C. GANTAR and C. ZANOLLA

GRAVITY AND MAGNETIC EXPLORATION IN THE ROSS SEA (ANTARCTICA)

Abstract. Potential field data were measured during the Italian offshore exploration in the Ross Sea, Antarctica, with gravimeters and magnetometers. The results of the measurements taken during the first three cruises (1998-1990) are presented as seismic line profiles and as bathimetric, Free-air and simple Bouguer gravity anomaly maps.

INTRODUCTION

In the years from 1988 to 1990, the Osservatorio Geofisico Sperimentale of Trieste (OGS) collected a large quantity of geophysical information along marine profiles in order to contribute to the structural knowledge of various areas in the southern hemisphere around the Antarctic continent. This activity was undertaken within the frame work of the Italian National Program for Antarctic Research, organized by ENEA.

The OGS activity began in the Ross Sea, where a notable amount of data existed already, in order to increase the geophysical detail.

The ship OGS EXPLORA, described by Berger et al. (1993), was used, which had already been employed by the Bundesanstalt für Mineral und Rohstoffe (BMR), Hannover, Germany and her instrumentation was left unaltered at the beginning. Subsequently, the gravity meter system was improved, by changing the stabilized platform and some of the electronics (in effect, from model Bodenseewerk KSS30 to KSS31); the navigation system was also upgraded from the INDAS V to the NAVDATA 3000 of Prakla-Seismos manufacture, and a GPS dedicated receiver (TRIMBLE 4000A with an atomic clock to extend the working temporal windows to 2-satellite periods) was added to the sensors connected to the integrated navigation system.

As expected, a better response of the gravity meter under rough sea conditions and a more accurate positioning were obtained from these changes; a noticeable benefit also came from the progressive increse of the NAVSTAR satellite constellation which allowed abandoning the Transit control in favour of GPS.

In the last of the mentioned cruises (1989-1990), the magnetometer was also changed, from the Geometrics single channel G801 to the gradiometer G811G, in order to obtain data unbiased by the temporal variations of the earth's magnetic field.

The main activity of the ship was still obviously the acquisition of multichannel seismic (mcs) profiling, which conditioned the choice of the location of the profiles along which the other geophysical parameters were also measured.

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OGS, Osservatorio Geofisico Sperimentale, P.O. Box 2011, 34016 Trieste, Italy.

The procedures in processing the geophysical data are described in another paper (Gantar et al., 1993).

GRAVITY MEASUREMENTS

The gravity meter observations were taken along all the seismic profiles, where accurate positioning was performed, and they are listed in the Table.

Controls for the determination of the scale factor and drift, and therefore for the definition of the gravity datum, were done by comparing the readings of the ship-borne gravimeter at the bases established in the harbours (Gantar, 1993b), referred to the IGSN71 (Morelli et al., 1971).

Given the availability now of an absolute gravity determination at the Italian Station of Terra Nova, a further check can conveniently be done in the future, when cruises are being planned in the Ross Sea again.

Several organizations have taken gravity measurements in the Ross Sea area, but only the BMR campaigns appear to be almost immediately homogeneous with the present OGS data, at least as far as the instrument is concerned (the same ship was employed by BMR). These data were made available by BMR and, since they cover systematically and at large meshes much of the area where the OGS measurements were located, their use in the preliminary version of the unified map was fundamental.

After the German data have been adjusted (for datum and intersection differences), the rest of the available gravity information will be easily inserted, to furnish a homogeneous net with improved detail for contouring.

Statistics will be published after this procedure is completed, and after the topographically corrected Bouguer anomalies are computed, since the final adjustment is planned to be done on the comparison of the anomalies, which are the final target, at the intersections of the profiles.

A synthesis of the Italian and German gravity measurements up to 1991 is plotted in the *Free Air Anomaly Map*, with a contour interval of 5 mGal (50 μN/m). Normal gravity as derived from Moritz's 1980 formula (AIG, 1980) has been applied, with no consideration of the gravity effect of the atmosphere.

To facilitate the interpretation of these anomalies, a *Simple Bouguer Map*, computed for a density of 2.4 g/cm^3 and *without terrain correction*, is presented at the same contour interval. The assumed density, lower than the usual 2.67 g/cm^3 usually considered in assembling continental scale maps, is intended to account for the depth variations of the sea bottom, which represents the top of the sedimentary sequence forming the prevalent depositional material in the area: this gravity map should therefore reflect the following features:

a) the probable progressive increase with depth of the density of the sedimentary strata lying over the basement of the sequence: this means that the lower sedimentary strata should be modelled with a positive density difference;

b) intrusive phenomena which, if relevant, could be detected from the magnetic profiles (or from aereomagnetic maps);

c) the topography of the basement rocks (granite-types with lower density contrast and/or basalt-types with higher density contrast), and by the presence of contrasting density intrusions under the (acoustic) basement;

d) changes in the distance to the Moho discontinuity to which the longer wavelength anomalies may be related, unless other intermediate discontinuities are deduced, e.g., as from large refraction experiments.

As a further remark, the assumed mean density of 2.4 g/m^3 should be a good mean value among those attributable to the upper sequence, from the sea bottom (evidently less dense, say as low as 2.0) to the top of the layers over the (acoustic) basement, where densities could be higher, reaching perhaps 2.7 and over, as in the hypothesis of Davey and Cooper (1987).

