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Middle Miocene to present sediment transport and deposits in the Southeastern Weddell Sea, Antarctica

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ABSTRACT

Understanding the transport and deposition of sediments along the Antarctic continental shelves helps to provide constraints on past ice sheet dynamics. Seismic stratigraphic and scientific drilling data from the Antarctic continental margins have provided much direct evidence concerning ice sheet evolution and sedimentation history. In this study, we describe a series of sedimentary features along the continental margin of the southeastern Weddell Sea to constrain glacial-influenced sedimentation processes from the Middle Miocene to the present. The Crary Trough Mouth Fan (CTMF), channel systems, Mix-system turbidity-contourites are investigated by using seismic reflection, sub-bottom profiler, and results from ODP Site 693. The sinuous, NE-SW-oriented turbidity-contourites are characterized by bathymetric highs that are more than 150 km wide, 700 km long, and have a sediment thickness of up to 2 km. The unique sedimentation environment of the southeastern Weddell Sea is controlled by a large catchment area and its fast (paleo-)ice streams feeding the Filchner Ronne Ice Shelf, turbidity/bottom currents as well as sea level changes. A remarkable increase in mass transport deposits (MTDs) in the Late Miocene and Early Pliocene strata has been related to, ice sheet loading, eustatic sea level fall, earthquakes, and overpressure of rapid sediment accumulation. Our seismic records also imply that fluctuations of East Antarctic ice sheet similar to those that occurred during the last glacial cycle might have been typical for southeastern Weddell Sea during glacial periods since the Late Miocene or even earlier.

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1. Introduction

Glacially derived depositional and erosional features dominate the seafloor and upper sedimentary strata of the continental margin of the southeastern Weddell Sea, Antarctica (Fig. 1). Interactions between downslope (turbidity current) and along-slope (bottom current) processes are common at all continental margins, and can create various depositional features (levees, drifts) (Hernández-Molina et al., 2010). Bottom currents are capable of building thick and extensive sediment deposits, often with a noticeable mounded geometry, which are interpreted as contourites (Stow et al., 2002; Rebesco et al., 2014). When turbidity currents are dominant, extensive channel levee deposits or giant sediment ridges can be formed. Either contourites or depositional ridges host valuable information on the past ocean circulation, flow velocities, ice-sheet stabilities and sea-ice coverage. Mass transport deposits (MTDs) are another typical depositional features caused by down-slope movements on the continental margin (Nelson et al., 2011; Piper et al., 2012).

Mounded sediment drifts (contourites) have been largely reported along Antarctic margins. Several elongate-mounded drifts were investigated in great detail at Antarctic Peninsula Pacific Margin (Drift 6, 7, Rebesco et al., 1996). Drift 7 is a 200 km long elongated feature, about 70 km wide and its sediments are up to 1 km thick. It has been interpreted to be formed by turbidity currents flowing in deep-sea channels extending from the margin to the abyssal plain, and redistributed by the SW-following boundary current derived from Antarctic Bottom Water (AABW) (Rebesco et al., 1996; Hernández-Molina et al., 2006). Similar in the northern Weddell Sea and Scotia Sea, extensive contourite drifts are suggested to be originated from AABW and Weddell Gyre flows (Maldonado et al., 2003, 2005). Uenzelmann-Neben and Gohl (2012) proposed that the flows of the proto-AABW and intensified southwest-flowing bottom currents are the main factors in the development of elongate-mounded drifts with lengths of 30 km in the Amundsen Sea. In Prydz Bay, Kuvaas and Leitchenkov (1992) identified 20–30 km wide mounded sediment ridges and attributed their formation to a westward flowing bottom current activity interacted with overbank flow from turbidity currents within the channel.

Large-scale down-slope movement has left MTDs as common occurrences on the Antarctic continental slopes. e.g. Scotia Sea (Ruano et al., 2014), the Amundsen Sea (Uenzelmann-Neben and Gohl, 2012), Wilkes Land margin (Donda et al., 2008). The gentle gradient of 1° in the southeastern Weddell Sea will have permitted increased deposition

