Bedrock Elevation Studies in Queen Maud Land, Antarctica

B.B. Bhattacharya and T.J. Majumdar*

Department of Applied Geophysics, Indian School of Mines, Dhanbad—826004.

ABSTRACT

Magnetic anomaly map prepared from the MAGSAT data over the Ross ice shelf has been correlated with the available bedrock elevation data to develop a model which has been subsequently used to generate the bedrock elevation data in Queen Maud Land region of Antarctica. The results are in agreement with some control data available from the Queen Maud Land region.

INTRODUCTION

Some geophysical work was carried out in Antarctica during the 1930s and 1940s but the 1950s saw the beginning of systematic seismic reflection, refraction, gravity, ground magnetic and aeromagnetic studies. Radio echo ice sounding from the air enabled continuous measurements of bedrock topography over large areas of Antarctica (Drewry, 1975). Aeromagnetic data have been obtained on a reconnaissance basis on widely spaced profiles from some parts of Antarctica. On the basis of aeromagnetic measurements, Behrendt and Wold (1963) and Behrendt (1964) reported more than 5 km thickness of the sedimentary column west of Ellsworth mountains. Jankowski and Drewry (1981) inferred thick sedimentary rocks in this area on the basis of aeromagnetic and radio echo ice sounding data. Behrendt et al. (1974) reported thick sedimentary rock between the Pensacola and Ellsworth mountains. Behrendt (1983) used the aeromagnetic data of 1960 from the Ross ice shelf area and obtained generalised bedrock elevation in the Ross ice shelf.

TABLE I

Brief description of MAGSAT information bulletin, 1980.

MAGSAT	Magnetic field satellite
Launch date	October, 1979
Orbit	Elliptical sun synchronous
Altitude range	350-550 km
Inclination	97°
Sensors	Two magnetometers — one scalar (dual lamp cesium vapour magnetometer) — one vector magnetometer
Resolution	350 km (approx.)
Major goals	To develop a world wide vector magnetic field model. Correlation and development of models for Earth's crust.
Operational	Till June, 1980
Data	In CCT Format

*Research Scholar (External), Department of Applied Geophysics, Indian School of Mines, Dhanbad-826004.

Ritzwoller and Bentley (1982) used MAGSAT data over Antarctica by which a preliminary map of the crustal scalar magnetic anomaly map over the land mass and surrounding oceans was produced. A correlation could be established between the various tectonic features off the ocean as well as of the main land mass. It is fortunate and interesting that magnetic fields generated by the crustal sources can be isolated from the satellite magnetic data and from those generated in the core and those external to the earth (Regan and Marsh, 1982; Ritzwoller and Bentley, 1983). Thus the MAGSAT can be gainfully employed to obtain a general picture of the thickness of the sedimentary column or depth to the bedrock over a large area of Antarctica. In this paper bedrock elevation studies have been attempted in the Queen Maud Land area of Antarctica (Fig. 1) by using MAGSAT data. A brief description of MAGSAT is given in Table I.

DATA SOURCE AND AREA OF INTEREST

Magnetic anomaly data over the Ross ice shelf have been obtained from Ritzwoller and Bentley (1983) who have used the various passes of MAGSAT over Antarctica to generate the total field