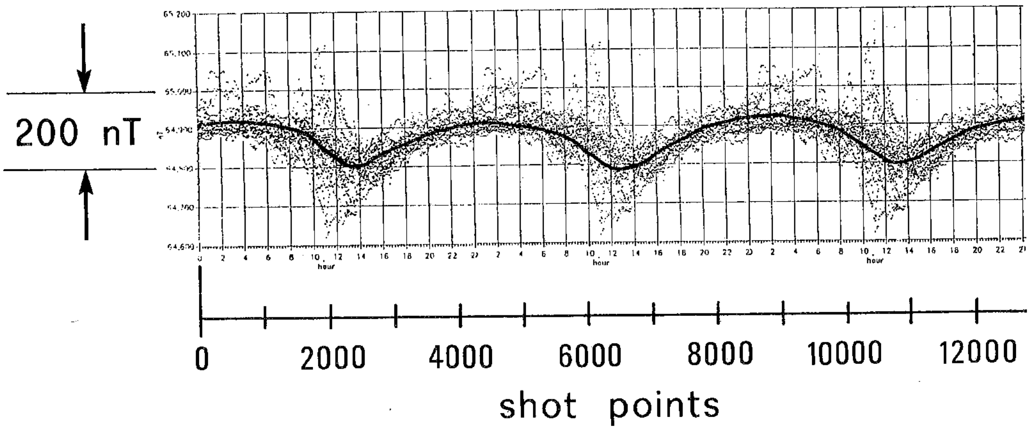

Fig. 1 — Averaged magnetic field time variations at Terra Nova, 1988, plotted as a function of time. S.P. at 50 m interval (from data by Azzara and Meloni, 1989, personal communication).

To help structural correlations, a *Bathymetric Map* is also presented, computed using the sound speed in water as suggested by Carter (1980). This map, assembled from the data corresponding to the gravity measurements, is to be used only for the gravity comparisons, and does not pretend to represent a complete bottom morphology of the area: interpolation toward the shores has therefore been done only under the assumption of zero depth at the shoreline.

The geographical layout and the adopted projection (Polar Stereographic, with $k_0=0.95$ at pole) is that proposed for the OGS maps of the circumpolar areas (Gantar, 1993a).

MAGNETIC FIELD MEASUREMENTS

The magnetometer measurements were taken along most of the seismic profiles: in some instances, the magnetometer was not working properly, and in others it was taken on board to avoid danger due to floating ice blocks.

For the 1989-90 expedition, the measurements were taken with the gradiometer which initially did not operate well, due to defective bird connections and other failures. The magnetic profiles given in this paper for that campaign are therefore derived from the data taken with the single sensor operating.

The magnetic measurements have been reduced by reference to the IGRF85, and no correction has been applied for the time related variations, due to lack of base recordings covering the whole period over which the marine measurements were taken.

It should be noted that the average wavelength of the mean diurnal variation corresponds to about 2200 shot points (S.P., see Fig. 1) and therefore covers about 100 km of marine profile: uncertainties still remain for short period variations which, if present, could interfere with anomalies of geologic origin.

The most extended magnetic signatures, such as those due to regional magmatic activity or to basement displacements, are better depicted in the aeromagnetic surveys (see, e.g., the GANOVEX maps). In fact, the main task of the magnetic data collection along the marine profiles was mainly local interpretation in terms of volcanism along the acoustic sections. Therefore, no magnetic map is presented for the whole Ross Sea area; the available BGR marine data were also missing this information.

DETAIL DATA ALONG THE SEISMIC PROFILES

The data along OGS profiles are presented in Figs. 2 to 8: they include gravity (Free air anomalies), depth and magnetic anomalies. The principal facts for these profiles are presented in the Table to facilitate their location on the maps.

