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RECORD No. 1965/24

WILKES GEOPHYSICAL SURVEYS, ANTARCTICA 1963

by

M. KIRTON

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SUMMARY

During 1963, the Australian National Antarctic Research Expeditions carried out two oversnow traverses in the vicinity of Wilkes Station, Antarctica. The Autumn Traverse reached a point about 100 miles east of Wilkes and the Spring Traverse a point about 300 miles south-east of Wilkes. Surface elevations were measured by barometric methods and ice thicknesses were determined by gravity and seismic techniques. Magnetic measurements were made and borehole temperatures were taken.

Experiments were conducted to devise means of improving the quality of the seismic reflection records. The optimum frequency range for the filter settings was found to be 90-215 c/s. A hand-drilled 4-ft shot-hole was adequate in the coastal or low plateau regions within 150 miles of Wilkes. Further inland, a shot-hole of at least 30-ft depth was required. The optimum charge size was one pound of explosive.

1. INTRODUCTION

In 1963, the Australian National Antarctic Research Expeditions (ANARE) made two oversnow traverses to make glaciological, meteorological, and geophysical observations in unexplored parts of Antarctica east and south-east of Wilkes Station. On these traverses, the author, a geophysicist with the Bureau of Mineral Resources, was responsible for the geophysical programme. This comprised the measurement of surface altitudes by barometric methods, the measurement of ice thickness by seismic and gravity techniques, the determination of the components of the geomagnetic field, and the measurement of borehole temperatures. In addition, experiments were carried out to improve the quality of the seismic reflection records.

The first traverse, known as the Autumn Traverse, reached a point 100 miles east of Wilkes (Plate 1) and the party was in the field from 6th April to 11th May 1963. The second, the Spring Traverse, reached a point 300 miles south-east of Wilkes and occupied the period from 28th September 1963 to 8th January 1964. While on traverse, the author acted as medical officer and continued the ANARE physiological programme.

Some test drilling and seismic work was also done at Cape Folger at the request of the glaciologist.

The personnel engaged on the traverses and the vehicles used are listed in Appendix 1. Details of the work completed and the materials used are given in Appendix 2 and details of the geophysical equipment are given in Appendix 3. Appendixes 4 and 5 contain some comments on the geophysical equipment and the traverse vehicles respectively.

2. PREVIOUS GEOPHYSICAL WORK AT WILKES

The 1961 ANARE expedition to Wilkes, with F. Jewell as geophysicist, carried out a traverse (Jewell, 1962) to a point 300 miles south of S-2, a glaciological station 52 miles from Wilkes (Plate 1). Surface altitudes were measured by altimeters and a bedrock profile, from S-2 to a point 200 miles south, was obtained by seismic reflection shots at 20-mile intervals. Here, the quality of the reflection records deteriorated and the results for the next 100 miles were unreliable. Between 40 and 80 miles south of S-2, a sub-ice valley of depth about 7500 ft below sea level was discovered. Jewell suggested that this feature may extend north-east and north-west and be responsible for the formation of the Totten Glacier to the east of Wilkes and the Vanderford and John Quincy Adams Glaciers to the west.

In 1962, D.J. Walker was geophysicist on two oversnow traverses (Walker, in preparation). The first was a gravity survey in the area between S-2 and the southern end of the Totten Glacier (Plate 1). This traverse was named the Totten Glacier Survey. The altitude measurements indicated that S-2 is on an ice dome, centred about 20 miles east of S-2, and which slopes down to the sea to the north and west and to the Totten Glacier to the east and south.

Walker's second traverse was to the U.S.S.R. Station 'Vostok', 900 miles south of Wilkes. Gravity, seismic, magnetic, and barometric measurements were made along the route, although from 250 miles south of S-2 no reliable reflections were recorded. A seismic shot 57 miles south of S-2 confirmed the existence of the deep sub-ice valley discovered by Jewell. Ice and rock surface profiles were obtained from the barometric and gravity readings.

3. OBJECTIVES OF SURVEY AND PROGRAMME

The programme proposed for the 1963 expedition consisted of two main parts :

1. Two helicopter gravity traverses across the southern ends of the Vanderford and John Quincy Adams Glaciers were to be followed by an oversnow traverse to the western edge of the John Quincy Adams Glacier during the autumn of 1963 in order to provide seismic control of the ice thickness measurements at the south-western ends of the helicopter gravity traverses. During the two weeks in January 1963, when the helicopters were at Wilkes with the relief ship, continuous low cloud over the Glacier prevented the flying of these gravity traverses. Thus, the main purpose of the proposed oversnow traverse was removed. It was realised later that this traverse would have been too long for the time available after the traverse vehicles became serviceable.

   Consequently, a shorter traverse was planned for the autumn to go from S-2 to longitude 114° E. on a true bearing of 100°, then to head due south to join with the 1962 Totten Glacier Survey, and finally to return to S-2 along the outward route of that survey. Such a traverse would provide more information about the region east of S-2, which was thought to be an ice dome, and also confirm by seismic methods the ice thickness as determined by Walker from his gravity measurements.

2. A long traverse to link up with the western end of the 1958/59 American traverse (i.e. as far as position 78°S, 130°E) was planned for the spring and early summer of 1963. On this traverse, gravity and altitude stations were to be read every three miles and seismic ice thickness measurements were to be made every twenty miles. In the area of poor seismic reflections, more than 200 miles south of S-2, an experimental programme, involving measurements of noise and the variation of parameters such as charge size, shot depth, filters, etc., was planned to determine the cause of the poor reflection quality. However, to reach the above objective, an airdrop of fuel would be required, but later this proved impossible to arrange. The plan was then modified to traverse as far as possible in the same direction with the maximum load of fuel that the vehicles could pull.

An addition to the original programme was a request from the glaciologist for some geophysical work at Cape Folger, about ten miles north of Wilkes in a region where the ice flow is faster than average. The glaciologist planned to measure the flow rate at various depths in the ice by taking core samples with the ANARE ice drill. Before drilling, he needed to know the thickness of the ice so that he could avoid damaging his drill by striking bedrock. When it was found that the ANARE ice drill was incapable of drilling more than a few feet into the ice, he wished to compare its performance with that of the Proline drill supplied for the geophysical programme.

4. RESULTS

Cape Folger

A refraction spread was used with twelve geophones spaced at 50-ft intervals and shot-points at distances of 10, 50, and 300 ft from each end of the spread. A time/distance plot of the first breaks showed a seismic velocity in the surface layer of 10,500 ft/s. Beneath this the seismic velocity was 11,500 ft/s, and beneath this again an apparent velocity of 17,000 ft/s was recorded shooting from one end of the spread only. This last velocity was assumed to be representative of the highly metamorphosed igneous rock common to the Wilkes area. The depth of this rock below the ice surface was computed from the intercept times to be 190± 30 ft.

The test drilling with the Proline drill was not successful owing to the hardness of the ice. A two-edge, 3½-inch-diameter cutting head drilled down to 12 ft and then the string jammed. On pulling out, it was found that the chips had refrozen around the flight of the bottom auger. Other cutting heads of different sizes would not cut at all, even when full power was used on the ram. Eventually a pin in the drilling clutch sheared and the attempt was abandoned before more severe damage occurred.

Autumn Traverse

The programme for this Traverse was not completed. The party reached latitude 114° E (Plate 2) where a shortage of fuel necessitated the return to S-2 along the outward route. Plate 3 and Table 1 show the results of this Traverse. Gravity and elevation readings were taken at the locations shown and seismic rock depths were obtained at the 19-and 51-mile points. The methods of navigation used on this Traverse were the same as those employed on the Spring Traverse, described later in this Record.

Elevation measurements. Owing to the continuously poor visibility that was experienced on the outward journey of this Traverse and the danger of crevasses in the Totten Glacier area, it was considered safer for all the vehicles to travel in sight of each other. Consequently, the 'modified leap-frog' method of measuring altitude differences could not be used. A radio failure prevented the use of this method again on the return journey. The six altimeters were read together at each station and the mean readings were corrected for the atmospheric changes recorded at Wilkes Meteorological Station. The method described by Robin (1958) was used for this correction and the correction for the temperature of the air column was calculated by the formula given by Dooley (1963). At a number of stations, the altimeter readings were repeated on the return journey. The root mean square difference between the outward and return altitudes at these stations was 130 ft.

Gravity results. The gravity meter had a very erratic drift rate, which was partly due to temperature variations. Consequently, no drift corrections were applied to the gravity readings. The Bouguer corrections were computed using values of 0.88 and 2.67 g/cm^3 for the densities of ice and rock respectively. There was a considerable difference between the ice thickness computed from the Bouguer anomalies and the value given by the seismic shots. This was partly due to the erratic behaviour of the meter and partly to the relatively shallow bedrock and the irregular topography along the greater part of the Traverse. Therefore, the rock profile derived from gravity measurements was adjusted to fit the seismic depths at S-2 (Jewell, 1962) and at the 19-and 51-mile stations.

Seismic results. At the 19-mile point, a 215-ft hole was drilled and an uphole shoot was attempted. Times from shots at three depths in the hole were recorded before the hole caved in. At the 51-mile point, shallow-refraction work was done. Unfortunately, it was afterwards discovered that the greatest shot-to-geophone distance used was not sufficient to record the maximum seismic velocity of the ice. In order to calculate a weathering correction, the value of this velocity and its intercept time were obtained from the time/distance curve of the noise spread shot at S-2 on the Spring Traverse, as it was thought that the surface layers of neve would be similar at S-2 and the 51-mile point. The results of this refraction spread and the weathering information computed from them are shown in Table 4.

At both seismic stations, a quarter-mile spread was laid out with a geophone station interval of 110 ft and groups of six geophones to each geophone station. The geophone spacing within each group was 22 ft. Table 3 gives details of the reflection recording techniques and reflection times.

Very strong reflections were recorded at each shot-point. At the shot-point at 19 miles, the shots in the hole at depths ranging from 20 ft to 210 ft all gave about the same quality reflection, and these were only slightly better than a shallow pattern-shot consisting of 5 holes at 22ft-spacing, with one pound of explosive in each hole at a depth of 3½ ft. At the 51-mile point, only a single hole with three pounds of explosive at a depth of 4 ft was used and a very strong reflection was again recorded.

Spring Traverse

The party followed Walker's southern route to a point 102 miles south of S-2, then proceeded on a true bearing of 160° (Plate 2). After travelling 165 miles in that direction, the poor mechanical conditions of all vehicles necessitated the return to Wilkes. Up to this point, a considerable amount of time had been lost owing to bad weather. The snow surface was very rough with sastrugi up to a few feet in height, which caused much damage to the vehicles.

