Marine Micropaleontology 118 (2015) 50–62

Contents lists available at ScienceDirect

Marine Micropaleontology

journal homepage: www.elsevier.com/locate/marmicro

Research paper

Middle Eocene-Lower Oligocene calcareous nannofossil biostratigraphy and paleoceanographic implications from Site 711 (equatorial Indian Ocean)

Chiara Fioroni [a,*], Giuliana Villa [b], Davide Persico [b], Luigi Jovane [c]

[a] Università degli Studi di Modena e Reggio Emilia, Dipartimento di Scienze Chimiche e Geologiche, Via Campi, 103, 41125 Modena, Italy
[b] Università degli Studi di Parma, Dipartimento di Fisica e Scienze della Terra, Parco Area delle Scienze, 157 a, 78, 43100 Parma, Italy
[c] Instituto Oceanográfico, Universidade de São Paulo, Praça do Oceanográfico, 191, SP 05508-120, São Paulo, Brazil

ARTICLE INFO

Article history:
Received 8 October 2014
Received in revised form 3 June 2015
Accepted 7 June 2015
Available online 9 June 2015

Keywords:
Calcareous nannofossils
Biostratigraphy
Eocene
Oligocene
Paleoceanography

ABSTRACT

Nannofossil data from ODP Site 711 (equatorial Indian Ocean) yield a set of consistent, reliable biohorizons that form the basis of a revised calcareous nannofossil biostratigraphy for the low-latitude Eocene-Oligocene. We discuss 31 biohorizons occurring over an 11 myr time interval which we correlate to previous magnetostratigraphic data. Calcareous nannofossils from the middle Eocene through the lower Oligocene of the studied section are characterized by moderately well preserved assemblages consisting largely of low latitude and cosmopolitan species.

A significant nannofossil dissolution interval is evidenced at the middle Eocene Climatic Optimum (MECO). We document a significant increase in late Eocene nannoplankton exhibiting a eutrophic preference. Analysis of the assemblage suggests important changes in the equatorial oceanic regime just before the onset of the Eocene-Oligocene transition (EOT), that foreshadow the more dramatic climatic shift of the early Oligocene.

1. Introduction

Ocean Drilling Program (ODP) Leg 115 took place in the Indian Ocean along a south–north bathymetric transect in order to investigate the Reunion volcanic system and Paleogene to Quaternary stratigraphy and paleoceanography, focusing on the carbonate dissolution history of the Indian Ocean (Duncan et al., 1990).

Paleomagnetic data from the Initial Report (Backman et al., 1988) provided a poorly constrained magnetostratigraphic interpretation for part of the late Oligocene and late Miocene-Pleistocene interval, thus the lower part of the cored succession was dated only by means of biostratigraphy.

Subsequently, the shipboard nannofossil specialists (H. Okada and D. Rio) produced several papers based on both semi-quantitative and quantitative analyses from the Paleogene to the Quaternary (Rio et al., 1990a; Fornaciari et al., 1990; Matsuoka and Okada, 1990; Okada, 1990). However, the "standard" zonations of Martini (1971) and Okada and Bukry (1980) have been proven to be of limited use for the Eocene-Oligocene because of the low reliability or scarcity of some markers. In the last decade, calcareous nannofossil biostratigraphy of the lower Eocene-Oligocene sediments has shown great potential for improvement, through identification of many new nannofossil species (e.g., Fornaciari et al., 2010; Bown and Dunkley Jones, 2012; Toffanin et al., 2013). These studies formed the basis for the revised nannofossil biozonation of Agnini et al. (2014).

In this study we present a quantitative record of nannofossil assemblages through the middle Eocene-lower Oligocene succession in Hole 711A (ODP Leg 115). The abundance pattern and the stratigraphic range of nannofossil markers allowed us to increase the number of bioevents and to compare their reliability and synchroneity in other areas. Site 711 has been the focus of a recent magnetostratigraphic study (Savian et al., 2013) that spans the interval between Chrons C20n (middle Eocene) and C12n (lower Oligocene). Although at times the magnetic stratigraphy is of low resolution (Fig. 2) because of the high number of samples with no reliable magnetic directions (Savian et al., 2013), we have achieved a biochronology by means of higher resolution sampling and by using new biostratigraphic and taxonomic updates.

A further aim of this work is to determine if abundance variations of selected nannofossil taxa reflect the global paleoclimatic changes during this crucial time interval of the Earth climatic evolution. In fact, there is general agreement on the usefulness of calcareous nannofossils as proxies for Paleogene paleoenvironmental reconstructions (e.g., Wei et al., 1992; Bralower, 2002; Dunkley Jones et al., 2008; Pearson et al., 2008; Villa et al., 2008).

* Corresponding author.
E-mail addresses: chiara.fioroni@unimore.it (C. Fioroni), giuliana.villa@unipr.it (G. Villa), davide.persico@unipr.it (D. Persico), jovane@usp.br (L. Jovane).