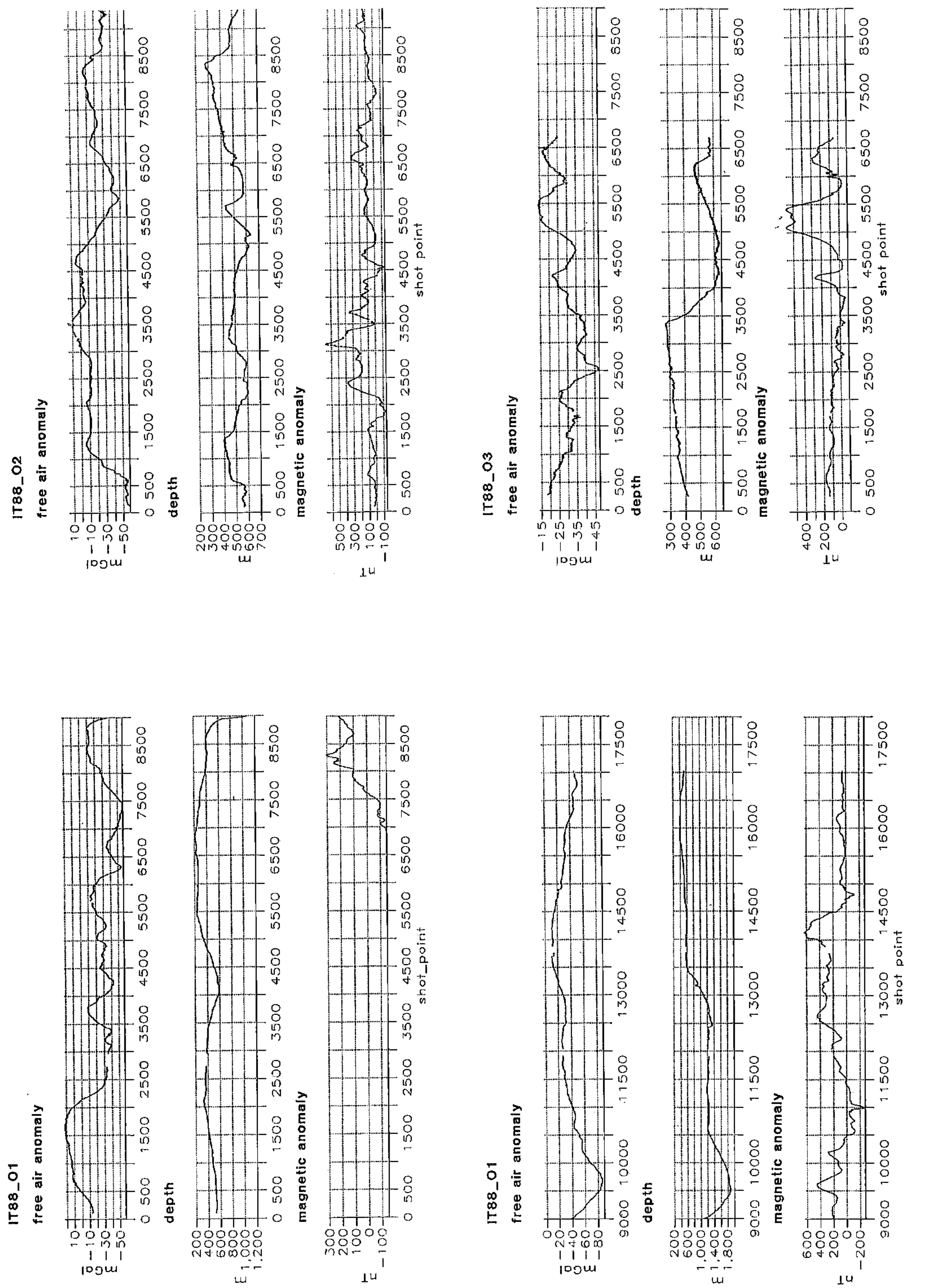

Fig. 2 — Gravity, magnetic anomaly and depth along MCS profiles.

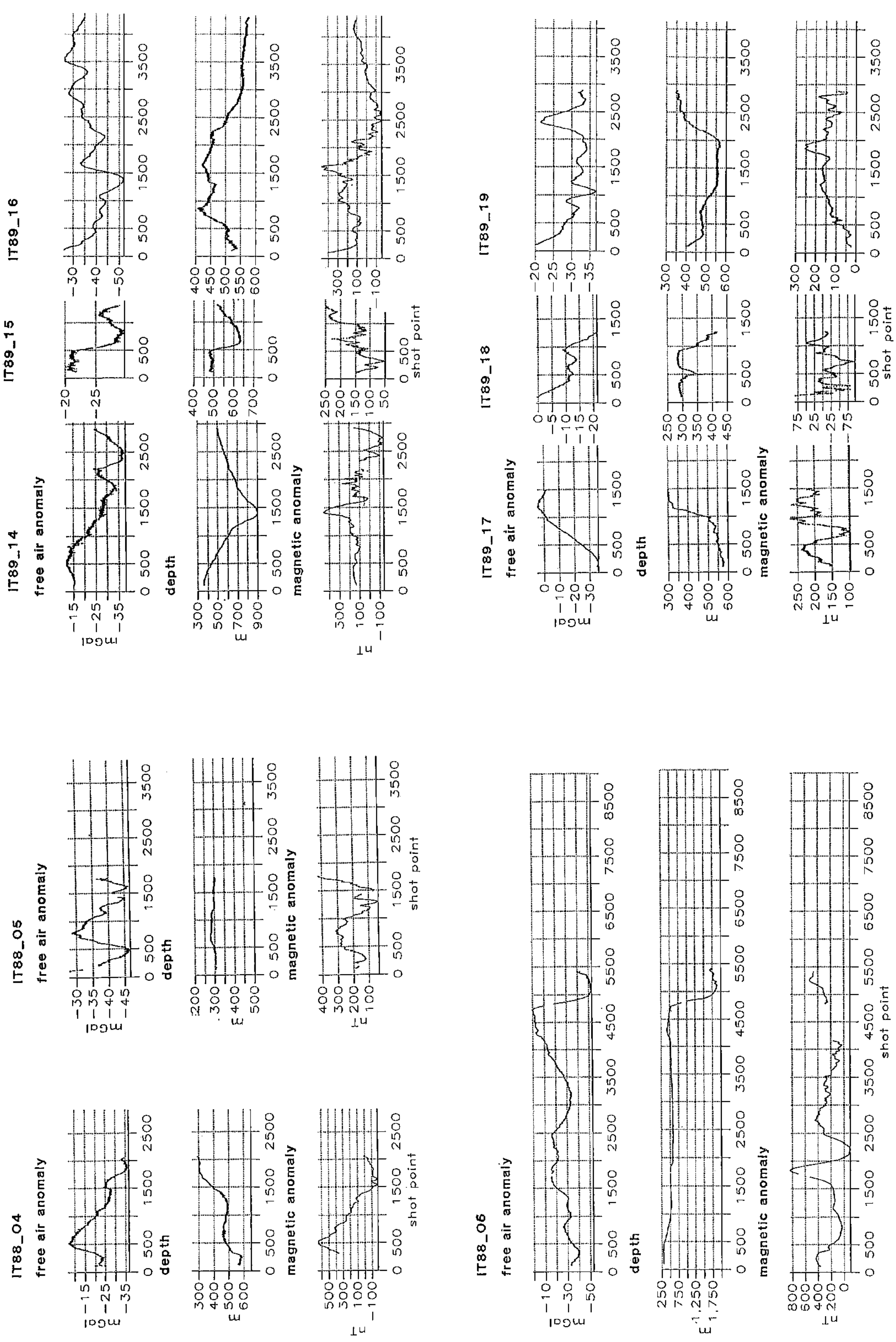

Fig. 3 — Gravity, magnetic anomaly and depth along MCS profiles.