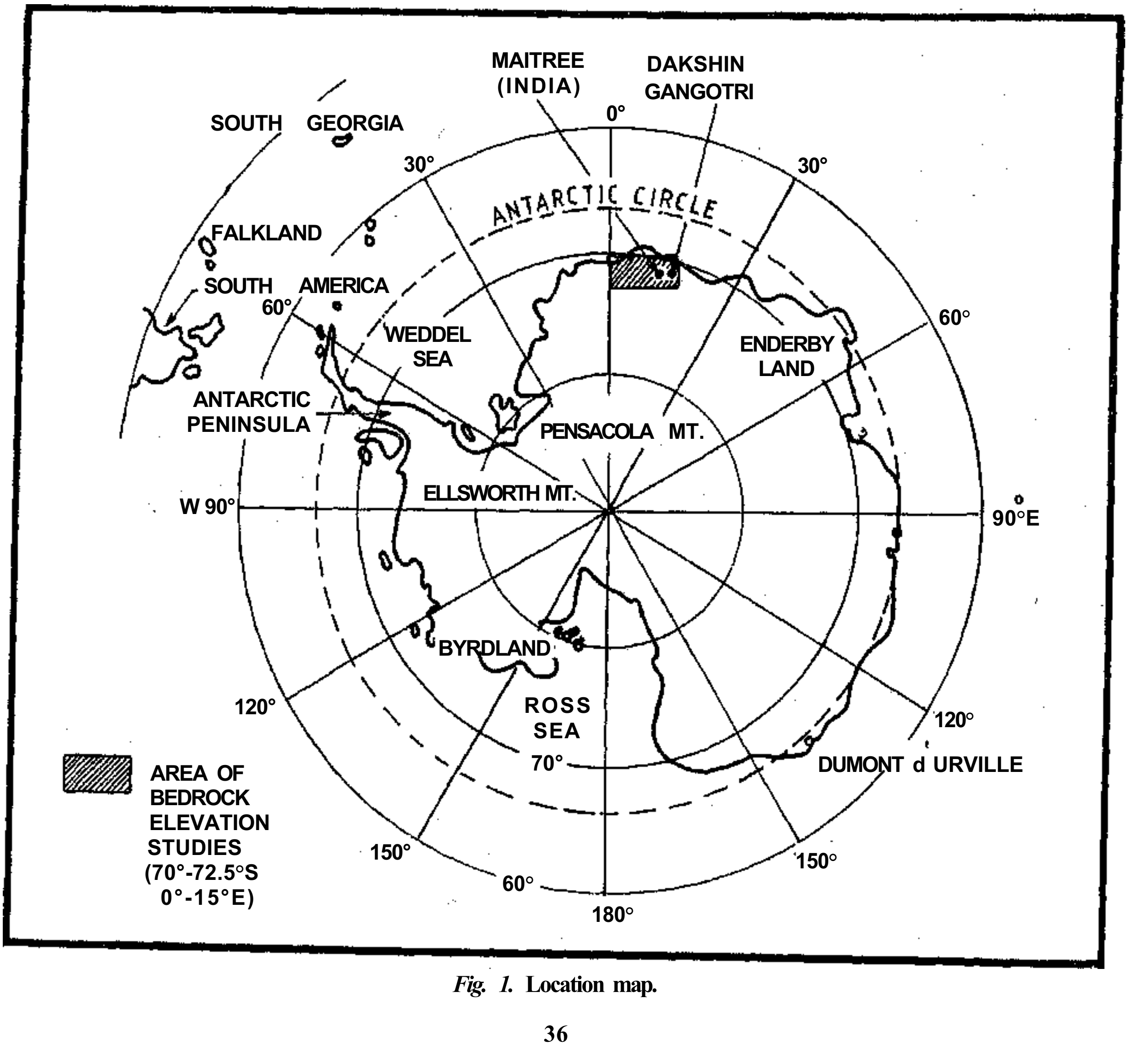
