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SOUTHERN GEORGINA BASIN SEISMIC SURVEY, NORTHERN TERRITORY AND QUEENSLAND 1965

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SUMMARY

After a month of preliminary experimental seismic work in the latter part of 1964, the Bureau of Mineral Resources made a reconnaissance seismic survey of the southern part of the Georgina Basin, mainly in the Northern Territory, from April to October 1965. In most areas reflections were very difficult to obtain. Noise tests led to trials of various shot and geophone pattern arrangements. Collinear offset shooting, airshooting, and multiple coverage were also tried, but no technique provided consistently good reflections. The seismic results tend to confirm gravity indications that there is a shelf area between BMR No. 12 Bore and Tobermory with few deep reflections that could represent deep Palaeozoic sediments similar to those found in the Toko Syncline.

1. INTRODUCTION

From 1956 to 1965 the Bureau of Mineral Resources (BMR) made reconnaissance geological and geophysical investigations of the Georgina Basin. The geological investigations included surface mapping and stratigraphic drilling, and the geophysical investigatons consisted of aeromagnetic, gravity, and seismic surveys.

Seismic work commenced in the Marion Downs (Robertson, 1965) Toko Syncline area of the southeastern part of the Georgina Basin in 1963, and continued through 1964 (Jones, 1965; Chenon, 1966). Objectives for these surveys had been indicated by previous geological and geophysical work; the main objectives were to investigate shooting and recording conditions in an area where the Lower Palaeozoic formations are covered by a thin section of Mesozoic and Tertiary sediments, to investigate the extension of the Toko Syncline to the southeast indicated by gravity work, and to make a stratigraphic tie between the supposed Upper Proterozoic sediments in the Canary Bore and the outcropping Upper Proterozoic sediments of the Sylvester Creek area.

The objective of the 1965 seismic survey was to obtain regional information on a large area in the southern part of the Georgina Basin to the northwest of the 1963 and 1964 survey areas, which would assist in the interpretation of existing geological, gravity, and aeromagnetic data in the area, with particular reference to petroleum prospects.

It was expected that seismic reflection or refraction traversing across the consolidated limestone and dolomite rocks of the Lower Palaeozoic formations, which cover a large portion of the Georgina Basin, would be difficult and might require unusual and elaborate techniques. For this reason it was decided that a seismic survey in this part of the Georgina Basin should commence with experimental work to develop a satisfactory technique for use in reconnaissance traversing. Therefore, in the last four weeks of the 1964 field season, experimental shooting was carried out on the Lower Palaeozoic carbonate rocks of the Georgina Basin at BMR 12 (Cockroach) Bore near the centre of TOBERMORY* to develop a useful technique for reconnaissance traversing in the Basin (Chenon, 1966). It appeared that, in the area where this experimental work was carried out, satisfactory results could be obtained using a fairly elaborate technique.

In 1965, BMR Seismic Party No. 1 surveyed a number of reconnaissance traverses in the Southern Georgina Basin in the eastern portions of TOBERMORY and SANDOVER RIVER and in the southwestern corner of URANDANGI. It was found that

* In this report the names of 1:250 000 Sheet areas are written in capital letters to distinguish them from ordinary place names.

the area in which the experimental survey was carried out in 1964 was not typical of the region, and that useful reflection results were usually more difficult to obtain.

The survey commenced on 20 April 1965, and was carried out from a base camp 22 kilometres northeast of Cockroach Waterhole in TOBERMORY. In order to keep crew travelling time to a minimum, fly camps were occupied from time to time as the party approached the NT/QLD border. For the last two months of the survey, the party operated from a camp 8 km south of Bulgera Waterhole on Gordon Creek. Field work was completed on 29 October 1965. Details of staff and equipment are given in Appendix A, and operational statistics are presented in Appendix B.

2. GEOLOGY AND STRATIGRAPHIC DRILLING

The following outline of geology is extracted from the BMR Bulletin by Smith (1972):

'Definition of the Georgina Basin

The name Georgina Basin has been used in a topographical and geographical as well as sedimentary sense. The Barkly, Oban, Undilla, and Ammaroo Basins are now regarded as part of the Georgina Basin and the names have been discontinued.