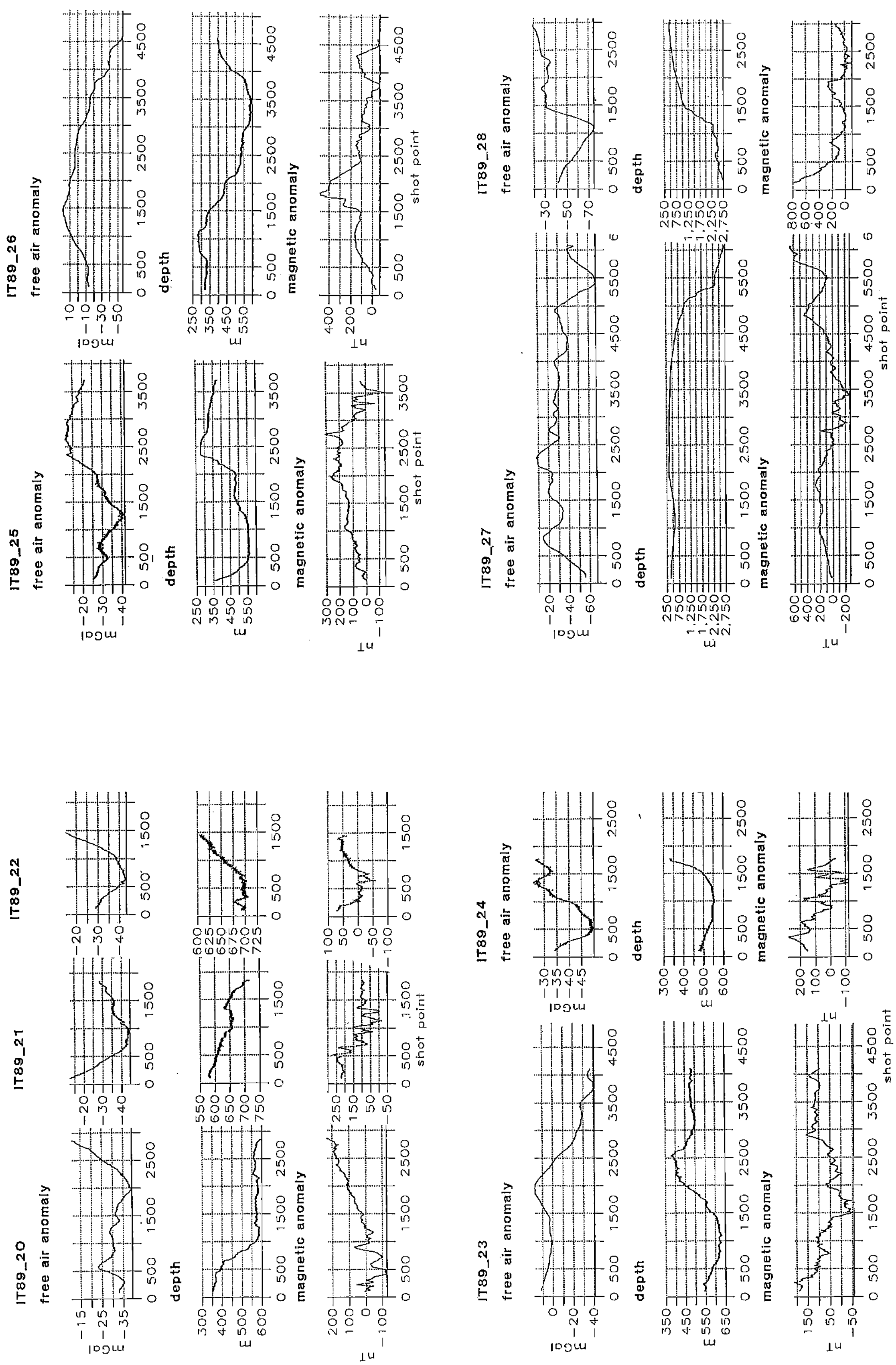

Fig. 4 — Gravity, magnetic anomaly and depth along MCS profiles.

