BOLLETTINO DI GEOFISICA TEORICA ED APPLICATA VOL. XXXV, N. 137-138 - MARCH-JUNE 1993

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EQUIPMENT AND DATA ACQUISITION TECHNIQUES EMPLOYED BY THE ITALIAN GEOPHYSICAL EXPLORATION IN ANTARCTICA PERFORMED BY OGS CRUISES 1987-88, 88-89 AND 89-90

Abstract. During the Antarctic summers 1987-88, 1988-89 and 1989-90, the Osservatorio Geofisico Sperimentale of Trieste (O.G.S.) performed three geophysical surveys in the seas surrounding Antarctica. The research was carried out in the framework of the Italian Research Program in Antarctica, promoted by the National Scientific Commission for Antarctic Research headed by the Ministry of Universities and Scientific and Technological Research (MURST). The exploration involved different areas of interest in the Ross Sea, in the South Pacific Ocean, in the Weddel Sea, in the Amundsen and Bellingshausen Seas, in the areas surrounding the Antarctic Peninsula and in the South Atlantic Ocean. All the cruises were undertaken by the r/v OGS EXPLORA, and consisted in a systematic collection of reflection seismic, gravity and magnetic data. During the second and third surveys, some refraction seismic profiles (with sonobuoys) were acquired in cooperation with the United States Geological Survey (U.S.G.S.). The three campaigns gave a total of 16,923 km of seismic profiles and a total of over 20,000 km of gravity and magnetic continuous recording.

Description of the main characteristics of the geophysical research ship OGS EXPLORA and her geophysical equipment is summarized in the following.

INTRODUCTION

During the 1987-88, 1988-89 and 1989-90 austral summers, the O.G.S. carried out three geophysical campaigns in the waters surrounding Antarctica, collecting seismic, magnetic and gravity data. The latter were also collected whenever possible during the transit from South America and New Zealand to the operations area and during the return voyages to the first port of call. With the second and third cruises the scientific data collection was augmented by seismic refraction profiles (with sonobuoys) acquired in cooperation with the United States Geological Survey (U.S.G.S.).

During the cruises, areas with different scientific targets were explored. The aim of the first O.G.S. marine campaign was the geophysical investigation of the Ross Sea area. Six seismic lines, one with a long record length (crustal seismic) were shot in the Ross Sea. The location of the lines, chosen by the O.G.S. researchers, was left partly flexible, to give the personnel working on the vessel the opportunity to extend them, for taking maximum advantage from the possible absence of ice in crucial areas. The base program was almost totally completed, bringing to a success the first geophysical cruise by researchers and technicians of an Italian research institution, using an Italian seismic vessel. The second campaign was intended to investigate two different areas: the triple junction between the Antarctic, Indian and Pacific Plates, and the Ross Sea. The first is an area of very great interest, where almost no geophysical data were available. A related scientific program was the analysis of the arrangement of the

Manuscript received, September 29, 1991; accepted, March 15, 1992.

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Balleny Islands, which are subparallel to the great transform fractures in the area. The volcanic origin of the islands and the chemical constitution of the rocks indicate that they represent the prosecution of a large fault originating in the oceanic rift. The location of the profiles in the Ross Sea was set up for delimiting more accurately the structural elements determined during the first cruise, and for correlating their evolution with that of the Antarctic Mountains. Other scientific themes of investigation were the crustal reconstruction of the Ross Sea, according to the model intracratonic basin,and the study of the evolution of the Antarctic slope and its relation to the oceanic plain. Some technical improvements with respect to the first cruise were effected immediately prior to departure from Trieste to guarantee better management of field operations and greater accuracy in the geophysical data acquisition. The previous navigation system Indas Vo was replaced by the newer Navdata 3000. A new high precision atomic clock and two GPS-Trimble receivers were connected to it, for a better positioning of the vessel.The gravimeter Bodenseewerk KSS30 was updated to model KSS31. Finally, for the seismic refraction profiles suggested by the U.S.G.S., sonobuoys were supplied by that institution, which also supplied the on board recording equipment.

The scientific program of the third Antarctic cruise was developed to investigate the main geophysical aspects of three different areas following different scientific themes:

a) Weddel Sea
   In this area, interest is concentrated on two topics:
   a1) The Scotia Arc program consisted in the study of the mountain belt, submarine ridges and islands linking South America eastwards to Antarctica.
   a2) The Adelie Land program consisted in the study of the Antarctic prolongation of the Andes Mountains through the displacement of the Scotia Sea and related islands.

b) Amundsen and Bellingshausen Seas
   In this area the main scientific aim was the study of the evolution of the continental slope and the Cenozoic volcanic activity using gravity and magnetic data.

c) Southern Pacific Ocean and Ross Sea
   c1) The cruise in the Southern Pacific Ocean had as main purpose a continued study of the triple junction between the Antarctic, Pacific and Indian Plates. This is an area of great interest where few data are available; in particular the location and orientation of the fracture zones between the plates, as well as other geological structures are not well known. A good understanding of these displacements could be very important for reconstruction of the Gondwana supercontinent.
   c2) The cruise in the Ross Sea was planned to improve the areal coverage obtained during the first and second campaigns in order to continue the studies outlined in previous years. Other scientific objectives were the study of Cenozoic magmatic phenomena and the identification of sites where stratigraphic studies may be developed. During this part of the cruise, some refraction seismic profiles were planned.

As in previous years the program was left flexible to give the scientific staff a wide range of possibilities in case the ice coverage in some areas exceeded the operational limits. In summer 1989 and immediately before the beginning of this campaign, some new instruments and equipment were installed on board to improve and update the vessel's research capabilities; namely, a side "A" frame to allow bottom sampling using one of the available deck winches, and a new hydrological winch with slip ring and 6.3 mm wire rope for oceanographic data collection (CTD). On the instrument side the most important improvements consisted in the installation of an OYO camera in the recording room, and the installation of the new EG & G 811 magnetometer/gradiometer. All the instruments necessary for the acquisition of refraction seismic profiles were supplied and installed by the U.S.G.S. in the framework of a cooperation with O.G.S. initiated the previous year. Refraction data were acquired by sonobuoys dropped from the vessel; the sonobuoy consists of a hydrophone which detects the refracted seismic waves, an amplifier, and a radio transmitter operating in the band between 162.250 and 173.125 MHz. The signals detected by the sonobuoy are transmitted to the vessel, where a dedicated receiver and all the recording equipment are installed. To avoid interference between sonobuoys, after a predetermined time (4, 8 or 16 hours) the sonobuoy sinks.

Fig. 1 - The research vessel OGS EXPLORA.

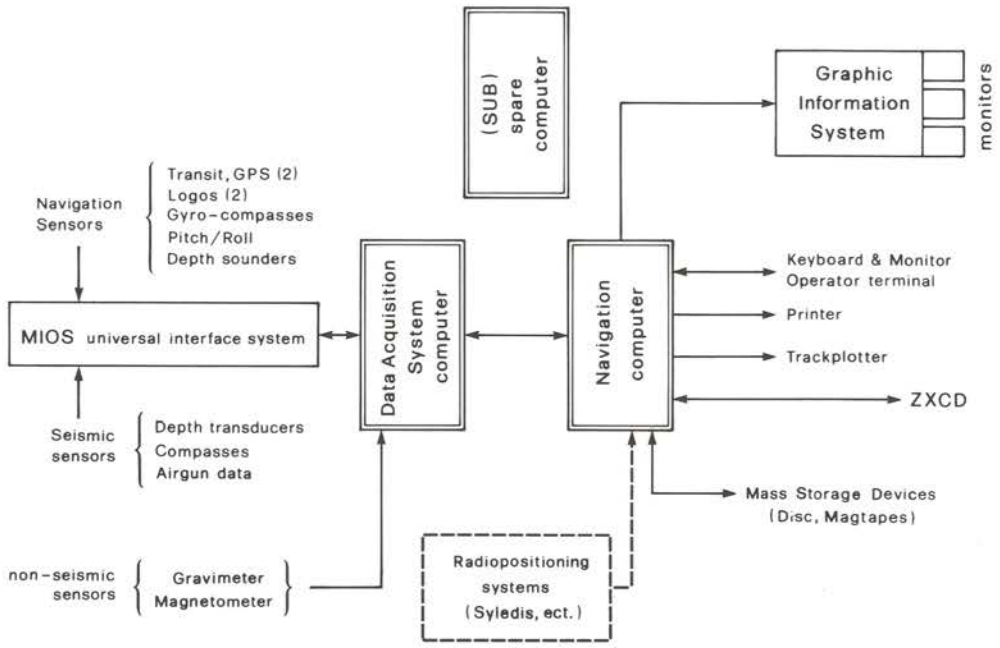

Fig. 2 - Hardware configuration of the **NAVDATA 3000** navigation system.

THE RESEARCH VESSEL OGS EXPLORA

The research ship OGS EXPLORA is a multipurpose deep sea exploration vessel (Fig.1) for offshore geophysics and oceanography, characterized by engines, gearing and propeller designed for minimum vibration and cavitation when operating at optimum recording speed with all outboard equipment deployed. The vessel is equipped with independent twin main engines (1294.5 kW each unit) for a total of about 3500 HP, driving one variable pitch propeller, and with a bow thruster of 260 kW. She is registered in Italy with home port Trieste, is classified by the Registro Italiano Navale (RINA 100A11IL ST IAQ1 RG2), and sails under the Italian flag.

The main characteristics of the vessel are:

Name	: OGS EXPLORA
International call sign	: IXWQ
Length o.a.	: 72.63 m (238'3")
Beam	: 11.80 m (38'9")
Draught	: 4.15 m (13'7")
Tonnage	: 1408 GRT
Displacement	: 1845 metric tons (full load)
Main engines	: 2, for a total of 3500 HP
Bow thruster	: 260 kw

The operational time at sea is up to 45 days, with a cruise range of 12000 nautical miles, while her cruising speed is up to 14-15 kn (from 4 to 6 when in survey). She has been proved stable and capable of satisfactory operations under sea conditions up to 5, and has been provided with additional reinforcement on the bulbous bow for operating in polar seas. The crew is composed of 17 to 18 persons, while the technical and research staff may include up to 24 persons.

Power supply is by four generators at 220/380 V 50 hz for a total of up to 768 kw. Lifting

gear includes a 10 ton derrick ahead and a 3.5 ton crane astern. Besides the reel for the streamer and the magnetometer winch, an oceanographic winch with 600 m of 6 mm steel wire, a hydrological winch with 2900 m of 6,3 mm one conductor steel armored cable and a side A-frame for bottom sampling (gravity corer and grab sampler) are on board. There is a platform to support helicopter operations on the aft deck over the streamer winches (however, helicopter landing is not possible). The communication system includes a 2 kw SSB radio station, an emergency SSB radio transceiver, a 73 channel VHF radiotelephone, a 100 w SSB radiotelephone to deal with land based radiopositioning stations, plus several VHF portable sets for local communications. For long distance communications, two INMARSAT satcom terminals are installed with telex, telephone and fax capability. The radio station is completed by a weather chart receiver.