The party returned to Wilkes along the outward route. Altitude and gravity readings were made every three miles on both the outward and return journeys. Seismic reflection records were obtained at approximately twenty-five mile intervals and magnetic measurements were made whenever the weather permitted.

Navigation. The vehicles were driven on a bearing given by carefully compensated magnetic compasses mounted on outriggers in front of the drivers. An astro-compass was of little value on the Autumn Traverse and on the outward part of this traverse as the sky was usually overcast. All the astro-fixes shown in Plate 2 were obtained from the mean of several observations of celestial bodies, and these were usually consistent to within $\pm$ 3 miles. The positions of the intermediate stations were obtained from their distances from the astro-fix stations, measured by the Snowtrac odometer. Owing to the vehicles being forced to deviate around the worst patches of sastrugi, the odometer readings gave distances that were too high by about 10%. Consequently an additional error of $\pm$ 1 mile was introduced into the position of these intermediate stations.

Elevation measurements. The usual 'modified leap-frog' method of measuring altitude differences was employed; one set of altimeters was always three miles ahead of the other set while travelling and both sets were read simultaneously at the three-mile stations. Before travelling each day, all the altimeters were set to the same reading. It is believed that this would eliminate the differences in calibration between the meters, so no calibration corrections were applied to the readings. At the end of a day's journey all the meters were again read together and any difference between the two sets was distributed among the day's readings. The altitude differences between successive stations were corrected to an air column temperature of + 15°C by the method given by Dooley (1963).

The starting point for the altitude and gravity measurements was to have been Station V96 on the Wilkes-Vostok Traverse, the altitude of which was determined by Walker and Jewell. However, it was later discovered that the 'turn-off' point on the Spring Traverse (Station 5-mile, Plate 2) was five miles to the east of the Southern Trail. On the return journey, an altitude and gravity tie was run across to Station V96 from the 'turn-off' point.

The elevations shown in Table 2 and Plate 3 are the means of the values measured on the outward and return journeys at each station. The root mean square difference between the outward and return values is 42 ft. Therefore, the standard deviation of the mean altitude at any station should be about 20 ft. Part of this is due to errors in relocating the original station on the return journey. Any error in the adopted value of the altitude of Station V96 will be added to this standard deviation at each station.

Gravity results. The gravity meter continued to have an erratic drift rate. On three occasions the bulb burned out and the geodetic dial was removed to renew it. After the dial was replaced and reset, there was a considerable difference in the readings. This made it impossible to determine long-term drift rates from the difference between the readings taken on the outward journey and the return journey.

Only readings taken on the return journey have been used for the ice thickness computations because the meter experienced a much smaller temperature variation and so would have a smaller drift rate than that on the outward journey. No corrections for meter drift were applied to the readings taken while travelling. When the party was stationary for more than a few hours, the meter was read at the beginning and end of this period and the amount of drift measured was subtracted from the subsequent readings. All the gravity values on this traverse are based on Walker's value of gravity at Station V96. The ice thicknesses given in Table 2 and Plate 3 were computed from the Bouguer anomalies. The rock profile shown in Plate 3 has not been adjusted to the seismic ice thickness values in general, as it showed fair agreement with them. There is some significant variation between the gravity and seismic depths at Shot-points 2 and 3, however.

Seismic results. At Shot-point 3 a refraction shot was made into a spread composed of alternate horizontal and vertical geophones. The time/distance curves (Plate 4) show the recorded compression wave velocities (Vp) and the transverse wave velocities (Vs). The values of Vp = 13,200 ft/s and Vs = 6400 ft/s give a value of Poisson's Ratio of 0.35.

A noise test was made at Shot-point 1 and the velocities of the compression waves recorded on these records are shown in Plate 5. The velocities and intercept times obtained from the spreads at Shot-points 1 and 3 are listed in Table 4. As there was no significant difference between the results obtained at the two locations, the averages of the velocities and intercept times were used to compute the depths and thickness of the surface layers.

Table 3 gives details of the seismic reflection records used for the ice thickness determinations on this traverse. The spreads were always laid out in a true north-south direction. They were not levelled, as the small variations in altitude along the length of a spread were not sufficient for the altimeters to detect. At Shot-points 1, 2, 3, and 4, the spreads consisted of twelve groups of six geophones, the geophone spacing in the groups being 22 ft and the distance between the centres of the groups was 110 ft. At Shot-points 5 and 6, twelve single geophones spaced at 50-ft intervals comprised the spread. At each Shot-point, several shots were fired with various recording parameters; the results of these are discussed below. The best record at each location was used for the rock depth measurement and these are shown in Plates 7 & 8. The weathering corrections for all the spreads on this Traverse were computed from the mean velocity distribution given in Table 4. A value of 13,200 ft/s was used for the reflected wave velocity and the measured ice thickness varied from 10,800 ft at Shot-point 2 to 5880 ft at Shot-point 6.

At Shot-point 1, a comparison was made between various sizes of charge in a deep hole, and it was found that one-pound charges gave records of at least equal quality to those with larger charges. At Shot-points 4 and 7, half-pound charges were found to be satisfactory.

Several attempts were made to determine the minimum shot-hole depth necessary for good reflections. At S-2 and Shot-point 7, as at the two shot-points on the Autumn Traverse, 4-ft hand-augered holes, either singly or in patterns, gave good reflections and a reasonable signal-to-noise ratio. Further south, shallow holes caused a large increase in surface noise when compared with deep shot-holes, and a relative decrease in reflection amplitude. The reflection quality deteriorated to the south using 4-ft shot-holes, and south of Shot-point 3 no reflections could be recognized on these records. Various patterns of 4-ft holes also proved ineffective at Shot-point 1. At Shot-point 3, the minimum hole depth required to produce a distinguishable reflection was 22 ft. However, the shots at 45 ft in this hole gave a better quality reflection, its amplitude being much higher relative to the general noise level. In general, hole depths of 30 - 40 ft were satisfactory, but there were no direct comparisons with the deeper shots, which were only obtained at Shot-points 1 and 2.

Five-point air-shots consisting of half-pound charges tied to the tops of 10-ft poles gave fair quality reflections, which were better than for the 4-ft pattern holes but not so good as those obtained from 35-ft shot-holes at Shot-points 4 and 5.

At several locations, comparison records with similar charges and depths, but different filter settings, were made. Since automatic gain control of the amplifiers was used, it was not possible to measure signal-to-noise ratios, although a qualitative assessment of this could be made. Settings KK90 -K210 gave the best signal-to-noise ratio. Lower filter-settings gave a lower apparent noise-level but also a relative decrease in the reflection amplitude and a poorly defined onset of the reflection pulse. Higher filter-settings, e.g. KK210 - K320, gave an increase in reflection amplitude but also a large increase in high-frequency noise. This latter effect could be partly due to the galvanometers responding at their natural frequency of 300 c/s. Records 20, 22, 35, and 45 from Shot-points 1, 2, and 3 (Plate 7) are examples of the filter comparisons obtained.

Three noise tests were made : at the airstrip near Wilkes, at S-2, and at Shot-point 1. These locations were chosen as being typical of the coastal 'blue ice' regions, the intermediate plateau, and the high inland plateau respectively. These noise tests were made similarly to those described by Graebner (1960). The spreads consisted of twelve single geophones spaced at 10-ft intervals, and the shot-point-to-spread distance was varied from 1800 to 600 ft. The charges were fired in 4-ft shot-holes and the amplifiers operated on constant gains.

At the airstrip, the noise recorded was of very low level and mainly of high frequency (about 300 c/s). The surface waves did not have sufficient amplitude to allow their parameters to be measured.

Plates 5 and 6 show results obtained at the other two locations. The points on the time/distance curves correspond to the peaks of the most prominent cycle in each wave group. At each location, two distinct wave groups were recorded. They have been named A and B. The approximate wave form of each group is shown in Plates 5 and 6. The properties of these groups are set out in Table 7, and were obtained as follows:

1. The amplitudes were obtained from comparisons with test records using the same amplifier gain settings. The voltages refer to the equivalent input signal to the amplifiers.

2. The periods were measured from the records. They refer to the centre cycle in the wave group for the shot-point distances specified.

3. The velocities were given by the slope of the time/distance curve.

4. The frequency and wavelength were computed from the period and velocity.

5. The bandwidths were computed from the approximate formula :

$$\text{bandwidth} = (1 - \frac{1}{c})/Ta \quad \text{to} \quad (1 + \frac{1}{c})/Ta,$$

where c = number of cycles in the wave group,
and Ta = average period of wave group.

Borehole temperatures. At each seismic station, a thermohm was lowered 30 ft down the borehole and the temperature was allowed to stabilise for at least 24 hours. The thermohm's resistance was then measured with a Wheatstone Bridge and, when converted to degrees, gave the mean annual temperature of the area. The thermohm was calibrated against a U.S. Weather Bureau toluene thermometer and the corrected borehole temperatures are accurate to $\pm$ 0.5°C. The results are given in Table 5.

Magnetic observations. Measurement of magnetic declination, horizontal intensity, and vertical intensity (Table 6) were made whenever weather conditions permitted. A value of residual torsion (α) of minus 4.6 minutes was obtained from intercomparison observations made at Wilkes in March 1963, and this value has been used in the declination computations. No corrections to a magnetic standard have been applied to the values in Table 6 as no corrections have yet been adopted for the Wilkes Observatory instruments with which the traverse instruments were compared.

5. DISCUSSION OF RESULTS

Autumn Traverse

The geophysical objectives of this Traverse, i.e. to obtain surface and bedrock profiles, were achieved. However, the measured altitudes would have been more accurate if the 'leap-frog' method had been used. The bedrock profile between the seismic stations is very uncertain for reasons mentioned above. No comparison has been made between this profile and Walker's Totten Glacier Survey as Walker did not make any seismic ice thickness measurements, and hence his profile, determined from gravity measurements, could not be adjusted to seismic depths. The altitudes obtained on the Autumn Traverse agree with the surface contours drawn up by Walker, thus confirming the existence of an ice dome in the area to the south-east of S-2.

Spring Traverse

The geophysical objectives of this Traverse were achieved although a relatively short distance was travelled. Rock and ice surface elevations in general, were considerably lower than those measured by Walker, but were similar in that the ice surface rises, and the bedrock becomes deeper, towards the south.

