Seismic reflection data of the Eirik Drift: A first step to decipher the Neogene development of the Western Boundary Undercurrent (WBUC)

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The Eirik Drift off the southern tip of Greenland contains sedimentary records since the Miocene. This archive of depositional processes has been shaped by the Western Boundary Undercurrent (WBUC), the Greenland ice sheet, and material input from the Labrador Sea through the Davis Strait. The WBUC is a main contribution to the lower branch of the global Thermohaline Circulation, which determines the world's climate. Therefore, changes in strength and direction of the WBUC are closely connected to climate changes.

The high-resolution multichannel seismic reflection data network collected during RV *Maria S. Merian* cruise MSM 12/2 connected ODP Leg 105 Site 646 and IODP Expedition 303 Sites U1305, U1306, and U1307 (Fig. 1). The seismic reflection data were incorporated with geological information from the ODP and IODP sites to deduce information on the development of the WBUC as well as the dimensions and expansion/retreat of the Greenland ice sheet and a much clearer understanding of the evolution of the climate southwest of Greenland.

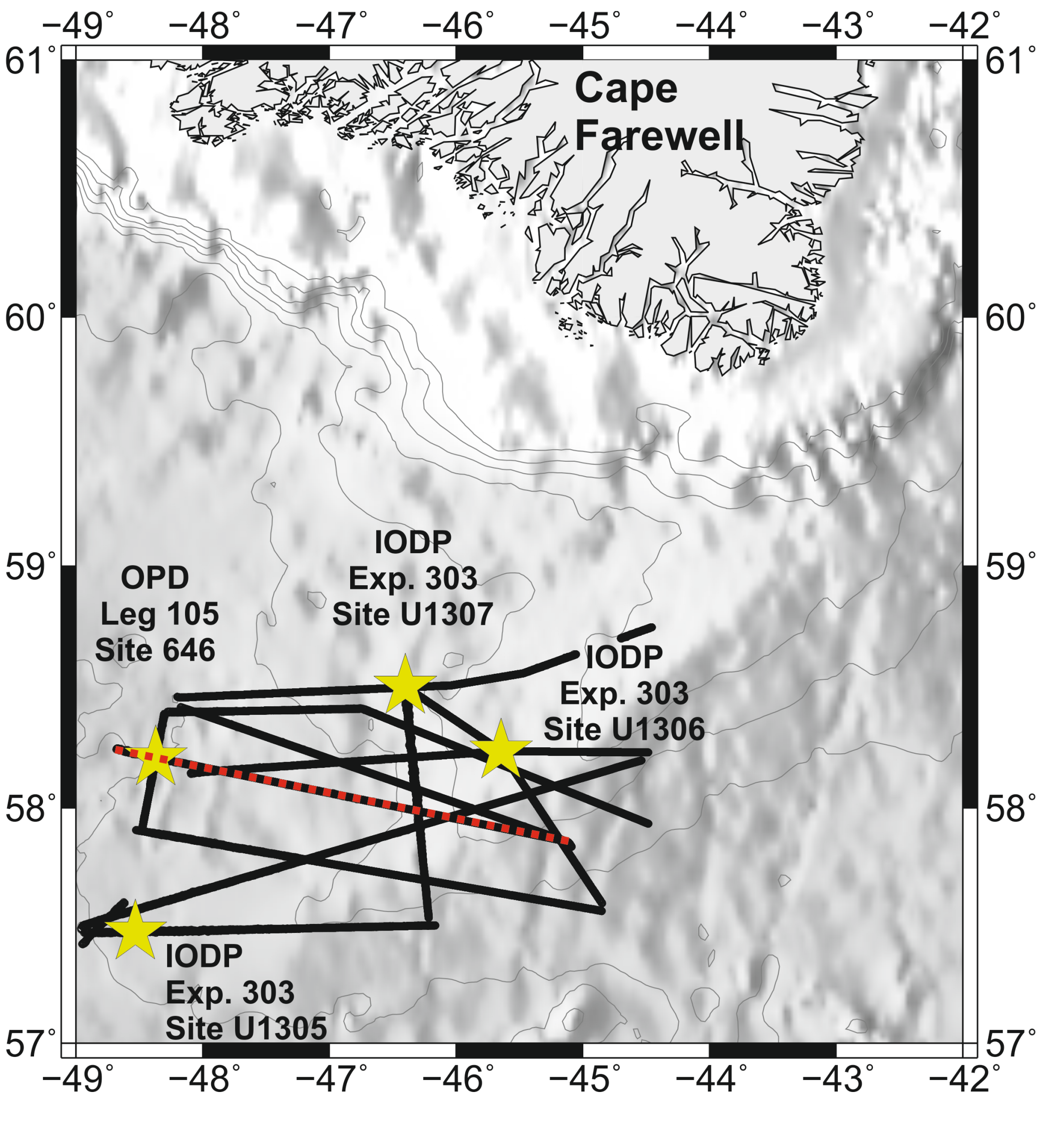

Figure 1: Bathymetric map (Smith and Sandwell, 1997) of the vicinity of the Eirik Drift south of Cape Farewell (Greenland) showing the locations of the seismic profiles (black lines) and the ODP/IODP Sites (yellow stars). The red dashed line highlights the location of profile AWI-20090004 presented in Figure 2.