The normal equipment for general and safe navigation includes:

- the vessel gyrocompasses system;

- an automatic pilot system;

- three radars: a SELESMAR ARPA with automatic target tracing; a DECCA 99 BT X band; a DECCA AC-S-1230C;

- two echosounders: KRUPP-ATLAS DESO 10 (210 and 33 kHz) with digitizer EDIG 10 (up to 1400 metres depth), and the digital ELAC DEEP SEA LAZ 72 (12 kHz, range up to 12000 m).

- an electromagnetic log PLATH NAVIKNOT;

- a Doppler sonar ATLAS DOLOG 12A.

NAVIGATION AND POSITIONING EQUIPMENT

The navigation control, based until the first cruise on the INDAS V system, was then upgraded by installing the NAVDATA 3000 system. At present, this realtime control, a basic need for continuous acquisition of geophysical data, is performed under the logging and computational capabilities of the NAVDATA 3000 PLUS, a new version of the NAVDATA 3000, which is a multitask intelligent and flexible system developed to meet industrial standards in marine seismic prospecting. The possibility of combining all presently available positioning systems leads to a high degree of navigation accuracy. The operating dialogue is menu oriented, and the hardware configuration (Fig.2) is based on three computers which, according to their specific main tasks, are named as follows:

NAV computer, dedicated to navigation control,

DAS computer, performing the data acquisition, and

SUB computer, kept as spare unit;

In addition, there are the following peripherals:

- a MIOS universal interface system, dedicated to the various sensors;

- two magnetic tape units for input (of the operating software) and output (of navigation and other logged data);

- hard disk storage (160 Mb) for navigation data from the current profile to allow backup of all data in case of failure of the current tape unit;

- a graphic information system (GIS) for realtime evaluation of the course with respect to the planned profile (helmsman plot), and which gives the statistics needed to evaluate the general performance of navigation in industrial surveys: it consists of a separate computer, a floppy disk reader and three dedicated colour monitors (for LOP error ellipse; for helmsman display; for histograms of shotpoint spacings and/or off-tracks and/or differences between system positions and radio navigation);

- one plotter for the visualization of the lines and shot points, as well as for the production of location maps;

- a monochrome monitor and a line printer for the operator, dedicated to the navigation parameter and menu guidance.

The following sensors are logged by the NAVDATA 3000:

- the three Plath Navigat II gyrocompass units which are averaged to forward course;
- the electromagnetic and Doppler sonar logs, to give the ship's speed;
- a satellite receiver MAGNAVOX TRANSIT-GPS MX1107, dedicated to Transit fixes;
- two GPS TRIMBLE 4000A Navigator units and an EFRATOM rubidium clock, dedicated to GPS fixes for operating when only two satellites are active;
- a TRIMBLE NAVIGATION 10X LORAN-GPS receiver for operating in areas covered by Loran-C chains;
- the echosounders;
- a gravity meter system;
- a magnetometer.

The NAVDATA 3000 can provide control for:

- up to 4 streamers, each with up to 24 compasses and 24 depth transducers, whose data can be logged;
- up to 5 air gun arrays;
- up to 6 radio fixes with up to 8 LOP's each for realtime processing; and up to 24 recordable LOP's to which selectable corrections can be applied (fixed base station, fixed receiver or variable C-O correction);
- up to 2 hardcopy printers, each with its selectable index list.

SEISMIC DATA ACQUISITION SYSTEM

A SERCEL SN 358 DMX seismic recording system is installed on board and provides the recording of seismic data in demultiplexed format (SEG-D 8015) with 6250 bpi on the three STORAGE TECHNOLOGY Co. mod. 1960, 9 track, 1/2 inch magnetic tape units in auto-switching. It is able to record up to 246 data channels plus eight auxiliary channels at a sampling rate of 2 or 4 ms. The recording filters are: low cut in/out, 18 dB/octave 4 Hz or 8 Hz; high cut (anti-alias) 154.4 Hz for 2 ms, 77.2 Hz for 4 ms with a slope of 70 dB down. The fixed gain is selectable from a minimum of 24 to a maximum of 132 dB. The dynamic gain control (IFP) is 90 dB in 6 dB steps. The analog to digital conversion is done with two 8-bits converters so that the sample is coded into 15 bits. At each acquisition cycle, data are first written to double access 1 Megaword memory, then read in sequential form, formatted in demultiplexed form (SEG-D) and sent to the tape units. Monitoring is performed with an OYO DFM 250 digital field monitor, capable of plotting up to 240 data channels plus 4 auxiliary channels, with selectable plot groups from an input of up to 1024 channels. In addition, two single trace recorders each consisting of a NEC PINWRITER P3 operate in variable area format, with 1600 samples per line, trace width 3.5 mm, on 37.5 cm wide paper.

The interface between the piezo-electric elements of the streamer and the recording instruments is a SEISMIC ENGINEERING COMPANY DSS V. It is a standard version, with up to 256 channels, sum/subtracting capability over up to 15 channel (7 adjacent on either side of the centre channel), 80 dB of channel dynamic range and a low frequency cutoff of 3.5 Hz. The adopted Prakla Seismos streamer, is a trasformerless type with 256 group charge amplifiers on board, neutrally buoyant, oil filled, flexibly jacketed and designed for cold environments with appropriate compliable stretch sections between the nearest hydrophone group and the ship, and between the farthest hydrophone group and the tail buoy, and sufficient pairs for interfacing up to 256 seismic channels, plus 8 auxiliary channels. The active sections of

the streamer are 50 m long, with a diameter of 68 mm (3 mm thick), and can be operated to a maximum depth of 70 meters. Polyurethane hose-pipe was preferred to PVC, since its Young's modulus at 2°C is one tenth that of PVC. Stretch sections have an attenuation in the 8-12 Hz band of at least 6 dB per 50 meters. The hydrophone groups are 8 or 4 or 2 per section, distributed therefore at distances (mid to mid) of 6.25 m, 12.5 m, or 25 m. The length of the hydrophone group is 4.8 m (all distances vary according to stretch). The charge-pressure sensitivity of each group is 1.6 μC/bar. Eight GEOMECHANIQUE HC-202-E hydrophones are set in parallel for each group in the 8 groups per section configuration, and 16 hydrophones per group in the 4 groups configuration. These hydrophones are of piezo-electric type with a sensitivity of 24 V/bar $\pm$10% or 92 dB re 1 V/μbar $\pm$1 dB with acceleration sensitivity of -70 dB re 1 V/g, a capacity of 13000 pF $\pm$ 5% and may operate down to 100 m depth without sensitivity change (they can be immersed down to 500 m without damage). A minimum of 6 depth transducer/waterbreak units, 1 m long, are distributed along the active streamer, with the same dimensional and strength characteristics as the active streamer sections. The depth transducers are of piezo-resistive bridge type operating with basic frequency of 1000 Hz, and a frequency shift to pressure ratio of 100 Hz/bar; the accuracy is $\pm$0.5 m in the range of 0 to 30 m at a temperature working range of -2 to 30°C. The waterbreak hydrophone is composed of two hydrophones with transformer coupling. The position of the streamer is controlled by a standard SYNTRON system, including RCL-2 cable levelers, RCU-831 compass units and a CUS-8301 controller. Streamer position is shown on a monitor and recorded on the navigation tape at each shot point. Servicing the streamer is facilitated by a KALAMOS mod. M6 fault locator. The streamer winch reel, placed astern, which was able to accommodate 3600 metres of streamer and was remodeled in 1990: now two reels are installed, giving a total capacity of 9000 metres of streamer(s). A further improvement consists in a slip-ring mating now available on the axis of the storage reels, instead of the plug and socket coupling employed during the first period of Antarctic cruises.

The shooting geometry is reported in Fig.3. No tail buoy positioning system is presently active on board but may be provided when specifically requested.

AIRGUN SEISMIC SOURCE

The airgun system of the r/v OGS EXPLORA consists of various tuned arrays operating at 140 bar (2000 psi). The array selected for the Antarctic operations is the "W 82". This array has good high frequency characteristics when used at 4-6 m depth and consists of two identical chains towed behind the vessel at a mutual distance of 20 meters, in order to insure that the air guns are in the wake of the ship for safety from ice. The total volume of the array is 45.16 l (2756 cu.in). The far field pressure signature is shown in Fig.4. A calibrated hydrophone lowered with a dedicated winch is available on board for the far field monitoring. Three diesel driven air compressors providing 424 l/min of compressed air at 140 bar (2000 psi) are installed. The firing control unit allows independent timing control of up to 2x20 individual air guns with adjustable delay between firing command, and firing time in steps of 0.2 ms with an accuracy of $\pm$1 ms. Feedback and control to maintain synchronization are computerized.

Interfacing of the equipment indicated in the preceding paragraphs is through the ZXCD central control system. This device controls the data flow between the various seismic survey system components and coordinates their operations (Fig.5). The seismic survey cycle is started by the navigation computer (SST signal) in location or time dependent mode, and the ZXCD generates the header (HDR) with all the data pertinent to the shot point (SP); subsequently, the seismic recording instrument indicates that it is ready to accept seismic data (wire blast, WB signal): the air gun synchronizer VZAD is prepared (START) and the air gun arrays are released, and after the field time break (FTB) signal is received from the VZAD, the recording instrument starts to acquire the seismic signal and to record the data on the magnetic tape.

