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BMR Record 1990/83

WERNER DECONVOLUTION OF MAGNETIC DATA FROM THE GREAT AUSTRALIAN BIGHT REGION

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by

H.M.J. Stagg & J.B. Willcox

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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

Division of Marine Geosciences and Petroleum Geology

BMR Record 1990/83

WERNER DECONVOLUTION OF MAGNETIC DATA FROM THE GREAT AUSTRALIAN BIGHT REGION

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H.M.J. Stagg & J.B. Willcox

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INTRODUCTION

While magnetic data are routinely acquired on marine geophysical surveys, in contrast to reflection seismic data they generally receive scant attention except in studies of oceanic spreading anomalies. This is despite the fact that even where good quality seismic data are available, the magnetic data frequently contain more deep crustal information. The line separation of regional marine geophysical surveys is not conducive to the contouring of magnetic data and the interpretation techniques associated with contouring; hence the interpretation of marine magnetic data must typically be done on 2-D profiles. If these profiles are sufficiently long (say >80 km) and approximately perpendicular to strike, then they lend themselves to the automatic interpretation of shallow to mid-crustal (1-12 km) features, providing that magnetic discontinuities are present. Techniques of interpretation of depth to magnetic features range from the manual measurement of anomaly characterists and the application of empirically-derived formulae, to modern automated analysis of magnetic data with no basic assumptions of model type (*eg* Thompson, 1982). One of the most useful of the automatic techniques for the examination of magnetic profiles is that known as 'Werner deconvolution' (Werner, 1953; Hartman & others, 1971; Aero Service, 1974; Jain, 1976; Hsu & Tilbury, 1977).

This report will summarise some of the work of Stagg & others (1989) which analysed the response of some simple geological models to the Werner deconvolution technique and presented an interpretation of selected Werner-deconvolved magnetic profiles from the Great Australian Bight (Fig. 1). The principal function of this Record is to present the full set of profiles that have been compiled in the Great Australian Bight (Plates 2-6), together with background background information explaining their derivation and the geological models. For a detailed geological interpretation of the data, the reader is referred to Stagg & others (1989).

WERNER DECONVOLUTION - BACKGROUND TO THE METHOD

The magnetic data interpretation technique of Werner deconvolution applied here is that described by Hsu & Tilbury (1977) and Aero Service Corporation (1974). The model used in the interpretation assumes that the observed magnetic field arises from two discrete magnetic sources and a quadratic magnetic background 'noise'; these sources are either thin sheets (dykes) or interfaces. The equations defining the model are solved analytically using observed data values. We first summarise the approach given by Hsu & Tilbury (1977).

For a simple thin sheet model, the equations defining its magnetic intensity can be written as -

$$T(x) = (A.h + B(x-x_0))/((x-x_0)^2 + h^2)$$

--- Hsu & Tilbury (1977), equation (1)

where x is the distance along a line perpendicular to the

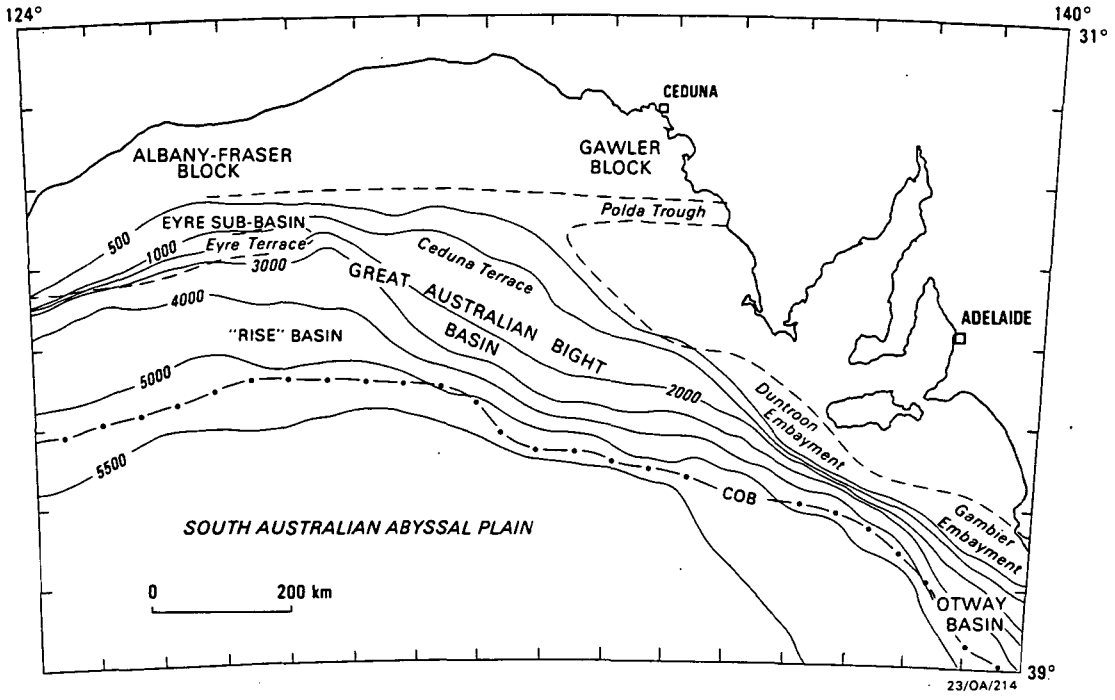

Figure 1: Bathymetry of the southern margin of Australia, showing bathymetric and structural provinces; contours in metres.

strike of the thin sheet, relative to an arbitrary origin;
T(x) is the total magnetic field intensity at x;
h is the depth to the top of the thin sheet;
x_0 is the position of the top, projected vertically to intersect the line;
A and B are parameters related to the magnetic properties and the thickness of the thin sheet as well as its orientation relative to the direction of the Earth's field.

For the more complex model which Hsu & Tilbury (1977) adopted, the anomalous magnetic field is considered to be the combination of the fields due to two thin sheets and a quadratic background magnetic interference. The magnetic field intensity arising from such a model can be expressed as

$$T(x) = ((A_1h_1 + B_1(x-x_1))/((x-x_1)^2 + h_1^2) + (A_2h_2 + B_2(x-x_2))/((x-x_2)^2 + h_2^2) + (a_0 + a_1x + a_2x^2)$$ --- Hsu & Tilbury (1977) equation 2

where the three terms correspond to the two thin sheets and the background, respectively. Since the horizontal derivative of the magnetic field arising from a magnetic interface has the same mathematical form as that of a thin sheet (equation 1, above), the same interpretation procedure can be applied to horizontal gradients of magnetic data, yielding the position, depth, and magnetic contrast of buried interfaces.

Equation (2) above contains 11 unknowns (A_1, h_1, B_1, x_1, A_2, B_2, h_2, x_2, a_0, a_1, a_2), of which the first eight are pertinent to the interpretation. To solve for these unknowns analytically at one point on the profile, a 'window' of 11 equi-spaced observed data values are required.

The interpretation is repeated for a number of passes of the sampling window, with the interpretation window opening wider at each pass (or 'level'), scanning progressively lower frequency events; in effect, this means that the technique searches for successively deeper sources. For deeper passes, the magnetic field is upward-continued to remove the high frequency components and, hence, the effects of shallow sources.

Each interpretation window produces a set of solutions based on either the interface model or the thin sheet model, but not both; the interpreter will normally require solutions from both models to produce a meaningful interpretation. While these models are simple geometrically and realistic geologically, magnetic anomalies may frequently arise from a variety of sources that have little correspondence to the models used in the Werner deconvolution program. In these cases, spurious estimates will be produced as the interpretation window scans over the 'bad' magnetic source.

WERNER DECONVOLUTION OF SIMPLE GEOLOGICAL MODELS

From their model studies, Stagg & others (1989) deduced the characteristics of sets of solutions associated with four different models (buried scarp, graben, half-graben, reversely magnetised horizontal sheets in contact; Figs 2-5). The principal conclusions

were that:

- When a major fault occurs in basement (eg a head-wall fault), the interface model will reliably define the upper extent and position of the fault whereas thin sheet solutions provide a reasonable indication of its throw (Figure 2);

- The narrow graben is accurately defined in position by the interface model, but depth estimates of the flanking basement are about 15% too shallow (Figure 3); the error in depth estimate of the flanking basement increases as the graben becomes narrower until the limiting case of Figure 5 (zero graben width) is reached. Modelling of grabens with a range of width:depth ratios shows that the depth extent is quite well-defined by the thin-sheet model (Figure 3);

- The bottom corners of a graben will only be resolved if the graben walls have low dip;

- The corners of a half-graben are fairly well resolved by the interface model and the depth extent by the thin sheet model (Figure 4);

- In nearly all cases, the Werner solutions have a tendency to over-estimate dip;

- Adjacent blocks of reversed magnetisation in contact (Figures 5), which simulate the case producing oceanic spreading anomalies, produce an interesting result. The interface model under-estimates the depth to the boundary by as much as 40%; in contrast, the thin sheet model defines the interface very closely. This agrees with the findings of Aero Service Corporation (1974). By using the thin sheet model, it should be possible to produce profiles of depth to oceanic crust and variation in thickness of the magnetised layer when seismic data are not available.

Finally on these simple models, Stagg & others (1989) noted the presence of characteristic 'outlier' groups of estimates (see particularly Figures 2, 3, & 5), which frequently cluster to form ellipses or spirals. Such clusters are geometrically related to the particular model and can, in some cases, be used as an interpretational aid. Specific examples of these features occur -

- in the case of basement corners (scarp, graben) generated with the interface model, where ellipses are produced on the upfaulted side with the lower edge of each ellipse at the same depth as the basement surface (Figures 2, 3), and where spirals are produced on the low magnetisation side of the fault plane (Figure 2).

- With the adjacent reversely-magnetised blocks (Figures 5), where spirals are present on each side of the boundary, but at a much shallower level.

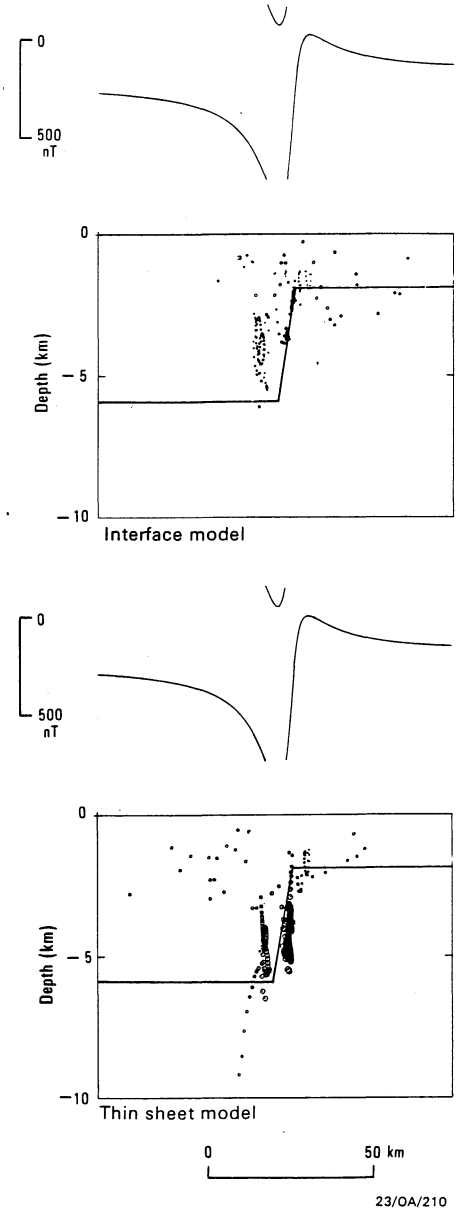

Figure 2: Magnetic depth estimates for a buried scarp - interface and thin sheet models. In this and Figs 3-5, estimates are plotted with the size of the symbol proportional to the square of the log of intensity, and the direction of annotation of the symbol being the direction of magnetisation. Vertical exaggeration is 8.2:1.

