to touch on topics beyond the material covered in the lectures, including career advice and insights into the interaction between researchers, politicians and policy-makers.

The overall aim of the Summer School was to give all participants an overview over the variety of the fields of paleoclimatology, to broaden their expertise of methods and proxies used in paleoclimate research. Furthermore, getting together with fellow Ph.D. students and senior paleoclimate researchers offered opportunities for a lively exchange and discussions to get new perspectives on their own studies and stimulate their development.

The aim of my Ph.D. project is to study short-lived warming events in the Eocene and Miocene and their effect on benthic ecosystems and oceanic circulation. In detail, in the first part of my Ph.D., I investigate the effects of the Middle Eocene Climatic Optimum (MECO) on

benthic foraminiferal ecosystems by establishing assemblage counts of samples from Ocean Drilling Program (ODP) Site 1051 (Blake Plateau, North Atlantic). First results show that there is a distinct shift of an epifaunal-dominated assemblage to an infaunal-dominated assemblage during the peak warming of the MECO. This points toward an enhanced organic matter input and oxygen depletion in bottom waters. Investigation of and comparison with ODP Site 738 shall serve to verify these results and to propose a sophisticated paleoecological/ paleoceanographic interpretation.

Many of the topics covered during the summer school were of great importance for my project. Especially insightful were the lectures by F.J. Jorissen, J. Zachos, A. Sluijs, B. Wade, H. Spero, P. DeMenocal, L. Lourens and R. DeConto.

A few lectures at the beginning of the course aimed to give an overview over the fundamentals of stable isotopes and their role in paleoclimate research. Although these basics were mostly known to me, it was very helpful to get a summery over the theory and to learn about the historic development of stable isotope geochemistry.

Howard Spero and several other lecturers focused on the carbon cycle. The principles of the system were explained in great detail in introductory talks, while others covered carbon cycle modeling. Because the carbon system is extremely complex and had many feedbacks that are presently not yet fully understood, these sessions were very important.

Subsequently, Frans Jorissen lectured on the basics of benthic foraminifers as a paleoclimate proxy. Previous to my Ph.D. project I had never worked with foraminifers. When I started, I read several papers about the principles of their ecology, but it was greatly insightful to learn in more detail about the behavior, morphology and biology of benthic foraminifers from an expert in the field. Jorissen described the differences and characteristics of epifaunal, as well as shallow and deep infaunal species and explained how oxygen content and organic matter input determine the occurrence of various species within the sediment column. This is especially important for my project because the peak-warming interval of the MECO is characterized by a faunal turnover. While the benthic foraminiferal assemblage prior to the event shows a dominance of mainly epifaunal or shallow infaunal taxa, whereas the MECO fauna is dominated species that live deeper within the sediment column. Generally, those species are more adapted to low oxygen conditions and high organic matter input. Therefore, an assemblage dominated by infaunal species is indicative of eutrophic conditions and/or deep-water low oxygen conditions.

Appy Sluijs held two lectures on hyperthermals with a focus on the PETM, but also addressing the Early Eocene Hyperthermals and the MECO. Learning in detail about preceding warming events similar to the MECO increased my understanding of the underlying mechanisms that are thought to have caused the respective events. We

discussed the different mechanisms that are proposed to cause hyperthermals. The most widely excepted hypothesis for the PETM and the Early Eocene Hyperthermals is dissolution of methane hydrates due to slope failure or ocean warming which leads to the release of methane into the atmosphere where it operates as a strong greenhouse gas, leading to intensified warming and a pronounced negative $\delta^{13}C$ excursion. Several other possibilities are discussed, including melting of permafrost, widespread fires, extensive ridge or arc volcanism and erosion of metamorphic decarbonation. The latter is the favorable explanation for the MECO, because in contrast to the other hyperthermals it is not accompanied by a pronounced $\delta^{13}C$ excursion, but merely a very short shift of 0.5 ‰ at the peak warming of the event. However, the effects observed during the PETM and other hyperthermals seem to be similar to those during the MECO. They all show an increase of pCO_2 and hence a substantial rise of the CCD. Especially the well studied PETM and my preliminary results from the MECO give evidence for a global intensification of the hydrological cycles during the warming. This results in increased continental run off and therefore, enhanced productivity and at great depth regionally hypoxia.

Furthermore the lectures of Maureen Raymo, Robert DeConto and Lucas Lourens explained the concept of orbital tuning and how Milankovitch cycles can be identified in the geological record. To make this more visual and tangible we had the chance to measure orbitally paced sections in the field and then learn the use of Analyseries by analyzing our results and trying to identify orbital cycles in our sections. This was of a particular interest for me because several studies from recent years found orbital cycles in Eocene records. It is not in the scope of my Ph.D. project to solve the question of the causation of the MECO and whether Milankovitch cycles contributed to it. However, these lectures and exercises helped to gain a deeper understanding of the complex processes that caused these hyperthermals and will undoubtedly be valuable for my future research.

The lecture by Peter DeMenocal dealt with the monsoonal system. He explained the principles of the monsoon, it's impact on regional climate and weather and indications of a paleomonsoon in the geological record. The Asian Monsoon System is most widely known, but an American Monsoon also exists. Although it is comparatively weak, there is some evidence that it the American Monsoon intensified during periods of elevated temperatures like in the MECO and influenced the Blake Plateau region. Therefore, it is important to gain a better understanding of the monsoonal system and its processes in general and how to recognize changes in the monsoon in the sedimentary record.

It had been one of my aims at this course to learn more about climate Models, since I had not worked with them previously. Andy Ridgwell gave an introduction early during the summer school, explaining in depth and on the example on a comparably easy model how

they work, how to use them and how to interpret the results. Several lecturers presented their own modeling work towards the end of the course and compared their results to proxy studies, thereby showing the pros and cons of both methods and explaining if and how they are indeed comparable. It is not directly applicable to my current project. However, this knowledge will undoubtedly be useful in my further career. Furthermore, it enables me to read and understand modeling papers better and look critically on the assumptions and simplifications that were put into the model.

Finally, the attendance of this summer school enabled to me to get in touch with fellow Ph.D. students who work on similar or even related projects and exchange thoughts and ideas about our work. Beginning to establish these international relationships and cooperations that will undoubtedly be mutually valuable. Moreover, I was given the opportunity to meet some of the leading scientist in the field, thereby providing the chance to discuss my current research and ideas of my Ph.D., as well as learning more about their research and discuss their work in a casual post-lecture atmosphere.