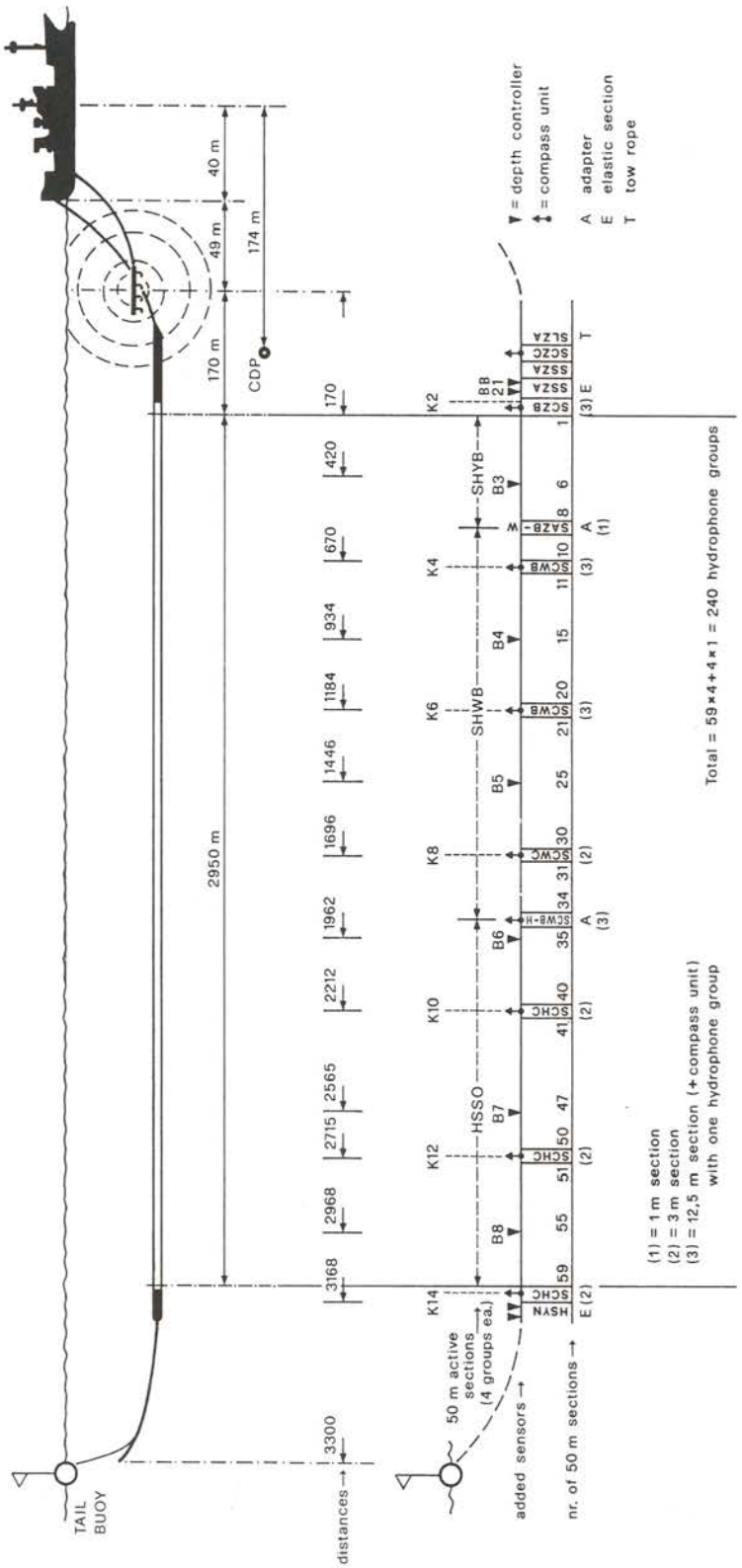

Fig. 3 - Shooting geometry.

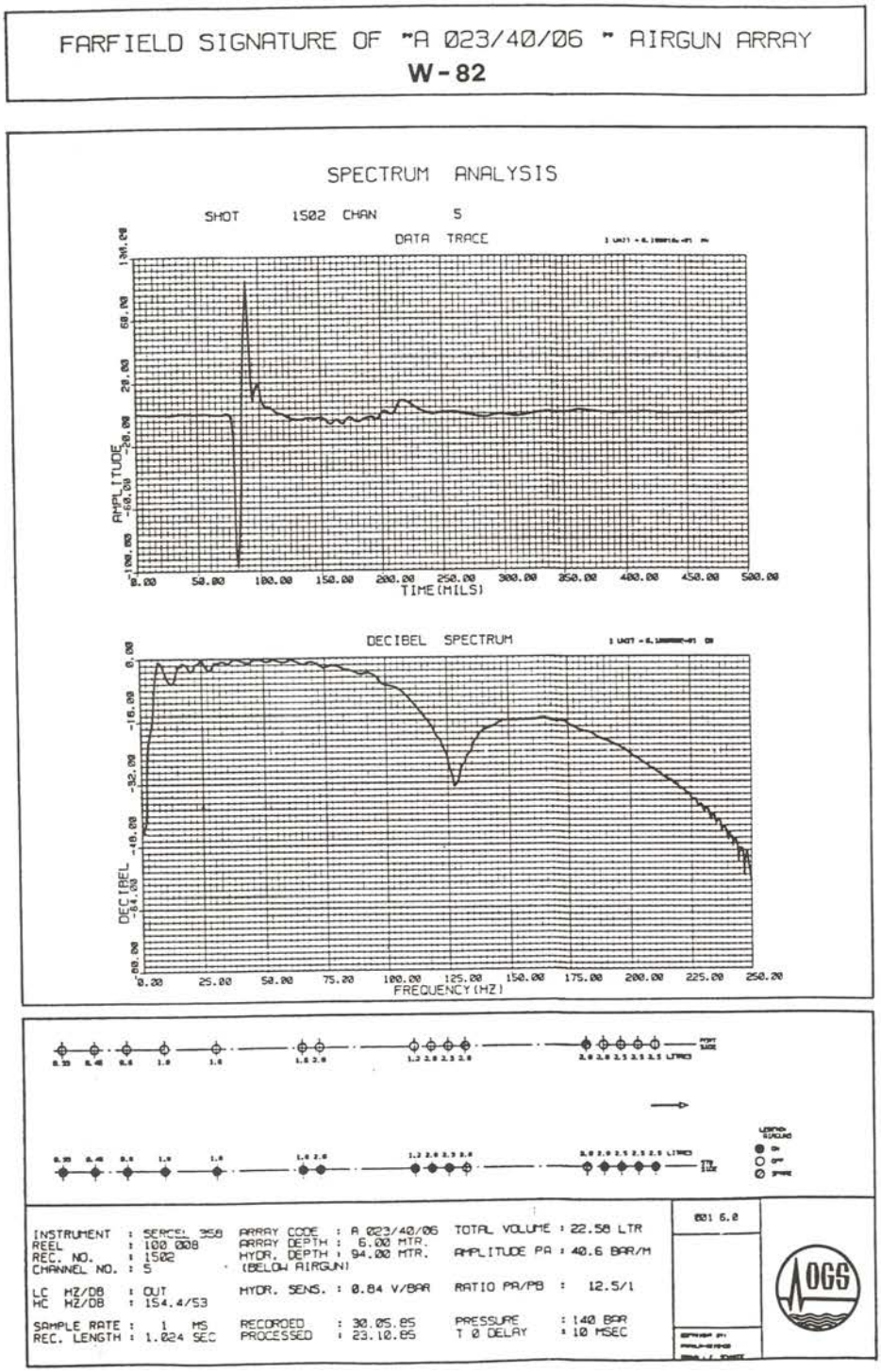

Fig. 4 - Far field signature of **W-82** air gun array.

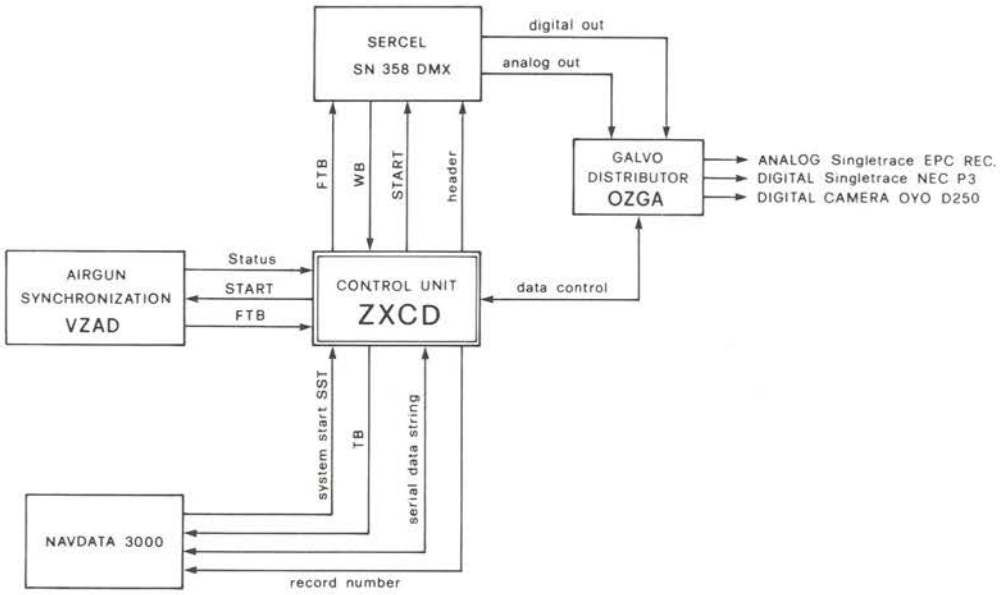

Fig. 5 - Interfacing of the equipments through the **ZXCD** central control system.

GRAVITY METER SYSTEM

Marine gravity measurements were taken continuously with a BODENSEEWERK KSS30 gravity system, connected to the NAVDATA 3000. Typical features of this system are a valid mathematical selectable filtering (on which the response time lag depends), a linear drift, a stable calibration and a measuring range of 10 Gals. After the first campaign, the system was remodeled into the KSS31, keeping the same sensor (n. 14). This new version is provided with a more efficient gyrostabilized platform. Accuracy (in mGal rms) given by the manufacturer on dynamic tests is:

± 0.5 for vertical accelerations lower than $\pm$ 15000

$\pm 1{,}0$ in the range 15000 to 80000

± 2.0 in the range 80000 to 200000.

The platform freedom is $+40°$ in roll and in pitch. Total weight is less than 300 kg.

A WORDEN and a LACOSTE & ROMBERG (G433) gravimeter are provided for harbor base connections, the latter being especially suitable when large gravity differences have to be measured for connections with distant known stations.

