Radio Echo Sounding in western Dronning Maud Land, 1971 – a Preview

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Twelfth South African National
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Introduction

In 1971 for the first time in the history of South African Antarctic Research a radio echo sounding programme was undertaken with a view to obtaining more information about the ice-cap and subglacial topography in western Dronning Maud Land. This is a preliminary report on the year's work and results. Findings will be discussed here only in general terms, and a more comprehensive discussion will be prepared after the data have been processed.

Equipment

The investigations were made using a Scott Polar Research Institute Mark 2 Radio Echo Sounder. This is a pulsed radar system operating at 35 MHz. The transmitter has a peak pulse power of 500 W, a pulse duration of 0,3 microseconds and a pulse repetition frequency of 16 kHz. The receiver has a 3 db bandwidth of 14 MHz. The majority of soundings were made with a folded dipole antenna and a transmit-receive switch. The received signals were displayed on two Telequipment S54U oscilloscopes. One, the A-scope, was used to monitor the record, and the second, which was Z-modulated, was recorded continuously on 35 mm film driven through the gate of a camera by a stepping motor (Shackman recording camera, using Kodak 2492 RAR Estar-AH base film).

The equipment was installed in the expedition's Geophysical Caboose, this being a commercially manufactured caravan which had been suitably modified. The modifications included the placing of 25 mm of expanded polystyrene sheeting between the inner and outer walls of the Caboose, and 50 mm of similar insulation between the inner and outer floors. The Caboose was mounted onto a strong but flexible metal sledge via a suspension consisting of rubber shock absorbers. The echo sounder, radios and other geophysical instruments were lashed to racks which were fixed to a work bench via small shock mounts (Plate 1). The protection afforded by these mounts plus the shelter given by the Caboose meant that the instruments were not subjected to severe treatment and, in fact, all equipment was relatively trouble-free throughout the course of the expedition.

A 2 kVA alternator and battery charging system was mounted on a platform on the rear of the Caboose sledge. Two booms fixed to the Caboose supported the echo sounder's folded dipole antenna 2 m from the Caboose and 2 m above the snow surface (Plate 2).

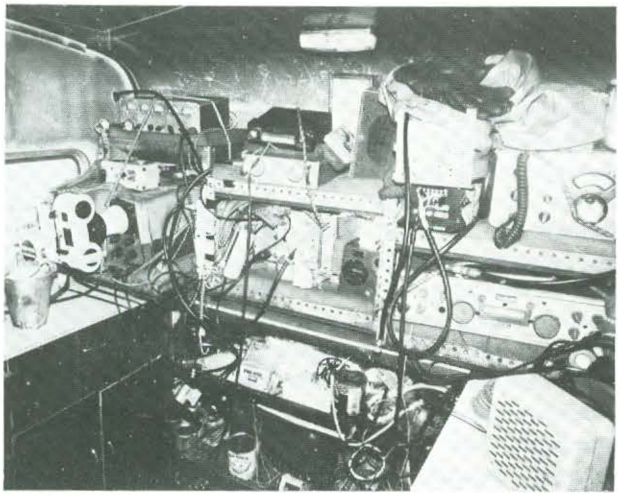

PLATE 1. Interior view of the Geophysical Caboose showing the instrument racks

PLATE 2. The Geophysical Caboose with supporting booms for echo sounder folded dipole. The motor-generator set is visible at the rear of the caboose