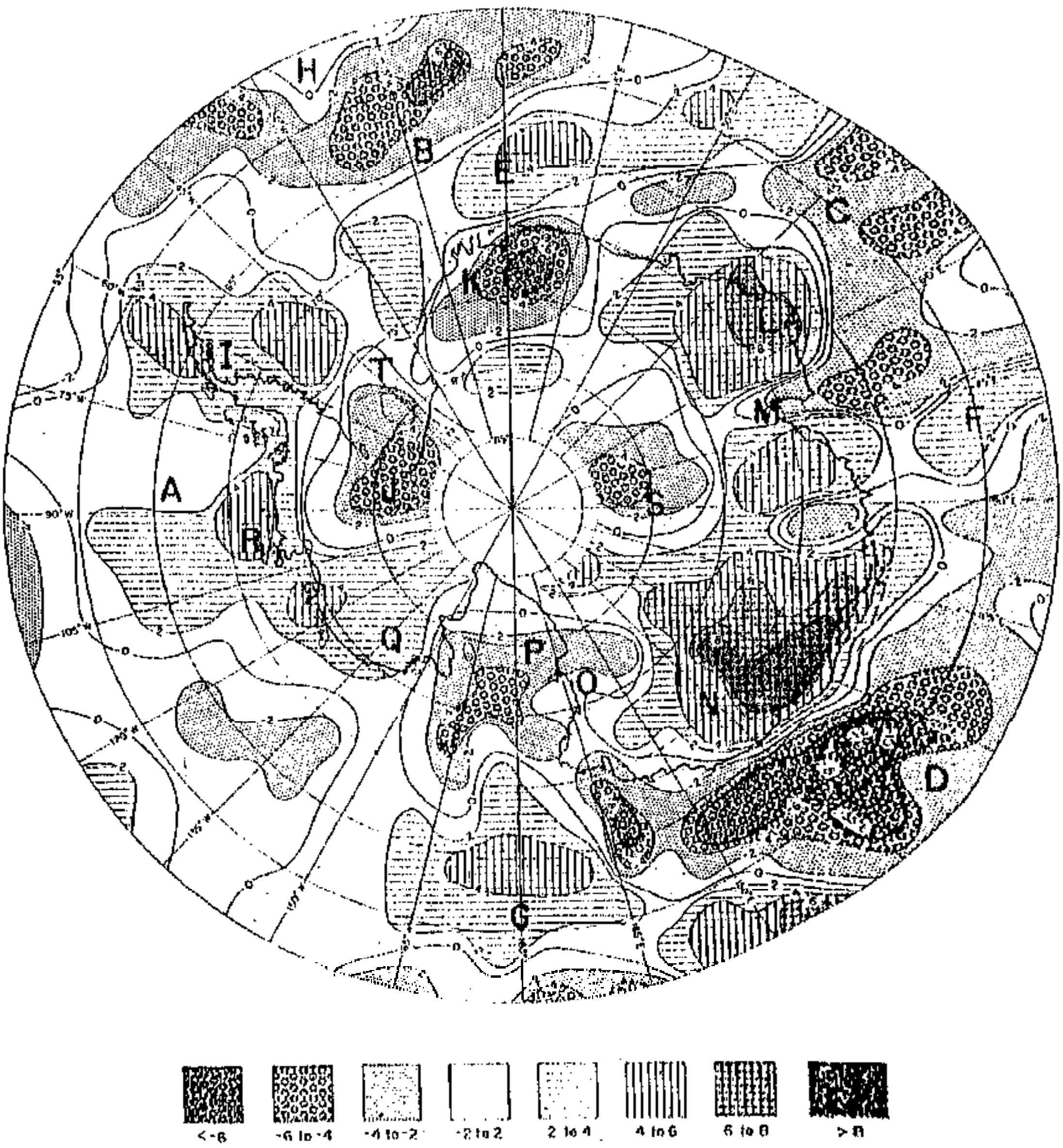