http://dx.doi.org/10.1016/j.marmicro.2015.06.001
0377-8398/

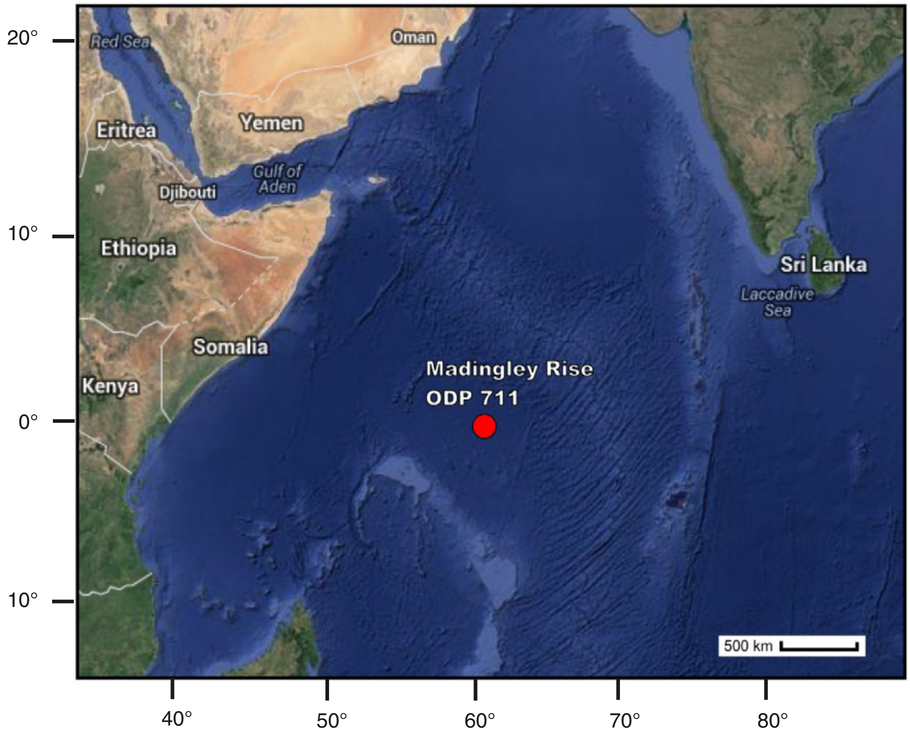

Fig. 1. Location map showing the position of the studied site.

Site 711 has a paleodepth of greater than 3000 mbsl and, along with Sites 1218 and 1219 (Lyle et al., 2005) and Integrated Ocean Drilling Program (IODP) Sites U1331–U1334 (Pälike et al., 2010), is one of the equatorial sites that represents an opportunity to study the carbonate accumulation history and the large fluctuations of the carbonate compensation depth (CCD) during the Eocene (e.g., Coxall et al., 2005; Pälike et al., 2012). The investigated interval encompasses the Middle Eocene Climatic Optimum (MECO), whose top is correlated with a dissolution event (Bohaty et al., 2009), and the long cooling trend that leads to the Oligocene glacial state (Oi-1, Miller et al., 1991). The relationship between CCD fluctuations, ocean acidity variations, pCO_2 concentrations, and ultimately climate are matters of intense discussion (e.g., Pearson et al., 2008; Coxall and Wilson, 2011) and the study of calcareous nannofossils has been shown to be an excellent tool to add information on paleoclimate history (Villa et al., 2014).

2. Material and methods

ODP Leg 115 drilled five sites along a depth transect in the western equatorial Indian Ocean of which Site 711 represents the deepest end member. Hole 711A is located on Madingley Rise, at 2°44.56′S and 61°09.78′E at a water depth of 4428.2 mbsl (Fig. 1). For the studied interval the paleodepth has been estimated to have been between 3450 and 3750 mbsl (Peterson and Backman, 1990).

The studied samples were collected from Core 711A-14 to Core 711A-25, spanning the middle Eocene-early Oligocene interval. The mean sampling resolution is ~90 cm, and in key time intervals, it is as high as 37 cm, allowing an average biostratigraphic resolution of 0.42 kyr, that reaches a value of 0.34 kyr in the Eocene. The studied cores in Hole 711A are composed of nannofossil oozes or clay-bearing nannofossil oozes with a consistent occurrence of radiolarians and comprise part of the lithologic units III and IV of Backman et al. (1988) providing a continuous middle Eocene–lower Oligocene stratigraphic sequence.

To better constrain the position of some bioevents of taxa with rare and scattered distribution (i.e., the topmost stratigraphic presence of *Nannotetrina* spp., *Chiasmolithus gigas*, and *Chiasmolithus solitus*) we supplemented our dataset with data from Wei et al. (1992). The smear slides were prepared from unprocessed samples using standard techniques (Bown and Young, 1998), and quantitative analyses were conducted in the light microscope at a magnification of 1250×, counting at least 300 specimens per sample. Two additional long traverses, corresponding to 12.56 mm^2, were scanned in order to identify rare taxa.

In order to create a clearer picture of assemblage changes over time the absolute abundance of each taxon was calculated by converting the number of observed specimens to the total number of specimens in an area of 1 mm^2.

In addition, the same data plotted versus age, representing the assemblage variations, may indicate the paleoecological response to paleoclimatic events previously highlighted (Coxall et al., 2005; Bohaty et al., 2009; Villa et al., 2014). In this study we did not use percentage values because of the dissolution affecting some intervals, that could overestimate the dissolution-resistant taxa (e.g., *Discoaster* spp. and *Cyclicargolithus floridanus*). Only *Clausicoccus* spp. and *Cribrocentrum erbae* were plotted as percentage values because their definition as bioevents is strictly related to their increase in abundance versus the total assemblage (Fornaciari et al., 2010). In the studied material, nannofossils are moderate to well-preserved, and dissolution seems to affect moderately the assemblage, whereas the overgrowth is weak but persistent along the studied interval. We observed at times a slight to moderate etching and a slight to moderate overgrowth in the same sample, which could be indicative of secondary overgrowth on more robust nannofossils at the expense of more delicate ones. At times this makes it difficult to distinguish some taxa consistently at specific levels (e.g., overgrowth of *Nannotetrina* and *Discoaster* nannoliths, and etching of the central area of *Reticulofenestra*). The scarcity of holococcoliths, represented here only by *Zygrhablithus bijugatus*, could be explained by a moderate dissolution and/or by low nutrient availability, a feature of open