'The Georgina Basin is defined as a sedimentary basin containing lower and middle Palaeozoic sediments, which extend in a belt trending northwest from western Queensland into the Northern Territory; it is bounded on the east, west, southwest, and north by Precambrian rocks; the northwestern and southwestern margins are covered by Mesozoic sediments. Early Middle Cambrian sediments are regarded as the base of the Georgina Basin succession, but in some marginal areas over a thousand metres of unmetamorphosed Adelaidean or Lower Cambrian sediments underlie the Middle Cambrian sequence.

'The outcrop area of the basin is about 285 000 sq km. In the southeast an additional area of about 40 000 sq km is concealed; its margins have been defined approximately by geophysical surveys and test drilling, but the Palaeozoic stratigraphy is little known and the available evidence indicates that Palaeozoic sediments are preserved in grabens separated by horsts of older rocks.

'The northwestern margin of the basin has not been delineated geophysically; at present the boundary is placed roughly where the Middle Cambrian sediments are overlain by a continuous sheet of Mesozoic sediments. Cambrian units in the basin are probably connected in the subsurface with those in the Daly River Basin, which are covered by Mesozoic rocks at about latitude 16 S; if the two basins are separated by a basement ridge, it may have a northerly trend in accordance with the strike of the Precambrian rocks in the Katherine-Darwin region.

'The western boundary of the basin has not been determined in the Barrow Creek area, where the Cambrian sediments of the basin may be continuous in the subsurface with those of the Wiso Basin; however, this has not been proved, and there is no real evidence to support the possibility.

Stratigraphy

'The Georgina Basin contains Cambrian and Ordovician marine sediments and Devonian and Siluro(?)-Devonian freshwater sequences. The Cambrian and Lower Ordovician sediments consist predominantly of carbonate rocks, the Middle Ordovician sequence mainly of sandstone and siltstone, and the Devonian and Siluro(?)-Devonian formations of sandstone. The only volcanic rocks known are Middle Cambrian basalts near the northern margin in the Mount Drummond Sheet area.

'The sequence has not been metamorphosed or intruded by igneous rocks, and large areas have not disturbed tectonically. Although there are well documented breaks in sedimentation, many of them were caused by uplift and erosion without deformation. The most severe deformation occurred in the south during the post-Devonian Alice Springs Orogeny; faulting predominated and most of the deformation is south of latitude 22^{o} S, but some faults extended northward to about latitude $21^{o}30'$S. In the east, an earlier (Lower Ordovician) tectonism affected Cambrian oand Lower Ordovician rocks in the Duchess-Boulia area, but in the north the deformation is confined to the northern margin, where the Middle Cambrian sediments have been disturbed along faults trending west. The age of the faulting is unknown.

'Most of the northern part of the basin consists of a thin undisturbed blanket of Middle Cambrian carbonate rocks, with Upper Cambrian sediments in the Burke River Outlier (Opik, 1961) and some doubtful Upper Cambrian carbonate rocks in the Avon Downs and Frew River Sheet areas. The Ordovician and Siluro(?)-Devonian sediments, and most of the Upper Cambrian sediments, are restricted to the southern part of the basin. The thickest sequences exposed at the surface are in the Huckitta, Tobermory-Glenormiston, and Boulia areas.

'In the Huckitta area 1700 m of one sequence comprises carbonate rocks, with subordinate sandstone, siltstone, and shale. It ranges from Middle Cambrian to Middle Ordovician; parts are richly fossiliferous, and it includes potential source, reservoir, and cap rocks for petroleum. The sequence is capped by about 640 m of Devonian freshwater sandstone, and is underlain by Lower Cambrian and Adelaidean sediments.

'In the Tobermory-Glenormiston area the sequence comprises 1800 m of carbonate rocks with subordinate sandstone and shale. The sediments are richly fossiliferous in parts, and include potential source, reservoir, and cap rocks for petroleum. The basal Middle Cambrian unit rests unconformably on an Adelaidean sequence, and Upper(?) Silurian-Devonian sediments overlie the youngest Middle Ordovician formation.