Fig. 1. Location map.

magnetic anomaly map (Fig. 2). Bedrock elevation data have been generated from Behrendt (1983) who has prepared the bedrock elevation contours for the entire Ross ice shelf and its surroundings. Fig. 3 shows the bedrock elevation contours for the Ross ice shelf.



Average elevation 470 km. Capital letters indicate the approximate location of: A—Bellingshausen Abyssal Plain; B-Weddell Abyssal Plain; C-Enderby Abyssal Plain; D—Wilkes Abyssal Plain; E-Maud Rise; F-Kerguclen Plateau; G-Junction of the Mid-Indian Ocean Ridge and East Pacific Ridge; H-South Sandwich Island; I-Antarctic Peninsula; J-Ellsworth Mountains; K—Queen Maud Land; L—Enderby Land; M-Amery Ice Shelf/Lambert Glacier; N-Wilkes Land; O—Transantarctic Mountains; P-Ross Sea embayment; Q-Marie Byrd Land; R-Thurston Island; S—Gamburtsev Mountains; T—Weddell Sea embayment.

Fig. 2. MAGSAT total field magnetic anomaly map over Antarctica (After Ritzwoller and Bentley, 1983). Units in nT.

The main area of interest for this study lies in the region around Dakshin Gangotri Station (Fig. 1) with latitude range 70^0S-72.5^0S and longitude range 0 to 15^0E. Table II gives the data generated.

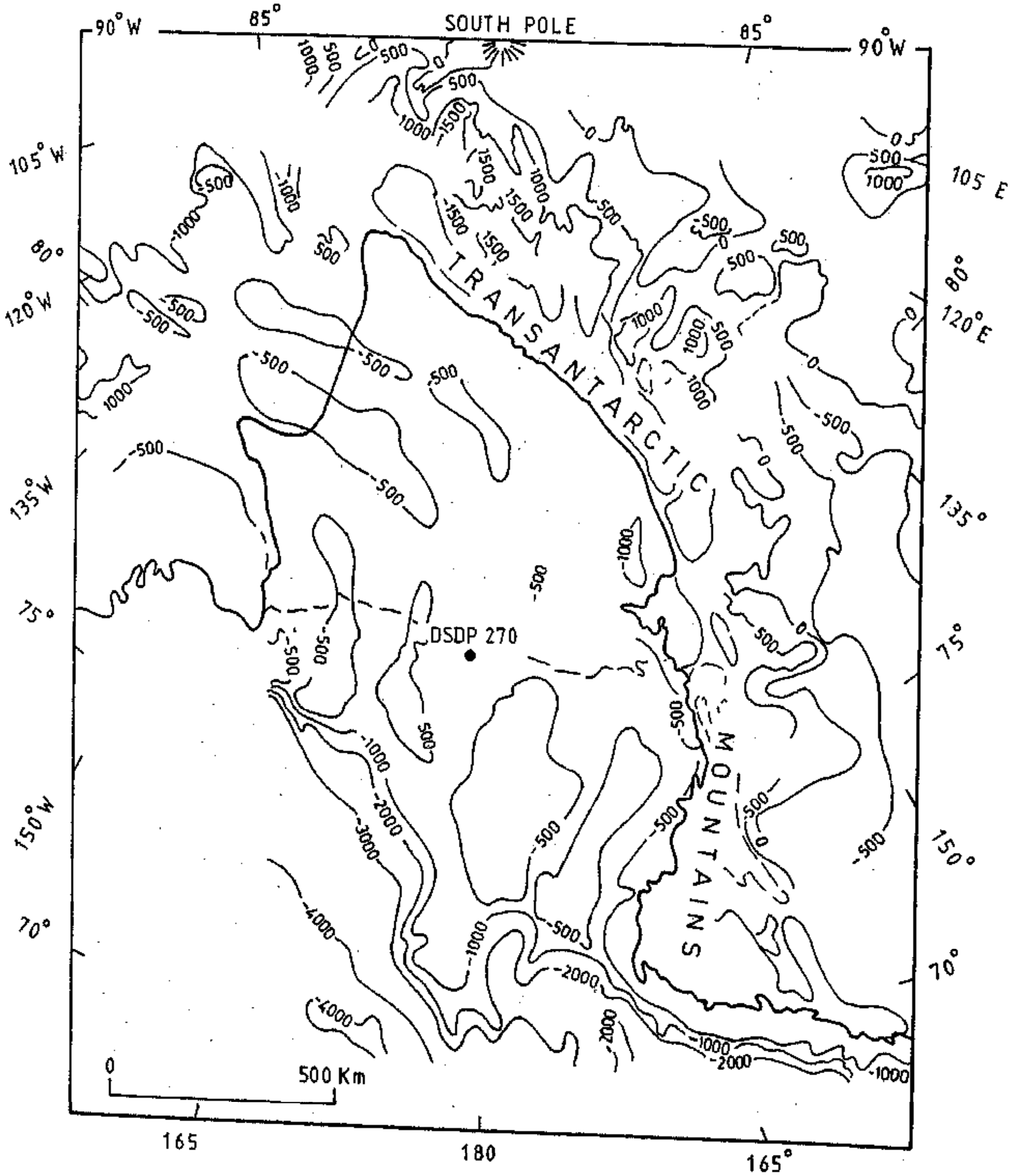


Fig. 3. Bedrock elevation map of the Ross ice shelf (after Behrendt, 1983.

