Deposition Mechanisms and Sources of Sediment in the Weddell Sea, Antarctica

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Introduction

Today's global trend of rising temperatures may elicit large scale melting of the polar ice caps which might give rise to elevated sea levels, altered deep-ocean circulation patterns, and other climate changes (Thomas, R., et al. 2004). In order to fully comprehend the effects of the polar ice cap melting, it is crucial to study and examine past occurrences of similar processes and reconstruct patterns of iceberg discharge.

This study focuses on the West Antarctic region where the marine-based ice shelf is highly susceptible to melting and discharge of icebergs from the Antarctic Ice Shelf into the Weddell Sea. This understanding of iceberg dynamics in the Weddell Sea will be achieved by reconstructing the provenance and examining the deposition mechanisms of the different sedimentary fractions deposited in the Weddell Sea (Fig. 1).

The main focus of this study is to identify the most probable and dominant sediment deposition mechanisms (ice-rafting vs. current transport) by using grain size distribution patterns from Weddell Sea sediments deposited during the last ~250 ka.

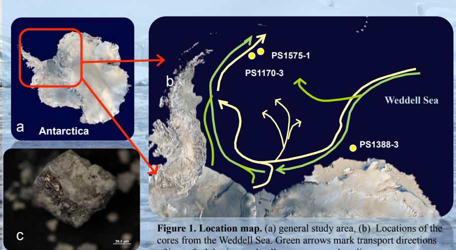


Figure 1. Location map. (a) general study area, (b) Locations of the cores from the Weddell Sea. Green arrows mark transport directions of ice-rafted detritus and yellow arrows mark sediment current transport path.(Diekman and Kuhn, 1999) (c) Large pebble particle from core PS 1388-3.

Objective

What were the deposition mechanisms and sources of sediments in the Weddell Sea, Antarctica, and what can they tell us about past climate changes?

When?

Ages previously established by $\delta^{18}O$ stratigraphy (Frank et al., 1995)

How?

Dominant method of sediment deposition?

Ice Rafted Debris (IRD) vs. Current Transport

Where?

Provenance of the sediments based grain size distribution and geochemical compositions

Results

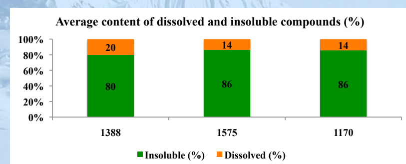


Figure 2. Dissolved compounds vs. insoluble residue. The range of insoluble residue fraction from the 3 core sites is between 80% and 86%. The samples from Core PS1388-3 contains on average 6% less of insoluble residue compared to Core PS1575-1 and Core PS1170-3.

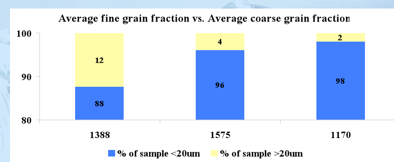


Fig. 3 Fraction of fine vs. coarse grain. The range of coarse grain (>20 um) weight fraction from the 3 core sites is between 88% and 98%. The sediment samples from core PS1388-3 contains on average 8-10% more of coarse grains compared to core PS1575-1 and core PS1170-3.

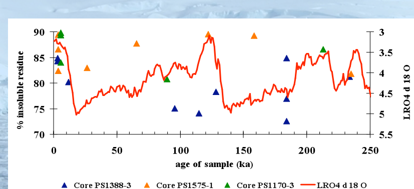


Fig. 4a Fraction of insoluble residue vs. age.
As a general trend the amount of insoluble residue appears to increase during the peaks of interglacial phases, marked by the peaks of the $\delta^{18}O$ stratigraphy. Cores PS1170-3 and PS1575-1 contain higher amounts of insoluble residue compared to Core PS1388-3.

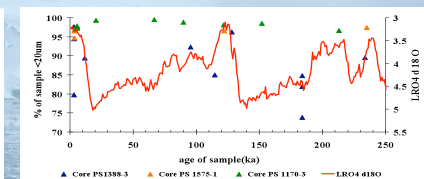


Fig. 4b Fraction of Fine Grains vs. Age.
Samples from core PS1170-3 and Core 1575-1 contain extremely high amounts of fine sediment particles (<20um), approximately between 95% and 100%. The amount of fine particles present in a sample increases during the peaks of interglacial phases (pink shadowed areas). Marginal samples, from Core PS1388-3, exhibit high sensitivity to climate changes as the fine grain percentages vary strongly between interglacial and glacial phases when compared to the other two core sites.