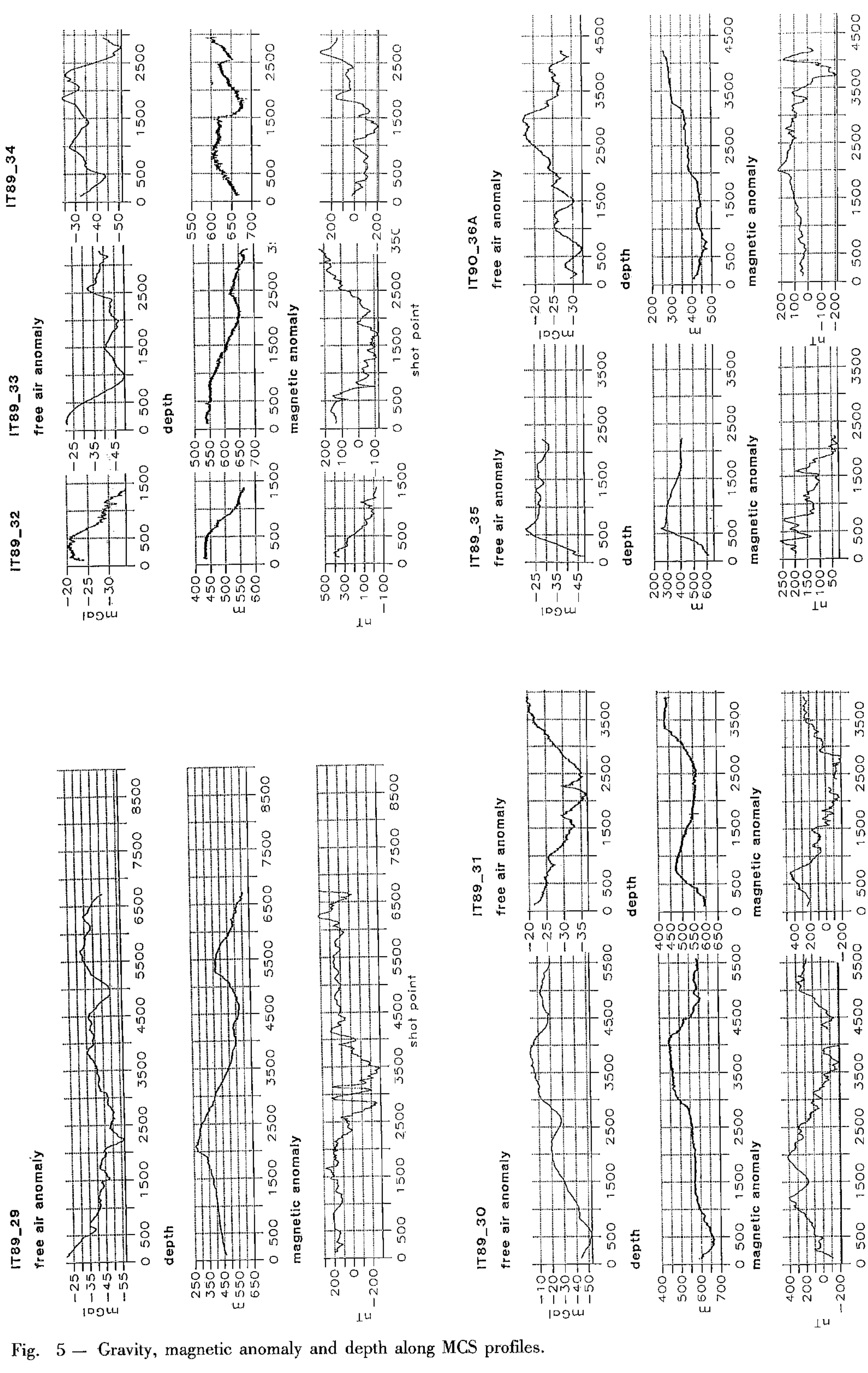

Fig. 5 — Gravity, magnetic anomaly and depth along MCS profiles.