After correlating synthetic seismograms based on density and P-wave velocity data from ODP Leg 105 Site 646 and IODP Expedition 303 Sites U1305, U1306, and U1307 with the processed seismic reflection data we identified four seismic units and the reflectors defined by *Arthur et al. (1989)* (Table 1; Fig. 2).

Reflectors/Seismic Units	Age	Paleoceanographic History
SU I		weakening of deep currents
R1	2.5 Ma	onset of ice rafting
SU II		strong deep currents
erosional unconformity	4.5 Ma	initiation of strong deep currents local erosion
SU III		increasing deep currents
R2	5.6 Ma	higher carbonate content
SU III		onset of Denmark Strait Overflow Water weak deep currents
R3/R4	7.5 Ma	change in water mass characteristics increased sedimentation rate
SU IV		corrosive, southern sourced bottom water

Table 1: Compilation of defined seismic stratigraphy (seismic units SU I - IV), seismic reflector (R1 - R3/R4) nomenclature and Paleoceanographic history at ODP Leg 105 Site 646 following *Arthur et al. (1989).*

Figure 2 shows seismic profile AWI-20090004 (red dashed line in Fig. 1) as an example with the location of ODP Leg 105 Site 646 and the identified reflectors and units (Table 1). Tracking of both reflectors and units leads to information about the redistribution of the WBUC in the vicinity of the Eirik Drift during the Neogene.