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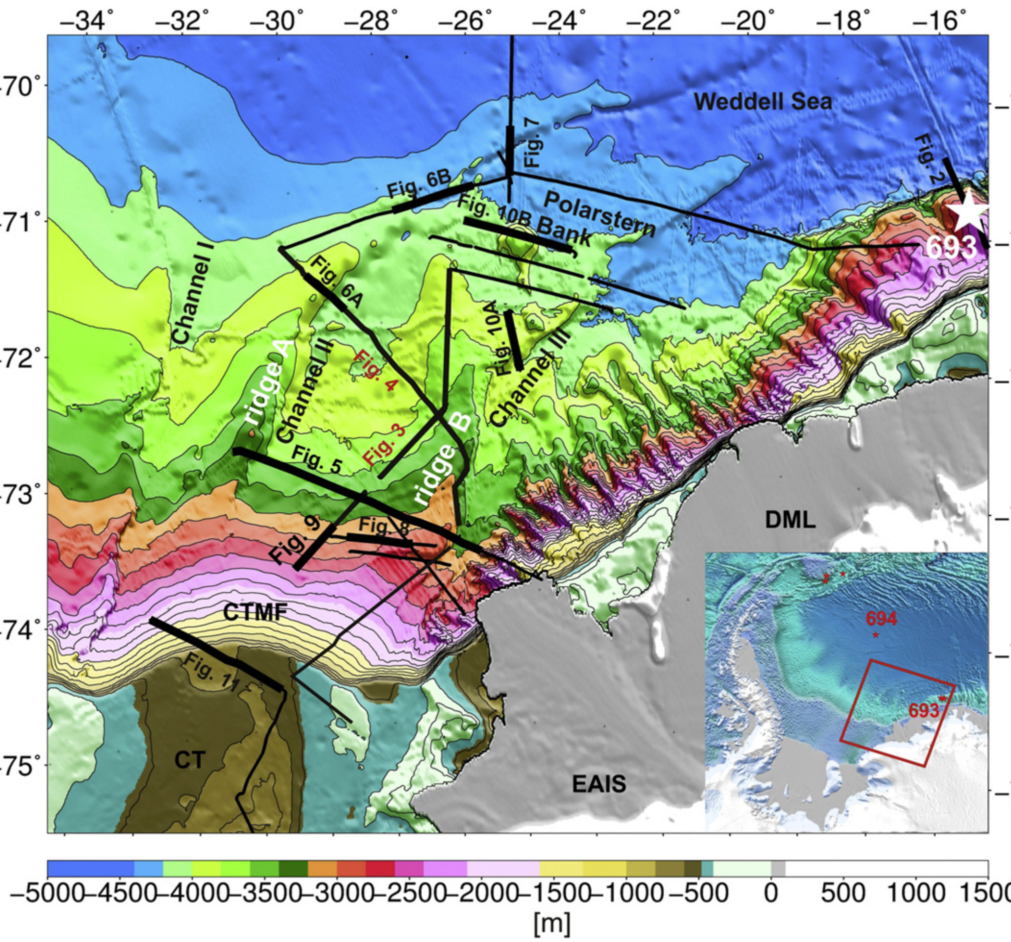

Fig. 1. Bathymetry map with locations of multi-channel seismic lines. Heavy red and black lines show the portions, which were displayed in our study. Background image: global seafloor topography grid (Arndt et al., 2013) EAIS: East Antarctic Ice Sheet; DML: Dronning Maud Land; FT: Filchner Trough; CTMF: Crary Trough Mouth Fan; Black lines: multi-channel seismic lines; white stars = ODP 693 site.

and preservation of MTDs on the distal, middle to lower continental slope (Fig. 1). Sediment loading, crustal rebound, sea level changes, earthquakes, active tectonics and fluids and/or gas hydrate dissociation are common triggers of MTDs (Bart et al., 1999; Shanmugam, 2006; Nelson et al., 2011; Piper et al., 2012; Vargas et al., 2012).

Trough-mouth fans are shelf-edge and upper-slope depocentres adjacent to the mouths of paleo-ice streams (broad zones of fast-flowing ice) that existed along formerly-glaciated continental shelves at high latitudes (Vorren and Laberg, 1997; Ó Cofaigh et al., 2003; Dowdeswell et al., 2004). Examples are the Belgica

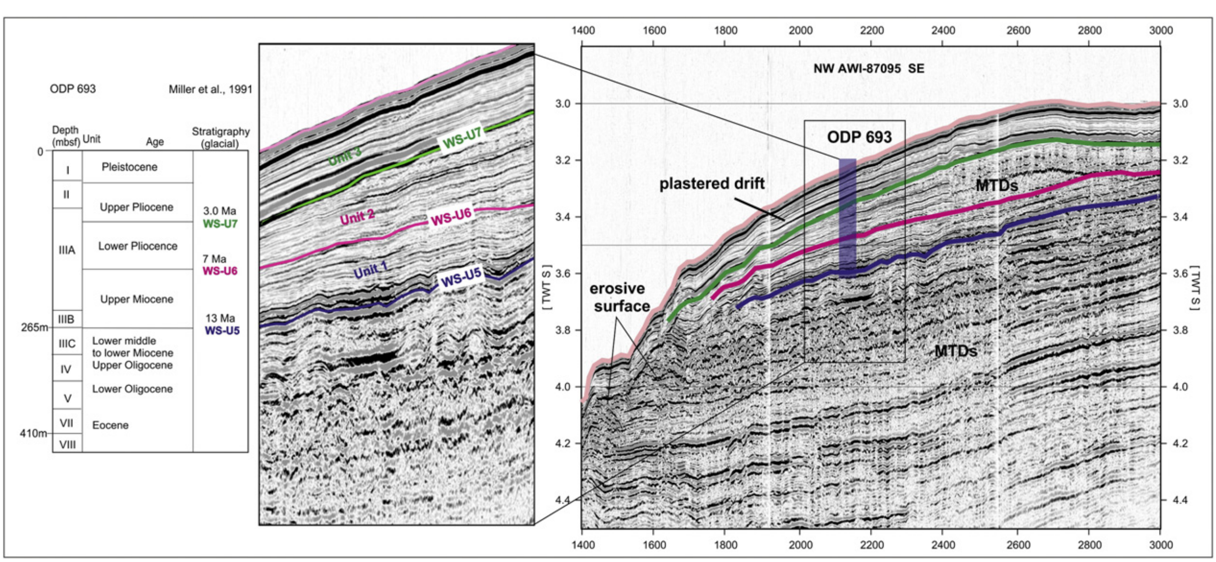

Fig. 2. The interpreted glacial key horizons of multi-channel seismic line from the ODP drilling site 693, and its correlation into the seismic data used in this study.

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