Geodynamic and paleoceanographic evolution of the Scotia Sea. IODP EXPEDITION 382

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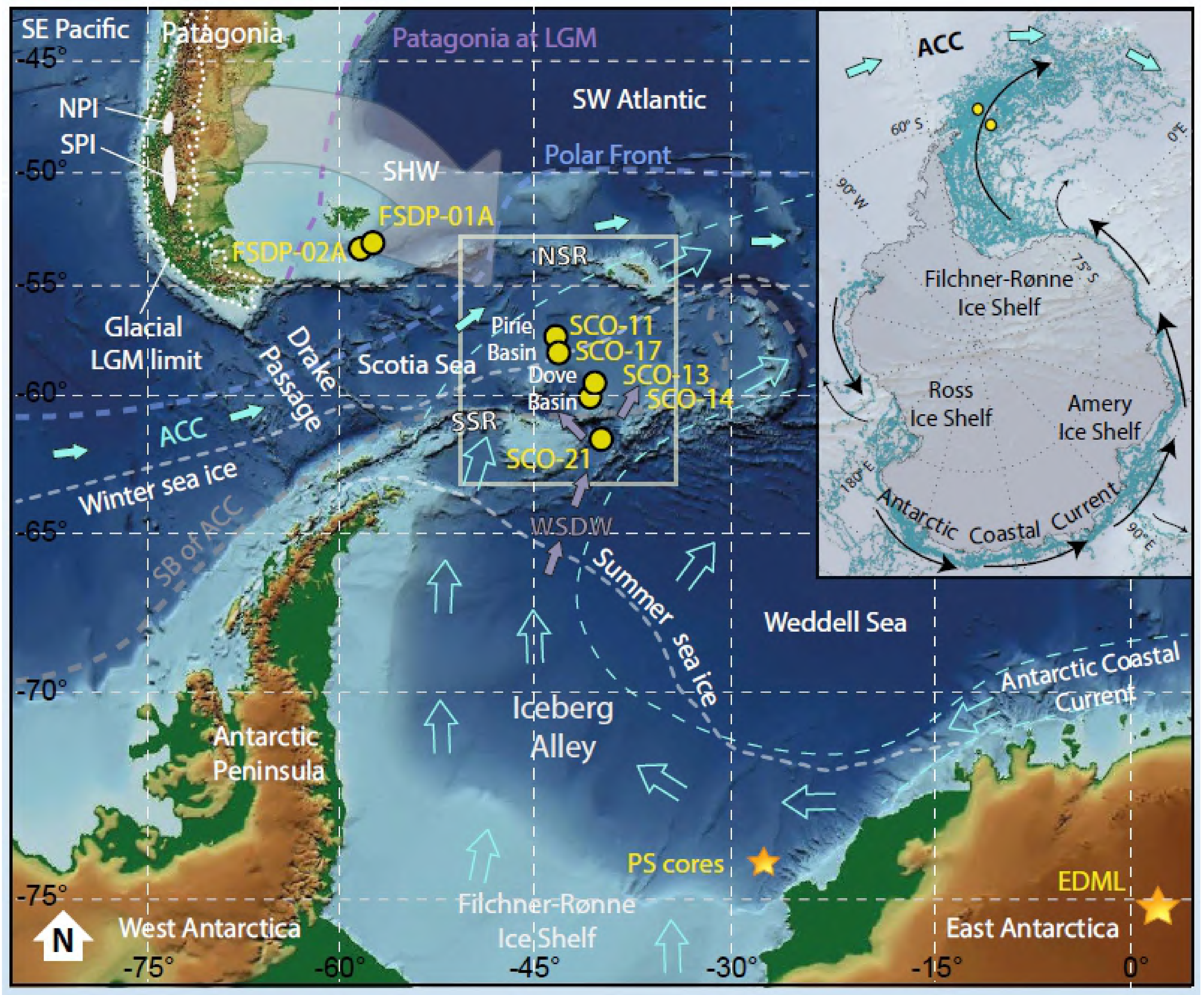
IODP 382 Expedition "Iceberg Alley"

Specific Scientific Objectives

- Decipher past Antarctic Ice Sheet (AIS) behavior
- Reconstruct atmospheric circulation and dust transport
- Drake Passage throughflow and paleoceanograhic change
- Role of sea-ice