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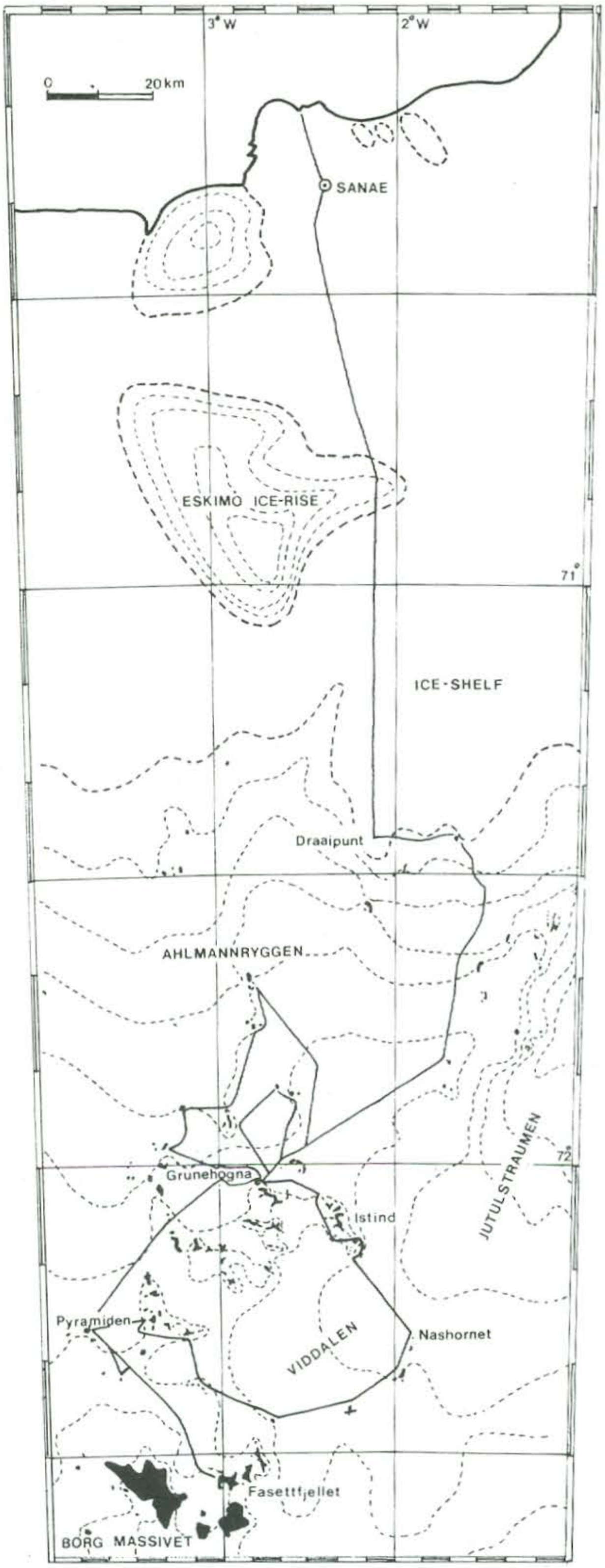

Fig. 1. Maps showing routes traversed

Measurements and Results

During the course of the expedition, profiles of subglacial topography were recorded over a distance of 630 km (Fig. 1). Most of the work was done in the Ahlmannryggen and along the boundaries of this mountain range. Navigation was particularly easy since the area had been mapped and consequently positions could be fixed to within a few hundred metres, relative to the maps, merely by making a resection with an ordinary prismatic compass.

In order to interpret radio echo sounding data more meaningfully it is necessary to determine the altitude of the snow surface. Such measurements were made, using barometric techniques, every few kilometres along the entire route.

South of Sanae on the ice-shelf strong continuous echoes were recorded, the depth ranging from 300 m at Sanae to approximately 700 m in the Draaipunt area which is roughly on the hinge line. These figures agree well with those obtained by the 1969 Belgian Summer Expedition (*Van Autenboer & Decleir*, 1970) which did echo sounding on this portion of the ice shelf. The ice-depths measured on previous South African gravimetric traverses (*Neethling et al.*, 1968) also agree closely with the echo sounding results. The subsurface of the ice-shelf is relatively smooth and flat. By studying bottom distortions it has been possible to determine where the ice-shelf is grounded in the Eskimo Ice Rise area.

The portion of the route which crosses the hinge area runs almost exactly east-west. Although the crossing can be somewhat hazardous and drawn-out it was decided that this was an excellent area in which to make a study of the correlation between ice depths measured by gravimetry and by echo sounding. The data thus obtained might be used at a later stage in crustal studies. Similar comparative soundings were also made at selected points along the rest of the traverse routes.

Southwards along the route from Marsteinen to Jekselen Depot the subglacial terrain was found to be of a gently undulating nature and here marked differences were noted between the ice depths obtained from echo sounding and those measured by gravimetric traverses (*Neethling et al.*, 1968).

