GEOLOGY AND SEISMIC STRATIGRAPHY OF THE ANTARCTIC MARGIN
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# DESCRIPTIVE TEXT FOR THE SEISMIC STRATIGRAPHIC ATLAS OF THE ROSS SEA, ANTARCTICA

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The Atlas that accompanies this report presents a set of 29 seismic stratigraphic maps, a bathymetry map, a gravity map, 6 drill-site correlation sections, and 10 regional mutichannel seismic reflection (MCS) profiles with nearly 4900 km of data across the Ross Sea. Two CD-ROMs accompany the Atlas and hold the digital information for the maps and seismic profiles [*ANTOSTRAT*, this volume]. The Atlas has been compiled over the past five years by many members of the Antarctic Offshore Acoustic Stratigraphy project, Ross Sea Regional Working Group. The stratigraphic maps were derived from analysis of over 35,000 km of MCS data, and include reflection-time, depth, and isopach maps for the eight principal regional unconformities and eight principal seismic units that overlie acoustic basement. Regional seismic profiles illustrate all major structures and stratigraphic features. Drill-site correlation sections tie stratigraphic horizons to MCS and single-channel seismic data. The bathymetry and gravity maps provide new compilations of available data. The Atlas is intended as a tool for education and cooperative research projects targeted at improving our understanding of the geologic and glacial histories of the Ross Sea region.

## INTRODUCTION

The Seismic Stratigraphic Atlas of the Ross Sea is the product of a multi-national effort within the Ross Sea Regional Working Group of the Antarctic Offshore Acoustic Stratigraphy (ANTOSTRAT) project. The project was initiated in 1990 under the auspices of the Scientific Committee on Antarctic Research (SCAR) Group of Specialists on Cenozoic Paleoenvironments of the Southern High Latitudes [*Cooper and Webb*, 1994] to compile, collate, and analyze all acoustic and geologic data from the Antarctic continental margin, principally to study Cenozoic paleoenvironments and global sea-level changes. The geophysical maps, seismic profiles, and drill-site correlations in the Atlas (Table 1) show compilations and representative examples of all multichannel seismic reflection data collected in the Ross Sea by six countries. The compilations, analyses, and verifications have taken five years of active collaboration between researchers from numerous institutions worldwide to achieve. This effort was coordinated by, and headquartered at, Osservatorio Geofisico Sperimentale in Trieste, Italy. Table 2 lists the contributions of the authors of the maps, sections, and profiles.

The compilation of all multichannel seismic data (MCS) needed for the Atlas was facilitated by the implementation in 1991 of the Antarctic Seismic Data Library System for Cooperative Research (SDLS), also under the auspices of the SCAR-ANTOSTRAT project. The SDLS provides access to Antarctic MCS digital data, via CD-ROMs, at twelve library branches in eleven countries [*Childs et al.*, 1994; *Cooper*, 1995]. MCS data were taken from the SDLS, with permission of the data owners, to be used for the Atlas Plates and the digital files on the accompanying CD-ROMs [*ANTOSTRAT*, this volume; *Childs et al.* this volume]. The nearly 4900 km of MCS profiles shown in the Atlas are a representative sample of existing profiles,

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TABLE 1. List of Atlas Plates

| Plate | Type | A | B | C | D |
|---|---|---|---|---|---|
| 1 | M | Bathymetry | Free air gravity | - | - |
| 2 | M | MCS tracks | - | - | - |
| 3 | D | DSDP-270 | DSDP-272 | - | - |
| 4 | D | DSDP-271 | DSDP-273 | - | - |
| 5 | D | CIROS-1 & MSSTS-1 | - | - | - |
| 6 | S | MCS Profile-1 | - | - | - |
| 7 | S | MCS Profile-2 | - | - | - |
| 8 | S | MCS Profile-3 | - | - | - |
| 9 | S | MCS Profile 4 | - | - | - |
| 10 | S | MCS Profile 5 | - | - | - |
| 11 | S | MCS Profile 6 | - | - | - |
| 12 | S | MCS Profile 7 | - | - | - |
| 13 | S | MCS Profile 8 | - | - | - |
| 14 | S | MCS Profile 9 | - | - | - |
| 15 | S | MCS Profile 10 | - | - | - |
| 16 | M | Travel time: SL- RSU1 | Depth: SL- RSU1 | Travel time: SL- RSU2 | Depth: SL- RSU2 |
| 17 | M | Travel time: SL- RSU3 | Depth: SL- RSU3 | Travel time: SL- RSU4 | Depth: SL- RSU4 |
| 18 | M | Travel time: SL- RSU4a | Depth: SL- RSU4a | Travel time: SL- RSU5 | Depth: SL- RSU5 |
| 19 | M | Travel time: SL- RSU6 | Depth: SL- RSU6 | Travel time: SL- Bsmt | Depth: SL- Bsmt |
| 20 | M | Isopach: RSS-8 | Isopach: RSS-7 | Isopach: RSS-6 | Isopach: RSS-5 |
| 21 | M | Isopach: RSS-4 | Isopach: RSS-3 | Isopach: RSS-2 | Isopach: RSS-1 |
| 22 | M | Isopach: SF - RSU2 | Isopach: SF - RSU6 | Isovelocity: SL - Bsmt | Isopach: SF - Bsmt |

M = map; D = drill site correlation section; S = seismic reflection data; SL = sea level; SF = sea floor

TABLE 2. Researchers who Participated in Compiling the Maps, Sections, and Profiles for the Atlas.

| Investigator | Organization[1] | Contribution |
|---|---|---|
| G. Brancolini | OGS | General coordination and MCS interpretation |
| M. Busetti[2] | OGS | MCS interpretation and map production |
| F. Coren | OGS | Gravity and bathymetry maps |
| C. De Cillia | OGS | Map production |
| L. De Santis | OGS | MCS interpretation |
| A. Marchetti[2] | OGS | Compiling reflection and refraction velocities and map production |
| C. Zanolla[2] | OGS | Gravity map |
| V. Belyaev | MAGE | MCS interpretation |
| M. Knyazev | MAGE | MCS interpretation |
| O. Vinnikovskaya | MAGE | Seismic interpretation |
| I. Zayatz | MAGE | MCS interpretation |
| G. R. Cochrane | USGS | Seismic refraction interpretation |
| A. K. Cooper | USGS | MCS interpretation , writing, and oversight reviews |
| F.Davey[2] | INS | Gravity and bathymetry maps |
| K. Hinz | BGR | MCS interpretation |

[1]See Table 11 for list of acronyms.
[2]Principal map compilers

TABLE 3. Research Groups that Contributed Data for the Seismic Stratigraphic Atlas of the Ross Sea, and Participated in Data Analysis and Compilation. Some Groups Host SDLS Branches, as noted.