The accuracy of the ice thickness determined from gravity measurements cannot be calculated because of the gravity meter's erratic drift rate, but it can be estimated by comparison with the seismic values of ice thickness. According to Jewell (1962), an ice thickness of 10,000 ft as measured by the seismic reflection method can be between 550 ft too large and 130 ft too small owing to possible errors in timing the reflection and in the value of velocity used. With two exceptions, the gravity and seismic values on this traverse agree to within these limits. This implies that the gravity results are fairly reliable. The disagreements at Shot-points 2 and 3 between the gravity profile and the seismic depths could be due to a change in density of the bedrock, or to a very deep, narrow depression in the bedrock.

The recorded seismic velocity of 13,200 ft/s for ice is slightly higher than the values reported by other workers. Jewell measured a velocity of 13,000 ft/s 200 miles south of S-2. Walker's values, measured much further south, were considerably less. However, it is possible that the shooting distances used by Walker were not sufficient to record the highest velocity refractor in view of the greater thickness of semi-consolidated neve existing in these areas. An error could be introduced into the velocities measured on the Spring Traverse by the timing motor being slow, as it had been several years since the timing system was last calibrated. This would not affect the ice thickness values as both reflection times and velocities were measured by the same timing system.

The bedrock reflection was recorded at each shot-point, and at Shot-point 1 was still quite a strong reflection. This was in contrast to Walker's records, which at a similar distance inland, were of poor quality. It appears that this improvement was mainly due to the higher filter settings used. The best filter settings for use in reflection shooting, as quoted in Section 4, i.e. 90 - 210 c/s, agree with those found by Weihaupt (1963) and Kapitza (1963). The noise tests at S-2 and Shot-point 1 show that the organised noise from the shot lies in the frequency range 30 - 90 c/s and this appears consistent with the use of a 90 - 210 c/s filter. Weihaupt and Kapitza also recommend 150-ft shot-holes, in comparison with the 30-ft holes found to be adequate at Shot-point 3. However, they were working in regions further south than those investigated on this Traverse.

Two effects have previously been suggested as reasons for deterioration in record quality on the high plateau. Sorokhtin (1960) postulated that heterogeneous layers in the neve act as a high-pass mechanical filter to reflected seismic waves. Thus, high electrical filter-settings in the seismic instruments are necessary to pass the reflected signal. However, this is contrary to what is found in seismic reflection work on land, where the low velocity soil and weathered surface layers attenuate the higher frequencies in the reflected pulse. Robin (1958) and Poulter (1947) suggest that the shot-generated surface waves increase in amplitude owing to the increased thickness of unconsolidated and semi-consolidated surface layers of neve found further south.

The noise tests at S-2 and Shot-point 1 do not suggest that an increase in organised noise from the shot is responsible for the deterioration in the quality of the reflections on the high inland plateaus areas. For instance, the noise amplitudes for the same charge are smaller at Shot-point 1 than at S-2. Moreover, with the increased thickness of ice, the bedrock reflection is recorded at times in excess of one second south of Shot-point 6, by which time the main energy of the organised noise has already passed the geophone spread; whereas in the ice-dome area, the reflection time is about 0.4 seconds, which lies in the time range of the noise. All the measured noise lies in the frequency band 30 - 90 c/s, and hence the use of a filter pass-band of 90 - 210 c/s should effectively eliminate the organised noise. The geophone group used, viz. 6 geophones at 22-ft spacing, has a wave number rejection band from 3.8×10^{-3} c/ft to 41.6×10^{-3} c/ft, and also assists in the rejection of the noise, since this lies in the range 5×10^{-3} c/ft to 24×10^{-3} c/ft. It is possible that the noise has a significant frequency component in the pass-band of the electrical filter (90-210 c/s) that was not measured, in which case it may have wave numbers up to 75×10^{-3} c/ft, which lie outside the rejection band of the geophone filter. A reduced spacing of geophones to 12 ft with a corresponding increase in the number of geophones to 10 or 12 would provide a better spatial filter if this is the case.

It was observed that there was a considerable increase in random noise level on the reflection records on the high plateau compared to the coastal regions. This was partly micro-seismic and partly shot-produced. The higher filter-settings again eliminated most of this noise, although, if it was found to be a problem, a greater number of geophones would be useful in order to reduce this noise by statistical filtering.

From the foregoing, it appears that the use of the higher filter band, 90 - 210 c/s, may be the answer to the problem of recording bedrock reflections on the high inland plateau. The difference in recording conditions may be that in the shallow bedrock areas, near the coast, the reflected signal has sufficient amplitude to override the low-frequency noise, but on the inland plateau, with much greater thicknesses of ice, the reflected signal is much smaller in amplitude and cannot be 'seen' through the low-frequency noise, which has to be filtered out. However, it should be noted that this Traverse only just reached the verge of the poor reflection area, and conditions may be vastly different further south.

6. CONCLUSIONS AND RECOMMENDATIONS

The techniques for measuring surface elevation and ice thickness used on the two traverses proved successful to within a reasonable degree of accuracy. The 'leap frog' method of measuring surface elevations gave a higher degree of accuracy than was required in view of the inherent errors in navigation in polar regions. Providing the rock surface was below sea level, ice thicknesses derived from seismic and gravity measurements showed good agreement. In coastal regions, where the ice is relatively thin and the rock surface is more rugged, seismic stations at 10-mile intervals or closer would be desirable.

On the high plateau, i.e. in areas more than 300 miles from the coast, good reflections are obtainable by using deep shot-holes, filter settings KK90-K215, and small charges (about one pound of explosive with reduced amplifier gains). It is suggested that Walker and Jewell used filter-settings too low to obtain good reflections in this area.

The results of the air-shots were sufficiently good to justify further experiments with this method.

No major equipment replacements are considered necessary, but some changes that would save time in the geophysical work are listed in Appendix 4.

7. ACKNOWLEDGEMENTS

The author wishes to express his appreciation of the assistance given by the other members of the traverse parties. Special acknowledgement must be extended to Mr. I. Thomas who performed the duty of shooter on both traverses, acted as observer when the writer was incapacitated, and without whose assistance the geophysical programme would have been greatly reduced.

The thermohm and Wheatstone Bridge were loaned by Mr. C. Webster of the U.S. Weather Bureau.

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TABLE 1

Elevation and Gravity Results, Autumn Traverse 6328

STATION (miles from S-2)	LATITUDE	LONGITUDE	ELEVATION (ft)	OBSERVED GRAVITY (mgal)	FREE AIR ANOMALY (mgal)	BOUGUER ANOMALY (mgal)	ICE THICKNESS (ft)	ROCK ELEVATION (ft a.s.l.)	ROCK ELEVATION ADJUSTED TO SEISMIC DEPTH (ft a.s.l.)
				982					
S-2	66°30.0'	112°13'	3820	050.2	+13.7	-29.2	3390	+430	+430
2½	30.2	18	3900	027.3	-1.9	-45.7	4120	-230	-330
6	30.4	26	4020	029.0	+10.8	-34.3	3620	+400	+150
10	30.6	34	4110	024.4	+14.5	-31.7	3500	+610	+190
10½	30.7	36	4140	024.2	+17.0	-29.5	3400	+740	+300
11½	30.8	37	4210	023.6	+22.9	-24.4	3180	+1030	+550
17	31.0	47	4340	023.7	+35.0	-13.7	2700	+1640	+920
19(SP)	31.5	54	4260	027.7	+30.9	-16.9	2840	+1420	+620
26	31.8	113°07	4050	-	-	-	-	-	-
31	32.5	18	3970	053.7	+28.5	-16.1	2810	+1160	+930
37	32.7	29	3920	075.9	+45.8	+1.8	2010	+1910	+1970
40	34.0	36	3780	078.8	+34.1	-8.3	2460	+1320	+1520
45	35.3	44	3500	091.6	+19.1	-20.2	2990	+510	+950
51(SP)	37.0	114°01	2450	169.5	-3.4	-24.1	3160	-710	+20

TABLE 2

Elevation and gravity results, Spring Traverse

STATION (miles)	LATITUDE	LONGITUDE	ELEVATION (ft)	OBSERVED GRAVITY (mgal)	FREE AIR ANOMALY (mgal)	BOUGUER ANOMALY (mgal)	ICE THICKNESS (ft)	ROCK ELEVATION (ft a.s.l.)
V96	67°59.2	112°12.4	4440	982 118.4	+44.1	-5.8	6200	-1760
5	58.0	26	4310	136.5	+50.3	+1.9	5860	-1550
7	59.8	28	4330	140.1	+54.9	+6.3	5660	-1330
10	68°02.0	32	4510	125.7	+55.1	+4.5	5740	-1230
13	04.7	34	4580	113.4	+46.6	-4.8	6160	-1580
16	06.8	36	4600	110.6	+43.5	-8.1	6300	-1700
19	08.8	38	4660	109.0	+41.7	-10.2	6400	-1780
22	11.0	41	4780	105.3	+50.7	-3.0	6080	-1300
25	13.0	44	4900	102.4	+57.0	+2.0	5850	-950
28	15.8	46	4930	101.7	+56.2	+0.8	5910	-970
31(SP 6)	18.0	48	4980	96.6	+53.5	-2.4	6050	-1070
34	20.2	52	5010	96.3	+53.7	-2.6	6060	-1050
37	22.8	54	5100	-	-	-	-	
40	25.4	57	5200	74.6	+44.6	-13.8	6470	-1270
43	27.4	113°00	5220	71.9	+41.7	-16.9	6690	-1470
46	29.7	02	5260	67.8	+39.0	-20.1	6840	-1580
49(SP 5)	32.0	05	5430	45.2	+30.0	-31.0	7320	-1890
52	34.3	06	5440	43.4	+26.3	-34.3	7460	-2020
55	36.8	07	5470	40.4	+23.4	-38.0	7630	-2160
58	39.8	08	5570	35.3	+25.3	-37.2	7590	-2020
61	42.4	09	5680	27.4	+24.7	-39.1	7680	-2000
64	46.0	12	5820	14.2	+22.0	-43.4	7870	-2050
67	47.6	16	5780	17.6	+19.6	-45.3	7950	-2170
70	50.0	19	5840	17.2	+22.2	-43.4	7870	-2030
73(SP 4)	52.1	24	5950	00.8	+14.0	-52.8	8290	-2340
76	54.0	28	6020	981 991.9	+9.7	-57.9	8510	-2490
79	56.2	32	6000	990.3	+4.1	-63.3	8750	-2750
82	58.2	37	6070	982.4	+0.7	-67.5	8940	-2870

TABLE 2 (Continued)