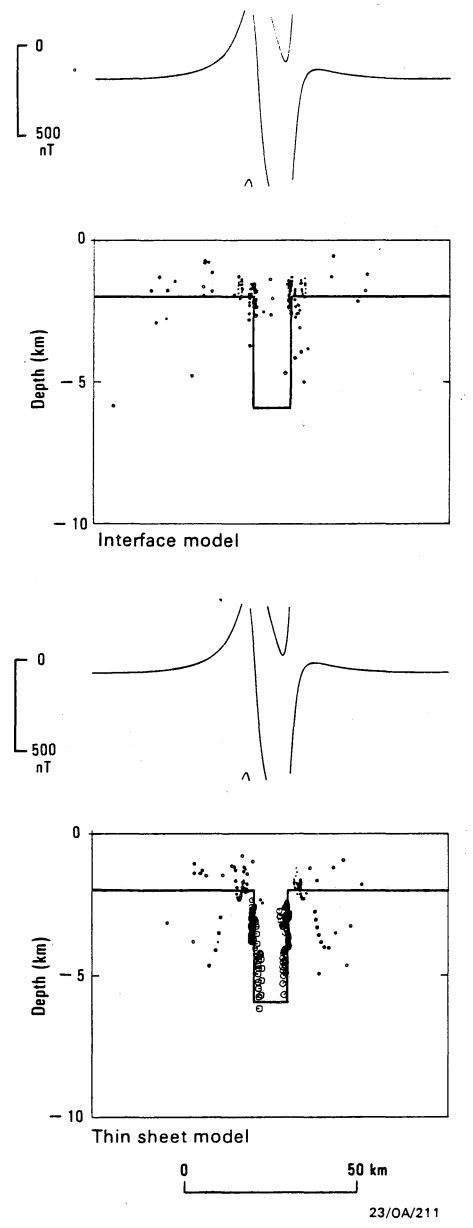

Figure 3: Magnetic depth estimates for a graben - interface and thin sheet models.

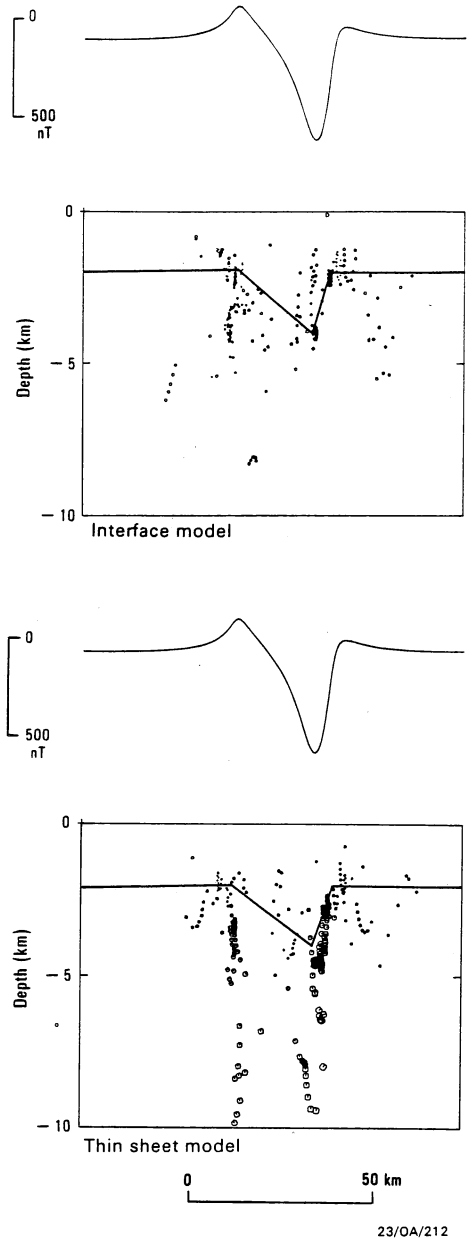

Figure 4: Magnetic depth estimates for a half-graben - interface and thin sheet models.

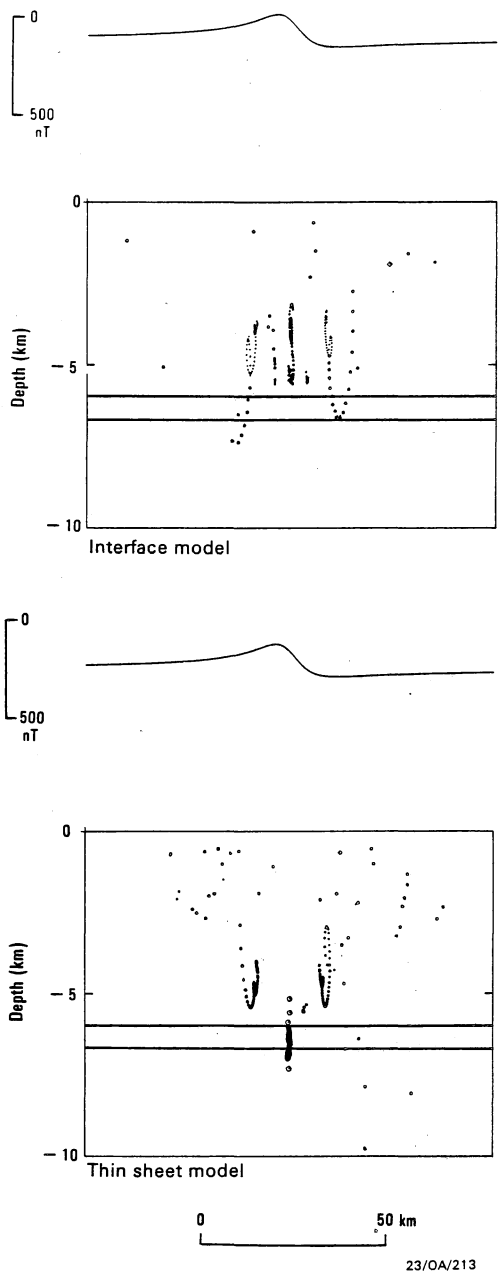

Figure 5: Magnetic depth estimates for adjacent reversely-magnetised horizontal sheets - interface and thin sheet models.

MAGNETIC DATA SET

The magnetic data from which the Werner-deconvolved profiles of this Record have been derived come from two sources (Plate 1), *viz* -

1) The Bureau of Mineral Resources (BMR) Continental Margin Survey (CGG, 1975). These data were recorded during Surveys 16 and 19 along lines that extended from near the coast to the abyssal plain. The data are of high quality and have had diurnal corections applied; low-quality reflection seismic data are available along these lines;

2) BMR Continenal Margins Program Surveys 65 (Willcox, Stagg, Davies, & others, 1988). This data set was recorded aboard the RV *Rig Seismic* during a program that was designed specifically to investigate the tectonic evolution of the cenral Great Australian Bight. Diurnal corrections have not been applied to the magnetic data; high-quality 24-fold reflection seismic data are available along the same lines.

Both data sets and files containing the interpreted Werner depth estimates are available from:

The Marketing Manager,
Division of Marine Geosciences & Petroleum Geology,
Bureau of Mineral Resources,
GPO Box 378,
CANBERRA ACT 2601 Australia.

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GREAT AUSTRALIAN BIGHT

SOUTHERN MARGIN

PLATE 1

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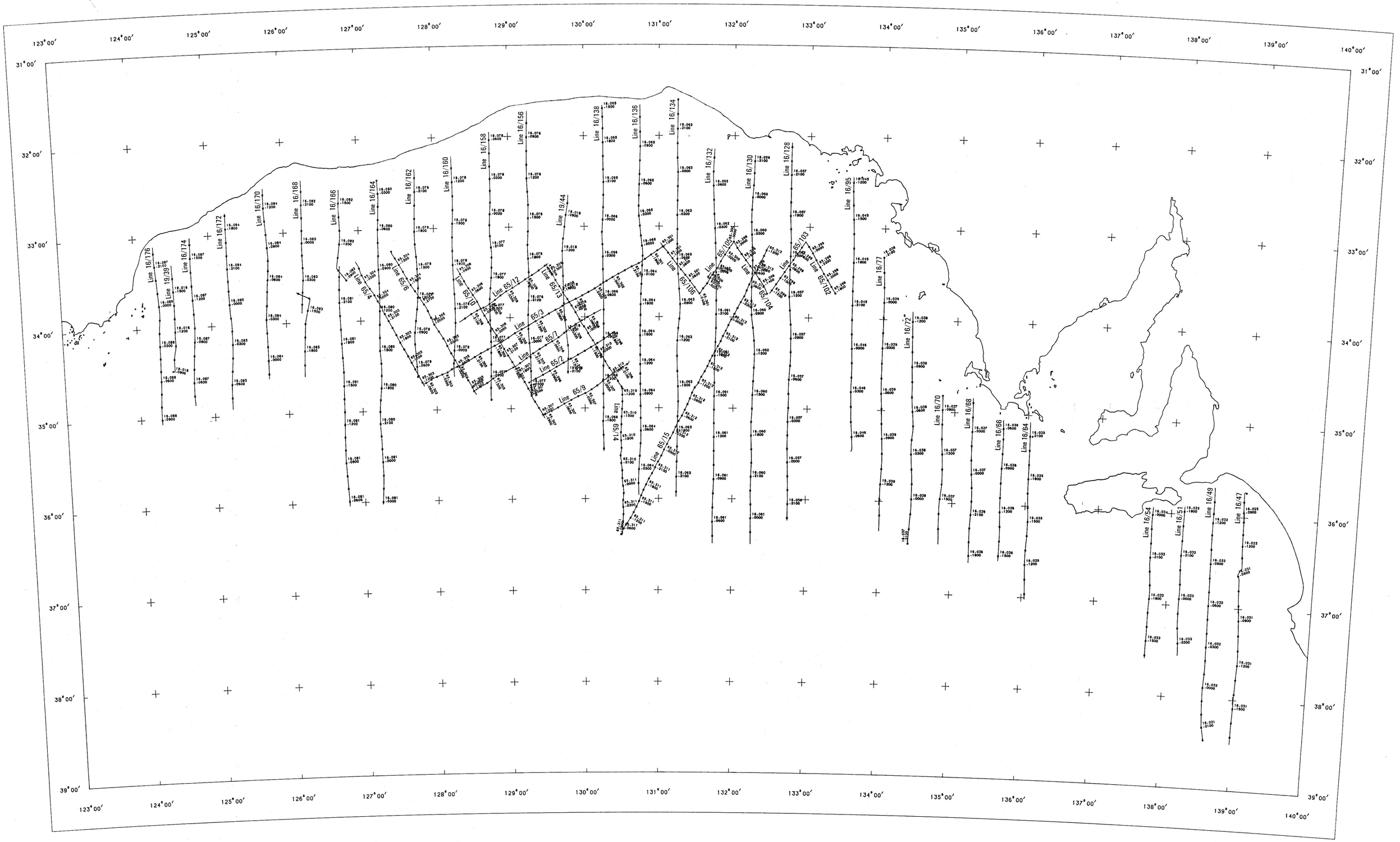
EDITION OF 1988/06/09