| Country | Contributing organization and SDLS branch[1] | Senior Antarctic researcher |
|---|---|---|
| France | Paris Branch:<br>Institut Français du Petrole (IFP)<br>Division Geologie-Geochimie<br>1 et 4 Avenue de Bois Preau<br>F-92500 Rueil-Malmaison | Dr. Jacques Wannesson<br>Tel: 33-1-47-49-0214<br>Fax: 33-1-47-52-7000 |
| Germany | Hannover Branch:<br>Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)[2]<br>Postfach 510153<br>D-3000 Hannover 51 | Dr. Karl Hinz<br>Tel: 49-511-643-3244<br>Fax: 49-511-643-2304<br>E-mail: foerstl@gate1.bgr.d400.de |
| Italy | Trieste Branch:<br>Osservatorio Geofisico Sperimentale (OGS)[2]<br>PO Box 2011, Opicina<br>34016 Trieste | Dr. Giuliano Brancolini<br>Tel: 39-40-21401<br>Fax: 39-40-327307<br>E-mail: branco@magrav.ogs.trieste.it |
| Japan | Tsukuba Branch:<br>Geological Survey of Japan (JNOC)[3]<br>Tsukuba | Dr. Yoshihisa Okuda<br>Fax: 81-298-54-3533 |
| Russia | Joint Stock Marine Arctic<br>Geological Expedition (MAGE)[2]<br>26 Perovskaya St.<br>Murmansk 183012 | Dr. Igor Zayatz<br>Tel: 47-789-10469<br>Fax: 47-789-10469 (Norway) |
| USA | Palo Alto Branch:<br>U.S. Geological Survey (USGS)[2]<br>345 Middlefield Road<br>Menlo Park, California 94025 | Dr. Alan Cooper<br>Tel: 1-415-354-3132<br>Fax: 1-415-354-3191<br>E-mail: alan@octopus.wr.usgs.gov |

[1] See *Cooper* [1995] for a complete list of SDLS branches worldwide where Antarctic MCS data can be openly accessed and used for cooperative research projects.
[2] Groups that participated in data analysis and compilation.
[3] MCS data were collected by Japan National Oil Corporation (JNOC) in cooperation with Geological Survey of Japan

and they cross all major geologic structures in the Ross Sea. Table 3 lists the six countries and research groups that have contributed data for the Atlas, and most of these groups host a branch of the SDLS.

The centerpiece of the Atlas is a set of 16 horizon-maps (i.e., in reflection-time and depth; Atlas Plates 16-19) for all major regional unconformities, and 11 isopach maps (i.e., thickness; Atlas Plates 20-22) of the bounded seismic sequences. The unconformities are principally of mid-Cenozoic and younger ages, and the maps thereby provide a previously unmapped regional view of geologic processes across the Ross Sea during Cenozoic glacial and inter-glacial times. New correlations of seismic data with Ross Sea drill sites are presented (Atlas Plates 3-5) to provide better ties of ground truth information to the acoustic stratigraphy than previously available. Ten regional seismic profiles are shown (Atlas Plates 6-15) to illustrate the subsurface geometries of the unconformities and seismic sequences that have been mapped. Bathymetry and gravity maps are presented (Atlas Plate 1) to help characterize the sea floor and the underlying structure of the continental margin, respectively. A map of all MCS tracklines in the Ross Sea is shown in Atlas Plate 2.

The intent of the Atlas is to present the initial map compilations and seismic profiles in both analog and digital formats to stimulate and facilitate ongoing and future cooperative multinational research projects on the geology, structure, and glacial history of the Ross Sea.

The following text describes procedures and guidelines that were used to make the maps, profiles and drill site correlations. Some descriptions of seismic unconformities and sequences are also provided. However, greater detail on descriptions and all interpretations of the maps are discussed in the research papers [e.g., *De Santis et al.*, this volume; *Brancolini et al.*, this volume, etc.]. The reader is also referred to the enclosed CD-ROMs, and descriptive text [*Childs et al.*, this volume], for the digital data used to make the contour maps and regional MCS profiles.

## SEISMIC REFLECTION DATA

The Atlas is based principally on compilations and analyses of multichannel seismic reflection data (MCS) because they, unlike the many thousands of kilometers of single-channel seismic reflection data in the Ross Sea, can be digitally processed to resolve geologic features below the sea-floor multiple-reflection (i.e., below about 700 m subsurface). Most regional seismic unconformities either lie entirely below this depth or pass through this depth at different locations around the Ross Sea. Single-channel data, because of their generally higher resolution, are used in the Atlas to correlate seismic reflectors with geologic units cored at Ross Sea drill sites.

### 2.1. *Data Contribution*

Multichannel seismic reflection data have been collected in the Ross Sea since 1980 and since that time over 35,000 km of data have been acquired (Figure 1). The location map of MCS tracklines is shown in Atlas Plate 2 at a scale of 1:2,000,000. Description of acquisition and processing techniques for these surveys have been discussed by *Berger et al.* [1988], *Brancolini et al.* [1988], *Cooper et al.* [1987], *Hinz and Block* [1984], and *Childs et al.* [this volume]. The Atlas maps incorporate all MCS data collected prior to 1991. This represents about 90% of existing MCS data at the 1995 cutoff time for publication of the Atlas. Table 4 lists the cruises and the amount of MCS data that each research institute contributed for the compilation of the Atlas. The principal individuals who provided the data from the institutions are identified in Table 3. Many researchers participated in the data compilation, and these people are listed as authors on each of the maps and in Table 2. M. Busetti and A. Marchetti were the principal compilers for the seismic maps. Researchers who wish to use the MCS data or have questions about the data should contact the person listed in Table 3. Use of the data is encouraged in the format of cooperative projects, which is also in the spirit of Antarctic research and is the philosophy of SCAR and the SDLS.

