ESF Scientific Report for Short Visit Grant

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The USSP2011 focused on the study of the present and past climate dynamics. The lectures concerned many different areas of paleoclimatology:

1) orbital forcing and cyclostratigraphy (field work and field analysis);
2) biostratigraphy for age models;
3) paleocenography;
4) proxy data for paleoclimate reconstructions (stable isotope of oxygen and carbon);
5) carbon cycle, especially the long-term carbon cycling and its implications on the climate changes (carbon pumps);
6) new paleoclimate proxies (Mg/Ca, Alkenones, TEX86);
7) climate modeling.

Moreover, we analysed the most important past-climate events (Cretaceous OAEs, P/E hyperthermals, the Greenhouse-Icehouse transition, Neogene and Quaternary climate dynamics, and millennial-scale variability) to understand how to reconstruct past climate using powerful tools like paleobiological and geochemical proxy data. In this way, the attendance of USSP 2011 has been very important for my education giving me a general paleoclimatic background, (regarding the most important disciplines involved in paleoclimatology) essencial for carrying out my Phd research project.

My Phd study is part of a bigger international project related to IODP scientific cruises. It is focused on the collection of micropaleontological data (calcareous nannofossil analysis) on oceanic sediments recovered during IODP Exp. 321 in the Eastern Equatorial Pacific (Site U1338), to improve the understanding of biotic response to a variable climate (Fig. 1).

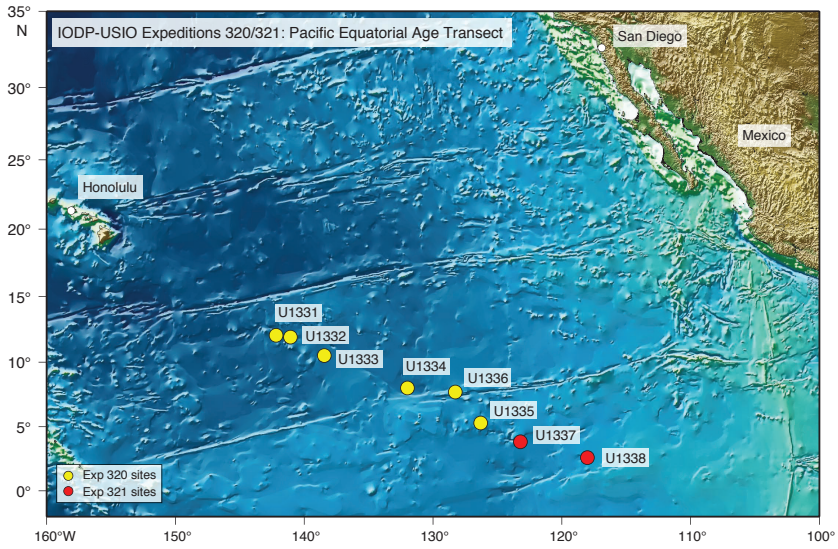

Fig.1 Location map of sites drilled during Expeditions 320 and 321

In particular, the main objectives of my study are: to relate the evolutionary signals (speciations and extinctions), observed in the Miocene *Discoaster* lineage (Miocene is

a period of major calcareous nannofossils evolution and diversification, e.g. there was the sudden explosion of 5 rays *Discoaster*, very importartant biostratigraphic marker in middle-late Miocene) (Fig. 2) , to the paleoenvironmental evolution of this time interval; to test the ecological affinity of *Discoaster* in selected sedimentary intervals (as those characterized by high abundance of diatoms), trying to understand the relationships between primary productors and nutrients availability. It's clear that the knowledge of the long-term carbon cycling dynamics is fundamental because changes in calcareous nannofossil abundance altered it consistently.

