# Chapter 2 Examples of NSG Partnership and co-operative research

## IODP Expedition 318: Cenozoic East Antarctic Ice Sheet Evolution from Wilkes Land Margin Sediments: Drilling the Greenhouse-Icehouse Transition

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When did Antarctica become glaciated? Were the ice sheets stable after they had formed? Understanding the evolution and dynamics of the Antarctic cryosphere from its probable inception during the Eocene–Oligocene transition (~34 Ma), through the periods of climate change during the Cenozoic, is of major scientific and societal interest *(Figure 2.1)*.

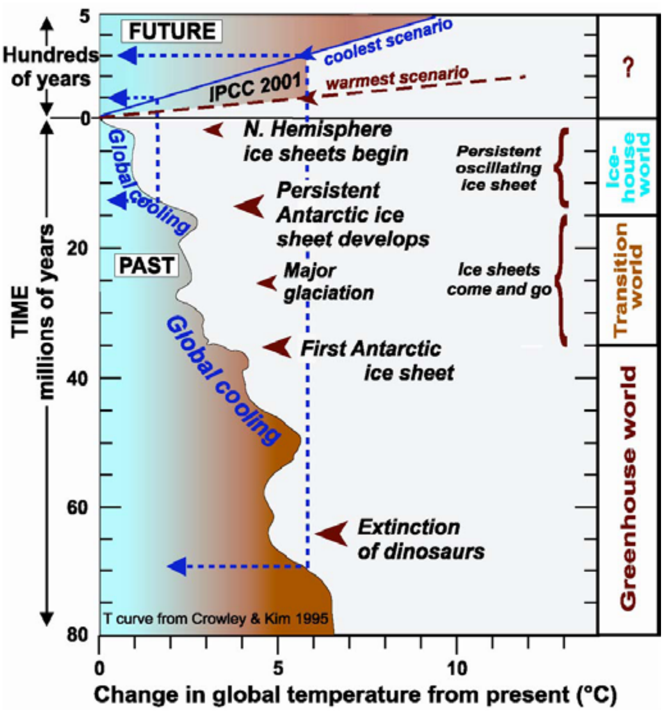


*Fig. 2.1: Earth's temperature variability during the last 80 m.y. bas.ed on reconstructions from deep-marine oxygen isotope records. Future atmospheric temperature scenarios, based on Intergovernmental Panel on Climate Change 2001 greenhouse trace gas forecasts, are shown at top of diagram.*

The transition from Greenhouse to Icehouse Earth was the most significant step in large-scale Cenozoic planetary change, impacting e.g., global sea level, albedo, and oceanographic and biotic evolution. State-of-the-art climate models combined with paleoclimatic proxy data now suggest that the main triggering mechanism for initial inception and development of the Antarctic glaciation was the decreasing levels of CO2 concentration in the atmosphere *(Figure 2.2)*. With current rising atmospheric greenhouse gases resulting in rapidly rising global temperatures, studies of polar climates, and the Antarctic cryosphere behavior in particular, are prominent on the research agenda. How stable will Antarctic ice be in the future? Important lessons from the past can be learned from the circum Antarctic sedimentary archive. Recognising this, international ocean drilling around the Antarctic margin over the past decades yielded important information, while ANDRILL is now breaking records in drilling continuous Neogene cores. Yet, crucial sectors of the Antarctic margin, notably the Wilkes Land margin south of New Zealand, remained uncharted. Here, the giant ice and moraine feeder channels of the East Antarctic Ice Sheet (EAIS) reach the ocean, as they did in the past. Some years ago, recognising the importance of this region, Carlota Escutia and colleagues produced a strong drilling proposal (482full) using a wealth of seismic information. Eventually, that proposal was combined with Ancillary Project Letter 638 (by Dunbar and others, Holocene), and transformed into IODP Expedition 318 to the Wilkes Land margin of Antarctica and planned for the *JOIDES Resolution*, operating under contract with the U.S. Implementing Organization (USIO). The expedition is currently scheduled to begin in Wellington, New Zealand, in January 2010 and end in Wellington the following March, with Escutia and Brinkhuis as co-chief scientists, and Klaus as staff scientist.
Drilling the Antarctic Wilkes Land margin is designed to provide long-term records from along an inshore to offshore transect *(Figure 2.3)*, of Antarctic glaciation and its intimate relationships with global climatic and oceanographic change. The principal goals are
**1.** To obtain the timing and nature of the first arrival of ice at the Wilkes Land margin (referred to as the «onset of glaciation») inferred to have occurred during the earliest Oligocene (Oligocene isotope event-1),

**2.** To obtain the nature and age of the changes in the geometry of the progradational wedge interpreted to correspond with large fluctuations in the extent of the East Antarctic Ice Sheet (EAIS) and possibly coinciding with the transition from a wet-based to a cold-based glacial regime (late Miocene–Pliocene?),
**3.** To obtain a high-resolution record of Antarctic climate variability during the late Neogene and Quaternary, and
**4.** To obtain an unprecedented, ultrahigh resolution (i.e., annual to decadal) Holocene record of climate variability.