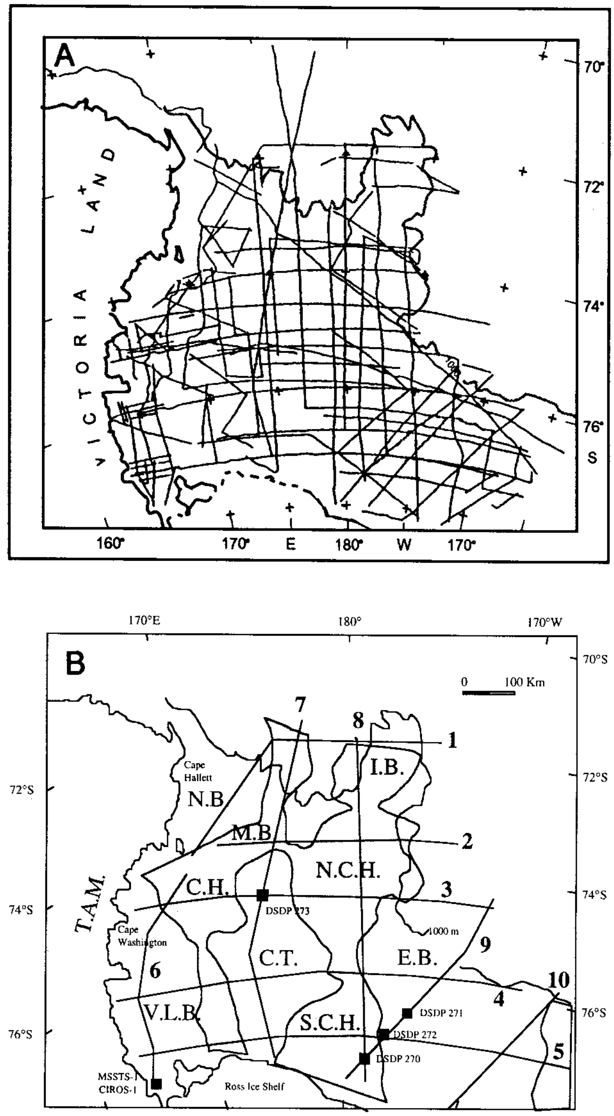



Fig. 1. Index maps for the Ross Sea showing (a) MCS tracklines (Atlas Plate 2) used to compile stratigraphic maps for the Atlas, and (b) locations for composite MCS profiles (Atlas Plates 6 to 15), drill sites (Atlas Plates 3 to 5) and major structural basins and highs. Shading denotes areas where sedimentary rocks are less than 1000 m thick. NB = Northern basin; CH = Central high; VLB = Victoria Land basin; CT = Central trough; IB = Iselin Bank; NCH = northern Central high; SCH = southern Central high; EB = Eastern basin; MB = Mawson Bank; TAM = Transantarctic Mountains.

TABLE 4. MCS Cruises in the Ross Sea used for Compilation of the Atlas

| Season | Country | Group | Km | SDLS CD-ROM[1] |
|---|---|---|---|---|
| 1979/80 | Germany | BGR | 6743 | SDLS-3,4,5 |
| 1981/82 | France | IFP | 2000 | SDLS-12 |
| 1981/82 | Japan | JNOC | 1670 | SDLS-9 |
| 1983/84 | USA | USGS | 1850 | SDLS-1 |
| 1986/87 | Russia | MAGE | 4320 | SDLS-13 |
| 1987/88 | Italy | OGS | 2323 | SDLS-2 |
| 1988/89 | Italy | OGS | 4202 | - |
| 1989/90 | Russia | MAGE | 3175 | SDLS-14 |
| 1989/90 | Italy | OGS | 2562 | - |
| 1990/91 | Italy | OGS | 577 | - |
| 1990/91 | Japan | JNOC | 3300 | - |
| | | TOTAL | 32722 | |

[1]CD-ROM number for the MCS data at the SDLS.
See Table 11 for list of acronyms.

Most MCS surveys in the Ross Sea have been conducted with knowledge of previous expeditions, hence the tracklines are mostly uniformly distributed with only minor overlaps between cruises. Different recording parameters covering a wide range of field configurations were used by all data collectors (Table 5). Attenuation of sea-floor multiple reflections is probably the most critical issue in the processing of Antarctic seismic data because strong sea-floor multiples due to a ubiquitous overconsolidated diamictite-layer close to the sea floor occur nearly everywhere. Nearly 80% of the MCS data have been collected using a streamer of 2400 m length or longer with a 2400% fold coverage or better (Table 5) to provide the "move out" necessary to effectively attenuate the multiples from the data. All cruises used air gun arrays as energy sources to attain the penetration needed to reach acoustic basement, except in the deepest parts of the basins.

## 2.2. *Seismic Unconformities and Sequences*

Previous investigators have defined seismic unconformities, sequences and units from multichannel seismic data in different sectors of the Ross Sea (e.g., *Hinz and Block* [1984] for Eastern basin and Central trough; *Cooper et al.* [1987] for Victoria Land basin; *Cooper et al.* [1991] for Eastern basin). In making the Atlas, we have followed the general identification criteria used by these investigators to derive a seismic stratigraphic framework for the entire Ross Sea. We adopted the geometric nomenclature used by *Hinz and Block* [1984], who in turn followed *Mitchum et al.* [1977], for identification and mapping the seismic horizons (unconformities) that bound the seismic units (sequences). The criteria we used are:

1. The seismic horizons should be unconformities (with correlative conformities) that can be traced regionally throughout the Ross Sea;
2. The seismic horizons (unconformities) bound seismic units (sequences) that have similar geometric characteristics within that unit in similar depositional environments. Geometries of overlying and underlying units (sequences) may vary in their internal geometry between aggrading and prograding; and

Following the above, we first verified that the seismic unconformities and sequences were indeed features that could be identified and mapped regionally (i.e., features being the likely product of basin-scale or larger events). We preserved essentially the same nomenclature of *Hinz and Block* [1984, Figures 2 and 3; Profile 9 in Atlas Plate 14] for the six major unconformities (U1 to U6) that they identified in the Eastern basin, and that we traced throughout the Ross Sea. We renamed their unconformities U1 to U6 as RSU1 to RSU6 using the prefix RS to clearly identify the horizons as belonging to the Ross Sea. We also included unconformity U4a of *Cooper et al.* [1991] as RSU4a. These seven unconformities, acoustic

TABLE 5. Parameters for MCS Data Collection in the Ross Sea by Different Research Groups

| Parameter | BGR | IFP | USGS | OGS | MAGE | JNOC |
|---|---|---|---|---|---|---|
| Streamer length (m) | 2400 | 2400 | 2400 | 3000 | 2400 | 600/1200 |
| Channels | 48 | 48 | 24 | 120 | 24 | 24 |
| Group interval (m) | 50 | 50 | 50 | 25 | 100 | 25/50 |
| Shot interval (m) | 50 | 50 | 25 | 50 (25[1]) | 50 | 25 |
| Coverage (%) | 2400 | 2400 | 2400 | 3000 (6000[1]) | 2400 | 600/1200 |

[1]for the 1989/90 cruise only
See Table 11 for list of acronyms.

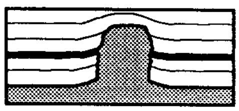
| Type | Representation | Atlas Examples | |
|---|---|---|---|
| | | Uncomformity | Profile : Shotpoints |
| **Erosion** |  | 4, 4a, 5 | 5 : 5500 - 6500 |
| **Toplap** |  | 1, 2, 3 | 9 : 4800 - 5400 |
| **Onlap** |  | 6 | 8 : 7400 - 7800 |
| **Downlap** |  | 4, 4a, 5 | 4 : 9400 - 10,400 |
| **Intrusion** |  | 4, 4a, 5, 6 | 5 : 700 - 800 |

Fig. 2. Schematic representations [modified from *Mitchum et al.*, 1977] of different types of terminations of seismic unconformities (bold lines) observed on Ross Sea seismic profiles, and noted on the "time", "depth", and "isopach" maps of the Atlas. Typical examples from Atlas seismic profiles are indicated.

basement, and the sea floor bound eight seismic units that we refer to as Ross Sea seismic sequences RSS-1 to RSS-8 for the Atlas. We followed the stratigraphic convention of numbering the deepest sequence above acoustic basement as RSS-1 and the shallowest as RSS-8, as done for example by *Miller et al.* [1990] for the Weddell Sea (Antarctica) sequences. This numbering scheme is the reverse of that used by *Hinz and Block* [1984] for their sequences RS-1 to RS-6.