'In the Boulia area the sequence comprises 1200 m Upper Cambrian to Ordovician carbonate rocks, with minor sandstone and siltstone. Middle Cambrian sediments are unknown in outcrop, but about 690 m of siltstone and carbonate rocks are known in the subsurface in the Black Mountain No. 1 well.

'The stratigraphic units in each area are shown in Plate 3, which also shows the distribution of rock units, and the basement and cover rocks.'

Stratigraphic drilling

A few stratigraphic test bores have been drilled in recent years in the Georgina Basin. Lake Nash No. 1 Bore (Amalgamated, 1963) which was drilled on the Lake Nash Anticline, was plugged and abandoned at 401 m after penetrating 303 m of Cambrian carbonate rocks and 98 m of probably Proterozoic sedimentary rocks. A dolomitic unit from 241 m to 303 m contained viscous tar, but no drill stem test was carried out over this interval.

BMR 11 (Cattle Creek), on the Barkly Highway 37 km west of Camooweal, (in CAMOOWEAL, north of MOUNT ISA) was drilled by BMR to a total depth of 458 m after considerable trouble with loss of circulation. The succession drilled was mainly carbonates to 433 m after which a quartz sandstone and pebbly quartz sandstone, ferruginized at the base, was encountered. No velocity data were obtained, but electric, gamma-ray, and neutron logs were run.

BMR 13 (Sandover River) was drilled to a total depth of 1015 m. Precambrian gneiss was reported from 1006 m and granite from 1014 m. The section overlying this was Middle to Upper Cambrian, mainly carbonate rocks. Oil shows were reported from a low-velocity zone encountered on the sonic log between 899 m and 908 m and shown on the cuttings description log as a shale between 899 m to 907 m. Attemps to carry out a drill stem test were not successful. Electric, gamma-ray, sonic, and microcaliper logs were successfully run to total depth.

BMR 12 (Cockroach) bore was drilled in 1964 near Cockroach Waterhole on the main road 40 km east of Tarlton Downs (see Plate 4) to a total depth of 1219 m. This bore first penetrated 152 m of Ninmaroo Formation, then passed into the Arrinthrunga Formation consisting largely of limestone and dolomite, and finally into Marqua Beds at 829 m. Electric, gamma-ray, and sonic logs were run to 1216 m (Plate 21). A well velocity survey in BMR 12 was carried out by BMR Seismic Party No. 1 in November 1964 during the course of an experimental survey in the area. Velocities derived from the velocity survey and integrated sonic log are shown in Plate 22.

PAP Netting Fence No. 1 was drilled by Mines Administration Pty Ltd on the small Netting Fence Anticline structure in the southwestern corner of GLENORMISTON. The sediments penetrated were predominantly Cambro-Ordovician limestone and dolomite. Granite was encountered at about 2012 m and the hole was abandoned at a total depth of 2031 m. Laterolog, microlaterolog, gamma-ray, and sonic logs were run in the hole to total depth.

Alliance Mulga No. 1 (Alliance, 1965) was drilled in 1965 on SANDOVER RIVER (see Plate 4) by Alliance Petroleum Australia (NL) to a total depth of 915 m. The bore is believed to have penetrated 5 m of Quaternary deposits, 53 m of Ninmaroo Formation, 465 m of Arrinthrunga Formation, 79 m of Marqua Beds, and 314 m of Upper Proterozoic sediments. Electric, gamma-ray, neutron, sonic, and caliper logs were run to a depth of about 792 m.

