SHALDRIL I and II: Drilling from the Research Vessel Icebreaker *Nathaniel B. Palmer*

BY JOHN B. ANDERSON AND JULIA S. WELLNER

Understanding of Antarctica's climate and ice sheet evolution remains fragmented due to a paucity of outcrops and drill cores that contain deposits from the Neogene (~ 23–2.6 million years ago), when major environmental changes were occurring. Sea ice and icebergs hinder sampling from conventional drill ships, limiting recovery of continental margin strata that bear the most direct record of glaciation on the Antarctic Continent. Because the continental shelf has been deeply eroded by ice sheets, older strata typically lie within a few meters to tens of meters below the seafloor. In most cases, these strata are buried beneath till and glacimarine sediments that, even though thin, prevent sampling by conventional coring methods.

Nearly two decades ago, the Antarctic geoscience community began discussions of a new program whereby drilling operations would be conducted from an ice-breaking research vessel (Figure 1). Drilling would focus on the upper 100 m of the stratigraphic section, sampling targeted sections as quickly as possible and moving to new locations as shifting sea ice and icebergs demanded. This drilling strategy was also envisioned as being suitable for acquiring long sediment cores in fjords and bays where expanded Late Pleistocene (~ 126,000–11,700 years ago) and Holocene (~ 11,700 years ago to present) stratigraphic records could be acquired. The first decade of this new program was dedicated to planning and monitoring new drilling and coring technologies suitable for polar operations. In 2001, SHALDRIL (Shallow Drilling on the Antarctic Continental Margin) was initiated with submission of a proposal to the National Science Foundation that included plans to conduct drilling operations from the icebreaking research vessel *Nathaniel B. Palmer*. The next four years were devoted to ship modifications, including construction of a moon pool, researching various coring technologies, and planning for the first cruise.

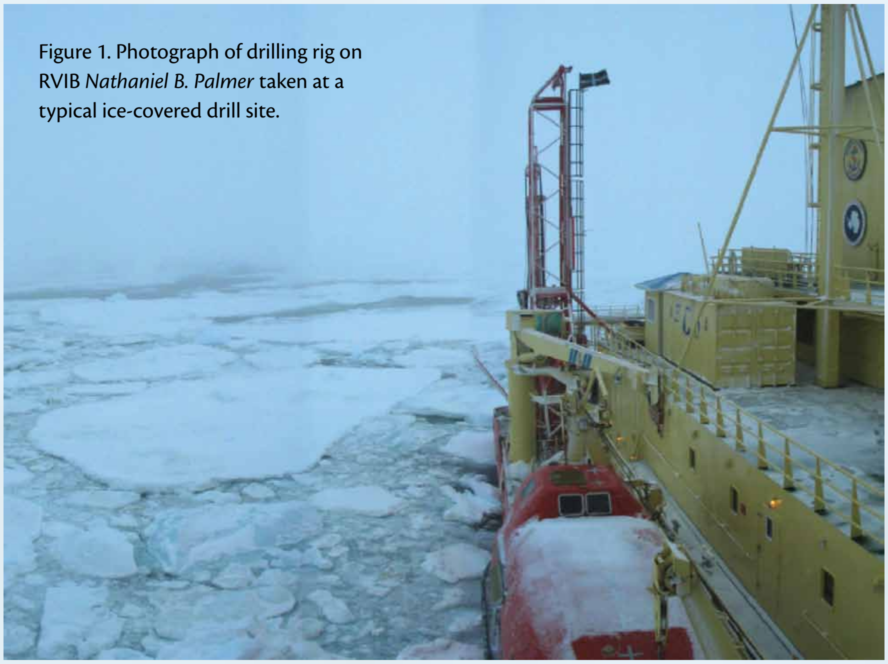

Figure 1. Photograph of drilling rig on RVIB *Nathaniel B. Palmer* taken at a typical ice-covered drill site.

Drilling operations were conducted during two cruises in 2005 and 2006 (SHALDRIL I and II) in the northern Antarctic Peninsula region (Figure 2). During SHALDRIL I, the first drilling operations, carried out in Maxwell Bay in the South Shetland Islands, resulted in the recovery of a 108 m section of Holocene strata that yielded one of the most complete climate records from this time interval (Milliken et al., 2009). Two other Holocene sites were drilled in Herbert Sound, on the north side of James Ross Island, and Lapeyrère Bay, on the northeastern side of Anvers Island, where thinner, less-complete records were obtained. Attempts to sample Neogene strata in James Ross Basin, located offshore of Seymour and James Ross Islands in the northwestern Weddell Sea, were unsuccessful but provided important lessons about drilling technology.

