Press Releases

JAMSTEC
Japan Agency for Marine-Earth Science and Technology

October 27, 2014
JAMSTEC

How does Orbital Variations Affect Ancient Antarctica?
~East Antarctic Ice Volume Change during Pliocene and Early Pleistocene~

1. Overview

The IODP Expedition 318 scientists, including Dr. F.J. Jimenez-Espejo from Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology (JAMSTEC; Asahiko Taira, President) conducted a detailed time-series analyses of ice-berg rafted debris collected from a sediment core adjacent to the Wilkes Subglacial Basin of the East Antarctic Ice Sheet (EAIS) (figure 1). As a result, it was found that the EAIS patterns have suffer a major change around 3.5 million years ago.

It is known that the changing pattern of the EAIS, which is sensitively affected by climate changes, responds to the Earth's orbital elements related to the sun energy reaching the Earth (figure 2). Precession is said to affect solar insolation during the summer, causing growth and melting of ice sheet, while obliquity affect mean annual insolation, which causes change in global seawater temperature.

Based on core samples collected in the Antarctic Ocean, this analysis examined the timing of the EAIS melting mode occurred between 4.3 and 2.2 million years ago. It found out that, prior to 3.5 million years ago, the sea ice melting was related mainly to variance in the obliquity cycle, and since 3.5 million years, it has been related to precession. In other words, the EAIS was sensitive to seawater temperature variations in the Antarctic Ocean during the period older than 3.5 million years, while it has been affected mainly by summer insolation since 3.5 million years ago.

This study results demonstrate how the EAIS volume, in particular melting, is caused when the global seawater temperature was 2 °C higher, as occurred during the early Pliocene. In facing global warming, it gives an important insight into the EAIS behaviors. Also, it is expected to contribute to prediction of future climate changes, because this study indicates that EAIS is not as stable as expected.

This study result has been published by the online journal, Nature Geoscience on October 26 (JST: 2:00am, October 27)
Title: Orbital forcing of the East Antarctic Ice Sheet during the Pliocene and Early Pleistocene
Author: M. O. Patterson[1], R. McKay[1], T. Naish, C. Escutia[2], F.J. Jimenez-Espejo[3], M.E.Raymo[4], S.R. Meyers[5], L. Tauxe[6], H. Brinkhuis[7], and IODP Expedition 318
1) Antarctic Research Centre, Victoria University of Wellington, Wellington, New Zealand

2) Instituto Andaluz de Ciencias de la Tierra, CSIC – University of Granada, Granada,Spain
3) Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan
4) Lamont-Doherty Earth Observatory of Columbia University P.O. Box 1000, 61 Route 9W, Palisades, NY, 10964, USA
5) Department of Geoscience, University of Wisconsin-Madison,1215 W. Dayton St. Madison, WI 53706, USA
6) Scripps Institution of Oceanography, La Jolla, CA 92093-0220, USA
7) Marine Palynology and Paleoceanography, Laboratory of Paleobotany and Palynology, Utrecht University, Budapestlaan 4, 3584 CD Utrecht, NL

