Fifth Indian Expedition to Antarctica, Scientific Report, 198S
Department of Ocean Development, Technical Publication No. 5, *pp. 151-155*

Magnetic and Seismic Investigations on the Ice-Shelf around the Indian Permanent Station in Antarctica

SHIKHAR CH. JAIN, RATAN DHAR AND K.N.S. REDDY

National Geophysical Research Institute,
Hyderabad-500007

Abstract

Results of magnetic and seismic investigations around the Indian Base Station in Antarctica have established the usefulness of geophysical tools in delineating sub-shelf structures. Of the explosives tried so far for selecting a suitable energy source for seismic studies, Low Temperature Plastic Explosives (LTPE) developed by ERDL, Pashan, has been found to be the best under sub-zero climatic conditions of Antarctica.

Introduction

Magnetic investigations initiated during Second Indian Antarctic Expedition were continued thereafter, including during Fifth Indian Antarctic Expedition. During this Expedition, another 26 km long magnetic traverse, 5 km east of Indian Permanent Station was completed.

Seismic investigations initiated during Fourth Indian Antarctic Expedition were continued during the Fifth Expedition with following objectives:

i) Testing suitability of Plastic Explosives (PEK) manufactured at Kirkee and Low Temperature Plastic Explosives developed by ERDL Pashan under Antarctic conditions, as gelatine based SGL-80 explosives, commonly used in seismic surveys in India, turned brittle due to non-availability of moisture in atmosphere in sub-zero conditions and thus were not found safe to use in Antarctic conditions; and

ii) To find out efficacy of a more portable Geometrics Nimbus 12 channel seismograph in delineation of sub-shelf structure.

The present paper describes the results of these investigations.

Geophysical Layout and Data Collection

For continuing magnetic investigation, another traverse, Traverse 9, 5 km east of Indian Permanent Station, Dakshin Gangotri, was laid in north-south direction, starting from the coast in the northern extreme to the deep un-negotiable water channels encountered 26 km south of the coast. Field magnetic measurements were carried out with geometrics G816/826 Proton Precession Magnetometer on magnetically quiet day. Diurnal magnetic measurements were carried out with NGRI made Proton Precession Magnetometer coupled with TOA recorder. Fig. 2 shows sample diurnal magnetic data, compared to diurnal magnetic data on the shelf on quiet days.

Reverse seismic shootings were carried out at four locations S3, S4 and S5 as shown in Fig. 1, and one-way refraction shooting was carried out at location S2. 14.7 Hz natural frequency geophones were placed 20 m apart with an offset of 50 m. Shot holes upto depth of 2 m were drilled with the help of hand auger. 25 sticks of PEK or LTPE with T-33 electrical detonators were used to shoot refraction profiles,

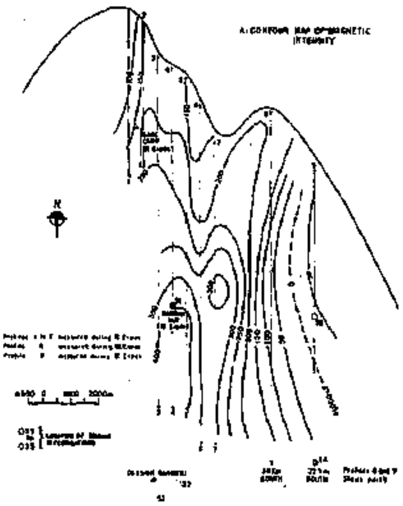

Fig. 1. Contour map of magnetic intensity in the ice shelf area around Dakshin Gangotri station

