ESF - Short visit grant - Scientific report

1. Purpose of the visit

The aim of the visit was the participation to the Urbino Summer School of paleoclimatology, from the 11th to the 20th July 2012.
This summer school offers a large view of different sections of the paleoceanography, (cyclostratigraphy, carbon cycle, stable isotopes, and marine proxies)
It allows also to listen and discuss with the most prominent researchers of very specific topics and to beneficiate of personal view, and direct advices.

Moreover, this summer school allows to meet young researchers, PhD or post-docs whose the subject research is close to our, and allow to develop and exchange ideas and information about specific proxies, specific time period and/or specific area.

My PhD subject concerns the climatic variations of the Equatorial Pacific during the Miocene-Pliocene. It implies stable isotope measurements ($\delta^{18}O$ and $\delta^{13}C$) on bulk carbonate, planktonic foraminifera and fine fractions (2-3 μm) enriched in calcareous nannofossils.
In parallel are led alkenone analysis to recover the SSTs. Alkenone are considered also to reconstruct past pCO_2 on a key period, like the Pliocene with the Pliocene warm period followed by the global cooling linked to the Northern Hemisphere glaciation.

In the first place, the use of these different proxies should be well understood. The interpretation of the obtained data shall consider the factors that may interact with the desired parameter. During this visit, three days have been then devoted to a large window of proxies, with an entire day on stable isotopes, and then information on marine inorganic, terrestrial and organic chemistry proxies.

In a second time, this work implies considerations in paleoclimatology, paleoceanography, and need to understand interactions between the different compartments like the marine biosphere, ocean, and atmosphere. These different themes are addressed during the USSP, with mechanisms interfering during key periods of the Mesozoic and Cenozoic.

It is then difficult in this report to review the description of the main results obtained, as obtain data was not the purpose. Results result mainly in new ideas to apply and reasoning way on the data.

2. Description of the work carried out during the USSP

After a day of global introduction about paleoclimate archives and past climate variability, the first part was devoted to the age models and cyclostratigraphy theory. Methods of biostratigraphy were explored, with an exercise on a real site, IODP site 1208A.

The cyclostratigraphy theory has then been presented by Lucas Lourens, with, among other things, the examples of the Sicilian nice section of Gibliscemi and Punta di Maiata.
This lecture helps also to learn about the software analyseries, with an application on the IODP site 1262 (leg 208, on the Walvis ridge), during the early Eocene. The aim was to familiarize ourselves with the main function of the software, and thereby, to unravel the orbital relationship and timing between two main events: the PETM and the ELMO horizons.

The use of the analyseries software is here a very positive point of this visit, as I can use it to compare my record to orbital cyclicity, either to determine cycles, either to identify key period of minimum or maximum amplitude, which could correspond to a climatic change illustrated by SST or isotopes.

A cyclostratigraphy exercise was also led on real data collected on different outcrops during a day of field trip in the Umbria-Marche area, through the Contessa and Bottaccione sections.
This field trip gave us the opportunity to examine very nice outcrops, with for example the OAE-1b (Urbino level, early Albian) and OAE-2 (Bonarelli level, latest Cenomanian) events, PETM and ELMO events, and the K/T boundary in gubbio, much better preserved than the one in Bidart (France).
We've been separate in small group, each on a different outcrop. Mine was working on the Paleocene section, and the aim was to measure and count every layer and bundles of marles/limestone in order to determine a controlled deposit by the orbital cyclicity or not.
The Paleocene section was not so easy, far from the nice alternations of Albian and Cenomanian sections.
The field data have then been processed on analyseries, and presented group by group. It was a nice experiment of real data treatment and group work.

A whole day was devoted to dynamics and patterns of the carbon cycle, with an approach of modelisation with the little numerical model C_Model, which represents the entire ocean with three boxes: one for the surface, one for the intermediate deep waters, and one for the deep ocean. This model allow to modify a wide range of parameters and test their effects on long time scale on the carbon cycle and ocean behavior.
Parameters take into account the physical considerations (thickness, ocean mixing coefficient), the rivers input, fate of organic carbon and organic phosphorus, $CaCO_3$ considerations (calcification, lysocline, calcium concentration…), the phytoplankton population dynamics and also the fractionation effects of photosynthesis, calcification, etc.

Then, a large part of this visit concerns the wide range of proxies used in paeloceanography, marine inorganic, organic or terrestrial. James Zachos and Howard Spero spoke during a day about the theory and systematic of stable isotopes. This proxy is largely used in paleoceanographic study, on different support (bulk, planktonic foraminifera, benthic foraminifera, fine fractions...) and is of prime importance in my PhD work. Interpretation is obviously not the same following time scales. However several parameters are likely to influence $\delta^{18}O$ and the most interesting part for me in the conferences is on the way to compute the temperature signal from the salinity and global glacial effect. One of the issues is

to reconstruct the $\delta^{18}O_{seawater}$, and then the paleosalinity, considering that the salinity-$\delta^{18}O_{seawater}$ relationships are not constant through time and through geographical area.
Regarding the $\delta^{13}C$, it is still difficult to interpret and I think I need a more global comprehension of the global carbon cycle to understand the different parameters which can interfere with the marine productivity.

Mark Pagani spoke about the organic chemistry principles and proxies, and this lecture was very interesting in that way I'm working with organic proxies like alkenones, but without academic background on organic chemistry. This conference allowed to review the different class of organic molecules and the attached proxies.
The two most important points to me are the discussion about the TEX_{86}, and about the reconstruction of the pCO_2:
- The TEX_{86} is a paleotemperature proxy that I want to test on my samples in order to compare with the alkenone SST results. This project will be conducted in collaboration with Appy Sluijs from Utrecht University, and granted by the ECORD Research Grant.
- The pCO_2 can be reconstructed with the $C_{37:2}$ alkenone concentrations and has been successfully tested on the IODP site 1338B during the Pliocene. Mark Pagani gave then advices about the continuity of this work, and on the application on the ODP site 806B.

The last part of this visit was devoted to the key periods of Mesozoic and Cenozoic (Mesozoic greenhouse world, Paleogene greenhouse world, Greenhouse to Icehouse transition and the Icehouse state and the Quaternary and Holocene). These lectures approached the main control factors on climate changes, as the pCO_2 effects, and explained the feedbacks mechanisms implied in this climate changes, on short or long time scale.
Very rapid events like the K/T boundary or PETM are well explored. However, some periods like the Miocene are unfortunately little shown. Moreover, during this time period, pCO_2 reconstructed values are very low and may not reflect the true levels. However this issue is still under debate.

Posters illustrating the PhD/post-doc work of each student were also hanged, allowing discussions during the breaks. This action permits both to discover new paleoclimatic sector/proxies, and to find person with the same interest, time period, proxies or area with the possibility to exchange data.

3. Description of the main results obtained - 4. Future collaboration with host institution - 5. Projected publication - 6. Other comments

Once again, it is difficult to speak about « main results obtained » or publications / articles resulting or to result from the grant. Future collaboration with the host institution has no reason to be, here. However this visit was an opportunity to discuss about other collaborations, in particular with Utrecht University.
Beyond the benefit of the lectures, results are mainly expressed by interactions with great researchers, new contacts, and discussion and advices from professors, like Mark Leckie about the foraminifera, Mark Pagani about the pCO_2, etc.

Contacts, new information and advices, new ideas to apply and reasoning way on the data are the best profits of this participation to the USSP.