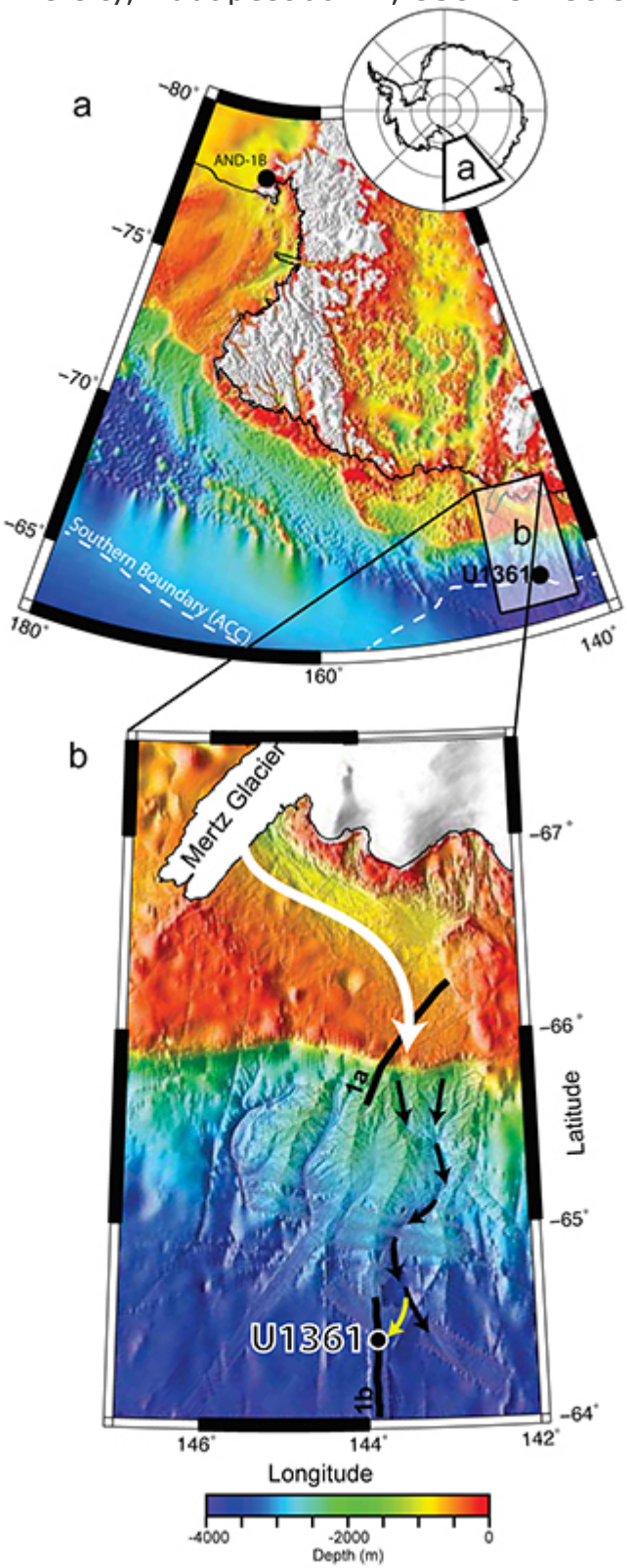

Fig.1: Integrated Ocean Drilling Program (IODP) site U1361 adjacent to the Wilkes Subglacial Basin of the East Antarctic Ice Sheet (EAIS). A white arrow shows the current route of past ice sheet flow.