SIMPLE CONICAL PROJECTION
WITH TWO STANDARD PARALLELS
AT 18°00′ AND 36°00′ SOUTH

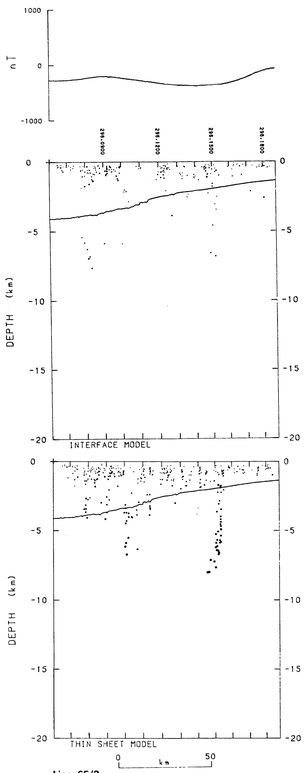
WERNER PROFILE
LOCATIONS

GREAT AUSTRALIAN BIGHT
SOUTHERN MARGIN

Record 1990/83

23/OA/574

PLATE 2



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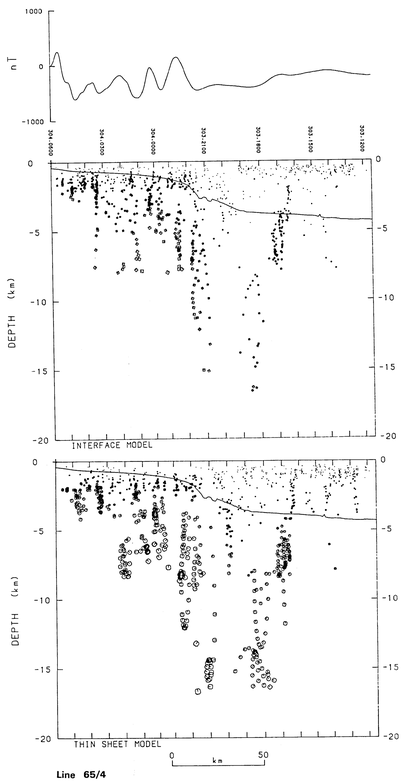

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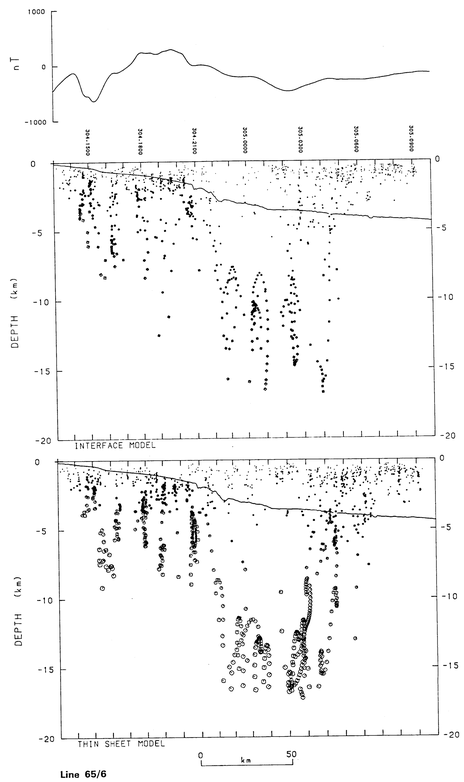

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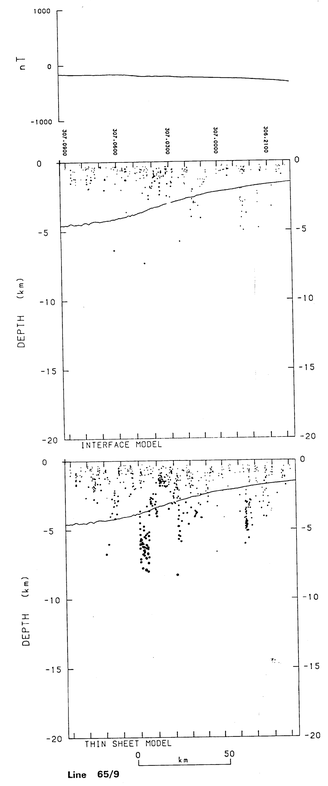

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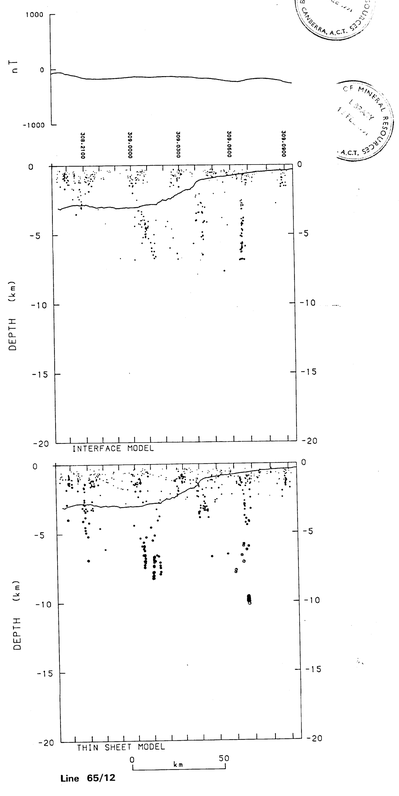

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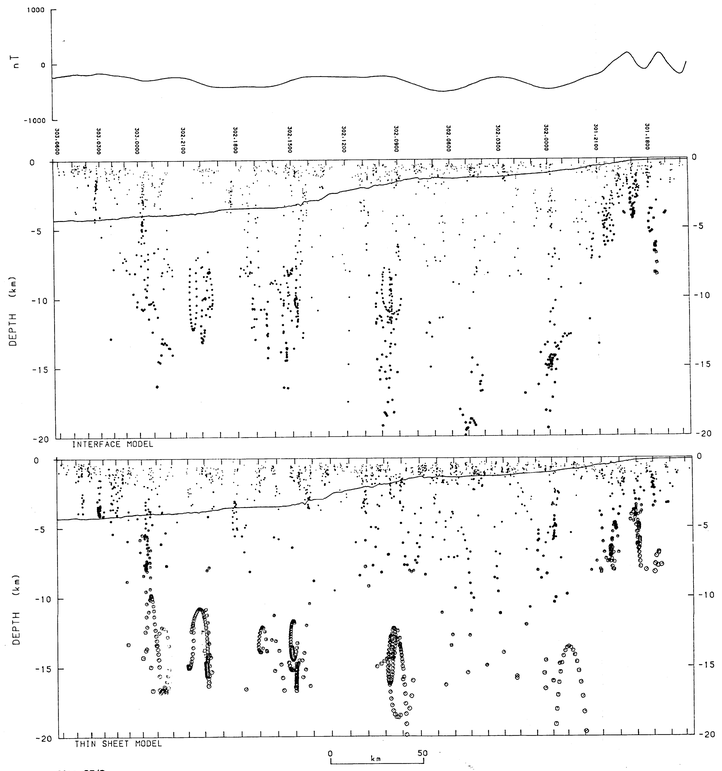

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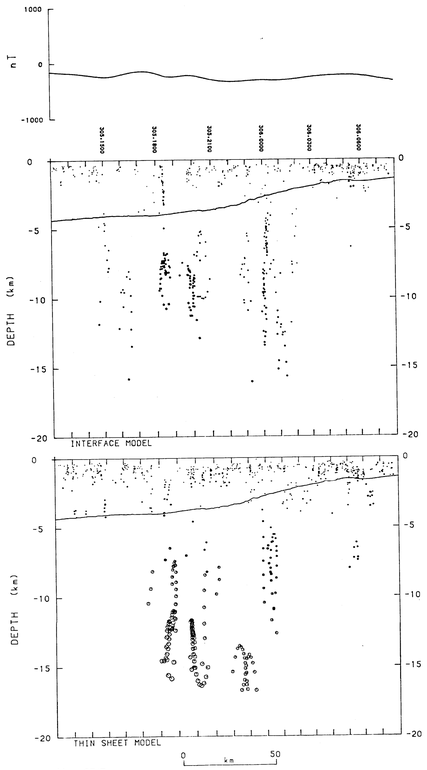

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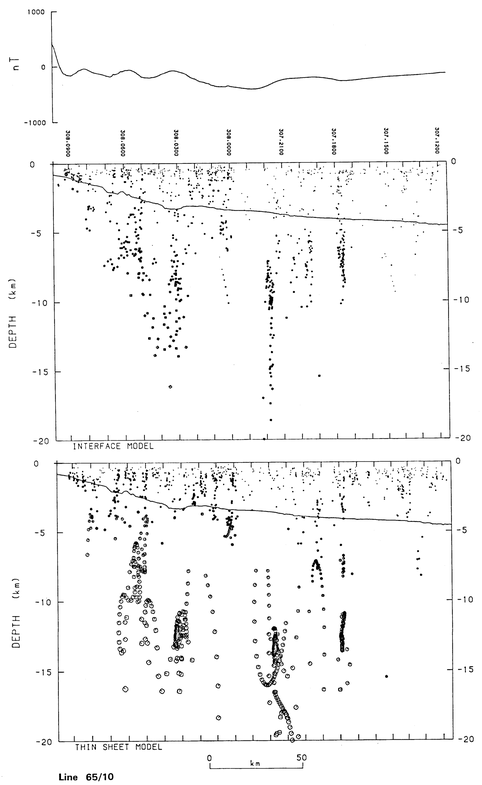

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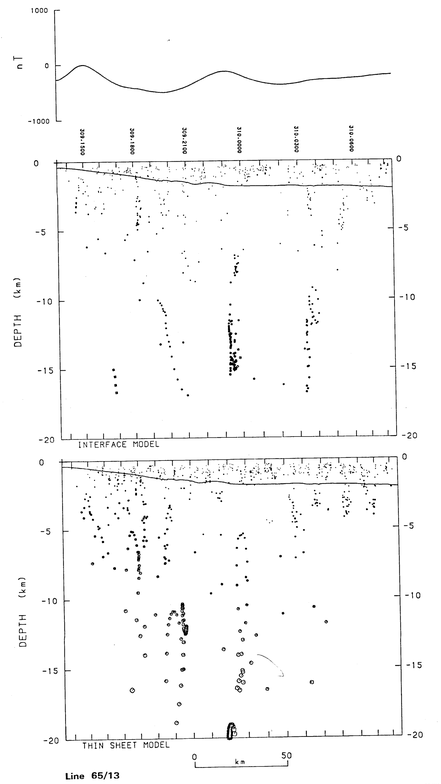

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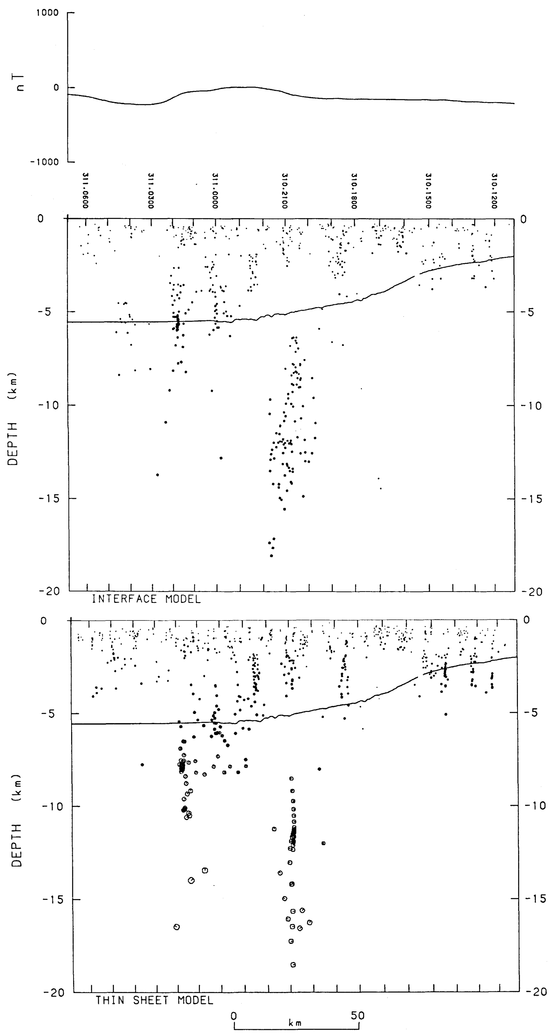

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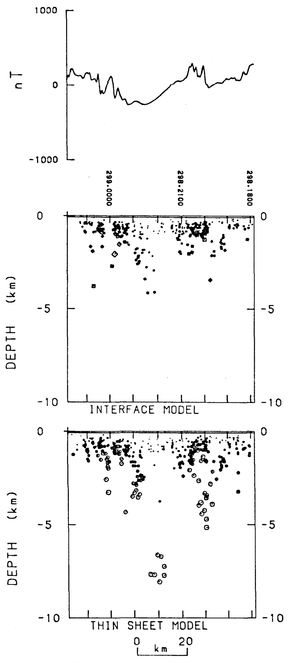

