INTERNATIONAL OFFSHORE STUDIES ON ANTARCTIC CENOZOIC HISTORY, GLACIATION, AND SEA-LEVEL CHANGE: THE ANTOSTRAT PROJECT

A. K. COOPER¹ and P. N. WEBB²

¹U.S. Geological Survey, 345 Middlefield Road, Menlo Park, CA 94025, USA
²Department of Geology, Ohio State University, 125 South Oval Mall, Columbus, OH 43210, USA

Abstract: The Antarctic Offshore Acoustic Stratigraphy project (ANTOSTRAT) is a recent international cooperative effort to coordinate and utilize all existing acoustic and geologic sample data from the Antarctic continental margin to study Cenozoic glacial history and the offshore effects of the Antarctic ice sheet. The project has, since its inception in 1990, conducted three workshops and has established a seismic data library system (SDLS) for cooperative research. Five segments of the Antarctic continental margin that have thick glacial sedimentary deposits (Ross Sea, Wilkes Land, Prydz Bay, Weddell Sea, and Antarctic Peninsula) have been targeted for detailed seismic and geologic studies by regional working groups. The end result of the ANTOSTRAT studies is projected to be a unified model for circum-Antarctic Cenozoic glaciation and global sea-level changes. Such a model would be the basis for future testing by scientific drilling of the Antarctic continental margin.

Key words: continental margin, glacial history, seismic data library system, sea level change, ANTOSTRAT

Introduction
In April 1989, the Scientific Committee on Antarctic Research (SCAR) Group of Specialists on the Evolution of Cenozoic Paleoenvironments of the Southern High Latitudes proposed a multi-year International project to study the Cenozoic sedimentary deposits around Antarctica, focusing in particular on the extensive sedimentary sections beneath the continental margin. The project, as adopted by SCAR in July 1990, seeks to integrate a variety of offshore geophysical, geological and glaciological data bases, and to incorporate them with ongoing studies to better understand the relationships between Cenozoic terrestrial and marine glacial-interglacial histories, and between Cenozoic ice-volume and global sea-level variations.

The new project is ANTOSTRAT (Antarctic Offshore Acoustic Stratigraphy; Fig. 1) in recognition that much of what is currently known about the Antarctic continental margin is derived from the vast quantity of acoustic data (e.g. high- and low-resolution seismic-reflection, bathymetry, and sidescan data) that has been collected since the 1960’s. Although extensive data exist, ANTOSTRAT is the first major international effort to compile and integrate all existing offshore acoustic data sets to study circum-continental Cenozoic events around Antarctica and to help plan future offshore geophysical and geological studies. In this paper, we briefly outline the background, objectives, and accomplishments to date of the ANTOSTRAT project.

Background
Several investigators have noted that the continental shelf is underlain in many places by Cenozoic sedimentary sequences that are many kilometers thick and have prograded the continental shelf up to 85 km (e.g. Hinz and Block, 1984; Haugland et al., 1985; Larue and Barker, 1989; Cooper et al., 1991). The Cenozoic sequences have been drilled on the continental shelves of the Ross Sea and Prydz Bay (Fig. 2) and are composed of glacial-marine rocks, some of which are at least as old as early-Oligocene age. These sequences have acoustic signatures suggesting that grounded ice sheets have episodically advanced to the continental shelf edge, and retreated, many times during the Cenozoic. The erosion and deposition of strata by these grounded ice sheets have left geologic records of the growth and decay of the Antarctic Ice Sheet, and these records can be used to infer ice-volume changes (Bartek et al., 1991; Hambrey et al., 1992;
Fig. 3). Deciphering the proximal record of Antarctic ice-volume changes and its correlation with the records of global sea-level variations and paleoclimates (Barrett, 1991) is the underlying goal of the ANTOSTRAT project.

The location and internal geometry of the offshore Antarctic Cenozoic sedimentary sequences are controlled by many factors including a) tectonics, b) supply, distribution and compaction of sediments, c) crustal flexure and sediment redistribution by fluctuating grounded ice-sheets, and d) sea level change. All factors must be considered to separate and ascertain the absolute sea level record (Anderson et al., 1983; Cooper et al., 1991). For example, as a result principally of ice erosion and limited sediment supply, most parts of the Antarctic continental shelf lie in water depths greater than 400 m, which is too deep to expose the shelf to subaerial erosion during common sea-level fluctuations of 100–300 m. Yet, such sea-level fluctuations greatly influence the size and extent of the Antarctic ice sheets which can reach thicknesses sufficient to erode even the deepest parts of the continental shelf.