STATION (miles)	LATITUDE	LONGITUDE	ELEVATION (ft)	OBSERVED GRAVITY (mgal)	FREE AIR ANOMALY (mgal)	BOUGUER ANOMALY (mgal)	ICE THICKNESS (ft)	ROCK ELEVATION (ft a.s.l.)
85	69°00.5	113°41	6080	-	-	-	-	-
88	02.5	46	6100	986.9	+3.7	-64.8	8820	-2720
91	04.8	50	6200	978.4	+2.3	-67.3	8930	-2730
94	06.4	53	6220	978.3	+2.4	-67.4	8940	-2720
97(SP 3)	08.8	114°00	6320	963.7	-5.1	-76.1	9320	-3000
99	10.5	00	6360	956.7	-10.1	-81.5	9560	-3200
102	12.2	01	6400	958.4	-6.3	-78.2	9410	-3010
105	14.6	02	6430	956.2	-8.1	-80.3	9510	-3080
108	17.0	04	6460	955.0	-8.9	-81.4	9560	-3100
111	19.0	06	6560	944.9	-11.6	-85.3	9730	-3170
114	21.3	08	6640	934.3	-16.9	-91.5	10,000	-3360
117	23.4	09	6680	927.2	-22.4	-97.4	10,270	-3590
120	25.7	10	6680	926.1	-25.8	-100.8	10,420	-3740
123	27.7	12	6710	925.8	-25.3	-100.6	10,410	-3700
126(SP 2)	30.2	14	6770	922.8	-28.1	-101.1	10,430	-3660
129	32.6	16	6840	918.3	-25.3	-102.1	10,480	-3640
132	35.2	17	6890	916.0	-25.5	-102.9	10,510	-3620
135	37.7	18	6940	914.4	-24.9	-102.8	10,510	-3570
138	40.0	20	6980	913.2	-24.6	-103.0	10,520	-3540
141	42.5	22	7010	917.1	-20.3	-99.0	10,340	-3330
144	45.0	24	7090	919.2	-13.1	-92.7	10,060	-2950
147	47.4	26	7160	914.8	-13.3	-93.7	10,100	-2940
150(SP 1)	50.0	28	7190	910.2	-17.3	-98.0	10,290	-3100
158	56.0	33	7250	904.5	-23.6	-105.0	10,600	-3350
159	56.7	33	7250	903.2	-25.6	-107.0	10,690	-3440
162	59.5	33	7270	900.1	-29.5	-111.1	10,880	-3610
165	70°01.5	33	7290	898.7	-31.9	-113.8	11,000	-3710

TABLE 3

Seismic reflection results

SHOT-POINT	SHOT NUMBER	HOLE DEPTH (ft)	CHARGE (lbs)	SHOT OFFSET (ft)	GEOPHONE GROUP (ft)	TRACE INTERVAL (ft)	SPREAD LENGTH (ft)	FILTER LOW	SETTINGS HIGH	GAIN	REFLECTION TIME (ms)	CORRECTED REFLECTION TIME (ms)	DEPTH (ft)	ROCK SURFACE ALTITUDE (ft)
Autumn Traverse														
19-ml	19(1)	215	3	40	6 at 22 ft	110	1320	K70	KK120	Full	562	552	3640	+620
51-ml	51(1)	4	3	540	6 at 22 ft	110	1320	K70	KK120	Full	407	367	2430	+20
Spring Traverse														
SP 1	20	110	1	130	6 at 22 ft	110	1320	K60	KK120	Full	1564	1554	10,250	-3070
SP 2	35	150	1	200	6 at 22 ft	110	1320	K70	KK120	Full	1640	1635	10,800	-4030
SP 3	45	45	1	110	6 at 22 ft	110	1320	KK90	K215	-30	1336	1318	8720	-2400
SP 4	68	35	½	100	6 at 22 ft	110	1320	L30	L215	-40	1266	1246	8230	-2260
SP 5	71	33	1	100	SINGLES	50	550	KK90	K215	-30	1115	1096	7240	-1820
SP 6	74	34	1	150	SINGLES	50	550	KK90	K215	-30	910	890	5880	-900
SP 7	79	35	1	460	SINGLES	460	5520	KK90	K215	-30	646	625	4130	-1480

The above figures are taken from the best record obtained at each location.

TABLE 4

Weathering data

Results of up-hole shoot, SP 19-mile, Autumn Traverse

Depth of charge	Up-hole time
210 ft	21 ms
170 ft	20 ms
33 ft	5 ms

Results of refraction spreads

SP 51-mile

Velocity	Intercept time	Layer thickness	Depth to top of layer
2000 ft/s	-	15 ft	-
(6500 ft/s)	14 ms	11 ft	15 ft
8200 ft/s	17 ms	96 ft	26 ft
11,000 ft/s	34 ms	160 ft	122 ft
13,200 ft/s	(52 ms, from S-2)	-	282 ft

SP 1		SP 3	
Velocity	Intercept time	Velocity	Intercept time
2400 ft/s	-	(2900 ft/s)	-
5600 ft/s	9 ms	(6200 ft/s)	12 ms
8800 ft/s	20 ms	9200 ft/s	20 ms
11,400 ft/s	39 ms	11,800 ft/s	38 ms
13,200 ft/s	56 ms	13,200 ft/s	55 ms

Average of SP 1 and SP 3

Velocity	Intercept time	Thickness of layer	Depth to top of layer
2400 ft/s	-	13 ft	-
5600 ft/s	10 ms	36 ft	13 ft
9000 ft/s	20 ms	114 ft	49 ft
11,600 ft/s	38 ms	161 ft	163 ft
13,200 ft/s	56 ms	-	324 ft

TABLE 5

Borehole temperatures, Spring Traverse

Position	Temperature (^{o}C)
SP 1	-36.5
SP 2	-34.3
SP 3	-31.8
SP 4	-31.4
SP 5	-28.0
SP 6	-26.8
SP 7	-20.8
S-2	-21.2
Airstrip	-13.0

TABLE 6

Magnetic results, Spring Traverse

Station	Latitude	Longitude	West declination	Vertical intensity (gammas)	Horizontal intensity (gammas)
158 miles	$69^{o}56.0'$	$114^{o}33'$	$106^{o}48.7'$	64,796	8756
SP 3	$69^{o}08.8'$	$114^{o}00'$	$102^{o}41.2'$	64,470	8735
SP 4	$68^{o}52.1'$	$113^{o}24'$	$102^{o}59.8'$	64,524	8581
SP 5	$67^{o}18.3'$	$112^{o}25.3'$	$93^{o}40.9'$	65,363	8214

TABLE 7

Analysis of noise tests

Station	Event	Amplitude (mv)	Distance from SP (ft)	Velocity (ft/s)	Period (ms)	Centre frequency (c/s)	Centre wave number (c/ft x 10^3)	Wave length (ft/c)	No. of cycles in wave group	Frequency bandwidth (c/s)	Wave number bandwidth (c/ft x 10^3)
S-2	A	2.2	1300	6800	19	53	7.8	128	6	44 - 62	6.5 - 9.1
			1800	6800	22	45	6.6	151	6	38 - 53	5.6 - 7.8
	B	1.4	800	3600	14	72	20.0	50	5	57 - 86	15.9 -23.9
			1800	4000	24	42	10.5	95	5	33 - 50	8.3 -12.5
SP 1	A	0.5	1000	4500	16	63	14.0	72	10	56 - 69	12.5 -15.3
			1800	5600	24	42	7.5	134	10	38 - 46	6.3 - 8.2
	B	0.5	900	2800	18	56	20.0	50	13	51 - 60	18.2- 21.4
			1800	3200	28	36	11.2	89	13	33 - 39	10.3 -12.2

APPENDIX 1

Personnel, vehicles, and traverse statistics

Cape Folger

Dates	Exploration trip	19th-20th February
	Seismic work	17th-20th March and 31st March - 2nd April
	Drilling	29th August - 2nd September
Personnel	M. Kirton (geophysicist) R. Simon (glaciologist) One other	
Vehicles	1 Robin-Nodwell Tracked Carrier RN110 1 Small Caravan	

Autumn Traverse

Dates	6th April - 11th May	
Personnel	R. Saxton	Officer in Charge and navigator
	G. Wilkinson	Diesel mechanic
	I. Thomas	Radio operator and meteorologist
	P. Ormay	Glaciologist
	M. Kirton	Geophysicist
Vehicles	1 Robin-Nodwell Tracked Carrier RN110 1 Porsche Snowtrac 1 Caterpillar D4 Tractor 1 large caravan 1 Proline drill and sledge 3 Norwegian cargo sledges	

Total number of days	36
Number of days spent travelling	16
Number of days spent on geophysical work	5½
Number of days spent on vehicles repairs	4
Number of days lost due to blizzard	10½
Total miles travelled	208
Minimum temperature recorded	-54.0°F
Maximum temperature recorded	-1.0°F

Spring Traverse

Dates	28th September 1963 to 8th January 1964.	
Personnel	R. Saxton	Officer in Charge
	V. Morgan	Senior diesel mechanic
	F. Spence	Diesel mechanic
	K. Gleeson	Meteorologist and glaciologist
	I. Thomas	Radio operator and assistant to geophysicist
	M. Kirton	Geophysicist

Vehicles	1 Robin-Nodwell Tracked Carrier RN110
	1 Porsche Snowtrac
	1 Weasel
	2 Caterpillar D4 Tractors
	1 large, 6-man caravan
	1 Proline drill and sledge
	10 Norwegian cargo sledges

Total number of days	103
Number of days spent travelling	31
Number of days spent on geophysical work	24
Number of days spent on vehicle repairs	11
Number of days lost due to blizzards	31
Number of days lost due to whiteout	6
Total miles travelled	640

Meteorological data

	Oct.	Nov.	Dec.	Jan. (7 days)
Average temperature ($^{\circ}F$)	-20.2	-19.7	-2.3	+14.7
Average wind (knots)	19.7	12.5	16.7	2.6
Days with wind under 10 knots	3	12	4	4
Visibility obstructed (days)	29	21	21	3
Blowing, drifting, or falling snow (days)	30	19	21	3
Minimum temperature ($^{\circ}F$)	-48.0	-48.0	-26.0	-3.0

APPENDIX 2

Table of work completed & materials used

Survey	Number of seismic stations	Number of seismic shots	Number of gravity stations	Number of magnetic stations	Consumables: Detonators	Consumables: Explosive (lb)	Consumables: Linagraph paper (rolls)	Consumables: Dectol (tins)	Consumables: Fixer (tins)	Holes drilled: No.	Holes drilled: Total footage
Cape Folger	1	29	-	-	31	61	3	4	4	-	-
Autumn Traverse	2	19	13	-	28	28	2	2	2	1	215
Spring Traverse including airstrip noise analysis	9	135	54	4	195	406	8	7	7	8	670
Miscellaneous testing at Wilkes					11	1	1				

APPENDIX 3

Geophysical equipment

Seismic

Model 7000B, 12-channel seismic amplifier system, manufactured by Texas Instruments Inc., Houston, Texas, U.S.A.