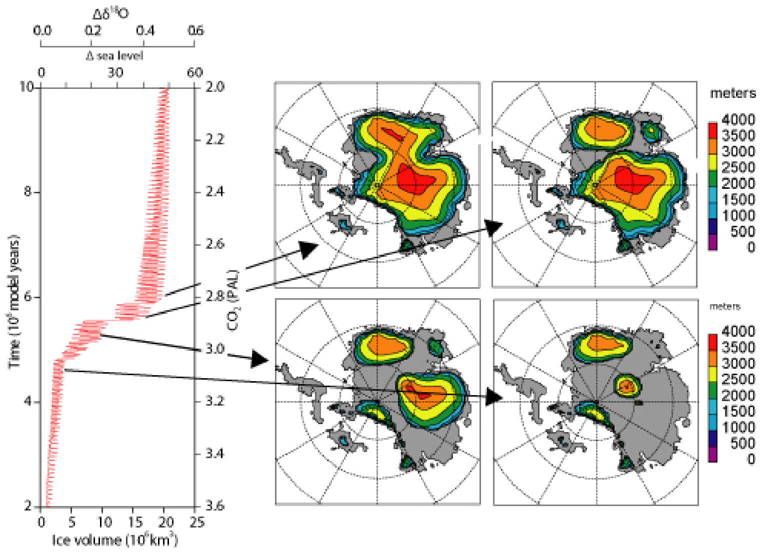


*Figure 2.2: Simulated initiation of East Antarctic glaciation in the earliest Oligocene, using a coupled GCM-ice sheet model (from DeConto and Pollard, 2003a). This model shows the main triggering mechanism for initial inception and development of the East Antarctic Ice Sheet were the decreasing levels of CO2 concentration in the atmosphere. Note these models show the initiation of glaciation to take place in a "two-step" cooling trend. The first step resulting in glaciation in the Antarctic continental interior, discharging mainly through the Lambert Graben to Prydz Bay, and the second step resulting in the connection an expansion of the ice sheet, reaching sea level in the Wilkes Land at a later stage.*

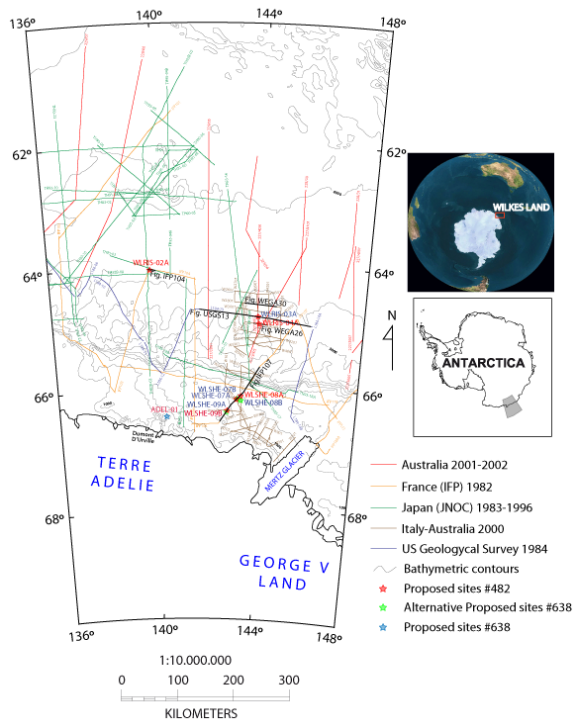


*Figure 2.3: Drilling sites and profile locations. Primary sites (red) and all alternate sites (blue) are shown in more detail on* ***http://publications.iodp.org/scientific_prospectus/318/index.htm***