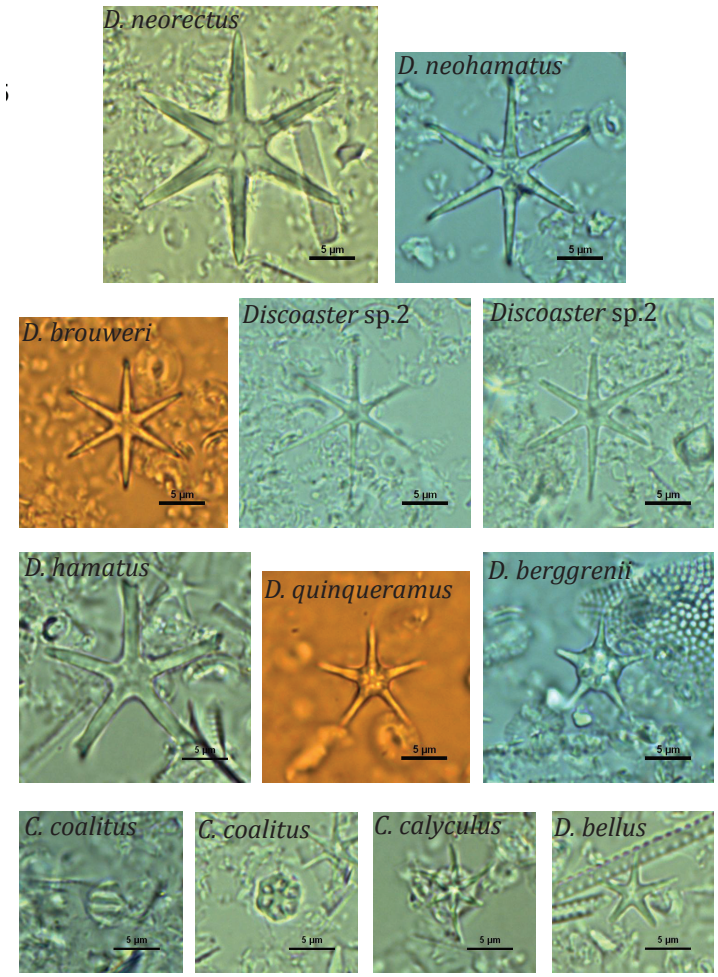

Fig.2 The main Late Miocene biostratigraphic markers in site U1338 (100X magnification)

The overall aim of IODP Exp. 320/321 is to obtain a continuous well-preserved equatorial Pacific sediment section that addresses the following primary scientific objectives:

1) Paleoclimate (Fig. 3), paleoenvironmental and paleoceanographic reconstructions;
2) Paleobiological and paleoecological reconstructions;
3) Chronostratigraphical reconstructions;
4) Paleogeographical reconstructions;
5) Study of Pacific Ocean as linked to the major changes in the global climate.

Pacific Ocean was chosen for this expedition because is one of the best locations to study the CO_2 effects on Earth:

- remained "more or less" the same during the geological time;

- since the Cenozoic the Pacific plate motion has had a northward component, the older sections are not deeply buried and can be recovered by drilling without extensive diagenesis;
- is the primary region for CO_2 exchange between the ocean and the atmosphere and significantly influences atmospheric CO_2 levels;
- equatorial upwelling and phytoplankton production responds to global variation in climate and it is this response that is reflected in biological 'rain' variation in the amount of sediments accumulated beneath the equatorial Pacific productivity region;
- Ocean stratification, nutrient availability and the productivity of the primary producers (calcareous nannofossils and diatoms) vary during the Miocene in response to climatic and tectonic influences.

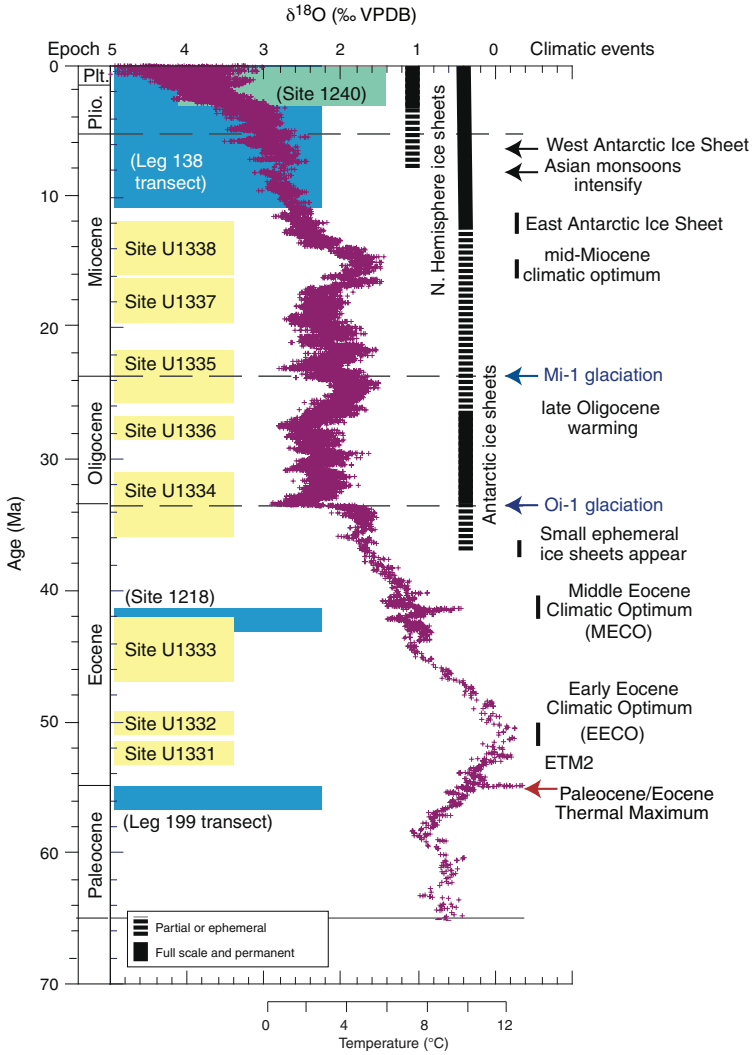

Fig. 3. Evolution of oxygen stable isotopes (δ18O) through the Cenozoic and related major phases of climate change (modified from Zachos et al., 2001b, 2008).