The 2006 cruise was more successful in terms of drilling technology but hindered by severe sea ice conditions. Only one of the priority drill sites in the James Ross Basin was sampled (Site 3C, Figure 2), but this site would eventually yield an important record of the initial onset of alpine glaciation in the northern Antarctic Peninsula (Anderson et al., 2011). Other sites were drilled along the southern flank of the Joinville Plateau where a virtually continuous section of Neogene strata was sampled (Figure 3). Although core recovery was not complete, the stratigraphic intervals sampled during SHALDRIL II represent key time periods in the glacial evolution of the northern Antarctic Peninsula (Anderson and Wellner, 2011). These time intervals include the latest Eocene, late Oligocene, middle Miocene, early Pliocene, and Pleistocene. The cores provide a record of climate evolution, and the evolution of fauna and flora, that took place over

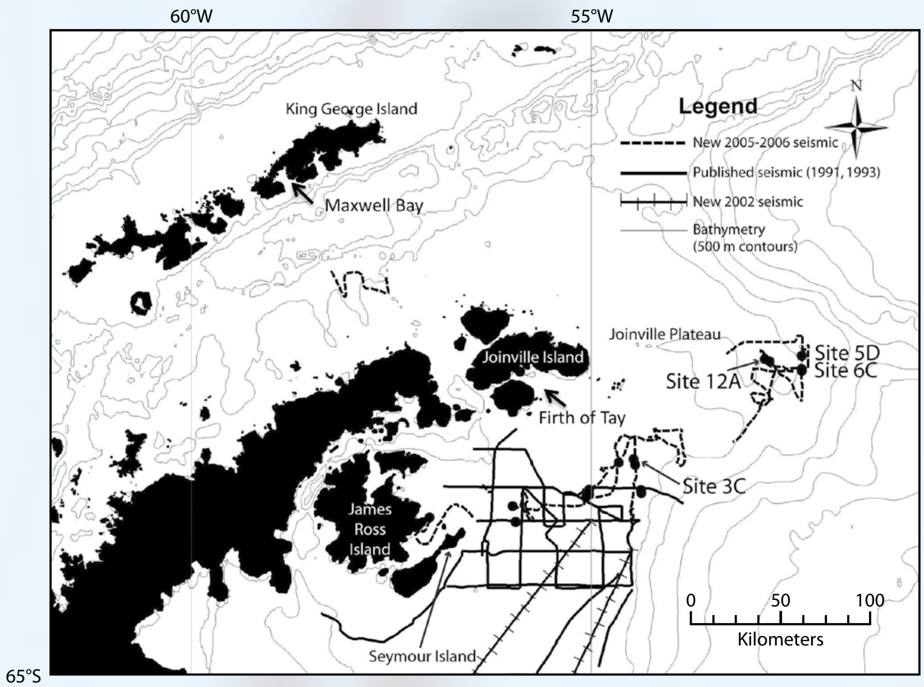

Figure 2. Map showing locations of SHALDRIL (Shallow Drilling on the Antarctic Continental Margin) drill sites and seismic lines used to select these sites.

the past 37 million years and culminated in expansion of the Antarctic Peninsula Ice Sheet onto the plateau in the early Pliocene. This long cooling history is argued to have resulted from the opening of ocean passageways and establishment of circumpolar circulation (Anderson et al., 2011), as originally proposed by Kennett (1977).

SHALDRIL II also yielded another long Holocene stratigraphic record from the Firth of Tay, located on the Weddell Sea side of the peninsula (Figure 2). Results from detailed analysis of this core revealed a diachronous climate evolution in the peninsula region, with deglaciation in the Firth of Tay lagging behind that of Maxwell Bay by approximately 5,000 years (Michalchuk et al., 2009).

The two SHALDRIL demonstration cruises proved the efficacy of shallow drilling from an icebreaker as a way to obtain previously out-of-reach sedimentary records on the Antarctic margin. Many technical lessons, regarding both drilling technologies to penetrate glacial sediments and ship handling in ice-covered waters, were learned. While the SHALDRIL approach to continental margin drilling offers many challenges, the results obtained during the first phase of the program are encouraging. A large moon pool has been included in the plans for the next generation research icebreaker; we hope this is one sign of plans for continued drilling in the ice-covered waters around Antarctica so that these lessons will be put to use. Obtaining more sedimentary records from proximal locations will provide the baseline knowledge of past Antarctic events and climate history necessary for developing a fuller understanding of Antarctica's role in global climate and sea level cycles.

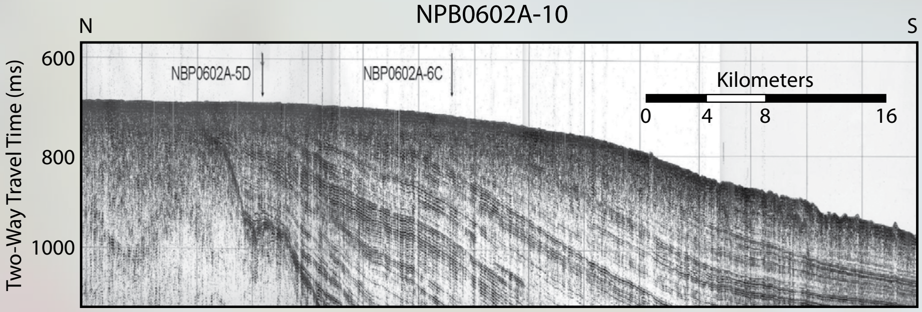

Figure 3. Seismic profile NBP0602A-10 shows an example of a seaward-dipping sedimentary succession where older strata are situated within reach of shallow drilling technology. Two drill sites (NBP0602A-5D and NBP602A-6C) were drilled during SHALDRIL II, yielding Miocene, Pliocene, and Pleistocene deposits. Attempts to core these deposits with conventional piston coring failed.

AUTHORS

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