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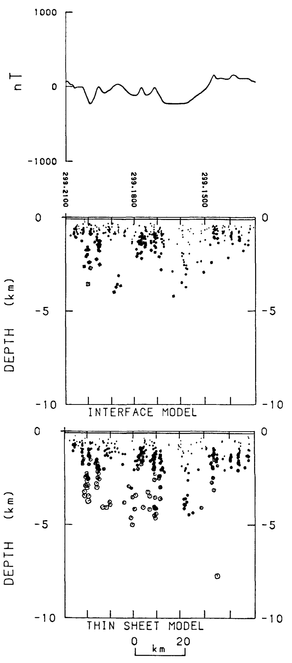

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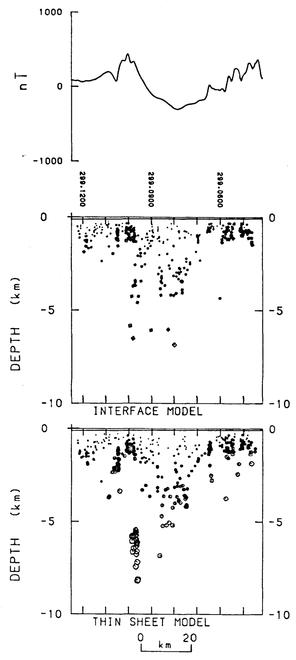

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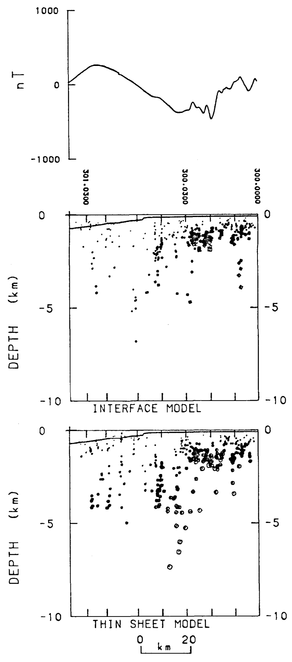

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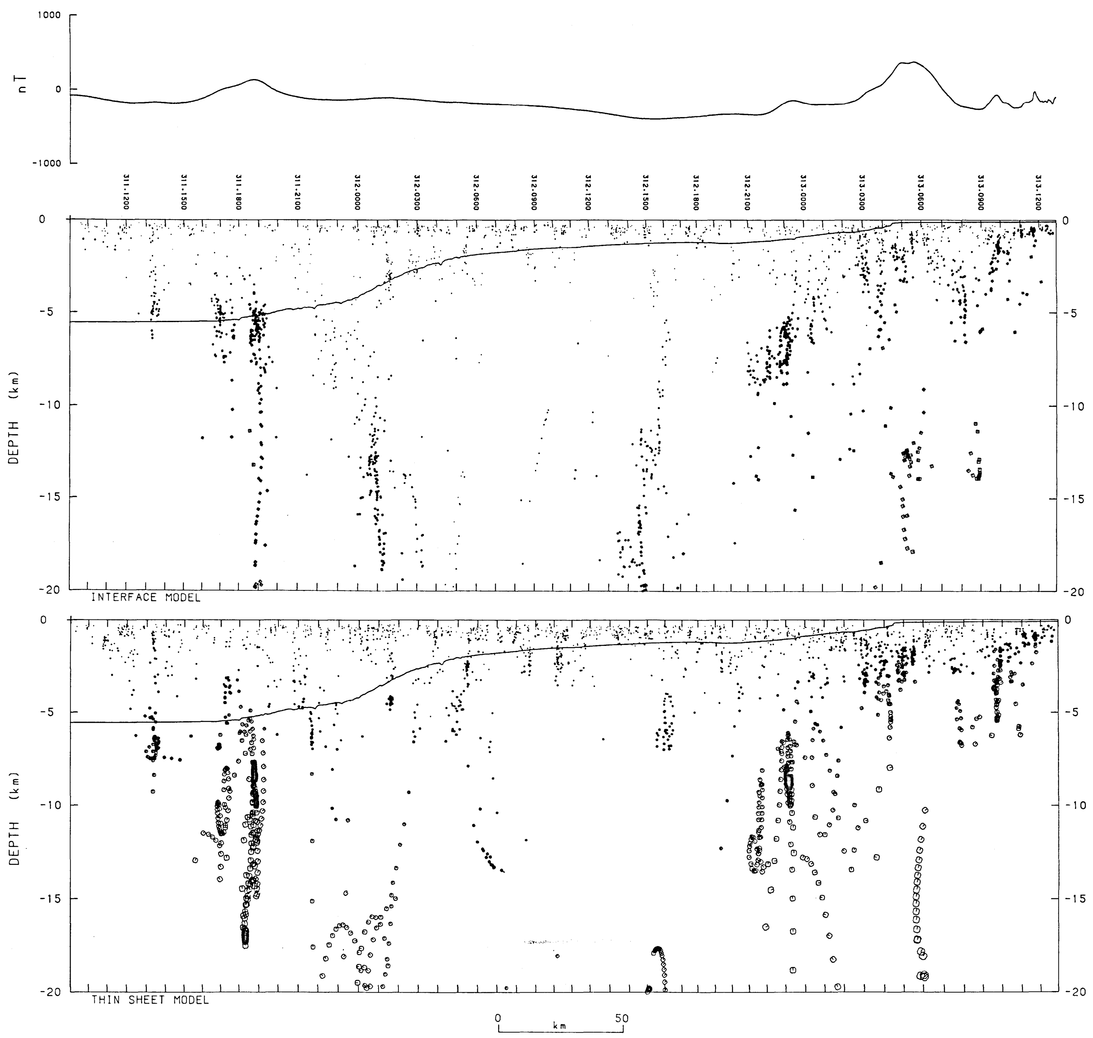

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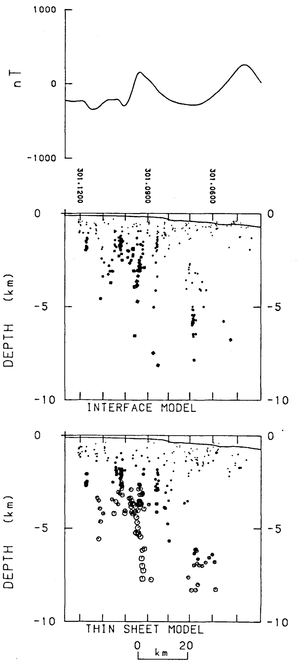

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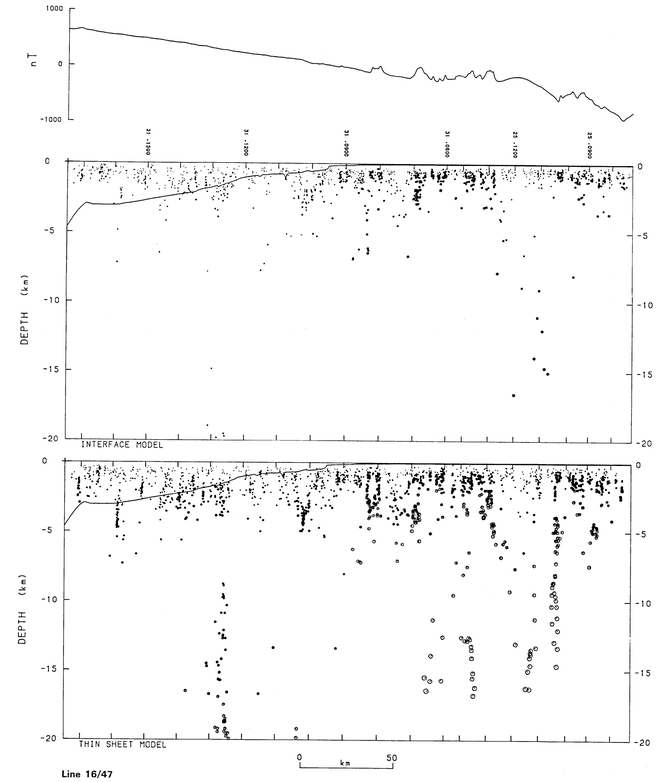
PLATE 4



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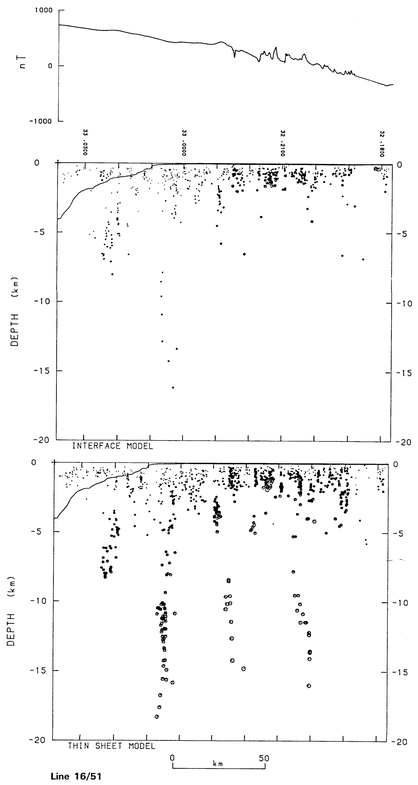

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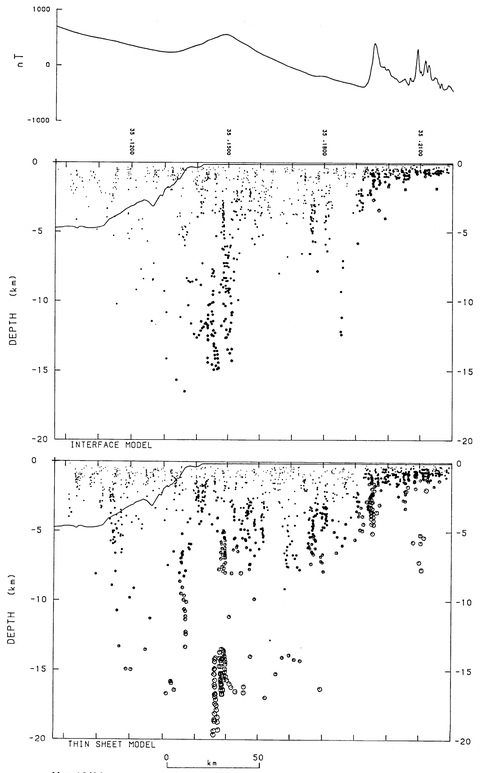

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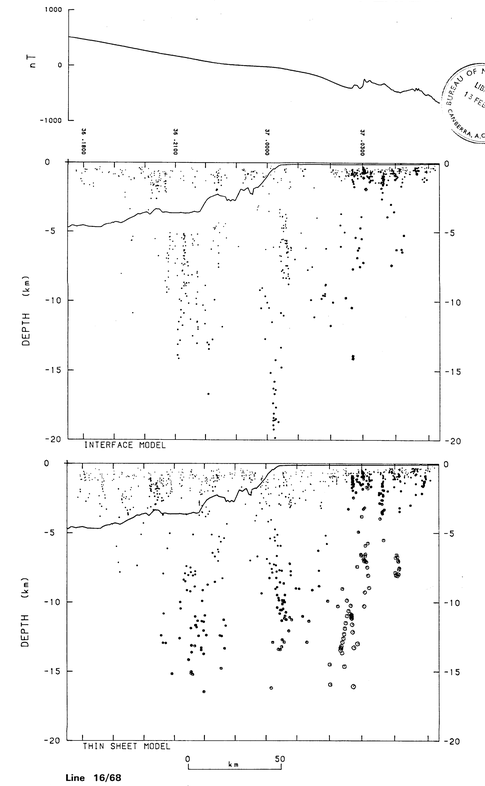

