University of Urbino Carlo Bo
DiSPeA – Department of Pure and Applied Sciences

Research Proposal

PhD Program – Research Methods in Science and Technology
2024/2025
XL cycle
Area: 04 Earth Sciences
GSD: 04/GEOS-02 PALEONTOLOGY, STRATIGRAPHIC GEOLOGY AND SEDIMENTOLOGY, STRUCTURAL GEOLOGY AND TECTONICS
SSD: GEOS-02/A Paleontology and paleoecology
PhD student applicant: Nicola Casadei

Title:
Palaeobiotic, paleoclimatic and paleoenvironmental reconstructions of the Late Cretaceous Oceanic Anoxic Events: unravelling the record in the Umbria-Marche Basin

Keywords: foraminifera, geochemistry, isotope, palaeoceanography, stratigraphy, Monte Petrano, Monte Cucco, Monte Nerone, Poggio Le Guaine, Italy.

1. General presentation of the project and state of the art

The Cretaceous Period was characterized by one of the most extreme greenhouse conditions in the entire Earth's history (Huber et al., 2002) with considerable tectonics changes (e.g. continental rifting and volcanism activity). It was marked by very high sea surface temperatures (SST), high sea level, low thermal latitudinal gradients and absence of the Arctic and Antarctic ice caps (Huber et al., 1995). These conditions were likely caused by increased concentrations of atmospheric greenhouse gasses related to extensive submarine volcanic degassing (Millán, et al., 2014). Several events of volcanic CO_2 release into the atmosphere were linked to the emplacements of Large Igneous Plateau (LIPs) (Matsumoto et al., 2022). The Cretaceous was also punctuated by the occurrence of Oceanic Anoxic Events (OAEs) of regional to global expression (Herrle et al., 2004). The OAEs were commonly characterized by enhanced marine productivity and oxygen deficiency that led to a great accumulation of organic matter at the seafloor and the deposition of dark-coloured, laminated, organic-carbon-rich shales (called "black shales") (Jenkyns, 2010). Some of these black-shale layers are synchronous and have a supra-regional or even global distribution such as the early Aptian Selli (OAE 1a) and the Cenomanian/Turonian Bonarelli (OAE 2) events (e.g., Bralower et al., 1994; Leckie et al., 2002). Others regionally and locally distributed black shales are common in the Aptian to Albian sedimentary successions of the Northern Tethys and the Northern and Central Atlantic Oceans such as the upper Aptian – lower Albian OAE 1b and the upper Albian OAE 1c and 1d (e.g. Leckie et al., 2002; Herrle et al., 2004; Tiraboschi et al., 2009). Microfossils (e.g., foraminifera and calcareous nannoplankton) and geochemical proxies have provided evidence of dramatic biotic turnovers during OAEs (Leckie et al., 2002). Although water oxygenation and eutrophic conditions may have significantly controlled the changes in microfossil community, a paleoenvironmental characterization is limited to some OAEs (e.g., OAE 1a, OAE 1b, OAE 2) (Schlanger et al., 1976). Oceanic Anoxic Events (OAEs) are important geological events that may be analogues to future climate-driven deoxygenation of our oceans. The Umbria Marche Basin (UMB), located in the Northern Apennines of central Italy, presents a complete and undisturbed record of pelagic marlstones and limestones deposited in the southern margin of the western Tethyan Ocean for the Cretaceous. Several records (e.g., Piobbico, Gorgo a Cerbara and Poggio le Guaine) have been investigated to describe the geological history of the mid-Cretaceous in the UMB. Due to a landslide, the site of Poggio le Guaine is no longer accessible and suitable for sampling, while the other available records encompass shorter intervals. In light of it, the successions outcropping in Monte Petrano (Cagli), Monte Cucco (Scheggia) and the Poggio le Guaine core might represent alternative records for the investigation of paleo-biotic, -climatic and -environmental changes in the Cretaceous.