TABLE II
Generated data sets *(Area: Ross ice shelf).*

Magnetic anomalies (nT)	-3	-5	-5	0	3	-2	3	-4	-5	-3
	0	1	2	0	0	-2.5	-2.1	-1	-0.5	-3
	3	4	5	5.5	5.8	6	2.5	3	1	0.5
Bedrock elevation (m)	-450	-500	-500	-500	-3500	-500	-525	-475	-4000	-3500
	-525	-475	-510	-500	-550	-750	-1000	-550	-400	-1500
	1000	0	0	-300	-200	-500	-600	-900	-100	-450

METHODOLOGY

It has already been observed that a high probability of correlation may exist between the satellite observed magnetic anomaly and the bedrock elevation contours underneath the thick sedimentary rock formations in the Ross ice shelf area, a linear correlation has been attempted for this area of interest. Quite interestingly, fairly high correlation exists for single traverses as shown in Fig. 4 as a typical case with correlation coefficient (γ) as high as 0.48. However, the overall correlation drops when the data are taken for all the different regions of the same area. In essence, a model is thereby developed with magnetic anomaly as the independent parameter and the equation obtained for the bedrock elevation is given by:

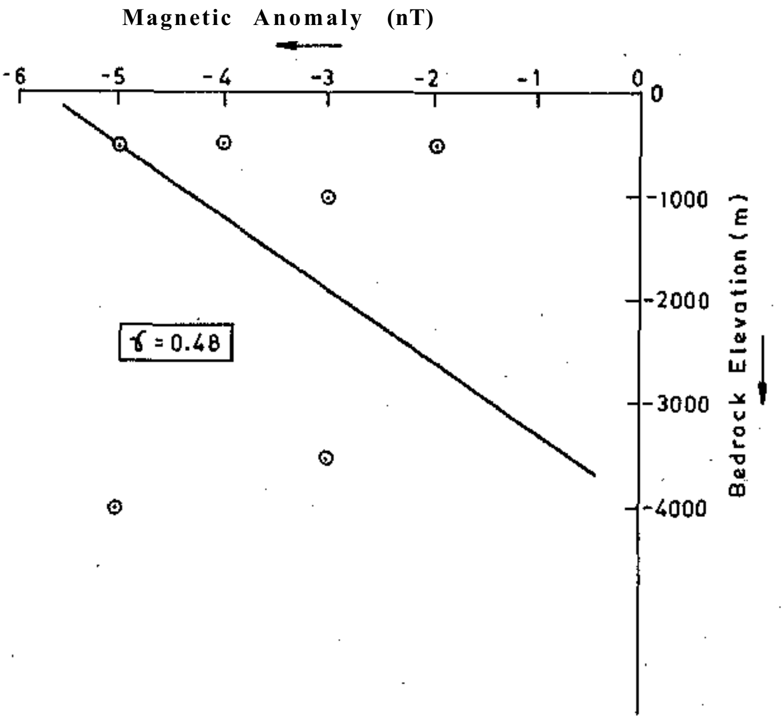


Fig. 4. A typical correlation of magnetic anomaly (nT) Vs. bedrock elevation (m).

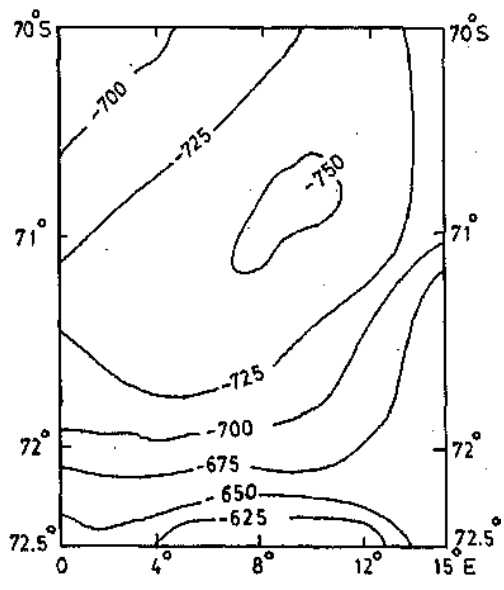


Fig. 5. Extracted bedrock elevation contours in Dronning Maud Land region.

$$BD = 8.0056\ (MG) - 690.77$$

where BD = Bedrock elevation in metres

and MG = Magnetic anomaly in nT with correlation coefficient (γ) as high as 0.28.