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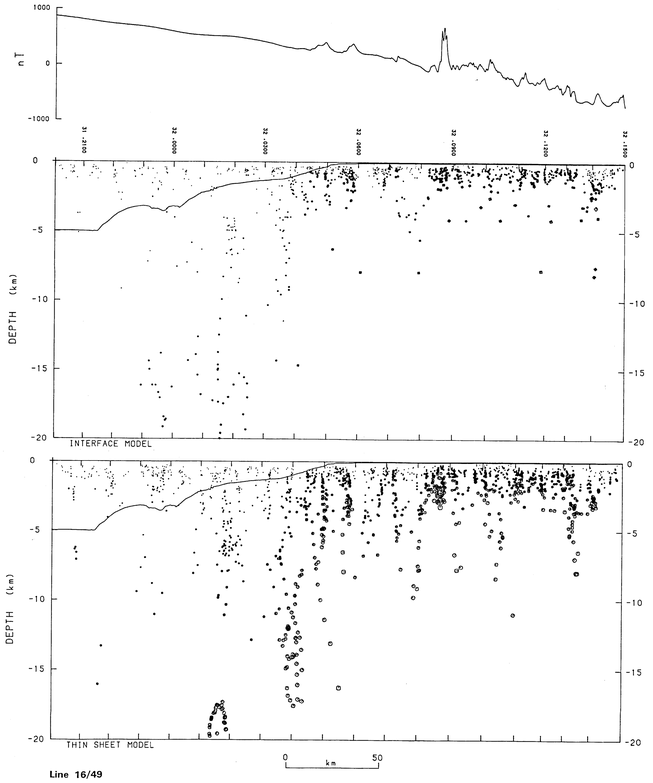

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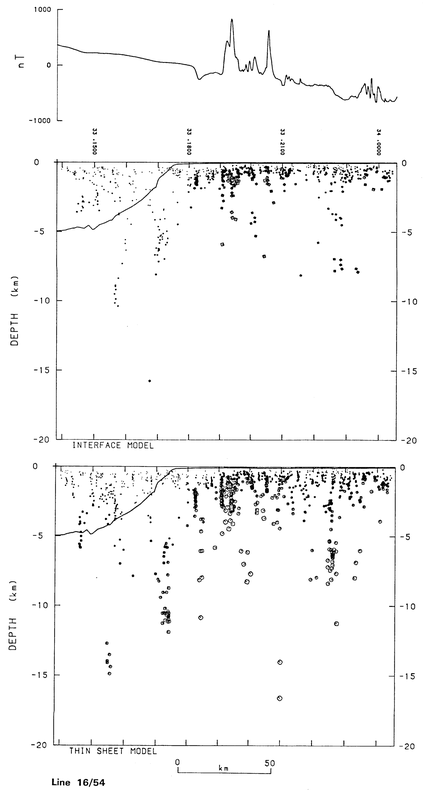

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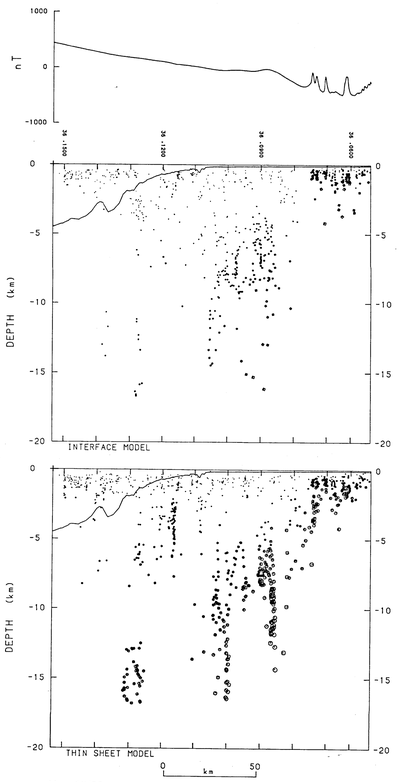

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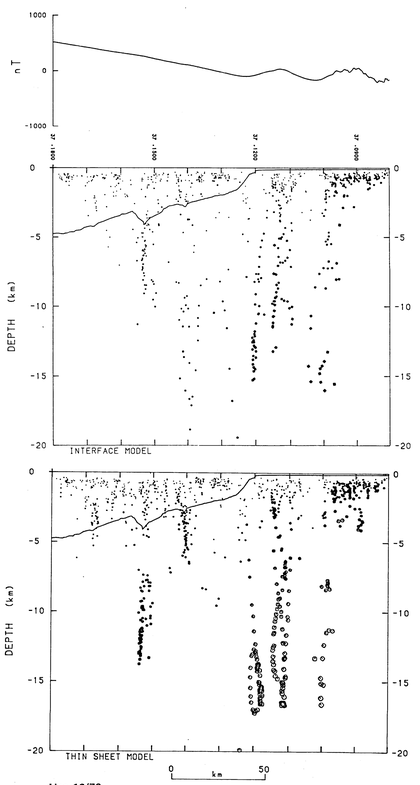

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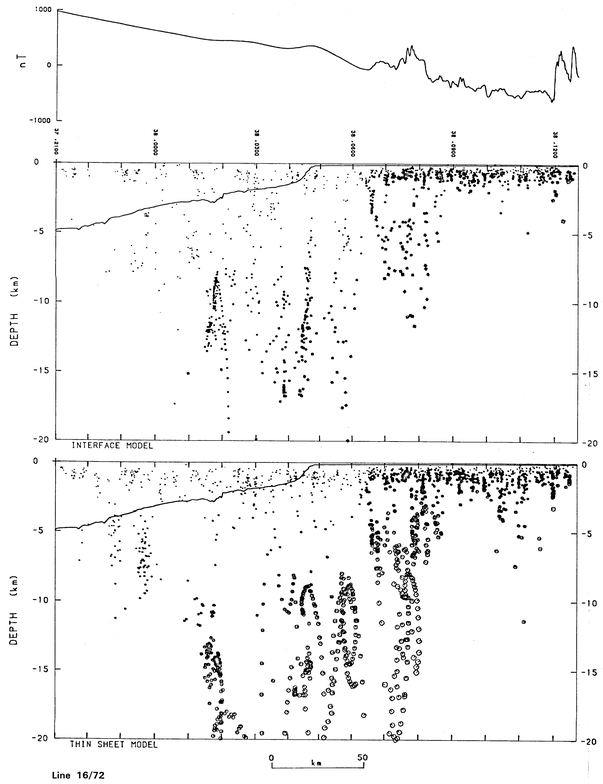
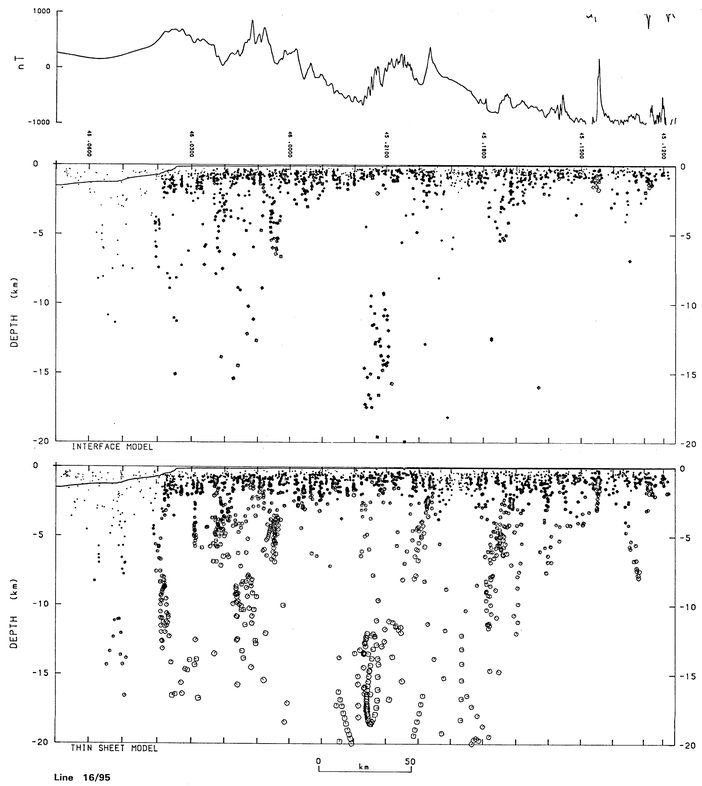
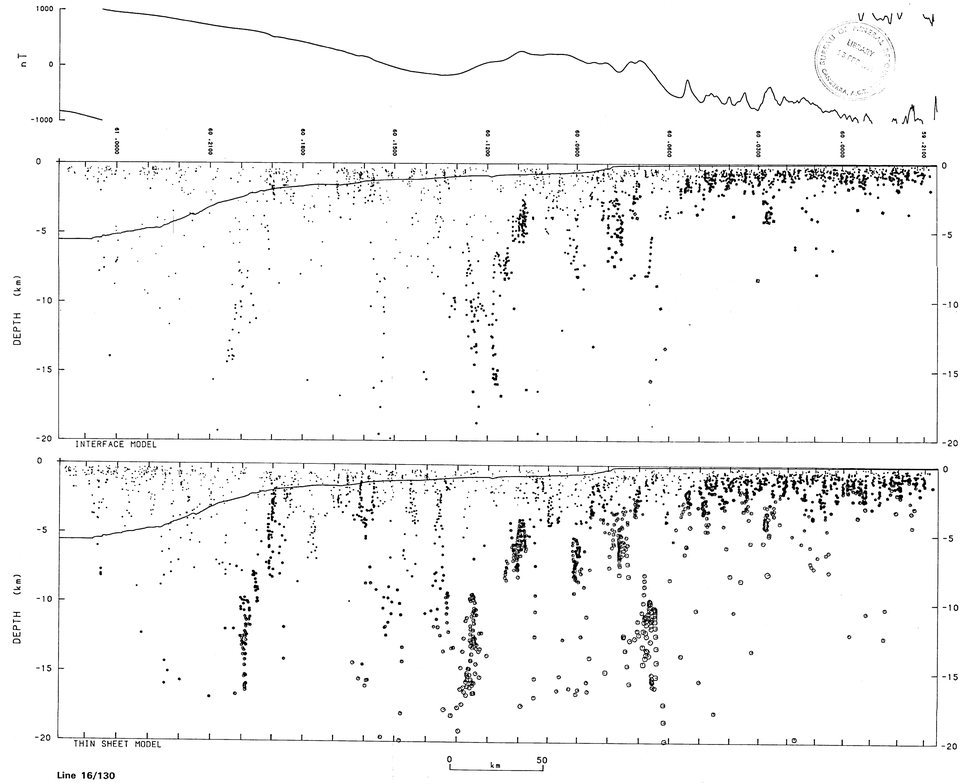
PLATE 5