Model 521, 25-trace oscillograph camera manufactured by Technical Instrument Co. (TIC), Houston, Texas, U.S.A.

Shot boxes	1. Technical Instrument Co. 90-volt blaster, condenser-battery system.
	2. South-western Industrial Electronics (SIE) 2000-volt blaster, condenser-generator system.
Geophones	14 TIC 20-c/s vertical geophones.
	6 SIE 5-c/s horizontal geophones.
	14 groups of 6 Electro-Tech. 20-c/s vertical geophones with 22-ft jumper cables.
Cables	Four rubber-covered, double-ended cables, with 13-conductor pairs and 13 moulded take-outs, at 115-ft intervals. Total length 1500 ft. Manufactured by Vector Co., Houston, Texas, U.S.A.
Explosives	RDX/TNT (60/40) in 1 lb charges with CE primer.
Detonators	Imperial Chemical Industries 'Seismic' with 6-ft and 30-ft leads.
	Du Pont 'Seismic' with 24-ft leads.
Photographic	Kodak Linagraph paper type 480, six inches wide in 200-ft rolls.
	Kodak acid fixer and Dectol developer, both in one gallon tins.
Drill	Proline HDBA7 Borer.

Gravity

Worden No. 140 Geodetic meter.

Magnetic

La Cour BMZ No. 121, and La Cour QHM No. 493.

Bore hole temperatures

Leeds and Northrop 100-ohm copper thermohm.

Rubicon Co. portable Wheatstone Bridge.

Altitudes

Two sets of three National Instrument Co. aircraft altimeters.

APPENDIX 4

Performance of geophysical equipment

Altimeters

The altimeters gave no trouble and appeared to work satisfactorily.

Gravity meter

The Worden gravity meter No. 140 performed poorly. Its optical system was so bad that, in strong external lighting or with any condensation or icing on the eye-piece lens or on the geodetic dial, it was impossible to see the cross-hairs. The drift rate was mainly temperature-dependent and of the order of +0.1 mgal/$^{\circ}$C. Any drift with time was obscured by the large temperature variations of the meter, despite its being carried in the Robin-Nodwell cab.

Magnetic instruments

Under suitable conditions (wind strength of less than ten knots and good lighting), these instruments gave trouble-free service and were easy to operate. However, on the two traverses, conditions were rarely favourable, so few magnetic observations were made. The mercury column in the BMZ thermometer was broken by the shaking it received while travelling and it could not be repaired. A small toluene thermometer was used to measure the BMZ temperature and so the vertical magnetic intensity measurements have a reduced accuracy. In previous traverses, mercury thermometers have become ineffectual owing to broken threads; in future it is suggested that they be replaced by toluene thermometers.

Proline drill

On both traverses, the drill gave excellent service, although at Cape Folger it was ineffective owing to extreme hardness of the ice. Before the Autumn Traverse the drill was mounted on a new sledge; otherwise it was used exactly as Walker had rebuilt it.

While drilling the deep hole on the Autumn Traverse, the oil seal at the top of the ram cylinder burst and was replaced. On the Spring Traverse, the strain set up by travelling over rough terrain caused guy wires supporting the mast to break. This allowed the mast to fall onto the gear box and break the bell housing. The rough terrain also caused damage to the drill sledge. In future the drill should travel with the mast lowered to prevent such damage recurring.

The 4-ft shot-holes were drilled with a hand auger of the post-hole digger type. This proved excellent in snow or neve.

Seismic equipment

Apart from a few minor electrical faults, the equipment gave no trouble. Following Walker's advice, ample provision was made for warming the equipment and charging the batteries.

Most records show cross-feed of the shot instant pulse onto the other traces; this is possibly due to the snow being a poor electrical earth. Much thought was given to curing the cross-feed; it was eventually reduced considerably by shooting with the blaster at least 100 ft from the cab, and relaying the count-down along a wire to the camera 'Talk' circuit.

Explosives

The charges did not explode on a few occasions at temperatures below - 30°F. The detonators were satisfactory except that below -40°F the plastic insulation on the leads cracked off.

Recommendations

In general the equipment gave a satisfactory performance. A few changes can be recommended to increase the speed of operations. They are:

1. A smaller model of the Proline drill, suitable for mounting on a Robin-Nodwell Carrier and being driven by the Robin-Nodwell engine, would save time in drilling and also eliminate the present heavy drill sledge.

2. A means of recording seismic traces, which does not require photographic solutions.

3. A light-weight portable magnetometer such as a fluxgate or a proton precession instrument, which could be read in any climatic conditions.

APPENDIX 5

Some comments on traverse vehicles

Robin-Nodwell Tracked Carrier RN110

On the Autumn Traverse, this vehicle was driven at an engine speed of 1500 rev/min and appeared to be very much underpowered at altitudes greater than 2000 ft. No higher gear than third could be used, even when the load was reduced to three tons, and frequently second gear was needed to climb high sastrugi. The steering mechanism had a deviation to the left and constant correcting of this reduced the speed. The engine always ran cold and also proved very difficult to start.

On the Spring Traverse, the vehicle was driven at an engine speed of 2300 rev/min. Loads of six tons on three Norwegian cargo sledges and about two tons in the cab were carried. At all altitudes the vehicle had ample power and would travel in fourth gear unless the rough surfaces necessitated a reduction in speed. Before leaving the station for this traverse, the engine compartment was insulated and so the engine operated at a higher temperature. It was also much easier to start. The steering defect was partly compensated for by offsetting the tow hook at the rear.

However, this journey revealed a weakness in the chassis when the two steel girders that located the right hand front wheel journal fractured. This was brought about by the Carrier leading and breaking trail for the other vehicles over many miles of very rough terrain, in which sastrugi four feet high were common. These broken chassis members will be replaced by stronger girders so that this trouble should not recur, providing the vehicle is carefully driven.

Porsche Snowtrac

This proved to be a useful scout vehicle in smooth country, but it was not considered to be sufficiently rugged to lead the traverse party over the rough terrain encountered on the Spring Traverse. Although it was driven in the tracks of the other vehicles, the Snowtrac still suffered damage to its suspension and ruined most of its tyres. The author would not recommend the Snowtrac as a scout vehicle for long polar traverses, because of its light construction and because it has little cargo capacity.

Weasel

This vehicle was many years old but still gave little trouble. It carried much heavy engineering equipment and pulled nearly two tons of fuel. Unfortunately, the vehicles are no longer in production and spare parts are not available for them, so they cannot be considered for future traverse work.

Caterpillar D4 Tractor

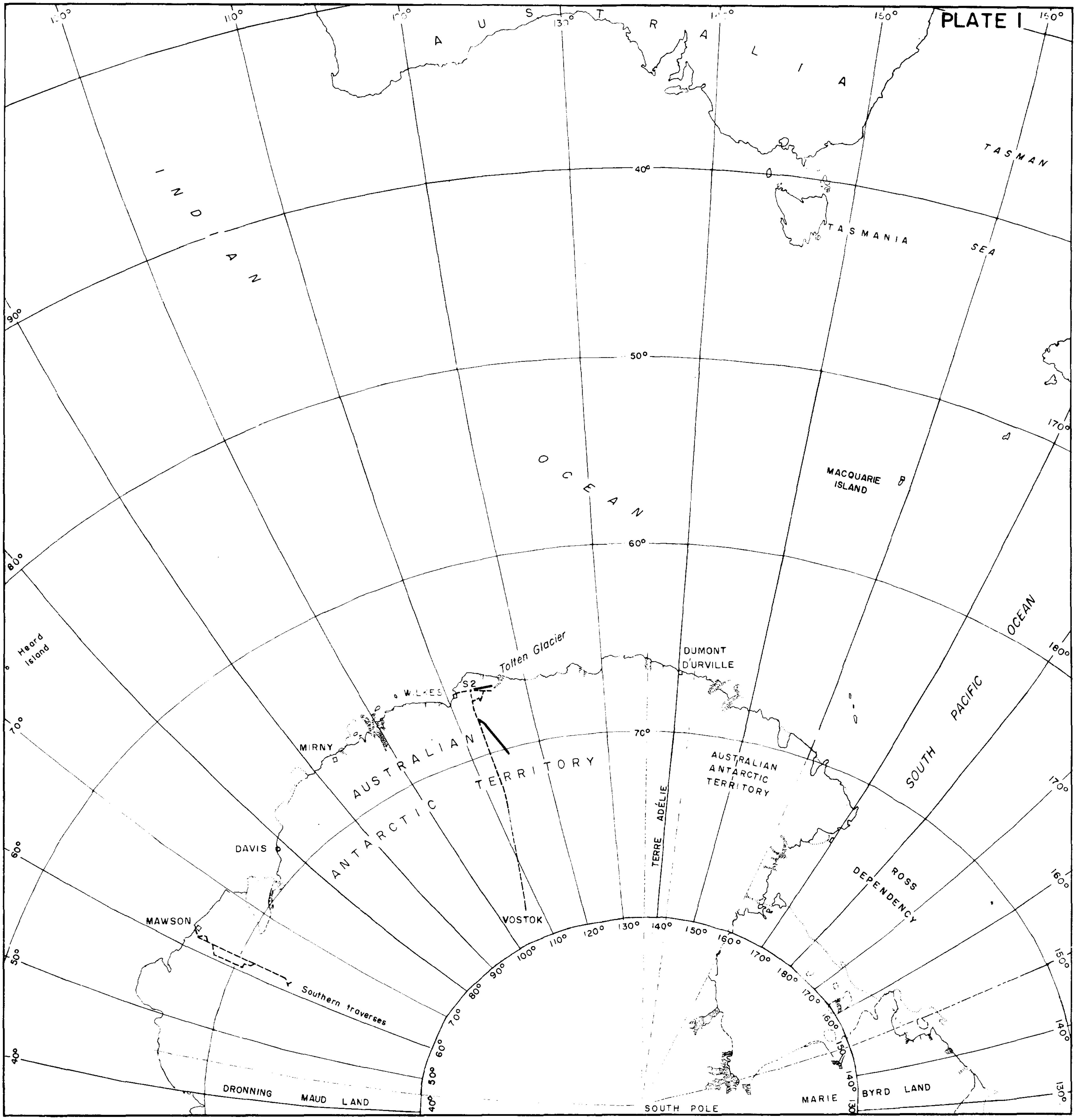
The performance of these vehicles is well known from many previous expeditions. They can pull loads up to 13 tons over all types of surface, although at slow speed (about three miles per hour). The two tractors used on the Spring Traverse gave reasonable performances but suffered many minor troubles owing to their age and the lack of proper servicing facilities in Antarctica. In addition to a cracked cylinder head, they suffered from broken fuel and oil lines, broken turbo chargers, loose combustion chambers, and worn track pins. The time taken in heating their fully exposed engines prior to starting caused considerable delay on every travelling day.