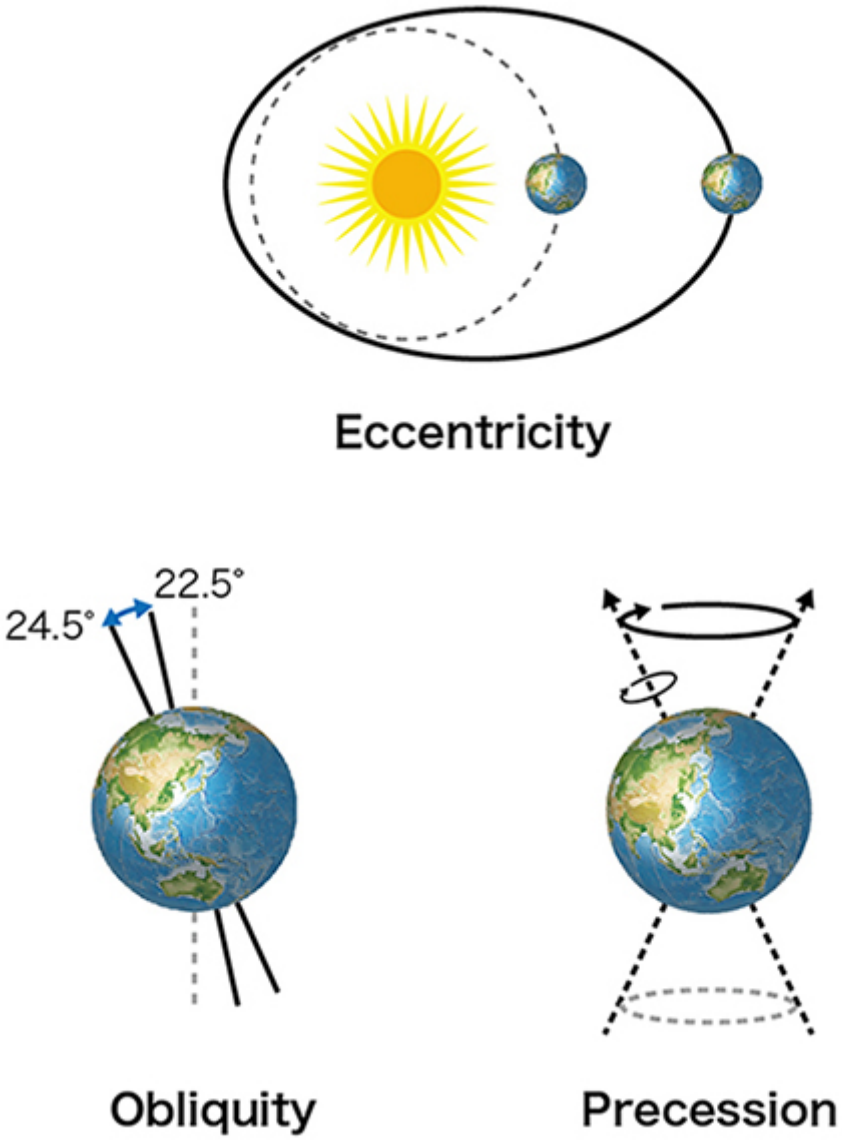

Fig.2: Overview of three orbital elements.
The top shows eccentricity follows a 100,000 year cycle; the bottom left shows obliquity a 40,000 cycle, and the bottom right precession with a 20,000 cycle.
http://www.sciencecourseware.org/eec/GlobalWarming/Tutorials/Milankovitch/

