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Sarkar, A., & Ogle, N. (2015). Late Quaternary climatic record from ODP Site 705 in the Northern Indian Ocean. *Procedia Earth and Planetary Science Letters*, *13*, 138-141. https://doi.org/10.1016/j.proeps.2015.07.033

Published in:
Procedia Earth and Planetary Science Letters

Document Version:
Publisher's PDF, also known as Version of record

Queen's University Belfast - Research Portal:
Link to publication record in Queen's University Belfast Research Portal

Available online at www.sciencedirect.com

ScienceDirect

Procedia Earth and Planetary Science 13 (2015) 138 – 141

Procedia
Earth and Planetary Science

11th Applied Isotope Geochemistry Conference, AIG-11 BRGM

Late Quaternary climatic record from ODP Site 705 in the Northern Indian Ocean

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Abstract

The uppermost 500cm sedimentary core from ODP site located at the Eastern flank of Najareth bank in the Northern Indian Ocean has yielded altogether twenty four species of planktonic foraminifera. Among all these species, *Globorotalia menardii* has been found to be consistently dominant in the faunal assemblages from most of the samples. The $\delta^{18}O$ measured on the tests of *Globorotalia menardii* from all levels help in precisely working out the sediment accumulation rates at different isotopic stages, and deciphering the change in climate in the Late Quaternary as well.

Peer-review under responsibilty of the scientific committee of AID-11.

Keywords: Planktonic foraminifera; temporal distribution; last glacial maxima; Interglacial maxima; $\delta^{18}O$; $\delta^{13}C$; isotopic stage.

Introduction

Planktonic foraminifera, an immensely productive group of microorganisms, have extensively been used as the proxy for the past climate and oceanographic changes during nearly six decades. In the present work, samples at an interval of 5 to 10 cm each from the upper ~550 cm of ODP core # 705A (13°10.02', 62°23.02' E; water depth 2307.5 meter below sea floor) at the Eastern flank of Najareth bank in Indian Ocean (Figure 1) have been studied. Lithology of the studied core is homogenous coarse grained foraminiferal ooze with a foraminiferal content of about

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Peer-review under responsibilty of the scientific committee of AID-11.
doi:10.1016/j.proeps.2015.07.033

95%, which yielded twenty four species of planktonic foraminifera belonging to three families and ten genera. Based on the foraminiferal and calcareous datum levels, the average sediment accumulation rate has been worked out to be 5.2 m/Ma. Dissolution of the microfossils has been very insignificant in the studied section[1], which shows that the change(s) in the abundance of planktonic foraminiferal tests in all the samples at each level are representative of the climatic and/or water mass change(s) at that time.

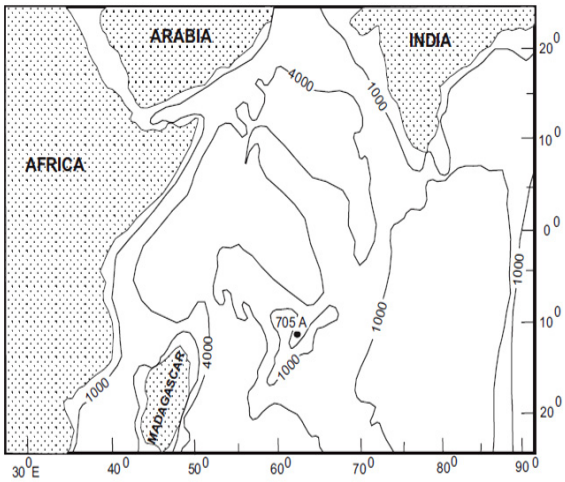

Figure 1: Location map of ODP Site 705

In the present study, understanding the climatic change through the Late Quaternary has been attempted by studying the temporal variations in the abundance of two globorotalid species viz., *Globorotalia menardii and Globorotalia tumida*. While the former is a tropical species, the latter is a subtropical species. These species have been successfully used to decipher the changes in the Quaternary climate in the North Atlantic[2,3] and in the Northern Indian Ocean[4,5].

Results and Discussion

In the present study, planktonic foraminiferal species belonging to Globigerinacea has been avoided as these are upper surface dwelling and hence their abundances may get perturbed by changes in the surface water mass conditions. Therefore, two deeper dwelling planktonic foraminiferal species viz. *Globorotalia menardii and Globorotalia tumida* have been considered to record the 'ice volume effect' only in the isotopic compositions of the tests.

As mentioned earlier, *Gr. menardii* and *Gr. tumida* are planktonic foraminiferal tropical and sub-tropical species respectively, and while a tropical species attains significant abundance peak corresponding to warmer episode, the sub-tropical species attains its peak abundance prior to and later than the peak abundance of the tropical species at the same location. But at the present location a very interesting phenomenon has been observed – trends in abundances of both *Gr. menardii* and *Gr. tumida* are comparable at all levels ($\gamma = 0.74$). All along the studied section abundances of *Gr. menardii* are about 4 to 8 times that of *Gr. tumida* (Figure 2). The rise and fall in abundance of these two species may be because of the following reasons: (i) location being at the boundary of tropical-subtropical provinces, does not witness the extreme of the tropical conditions, (ii) northern branch of colder North Atlantic Bottom Water (NABW) rises near the present location, which probably doesn't allow the significant rise of the temperature of the surface water in the region, (iii) during cool episodes, probably because of decreased productivity, the abundances of both the species is reduced. As the location does not witness the extreme climate, the abundances of both these species are equable and hence there occurs a significant positive correlation coefficient between them.