General conclusions

If the Robin-Nodwell engine were to be fitted with a turbo charger to compensate for the decrease in power with increasing altitude and if it had a more efficient steering system it would have almost the load capacity of a D4 Tractor and be capable of travelling at a much higher speed. The fuel consumption of the two vehicles is about the same at one mile per gallon. The Robin-Nodwell has the added advantage of an enclosed engine, making starting and repairs much easier and so less time-consuming. When fitted with navigation equipment, the Robin-Nodwell proved successful as a lead vehicle. In the opinion of the author, until seismic equipment is sufficiently light in weight to be carried on a dog sledge, the Robin-Nodwell Tracked Carrier is the best vehicle at present available for geophysical traverses.

However, there is little point in having vehicles capable of travelling at relatively high speeds when the rough terrain limits them to about three miles per hour. If the expeditions were arranged so that the traverse parties could leave the station in late November and return in late March, better surfaces would be encountered so that the travelling would be much faster, and much loss of time in starting vehicles and due to bad weather, etc. would be avoided.

PLATE I



LEGEND

- Antarctic base station
- ANARE ice thickness traverses prior to 1963
- " " " " 1963

LOCALITY MAP

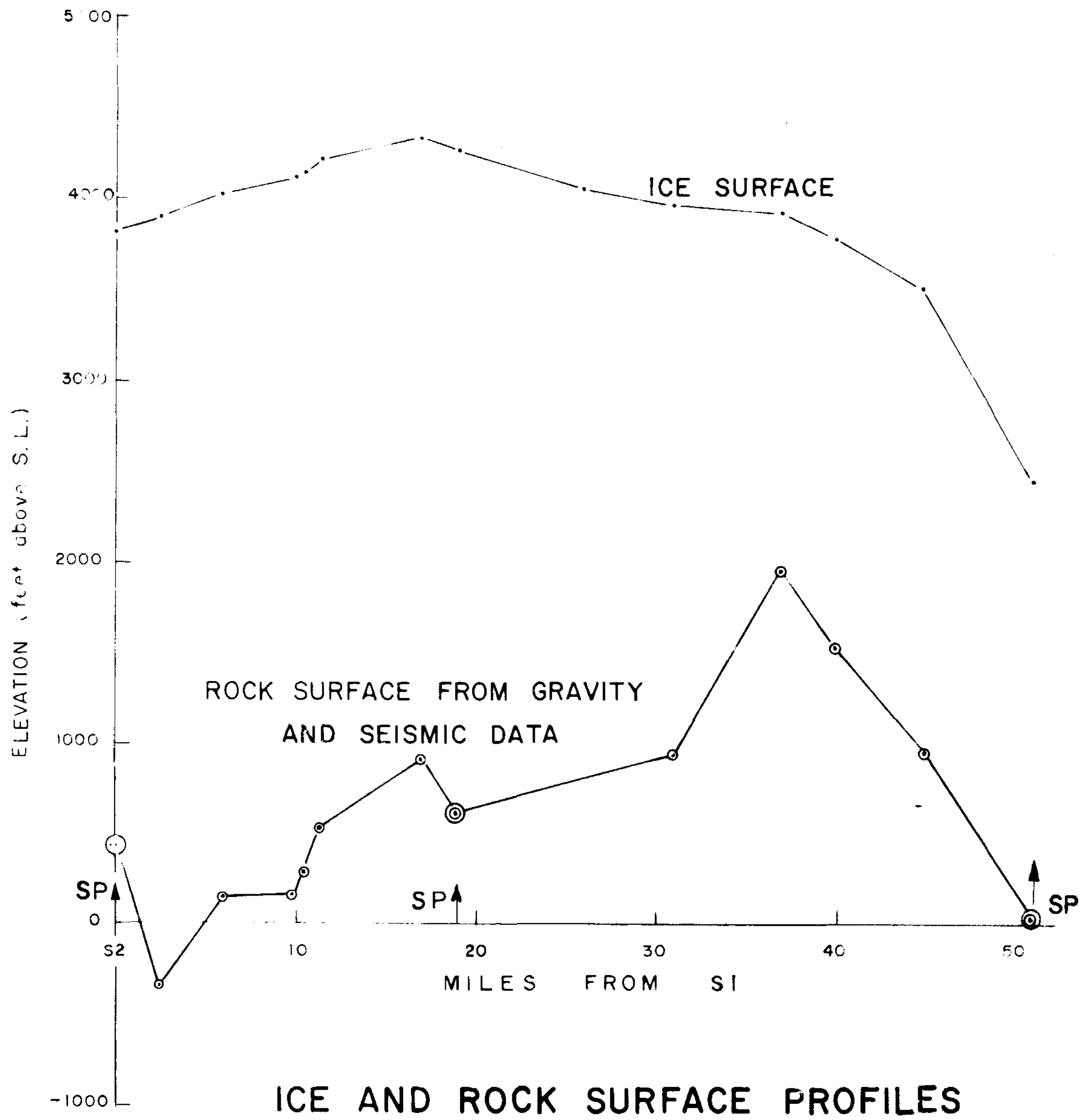
MILES
100 0 100 200 300 400 500 600 700 800

To accompany Record No 1965/24

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G265-97

WILKES, ANTARCTICA, 1963/64 TRAVERSES

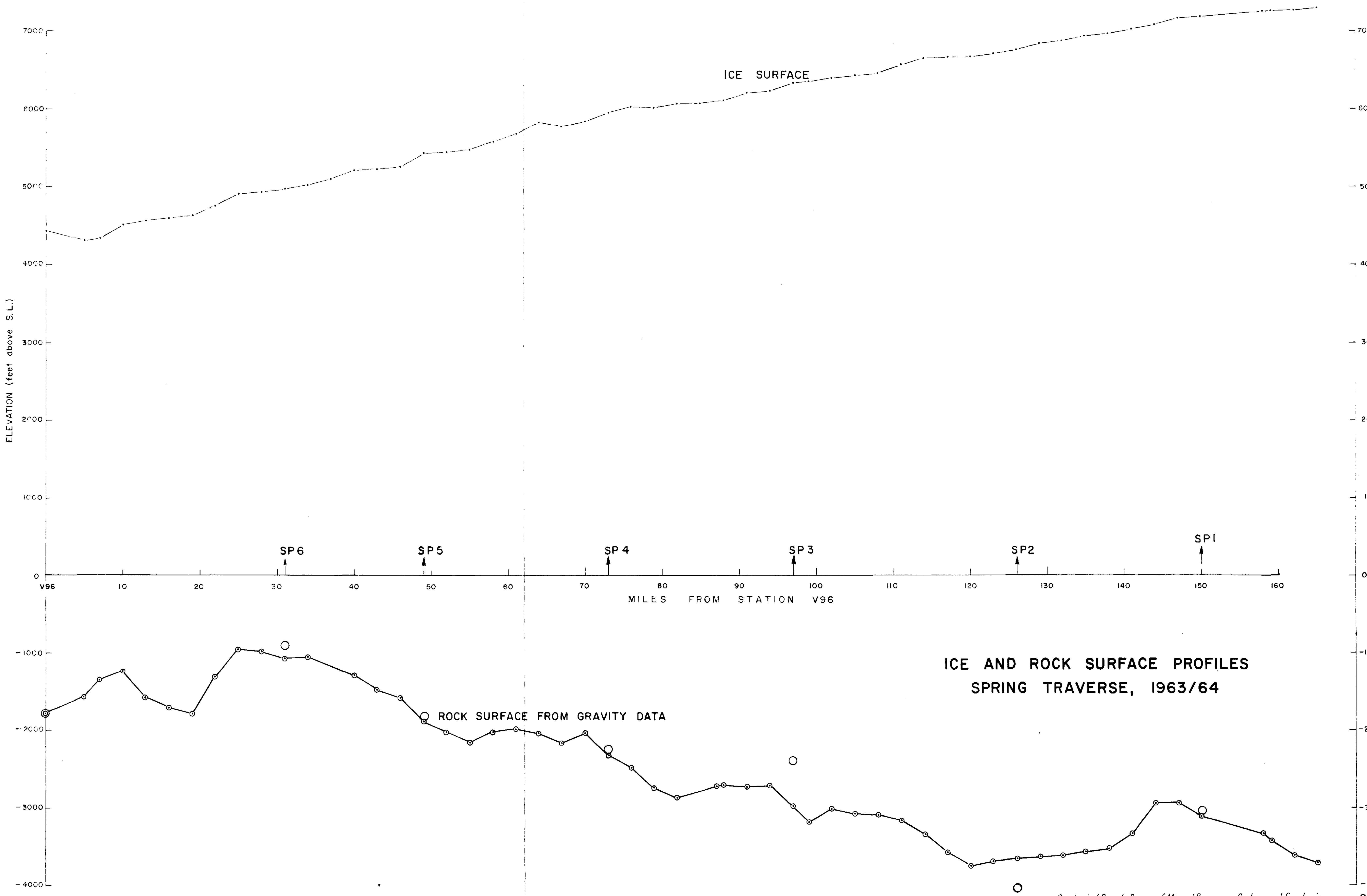
PLATE 3



ICE AND ROCK SURFACE PROFILES
AUTUMN TRAVERSE, 1963

LEGEND

- ⊙ Rock depth from gravity data
- ○ „ „ „ seismic „
- SP Position of seismic shot-point