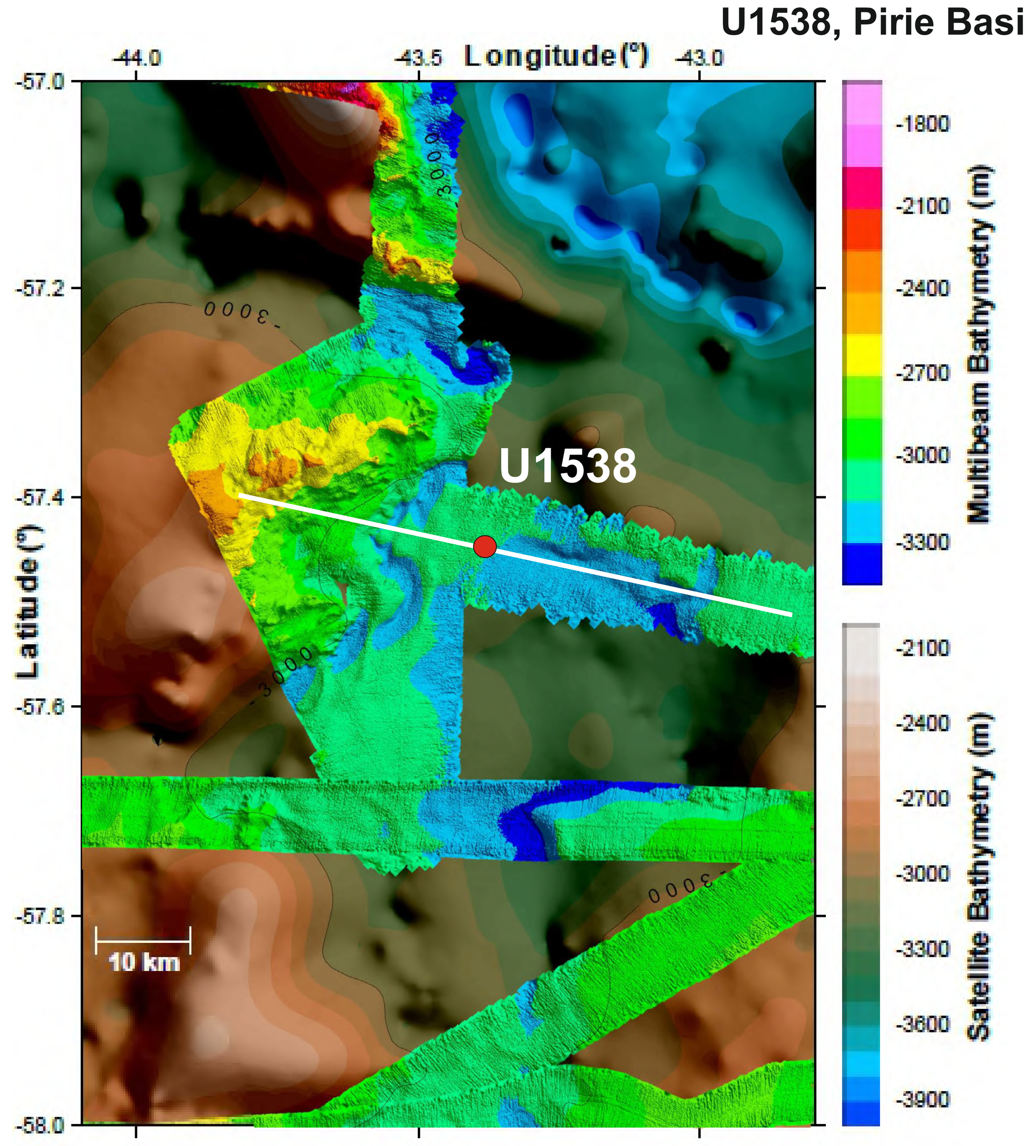
The objective of this work is to decipher the main changes in the tectonic, climatic and paleoceanographic conditions that led to major shifts in the depositional/erosional sedimentary processes recorded in high-resolution seismic profiles that can offer a regional perspective of the South Scotia Sea sub-basins.

