SCAR Fellowship Report - 2014/2015

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Research project title: "Biomarker based reconstruction of late Quaternary Palaeoceanographic conditions in the Indian sector of the Southern Ocean"

Duration: 26th January, 2016 to 27th May 2016.

Introduction

The Southern Ocean being the single most important connection between the Atlantic, Indian and Pacific Ocean basins, it plays an essential role in the redistribution of heat, salt, nutrients, gases and other properties throughout the global ocean (Rintoul et al., 2011; Bostock et al., 2013). Reconstruction of the late Quaternary climate changes and its impacts on the Earth system processes have been used to improve our understanding of past changes that would help us improve the projections of future climate and environment, and inform strategies for sustainability. The Indian Ocean sector of the Southern Ocean comprises a major portion in the Southern Ocean and therefore influences atmosphere-ocean processes on the regional and global scale. Sea surface temperature (SST), is a vital element in the global climate study and accurate estimates of past SSTs are crucial for the quantitative understanding of the global climate changes. Molecular proxies, especially biomarker approach for the investigation of SST, biological productivity as well as changes in the mineral dust input to the Southern Ocean that was so far thought to be restricted to the Atlantic sector of the Southern Ocean. Multiple proxy studies based on the SST records from different sectors of the Southern Ocean show a clear Antarctic pattern during the deglaciation records (Ikehara et al., 1997; Pahnke et al., 2003; Kiefer and Kienast, 2005; Kaiser et al., 2005). However, sedimentary carbonate production is low and/or the preservation of carbonate is poor typical of south of the polar frontal regime of the Southern Ocean.

The study focused on well-dated sediment cores from the Indian sector of the SO. Detailed research on various biomarkers on these samples carried out at Center for Advanced Marine Core Research (CMCR), Kochi University, (Kochi Core Centre-KCC), Japan scheduled during 26th January to 26th May, 2016. As part of the fellowship program, the undersigned participated on the Japanese Expedition to Southern Ocean on research cruise KH-16-1 by R/V Hukuho-Maru from 27th January to 27th February, 2016. The expedition started from Port Louis, Mauritius to SO and disembarked at Perth, Australia. During the expedition, different physical, chemical and geological experiments were carried out and the team deployed the sediment trap to the Indian sector of the SO. Unfortunately, no sediment cores collected during the expedition due to the rough condition and coring failure. The sediment core (DCR-1PC) collected from Del Cano Rise from the Indian sector of the SO (Fig. 1) during the previous expedition available at Kochi University are used for the above study. Detailed and high resolution analysis carried out on these sediment cores, in order to advance the understanding of the spatial and temporal variability of observed climatic and oceanographic changes and the forcing mechanisms. The proposed research work will focus on organic geochemical (biomarker) proxies along with the available stable isotope and other geochemical proxy data for the reconstruction of past environmental and climate change.

Detailed and high-resolution studies carried out on the sediment samples which is preserved in the Kochi Core Centre repository. The sediment core (DCR-1PC) sub-sampled in ~1 cm intervals for the first 516 cm (samples numbers - 456) for the present study. The core is well dated by accelerator mass spectrometry (AMS) radiocarbon (^{14}C) dating at selected intervals using the planktonic foraminifers. The age model is already developed using foraminiferal oxygen isotope data and other proxies available in this core. Accordingly, the preliminary age model suggests that 516 cm of the sediment core represent the past ~190 Ka BP, comprising last two glacial periods. The samples were freeze-dried, ground in agate mortar was used for measuring organic carbon, nitrogen and biomarker analyses. All the 456 samples and standards were analysed for the TOC and nitrogen analysis using acid-treated samples using CHNS Thermo Finnigan Flash EA 1112 analyser.