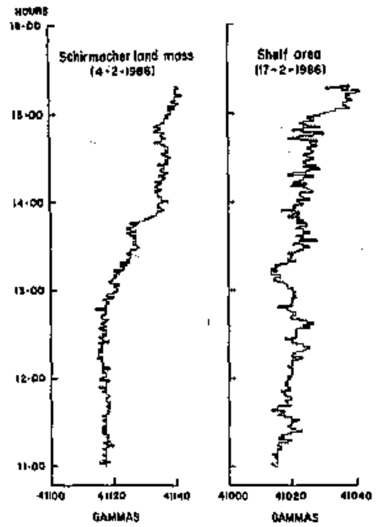

Fig. 2, Diurnal total magnetic field variation

Discussion of Results

Magnetic: Upper-most curve in Fig. 3 shows observed magnetic profile on Traverse 9 after applying base and diurnal correction. It was observed that in N-S magnetic profile the geomagnetic field increases from north to south and hence a regional gradient of 8 nT/km was applied to the corrected magnetic field. The second curve in Fig. 3 exhibits the anomaly pattern after this correction. To get idea of continuous depth profile for the basement, pseudo-gravity response was computed using the Hilbert Transform technique (Shuey, 1972). The third curve in Fig, 3 shows the computed pseudo-gravity anomalies of the profile. The basement topography along the traverse was then computed from the pseudo-gravity anomaly using Sazhina and Grushinsky (1971) method as described by Verma *et al.* (1987).

As traverse *9* is eastward continuation of earlier measured traverses during the Second and Fourth expeditions, assumption as by Verma *et al.* (1987) were made and a continuous depth section corresponding to the pseudo-gravity anomaly was computed, shown as fourth curve in Fig. 3. The basement topography is very similar to and the depths computed of the same order as reported by Verma et al. (1987). It is observed that the shallower depth of 406 m below sea level of the basement is found about 20.5 km south of coast line on the traverse.

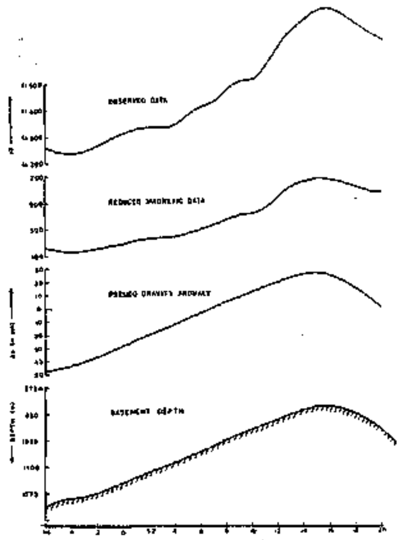

Fig. 3. Magnetic profiles, pseudo gravity anomaly and basement topography profile along traverse.9

Seismic: The analysis of refraction profiles showed increasing velocity upto 4150 m per second within 50 m from the surface, thus showing heterogeneous nature of the shelf. The high velocity layer at shallow depths, within 50 m from the surface means that even at such shallow depth ice is very compact. The analysis also shows that stratification in ice is not horizontal but dipping towards north, which is inferred from the reverse shooting (Fig. 4).

To check the relative performance of PEK explosives and LTPE (ERDL, Pashan) explosives, refraction shootings with equal amount of explosives were carried out along the same traverse. Fig. 5 is a sample record of the same. It is clear from the records that LTPE shows more efficient energy transmission resulting in enhanced signals. It was also found that at sub-zero conditions, LTPE retains plasticity while PEK turns brittle to a large extent.