MAGNETOMETERS

The standard magnetometer available was the well known GEOMETRICS G 801 proton free precession magnetometer. It measures the total intensity of the earth's magnetic field and has a range of 25000 to 80000 nT, a sensitivity of 1 nT and is capable of an accuracy, after processing, of ± 2 nT. Data are collected digitally on the navigation data tape and analogically on a paper chart recorder (paper chart 150 mm wide). In addition, a pair of high sensitivity GEOMETRICS G 811 magnetometers in gradiometer configuration have been on board since 1989. The main features of this model are an enhanced sensitivity and a high repetition rate (e.g., at 0,01 nT sensitivity, the cycle time is 6 s; at 0,1 nT the cycle is 0,73 s and at 1 nT the cycle is 0,16 s). The typical sensitivity of this marine gradiometer with a 500 foot separation between sensors (150 m) is 0.0003 nT per meter. The configuration consists of two conso-

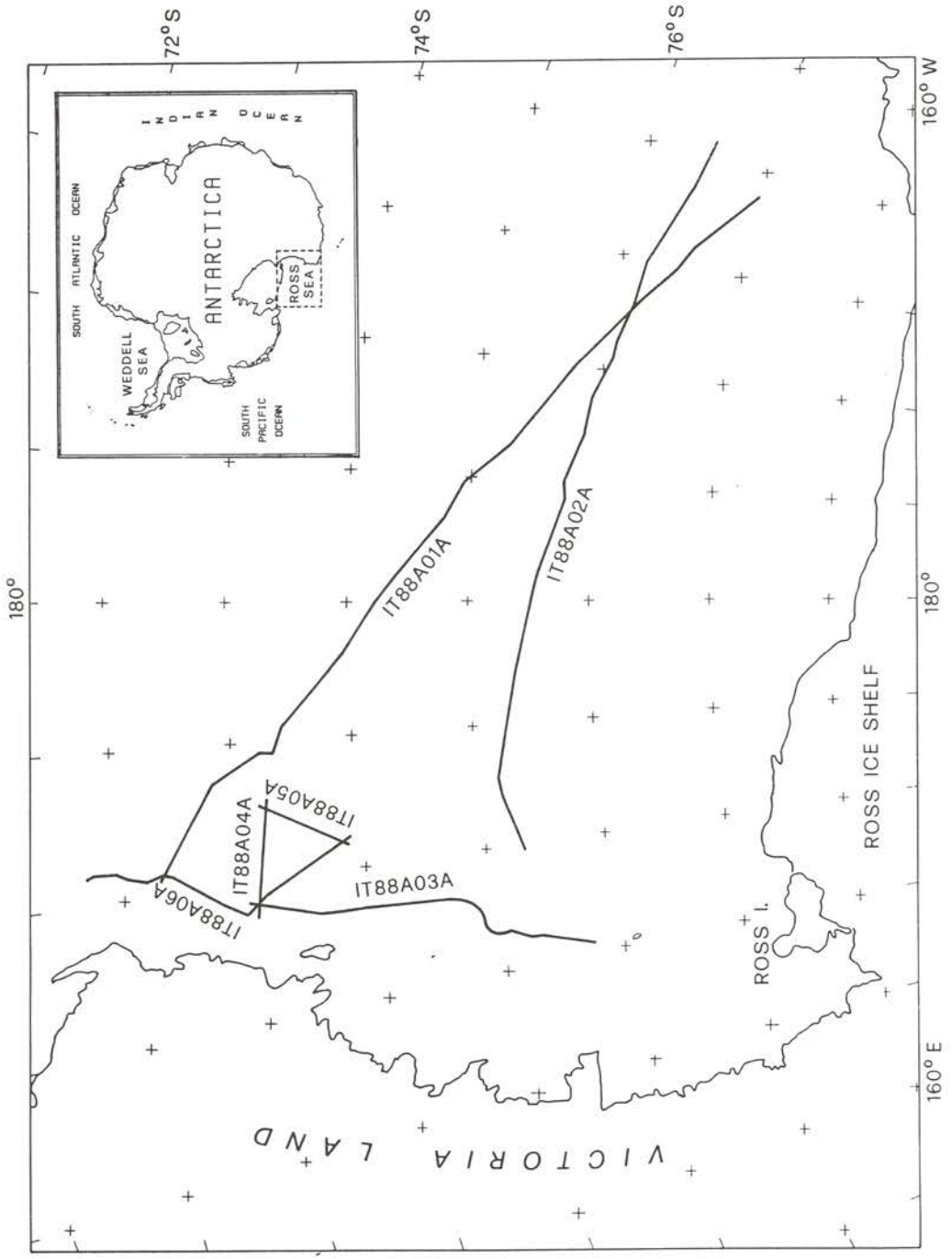

Fig. 6 - Lines acquired in the Ross Sea during the first campaign.

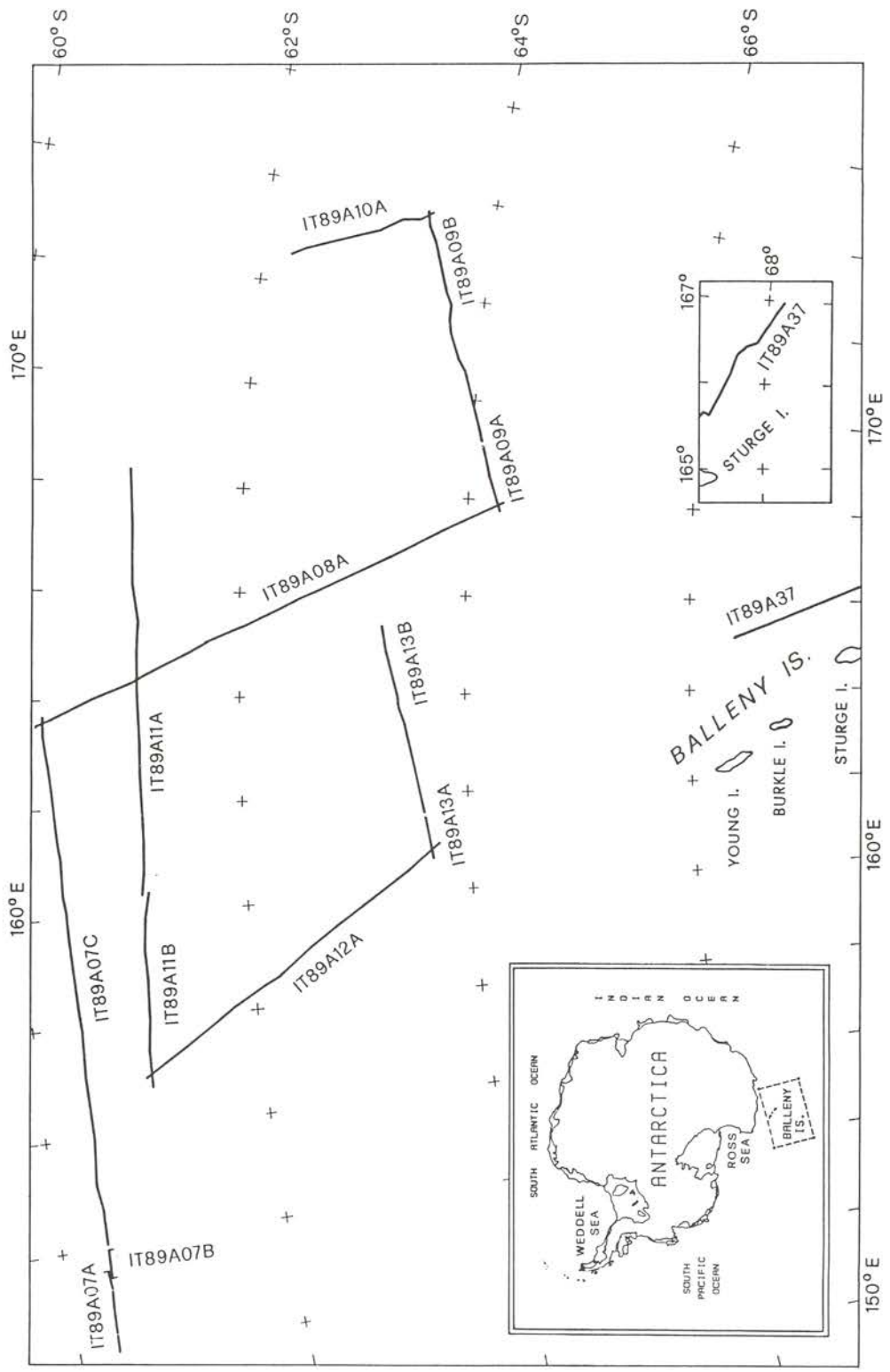

Fig. 7 - Lines acquired in the South Pacific ocean during the second campaign.

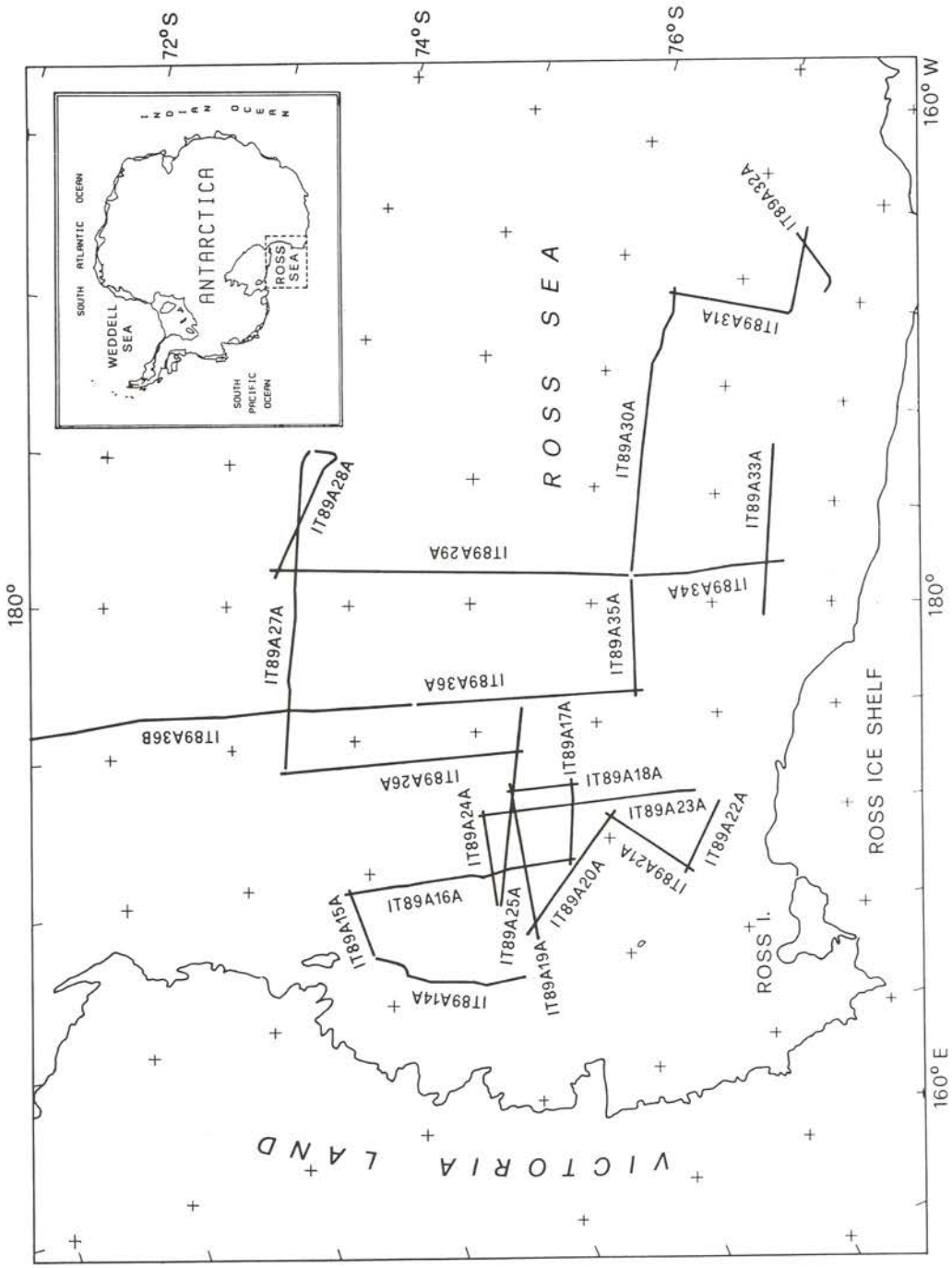

Fig. 8 - Lines acquired in the Ross Sea during the second campaign.

