Obliquity paced contourite cyclicity in Antarctic sediments from the Wilkes Land (IODP Site U1356) during Late Oligocene

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1 INTRODUCTION

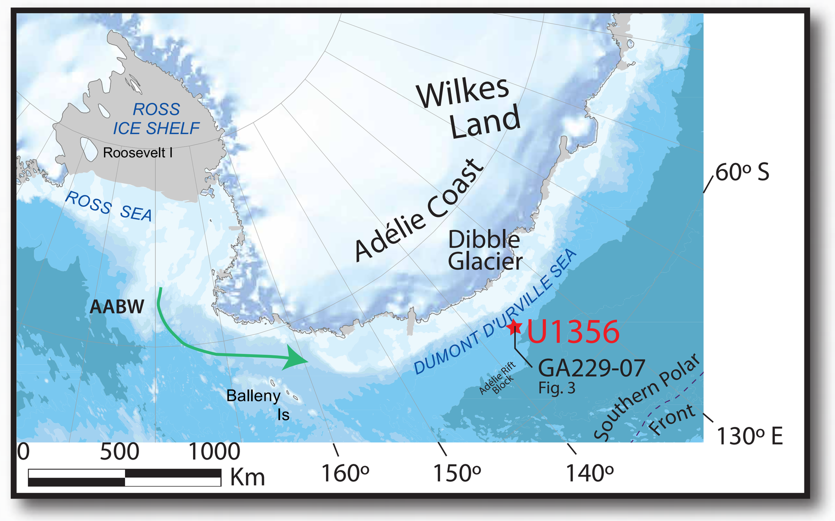
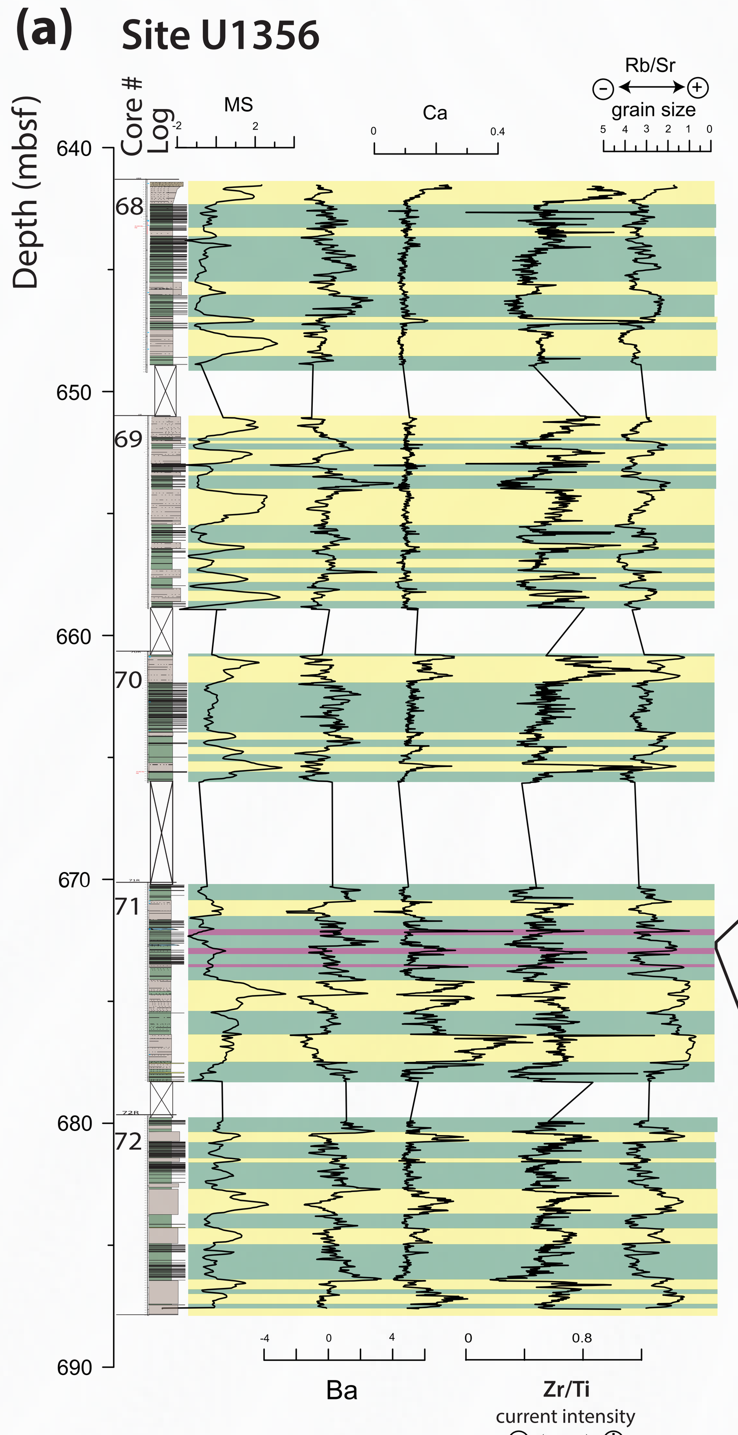