The majority of the remaining traverse lines were planned with a view to studying the subglacial features in the Ahlmannryggen region and along its boundaries. Lines of equal ice thickness drawn onto a map with surface features already plotted will be useful for studies of the structural geology of the area. A number of interesting subglacial features were noted and two are worth mentioning here. What appear to be graben valleys are clearly visible in the Grunehogna, Schumacherfjellet and Nils Jörgennutane areas. The second notable feature is that the bedrock was found to drop sharply to below sea level over a very short distance along the western and southern boundaries of the Ahlmannryggen. Fig. 2 shows the subglacial topography obtained from the radio echo sounder photographic record. The profile of the Stamnen-Pyramiden area demonstrates this feature clearly. Further to the west and south the level of the bedrock changes only very gradually. This may indicate tectonic control of the present subglacial topography.

A portion of the work which was particularly interesting was the comparison of ice depths measured by echo sounding on this expedition with those obtained seismically by Dr. G. Robin in Dronning Maud Land during the 1949-52 Norwegian-British-Swedish Expedition (*Robin*, 1958). The portions of

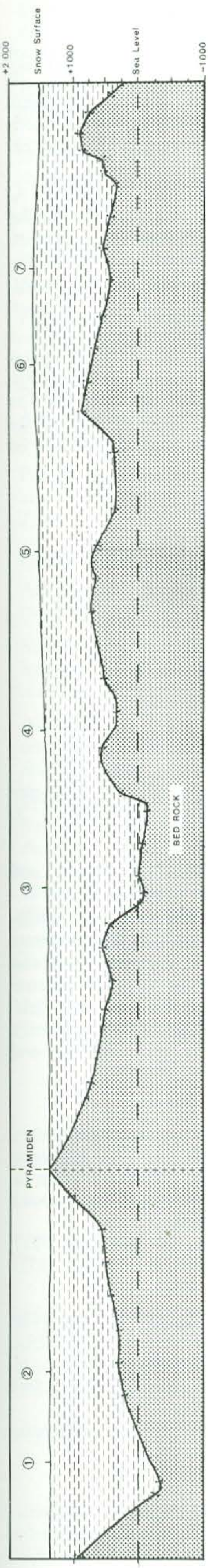

Fig. 2. Profile showing subglacial topography between Stamnen and Pyramiden and between Pyramiden and Fasettfjellet. The ordinate is in metres.

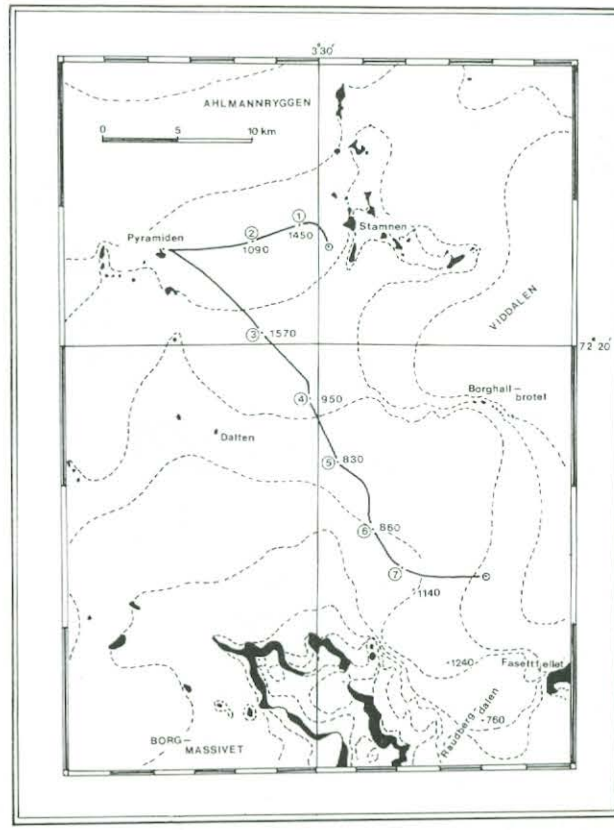

Fig. 3. Map showing section of Robin's (*1958*) *line of seismic stations traversed* (*scale 1: 250 000*)

Robin's line of seismic stations from Stamnen to Pyramiden and from Pyramiden to the north of Raudbergdalen were traversed. Robin made seven seismic soundings in this area, and the positions of these are indicated in Figs. 2 and 3.

The ice depths obtained by echo sounding on this expedition agree within 5 per cent with those obtained seismically by Robin. Both are tabulated below.

The discrepancies between the ice depths obtained by the two techniques may be accounted for partly by differences in the exact geographical positions at which the soundings were made. Most of Robin's seismic figures are smaller than the corresponding radio echo sounding figures, and this is probably due to his failure to take into account the effect of ice crystal anisotropy on seismic wave velocity when the seismic

Table 1

Comparison between ice depths obtained seismically (*Robin*, 1958) and by radio echo sounding along portions of Robin's line of seismic stations.