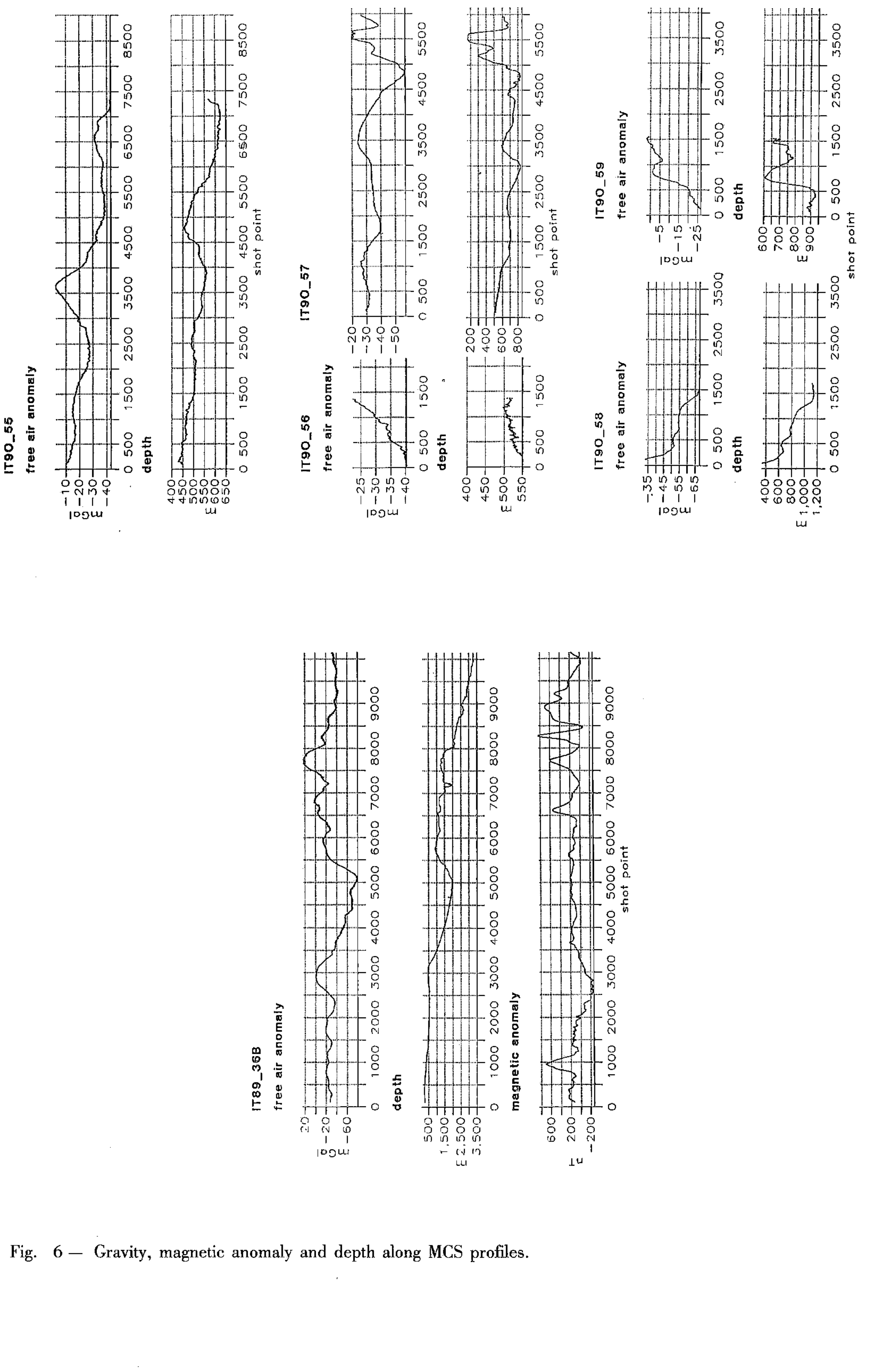

Fig. 6 — Gravity, magnetic anomaly and depth along MCS profiles.

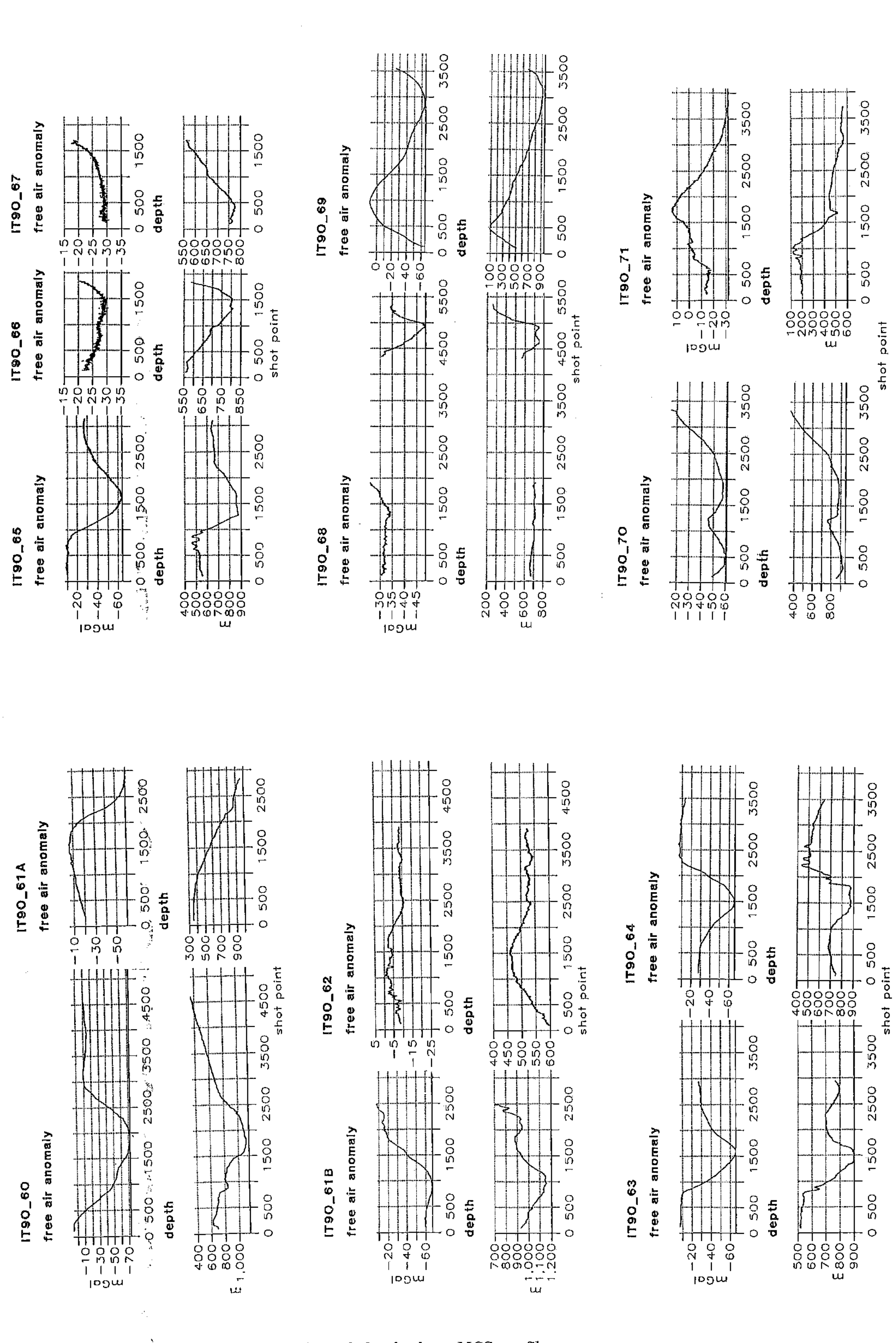

Fig. 7 — Gravity, magnetic anomaly and depth along MCS profiles.