The study of Miocene is important because it is a geological time interval characterized by (Fig. 2):

- **ocean reorganization** (a. the closing of the Panama Gateway (Keigwin, 1982; Haug and Tiedemann, 1998; Roth et al. 2000); b. the development of Antarctic ice);

- **paleoclimatic events** (Fig. 3) (a. the "Monterey Excursion" (17,5-13,5 Ma) Vincent & Berger (1985), a global event characterized by a positive excursion of $\delta^{13}C$ due to high marine productivity, increase in organic $\delta^{13}C$ accumulation into marine sediments and increasing in land coal storage; b. the glacial event at about 13,9 Ma associated with global cooling; c. other glacial events during 11,5-9,5 Ma time interval, described by Miller et al. (1991) and Zachos et al. (2008));
- **deposition of diatoms enriched layers** linked to siliceous biogenic productivity.

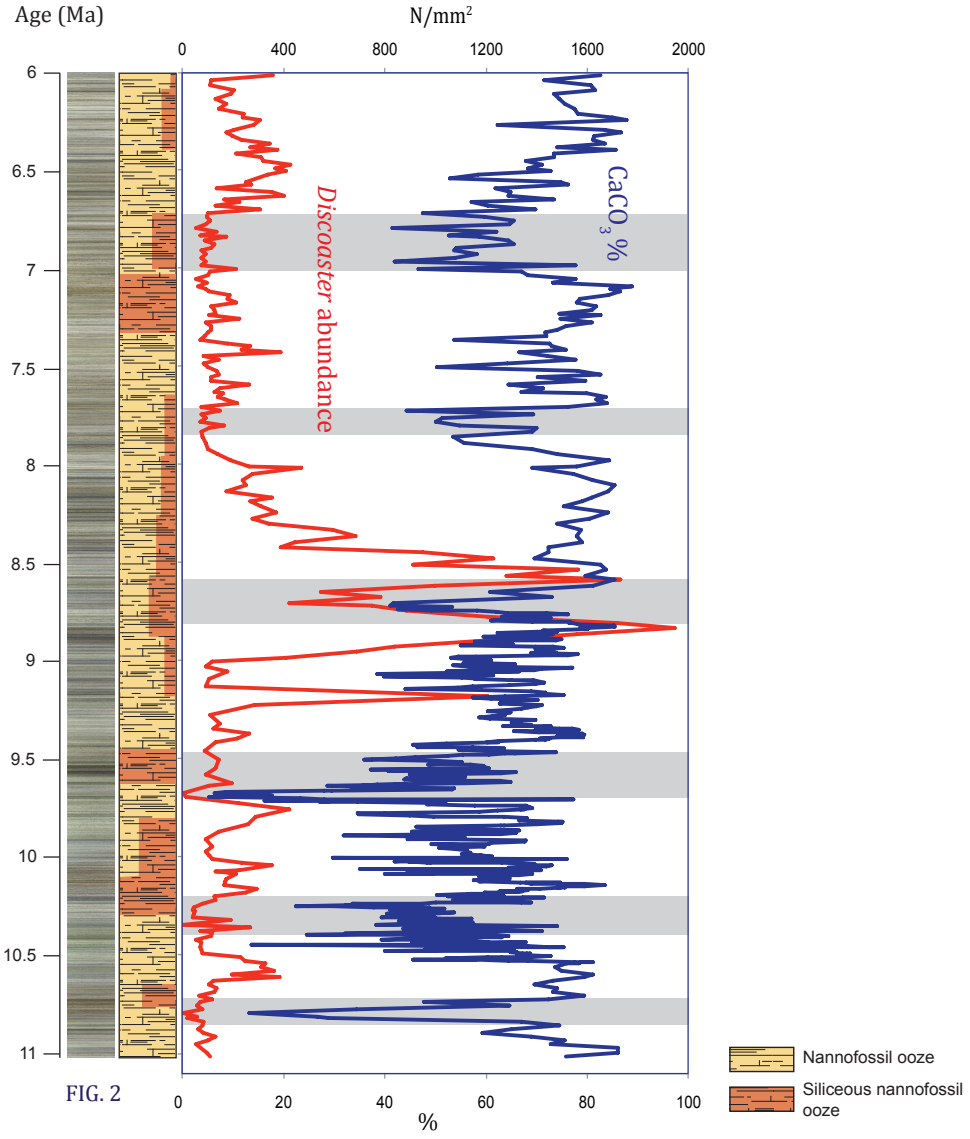

Fig. 4. *Discoaster* abundance distribution vs CaCO3% curve in site U1338

The most important part of my Phd work, lie in carrying out quantitative and semi-quantitative micropaleontological analysis on the Middle - Late Miocene sediments (Site U1338) (Fig. 4). These sediments consist of nannofossil ooze and chalk with varying concentrations of biosiliceous components and shows decimeter to meter lithological cicles that reflect changes in production, dissolution and photic zone paleoecology (Fig. 4).
My micropaleontological analysis mainly involve genus *Discoaster* (Fig. 2) because it is very sensitive to productivity, upwelling and sea temperature variations. Finally,

Discoasterids are a powerful tool to understand climate and oceanographic changes during Miocene. Getting high resolution data, I'll try to better understand the mechanisms of cause and effect leading to important and globally recorded geological/oceanographic events (e.g. Monterey Excursion), and to understand variability in nannofossil assemblages as related to diatom enriched intervals. To examinate the photic zone paleoecological variability during the Miocene, my micropaleontological data will be integrated with geochemical analysis on oxygen/carbon stable isotopes (calculated on planktonic and benthic fomininifera), biogenic silica (study and quantification of diatoms and other silica producers), calcium carbonate and Mg/Ca ratio, essential for the reconstruction of oceanic sea-water paleotemperatures. This geochemical multi-proxy approach, together with the comparation of changes in species abundance and composition for two of the primary producers (calcareous nannofossils and diatoms), will elucidate the biotic response to different climatic and oceanographic conditions.
