

Bottom currents-controlled sedimentary archives in the southeast Weddell Sea

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Abstract: Understanding the transport and deposition of sediments brought to the Antarctic continental shelves by major ice streams helps provide constraints on past ice sheet history. In this study, we investigate a series of iceberg erosional and current reworked features along the continental margin of the southern Weddell Sea to understand glacial sedimentation processes from the middle Miocene to the present. The Crary Trough Mouth Fan (CTMF), channel systems, levee deposits, and giant elongate mounded sediment drifts are investigated using high-resolution seismic reflection, sub-bottom profiler and swath bathymetry data. The formation of the giant elongate mounded sediment drifts is ascribed to the semi-enclosed drainage basin, large glacial trough-Crary Trough, paleo-ice streams, plenty of sediment supply, sufficient accommodation space, intensified bottom current (WSBW) and Coriolis effect. The well-developed networks of gullies and channels that we observe cut into the continental shelf edge of Dronning Maud Land were formed during incision by sediment-laden meltwater and associated with sediment gravity flows from the base of ice sheets grounded at the shelf edge. A remarkable increase in mass transport deposits (MTDs) in the late Miocene and middle Pliocene strata is related to collapses of the CTMF, ice advances, overpressure of rapid accumulation of sedimentary as well as the steep topographic gradients.

Key words: Weddell Sea, seismic reflection data, elongated mounded drift

INTRODUCTION

Glacially derived depositional and erosional features and deposits reworked by ocean currents dominant the seafloor and upper sedimentary strata of the continental margin of the southeastern Weddell Sea. The prominent glacial trough located on the Filchner Shelf, the Crary Trough, is 100-150km wide, 800m deep, and extends from beneath the Filchner Ice Shelf to the continental shelf edge (Fig. 1). The associated Crary Trough Mouth Fan (CTMF) formed when grounded ice reached the continental shelf edge as fast-flowing ice streams, delivering large volumes of sediments directly to the upper slope. The margin of the southeast Weddell Sea is dominated by gullies and channels eroded by melt water and/or dense shelf water flowing down-slope or by turbidity currents originating from debris flows (Hillenbrand et al. 2009) (Fig. 1).

This paper aims to describe the seismic features of the continental margin of the southeast Weddell Sea by focusing on the depositional history of the giant elongate mounded sediment drifts and mass-wasting deposits off the Crary Trough. These findings will be used to draw conclusions concerning the glacial sedimentary processes that have influenced the margin's shape. We use high-resolution seismic, sub-bottom profiler and bathymetry data to investigate the sedimentary characteristics.

DATA AND RESULTS

The most prominent pattern of linear wedge-shaped sediment accumulations is interpreted as a set of giant, elongate-mounded drifts. Elongate-mounded drifts have

built up in the southeastern Weddell Sea since the middle Miocene.

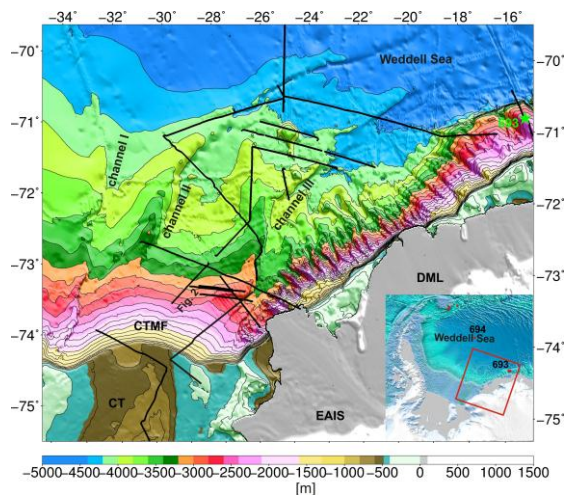


FIGURE 1. Bathymetry map of the southeast Weddell Sea. Black lines are the seismic reflections lines. Green stars = Drilling site; CT = Crary Trough; CTMF = Crary Trough Mouth Fan; DML = Dronning Maud Land; EAIS = East Antarctic Ice Sheet.

These drifts are characterized by sinuous bathymetric highs running nearly perpendicular to the southern margin (Fig. 1). Together with seismic reflection profiles, the bathymetric pattern constrains the drifts to be more than 150km wide, 700km long, and 1km thick (Fig. 1). These drifts are typically externally asymmetric in shape, with a steeper and rougher eastern face and a gentler, smoother western face (Fig. 2). The drift in figure 2 is located on the NW margin of Channel III, close to the CTMF. Its steep side is characterized by relatively high amplitude reflectors that terminate laterally at the seafloor. In contrast, the more gentle side

shows parallel or sub-parallel internal reflectivity, which conforms to the sea floor above WS-u6. Hummocky or chaotic reflectivity is observed at both sides of the mound and is interpreted as buried channels underneath the unconformity WS-u6. It appears that the mound has migrated to the west since the middle Miocene, perhaps due to Coriolis effect.