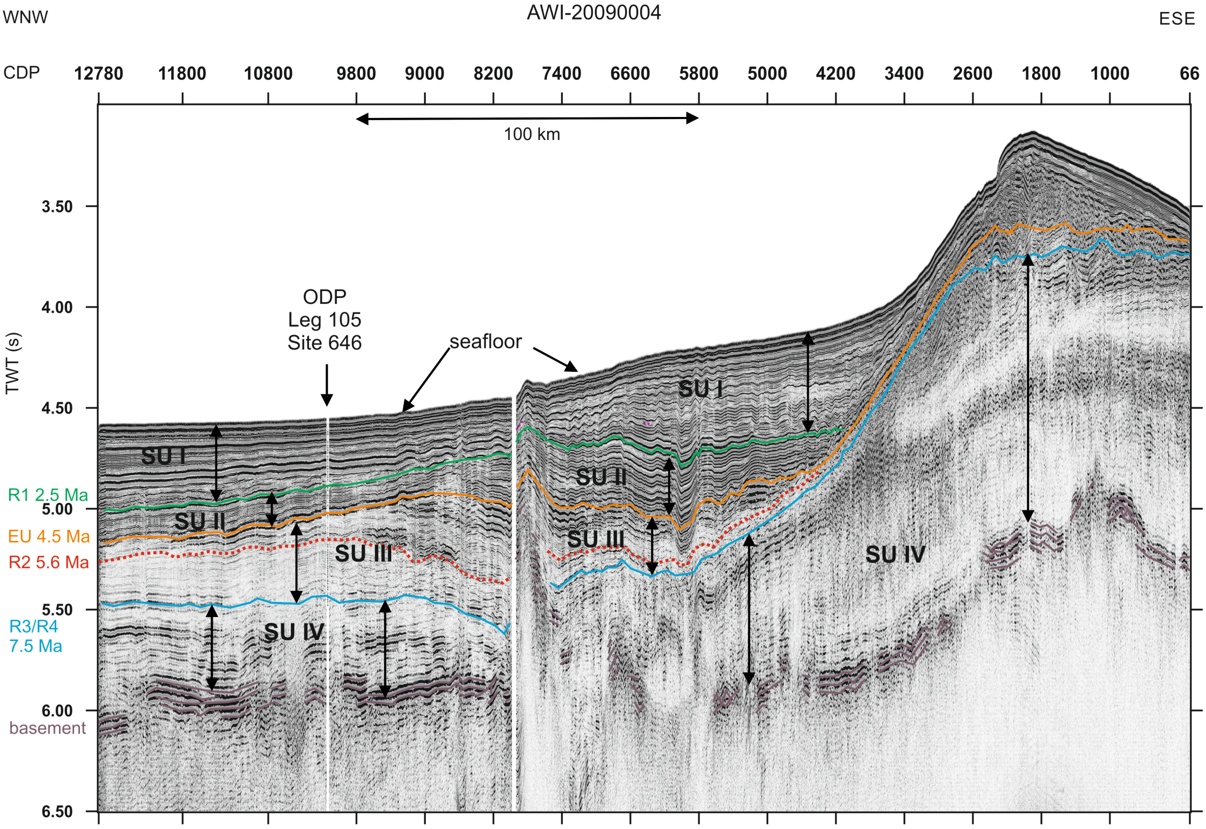

Figure 2: Seismic profile AWI-20090004 (red dashed line in Fig. 1) including the location of ODP Leg 105 Site 646 and the identified reflectors and units. R1 (green), erosional unconformity (orange), R2 (red dashed), R3/R4 (blue) and the acoustic basement (brown). The solid reflectors comprise the seismic units SU I - SU IV.

Seismic unit IV (SU IV; > 7.5 Ma) is bounded by the acoustic basement (brown) and the reflector doublet R3/R4 (blue). SU IV shows a high sediment accumulation at the main drift mound in the east (CDP 66-5000), more than twice as high as the more uniform thickness in the west (CDP 5000-12780). This indicates a strong deep current influence in northward direction at the western flank of the main mound (~ CDP 5000) depositing the sediments to the right of the flow. In this phase it is believed that the water masses are mainly of southern origin before a more modern pattern of the WBUC was established at the R3/R4 boundary (~8.2-7.5 Ma) (*Kaminski et al., 1989*). SU III (7.5-4.5 Ma) is bounded by reflector doublet R3/R4 (blue; 7.5 Ma) and the erosional unconformity (orange; 4.5 Ma) and is subdivided by reflector R2 (red dashed; 5.6 Ma). The lower part of SU III (7.5 - 5.6 Ma) is acoustically transparent and of uniform thickness in the west (CDP 8000-12780) and thins towards the western flank of the main mound (CDP 5000) with no deposition on top of the main mound. This indicates a decreased deep current influence, not strong enough to deposit sediments on top of the main mound. We observe a thinning of the unit at CDP 5000, which we interpret to represent erosion due to the location of the current core. The upper part of SU III (5.6 - 4.5 Ma) shows two depositional centers, one on top of the main mound (CDP 66-2600) and one in the center of the profile (CDP 5000-10000). This distribution of the sediments suggests that the deep current divided into two northward-directed branches located near CDP 4000 and CDP 11000. This deposition pattern and the higher amplitudes within this unit suggest increased deep current activity. Some reflectors wedge out at the upper boundary (CDP 9000-10000), which indicate erosion at the erosional unconformity caused by strong deep currents. SU II (4.5 - 2.5 Ma) is bordered by the erosional unconformity and reflector R1 (green; 2.5 Ma) and consists of high amplitude reflectors. The shape of SU II still points towards still two branches of the deep current. These probably shifted upslope towards CDPs 3500 and 9500, respectively. SU I (< 2.5 Ma) comprises the interval between reflector R1 and the seafloor. The almost uniform thickness of SU I in the west (CDP 4000-12780) suggests that the western branch of the WBUC ceased at formation of reflector R1 with the onset of ice rafting under glacial conditions. The main branch of the deep current weakened and shallows towards CDP 3000 under a glacial regime.

The changes in deposition of sediments are assigned to changes in direction and strength of the WBUC in the vicinity of the Eirik Drift. Based on our data drift building started before 7.5 Ma. This is in contrast to *Arthur et al.'s (1989)* observation, who dated the onset of drift building at 4.5 Ma based on ODP Leg 105 Site 646 results and seismic reflection data in the vicinity of this ODP Site in the west of our investigation area. In the time interval 7.5 - 5.6 Ma our observation indicate a weak WBUC, followed by increasing WBUC activity and the separation of the WBUC into two branches (5.6 - 4.5 Ma). At 4.5 Ma we observe strong WBUC activity with local erosion and the two branches of the WBUC are preserved and move upslope in the transitional phase to a glacial regime. With the onset of ice rafting and the glacial regime at 2.5 Ma the western branch of the WBUC cannot be detected any longer and is interpreted to weaken and shallow. This is correlated with major changes in the Thermohaline Circulation as deep-water formation was restricted and intermittent during the Pleistocene and shifted to intermediate water depth (Glacial North Atlantic Intermediate Water; Sarnthein et al., 2000).

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