ANTOSTRAT Project

As noted previously, the goal of the ANTOSTRAT project is to integrate a variety of acoustic and geologic data bases to correctly resolve the Cenozoic history of ice sheet movements and sea-level changes that are recorded in glacial rocks beneath the Antarctic continental margin (Webb et al., 1984; Webb, 1990). The scientific goals and procedures for the ANTOSTRAT project are established and implemented by a nine-member international steering committee that is guided by advice from the geoscience community. As such, ANTOSTRAT presently functions in advisory and coordinating roles to national programs within the Antarctic geoscience community. Scientific interchange is through workshops and regional working group meetings dedicated to topics on Antarctic Cenozoic history of global scientific

Fig. 2. A) Antarctic map showing ice-flow directions during last glacial maximum and locations of prograding sedimentary sequences and B) a profile across the prograding sedimentary sequences that were drilled in Prydz Bay on ODP Leg 119 (modified from Cooper et al., 1991).

Fig. 3. Model for deposition of prograding sedimentary sequences by grounded ice sheets and their relationship to global sea-level fluctuations (from Cooper et al., 1991).
interest. At the first ANTOSTRAT workshop in June 1990 (Cooper and Webb, 1990), existing data holdings were displayed, and factors controlling the deposition of offshore Cenozoic glacial strata were discussed. Additionally, working groups with regional coordinators were established for five regions of the Antarctic continental margin (Antarctic Peninsula, Ross Sea, Wilkes Land, Prydz Bay, and Weddell Sea) to facilitate multinational data compilations and interpretations and to investigate regional problems.

**Antarctic seismic data library system**

The second ANTOSTRAT workshop was held in April 1991 to discuss and design procedures for the use and dissemination of multichannel seismic reflection (MCS) data collected around Antarctica (Fig. 4). MCS data are the principal tool for mapping and determining the detailed structure and evolution of the earth’s crust. By consensus, a new Antarctic seismic data library system (SDLS) for cooperative research was designed by participants of the workshop. In June 1991, the SDLS was formally approved as a SCAR initiative under ANTOSTRAT (Fig. 1), and in October 1991 the Antarctic Treaty Consultative Parties adopted a resolution endorsing the SDLS as the agency for initial MCS data dissemination.

Under guidelines for the SDLS (Cooper et al., 1992), all MCS data will be openly available to Antarctic researchers for viewing and cooperative studies with data collectors four years from the time of data collection (Fig. 5). Data will be distributed to library branches located at data-collector’s institutions worldwide via CD-ROM (compact disc—read only memory). Some restrictions will apply to the use of the data during the four years that they are in the SDLS. Eight years after data collection, the MCS data will be sent to the World Data Center, or alternative, for unrestricted access and use of the data.

**Other workshops and future directions**

The third ANTOSTRAT workshop was held in Tokyo, Japan in September 1991. There, discussions among 40 scientists from 12 countries centered on greater coordination and compilation of offshore acoustic data sets in support of stratigraphic mapping projects for each of the five working regions of the Antarctic continental margin. Techniques and locations for possible scientific drilling,
Possible Sites for SDLS Branches

Fig. 5. A) World map showing possible locations for Antarctic seismic data library (SDLS) branches for cooperative research. B) Flow diagram showing the new concept of the Antarctic SDLS under the ANTOSTRAT project.

sea-floor coring, and dredging were discussed and evaluated to facilitate obtaining critical information on ages and depositional environments of the Cenozoic prograding sequences. Available seismic and geologic sample data shown at the workshop from all parts of the Antarctic continental margin suggest close ties between the waxing and waning of the Antarctic ice sheets and the erosion and deposition of Cenozoic sedimentary sequences.

Future thematic workshops are planned, and geoscience researchers who are interested in contributing data (existing or planned) and ideas to ANTOSTRAT’s scientific objectives are encouraged to participate. Further major advances in the resolution of Cenozoic glacial history are likely to come, in the near future, from offshore areas where the Cenozoic record is well preserved. Multidisciplinary geoscience studies of these areas are needed, especially scientific drilling programs that can sample below the ubiquitous surficial diamictons. The greatest benefits to Antarctic Cenozoic geoscience will come through coordinated international studies, which ANTOSTRAT strongly advocates and encourages.

REFERENCES