Fig. 1) Location of site U1356 from the Integrated Drilling Program (IODP) Expedition 318 (Escutia et al., 2011) on the Adélie Coast continental rise. Bed topography from IBCSO (Arndt, JE et al., 2013).

IODP Expedition 318 drilled seven sites in two transects across the Wilkes Land (WL) margin of Antarctica (Fig.1). The expedition obtained a long-term record of the Cenozoic Antarctic glaciation in response to climatic changes, including major transitions. Our study focuses on characterizing sedimentary processes and environmental changes accross the warm late Oligocene event (LOWE) at Site **U1356**.

Our analysis comprises cores 68R to 72R (640 to 690 mbsf) that span about 1 myr (25.2-26.2 Ma) Tauxe et al. (2012). Sediment cores were studied using a detailed facies analyses, X-Ray Fluorescence (XRF) core-scanner data at 2cm resolutioVn, X-Ray computed tomography (CT-scans), and Scanning Electron Microscope (SEM) images (Fig. 2). The regional context for the interpreted stratigraphy is provided by the integration of results from Site U1356 with multichannel seismic reflection profiles that cross the Site (Fig. 3).

2 SEDIMENTS, SEDIMENTARY PROCESSES, GLACIAL & PALEOCEANOGRAPHIC HISTORY



Sedimentation is characterized by an alternation between two facies (Facies 1 and 2) that based on their sedimentological, geochemical and biogenic characteristics are interpreted as contourites deposited during glacial and interglacial conditions and under low to moderated velocities, respectively.

No ice rafted grains (IRD) from icebergs or sea ice have been observed in both Facies. This contrasts with early Oligocene sediments that contain IRD and dynocists indicative of ice rafting and sea ice (Houben et al., 2013). This observation suggests warmer conditions with less or no calving from glaciers reaching the coast or glaciers inland during the late Oligocene.

