Urbino summer school in Paleoclimatology

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The courses proposed during the Urbino Summer School have been high quality and useful with a program encompassing classes, exercises and field trips.

A/ Courses

The courses have included several aspect of paleoclimatology. Paleoclimate Archives, cyclostratigraphy, carbon cycle, stable isotope, different proxies, geochemical modeling, and climate models...

1/ Benthic foraminifera contributions to paleoceanography

We have made a good revision on benthic foraminifera and their interest in paleoceanography. This review has been based on:

- The different benthic formainifera life style (epifaunal species, shallow infaunal species, intermediate infaunal species, and deep infaunal species) and their microhabitats which are mainly controled by nutrient export (organic flux).
- Proxies of benthic foraminifera based on the chemical composition of their test and based on the characteristics of the fossils faunas;
- The use of benthic foraminifera for the reconstruction of bottom water oxygenation based on calculation of indices such as Benthic Foraminiferal Oxygen Index (BFOI), Jannink's Oxyphilic Species Index, Combination of High and Low Oxygen Tolerant (Deep Infaunal) Taxa and Diversity Indices proposed by Schmiedl et al., 2003 and method proposed by Jorissen et al. (2007) using deep infaunal taxa.

2/ Monsoons

In the lessons on Monsoons, the issues were monsoonal climate variability and orbital precession forcing, abrupt and gradual response (for example: vegetation response). From my point of view, the most interesting point was the monsoonal impact on human population.

3/ Climate models

Within the climate models courses, the topics included:

- The aim of model climate as tool for understanding climate dynamics and future prediction;

- Types of models: conceptual, empirical and predictive. The latter being used for future climate change;
- How models need to include complex climate feedback parameters such as cloud cover, water vapour concentration in the atmosphere, ice albedo, for accurately predicting climate.

Teacher also illustrated examples on past climate modelling (late Cretaceous, middle Paleogene and Miocene-Pliocene) explaining uncertainty in model predictions that can result from data problems (sampling problems, diagenesis, mis-understood proxy…) or model problems (natural internal variability, errors in model parameterisations of climate processes…)

4/ Other courses

The courses allow extending our knowledge on:

- All proxies used in biogenic carbonates ($\delta^{18}O$, $\delta^{13}C$, $\delta^{11}B$, Mg/ca, Cd/ca, Ba/ca, Zn/ca, B/ca, U/ca, Sr/ca, P/ca...)
- Paleoclimate archives (different types of archives used to reconstruct paleoclimate: marine sediment including lithogenic and biogenic sediment, terrigenous sediment, ice core);
- Stable isotopes (^{2}H, ^{13}C, ^{15}N, ^{18}O, ^{34}S...) and their using;
- Ocean acidification ,
- Holocene climate variability
- Biomagnetostratigrapy of Paleocene hyperthermals (how biostratigraphy, magnetostratigraphy, and orbital cycles are used to ordinate core depths in geologic time)
- The Mesozoic greenhouse world (Jurassic and Cretaceous greenhouse world: the involving nature ocean atmosphere system particularly as it affects the carbon cycle; the sedimentary evidence for Ocean Anoxic Event (OAE); manifestations of an extreme hyperthermal state)
- The Paleogene greenhouse: Paleocene-Eocene Thermal Maximum and Eocene Thermal Maximum 2. These events are related to ocean-atmosphere systems changes with a rapid carbon input inducing ocean acidification and anoxia recorded in biological changes and hydrological cycles changes
- Dinoflagellate and their cysts (classification, morphology, ecology and applications)

- Planktonic foraminifera: Cenozoic planktonic foraminifera classification (based on their wall structure that is related to their life strategies); factors controlling the distribution of planktonic foraminifera (temperature, structure of the water column, ocean circulation and gyres); spatial distribution with relationship between planktonic foraminifera size and temperature; evolution of planktonic foraminifera from upper Jurassic to recent.

B/ Exercises and field trips

During the field excursion, we visited several geological formations outcropping in the region. One example is Cretaceous and Paleogene formations where the K/T boundary is remarkably well exposed at Bottaccione. Above of this K/T boundary, Palaeogene is characterizing by Paleocene and Eocene sediments. Cretaceous (Albian, Cenomanian, Turonian) is represented by a nice outcrop where pelagic sediments with organic-rich horizons are well recognizable. The objective of the field work was to practise the cyclostratigraphy method using the integration of field layer count and statitistical analyses (AnalySerie software).

Practise on softwares:

- **AnalySeries** for cyclostratigraphy
- **JAVA** for carbone cycle modelling.

  I am not a modeller but the course on Carbon cycle allows me to understand the significance of numerical models in the climate system and/or global biogeochemical cycles. We used a model with 3 boxes representing the entire global ocean. These 3 boxes being: the surface layer, the intermediate depths, and the deep ocean. The only circulation in the model is made by mixing between the boxes. It was possible to calculate the change in carbon cycle properties (for example nutrient concentrations in the ocean boxes). It was possible to see how various parameters (mixing, phosphorous, organic carbon, $CaCO_3$ dissolution) interact.

The exercise on Carbon and Oxygen Isotopes, allowed us to make a good revision on the basics; ratios and notation; on the computing of fractionation factor α and isotopes delta values. For example, the using the equation from Kim and O'Neil (1997) to compute the

water-calcite fractionation factor for oxygen isotopes at different temperatures and the calculation of SST based on Mg/Ca.

C/ Acknowledgment

I currently write a paper in which I use one of oxygen index that we have learned during the “benthic foraminifera contributions to paleoceanography” lessons. This index based on Combination of High and Low Oxygen Tolerant (Deep Infaunal) Taxa and Diversity Indices proposed by Schmiedl et al., 2003. For this reason, I thank the ESF in my paper that allowed me to take part in this summer school brought me financial assistance.

D/ Comments

Urbino is a very beautiful town, isolated, peaceful and thus allows an optimal monitoring of courses. This summer school is a very interesting and very rewarding because not only for learning a lot of but also for gathering students or researchers that work in the same field and stimulating discussions.