In mapping the seismic unconformities, we followed conventional seismic stratigraphic procedures [e.g., *Mitchum et al.*, 1977], and used continuity of reflectors and geometric relationships between overlying and underlying seismic sequences. In situations where buried seismic unconformities terminate due to more recent erosion, the name of the younger seismic unconformity is assigned to the eroded area. Areas where seismic unconformities terminate are noted on the maps, and we distinguish the type of termination for the unconformity (e.g., downlap, toplap, etc.). Schematic examples of the different types of terminations, with reference to typical real examples from the Atlas seismic profiles, are given in Figure 2.

The seismic sequences were correlated with drill sites in the Ross Sea (DSDP Sites 270 to 273, CIROS-1 and MSSTS-1, Atlas Plates 3 to 5), to establish ages for the "RSS" sequences. Table 6 summarizes the age-correlations with the unconformities recognized by previous researchers. The reader is referred to papers by *Busetti et al.* [1994], *Busetti and Cooper* [1994], *Cooper et al.* [1994a], *Barrett et al.* [this volume], *Brancolini et al.* [this volume] and *De Santis et al.* [this volume] for more comprehensive discussions on acoustic characteristics, age correlations, origins, and inferred paleoenvironments for the Ross Sea seismic sequences.

In many areas, it is difficult to correlate seismic sequences between the four major basins in the Ross Sea due to the extensive erosion of the now-thin sedimentary sections lying across the crests of buried basement ridges (e.g., Central and Coulman highs). A further and potentially more serious problem with correlation is the extensive tectonism (e.g., faulting, magmatic intrusion, folding, etc.) that occurs around the perimeter of the Victoria Land basin. There are only a few places near the north end of the basin where

TABLE 6. Seismic Sequences in the Ross Sea, and Correlation with Previous Interpretations

| Seismic sequence | Bounding unconformities | Ages | H&B[1] unconformities | C[1] units |
|---|---|---|---|---|
| RSS-8 | Sea floor-RSU1 | Plio-Pleistocene | Sea floor-U1 | V1 |
| RSS-7 | RSU1-RSU2 | early Pliocene | U1-U2 | V1 |
| RSS-6 | RSU2-RSU3 | late Miocene | U2-U3 | V1 |
| RSS-5 | RSU3-RSU4 | midddle Miocene | U3-U4 | V1 |
| RSS-4 | RSU4-RSU4a | early Miocene | U4-U4a[2] | V2 |
| RSS-3 | RSU4a-RSU5 | early Miocene | U4a[2]-U5 | V2,3 |
| RSS-2 | RSU5-RSU6 | early Miocene and late Oligocene | U5-U6 | V3,4 |
| RSS-1 | RSU6-Basement | early Oligocene and older | U6-Acoustic basement | V4,5 |

[1]H&B: *Hinz and Block* [1984]; C: *Cooper et al.* [1987]
[2]Unconformity U4a is from *Cooper et al.* [1991].

the sedimentary section is not disrupted or is not highly eroded, to allow unambiguous correlations of some horizons into the Victoria Land basin. In cases where correlations are equivocal over ridges and near disrupted zones, we have made them by comparing the seismic character and geometries of the unconformities and sequences on both sides of the problematic zones. A further discussion on potential errors in the Atlas maps is given in section 2.6. The availability of a large seismic data grid with many cross-line points has greatly helped to minimize the uncertainties in these correlations.

### 2.3. *Regional Seismic Profiles*

The Ross Sea (Figure 1) is underlain by several north-south-trending sedimentary basins [*Hinz and Block*, 1984; *Cooper et al.*, 1991, 1994b], the Victoria Land basin, Northern basin, Central trough, and Eastern basin that are separated by basement ridges, the Central and Coulman highs. Ten composite seismic profiles are shown on Atlas Plates 6 to 15 to illustrate the main depositional and structural features of the region. The seismic profiles cross the structural features both in dip and strike directions. The profiles are composed of segments of MCS profiles that have been recorded and processed by two or more different institutions. Most profiles were assembled by reading the digital SEG-Y data for the desired segments from the CD-ROMs of the seismic data library system (SDLS). The segments were then merged and desampled to 100 m trace intervals and 6 second record lengths for uniformity of scale and presentation. The profiles were plotted at a horizontal scale of 100 shot points equals 5 kilometers (i.e., 1:400,000), giving a vertical exaggeration at the sea floor of about 13:1. The shot point numbers that are annotated across the top of the profiles are the same as those shown in the trackline navigation plot of Atlas Plate 2. No further data processing was done, other than muting water column noise and balancing seismic traces using a fixed-length (500 msec) automatic gain control operator. The points at which different profile segments from different institutions begin and end are marked, and can be recognized on most composite profiles by a change in data appearance.

The MCS profiles show the stratigraphic positions of the regional unconformities (i.e., RSU1 to RSU6) and acoustic basement that are used to make the time and depth maps for these horizons (Atlas Plates 16 to 19). The profiles also illustrate the relative thickness (in reflection time) of the seismic sequences (i.e., RSS-1 to RSS-8) for which isopach maps (in meters) have been made (Atlas Plates 20-22). The locations of inferred faults and magmatic intrusions are based on interpretation of the composite profiles, and are included to illustrate the general control of these inferred features on subsurface geometries of horizons and sequences. The reader is referred to the larger-scale seismic sections that were used to compile the Atlas maps, for a more detailed analysis of Ross Sea structures, such as that of *Cooper et al.* [1994b,c].

Profiles 1 and 9 (Atlas Plates 6 and 14) illustrate the geomorphology and acoustic geometries of the outer shelf and slope of the Northern and Eastern basins, respectively, where depositional sequences are thicker and geometrical relationships more distinct. These two profiles are denoted the Ross Sea "type profiles", on which sequences can best be observed across the outer shelf and slope. Profile 1 illustrates all sequences including RSS-6, whose existence in the Northern basin is speculative because the sequence is not crossed by other seismic profiles and cannot be traced to the Eastern basin where RSS-6 has also been recognized (e.g., Profile 9). Hence, we were not able to include RSS-6 on maps of the Northern basin (e.g., Atlas Plate 20).

Profile 1 (Atlas Plate 6) crosses a deep-water area of the northern Ross Sea (i.e., between Mawson and Iselin Banks) where seismic lines do not extend directly from the continental shelf into the abyssal basin, to provide stratigraphic ties between these areas. The stratigraphic sequences noted on Profile 1 in this area are included for illustrative purposes, and are based solely on the similarities of seismic character with the Northern basin and Central trough. Similar "indirect" ties of seismic sequences on the shelf and in continental rise areas east of Iselin Bank (e.g., Profile 3, Atlas Plate 8) have been made in the same way to illustrate likely stratigraphic correlations. In some areas of the eastern Ross Sea (e.g., Profile 9, Atlas Plate 14), the seismic sequences can be directly traced across the shelf, slope, and upper rise, especially the upper sequences. Further data are needed to make direct stratigraphic ties into the deep-water areas.

In many profiles, RSS-7 and RSS-8 cannot be distinguished and have been mapped as one sequence due to insufficient seismic resolution or uncertainty in identifying different sequence geometries. Where identification is uncertain, the two sequences have not been mapped. In the Victoria Land basin RSS-7 and RSS-8 have only been delineated where the total thickness of the confined section exceeded 200 msec, and in these areas the unit has arbitrarily been denoted as RSS-7. Higher resolution seismic-reflection studies, like those of *Anderson and Bartek* [1992] in the Ross Sea, are needed to map the thin shallow sedimentary sequences.