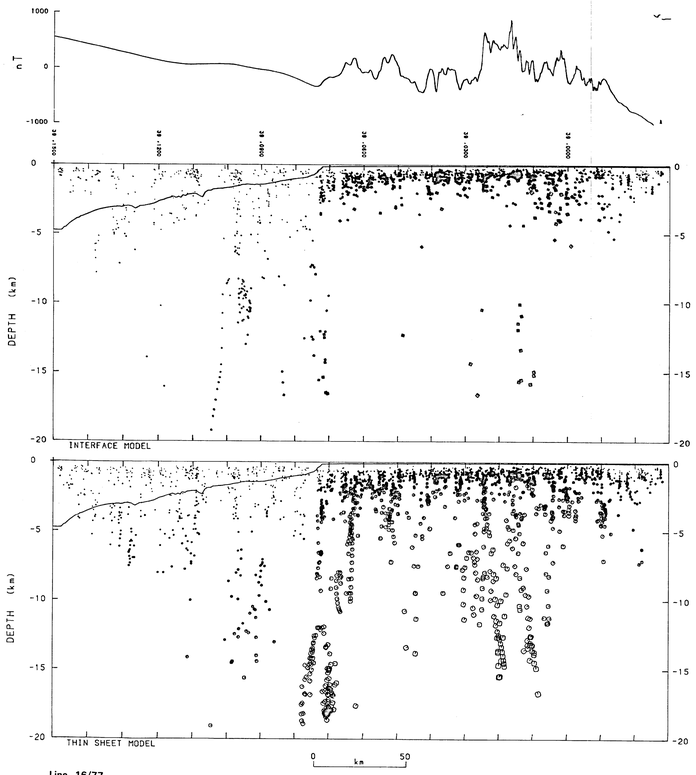
Line 16/72



Line 16/95



Line 16/130



Line 16/77

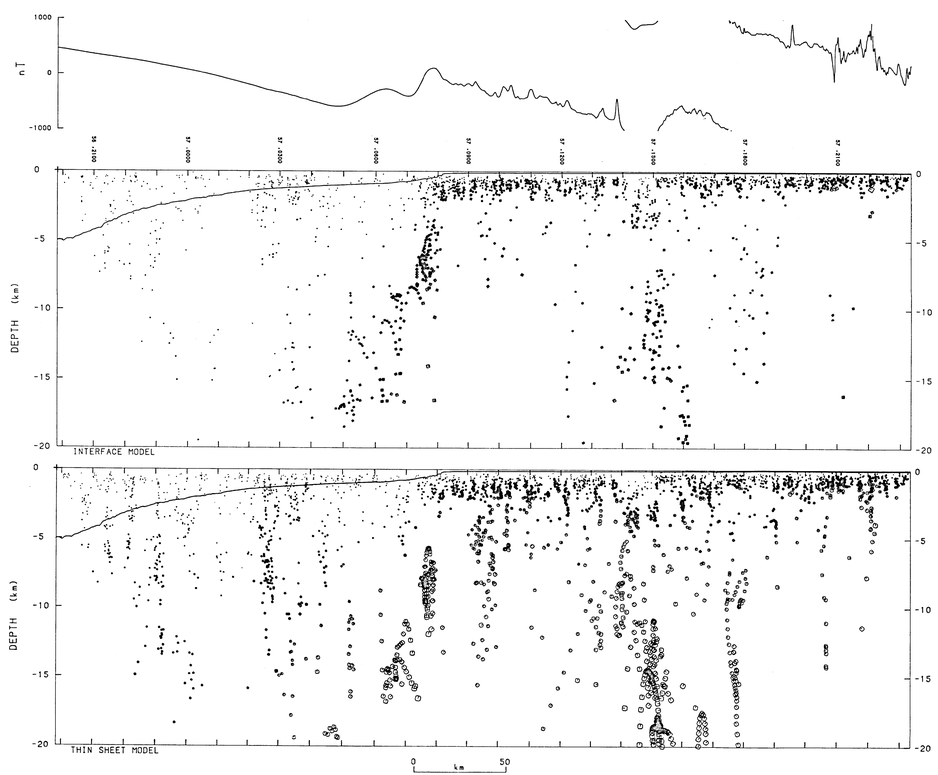


PLATE 6

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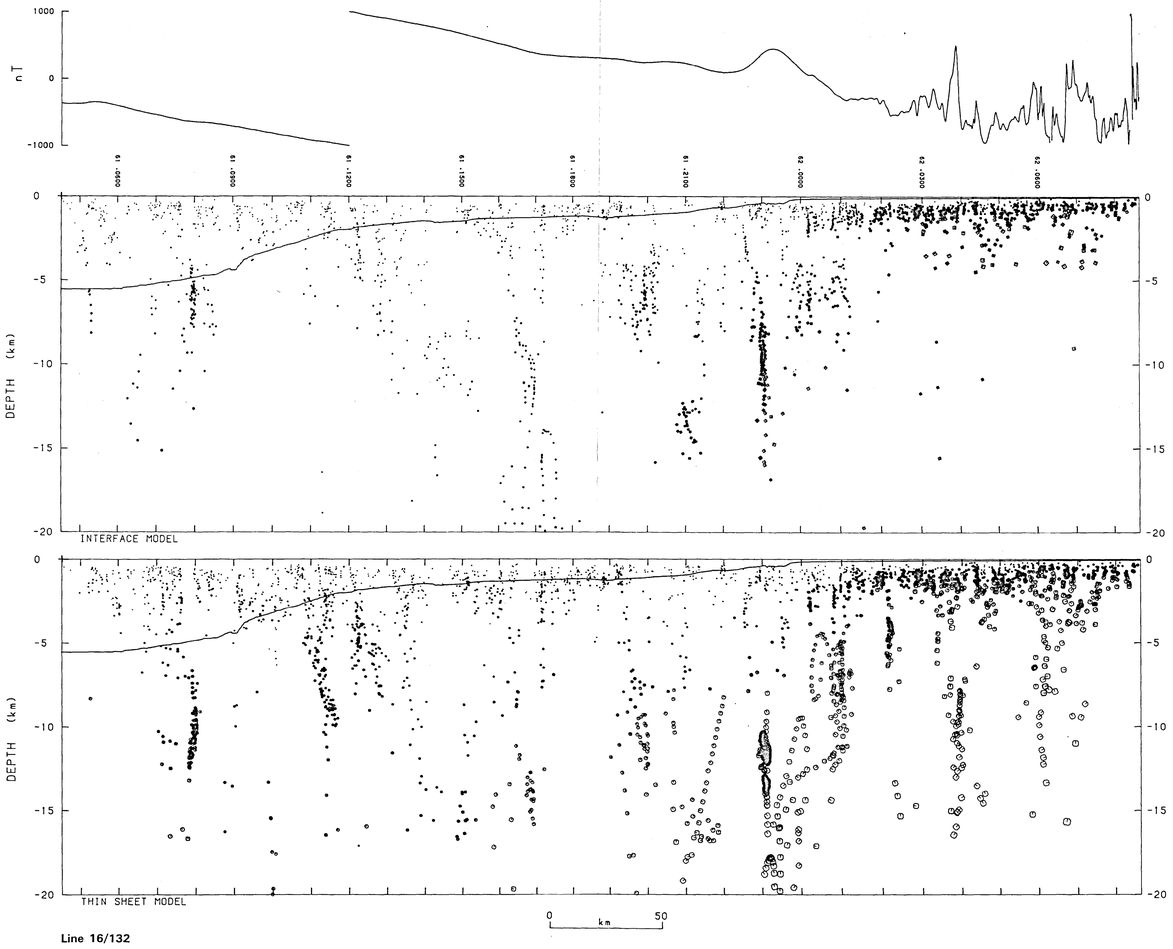
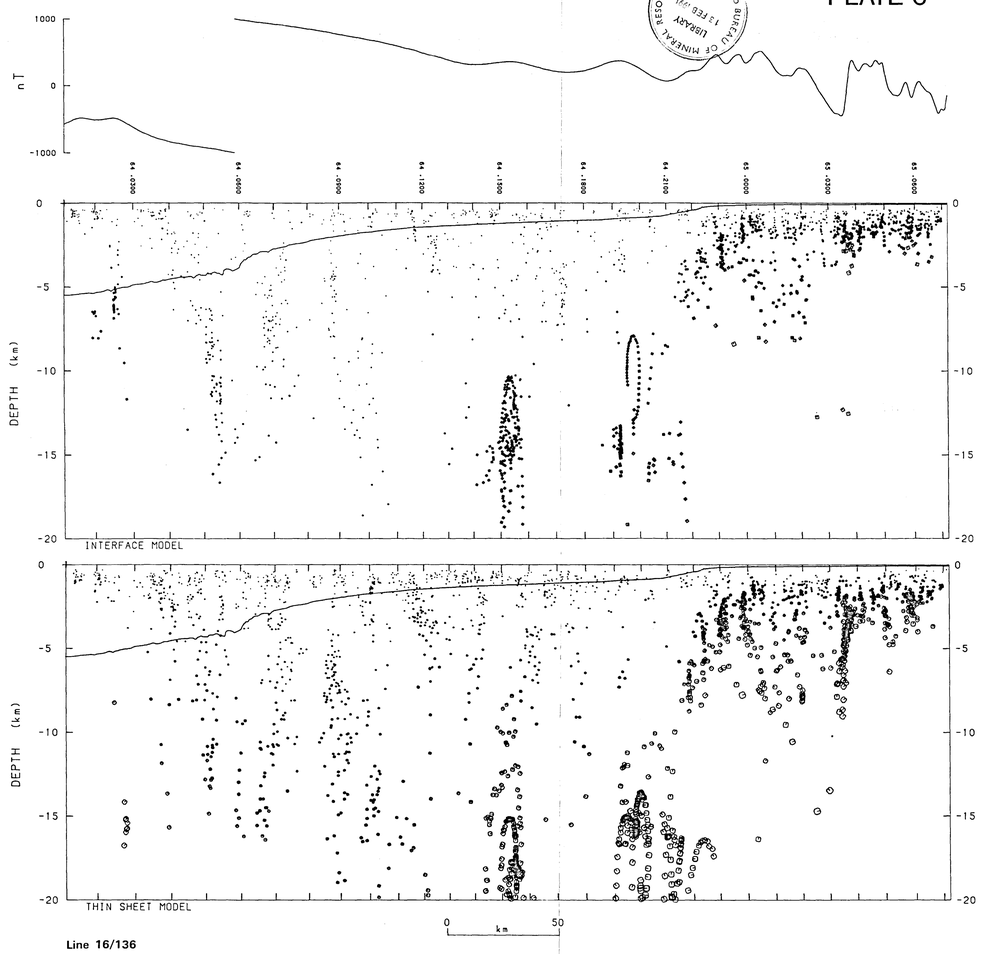
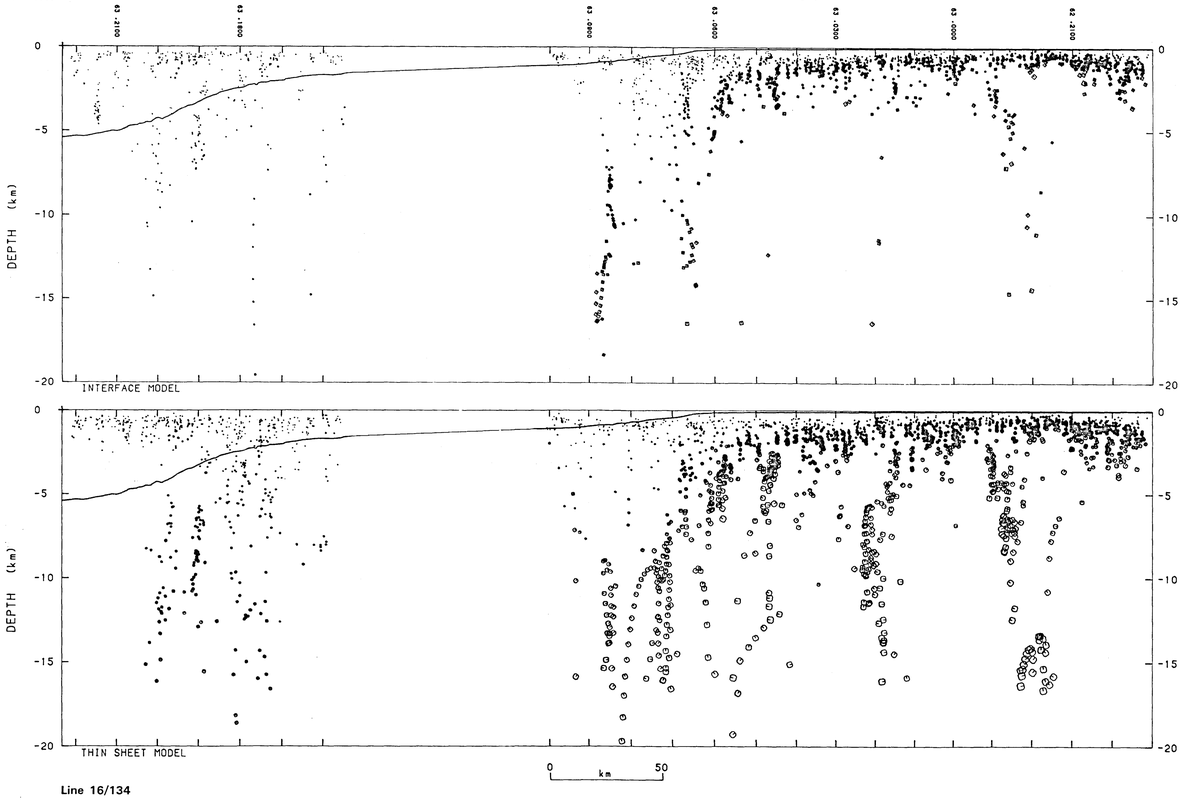