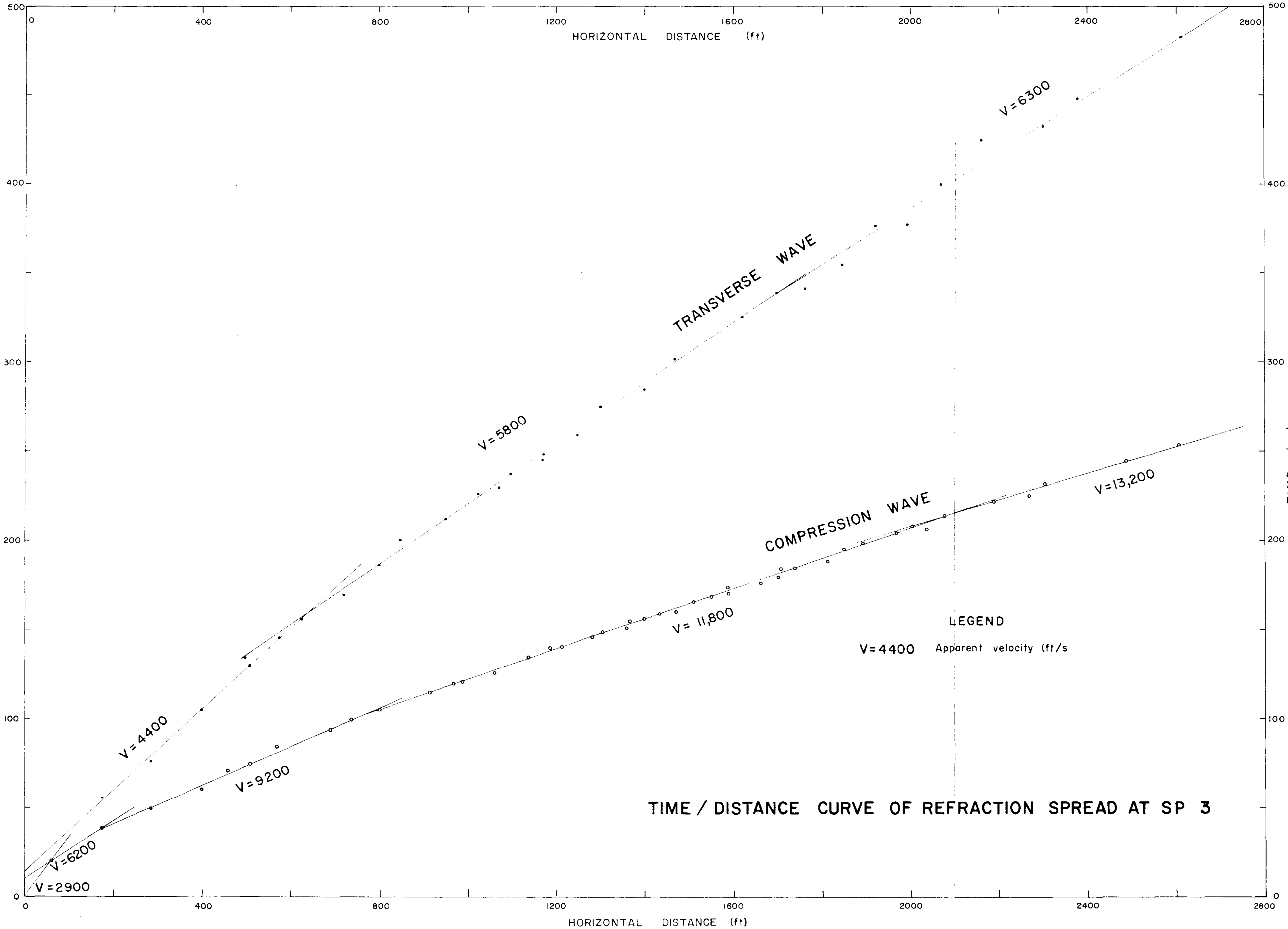


ICE AND ROCK SURFACE PROFILES
SPRING TRAVERSE, 1963/64

To accompany Record No. 1965/24

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

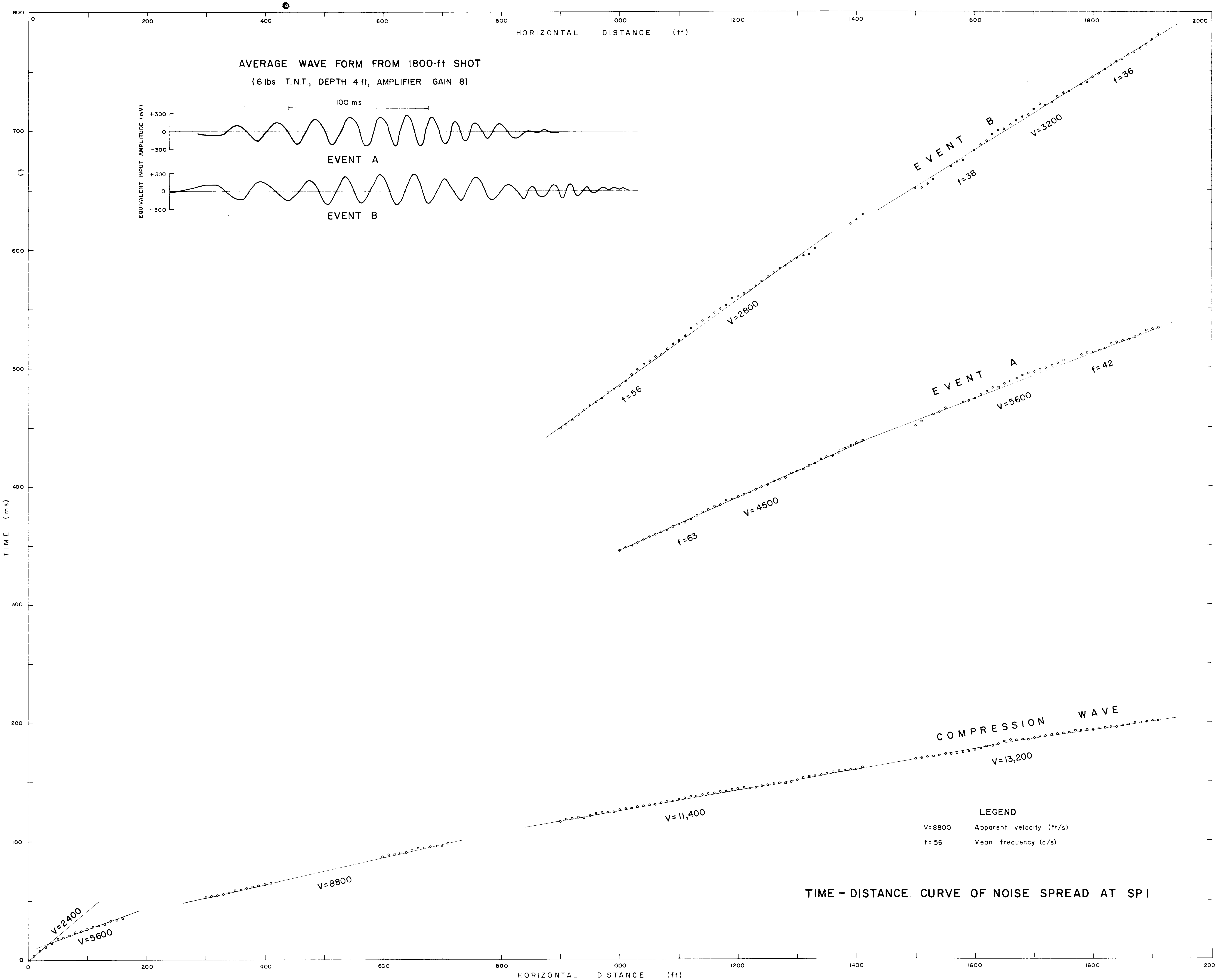
G 265-79



TIME / DISTANCE CURVE OF REFRACTION SPREAD AT SP 3

WILKES, ANTARCTICA, 1963/64 TRAVERSES

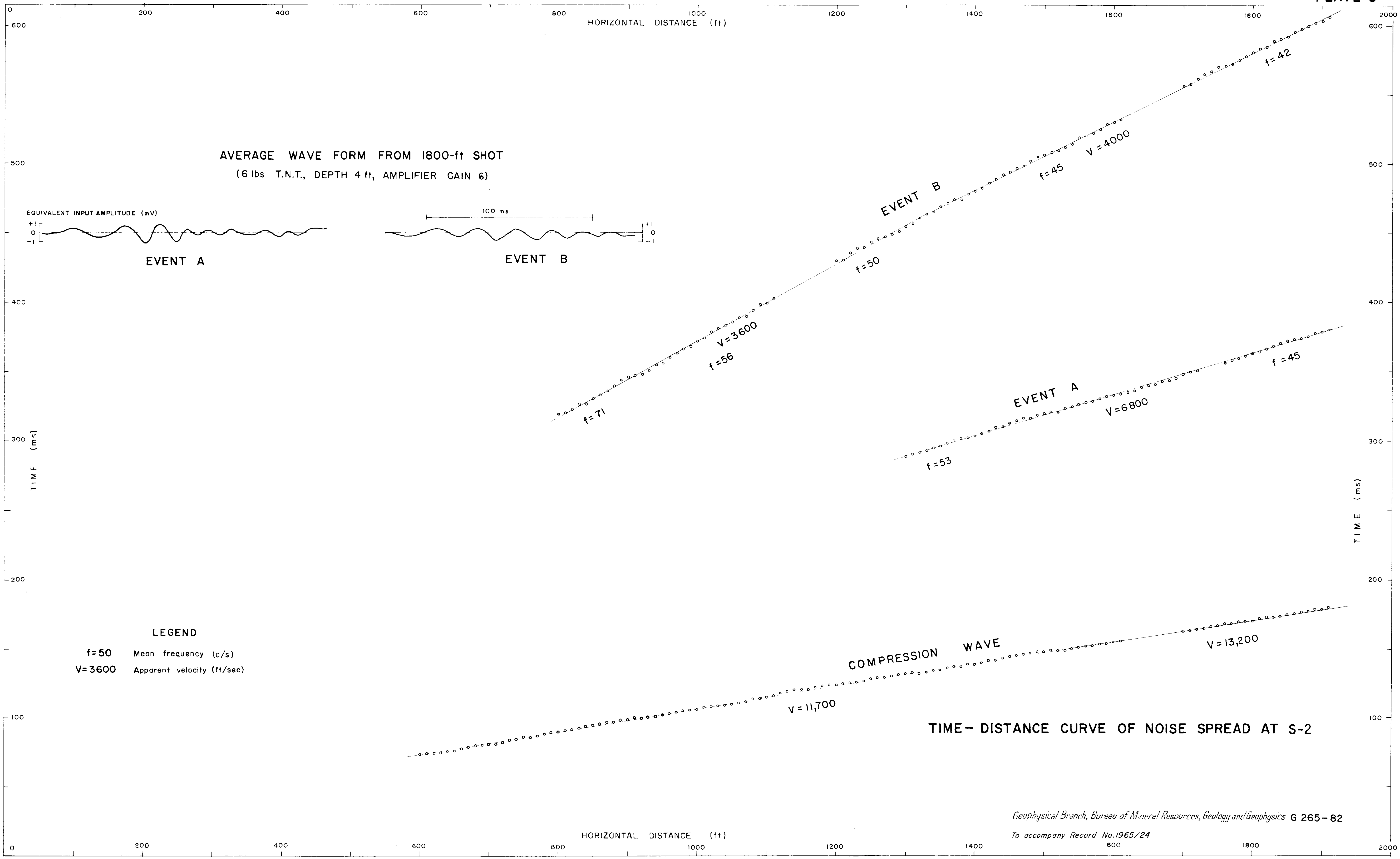
PLATE 5



WILKES, ANTARCTICA, 1963/64 TRAVERSES

To accompany Record No. 1965/24

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 265-81



TIME– DISTANCE CURVE OF NOISE SPREAD AT S-2

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics G 265–82

To accompany Record No.1965/24

PLATE 7

BUREAU OF MINERAL RESOURCES
GEOLOGY & GEOPHYSICS

SEISMIC SURVEY

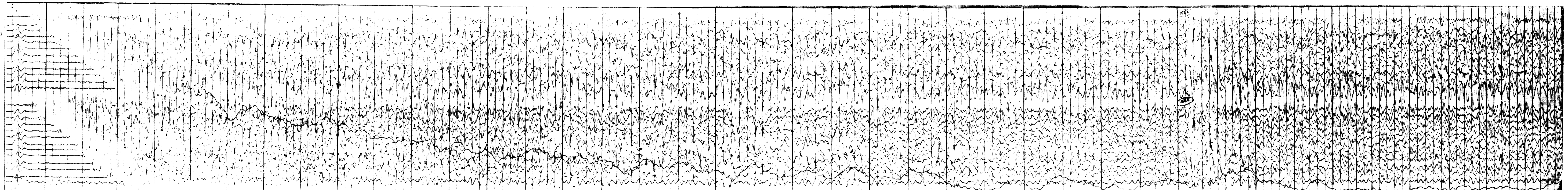
Area WILKES, ANTARCTICA
S.P. 1 Trav. Spring Date 16-11-63
Shot 20 Charge 1 lb Depth 110'
Spread No 1 185'S; No 12 1395'S
Geos 20 c/s Amp 7000 Com TIC

	Orig'l Recording	Play Back
Filters	KK 60 K 120	
Gains	Full	
Mixing	A	
A.G.C.	HR	
Presupp	-40	

Pattern Geophones
No. 6 per trace Spacing 22'
Layout in line

Pattern Holes
No 1 Spacing
Layout

Remarks



BUREAU OF MINERAL RESOURCES
GEOLOGY & GEOPHYSICS

SEISMIC SURVEY

Area WILKES, ANTARCTICA
S.P. 1 Trav. Spring Date 16-11-63
Shot 22 Charge 1 lb Depth 150'
Spread No. 1 185'S; No. 12 1395'S
Geos 20 c/s Amp 7000 Com TIC

	Orig'l Recording	Play Back
Filters	KK 36 K 215	
Gains	Full	
Mixing	A	
A.G.C.	WB	
Presupp.	-50	

Pattern Geophones
No. 6 per trace Spacing 22'
Layout In line

Pattern Holes
No 1 Spacing
Layout

Remarks

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SEISMIC SURVEY

Area WILKES, ANTARCTICA
S.P. 2 Trav. Spring Date 6-12-63
Shot 35 Charge 1 lb Depth 150'
Spread No. 1 1465'N; No. 12 255'S
Geos. 20 c/s Amp. 7000 Com. TIC

	Orig'l Recording	Play Back
Filters	K 70 KK 120	
Gains	Full	
Mixing	A	
A.G.C.	WB	
Presupp.	-50	

Pattern Geophones
No. 6 per trace Spacing 22'
Layout in line

Pattern Holes
No 1 Spacing
Layout

Remarks

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GEOLOGY AND GEOPHYSICS

SEISMIC SURVEY

Area WILKES, ANTARCTICA
S.P. 3 Trav. Spring Date 17-12-63
Shot 45 Charge 1 lb Depth 45'
Spread No 1 165'N; No. 12 1375'N
Geos 20 c/s Amp. 7000 Com. TIC