2. Research Objectives

The purpose of the present research proposal is to pursuit and characterize additional accessible Cretaceous records in the UMB. Specifically, the PhD research aims at: 1. providing a continuous and complete record for the Aptian-Turonian time interval; 2. constraining and characterizing the OAEs (i.e., OAE 1b, OAE 1c, OAE 1d and OAE 2); 3. understanding the causal links among geological, paleoceanographic, and paleoclimatic events as well as their palaeobiotic and paleoenvironmental consequences. This will be achieved by applying a multidisciplinary approach based on stratigraphic, micropaleontological, geochemical, and paleomagnetic analyses.

3. Methodology

On the basis of preliminary investigations and available data, two successions outcropping in Monte Petrano (Cagli), Monte Cucco (Scheggia) and the Poggio le Guaine core might provide a complete and continuous record for the Aptian-Turonian time interval in the UMB. The Monte Cucco and Monte Petrano successions would span from the lower Aptian to the upper Albian and from the upper Albian to the lower Turonian, respectively and encompass, therefore, the Marne a Fucoidi and Scaglia Bianca Fms, whereas the Poggio le Guaine core spans the uppermost Barremian to the lowermost Cenomanian that is the Maiolica, Marne a Fucoidi and Scaglia Bianca Fms.

A lithostratigraphic log will be prepared for Monte Petrano and Monte Cucco successions and a tie point (i.e., lithostratigraphic marker such as the occurrence of the Cretaceous Oceanic Red Bed 5) will be identified for correlating them. Then, high-resolution sampling will be carried out for: a) biostratigraphical; b) micropaleontological (i.e., foraminifera); c) geochemical (i.e., isotopes and trace elements); d) paleomagnetic and e) cyclostratigraphic analyses. These records will be then compared to the Poggio le Guaine core that represents a reference record for the uppermost Barremian to the lowermost Cenomanian interval.
Hard limestones will be dissolved with both acetic acid, whereas soft-shale materials will be treated with hydrogen peroxide to retrieve the calcareous foraminifera for biostratigraphical (a) and micropaleontological (b) purposes. Geochemical analyses (c) encompassing the determination of calcium carbonate, isotopes (i.e., $\delta^{13}C$, $\delta^{18}O$, and $^{187}Os/^{188}Os$) and trace elements will be done at the Urbino University (Italy) and also with the collaboration of the University of Tsukuba (Japan) and the University of Brasilia (Brazil). Paleomagnetic analyses (d) including paleomagnetism and environmental magnetism will be carried out at the Urbino University (Italy), the Alpine Laboratory of Palaeomagnetism (Italy) along with at the Federal University of Rio Grande do Sul (Brazil). Cyclostratigraphic analysis will be performed at the Urbino University (Italy).

4. Expected results

This research project contributes to a major goal in the understanding the effects of OAEs. The collected data will provide: 1. the framework for computing a high-resolution magnetostratigraphy, in particular a relative paleointensity reference curve for the Aptian-Turonian time interval in the UMB interval of the long normal Cretaceous superchron; 2. a biostratigraphically-constrained, unique, complete and continuous record for OAEs to unravel the paleobiotic and paleoenvironmental changes; 3. a robust age model based on cyclostratigraphy and astronomical tuning to define the time, mode and durations of OAEs and other paleoclimatic events as well as to update the geological timescale.

5. Description of the research in the three-year period (feasibility)

Year 1: Literature survey, laboratory preparation, definition of sampling strategy, collection of rock samples, laboratory treatment, lithostratigraphic, biostratigraphic and micropaleontological analyses. Preparation of samples for geochemical (i.e., isotopes and trace elements) and paleomagnetic analyses. Possible participation of congress (e.g., TMS, EGU) and training schools (e.g., ISF, USSP).
Year 2. Additional micropaleontological analyses and geochemical and paleomagnetic analyses. Research mobility (i.e., 6 months). Possible participation of congress (e.g., Forams, TMS, EGU) and training schools (e.g., ISF, USSP).
Year 3. Data elaboration, interpretations of the results obtained and PhD thesis preparation and submission. Possible participation of congress (e.g., TMS, EGU) and training schools (e.g., ISF, USSP).
Although the present proposal meets all the legal, operational, technical and schedule feasibility requirements, a continuous analysis will be used to predict the risks and to prevent the project from delivering on time or failing.

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