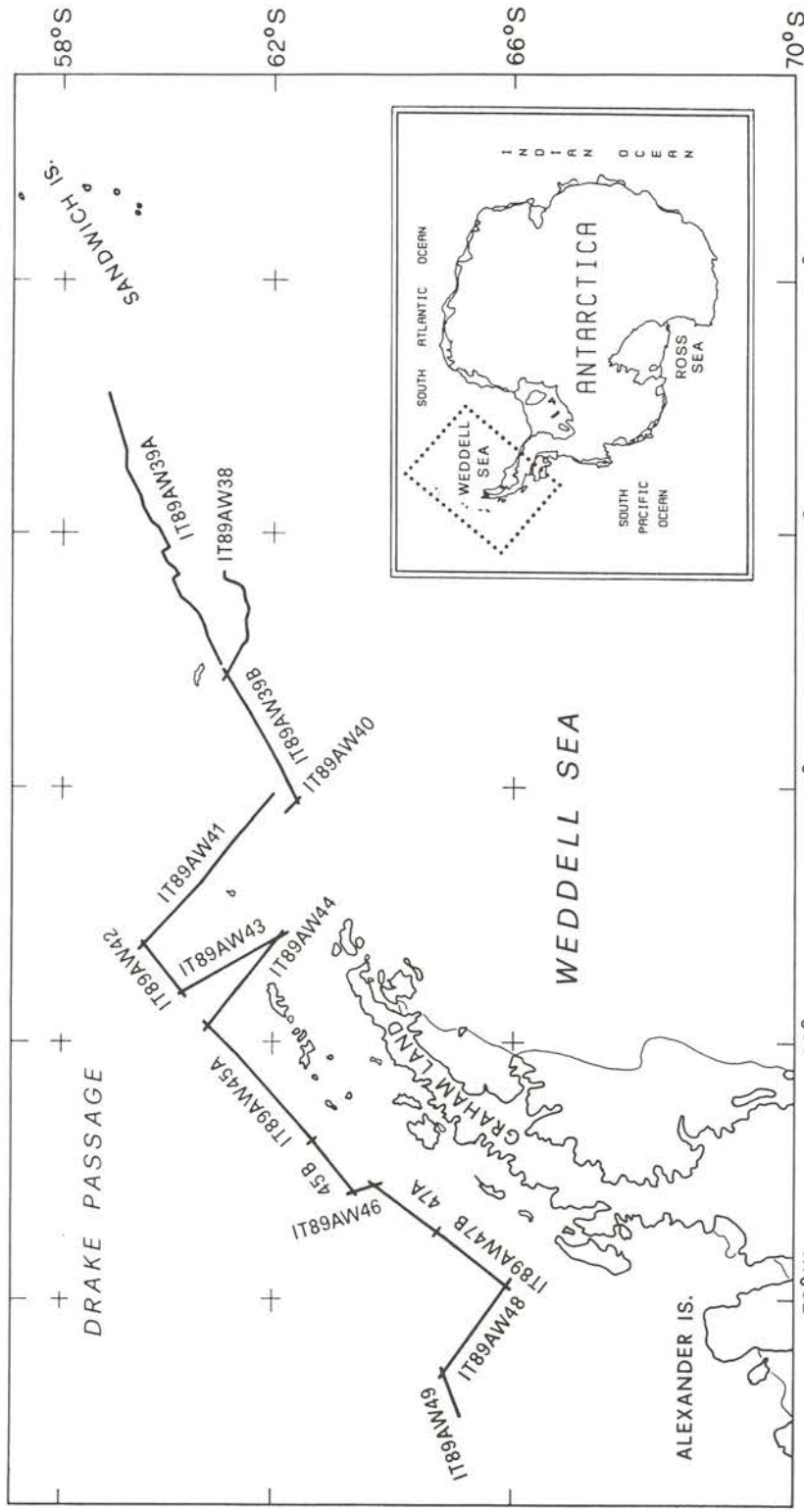

Fig. 9 - Lines acquired in the area surrounding the Antarctic Peninsulas and in the Weddel and Bellingshausen seas during the third campaign.

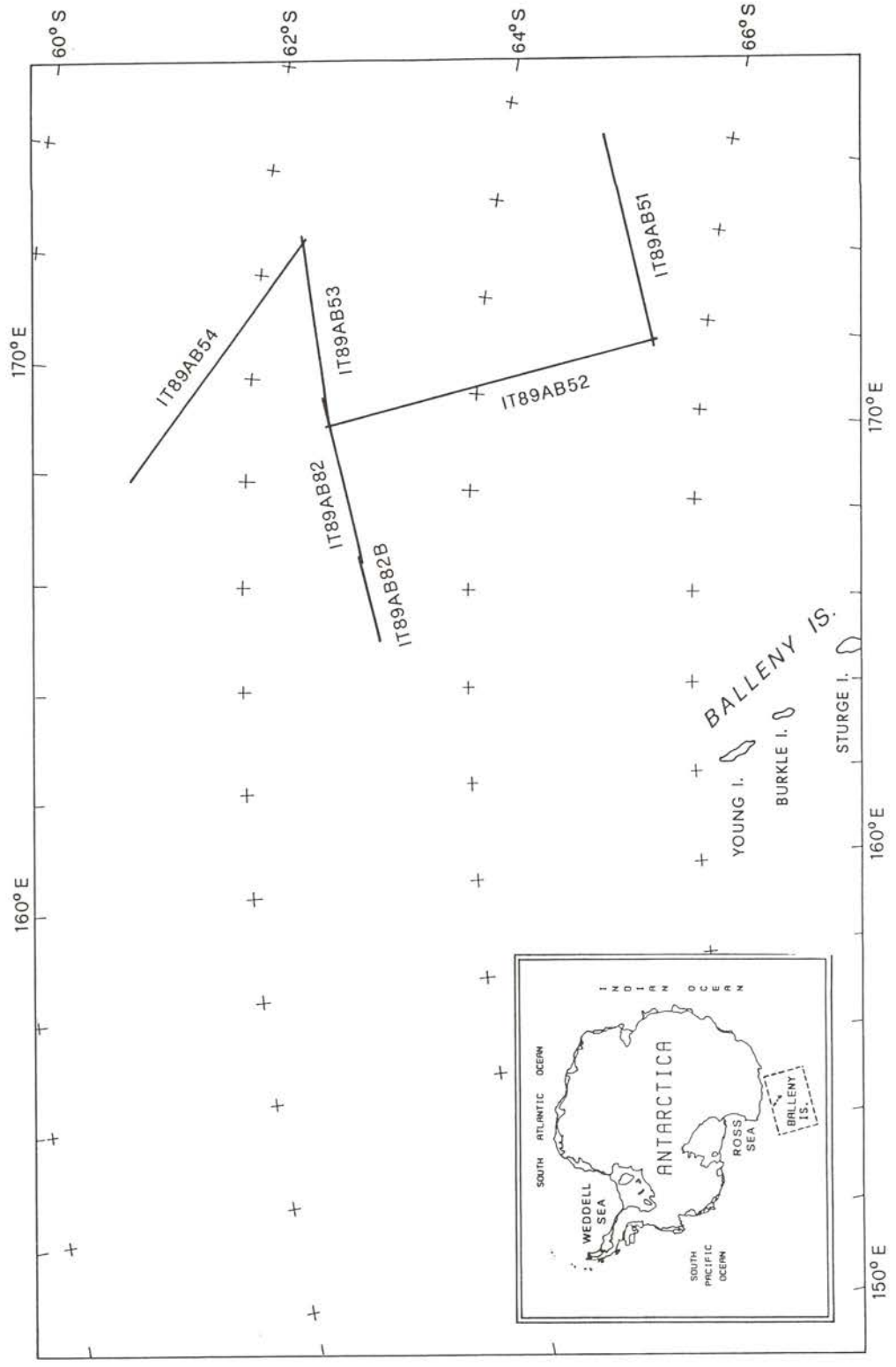

Fig. 10 - Lines acquired in the South Pacific ocean during the third campaign.

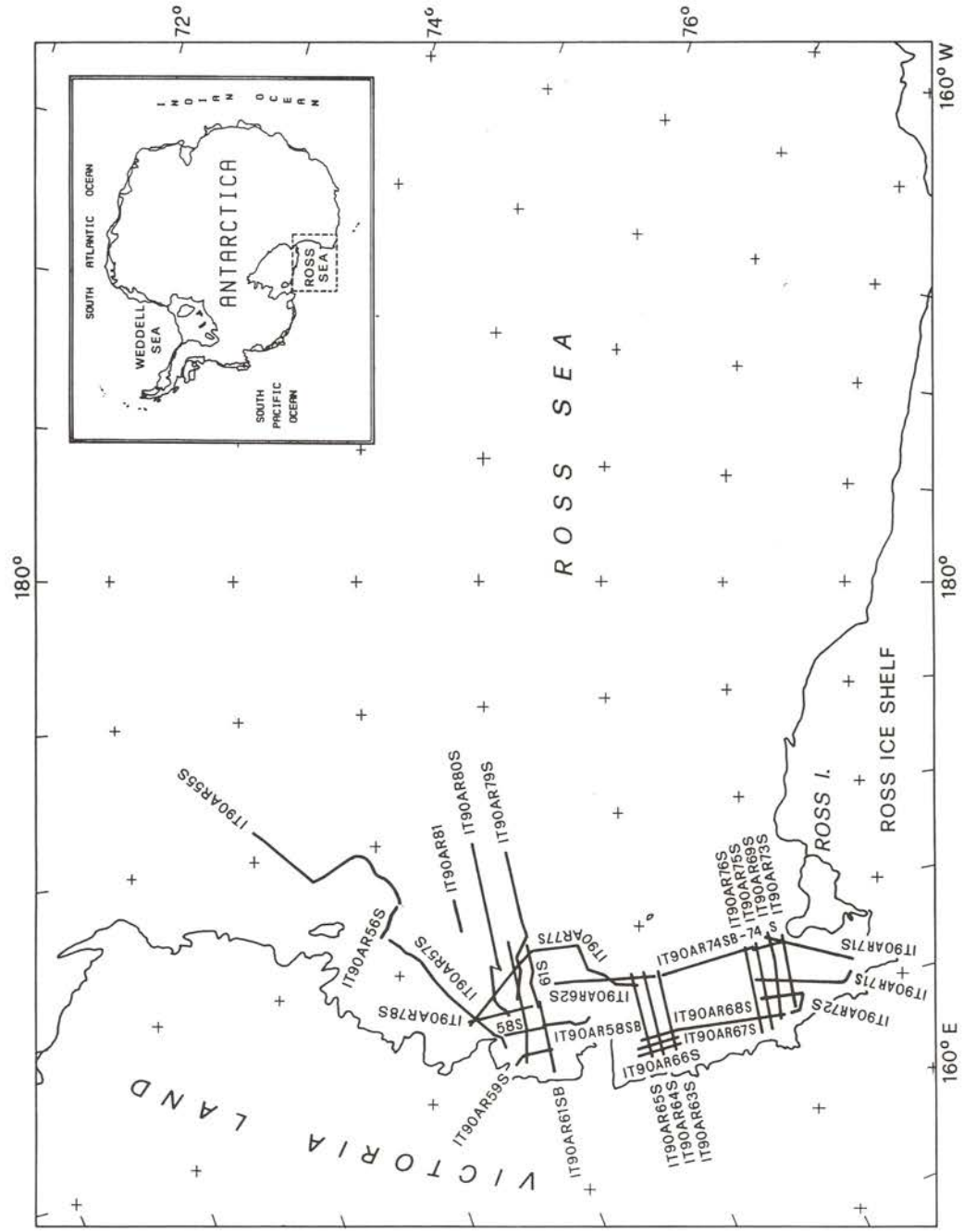

Fig. 11 - Lines acquired in the Ross Sea during the third campaign.