The close examination of the temporal variations of both the species depicts three distinct trends with intermittent rise and fall. An increasing abundance trend continues from ~500cm to 300cm, a decreasing trend from 300cm upwards to ~90cm followed by a slight increasing trend upwards. Following the Ericson zonation[2-5], which are standard paleoclimatic (glacial and interglacial) zones delineated based on the abundance of *Gr. menardii* (a tropical planktonic foraminiferal species), it may be interpreted that the rise and fall in abundances of these two species corresponds to warming and cooling episodes respectively.

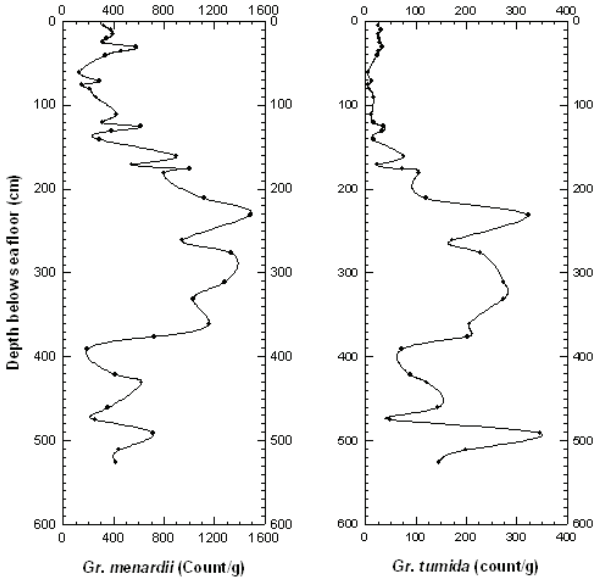

Figure 2: Temporal variation of the abundances of *Gr. menardii* and *Gr. tumida* in ODP Core #705

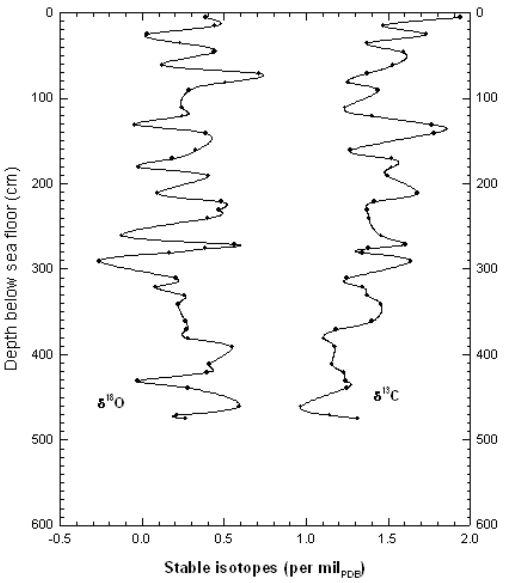

Figure 3: Temporal variation in $\delta^{18}O$ and $\delta^{13}C$ of *Gr. menardii* in ODP Core #705

$\delta^{18}O$ in the upper ~500cm core shows amplitude of nearly 1.25 per mil with a maximum value of 0.95 per mil and a minimum of -0.26 per mil (Figure 3). The increasing and decreasing trends in the $\delta^{18}O$ are discernible and are anticorrelated with the trends in the abundances of the two species studied in the present work. The maximum enrichment in $\delta^{18}O$ at 70 cm may be designated as the last glacial maxima (LGM, isotopic stage 2), which is corroborated well by the minimum abundances of both *Gr. menardii* and *Gr. tumida* at that depth/time. The maximum depletion at ~300cm has been correlated with the last interglacial maxima (LIG, isotopic stage 5)[6], which again is corroborated by the maximum abundances of both *Gr. menardii* and *Gr. tumida* at that depth/time (Figures 2 and 3).

$\delta^{13}C$ in the present site ranges from 0.97 to 1.94 per mil. Unlike $\delta^{18}O$, $\delta^{13}C$ with minor fluctuations shows a steady increase from ~500cm to 170 cm, depicting an increment in the primary productivity in this section.

Conclusions

The sediment accumulation rate in a sedimentary sequence cannot be constant through time. Because of various factors, the sediment accumulation rate varies a lot. Hence, sediment accumulation rate stated in the ODP initial report is over simplification. Considering the isotopic age assignments to the depth in the sediment core, average sedimentation rate during last interglacial maxima-last glacial maxima transitions work out to be 2.15cm/ka and the sedimentation rate after the post LGM episode works out to be 3.88 cm/ka. Pestiaux *et al* (1988) based on the $\delta^{18}O$ of *Nonion* and *Neogloboquadrina pachyderma*, documented from a deep sea core at nearly 43° S latitude 10cm/ka

and 16cm/ka during LIG-LGM transition and post LGM periods respectively. Hence, the isotopic data in the present core corroborates the interpretations made on the micropaleontological observations.

Acknowledgements

AS acknowledges Indian School of Mines, Dhanbad for kindly providing the necessary facilities for micropaleontological work. Stable isotopic measurements have been done in the Environmental Engineering Research Centre, The Queen's University of Belfast, Belfast, Northern Ireland.

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