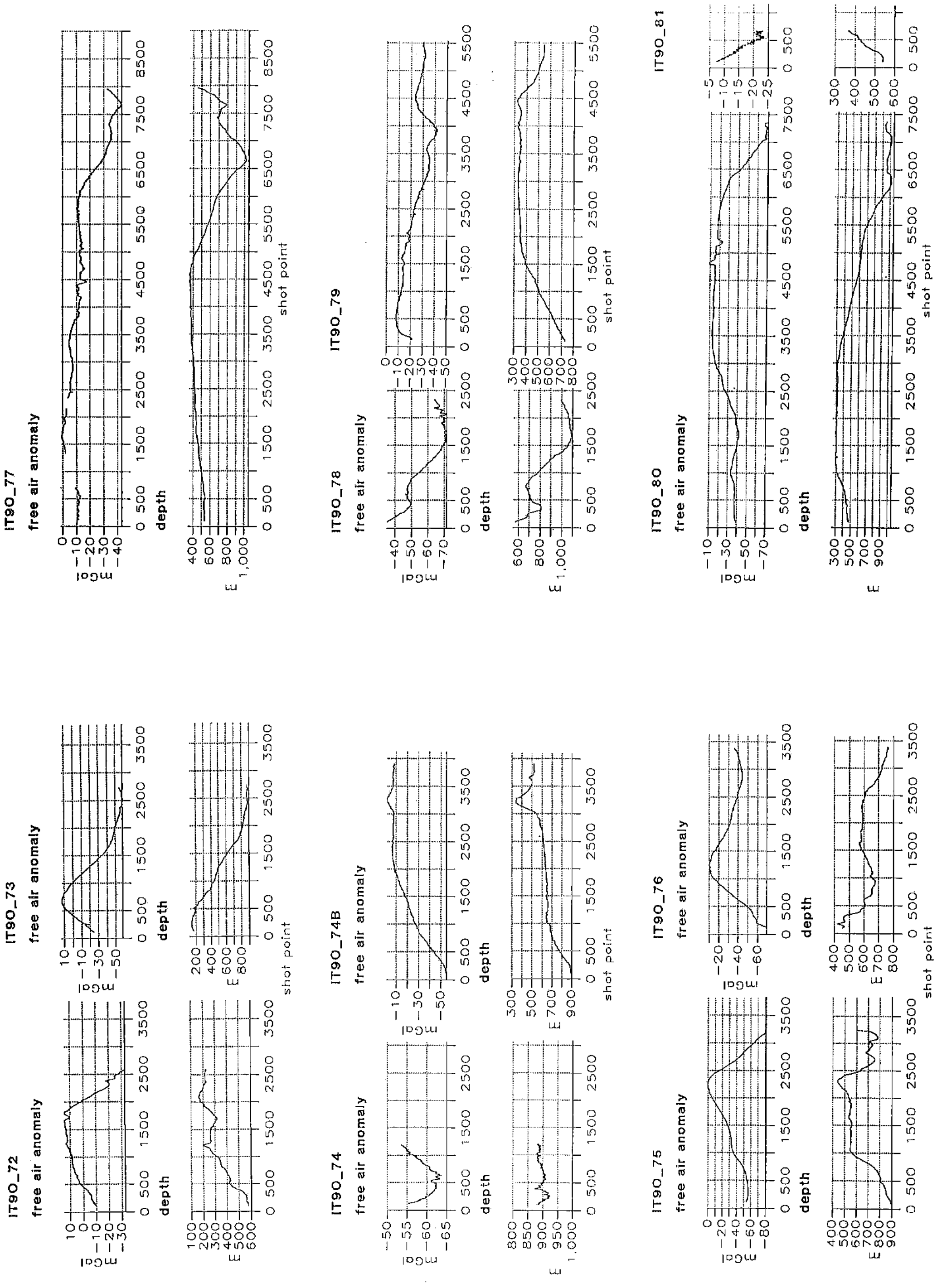

Fig. 8 — Gravity, magnetic anomaly and depth along MCS profiles.

Table — List of O.G.S. marine profiles in Ross Sea until 1990.