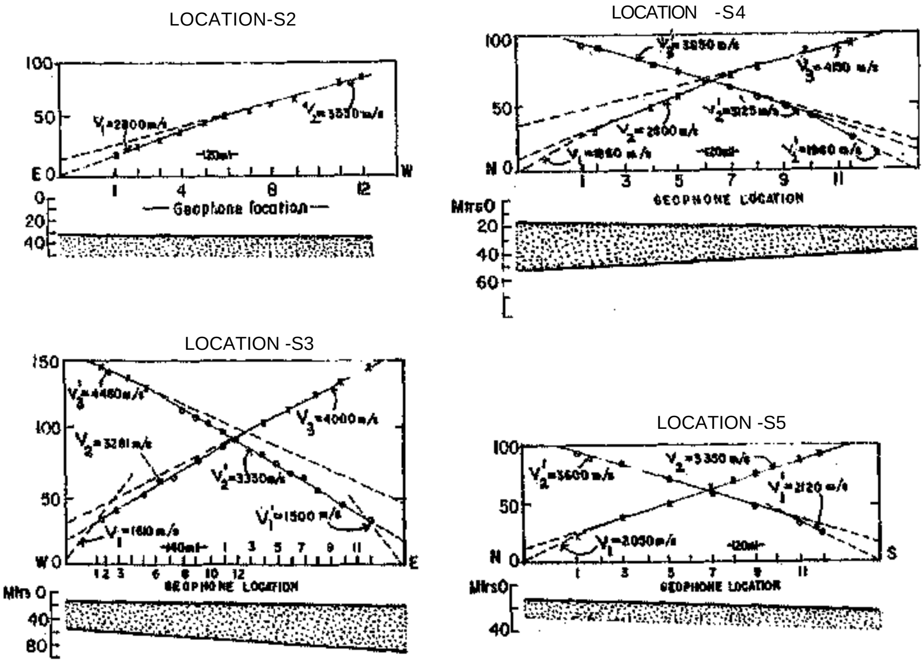

Fig. 4. Shallow seismic refraction studies showing heterogeneous character of the top unconsolidated ice layer

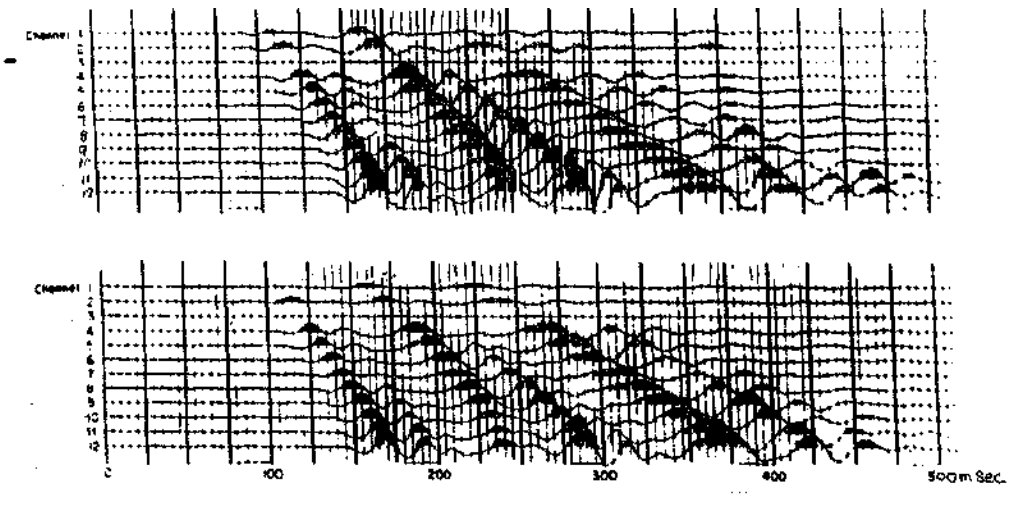

Fig. 5. Comparison between seismic profile shot with LTPE (top) and PEK explosive (bottom). Location, near Dakshin Gangotri station, Antarctica
The record obtained using LTPE shows more efficient energy transmission resulting in enhanced signals

Acknowledgements

The authors are grateful to Prof V.K. Gaur, Director, NGRI, Hyderabad for permission to participate in the Expedition. They are also thankful to Dr. S.2. Qasim, Secretary, DOD, New Delhi, for providing all the infrastructural and logistic facilities for carrying out the experiment.

References

SAZH1NA, N. AND GRUSHINSKY, N. (1971): Gravity Prospecting, MIR Publishers, Moscow, pp. 480-481.

SHNEY, R.T. (1972): Application of Hilbert Transforms to magnetic profiles. *Geophysics,* 37, pp. 1043-1045.

VERMA, S.K., MITAL, G.S. RAMBABU, H.V., VENKATARAYUDU, M. AND SRINATHAREDDY, K.N. (1987): Magnetic survey over the Ice-shelf around the Indian Permanent Station in Antarctica. *Fourth Indian Scientific Expedition to Antarctica. Scientific Report. DOD Technical Publication No. 4,* pp. 55-67.

VERMA, S.K., MITAL, G.S., DIXIT, M.M., REDDY, K.N.S., VENKATARAYUDU, M. AND PANTULU, K.P. (1987): Seismic investigations on the Ice-shelf near Dakshin Gangotri, Antarctica. *Fourth Scientific Expedition to Antarctica. Scientific Report. DOD Technical Publication No. 4,* pp. 83-91