Some structural features shown in the seismic profiles are labeled as possible “magmatic intrusions?”. These features have not been sampled directly, and the evidence for a magmatic origin of the features is only from seismic character and in some cases magnetic data. The features occur throughout the Ross Sea, but are most evident in the western Ross Sea, especially in areas where volcanic rocks outcrop nearby onshore (e.g., Coulman Island, Mt. Melbourne, Franklin Island, Ross Island) and where volcanics are inferred from detailed aeromagnetic surveys offshore [e.g., *Behrendt et al.*, 1991]. In other areas, the evidence for magmatic intrusions is only from seismic character. The likelihood of magmatic origin for these features varies across the Ross Sea, with greater likelihood in the western sector of the Ross Sea (e.g., western parts of Profile 1, 3, 4, 5 and 6, Atlas Plates 6, 8, 9, 10, and 11) and lesser likelihood in the central and eastern sectors (e.g., central part of Profile 1, Atlas Plate 6).

### 2.4. *Drilling Data*

Seismic data have been correlated with drill sites at six locations in the Ross Sea (Figure 1, Tables 6 and 7; Atlas Plates 3 to 5). At all sites except MSSTS-1, the correlation has been made using both single-channel seismic data (SCS; higher resolution) and multi-channel seismic data (MCS; lower resolution) to determine depths to seismic horizons and estimate (indirectly) likely ages for stratigraphic units within the drilled sedimentary sections.

The SCS data (e.g., "PD" lines) were collected by and processed at Rice University, and provided in digital format by John Anderson. The MCS data were obtained, with owner permission, from CD-ROMs in the SDLS. The seismic data were plotted at the same horizontal and vertical scales, with exception of PD-46 which has a non-linear distance scale (i.e., shots fired on time with minor changes in ship speed), to facilitate correlations and comparisons. Technical information about the recording and processing of these seismic profiles are summarized in the side label of each Plate. At some sites, the seismic profiles do not cross directly over the drill site, as can be seen in the 1:1,000,000 index map on each Atlas Plate. For these profiles, the drill site has been projected along strike to the profile.

TABLE 7. Drill Site Correlation with Seismic Data

| Drill site | Core recovery (%) | Atlas plate | Seismic profiles SCS | Seismic profiles MCS |
|---|---|---|---|---|
| DSDP Site 270 | 62 | 3 | PD-21 & PD-30 | JNOC-17 |
| DSDP Site 271 | 7 | 4 | PD-30 | JNOC-17 |
| DSDP Site 272 | 37 | 3 | PD-30 | JNOC-17 |
| DSDP Site 273 | 25 | 4 | PD-36 & PD-37 | BGR-1 |
| CIROS-1 | 98 | 5 | PD-46 | IT-71 |
| MSSTS-1 | ~60 | 5 | - | IT-71 |

See Table 11 for list of acronyms.

The drill site information on core recovery and lithologies are from *Hayes, Frakes et al.* [1975] for DSDP sites, and from *Barrett* [1986, 1989] for MSSTS-1 and CIROS-1 sites. The ages shown are synthesized from *Hayes, Frakes et al.* [1975], *McDougall* [1977], *Savage and Ciesielski* [1983], *Leckie and Webb* [1986], *Barrett* [1986, 1989], *Steinhauff and Webb* [1987], and *Hanna* [1994]. The reader is referred to papers by *Brancolini et al.* [this volume] and *De Santis et al.* [this volume] for more detailed explanation of the age synthesis.

Detailed velocity data for the drill sites were not available because continuous sonic logs were not recorded and down-hole logging was not done. Subsurface velocities were derived from standard velocity-analysis techniques on MCS data for profile segments close to the drill sites. These analyses were used to calculate velocity versus reflection-time points (e.g. p1, p2 etc., Atlas Plates 3 to 5; Table 8), from which the best-fit curve was estimated. Synthetic seismograms were calculated for all drill sites except DSDP Site 271 where core recovery was only 7%. Because core recovery at drill sites was variable and relatively low (average of 46%, excluding CIROS-1 (98%) and DSDP Site 271; Table 7), an empirical relation was developed by OGS authors to obtain "pseudo acoustic impedances" based on relative clay concentrations reported by *Hayes, Frakes et al.* [1975] and *Barrett* [1986, 1989] for drill cores. A detailed analysis of clay contents and seismic amplitudes was done for DSDP Site 270 to establish the empirical curve, which was then applied to all drill sites. Pseudo acoustic impedances derived in this way were convolved with with a minum phase wavelet that was filtered at two frequency ranges (8-40 Hz and 30-90 Hz) to obtain the synthetic seismograms for comparison with MCS and SCS data. The synthetic seismograms were time-shifted to plot the first arrival at the sea floor of the seismic profile.

The seismic correlations are the best now possible, but are approximate because (a) the synthetic seismograms are necessarily based only on data from recovered core-sections with an average recovery of about 46%, (b) lithologic boundaries in the cores are inferred, for the synthetic seismograms, from variations in clay concentration only, (c) the effects of compaction, which can be significant for clays, have not been included due to the lack of data, and (d) relatively low precision of MCS velocities for thin sedimentary sections (i.e., the drilled sequences) at shallow subsurface depths. Further drilling with down-hole logging and high core-recovery will be required to improve the correlations.

### 2.5. *Seismic Maps*

The compilation of the large suite of maps for the principal seismic sequences of the Ross Sea has been the principal project undertaken by the ANTOSTRAT Ross Sea Regional Working Group, with help of researchers from organizations in many countries (Table 2). Atlas maps are the end product of many iterations of interpretations of the seismic data from the Ross Sea. The ANTOSTRAT Ross Sea mapping effort headquartered in Italy (OGS) was initially conducted in parallel with Ross Sea mapping projects in Germany [BGR; *Hinz*, 1992] and Russia (MAGE), with several sets of final and preliminary maps being produced. The maps were discussed and compared during a Ross Sea working group meeting in mid-1993 [*Cooper et al.*, 1994a]. Thereafter, the time maps were revised, taking into account differences between the various MCS interpretations. Once the time maps had been completed, the depth maps were calculated using a composite velocity file derived from available sonobuoy and MCS data. Once finalized, the depth maps were used to calculate the various isopach maps. Digital files for all maps shown in the Atlas are included on the CD-ROMs that accompany this volume.

TABLE 8. MCS Seismic Lines (and Shot Points) used to Calculate Velocity Versus Reflection-Time Curves for Drill Site Correlation Plates in the Atlas

| Label | DSDP 270 | DSDP 271 | DSDP 272 | DSDP 273 | MSSTS-1 | CIROS-1 |
|---|---|---|---|---|---|---|
| P1 | IT33-2212 | BGR3-7634 | BGR2-5540 | BGR1-5617 | IT71-140 | IT71-140 |
| P2 | IT33-2412 | BGR3-7561 | BGR2-5620 | BGR1-5689 | IT71-240 | IT71-240 |
| P3 | IT34-411 | - | - | - | USGS401-50 | USGS401-50 |
| P4 | BGR7-3280 | - | M4B-3600 | M2-5707 | USGS401-170 | USGS401-170 |
| P5 | Best fit | - | M5-1 | Best fit | Best fit | Best fit |
| P7 | M4B-4550 | - | - | - | - | - |
| I | - | - | Best fit | - | - | - |

See Table 11 for list of acronyms.