les to which a towing system is added: from the winch, a 32-conductor cable leads to a splitter box from which a 15 ft. 16-conductor cable leads to a "slave" sensor and, after 500 ft of similar cable, to a "master" sensor (which is less subject to the influence of the ship's hull). The two sensors are identical (20 cm in diameter and 120 cm long), and provided with stabilizing fins. They operate typically at a depth of 30-50 m below the surface, which prevents entanglements with other towed equipment (air gun array, etc.).

The dynamic operating range is 17000 to 95000 nT, with fully automatic tuning. Digital recording is done on a dedicated PC, data being written to floppy disks.

GRAVITY AND MAGNETIC OPERATIONS

Measurements with the gravity meter were taken during all the seismic profiling, with a reading recorded at each shot-point. In addition, since the gravimeter had to be in operation all the time during the cruise period in order to take base readings at harbuors to check drift and provide reference gravity for profile computations, gravity is also available over most part of the ship's track during transfers to and from the seismic surveys areas. Magnetic measurements were also taken along the seismic profiles; in addition, they were also taken along with the above mentioned additional gravity measurements during some of the transfers. In 1989 the G811G magnetic gradiometer was installed but did not operate satisfactorily on its first campaign: the coupling of the two magnetometers is rather critical as far as both hardware and software are concerned. Better results were obtained in the subsequent 1990-91 cruise.

SONOBUOY PROFILING

Some sonobuoy experiments were carried out in cooperation with the U.S.G.S.. The sonobuoys were launched by a "mortar" composed of a pipe connected to the high pressure air supply of the air guns: the sudden opening of a valve ejects the sonobuoy through this pipe at the side of the ship to a distance of about 40 meters. Salt water activates radio broadcasting of the signal (in the 162-173 MHz band): the signal received on board is amplified and recorded on an HP 8389 magnetic recorder with a frequency modulated channel. A graphic recording on a Raytheon Scan Recorder is also made, after bandpass filtering. The time break signal from the reflection seismic system is used to start this graphic recorder and is also recorded on the HP device; on a third channel of the same HP recorder the signal coming from the nearest hydrophone group in the streamer is also recorded for use in the data processing.

SEISMIC DATA ACQUISITION

During the first cruise, the following recording parameters were adopted:

Cable length	:	2400 m
Number of traces	:	96
Distance between traces	:	25 m
Shot interval	:	50 m
Coverage	:	2400 %
Recording length	:	12 s
Sampling rate	:	2 ms
Seismic sources	:	2x16 guns
Total volume	:	45.16 l
Low-cut filter	:	8 Hz, 18 dB/oct
High-cut filter	:	154 Hz, 18 dB/oct

For the acquisition of the deep reflection line IT88A02A, some recording parameters were changed so:

Shot interval	:	75 m

Coverage	:	1600 %
Recording length	:	24 s
Sampling rate	:	4 ms

The quality of the data collected was controlled by plotting one complete record in every 40 on a raster device, and producing a single trace monitor. The signal-to-noise ratio, checked during the first 10 seconds of recording length, was good due to the high energy produced by the firing system and to its favourable penetration. As expected, multiple reflections were present on many records, necessitating their removal during processing. The experience gained during the first campaign convinced the team to use a longer streamer for better velocity control of the deep reflectors. Therefore, during the second and third campaigns (excluding most of the work carried out in the Ross Sea area), the recording parameters were changed as follows:

Cable length	:	3000 m
Number of traces	:	120
Distance between traces	:	25 m
Shot interval	:	50 m
Coverage	:	3000 %
Recording length	:	16 s
Sampling rate	:	4 ms
Seismic sources	:	2x16 guns
Total volume	:	45.16 l
Low-cut filter	:	8 Hz, 18 dB/oct
High-cut filter	:	77 Hz, 18 dB/oct

For the lines shot in the Ross Sea during the 1989-90 cruise (excluding line IT90AR81S), where a higher resolution was required, the following recording parameters were adopted:

Cable length	:	3000 m
Number of traces	:	120
Distance between traces	:	25 m
Shot interval	:	25 m
Coverage	:	6000 %
Recording length	:	6 s
Sampling rate	:	2 ms
Seismic sources	:	1x16 guns
Total air gun volume	:	22.5 l
Low-cut filter	:	8 Hz, 18 db/oct
High-cut filter	:	154 Hz, 70 db/oct

Comments on the recorded data should be made only after the final processing. However from an analysis using the real time monitoring system installed on board, it seems that the quality of the data acquired during the three surveys is good. The multiple reflections observed in the Ross Sea were to be expected, and will be removed during the data processing.

SCIENTISTS AND TECHNICAL PERSONNEL

a) **First Cruise, 1987-88**

During the first cruise, the scientific team was organized as follows:

1 Expedition Chief

1 Expedition Assistant

2 System Engineers

3 Navigation Technicians

4 Seismic Instrument Operators

2 Airgun Technicians

The scientific staff, headed by dr. P. Berger was composed of O.G.S. personnel and one researcher from the University of Trieste (Institute of Geodesy and Geophysics). The crew, headed by Capt. F.Scharffetter, had participated also in previous exploration cruises in Antarctica.

b) **Second Cruise, 1988-89**

During the second and third cruises, the scientific team was composed of the following 17 members:

1 Expedition Chief

1 System Engineers

3 Navigation Technicians

6 Seismic Instrument Operator

6 Air gun Technicians

The scientific staff headed by dr. D. Nieto was formed by O.G.S. technicians and included researchers from the Marine Geology Institute of the C.N.R. of Bologna, from ENEA and U.S.G.S.. Dr. G.R. Cochrane of the U.S.G.S. took part in a scientific cooperation of sonobuoy profiling. The crew, was headed by Capt. S.Valles, who had previously participated in other scientific expeditions to Antarctica.

c) **Third Cruise, 1989-90**

The O.G.S. staff headed by dr. D. Nieto was supplemented by three technicians from ENEA, and dr. J.R. Childs, a seismic refraction specialist from the U.S.G.S.. The crew was headed by Capt. G. Tomat who had previously participated to other expeditions to Antarctica.

SEISMIC LINES

In Table 1, the seismic lines acquired by O.G.S. during the first research cruise in the Ross Sea area are listed. In the period from 26.01.88 (departure from Ushuaia) to 08.03.88 (arrival in Wellington harbor), about 2300 km of seismic and magnetometric lines were acquired. The quantity of the geophysical information collected is very high, considering the expectations of the basic scientific program planned by the researchers. All the data, after the vessel's return to Trieste harbour were transferred to the Seismic Data Processing Center of O.G.S..

Table 1. Location of starting and ending points of the seismic lines during the first cruise.

LINE	START POINT		END POINT		LENGTH
	lat.	long.	lat.	long.	km
IT88A01A	72 20,3 S	172 30,8 E	76 59,8 S	164 57,1 W	847,5
IT88A02A	76 31,9 S	163 31,4 W	75 18,5 S	172 02,0 E	694,6
IT88A03A	75 45,0 S	168 22,0 E	75 03,8 S	171 22,0 E	330,8
IT88A04A	75 05,0 S	171 16,0 E	73 15,8 S	174 13,4 E	98,9
IT88A05A	73 11,3 S	174 07,6 E	73 50,8 S	172 40,8 E	84,8
IT88A06A	73 51,5 S	172 54,5 E	71 42,8 S	172 40,9 E	266,9
				TOTAL	2323,5

Table 2 lists the seismic lines acquired in the South Pacific (Triple Junction and Balleny Islands area) by O.G.S. during the second cruise, performed in the context of the National Research Program in Antarctica, while Table 3 summarizes the multichannel reflection seismic profiles taken in the Ross Sea. The quantity of geophysical data collected, indicated in the tables, has to be added to the magnetometric and gravimetric profiles acquired during transfers from Australia to New Zealand, and between the various operations areas. All the data, after the vessel's return to Trieste harbour were transferred to the Data Processing Center of O.G.S..

Table 2. Location of starting and ending points of the seismic lines acquired during the first phase of the 1988-89 cruise (Southern Pacific).

LINE	START POINT lat.	START POINT long.	END POINT lat.	END POINT long.	LENGTH km
IT89A07A	60 20,7 S	152 07,4 E	60 22,3 S	153 36,0 E	79,0
IT89A07B	60 23,2 S	153 26,1 E	60 24,2 S	153 49,7 E	22,0
IT89A07C	60 24,0 S	154 04,4 E	60 14,9 S	163 36,8 E	534,0
IT89A08A	60 15,0 S	163 35,0 E	64 16,7 S	167 55,5 E	505,0
IT89A09A	64 15,5 S	167 54,3 E	64 05,8 S	169 08,4 E	63,0
IT89A09B	64 06,7 S	169 05,2 E	63 24,6 S	173 37,2 E	232,0
IT89A10A	63 24,9 S	173 35,2 E	62 16,1 S	172 36,1 E	144,0
IT89A11A	60 59,3 S	168 16,6 E	61 05,6 S	160 20,9 E	424,0
IT89A11B	61 07,9 S	160 24,4 E	60 59,8 S	156 37,5 E	187,0
IT89A12A	61 00,0 S	157 00,0 E	63 40,9 S	160 52,1 E	359,0
IT89A13A	63 40,0 S	160 50,0 E	63 36,3 S	161 33,9 E	39,0
IT89A13B	63 36,6 S	161 30,3 E	63 15,7 S	165 23,2 E	195,0
IT89A37	68 08,8 S	168 57,4 E	66 24,6 S	165 09,6 E	270,0
				TOTAL	3053.0

Table 3. Location of starting and ending points of the seismic lines acquired during the second phase of the 1988-89 cruise (Ross Sea).