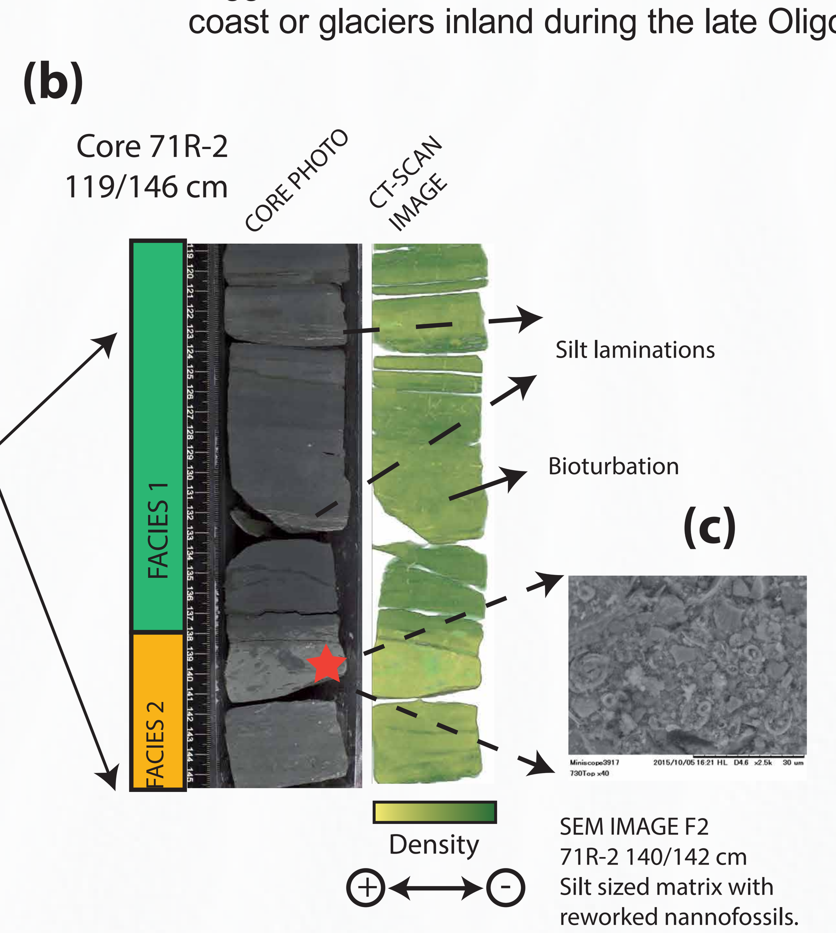


Fig. 2) (a) XRF plot against U1356 log. (b) Detail of the core Facies with CT-scan. (c) SEM image extracted from Facies 2.

Preservation of Carbonate in some of the sediments from Facies 2 could be explained by the presence of at least two water masses, supporting previous paleoceanographic studies that consider at least a two layer ocean with a proto-ABBW (Antarctic Bottom Water undersaturated with respect to calcium carbonate) and a warmer NCW (North Component Water) (Pekar et al., 2006, Katz et al., 2011). Under these conditions, sediments from Site U1356 would have been directly influenced by deep water formed near the Antarctic margin (AABW) except during some interglacials when warmer North Component Water (NCW) would have influenced Ca preservation in this location.

Because our records do not support ice-sheet reaching the margin in this sector of the WL we suggest the proto-AABW originates in the Ross Sea spilling over to the WL.

	Lithological description	Contacts		Bioturbation	Nannos	IRD	Magnetic susceptibility (MS)	XRF-Scanner elements concentration			Formation process	Facies interpretation
		Top	Bottom					Zr	Ba	Ca		
Facies 1	Bioturbated green claystones with thin silt laminae with planar and cross-bedded laminations	Gradual, bioturbated	Sharp	Sparse bioturbation. Primary structures preserved	Barren	No	Low, (high in silty laminations)	Low, (high in silty laminations)	High, (max. values on bottom)	No	Bottom currents of fluctuating intensities	Higher accumulation rates. Cold periods. Supply of terrigenous by density current flows and also glacial melting
Facies 2	highly bioturbated, thicker pale-brown, silty-claytones	Sharp	Gradual, bioturbated	Strong bioturbated. Massive. No primary structures preserved	Barren to variable abundance and preservation	No	High	High, (max. values on top)	Low	Variable, low to high	Bottom currents with higher velocity and constant flux	Low sedimentation rates. Warm periods with reworking of sediments by bottom currents

Table 1. Types of facies differentiated by physical, geochemical, and biological character and their interpretation in terms of sedimentary processes and paleoclimate.