Line	From: φ	λ	To: φ	λ		number of S.P.'s	
IT88-01	72 20,3S	172 30,8E	76 59,8S	164 57,1W	*	16407	
IT88-02	76 31,9S	163 31,4W	75 18,5S	172 02,0E		9058	ϱ
IT88-03	75 45,0S	168 22,0E	75 03,8S	171 22,0E		6362	
IT88-04	75 05,0S	171 16,0E	73 15,8S	174 13,4E		1956	
IT88-05	73 11,3S	174 07,6E	73 50,8S	172 40,8E		1566	
IT88-06	73 51,5S	172 54,5E	71 42,8S	172 40,9E		5235	
IT89-14	75 04,9S	167 59,8E	73 55,7S	169 31,3E		2820	
IT89-15	73 54,9S	169 38,8E	73 49,4S	171 34,4E		1210	
IT89-16	73 48,4S	171 30,1E	75 41,0S	171 29,7E		4205	
IT89-17	75 39,8S	171 27,8E	75 44,8S	174 03,9E		1398	
IT89-18	75 44,9S	173 59,2E	75 13,8S	174 00,0E		1155	
IT89-19	75 15,0S	174 00,0E	75 16,8S	169 07,6E		2780	
IT89-20	75 11,0S	169 17,0E	76 02,7S	172 48,3E		2761	
IT89-21	76 02,0S	172 44,8E	76 36,8S	170 30,6E		1745	
IT89-22	76 35,9S	170 33,9E	76 56,3S	172 43,5E		1360	
IT89-23	76 45,0S	173 15,7E	74 56,9S	173 19,2E		4005	
IT89-24	75 00,0S	173 19,9E	74 59,9S	170 25,5E		1670	
IT89-25	75 02,1S	170 27,4E	75 23,6S	176 36,2E		3609	
IT89-26	75 22,7S	175 15,0E	73 23,9S	175 14,8E		4490	
IT89-27	73 24,9S	175 14,7E	73 38,5S	175 26,7W		5985	
IT89-28	73 40,0S	175 26,4E	73 25,0S	179 00,8W		2905	
IT89-29	73 25,4S	178 56,8W	76 21,0S	179 01,7W		6612	
IT89-30	76 19,8S	179 05,6W	76 27,4S	168 49,0W		5470	
IT89-31	76 26,4S	168 55,0W	77 25,8S	165 31,2W		3820	
IT89-32	77 23,3S	165 57,7W	77 41,6S	167 50,5W		1275	
IT89-33	77 26,7S	174 00,1W	77 25,4S	179 32,0E		3160	
IT89-34	77 34,6S	178 26,0W	76 18,8S	179 01,4W		2850	
IT89-35	76 19,9S	179 01,7W	76 19,9S	176 54,9E		2135	
IT89-36A	76 20,0S	177 00,0E	74 28,9S	176 59,9E		4130	
IT89-36B	74 28,9S	176 59,9E	70 05,5S	176 10,6E		10040	
IT90-55	73 02,0S	172 44,4E	74 06,4S	170 09,5E		7234	#
IT90-56	74 05,5S	170 04,8E	73 55,3S	169 15,6E		1271	#
IT90-57	73 58,9S	169 06,2E	74 42,5S	165 07,6E		5875	#
IT90-58	74 42,5S	165 31,0E	75 04,0S	165 26,9E		1601	#
IT90-59	75 02,4S	164 41,3E	74 44,4S	164 28,8E		1457	#
IT90-60	74 50,0S	164 30,5E	74 55,1S	168 22,4E		4501	#
IT90-61A	75 04,0S	168 20,7E	75 03,3S	166 01,3E		2732	#
IT90-61B	75 03,4S	166 05,6E	75 01,6S	164 00,1E		2392	#
IT90-62	75 13,2S	166 44,4E	76 05,7S	166 08,4E		3801	#
IT90-63	76 03,7S	166 15,5E	76 02,1S	163 37,1E		2842	#
IT90-64	75 55,9S	163 41,1E	75 56,8S	166 48,8E		3401	#
IT90-65	75 50,9S	166 26,6E	75 50,1S	163 39,3E		3052	#
IT90-66	75 42,7S	163 42,6E	76 06,2S	164 43,8E		1741	#
IT90-67	76 04,8S	163 58,1E	75 43,4S	163 57,3E		1604	#
IT90-68	75 48,2S	164 12,3E	76 58,3S	163 41,4E		1031+1814	#
IT90-69	76 56,8S	163 30,4E	77 01,6S	166 55,1E		3451	#
IT90-70	77 00,5S	166 38,5E	77 38,7S	165 04,4E		3230	#
IT90-71	77 35,6S	164 33,8E	76 50,0S	165 11,1E		3626	#
IT90-72	76 49,3S	164 28,8E	77 04,3S	163 40,2E		2489	#
IT90-73	77 05,4S	163 46,5E	77 08,1S	166 24,9E		2631	#
IT90-74A	77 08,0S	166 20,0E	76 53,3S	166 21,6E		1096	#
IT90-74B	76 54,9S	166 21,7E	76 04,0S	166 08,9E		3801	#

IT90-75	76 54,4S 166 21,3E	76 51,2S 163 15,7E	3146	#
IT90-76	76 45,8S 163 15,3E	76 48,1S 166 28,0E	3281	#
IT90-77	75 50,0S 166 04,9E	74 29,1S 166 07,4E	7861	#
IT90-78	74 30,0S 166 09,9E	74 59,8S 166 10,8E	2230	#
IT90-79	74 55,2S 166 46,3E	75 02,3S 171 11,7E	5361	#
IT90-80	74 47,0S 171 32,0E	74 49,0S 165 59,9E	7265	#
IT90-81	74 33,9S 169 02,7E	74 33,2S 169 59,6E	571	#

S.P. intervals are 50 m except: ϱ) S.P. interval=75 m
#) S.P. interval=25 m
*) due to its length broken into two parts in Fig. 2.

Acknowledgements. The single magnetometer readings recovered from the defective gradiometer operations in the third campaign were processed by Dr. Coren of OGS, whose contribution is acknowledged.

The maps incorporate the gravity and depth information kindly put at our disposal by Prof. K. Hinz (BGR), and which was needed for complete coverage of the area.

Similar data have been received also from Drs. F. Davey and A. Cooper but have not yet been incorporated at this stage, since they require further adjustments for the different datums.

The contouring program used was that developed by Dr. Klingele, whose help is acknowledged.

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