LINE	START POINT lat.	START POINT long.	END POINT lat.	END POINT long.	LENGTH km
IT89A14A	75 04,9 S	167 59,8 E	73 55,7 S	169 31,3 E	142,0
IT89A15A	73 54,9 S	169 38,8 E	73 49,4 S	171 34,4 E	62,0
IT89A16A	73 48,4 S	171 30,1 E	75 41,0 S	171 29,7 E	212,0
IT89A17A	75 39,8 S	171 27,8 E	75 44,8 S	174 03,9 E	71,0
IT89A18A	75 44,9 S	173 59,2 E	75 13,8 S	174 00,0 E	59,0
IT89A19A	75 15,0 S	174 00.0 E	75 16,8 S	169 07,6 E	140,0
IT89A20A	75 11,0 S	169 17,0 E	76 02,7 S	172 48,3 E	139,0
IT89A21A	76 02,0 S	172 44,8 E	76 36,8 S	170 30,6 E	89,0
IT89A22A	76 35,9 S	170 33,9 E	76 56,3 S	172 43,5 E	69,0
IT89A23A	76 45,0 S	173 15,7 E	74 56,9 S	173 19,2 E	200,0
IT89A24A	75 00,0 S	173 19,9 E	74 59,9 S	170 25,5 E	85,0
IT89A25A	75 02,1 S	170 27,4 E	75 23,6 S	176 36,2 E	182,0
IT89A26A	75 22,7 S	175 15,0 E	73 23,9 S	175 14,8 E	226,0
IT89A27A	73 24,9 S	175 14,7 E	73 38,5 S	175 26,7 W	300,0
IT89A28A	73 40,0 S	175 26,4 E	73 25,0 S	179 00,8 W	151,0
IT89A29A	73 25,4 S	178 56,8 W	76 21,0 S	179 01,7 W	332,0
IT89A30A	76 19,8 S	179 05,6 W	76 27,4 S	168 49,0 W	273,0
IT89A31A	76 26,4 S	168 55,0 W	77 25,8 S	165 31,2 W	191,0
IT89A32A	77 23,3 S	165 57,7 W	77 41,6 S	167 50,5 W	64,0
IT89A33A	77 26,7 S	174 00,1 W	77 25,4 S	179 32,0 E	158,0
IT89A34A	77 34,6 S	178 26,0 W	76 18,8 S	179 01,4 W	142,0
IT89A35A	76 19,9 S	179 01,7 W	76 19,9 S	176 54,9 E	107,0
IT89A36A	76 20,0 S	177 00,0 E	74 28,9 S	176 59,9 E	206,0
IT89A36B	74 28,9 S	176 59,9 E	70 05,5 S	176 10,6 E	502,0
				TOTAL	4102,0

A summary of the seismic line production in the different areas investigated during the third cruise is listed in Tables 4, 5 and 6, while Table 7 summarizes the main details of the seismic refraction profiles acquired in the Ross Sea in cooperation with the U.S.G.S. All the data, after the vessel's return to Trieste harbour were transferred to the Data Processing Center of O.G.S..

Table 4. Location of starting and ending points of the seismic lines acquired during the third cruise (Antarctic Peninsula, Weddel and Bellingshausen Seas).

LINE	START POINT lat.	START POINT long.	END POINT lat.	END POINT long.	LENGTH km
IT89AW38	61 07,5 S	45 36,8 W	61 04,2 S	41 33,5 W	264,0
IT89AW39A	58 52,5 S	34 30,6 W	61 06,6 S	45 22,9 W	704,5
IT89AW39B	61 06,0'S	45 21,0 W	62 25,6'S	50 32,6 W	314,6
IT89AW40	62 25,0 S	50 30,0 W	62 12,7 S	50 56,5 W	35,0
IT89AW41	61 57,2 S	50 23,4 W	59 35,2 S	56 06,5 W	412,5
IT89AW42	59 36,0 S	56 05,0 W	60 20,6 S	58 01,8 W	135,2
IT89AW43	60 19,8 S	57 59,2 W	62 06,0 S	55 48,2 W	230,0
IT89AW44	62 04,9 S	55 49,9 W	60 49,3 S	59 21,9 W	237,5
IT89AW45A	60 48,0 S	59 14,9 W	62 45,5 S	63 59,3 W	335,0
IT89AW45B	62 44,6 S	63 57,1 W	63 25,7 S	65 51,9 W	124,3
IT89AW46	63 25,7 S	65 51,9 W	63 25,0 S	65 49,8 W	43,9
IT89AW47A	63 45,0 S	65 33,0 W	64 55,9 S	67 36,2 W	166,5
IT89AW47B	64 55,1 S	67 35,5 W	65 55,0 S	69 30,5 W	144,0
IT89AW48	65 55,2 S	69 23,9 W	64 54,0 S	72 54,1 W	199,0
IT89AW49	64 55,0 S	72 52,0 W	65 10,9 S	74 31,0 W	84,5
IT89AW50	69 07,6 S	99 11,3 W	68 49,7 S	97 35,8 W	72,8
				TOTAL	3503,3

All lines are identified by the common line number IT90AR followed by the individual line number (i.e. IT90AR - 86S and following).

CHRONOLOGY OF THE FIELD OPERATIONS

a) First Cruise 1987-88

At 04.10 Local Time on 26.01.88, the OGS EXPLORA left the harbour of Ushuaia. After passing Cape Horn, at 20.00 of that day, the magnetometric and gravimetric data acquisition started. While the latter acquisition continued almost regularly, the magnetometric data acquisition was sometimes interrupted, mainly due to bad weather conditions encountered during travel to and from the Ross Sea. After some days of navigation and some problems caused by the ice, the vessel finally entered the Ross Sea on 8.02.88, and moved towards Cape Hallet, for a logistic meeting with the helicopters of the Italian Base in Terranova Bay. The following day, the streamer was deployed at sea for balancing and testing. After this operation and tests of the gun array, the recording of seismic data started. In the following days, good weather conditions allowed smooth operations. Six seismic lines were recorded, for a total of 2323 km, at a mean speed of 5.3 knots. Icebergs, sometimes of great size, were often encountered, forcing the vessel to change course. These alterations were kept as smooth as possible to facilitate the seismic data processing. The low temperature caused some problems,such as breakages in the pipes conducting compressed air to the guns and frosting of the air guns when hauled on deck for maintenance.

After reaching the southernmost point of the cruise, (76°59.5'S, 164°57'W), the vessel pointed towards the Italian base, in Terranova Bay, where a meeting with colleagues and bunkering from the base support vessel Polar Queen were scheduled. After a storm and various attempts to force the ice barrier surrounding the Italian base, it was decided to continue the cruise, taking into account that there was fuel enough on board to reach New Zealand. The seismic program continued until a very strong storm, wind force 11 and sea state 10, interrupted the data acquisition, and at 18.00 on 28.02.88, the course for the destination harbour of Wellington was set. During the voyage the gravimetric measurements continued, while the magnetometric measurement were affected by the weather rapidly changing conditions. All of them terminated at 22.00 on 05.03.88, when the Explora entered New Zealand national waters.The harbour of Wellington was reached on the morning of 08.03.88.

Table 5. Location of starting and ending points of the seismic lines acquired during the third cruise (South Pacific Ocean).

LINE	START POINT lat.	START POINT long.	END POINT lat.	END POINT long.	LENGTH km
IT89AB51	64 51,2 S	175 39,3 E	65 31,7 S	171 24,9 W	213,5
IT89AB52	65 31,3 S	171 27,3 E	62 41,7 S	169 08,5 W	335,5
IT89AB53	62 43,0 S	169 10,0 E	62 19,7 S	172 42,5 W	187,0
IT89AB54	62 20,0 S	172 40,0 E	60 59,4 S	167 58,0 W	291,0
IT89AB82	62 38,8 S	169 41,1 E	63 03,8 S	166 30,7 W	169,2
IT89AB82B	63 02,9 S	166 32,8 E	63 13,7 S	164 57,8 W	84,3
				TOTAL	1280,5

b) Second Cruise 1988-89

The field operations for this season were subdivided into two phases: in the South Pacific and in the Ross Sea. On 10.12.88 the OGS EXPLORA left Hobart (Tasmania, Australia). As usual, before departure the vessel's gravimeter was connected to a local gravimetric network set up near the harbour. After some days of hard navigation due to bad weather conditions, the streamer was deployed at sea and balanced. In the afternoon of 15.12.88, seismic data collection started. This continued until 10.00 on 04.01.89, and although often disturbed by very hard sea conditions and stopped by not less than 9 storms, 12 multichannel seismic lines

Table 6. Location of starting and ending points of the seismic lines acquired during the third cruise (Ross Sea).

LINE	START POINT lat.	START POINT long.	END POINT lat.	END POINT long.	LENGTH km
IT90AR55S	73 02,0 S	172 44,4 E	74 06,4 S	170 09,5 E	182,1
IT90AR56S	74 05,5 S	170 04,8 E	73 55,3 S	169 15,6 E	33,3
IT90AR57S	73 58,9 S	169 06,2 E	74 42,5 S	165 07,6 E	143,2
IT90AR58S	74 42,5 S	165 31,0 E	75 04,0 S	165 26,9 E	41,5
IT90AR58SB	75 03,0 S	165 29,3 E	75 25,4 S	165 23,4 E	46,4
IT90AR59S	75 02,4 S	164 41,3 E	74 44,4 S	164 28,8 E	37,8
IT90AR60S	74 50,0 S	164 30,5 E	74 55,1 S	168 22,4 E	114,0
IT90AR61S	75 04,0 S	168 20,7 E	75 03,3 S	166 01,3 E	69,5
IT90AR61SB	75 03,4 S	166 05,6 E	75 01,6 S	164 00,1 E	58,7
IT90AR62S	75 13,2 S	166 44,4 E	76 05,7 S	166 08,4 E	96,5
IT90AR63S	76 03,7 S	166 15,5 E	76 02,1 S	163 37,1 E	72,5
IT90AR64S	75 55,9 S	163 41,1 E	75 56,8 S	166 48,8 E	86,5
IT90AR65S	75 50,9 S	166 26,6 E	75 50,1 S	163 39,3 E	77,8
IT90AR66S	75 42,7 S	163 42,6 E	76 06,2 S	163 43,8 E	45,0
IT90AR67S	76 04,8 S	163 58,1 E	75 43,4 S	163 57,3 E	41,5
IT90AR68S	75 48,2 S	164 12,3 E	76 58,3 S	163 41,4 E	132,7
IT90AR69S	76 56,8 S	163 30,4 E	77 01,6 S	166 55,1 E	86,5
IT90AR70S	77 00,5 S	166 38,5 E	77 38,7 S	165 04,4 E	82,2
IT90AR71S	77 35,6 S	164 33,8 E	76 50,0 S	165 11,1 E	92,0
IT90AR72S	76 49,3 S	164 28,8 E	77 04,3 S	163 40,2 E	63,5
IT90AR73S	77 05,4 S	163 46,5 E	77 08,1 S	166 24,9 E	67,3
IT90AR74S	77 08,0 S	166 20,0 E	76 53,3 S	166 21,6 E	28,9
IT90AR74SB	76 54,9 S	166 21,7 E	76 04,0 S	166 08,9 E	96,5
IT90AR75S	76 54,4 S	166 21,3 E	76 51,2 S	163 15,7 E	80,0
IT90AR76S	76 45,8 S	163 15,3 E	76 48,1 S	166 28,0 E	83,5
IT90AR77S	75 50,0 S	166 04,9 E	74 29,1 S	166 07,4 E	198,0
IT90AR78S	74 30,0 S	166 09,9 E	74 59,8 S	166 10,8 E	57,2
IT90AR79S	74 55,2 S	166 46,3 E	75 02,3 S	171 11,7 E	135,5
IT90AR80S	74 47,0 S	171 32,0 E	74 49,0 S	165 59,9 E	182,7
IT90AR81	74 33,9 S	169 02,7 E	74 33,2 S	169 59,6 E	30,0
				TOTAL	2562,8