The Wilkes Land drilling will provide constraints of the age, nature, and paleoenvironment of deposition of the previously only seismically inferred glacial sequences. Determining the chronostratigraphy of the Wilkes Land sediments, which is at present nonexistent, is critical to ground-truth the existing glacial-stratigraphic and ice sheet volume models for this margin. Ice sheet models suggest that the Wilkes Land margin became glaciated in the later stages of East Antarctic glaciation, after Prydz Bay and the Weddell Sea; therefore, it is presumed to be more sensitive to future temperature changes. Drilling the Wilkes Land margin has a unique advantage in that Unconformity WL-U3, inferred to separate preglacial strata below from glacial strata above in the continental shelf, can be traced to the continental rise deposits, allowing sequences to be linked from shelf to rise *(Figure 2.4)*. The EAIS in the Wilkes subglacial basin is grounded below sea level and therefore may have been more sensitive to climate changes in the late Neogene. The sedimentary sections on the Wilkes Land margin may therefore not only hold the record of the time when the EAIS first reached this margin, but also the record of ice sheet fluctuations during times when the EAIS is thought to be more stable (15 Ma–recent). This information is critical for developing reliable models of future Antarctic ice sheet behavior.

To obtain the most complete record of the history of Antarctic glaciation, the drilling strategy is to sample sediments from this margin in a shelf-rise-abyssal plain transect. The continental shelf strata *(Figure 2.4)* contain the direct (i.e., presence or no presence of ice), albeit low, resolution record of glaciation. The corresponding continental rise and abyssal plain strata *(Figure 2.4)* contain the distal (i.e., cooler versus warmer) but more continuous and easier to date record of glaciation. Our plan is to conduct coring and wireline logging operations at five sites: one on inner shelf continental shelf deep basins (proposed Site ADEL-1B or alternates), two on the continental shelf (proposed Sites WLSHE-09B and WLSHE-08A or alternates), one on the continental rise (proposed Site WlRIS-04A-or alternate), and one on the abyssal plain (proposed Site WLRIS-02A or alternate) *(Figure 2.3)*. Furthermore, Site ADEL-01B and alternate proposed Site ADEL-01C *(Figure 2.3)* is designed to sample the 200–230 m of unprecedented expanded Holocene sedimentary drape (the drift unit) overlying a hard reflector that is interpreted as a glacial diamict.

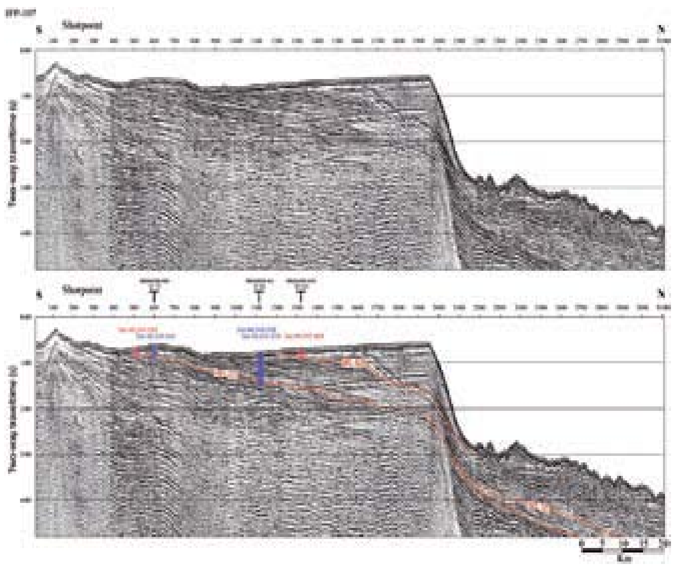

*Figure 2.4: Uninterpreted and interpreted multichannel seismic reflection Profile IFP-107 across the Wilkes Land shelf and continental slope and base of slope. The profile crosses one of the Wilkes Land shelf banks (where Sites WLSHE-09A,-09B, -07A and -07B are located) and an erosional shelf trough (where sites WLSHE-08A and -08B are located). The two main regional erosional unconformities in this margin are shown in the interpreted profile. Unconformity WL-U3 is interpreted to separate preglacial strata below from glacial strata above. Unconformity WL-U8 is interpreted to mark a change in the glacier regime possibly coinciding with the transition from wet-based to a cold-based more persistent ice sheet. Also shown are the locations of proposed priority sites (red) and alternate sites (blue). See Fig. 3 for location of profile.*

It won't be an easy ride. The planned drill sites are situated in an area of pronounced latitudinal gradients in wind because of the effects of the off-the-continent katabatic winds as well as the location of the frontal zone between polar easterlies and westerlies. Average January–March wind speeds can be from 6.4 to 7.7 m/s, but may reach up to 23 m/s at the shelf sites. The sea ice conditions, based on analysis on satellites, ships, continental stations, and synoptic modeling, may vary strongly from year to year. Whereas the sites farthest offshore may be ice free in the Austral summer, the shelf sites may not. But nothing we can't handle – cross your fingers!

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