3 REGIONAL CONTEXT

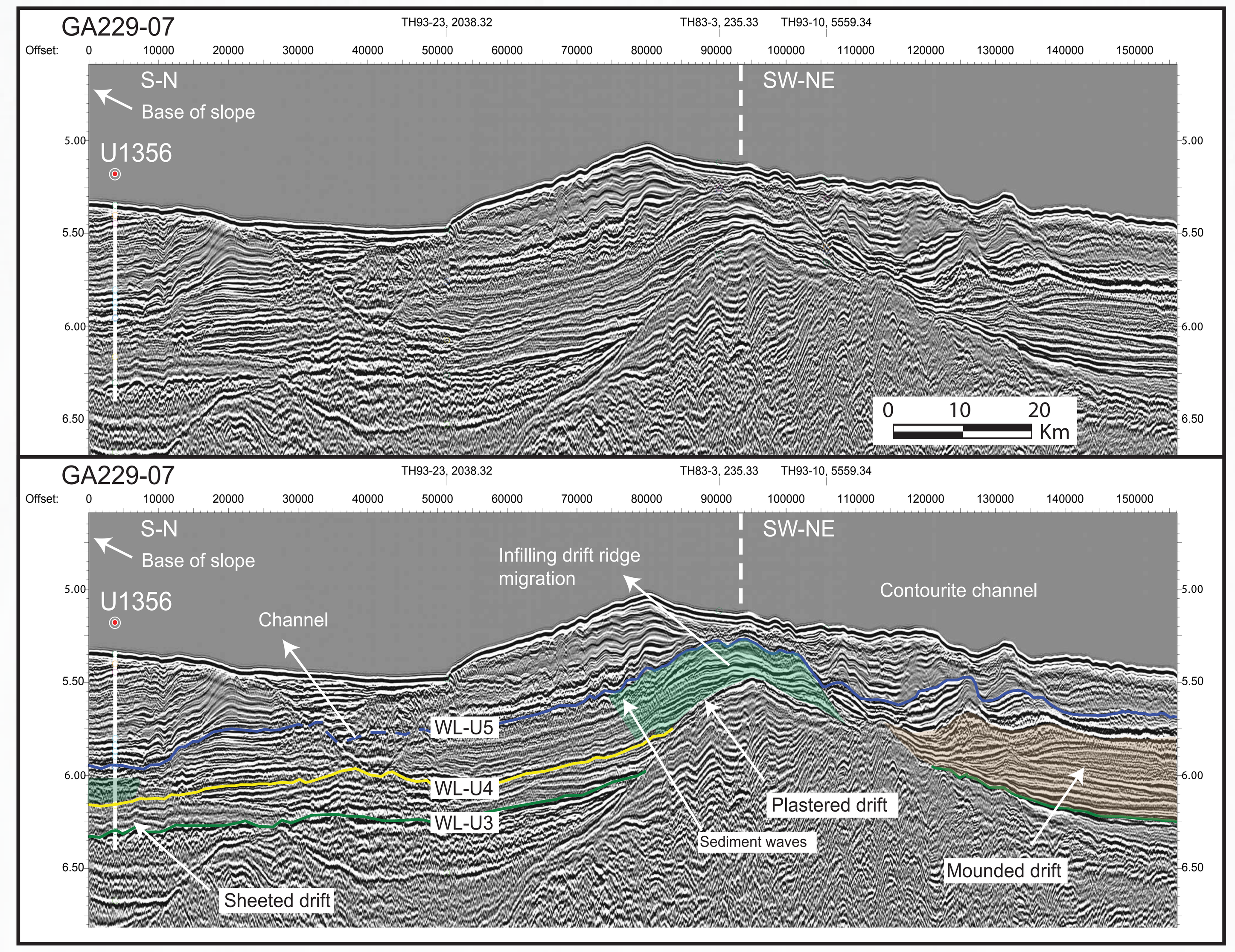