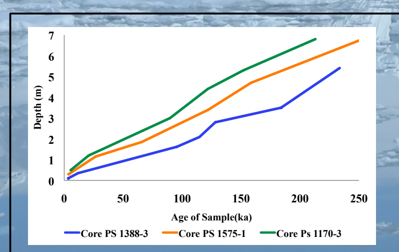


Figure 5. Age models for studied cores (from: Frank et al., 1995). Core PS 1170-3 shows the steepest slope out of the three cores sites, indicating a relatively higher rate of sedimentation compared to the other two core sites. Core PS1388-3 displays high sensitivity to changes in the deposition environment, associated with climate changes, as the degree of the slope increases sharply during interglacial phases.

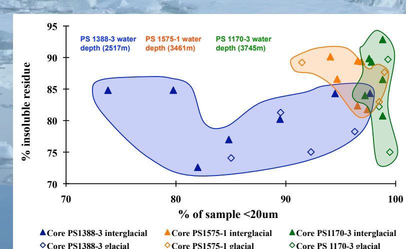
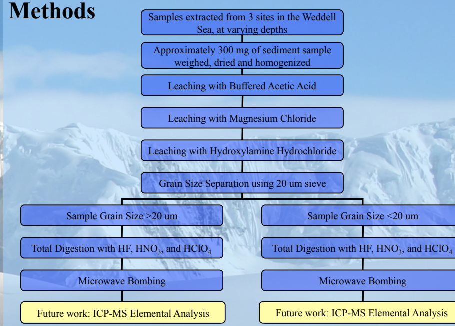


Fig. 6 Insoluble residue distribution vs. fine grain fraction
These are the results for 21 samples and 8 replicates. In PS1575-1 and PS1170-3, a higher percentage of fine grains within the sample corresponded to a higher percentage of insoluble residue. On the other hand, PS1388-3 exhibits a widely spread range of fine grain weight fractions from approximately 75% to 98% with seemingly no particular correlation to the amount of insoluble residue within the sample.

Methods



Conclusions

- This study focuses on three sediment cores comprising of Late Quaternary sediments deposited in the Weddell Sea, Antarctica. One is located along the path of current transport of fine sediments from East Antarctica (core PS1388-3) and the other two are located along the path of icebergs drifting into the southern ocean.
- Core PS1388-3 exhibited high sensitivity to climate changes (Fig.4b), whereby the distribution of fine and coarse particles changes dramatically between glacial and interglacial periods (Fig. 6). In general, this core contains a high concentration of coarse particles (Fig. 3) due to its proximity to land and its shallow water depth of 2517m. Deep Sea samples from cores PS1571-1 and PS1170-3, exhibited high concentrations of fine particles (Fig.3 and 6) while their grain size distribution is consistent over time (Fig. 6).
- The grain size data reflects the geographical location of the sites. The further away the sites are located along the sediment transport path, the more likely the content of fine grain is larger. This reflects sediments transported by sea currents. However, coarse ice-rafted debris can be found in distant sites (e.g. PS1170-3 and PS1575-1)
- The results of this study show the dominant source of sediment at site PS1388-3 is nearby, probably delivered through ice-rafting events as indicated by the poorly sorted sediments and angular edges (Fig. 1b). In addition, ice rafting events occurred more frequently during interglacial periods (Fig. 6), as warmer temperatures trigger iceberg discharges. At the same time, we observe strong variability in sediment sizes and origin between glacial and interglacial periods, reflecting the strong control of continental ice volume on deposition mechanisms at this site (Fig. 6). On other hand, sites PS1575-1 and PS1170-3, current transport is the more dominant mechanism responsible for the high concentration of the fine grain particles and rapid sedimentation rates (Fig. 5).
- Future measurements of the chemical composition of the sediments will provide more insight into the source and transport mechanisms of the studied sediments.

References

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