**2.5.1. *Time maps (Atlas Plates 16 to 19).*** The production of time maps was started by compiling all MCS trackline locations. Navigation data were obtained from the different institutions in UKOOA format, the standard format used by the ANTOSTRAT project, and were compiled in the master Ross Sea data base held at OGS. The master compilation is shown in map form (Atlas Plate 2), and is provided in digital form [*ANTOSTRAT*, this volume]. All navigation is by satellite, initially using Transit satellite systems, and from the mid 1980s using GPS satellite systems. The accuracy of the Transit data sets exceeds 400 m and the GPS data sets exceeds 100 m.

Paper copies of all MCS profiles were provided by the organizations that had acquired the data. The data were mostly unmigrated, deconvolved, stacked and filtered data that had been processed using the standard procedures of each specific organization. No additional processing was done to the data by the working group. Because all organizations used different data-recording and processing systems, the seismic records used for making the maps had variable resolution, depth penetration, and multiple-attenuation. These factors made the interpretations more challenging, and a bit less certain, than if a "uniform" data set from a single organization had been used.

Once data were collated, the principal seismic unconformities were identified based on criteria listed above in section 2.2., and on tying them to unconformities U1 to U6 that had previously been identified in the Eastern basin by *Hinz and Block* [1984] and *Cooper et al.* [1991]. The unconformities were carefully traced throughout the data sets, and the time-picks for the interpreted traces were checked by verifying that they agreed at seismic line crossings. The interpreted horizons were then digitized and entered into the master data base. All digitizing and map calculations were done on an Apollo Workstation running the program "MAPSTAR" from Haliburton Geophysical Services (now Western Geophysical).

After all horizons had been digitized, contour time-maps were made for each horizon. The data picks for each horizon were first gridded then filtered and finally plotted. A grid spacing of 10 km by 10 km was used, after several tests and comparisons with the seismic trackline spacing were done to find the smallest usable grid interval. The gridded values were low-pass filtered to minimize the computational "bulls-eye-contour" effect caused by large localized variations. The contour maps were again checked against the MCS profiles for accuracy and consistency at seismic line crossings, and modified as needed.

**2.5.2. *Depth maps (Atlas Plates 16 to 19).*** Maps showing the depths to unconformities in meters were produced from the data base used to create the time maps and from regional velocity information. The gridded data for each time map was converted to a grid of depth values by using the velocity versus depth information (see section 2.5.4. below) to convert reflection travel time in seconds to depth in meters. Once obtained, the gridded depth data were filtered, contoured, and masked following procedures similar to those described in the previous section.

The depth maps are highly sensitive to the velocities used to do the time-to-depth conversion, especially for large depths (greater than about 4-5 km) where multichannel seismic reflection velocities become less accurate due to the small moveout. Between 5 and 10 km depths, a weighted average of reflection and refraction velocities has been used, with greater weight (up to 50%) applied to refraction velocites. At depths greater than about 10 km, such as in the Victoria Land basin, velocities are based principally on downward projection of shallower velocity gradients, again leading to likely over-estimates of real depths. The digital velocity data from which the velocity versus depth functions were calculated are provided on the accompanying CD-ROM [*ANTOSTRAT*, this volume].

**2.5.3. *Isopach maps (Atlas Plate 20 to 22).*** Isopach maps were made to illustrate the thickness in kilometers of sedimentary sequences lying between all major unconformities, and between selected horizons (e.g., sea floor and basement, RSU6 and basement, etc.). Each isopach map was calculated by subtracting the gridded depth values for the unconformities that bound the specified seismic sequence. The resultant grid of thickness values was then filtered and contoured to produce the isopach maps. Like the depth maps, thickness values for the isopach maps were not calculated for each of the points that were picked (i.e., in reflection time) from the MCS profiles. Hence, the digital data files for the isopach maps on the CD-ROM [*ANTOSTRAT*, this volume] contain only the contour values and do not have the data-pick points. Gridded values for depth maps, from which isopach maps were derived, are included on the CD-ROM.

In places, the upper or lower bounding unconformity for the specified sequence terminates (e.g., by onlap, downlap, erosion, etc.)(Figure 2). In these areas, the next existing shallower or deeper unconformity was used to determine the thickness values. For example, in places where unconformities terminate against basement, the basement was used as the lower bounding horizon. The various types of horizon terminations are noted on the maps. The bounding unconformities for each isopach map are noted in the map title, but care should be taken to compare the depth maps of the bounding unconformities to establish areas, if any, where the bounding unconformities may be missing and different unconformities have been used.

As noted above, there is uncertainty in some areas as to the continuity of unconformities across regions of shallow basement where sedimentary sequences are thin, eroded, or structurally disrupted. In some isopach maps (e.g., RSS-1, 5, 7, and 8) there are isolated centers where the sequence is mapped. In some cases (e.g., RSS-1 and 8), one of the bounding horizons is continuous, and the other is inferred from seismic-stratigraphic and regional structural factors. In other cases (e.g., RSS-5 and 7), both bounding horizons are missing and the existence of the sequence is based on superposition, seismic characteristics, and limited sampling information. Equivalence of isolated seismic sequences is more likely where one bounding horizon is continuous between the isolated segments. The reader is referred to papers by *Busetti et al.* [1994], *Cooper et al.* [1994a], *Brancolini et al.* [this volume] and *De Santis et al.* [this volume] for interpretation and further explanation of the seismic sequences.

**2.5.4.** ***Isovelocity map (Atlas Plate 22).*** Seismic velocity information were compiled for the Ross Sea from MCS data (RMS velocity) on many cruises and from sonobuoy-seismic stations (refraction velocity) throughout the Ross Sea, to use in converting reflection-time maps to depth maps. The MCS and sonobuoy velocity data are provided in digital format in two files on the CD-ROM [*ANTOSTRAT*, this volume]. These data were synthesized, and are shown in an isovelocity map for acoustic basement, which gives the average velocity from the sea surface to acoustic basement. Similar isovelocity maps were calculated for every unconformity (e.g., RSU1 - RSU6), but are not shown.

The isovelocity maps were calculated by the "MAPSTAR" software by first calculating velocity versus reflection-time functions for the MCS and sonobuoy data, gridding the two data sets, and then averaging them, to create a master velocity versus reflection-time grid for the Ross Sea. Time maps were converted to depth maps by multiplying the gridded reflection-time data by the appropriate velocity values from the master velocity grid. The isovelocity map (Atlas Plate 22) was produced by using the master velocity grid to determine the velocity for each point on the reflection-time grid for the basement map. These velocity values were then filtered and contoured in the same fashion as described for the time maps (Section 2.5.1.).