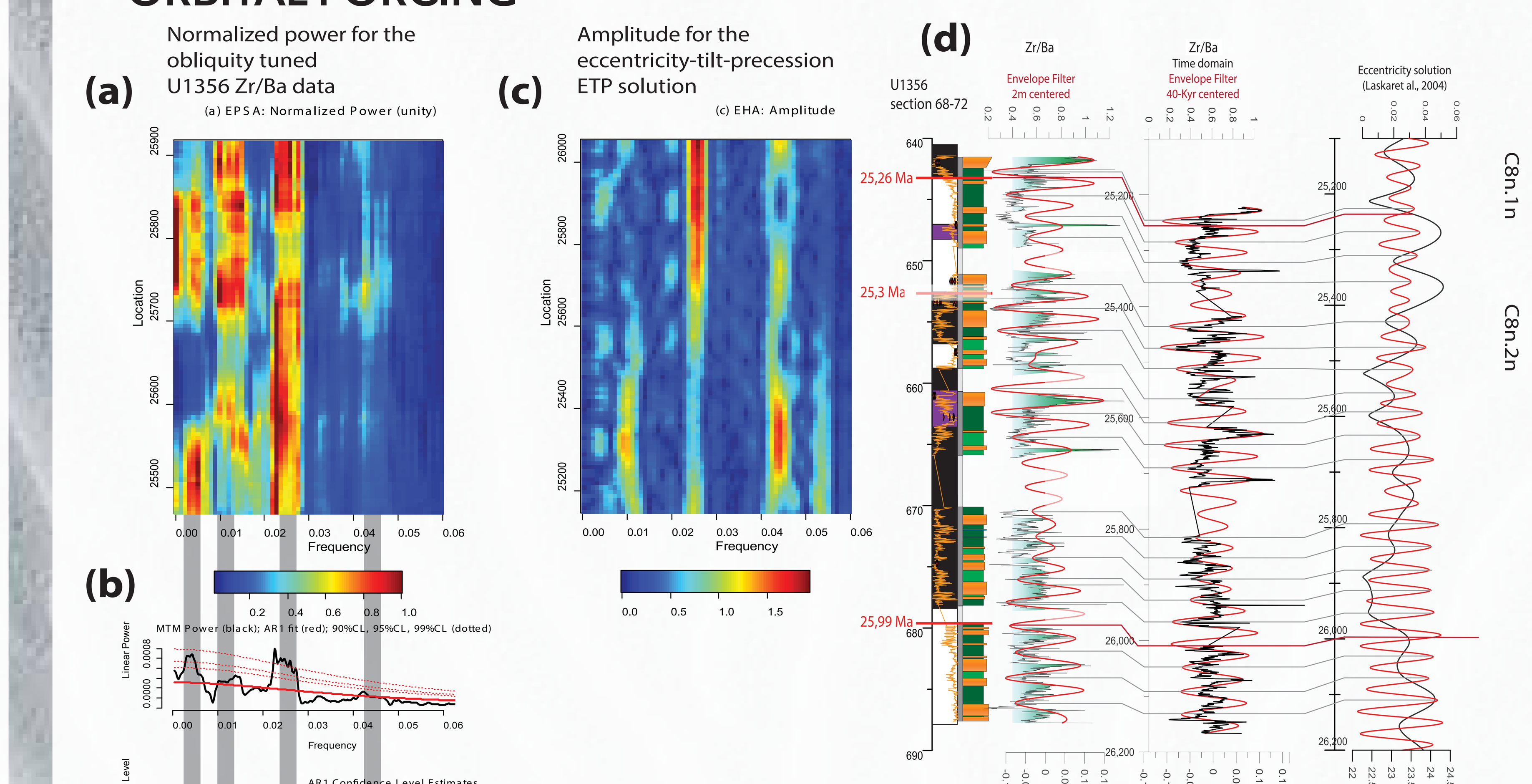