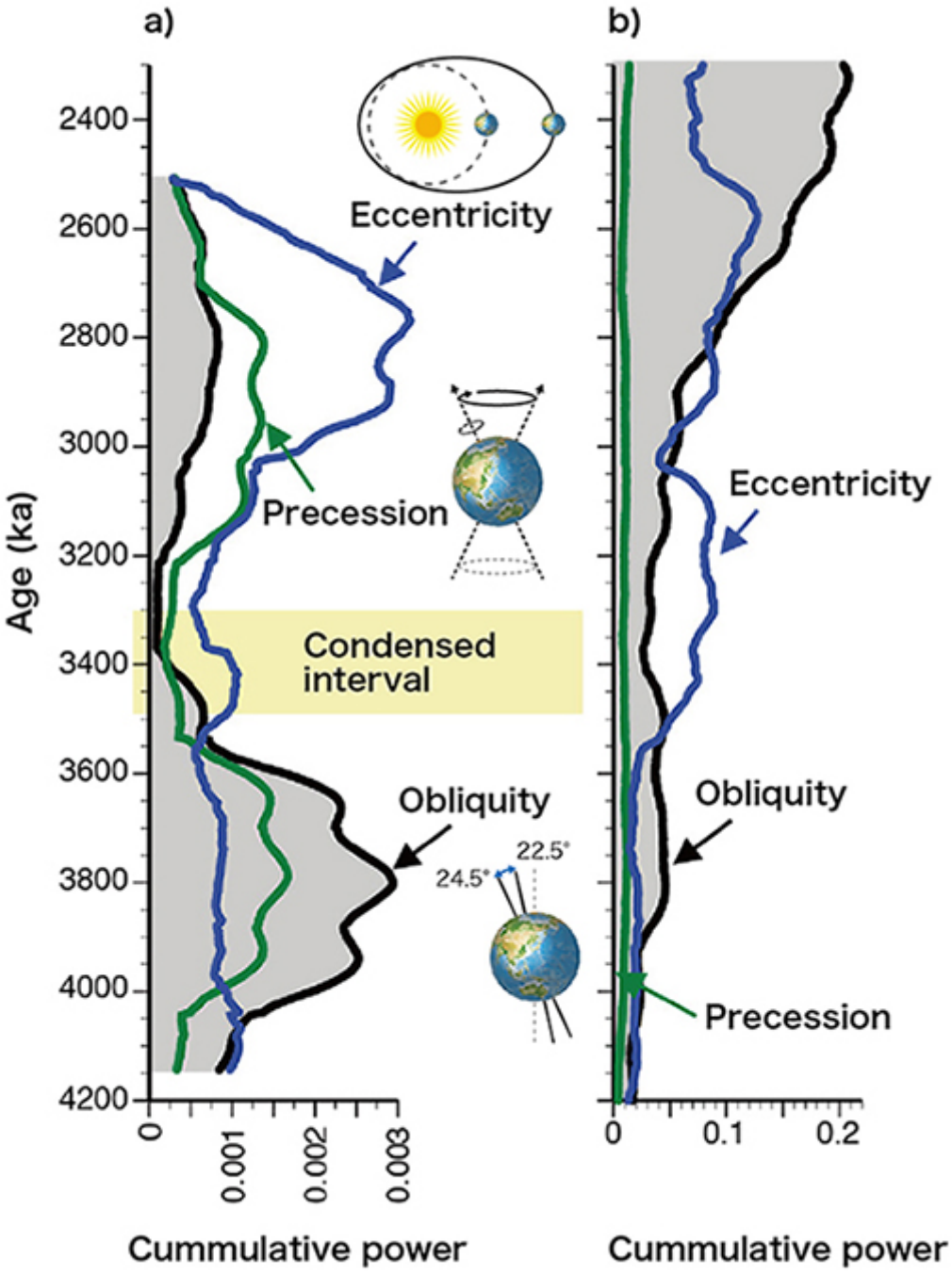

Fig 3:
Time-series behaviors of impacts on climate caused by the Earth's orbital elements. Overview of the result of periodic analysis.
a) It shows what impacts the Earth's orbital elements (eccentricity, obliquity, and precession) give the accumulation rate of the ice-berg rafted debris (IBRD) carried by ice sheet. Prior to 3.5 million years, the obliquity 's impact was much more significant, while eccentricity and precession have been affected more largely since 3.5 million years ago. The impact of eccentricity has been larger because of indirect effect of eccentricity variance, which amplifies precession. However, as shown in b), in oxygen isotope fractionation ($\delta^{18}O$) in benthic foraminifera (Lisiecki & Raymo 2005), a planetary signal for glacial/interglacial cycles, a different impacts of variance in obliquity can be seen, including even after 3.5 million years.

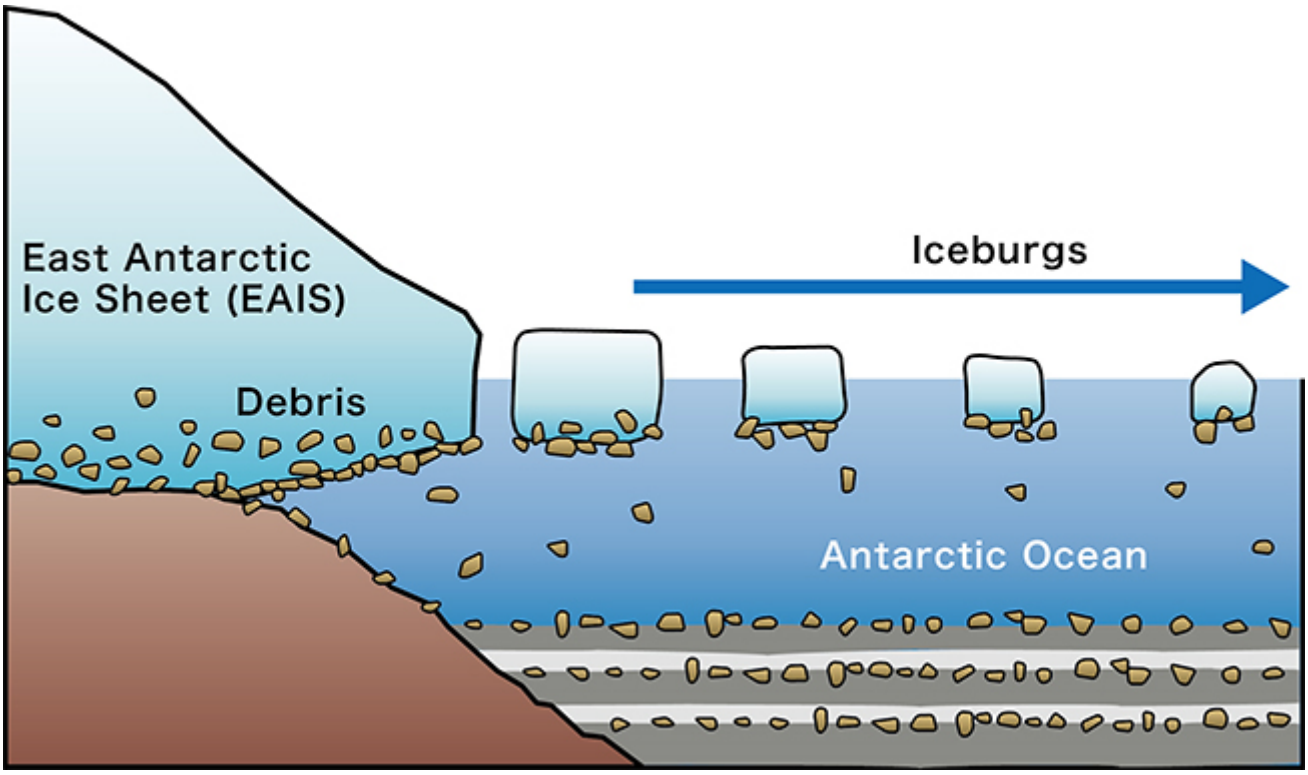

Fig.4. A diagram showing ice-berg rafted debris accumulating on the seafloor.

Contacts:
(For this study)
F.J. Jimenez-Espejo, Department of Biogeochemistry
(For press release)
Kazushige Kikuchi, Manager, Press Division, Public Relations Department