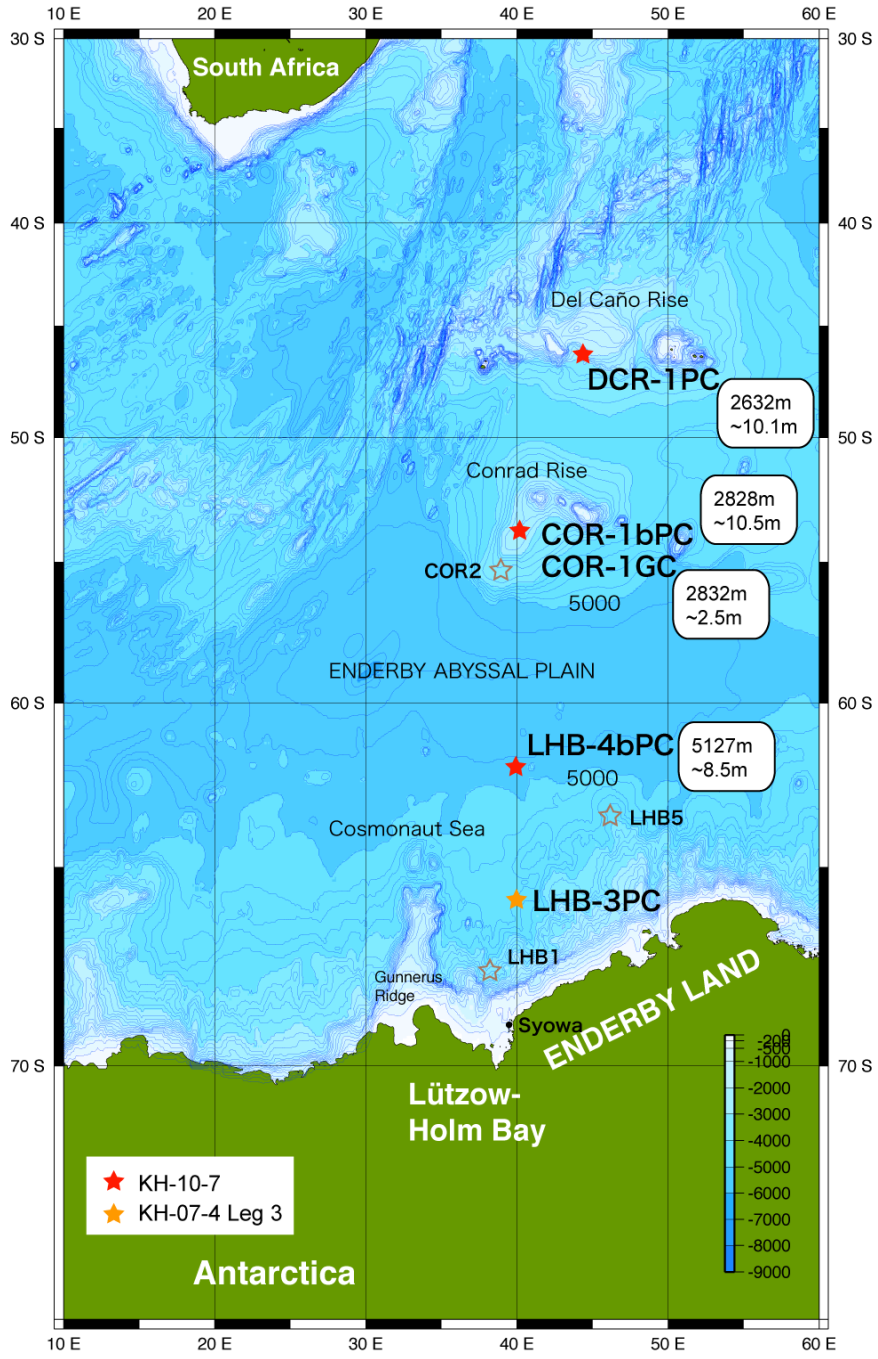

Fig. 1. Location map of the study area and core locations from the Japanese expedition to the Indian sector of the Southern Ocean

A total of 150 samples (every alternate sample) were analysed for the biomarker studies. Extraction of normal alkane biomarkers began with total lipid extraction using the Dionex Accelerated Solvent Extractor (ASE). In the ASE system, the samples rinsed in the solutions of dichloromethane (DCM), and methanol (MeOH) to which 5α-cholestane and cholesterol had been added as internal standards at temperatures of 100°C and a pressure of 1000 psi. The solvent of the extracts was removed by the evaporation using Turbovap. The extracts

were separated into four fractions: N1 (hydrocarbons), N2 (aromatic hydrocarbons), N3 (ketones), and N4 (alcohols and sterols) via column chromatography using solvent mixtures (four mixtures) of Hexane, Hexane/DCM, DCM/Methanol and Methanol. Fraction hydrocarbon (N1) and ketone (N3) were analysed using a Gas chromatography with flame ionization detection (GC–FID: Agilent 6890 N Gas Chromatograph, Agilent Technologies. Each compound was identified by using GC–mass spectrometry (GC–MS: Agilent 5973 Network MSD, Agilent Technologies). Identification of alkenones was conducted by comparing gas chromatographic retention times.

We are currently processing the data set which is derived from the measurement to understand the palaeo-temperature, terrestrial input and productivity in the Southern Ocean. This proposed study with multiple biomarkers along with the available stable isotope and other geochemical proxy data would allow the reconstruction of millennial-scale variability over the Southern Ocean and their global linkages. A better understanding of how changes in sea-ice conditions, particularly extent and duration, have affected past climates allows us to understand how the presence or absence of sea ice will affect our present and future climate.

Future Work

The work carried out will help us to obtain the quantitative records of SST and salinity, which is essential for decoupling the impact of past climate change on these crucial parameters of climate change. The high-resolution records during the late Quaternary generated will be very valuable for the modelling of the Southern Ocean processes towards basin-wide millennial climate variability. The research work carried out would also benefit the host institution as the research will directly contribute to the ongoing project in Southern Ocean at CMCR and would also contribute to the proposed future IODP project in the Indian sector of the Southern Ocean. Further, the technical and scientific skills developed during the fellowship program would support future capacity building in BSIP and would help future collaborative scientific programs with the host institute.

Poster presentation

Minoru Ikehara and Scientific Members of the KH-16-1 Cruise Summary of marine geological survey in the Indian sector of the Southern Ocean: Preliminary reports of KH-16-1 cruise. Japan Geoscience Union Meeting 2016. Chiba-city, Japan.

Financial Statement

A total of $10000 fellowship money was allotted for this study. $4000 was used for travelling between India and Japan and for the travelling expenses for the Japanese Southern Ocean Expedition. An amount of $2000 was used for housing in Kochi and rest of the money was spent for internal travel and living in Kochi for ~4 months.

Acknowledgement

This research work was made possible by the fellowship grant from the Scientific Committee on Antarctic Research. I thank Dr. Minoru Ikehara for accepting the application as my mentor and giving me the immense support throughout the work in his lab. I am extremely thankful to Mrs. Y. Fujimura for the technical support during the laboratory work. My special thanks to Miss. Mika Sata, Dr. Lallan Gupta and all the rest of the KCC members for their kind support. I am thankful to all scientific and staff crew members of the KH-16-1 (Japanese Expedition-Southern Ocean). The continued support and encouragement by the director BSIP, Prof. Sunil Bajpai is greatly acknowledged. Special thanks to Dr. Thamban Meloth for his motivation, support and advice.