The USSP 2011 course gave me some good inputs for my first paper: "Environmental response of genus *Discoaster* in the Late Miocene of the eastern equatorial Pacific (IODP Expedition320/321)". It is focused on the biological response of genus *Discoaster* to environmental changes in the photic zone linked to Miocene climate variability. This paper investigates the ecological affinity of *Discoaster* and their evolution connected to the nutrient availability (eutrophic or oligotrophic conditions). In particular, the final aim is to relate the evolutionary signals (speciations and extinctions) observed in the *Discoaster* lineage to paleoenvironmental evolution, namely to deposition of diatom enriched intervals, trying to provide new insights on what are the proper paleoecologic meanings of calcareous nannofossils. The long term distribution of the major Miocene *Discoaster* markers is discontinuous because they are strongly influenced by nutrient availability (Fig. 4). This is in agreement with the well known "oligotrophic" ecological affinity of *Discoaster*.

E. Equatorial PACIFIC - Site U1338

MEDITERRANEAN Metochia - Gavdos

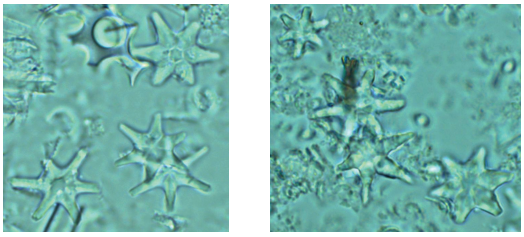

Fig. 5 "Odd discoasterids" in EEP site U1338 and in Mediterranean Metochia-Gavdos section

Moreover, "odd morphotypes of discoasterids" (not ascribed to known species) (Fig. 5), recorded in pre-Messinian sediments (in both Pacific and Mediterranean sediments), are associated with diatoms rich intervals, showing and independent behavior respect to the typical *Discoaster* ecological affinity: this observed response seems to reflect a species-specific behavior. These "odd *Discoaster*" show abundance peaks in intervals with low values of $CaCO_3$ and high abundance of diatoms. This observation casts some doubts on the "dogma" of "*Discoaster* species as exclusively oligotrophic taxa", and could give new hints for improving our understanding of ecologic affinities of this important nannofossil taxon. Since the time scale is provisional because orbital tuning is not available yet, the exact correlation between the biostratigraphic events recorded in Eastern Equatorial Pacific and in

Mediterranean Metochia-Gavdos sections, is not accurate but confirmed by other biochronologic data.
Finally, USSP 2011 has been important because gave me some fundamental tools to insert my biostatigraphic data in a paleoclimatic contest, to better understand the climate dynamic and how the climate acts on marine biota, to study the influence of the primary marine productors (calcareous nannoplankton and diatom) on the global carbon cycle, to integrate the most important paleoclimatic geochemical proxies ($\delta^{18}O$, $\delta^{13}C$, Mg/Ca) and biostratigraphic data to reconstruct a paleoclimate curve and a reliable age model.

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