An extension of this model has been attempted in the shelf areas, in and around Dakshin Gangotri station.

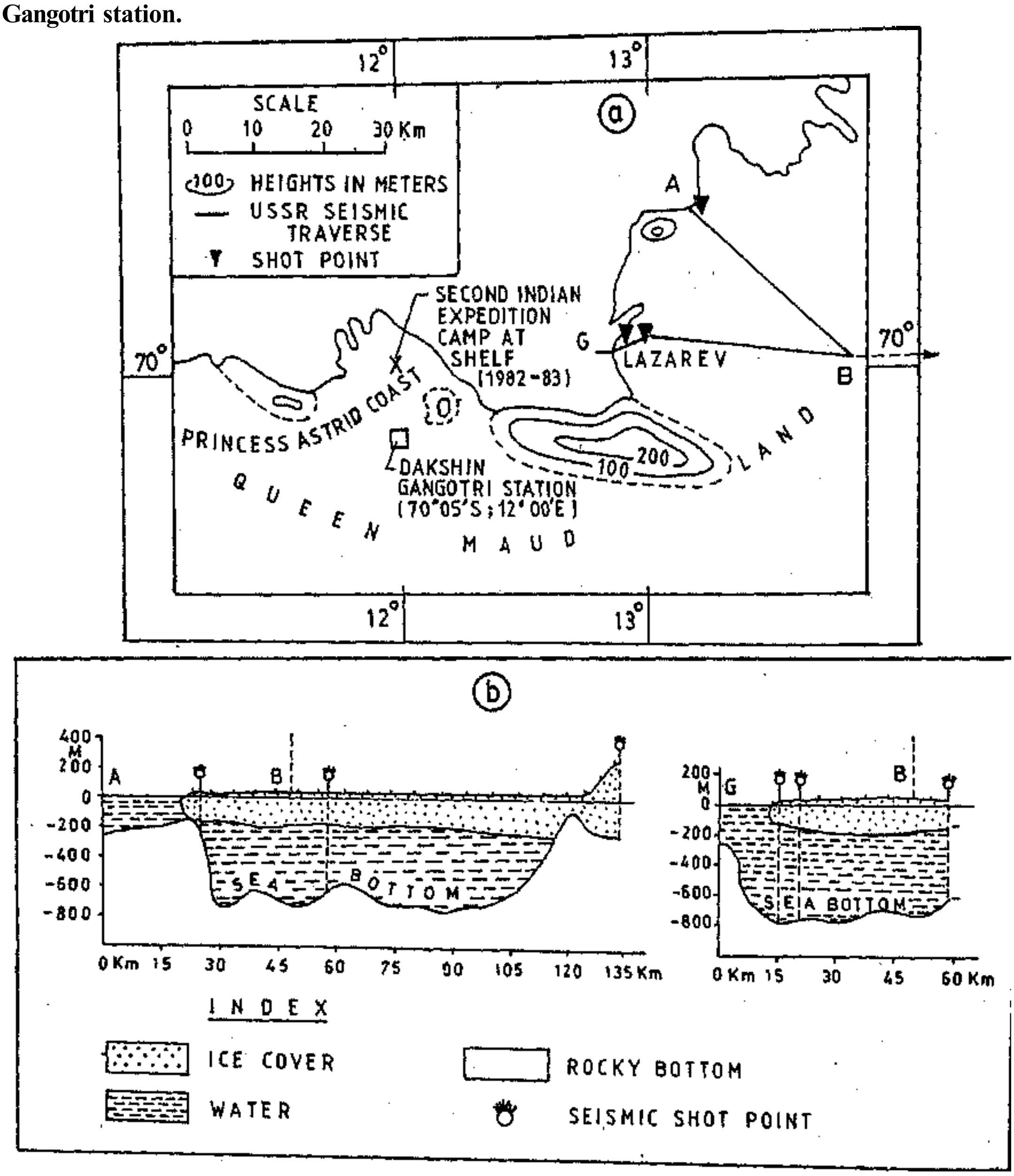


Fig. 6. **(a) Depth of the bedrock near the Lazarev Coast, Queen Maud Land, (b) seismic sections (After Atlas Antartiki, Vol. 1, 1966).**

