


Understanding Large-Scale Retreat Mechanisms of the Antarctic Ice Sheet through Seamless Sea-Land Geological Drilling

	Principal Investigator	National Institute of Polar Research, Division for Advanced Research Promotion, Professor SUGANUMA Yusuke	Researcher Number : 70431898
	Project Information	Project Number : 24H00026	Project Period (FY) : 2024-2028 Keywords : Antarctic Ice Sheet, Mechanism of Ice Retreat, Sea Level Rise

Purpose and Background of the Research

● Outline of the Research

The rapid melting of the Antarctic ice sheet (AIS) and subsequent sea-level rise pose a significant concern. The mechanisms behind significant melt events during the past warmer periods, which are critical for accurate climate change predictions, are not fully understood. To address these uncertainties, our project will carry out comprehensive "sea-land seamless geological drilling" along the Antarctic coast. Utilizing advanced analytical methods since the last glacial period (ca. 20,000 yrs ago), we aim to reconstruct past climate and ocean conditions, uncovering the significant melt processes. Various modelling techniques are also applied to identify the triggers and conditions for the melting. This integrated strategy will enhance our understanding of the AIS melting mechanisms and refine climate change projections.

● Academic question

The AIS can potentially undergo large-scale melting; its long response time makes it difficult to understand the melting mechanism only with modern observations. The question is: "What are the triggers & conditions for the AIS large-scale melting?"

Background information

1. The acceleration of the AIS melting will likely cause a rapid rise in sea level shortly.
2. However, there is uncertainty in future projections of sea-level rise.
3. This uncertainty is primarily due to a lack of understanding of AIS melting mechanisms.

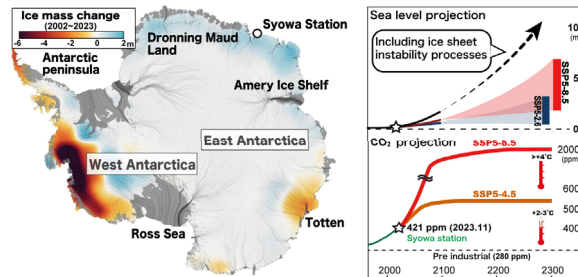


Fig. 1 Present AIS melting, Future projections for CO₂ and sea level rise (IPCC AR6).

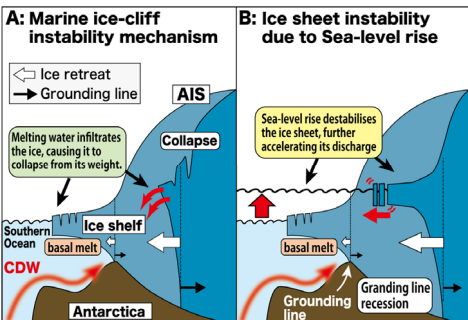


Fig. 2 Proposed mechanisms triggering AIS melt

Focused mechanism of the melting

AIS margins are disrupted by:

- A: Marine ice-cliff instability mechanism
- B: Ice sheet instability due to sea-level rise

Research contents

Sea-land seamless geological drilling along the AIS margin
 → climatic and oceanic conditions
 Ocean, ice sheet and sea level modellings
 → triggers and their conditions

● Key research points (innovation and internationality)

Original techniques, such as the drilling system and AI-based sample analysis system, will be used to reveal the AIS melting process and ocean conditions at that time. The project links to the international geological drilling project underneath the Ross Ice Shelf (SWAIS-2C).

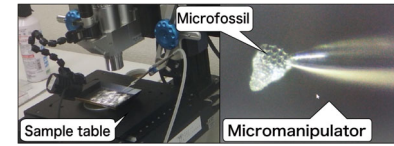


Fig. 5 AI-based identification/picking equipment for microfossils/particles.

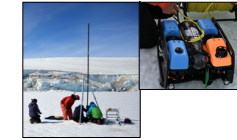


Fig. 6 Geological coring systems, and underwater drones.



Fig. 7 Logo of SWAIS2C, and participating institutions.

Expected Research Achievements

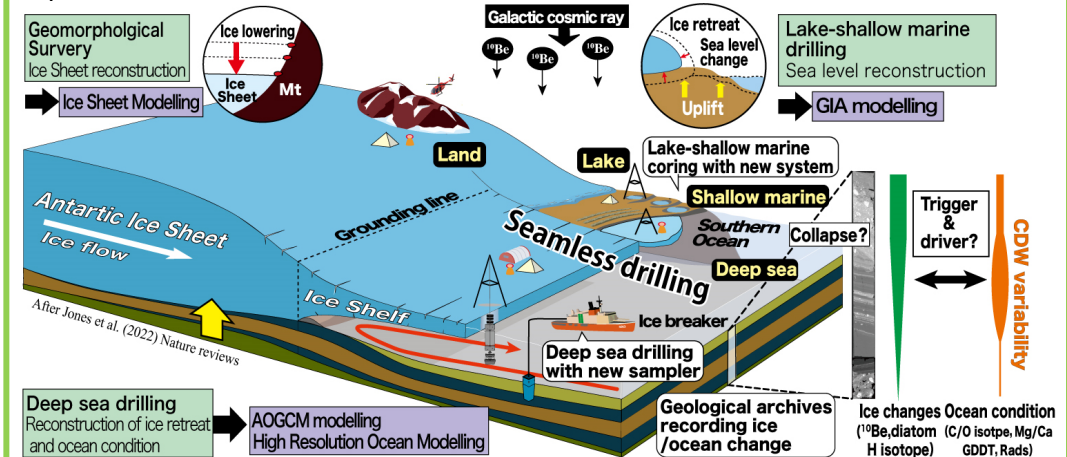


Fig. 3 Understanding Mechanisms of the AIS retreat through Seamless Sea-Land Geological Drilling

● Reconstruction of melting processes and oceanic conditions

The "sea-land seamless geological drilling" will be deployed at multiple points (Fig. 4). Based on sample analysis and high-precision dating, the timing, speed and magnitude of past AIS melt and the ocean conditions will be reconstructed.

● Analysis of ice sheet melting triggers and their conditions

Numerical modelling experiments will be compared with the reconstruction of oceanic conditions. Relative sea-level change at the AIS margin is also obtained based on crust deformation modelling. The timing of large-scale ice sheet melting and sea-level rise will be examined to determine the triggers of large-scale ice sheet melting.

● AIS melting mechanisms and regional characteristics

Based on the outcomes, we will address the question, "What are the triggers and triggering conditions for large-scale AIS melting?" These findings will not only address melting tipping points but will also contribute to reducing uncertainty in the future projection of AIS melting and sea-level rise.

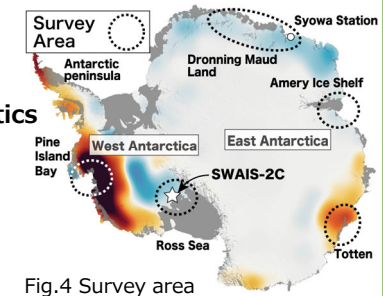


Fig.4 Survey area