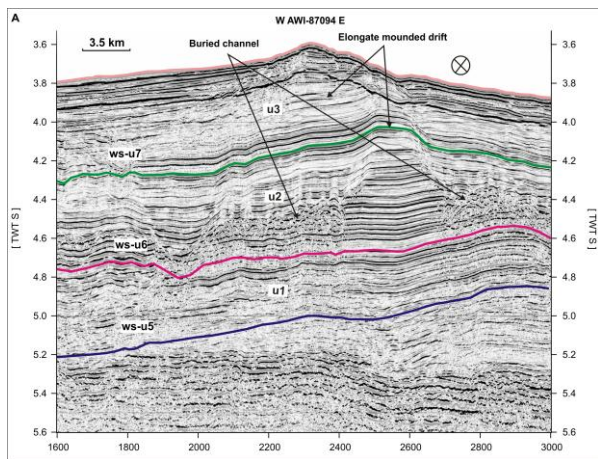


FIGURE 2. Example of the elongate mound sediment drift see the location on Fig. 1.

DISCUSSION AND CONCLUSIONS

The elongation trend, direction and degree of progradation of giant elongate-mounded drifts can vary with respect to the sediment supply, contours of the margin, interaction between topographic variability, the current system and intensity, and the Coriolis effect (Rebesco et al., 1997; Stow et al., 2002; Uenzelmann-Neben, 2006).

The great quantity of terrigenous sediment discharged to the continental slope and rise by ice streams and channel system in this way was further modified by bottom currents. Cold, dense WSBW forms with melted ISW (Ice Shelf Water) under the Filchner-Ronne Ice Shelf, flows out northwards, and branches out along the basin floor. The position and morphology of drift deposits are controlled by the pre-existing seafloor, which controls and directs the various branches of the bottom currents initially (McCave and Tucholke, 1986). The direction of the bottom currents is also interacted with drift topography subsequently. Thus, we affirm the NE-SW trends of the giant, elongate-mounded drifts and channels (Channel II and Channel III) were probably associated with the northeast flow direction of the WSBW in the southeast Weddell Sea. Data on the WSBW mass in the southern Weddell Sea is limited; we think that it could flow in any direction between the northwest and northeast. AABW circulates along the continental margin and flows towards the west in the southeast Weddell Sea, where it has contrived the asymmetric geometry of the drift bodies under the influence of the Coriolis force.

The unique sedimentation environment of the southeast Weddell Sea, with its semi-enclosed drainage

basin, large glacial trough, (paleo-)ice streams, abundance of sediment supply and accommodation space, intensified bottom currents (WSBW, AABW) and Coriolis effect are the keys for developing its giant elongate-mounded sediment drift.

REFERENCES

- Hillenbrand, C.D., Ehrmann, W., Larter, R.D., Benetti, S., Dowdeswell, J.A., Ó Cofaigh, C., Graham, A.G.C. & Grobe, H. 2009, Clay mineral provenance of sediments in the southern Bellingshausen Sea reveals drainage changes of the West Antarctic Ice Sheet during the Late Quaternary. *Marine Geology* 265, 1-18.
- McCave, I.N. and Tucholke, B.E., 1986, Deep current-controlled sedimentation in the western North Atlantic. In: P.R. Vogt and B.E. Tucholke (Editors), *The Geology of North America, Vol. M. The Western North Atlantic Region, Decade of North America Geology*. Geological Society of America, Boulder, Colo., pp. 451-468.
- Rebesco, M., Larter, R.D., Barker, P.F., Camerlenghi, A., Vanneste, L.E., 1997, The history of sedimentation on the continental rise west of the Antarctic Peninsula. In: Barker, P.F., Cooper, A.K. (Eds.), *Geology and seismic stratigraphy of the Antarctic margin, 2*. Antarctic Research Series, vol. 71, pp. 29-49. AGU.
- Stow, D.A.V., Faugères, J. -C., Howe, J.A., Pudsey, C.J., Viana, A.R., 2002, Bottom currents, contourites and deep-sea sediment drifts: current state-of-the-art. In: Stow, D.A.V., Pudsey, C.J., Howe, J.A., Faugères, J. -C., Viana, A.R. (Eds.), *Deep-water contourite systems: Modern drifts and ancient series*. Memoir. Geological Society of London, London, pp. 7-20.
- Uenzelmann-Neben, G., 2006, Depositional patterns at Drift 7, Antarctic Peninsula: along-slope versus down-slope sediment transport as indicators for oceanic currents and climatic conditions. *Mar. Geol.* 233, 49-62.