The Study Area

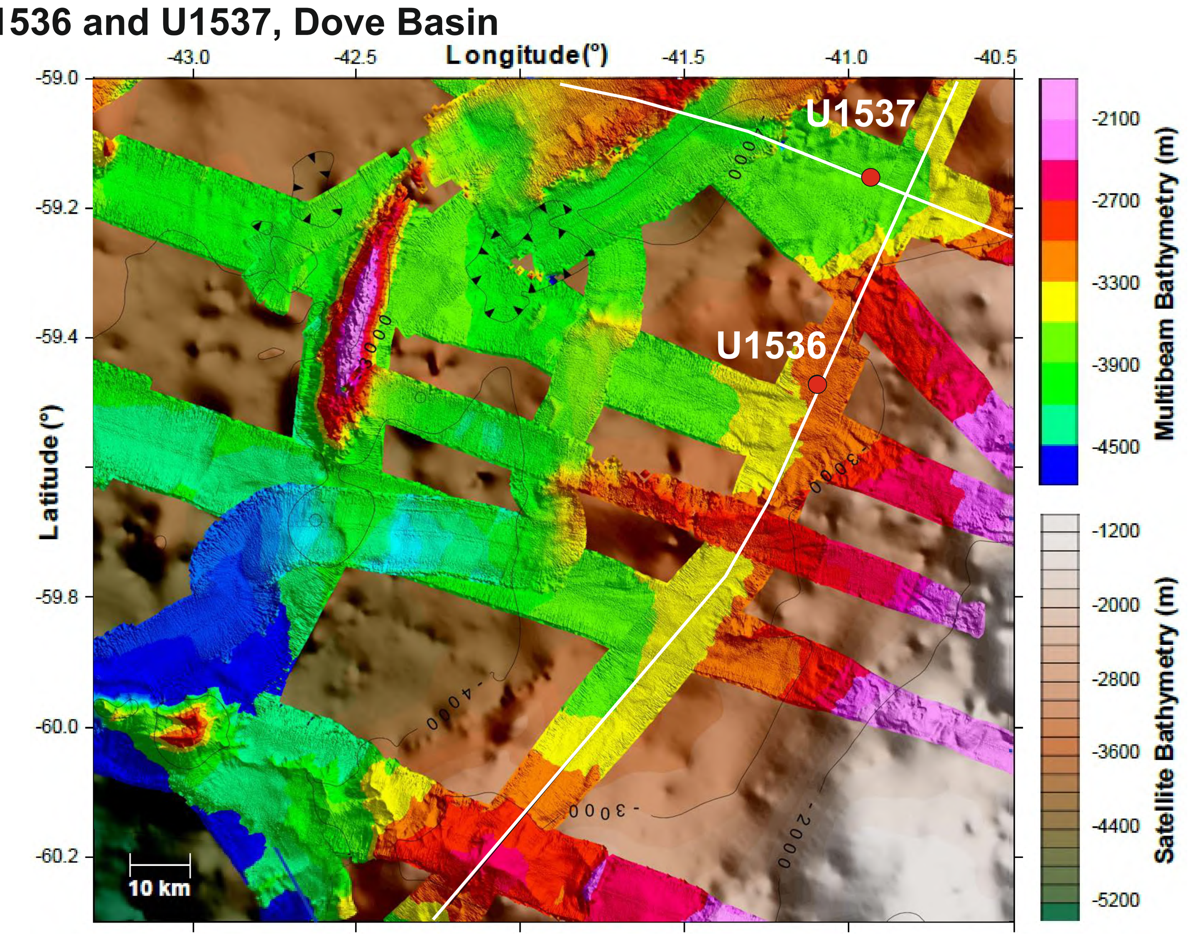


The sites are strategically located in two areas of Iceberg Alley, the major Antarctic gateway to lower latitudes, where nearly all Antarctic icebergs exit to the Southern Ocean, allowing for the first spatially integrated and longterm reconstruction of AIS variability and its relation to sea level and climate change. A recent proof-of-concept revealed that, at least for the Late Pleistocene, the sites are highly resolved and capable of deciphering rapid climate and ice-sheet changes on decadal-to-centennial timescales, including the discovery of substantial and repeated deglacial increase in iceberg discharge within decades (Weber et al., 2014), which has fundamental implications for projections of future AIS behavior in a warming world.