The isovelocity map provides a general guide to the distribution of velocities for the sedimentary section throughout the Ross Sea, especially when compared with the map of total sediment thickness (Atlas Plate 19) and the bathymetry map (Atlas Plate 1). However, the isovelocity map cannot be used to accurately compute depths to individual horizons in the sedimentary section on seismic reflection profiles. The velocity versus depth information on the CD-ROM should be used for this purpose.

### 2.6. *Potential Errors and Uncertainties*

The Atlas maps provide the most comprehensive mapping of Ross Sea seismic stratigraphic sequences to date. As with all map compilations, there is a great deal of interpretation inherent in the maps (e.g., in the tracing and selection of unconformities, in the selection of velocity functions, in the selection of map-display parameters, etc.). There are some uncertainties also, albeit these have been minimized by the large number of tracklines available and the numerous iterations on cross-checks between MCS profiles and the maps. The greatest uncertainty probably lies in the ability to resolve, and therefore consistently characterize, the geometry of seismic unconformities and seismic units in the highly variable glacial-marine sedimentary environments known from drilling to have existed during deposition of most of the mapped sedimentary section above RSU6. Resolution and identification of features deep within the sedimentary section is further clouded by strong primary and interbed multiple-reflections that are characteristic of glacial sedimentary sections with highly variable lithologies and compaction histories. However, the intertwining of MCS data that have been processed for different objectives (e.g., stratigraphic resolution, depth penetration) has provided different "views" of subsurface features, and has helped to clarify real (versus multiple) reflections and their associated unconformities. In general, the greatest certainties in seismic identifications are within the expanded sedimentary sections of the middle to outer shelf, slope and rise; whereas, greatest uncertainties are within the thin, eroded sections above basement rises, and within the strongly deformed sedimentary sections of the Victoria Land basin.

Potential errors in depths to horizons exist, and should be carefully considered if the maps are to be used for calculating volumes and possible sources of sedimentary units. The sources of the errors come from the smoothing and application of generalized velocity versus depth functions that have been calculated from MCS and sonobuoy refraction velocities. Although the data coverage is very good and there are many sonobuoy stations throughout the Ross Sea, more-detailed analysis and application of velocity-depth functions would be needed for detailed study of individual areas. The depth maps are filtered to provide an accurate regional interpretation of depths to horizons, and many small-scale features of interest to local studies may not appear on the maps, and their depths are likely to change slightly with application of different filter parameters or with use of local velocity functions. The above comments also apply to the isopach maps, which are based on the depth maps.

The general correlations of the drill site information and seismic stratigraphy are the best possible, with the available information on core lithologies. The correlations were made, however, without in-situ, down-hole logging (not done) and with only partial-recovery core-log information. Hence, there are uncertainties that can only be addressed by further drilling and logging to establish detailed rock- and seismic-stratigraphic correlations.

## BATHYMETRY DATA

The bathymetric data used in compiling Atlas Plate 1 come from a wide range of sources (Table 9). The trackline data coverage is shown in Figure 3. Adequate navigational control is essential for the compilation of accurate bathymetric maps, particularly in areas of highly variable morphology. All data sets used for this map were collected using satellite navigation systems. The Eltanin 27 data set collected in 1966 was the first to use the Transit satellite navigation system, which has an estimated accuracy of about 400 m. The Transit system was used until about 1984 when the Global Positioning System (GPS) became available. Since then, all data sets have been largely or completely GPS controlled. The Global Positioning System (GPS) has an estimated positional accuracy of about 50-100 m. To date, the more-accurate (10 m) differential GPS navigation system has not been used for bathymetric surveys. Some of the earliest data were recorded in areas which have not since been surveyed, and they are the only available data.

The bathymetric data were recorded by acoustic systems, usually in the 3.5 - 50 kHz range, and have been corrected for sound velocity variations using tables published by *Matthews* [1939] or their digital

TABLE 9. Details and Sources of Bathymetric Data

| Date | Ship | Institute[1] | No. Records (km) | Nav type |
|---|---|---|---|---|
| 1966 | Eltanin 27 | LDGO, Palisades, USA | 3335 | T |
| 1967 | Eltanin 32 | LDGO, Palisades, USA | 8576 | T |
| 1972 | Eltanin 51 | LDGO, Palisades, USA | 3315 | T |
| 1972 | Eltanin 52 | LDGO, Palisades, USA | 2961 | T |
| 1980 | Explora | BGR, Hannover, Germany | 30222 | T |
| 1981 | B. Bowring | DSIR, Wellington, NZ | 1313 | T |
| 1984 | S. P. Lee | USGS, Menlo Park, USA | 13423 | T |
| 1987 | Explora | OGS, Trieste, Italy | 1124 | G |
| 1988 | Explora | OGS, Trieste, Italy | 2019 | G |
| 1989 | Explora | OGS, Trieste, Italy | 1230 | G |
| 1990 | Explora | OGS, Trieste, Italy | 944 | G |
| 1990 | Polar Duke | Rice University, Houston, USA | 13138 | G |
| 1993 | Palmer | Rice University, Houston, USA | 35019 | G |
| 1994 | Explora | OGS, Trieste, Italy | 740 | G |
| 1994 | Palmer | Univ. Alabama, Tuscalosa, USA | 29456 | G |
| 1994 | Palmer | Rice University, Houston, USA | 39569 | G |
| 1995 | Palmer | Univ. Alabama, Tuscalosa, USA | 32272 | G |

[1]See Table 11 for list of acronyms.
G - Global positioning satellite system (GPS)
T - Transit satellite system

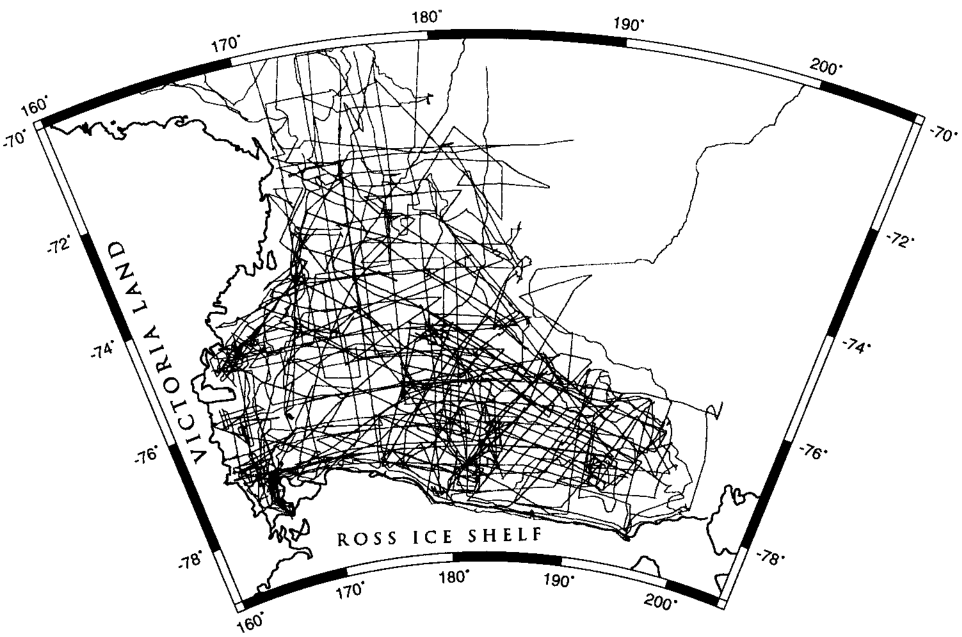



Fig. 3. Trackline map for Ross Sea cruises that collected bathymetry data used to make the bathymetric map shown in Atlas Plate 1.