Fig. 3) Multichannel seismic profile GA229-07.

Bottom current sedimentation at site U1356 has been described since the early Oligocene (Escutia et al., 2011). However, multichannel seismic reflection profiles show that mounded drift morphologies and moat channels form above unconformity WL-U4, preferably around the Adelie Rift Block. We interpret this to record an intensification in bottom current activity starting after 28 Myr. Above unconformity WL-U5 drift crests migrate towards the south and sediment waves become more apparent

The studied sedimentary section between 26-25 Ma corresponds to the seismic unit deposited between unconformities WL-U4 and WL-U5. Therefore, sediments are deposited after the observed current intensification in this margin at 28 Ma but before the shift observed above WL-U5.

4 ORBITAL FORCING



(e)

Core - Section	Depth used (m)	GPTS 2004 (Myr) (Tauxe et al., 2012)	GPTS 2012 (Myr)	Chron
68R-2	643.37	25.444	25.26	C8n.1n (o)
71R-6	678.98	26.154	25.99	C8n.2n (o)

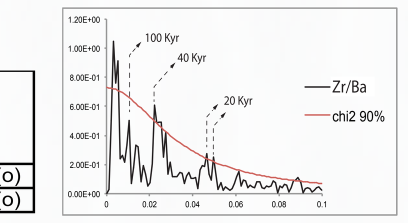


Fig. 4: **(a)** EHA and **(b)** MTM (Meyers, 2014) spectral analysis on Zr/Ba data. EHA normalized power with 300 time window with 3 DPSS tapers. **(c)** Amplitude for the eccentricity-tilt-precession ETP solution calculated for the same time period (Laskar et al., 2004). **(d)** Astronomical correlation of the U1356 section with Zr/Ba data filter at 2m/cycle with the obliquity solution (Laskar et al., 2004). Tuning of Zr/Ba record (in depth scale) and bandpass filtering were done in Analyseries (Paillard et al., 1996), centered at 0.5m/cycle. **(e)** Magnetostratigraphic age model is based on Tauxe et al. (2012) and is calibrated to the Geologic Timescale 2012.

Spectral analysis on the Zr/Ba and other elemental proxies, was carried out for the magnetostratigraphic age model provided by Tauxe et al., (2012). The spectra revealed frequencies around the obliquity band but also the eccentricity and precession.

A band-pass filter of the Zr/Ba ratio was tuned to the astronomical solution for obliquity. After the tuning, an alignment of the long (405-kyr) and short (100-kyr) eccentricity terms and precession occurred. This indicates that the cyclicity in the elemental composition of the sediments record the orbital forcing. The strong obliquity signal suggests that the alternation between facies is indicating the Glacial to Interglacial variability. Obliquity-driven cycles point towards interglacial-glacial ice sheet and paleoceanographic conditions recorded by significant sedimentary changes in the U1356 record.

We show the obliquity driven glacial-interglacial cyclicity prevailed in the Late Oligocene Wilkes Land. This shows similar processes that have been reported for the Oligocene record in the Ross Sea (Naish et al., 2001, McKay et al., 2009).

5 TAKE HOME MESSAGE

- Sedimentation during the LOWE (between 25-26 Ma) is characterized by an alternation between two facies interpreted to have been deposited by bottom-currents.
- Glacial sedimentation is characterized by Facies 1: Clay with silty laminations. The preservation of silty laminations is interpreted to represent fluctuating bottom current intensities. Interglacial sedimentation is characterized by massive bioturbated silty clays.
- Seismic profiles provide a regional context for the development of contourite deposits in this margin. Sheeted contourites prevailed from the Early Oligocene until after 28 Myr when we see evidence for the build-up of drift deposits (mounded, plastered, etc...) around highs in the acoustic basement.
- Lack of IRD in these Facies in comparison to early Oligocene conditions points to warmer conditions during the late Oligocene with less calving from glaciers or glaciers inland.
- Preservation of carbonate in some intervals of Facies 2 is explained by the presence of at least two layer ocean with a proto-AABW and a warmer NCW in support of Pekar et al., (2006). For most of the section the site is under the influence of a proto-AABW, except for some events when NCW would have influenced the preservation of C. Becasuse our records do not support ice sheets reaching the margin in the segment of the Wilkes Land, we suggest this proto-AABW originates in the Ross Sea and spilles over to the Wilkes Land margin as it does today.
- High recovery between 26-25 Myr ago allowed to conduct the first spectral analysis in Late Oligocene Antarctic sediments wichs shows that glacial/interglacial cyclicity is paced by Obliquity.

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