RESULTS AND DISCUSSION

The bedrock elevation contours as obtained with the help of the model developed here is shown in Fig. 5. The depth to the bedrock in the entire region is shallow. Thus the sedimentary column is insignificant from the point of view of the occurrence of hydrocarbons. The depths of the bedrocks are in good agreement with a few seismic refraction results obtained by the Soviet party along a profile approximately parallel to 70°S from the Lazarev coast to Verblyud dome (Atlas Antarktiki, Vol. 1, p. 138,1966) extending from 13°E to 16°E. Two depth profiles obtained from the seismic surveys carried out by USSR are shown in Fig. 6.

CONCLUSIONS

The development of a model for the prediction of bedrock elevation in the shelf areas may be quite useful for obtaining a first hand information on the thickness of the sedimentary formation over the different sectors of the Antarctic shelf areas. There are speculations that some of the sedimentary basins in the shelf areas of the western Antarctica may contain oil and gas (Behrendt, 1983). It, therefore, seems logical that other types of satellite data including the MAGSAT data should be studied over Antarctica for obtaining qualitative first hand information on other interesting features, e.g., show depth, ocean circulation near Antarctica etc. by using thermal infrared, altimeter data (Brooks et al., 1983). A synchronous observation of the ground measurements with satellite passes may be found to be more accurate for the prediction of various parameters of interest.

REFERENCES

Atlas Aantarktiki, Vol. 1,1966. Glavnoe Upravlemic Geodezii i Kartografii MG USSR, Moscow, 225 pp. (in Russian).

Behrendt, J.C., 1964. Distribution of narrow width magnetic anomalies in Antarctica. *Science*, 144: 993-999.

Behrendt, J.C., 1983. Geophysical and geological studies relevant to assessment of the petroleum resources of Antarctica. *Antartic Earth Science*, Cambridge University Press, Cambridge, p. 423-425.

Behrendt, J.C. and R.J. Wold, 1963. Depth to magnetic basement in West Antarctica. J. *Geophys. Res*., 68: 1145-1153.

Behrendt, J.C., J.R. Henderson, L. Mcister and W. Rambo, 1974. Geophysical investigations of the Pensacola Mountains and adjacent glacierised area of Antarctica. *U.S. Geol. Sur. Prof. Pap.,* 844.

Brooks, R.L., R.S. Williams (Jr), J.G. Ferrigno and W.B. Krabiu, 1983. Amery ice shelf topography from satellite radar altimetry. *Antarctic East Science*, Cambridge University Press, Cambridge, p. 441-445.

Drewry, D.J., 1975. Radio echosounding map of Antarctica (90°E-180°). *Pol. Rec.,* 17: 359-374.

Jankowski, E.J. and D.J. Drewry, 1981. The structure of West Antarctica from geophysical studies. *Nature,* 291: 17-21.

MAGSAT Information Bulletin, 1980, NASA Publication, USA.

Regan, R.D. and B.D. Marsh, 1982. The Bangui magnetic anomaly-its geological origin. *J. Geophys. Res.,* 87(B-2): 1107-1120.

Ritzwoller, M.H. and C.R. Bentley, 1982. MAGSAT magnetic anomalies over Antarctica and the surrounding oceans. *Geophys. Res. Lett.,* 9: 285-288.

Ritzwoller, M.H. and C.R. Bentley, 1983. Magnetic anomalies over Antarctica measured from MAGSAT. *Antarctic Earth Science,* Cambridge University Press, Cambridge, p. 504-507.