equivalent. The accuracy of the bathymetric depths depends on two factors, accuracies in ship position and in the acoustic velocity in the sea water. The errors in bathymetric depths due to variations in acoustic velocity are estimated to be up to 25 meters on the continental shelf. Errors due to navigation uncertainties can be much larger, as indicated by discrepancies in water depths of up to 100 m at track intersections where bathymetric relief is large. The bathymetry map, Atlas Plate 1, has been hand contoured, with exception of (a) the McMurdo Sound region, where a computer contoured map, prepared by *Henrys* [1993], has been used; (b) the Terra Nova Bay, where the detailed compilation of *Della Vedova et al.* [1992] has been incorporated; and (c) near the Edward VII Peninsula in the eastern Ross Sea, where the map of *Anderson* [1983] was used. In these three areas, the detailed maps have been simplified slightly by removing some contours, for plotting at the Atlas map scale. For the rest of the Ross Sea, we have contoured the data by assuming that the data controlled by GPS are the more accurate, and using those data in places where data from two surveys disagree. The contours under the Ross Ice Shelf are based on the over-snow traverse data from *Greischar et al.* [1992].

## GRAVITY DATA

The first marine gravity data in the Ross Sea were recorded using a Graf-Askania Gss2 gravity meter in 1967 during USNS Eltanin cruise 32, which was followed in 1971 by USNS Eltanin cruise 52. Navigation for both of these cruises was by Transit satellite system. Bathymetric data were recorded concurrently. Free-air gravity and bathymetric maps were produced from these data [*Hayes and Davey,* 1975], and delineated the principal gravity anomalies over the Ross Sea, exclusive of areas within 100 km of the western Ross Sea coast and in the northeast regions where ice conditions or permanent pack ice precluded surveying. Subsequent gravity surveys by New Zealand (M/V Benjamin Bowring in 1981) and the USA (R/V S. P. Lee in 1984) mapped the areas of the western Ross Sea. A survey over the central and eastern Ross Sea was conducted by Germany (R/V Explora in 1980). These data sets were integrated with the earlier USNS Eltanin data to produce revised gravity and bathymetry maps [*Davey and Cooper,* 1987], and delineated the large gravity low associated with the Victoria Land basin.

TABLE 10. Details and Sources of Gravity Data

| Date | Ship | Institute[1] | Tracks | Seagravimeter | Base tie |
|---|---|---|---|---|---|
| 1967 | Eltanin | LDGO, New York | 9200 | GSS2(25) | NZ |
| 1972 | Eltanin | LDGO, New York | 6000 | GSS2 | NZ |
| 1980 | Explora | BGR, Hannover | 8200 | GSS3 | Chile |
| 1981 | B. Bowring | DSIR, Wellington | 6000 | L&R(S80) | NZ, Ant. |
| 1981 | Explora | IFP, Paris | 2000 | GSS3 | Aus, NZ |
| 1984 | S P Lee | USGS, Menlo Park | 4900 | L&R(S53) | NZ, NZ |
| 1987 | Explora | OGS Trieste | 2350 | KSS30 | Chile, NZ |
| 1988 | Explora | OGS Trieste | 4100 | KSS31 | Aus, NZ |
| 1989 | Explora | OGS Trieste | 2550 | KSS31 | Chile, NZ |
| 1990 | Explora | OGS Trieste | 3400 | KSS31 | NZ, NZ |
| 1994 | Explora | OGS Trieste | 1570 | KSS31 | NZ, NZ |

[1]See Table 11 for list of acronyms.

Gravity surveys were also conducted by France (R/V Explora in 1982), by Japan (R/V Hoku Maru in 1983) and by USSR (R/V Geolog Dmitry Nalivkin in 1987 and 1989). Several surveys of the Ross Sea have been undertaken by Italy (R/V OGS Explora in 1988, 1989, 1990 and 1991), and these data were compiled with the 1980 Explora data to produce a gravity map [*Gantar and Zanolla,* 1993]. Cruises from the mid-1980s have used GPS satellite navigation systems, yielding significantly better positional accuracy to the order of less than 50-100 m. Other marine gravity surveys in the Ross Sea have included those by Italy (R/V Explora in 1994) and by the USA (R/V Polar Duke in 1990; R/V Nathaniel B. Palmer in 1993, 1994, and 1995). The four recent USA cruises represent an extensive data set, but these data were not finalized in time to be included in the present compilation, details of which are given in Table 10.

The gravity compilation is based on International Gravity Standardization Net 1971 (IGSN71) and the Moritz 1980 Normal Gravity Field [*AIG,* 1980]. Most of the surveys have been tied into the international gravity network through base stations in New Zealand, Tasmania or South America, and are thus linked only to gravity bases with lower gravity values than the range of values recorded during the surveys. Only the Benjamin Bowring data (and the later Nathaniel B. Palmer surveys) has been tied to the gravity bases at McMurdo Station, and are thus tied across the range of the gravity measurements. The gravity data have been adjusted for cross-over errors. The four Italian surveys (Explora in 1987, 1988, 1989, and 1990) were used as a master data set because 90% of the track cross-overs before adjustment were less than 1.5 mgal. Other surveys were subsequently adjusted to the level of these data. After adjustment, the data accuracy and self-consistency from discrepancies at track cross-overs was about 5 mgal.

TABLE 11. Acronyms used in this Report

| Acronym | Organization or meaning |
|---|---|
| ANTOSTRAT | Antarctic Offshore Acoustic Stratigraphy (Project) |
| BGR | Bundesanstalt für Geowissenschaften und Rohstoffe, Germany |
| DSIR | Department of Science and Industrial Research |
| DSDP | Deep Sea Drilling Program |
| GSJ | Geological Survey of Japan, Japan |
| IFP | Institut Français du Petrole, France |
| INS | Institute for Geological and Nuclear Science (New Zealand) |
| IT | Italy: M/V Explora cruise |
| JNOC | Japan National Oil Corporation, Japan |
| LDGO | Lamont Doherty Geological Observatory, USA |
| M | MAGE Cruise, Russia |
| MAGE | Joint Stock Marine Arctic Geological Expedition, Russia |
| OGS | Osservatorio Geofisico Sperimentale, Italy |
| PD | Polar Duke: Rice University cruise, USA |
| RU | Rice University, USA |
| SCAR | Scientific Committee on Antarctic Research |
| SDLS | Antarctic Seismic Data Library System for Cooperative Research |
| USGS | U.S. Geological Survey, USA |

The gravity contour map (Atlas Plate 1) has been produced by interpolating, from the adjusted observed gravity data, a grid of data points at 6 km by 6 km over the mapped area using a three dimensional cubic spline technique. These gridded data have then been contoured at 5 mgal intervals. The contours under the Ross Ice Shelf are based on the over-snow traverse data from *Greischar et al.* [1992].

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