Table 7. Summary of the sonobuoy profiles.

SONO	LINE	CDP START	CDP END	LINE DIRECTION	LENGTH KM
86	57S	5626	5776	265	4
87	58S	880	1700	180	12
88	59S	430	1313	000	16
89	61S	370	1350	270	16
90	61S	1400	2390	270	13
91	62S	755	1652	190	23
92	62S	3205	3900	190	16
93A	63S	1398	1572	270	4
93	63S	1578	2513	270	25
94	64S	220	900	090	16
95	65S	2024	2524	270	13
96	66S	1025	1840	180	16
97	67S	738	1700	000	23
98	68S	630	1685	180	26
99	69S	1400	2440	100	29
100	69S	2590	3408	090	16
101	70S	807	2000	210	29
102	71S	950	1863	030	13
103	72S	673	1105	180	9
104	74S	345	1195	006	21
105	75S	1525	2940	275	29
106	74S/B	1810	2532	000	27
107	74S/B	2910	3900	000	23
108	77S	4884	6004	320	27
109	78S	1669	2330	180	14
110	79S	3200	4167	095	24
111	80S	1396	2470	270	26
112	81	160	630	080	12
113	82	3100	3456	255	9

were recorded, totaling about 2700 km, while a further 1100 km of magnetic and gravimetric profiles were recorded during travel from and to New Zealand. Thus the part of the scientific program related to the Triple Junction area was completed. The attempt to extend the region of investigation more to the south was thwarted by the ice extent in that period. The first phase ended on 08.01.89, with the arrival of the OGS EXPLORA at the harbour of Dunedin, for bunkering and a partial change of personnel. After two days the OGS EXPLORA sailed from Dunedin, and a week later, the operations area was reached. The streamer was deployed at sea again, but operations were suddenly interrupted by the arrival of a storm that prevented any data acquisition until the 21st of January, when the vessel moved to Terranova Bay, where three tons of consumables were transferred from the OGS EXPLORA to the base. The following day the vessel left the area of the Italian base and the reflection seismic data acquisition started again, together with refraction seismic data acquisition. Only brief interruptions, due to temporary bad weather conditions, maintenance and some scouting of the very strong ice coverage interrupted the data acquisition operations. Seismic data acquisition in the Ross Sea continued until 15.02.89, when the OGS EXPLORA rapidly moved to the area of the Balleny Islands, where a recognition showed that ice conditions were more favourable than at the beginning of January. In the afternoon of 16.02.89 the streamer was deployed at sea and rebalanced due to the new thermoaline conditions. After one day of data collection, bad weather conditions forced a stop to seismic profile IT89A37A and the recovery of the streamer. The OGS EXPLORA remained in the area, waiting for a possible improvement in weather conditions, but this did not happen. Therefore on 20.02.89 the vessel moved towards New Zealand followed at some distance by the m/v BARKEN sailing from the Italian Base. During the voyage, some maintenance work on the streamer was completed and finally on 28.02.89 the two vessels entered the harbour of Lyttelton (Christchurch, New Zealand)

c) Third Cruise 1989-90

The 1989-90 Antarctic cruise was preceded by a multidisciplinary campaign in the Magel-

lan Straits. Antarctic operations were then subdivided into three phases: the first in the Weddel Sea, the second in the Amundsen and Bellinshausen Seas, and the third in the South Pacific Ocean and in the Ross Sea. During each phase a different area of the scientific program was explored.

After some days spent in the harbour of Punta Arenas to unload the oceanographic equipment used during the campaign in the Magellan Straits, to load new instruments and to outfit the vessel for the Antarctic program, the vessel sailed to the Weddel Sea on 26.11.1989. On 29.11 the streamer was deployed at sea for balancing. On the following day, while continuing the streamer balancing, gravity and magnetic data acquisition begun in the area of the Scotia Plate. In the morning of 2.12 the streamer was correctly balanced and seismic data acquisition could start. Operations in this zone continued with some difficulties due to bad weather conditions and intensive ice until the 20.12, when the vessel pointed towards Ushuaia, where she arrived on 22.12.1989. Despite the problems generated by ice and the stormy weather, during this first phase 3003 km of seismic lines, 3410 km of magnetic lines and 3,438 of gravity lines were recorded.

The OGS EXPLORA spent four days at Ushuaia for personnel changes, loading of provisions and waiting for the delivery of bunkers (delayed by banking problems in Argentina). On 27.12.1989 the vessel sailed from Ushuaia for the second leg of this cruise. On 28.12 the streamer was deployed at sea for testing after some maintenance work carried out at Ushuaia, and on 30.12 seismic recording started again in the area of the Antarctic Peninsula, to complete some lines left from the first phase. The following day the missing lines were completed, and immediately the vessel moved to the area of the Amundsen and Bellingshausen Seas. After some work in the area, it was decided to move towards the triple Junction area in the Southern Pacific, where the ice conditions would be less severe. Operations continued successfully in this area until 18.1, when all the equipment was recovered on board, and the vessel then sailed towards Dunedin, where she arrived on 21.01. This second leg was also affected by strong ice coverage, but production was satisfactory. A total of 1780 km of seismic lines and 4456 km of gravity and magnetic data were recorded.

During the vessel's call at Dunedin, besides the normal bunkering operations and loading of provisions for the vessel and for the Italian Base at Terra Nova Bay, all the equipment for the seismic refraction data acquisition was loaded and an U.S.G.S. researcher joined the scientific staff. On 23.1 the vessel sailed from Dunedin and, after some days of hard sailing due to bad weather conditions, she arrived in the Ross Sea, where on 29.1 operations begun. As the weather conditions in the Ross Sea were good the geophysical data acquisition continued until 13.2 with a short interruption on 31.1 when the vessel stopped for some hours at Terra Nova Bay to unload material and provisions. On 13.2 the vessel returned to Terra Nova Bay to concord a program of bottom sampling in an area close to the Base with geologists of the shore team. The following day, at the end of this program, four technicians, of the shore team embarked on the OGS EXPLORA for the voyage to New Zealand. During the transit some more data were acquired, but the weather conditions at the end of the season started to worsen and the very low temperature caused problems with the air supply pipes for the air guns. After a last attempt in the area of the triple Junction, on 22.02 it was decided to proceed to Lyttelton, where the vessel arrived on 27.02.90.

This third phase of the Antarctic cruise was very successful, and large amount of data was acquired. Reflection seismic, gravity and magnetic lines were collected for a total of 2,563 km, plus 29 refraction profiles (29 buoys launched) and 24 bottom samples.

CONCLUDING REMARKS

The three Antarctic cruises of the OGS EXPLORA represent the first Italian geophysical exploration of the "White Continent". Better knowledge of the Antarctic environment made possible a careful planning of the operations, thus giving to the researchers on the vessel maximum flexibility in the program, and the possibility of alternative programs when local conditions interfered too strongly with operations. This approach to possible problems in field operations

has proven to be the most convenient one, and the results of the first three Antarctic cruises may be considered a complete success. The amount of geophysical data collected during the first cruise was higher than the most optimistic predictions; this was possible due to the favourable weather conditions encountered during operations in the Ross Sea. Since this was the first geophysical cruise in the seas surrounding Antarctica totally performed by an Italian research institution using its own vessel, it gave valuable experience on such activities. The chosen data acquisition parameters proved to be effective, and management of the field operations was equally satisfying, as the only significant interruption in data acquisition was caused by a very intense storm. The configuration of the gun array, in two strings, proved convenient, even in the presence of ice. Critical was the use of the magnetometer, often discontinued by the presence of even small ice fragments. During travel to and from the Ross Sea, weather conditions were much worse than expected, and it was concluded that the limits of the operational window in the Ross Sea are very sharp, and therefore operations in that area must absolutely end before the 20th of February. Nevertheless the good behavior of the vessel in ice suggested using a longer streamer in subsequent cruises. Also during the second cruise, most of the research goals of the program were reached. During the first phase, the Triple Junction area and the related main crustal structures were investigated over 12 profiles, notwithstanding the very bad weather conditions in the area during December. The attempt to extend the program southward was discontinued due to the local ice extension. After completion of exploration activity in the Ross Sea, a new attempt was made in the same area, now free of ice. Unfortunately storms obliged the researchers to stop operations after having collected 270 km of seismic lines. In the Ross Sea, where the program mainly consisted in refining the seismic line grid of the previous Antarctic expedition, a large quantity of seismic, magnetometric and gravimetric profiles were collected and completed with refraction seismic data from sonobuoys. The 1989-90 program cruise in Antarctic waters was ambitious especially in the Weddel Sea area and in the Amundsen and Bellingshausen Seas, where a good part of the lines could be explored only under favourable ice conditions which were unlikely during this season. Due to the ice coverage, environmental conditions were worse than expected (and hoped) and operations had to be shifted more to the north into alternate programs. Nevertheless the cruise was very successful. A total of 7,273 km of reflection seismic lines, 10,225 km of gravity lines and 10,175 km of magnetic lines, plus 29 refraction seismic profiles represent a large quantity of geophysical data, and part was acquired in particularly remote and hardly accessible areas. The program in the Southern Pacific Ocean was performed nearly on schedule (although in a different period) and data acquisition in the Ross Sea continued.