U1538, Pirie Basin



U1536 and U1537, Dove Basin



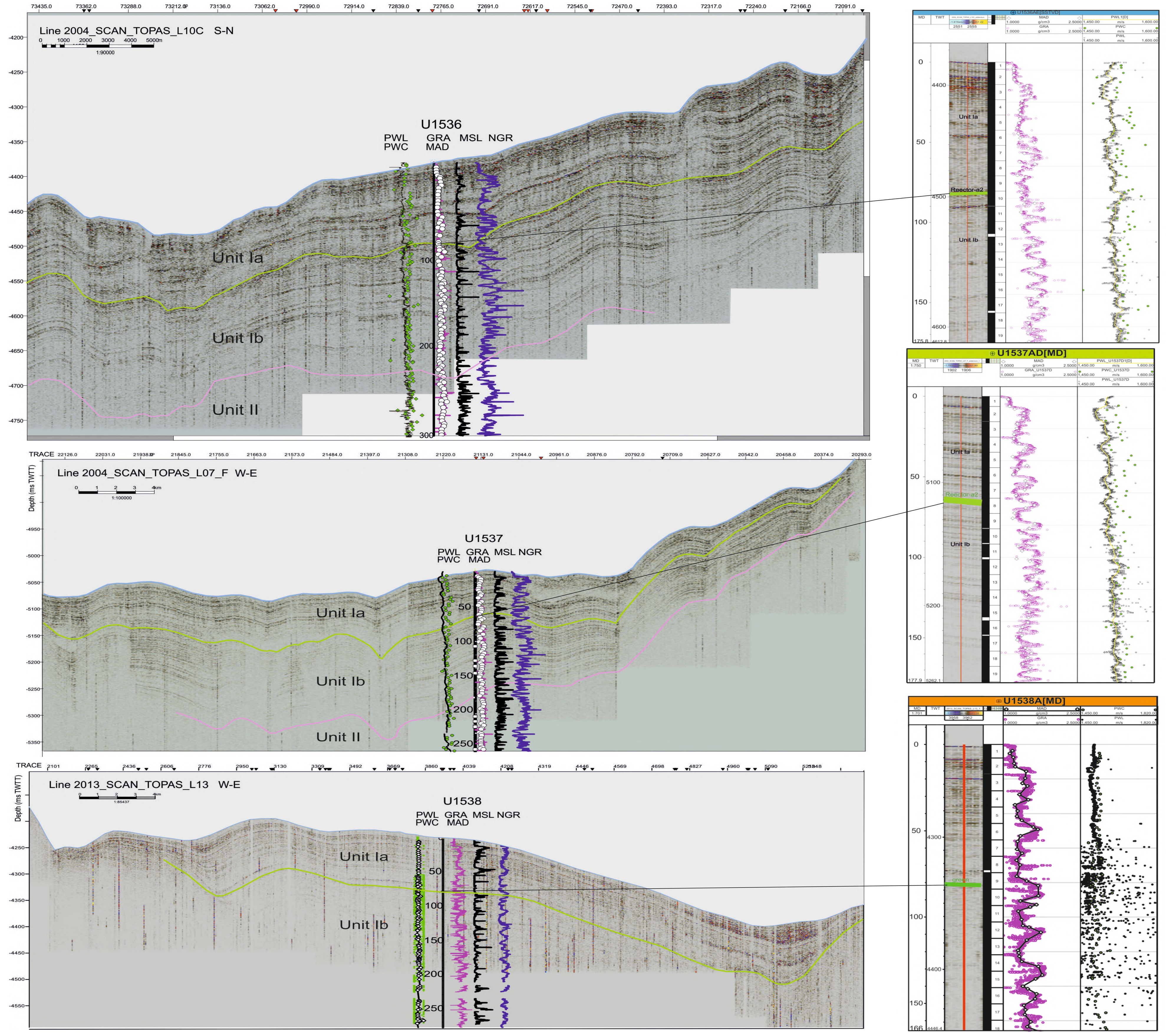
Datasets and methods

Physical property measurements were made during Expedition 382 for lithostratigraphic characterization, stratigraphic correlation and to tie core descriptions to downhole data and main seismic reflectors. Physical property data were key to generating first high-resolution and continuous data sets for hole-to-hole and site-to-site stratigraphic correlation, detection of discontinuities and inhomogeneities, obtaining information about differences in the composition and texture of sediment, identification of major seismic reflectors, and construction of synthetic seismic profiles. The thermal properties of the recovered material were also measured and combined with downhole temperature measurements to estimate geothermal heat flow. Different techniques and methods were used to characterize Expedition 382 cores on whole-round, split section-half, and discrete samples.