Station	Ice depths (m)	
	Seismic	Radio echo sounding
1	1 450	1 500
2	1 090	1 110
3	1 570	1 520
4	950	1 000
5	830	870
6	860	880
7	1 140	1 160*

*This sounding was made approximately 2 km north of the point where Robin's seismic measurement was made.

ice depths were calculated. *Bentley & Clough* (1970) estimated that ice depths calculated from seismic wave velocities based on seismic refraction measurements at the surface are approximately 2 per cent less than those calculated from seismic wave velocities which take ice crystal anisotropy into account.

It is worth noting that the maximum ice depth measured was 1 700 m and that continuous recording of bedrock echoes could be obtained only when the ice depth was less than about 1 500 m. This limited performance of the radio echo sounder was probably due, in part, to a large absorption of the radio waves by the ice. (Ice temperatures at depths of 10 m range from −15°C to −25°C in this area, and on this basis the absorption is expected to be approximately 2 db per 100 m.)

Acknowledgements

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Meetings during 1972

SYMPOSIUM ON ANTARCTIC UPPER ATMOSPHERE PHYSICS HELD AT CSIR, PRETORIA, ON 17-18 MARCH, 1972

Review and Projection of Upper Atmosphere Physics Programmes:

Ionosphere (i) Sanae *J. A. Gledhill*
Ionosphere (ii) Marion Island *R. W. Vice*
Cosmic Rays *P. H. Stoker*
Whistlers/Micropulsations *N. D. Clarence*
Aurora and Geomagnetism *G. J. Kühn*
Airglow *P. B. Zeeman*

Particle Precipitation (Open and Closed Field Lines)
Die moontlikheid om vasgevange presipiterende deeltjies in die Kaapse Stralingsanomalie met behulp van 'n NaI-kristal waar te neem op ballonhoogte (The possible detection of charged particles at balloon altitudes in the Southern Radiation Anomaly by using an NaI crystal) *P. J. König, Potchefstroom University*

Nighttime ionization enhancements at Sanae *M. R. Torr, NITR, CSIR*

Problems in explaining the behaviour of the ionospheric F-1 layer *D. G. Torr, NITR, CSIR*
Electron production due to precipitated electrons in various model atmospheres *A. Wulff, Rhodes University*

Magnetospheric electrons observed to the west of Sanae *J. G. Greener, Rhodes University*

Die tydelike verband tussen magnetiese en luggloed aktiwiteite (The temperal relationship between magnetic and airglow intensities) *P. B. Zeeman, University of Stellenbosch*

Presipitasie soos waargeneem met die riometer (Precipitation as observed with the riometer) *G. J. Kühn, Potchefstroom University*

Magnetic Effects and Micropulsations (Open and Closed Field Lines)
Magnetiese Sq-variasie te Sanae (Magnetic Sq variation at Sanae) *G. J. Kühn, Potchefstroom University*
Fase-omkering van dagvariasie in Z-komponent van magneetveld te Marion (Phase reversal in the diurnal variation in the Z component of the magnetic field at Marion Island) *G. J. Kühn, Potchefstroom University*
Whistlers and Micropulsations *N. D. Clarence and A. Woods, University of Natal*

Solar Effects
Die invloed van sonaktiwiteit op die resultate verkry deur 'n geiger ballonpakkie op Sanae (The influence of solar activity on the results obtained from a balloon-borne geiger counter payload at Sanae) *P. J. König, Potchefstroom University*
Waarneming op protonvlam van 24 Januarie 1971 (Observation of the proton flare of 24 January, 1971) *H. Moraal, Potchefstroom University*

Modulasie van kosmiese strale vanaf 1963 tot 1970 met behulp van die neutronmonitor op die *RSA* (Observations of the modulation of cosmic rays from 1963 to 1970 using the neutron monitor on the *RSA*) *P. H. Stoker, Potchefstroom University*
Solar control of F2 ionization in the Antarctic *M. H. Williams, Rhodes University*

Morphology
A critical examination of the wind theory of Antarctic foF2 behaviour *M. H. Williams, Rhodes University*
Luggloed intensiteite te Stellenbosch en Sanae (Air-