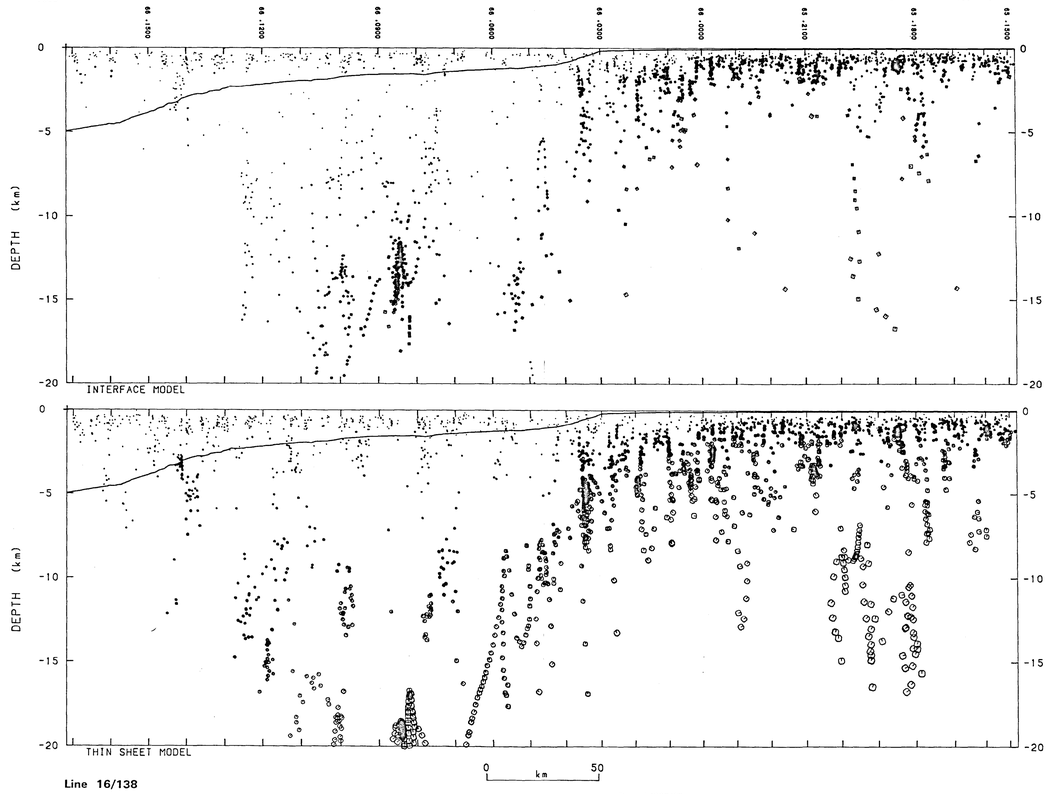
Line 16/132



Line 16/136



Line 16/134



Line 16/138

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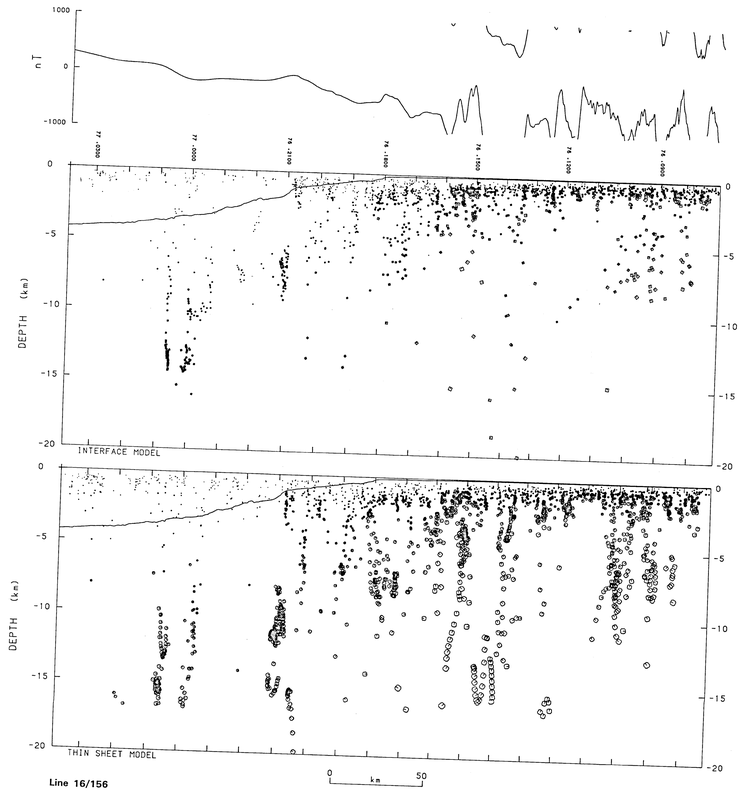
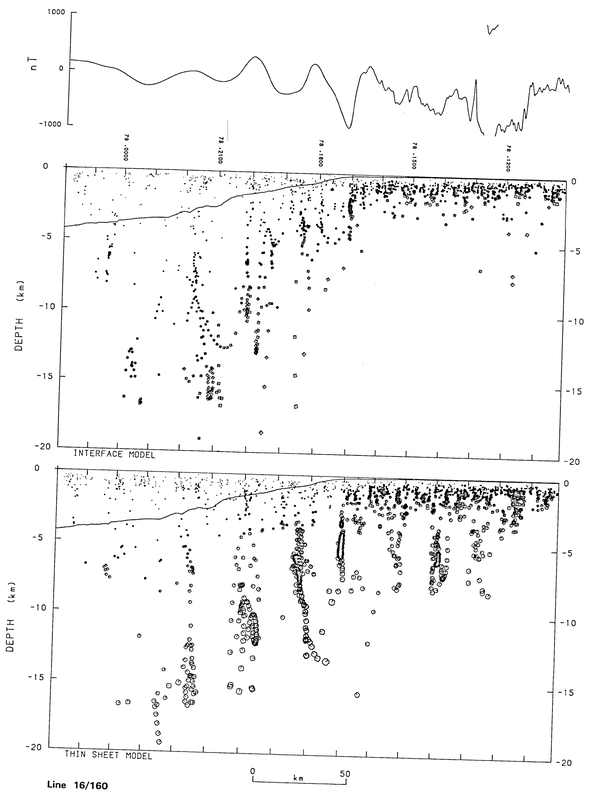
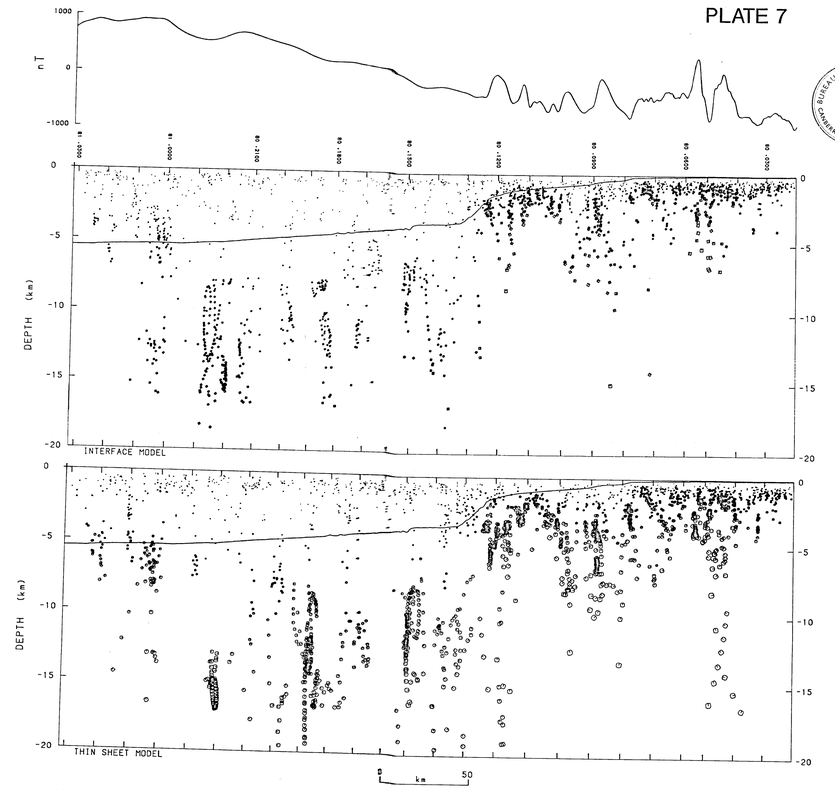
PLATE 7