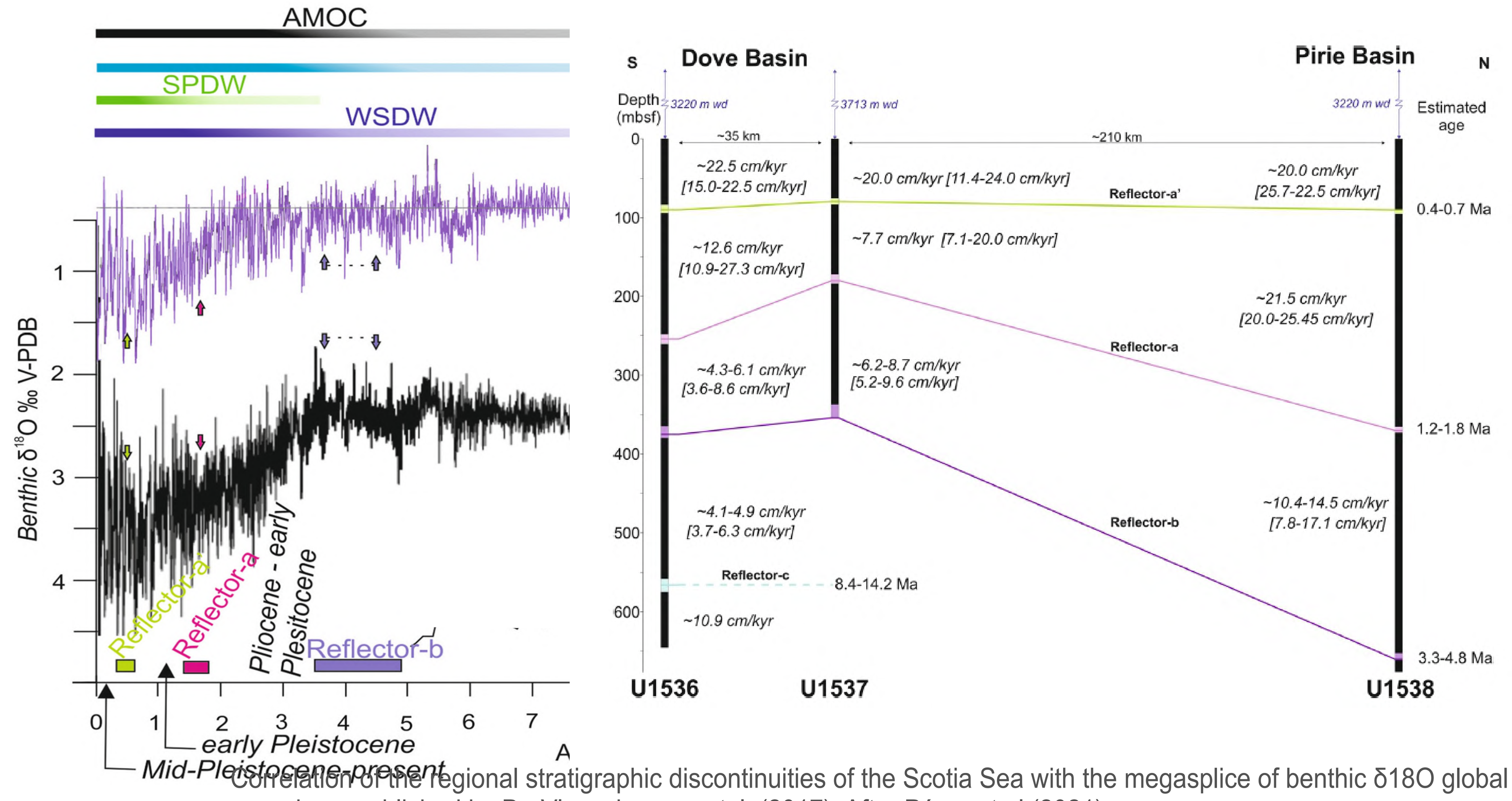
This work is based on physical databases collected on board the RV Hesperides during the SCAN cruises since 1997, including swath bathymetry and very high-resolution seismic reflection data. Swath bathymetric data were obtained with EM 12 and EM 120 SIMRAD™ systems. The equipment was operated at a frequency of 12 kHz and a swath aperture of 120°, obtaining seafloor coverage of about 3.5 times the water depth. Multibeam files were postprocessed with NEPTUNE™ and CARIS™ software. Datasets have been displayed and interpreted using Fledermaus™ and Global Mapper™ software. Regional bathymetric data have been obtained from compilations of global seafloor bathymetry (Smith and Sandwell, 1997; Ryan et al., 2009).