	Orig'l Recording	Play Back
Filters	No. 1-6 KK 90 K 215; No 7-12 KK 210 K 320	
Gains	-30	
Mixing	A	
A.G.C.	HR	
Presupp.	-30	

Pattern Geophones
No. 6 per trace Spacing 22
Layout in line

Pattern Holes
No. 1 Spacing
Layout

Remarks

To accompany Record No. 1965/24

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

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GEOLOGY AND GEOPHYSICS

SEISMIC SURVEY

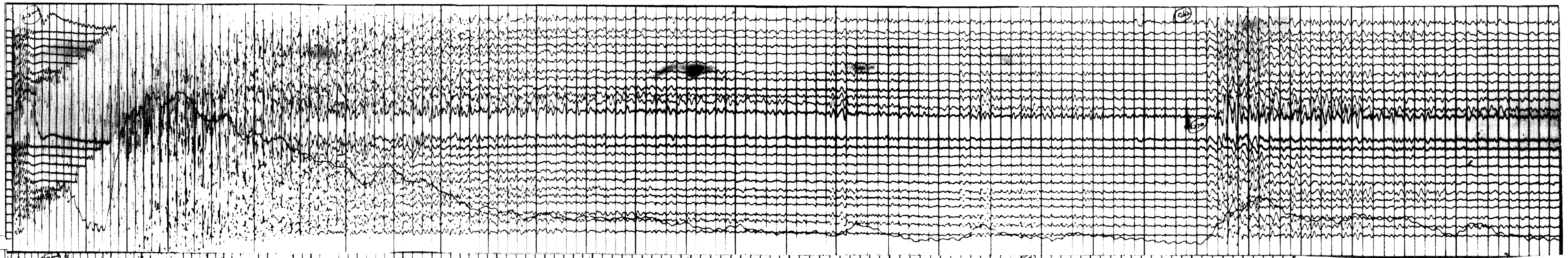
Area WILKES, ANTARCTICA
S.P. 4 Trav. Spring Date 21-12-63
Shot 68 Charge ½ lb Depth 35'
Spread No.1 1365'; No.12 155'
Geos. 20 c/s Amp. 7000 Cam. TIC

	Orig'l Recording	Play Back
Filters	L30 L215	
Gains	-40	
Mixing	A	
A.G.C.	WB	
Presupp.	-40	

Pattern Geophones
No. 6 per trace Spacing 22'
Layout in line

Pattern Holes
No. 1 Spacing
Layout

Remarks



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GEOLOGY & GEOPHYSICS

SEISMIC SURVEY

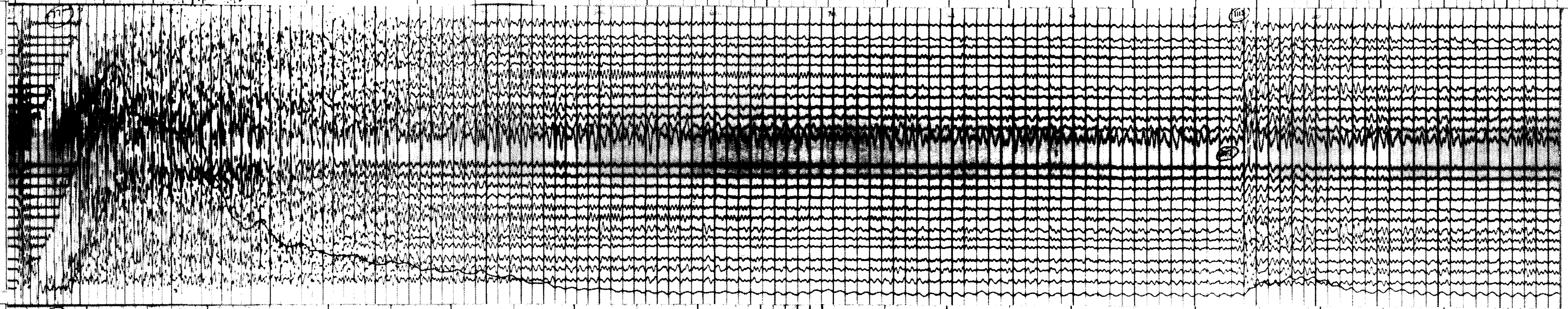
Area WILKES, ANTARCTICA
S.P. 5 Trav. Spring Date 24-12-63
Shot 71 Charge 1 lb Depth 33'
Spread No 1 650' N; No 12 100' N
Geos 20 c/s Amp 7000 Cam TIC

	Orig'l Recording	Play Back
Filters	KK 90 K215	
Gains	-30	
Mixing	A	
A.G.C	HR	
Presupp	-50	

Pattern Geophones
No 1 Spacing
Layout

Pattern Holes
No 1 Spacing
Layout

Remarks



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SEISMIC SURVEY

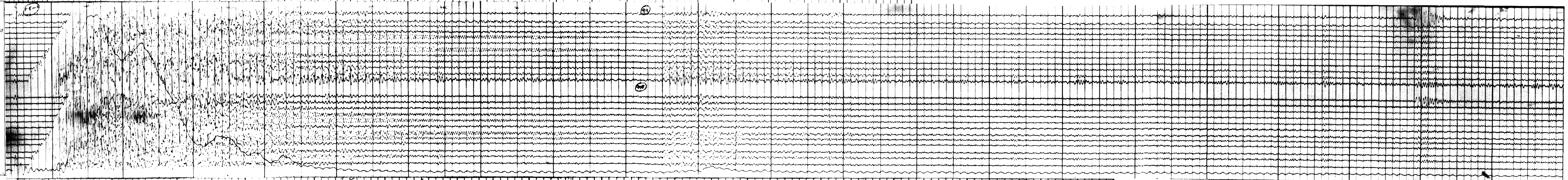
Area WILKES, ANTARCTICA
S.P 6 Trav Spring Date 28-12-63
Shot 74 Charge 1 lb Depth 34'
Spread No.1 700' N; No.12 150' N
Geos 20 c/s Amp 7000 Cam TIC

	Orig'l Recording	Play Back
Filters	KK90 K215	
Gains	-30	
Mixing	A	
A.G.C	HR	
Presupp	-50	

Pattern Geophones
No 1 Spacing
Layout

Pattern Holes
No 1 Spacing
Layout

Remarks Undershot



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SEISMIC SURVEY

Area WILKES, ANTARCTICA
S.P. 7 Trav Spring Date 6-1-64
Shot 79 Charge 1 lb Depth 35'
Spread No.1 5520'; No 12 460'
Geos 20 c/s Amp 7000 Cam TIC

	Orig'l Recording	Play Back
Filters	KK90 K215	
Gains	-30	
Mixing	A	
A.G.C	HR	
Presupp	-20	

Pattern Geophones
No 1 Spacing
Layout

Pattern Holes
No 1 Spacing
Layout

Remarks

To accompany Record No. 1965/24

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics.

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