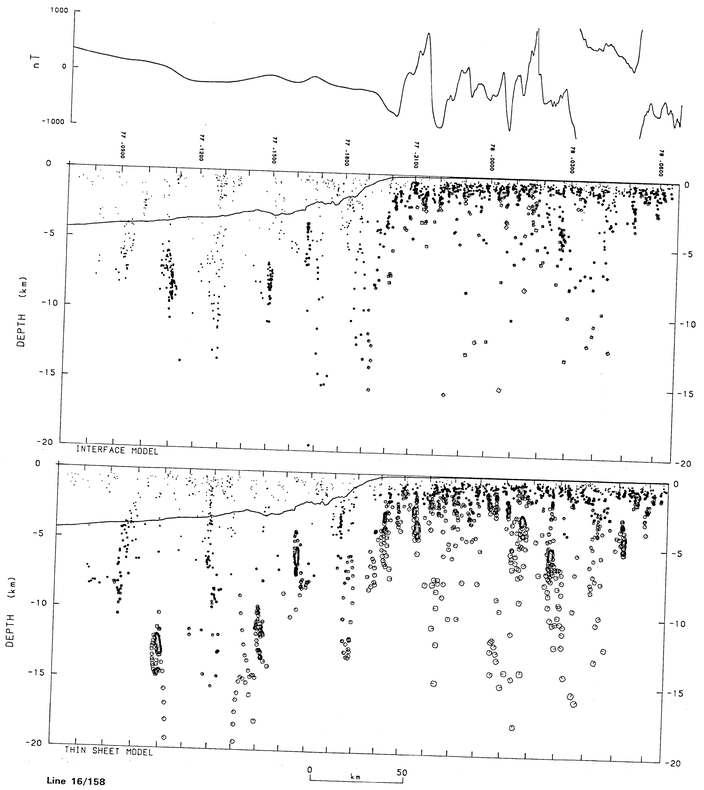
Line 16/156



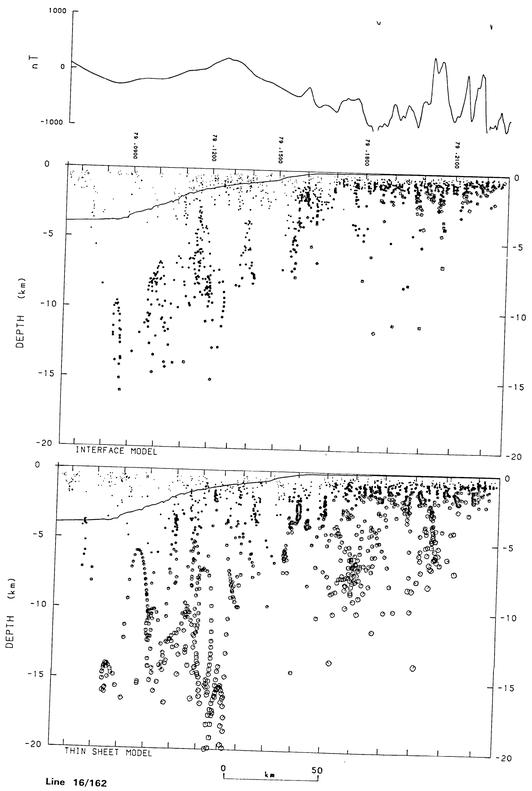
Line 16/160



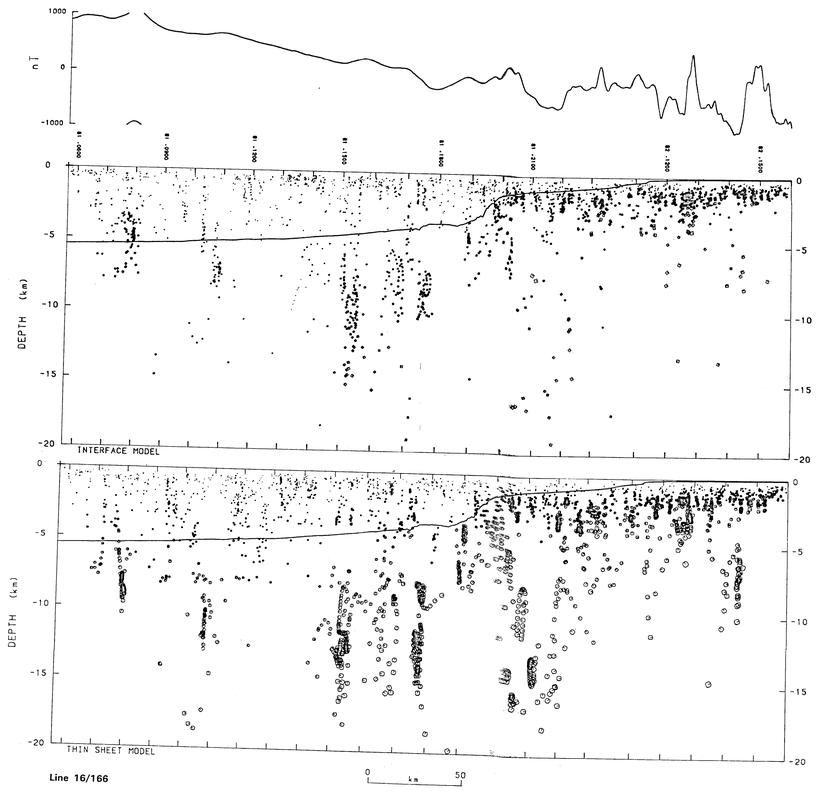
Line 16/164



Line 16/158



Line 16/162



Line 16/166

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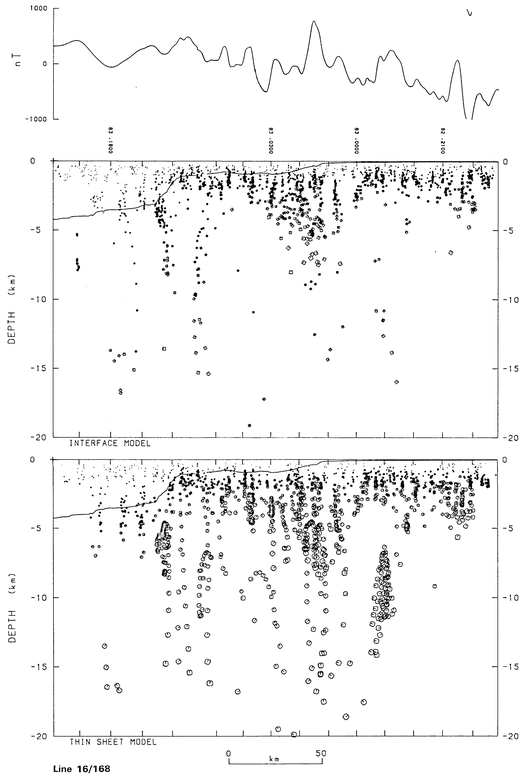
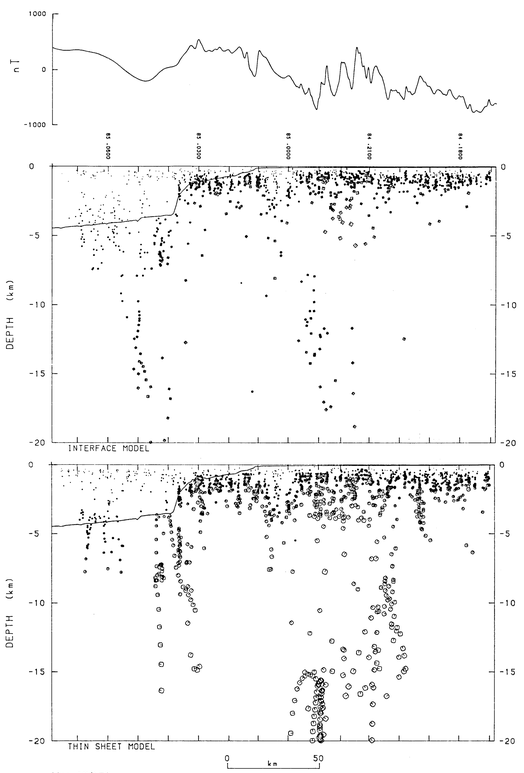
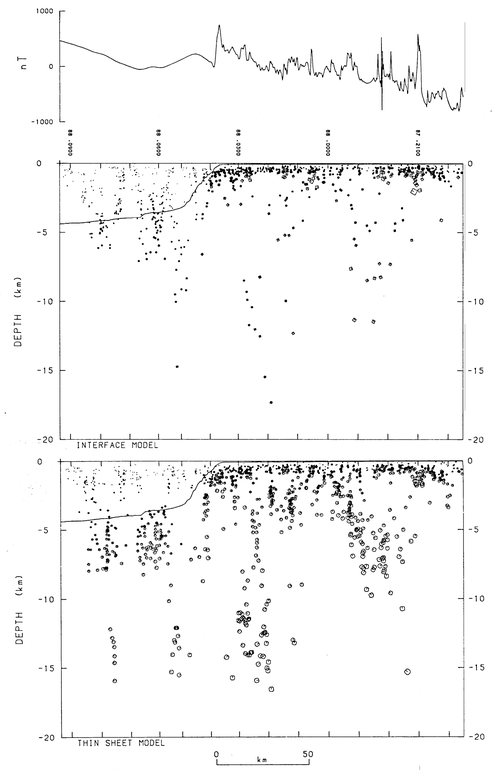
PLATE 8



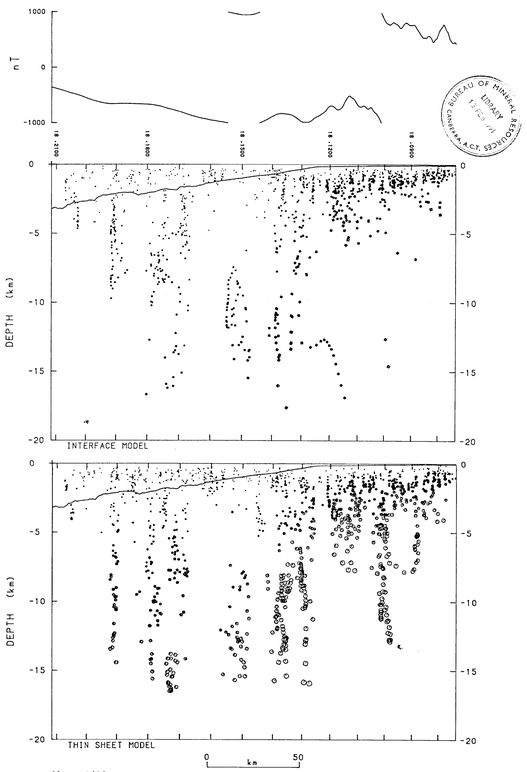
Line 16/168



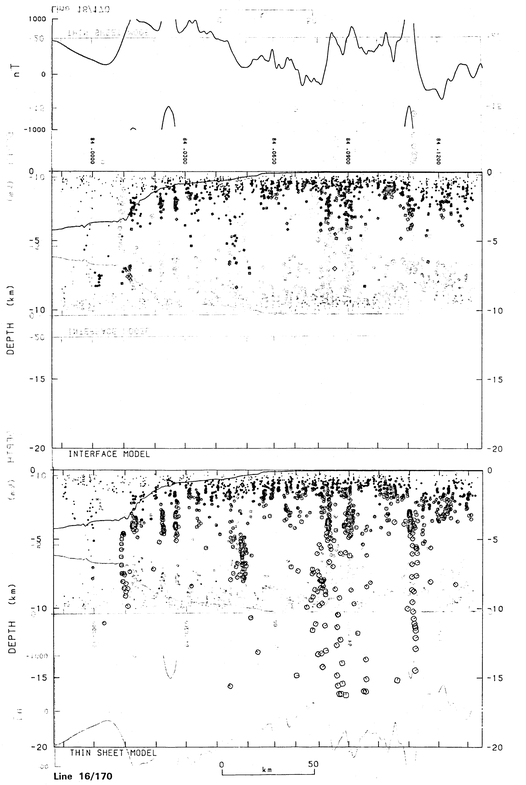
Line 16/172



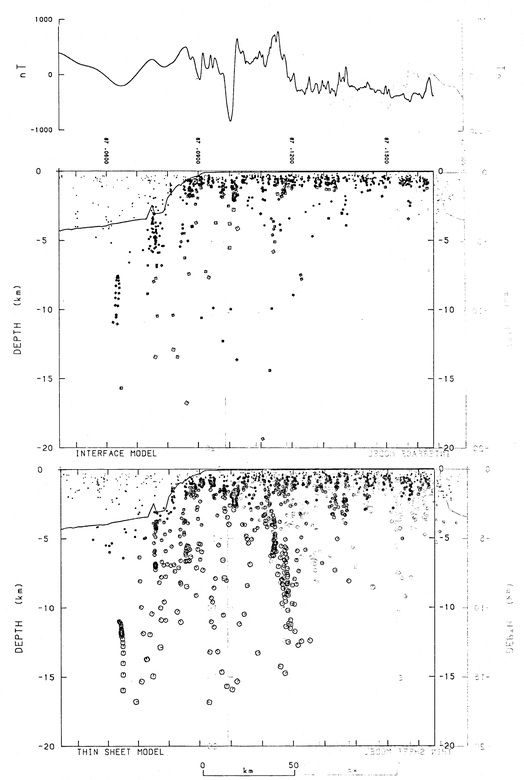
Line 16/176



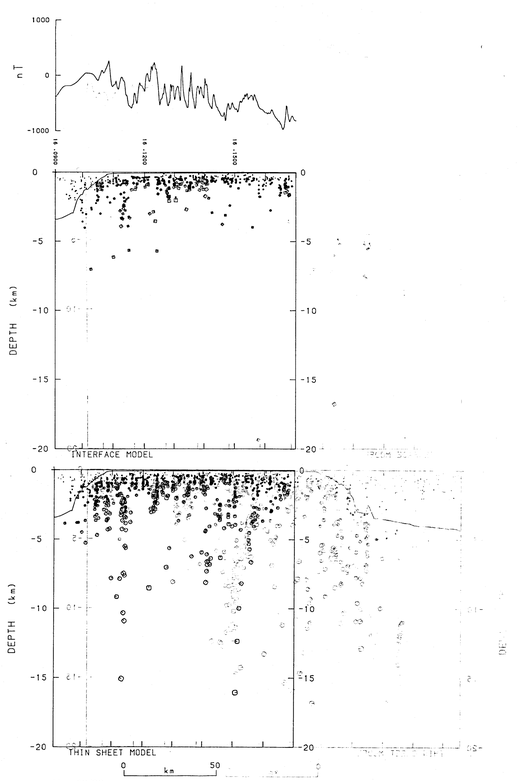
Line 19/44



Line 16/170



Line 16/174



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