High-resolution seismic profiles were simultaneously obtained with a TOPAS PS 18 (TOpographic PArameter Sonar) system, which operated in high-penetration (chirp) mode with a primary frequency of 18 kHz and up to 30 kW power. This provided a maximum penetration of about 100 m into the subsurface seafloor sediments with a resolution of 0.5–1 m. Pulse lenght was 25 ms and the shot interval ranged between 5000 and 7000 ms. Signal processing included: band-pass filter, swell filter, deconvolution, time variable gain, muting, and delay correction by using TOPAS™ and Radexpro™ softwares. The resulting SEG-Y files were imported into Kingdom Suite™ software for interpretation.

Results: core-seismic correlation



Discussion



Correlation of the regional stratigraphic discontinuities of the Scotia Sea with the megasplice of benthic δ18O global records as published by De Vleeschouwer etal. (2017). After Pérez et al (2021).

These results and the correlation with the age models established in the IODP 382 Expedition place the high-resolution data in the time interval following the mid-Pleistocene (Weber etal., 2021). Reflector-a has an age of ~1.7 Ma. Above, magnetic susceptibility and natural gamma radiation decrease, pointing to bottom current controlled sedimentation. A decrease in sediment input from the continental shelf is also suggested by abundant diatom ooze sedimentation above Reflector-a. In Pirie Basin, a sharp increase in the sedimentation rate above this reflector suggests fast growth of the contourite drifts from the Mid-Pleistocene to the present, that may result from more vigorous Pacific Overturning Circulation. The development of Reflector-a at ~1.7 Ma most likely reflects the regional Southern Hemisphere expression of major global climatic changes such as ice sheet advance over continental shelves, cold trends in different regions and sea level drop (Pérez et al., 2021).

Reflector-a' marks the predominance of oceanographic control over the sedimentation in the Scotia Sea, at about 0.6-0.4 Ma, within the time interval of Marine Isotope Stage (MIS) 11 (Pérez et al., 2021). The change in the physical properties of the Scotia Sea records is likely associated with the increased amplitude of the glacial-interglacial oscillations occurring after the Mid-Brunhes Transition (Barth etal., 2018). A generally high WSDW outflow through Scotia Sea after Reflector-a' would be consistent with the high sedimentation rates, and only supported with relative diminution of AABW volume limited to extreme interglacials (Barth etal., 2018). In turn, a recent study reported lack of WSDW export into the Atlantic sector of the Southern Ocean during the last two glacial maxima (Huang etal., 2020). The ACC and WSDW flows would have been maintained by dynamic AMOC.

Barth, A.et al., 2018. Climate evolution across the mid-brunhes transition. Clim. Past, 2071–2087; De Vleeschouwer, D., et al., 2017. Alternating Southern and Northern Hemisphere climate response to astronomical forcing during the past 35 m.y. Geology45, 375–378; Huang, H., et al., 2020. No detectable Weddell Sea Antarctic bottom water export during the last and penultimate glacial maxi-mum. Nat. Commun.11, 424; Pérez, L.F., et al., 2021. Miocene to present oceanographic variability in the Scotia Sea and Antarctic ice sheets dynamics: Insights from revised seismic-stratigraphy following IODP Expedition 382. Earth and Planetary Science Letters, 2021, https://doi.org/10.1016/j.epsl.2020.116657; Weber, M.E., et al, 2021. Iceberg Alley and Subantarctic Ice and Ocean Dynamics. Proceedings of the International Ocean Discovery Program, 382: College Station, TX (Interna-tional Ocean Discovery Program). https://doi .org /10 .14379 /diop .proc .382 .2021.