3. PREVIOUS GEOPHYSICS

Aeromagnetic surveys

BMR has carried out aeromagnetic reconnaissance surveys in 1958, 1963, and 1964 in the Georgina Basin and adjacent areas. The 1958 survey (Jewell, 1960) consisted of a series of widely spaced traverses in the western part of the Great Artesian Basin and included the southeastern part of the Georgina Basin. The results showed a good qualitative agreement between the main aeromagnetic anomalies and the known general structure of the basin. In 1963 BMR started an aeromagnetic survey of the Georgina Basin with the object of determining the thickness of the sedimentary section (Wells & Milsom, 1965). Coverage was obtained in MOUNT ISA, ELKEDRA, SANDOVER RIVER, URANDANGI, GLENORMISTON, and TOBERMORY using east-west flight-lines spaced at 3-km intervals. The remainder of the basin, coverying MOUNT DRUMMOND, LAWN HILL, RANKEN, CAMOOWEAL, FREW RIVER, AVON DOWNS, HUCKITTA, MOUNT WHELAN, and part of WALHALLOW and ALROY was completed in 1964. In addition, the northern half of ILLOGWA CREEK and HAY RIVER to the south of Georgina Basin were surveyed using flight-lines at 6 km spacing, to effect a tie between the Georgina Basin and Simpson Desert surveys.

There are problems in interpreting the aeromagnetic results in the Georgina Basin (Wells, Tipper & Milsom, 1964). Surveying of the basin margins has shown that much of the Proterozoic sedimentary sequence is magnetically indistinguishable from the Palaeozoic, and is considerably thicker than the Palaeozoic in many places. Deep magnetic basement is considered to vary between the Archaean and overlying magnetic strata within the Lower Proterozoic. Magnetic basement contours (Plate 5) therefore indicate depth to an uncertain stratigraphic level, above which are sediments of both Proterozoic and Palaeozoic age in unknown proportion. Further, the regions of deeper basement show few anomalies suitable for reliable depth estimation; consequently the control is usually inadequate for contouring. Nevertheless the aeromagnetic results do provide some regional data which would assist in the planning of future geophysical investigations.

The eastern margin of the basin is clearly defined by shallow basement contours on the eastern edges of MOUNT ISA, URANDANGI, and GLENORMISTON. The shallow contours are parallel to the outcropping Lower Proterozoic sediments, and the continuation of the contours to the south suggests the extension of the shallow basement below the Mesozoic and Palaeozoic cover.

The southern margin of the Georgina Basin in the extreme south of TOBERMORY, which is an area of outcropping granite, coincides with an east-trending depression indicated on the magnetic basement contour map, the deepest part of which is shown to be 2400 m below sea level. It is thought (Wells, Tipper & Milsom, 1964) that the smooth magnetic profile obtained in this area, which would normally indicate a thick sedimentary section, is due to the granite having a highly uniform magnetization near the surface.

Shallow basement is present over most of ELKEDRA with granite and Lower Proterozoic outcrops to the northwest. The magnetic basement deepens to 4000 ft (1220 m) below sea level in the extreme southeast corner of the sheet. The depth to basement of approximately 914 m indicated on the contour map in this area at BMR 13 compares with the depth of 683 m below sea level at which Precambrian gneiss was encountered in the bore. Highly disturbed magnetic profiles, indicative of shallow basement, extend from ELKEDRA to the northwest of SANDOVER RIVER. Farther east, however, the magnetic field varies slightly and the anomalies are generally of low amplitude. The boundary between these two provinces, which occurs in SANDOVER RIVER, is sharply defined and characterized by a decrease in the general magnetic level toward the east. The boundary is roughly semi-circular in shape, concave to the east, and skirts the central and southeastern portions of SANDOVER RIVER. To the west of the boundary there are many anomalies, and basement contours may be drawn with some confidence, although many sources appear to be below the basement surface. The basement here probably consists of Lower Proterozoic rocks similar to those outcropping in the Davenport Ranges, as the profile pattern is continuous from the ranges to the boundary previously discussed. It is not considered likely that Upper Proterozoic sediments are developed in this area, but they probably occur east of the boundary.

East of the boundary, anomalies are more widely separated, are of lower amplitude, and give widely fluctuating depth estimates. In many cases the sources are shallower than would be expected from the generally smooth profiles around the anomaly. It is possible that these shallow sources are lenses of volcanic rocks within a sedimentary sequence of considerable thickness, in which case two magnetic horizons are present. The lenses are unlikely to be younger than Proterozoic, so there is probably a thick Proterozoic sequence in the area. Another possible interpretation is that these shallower sources are within the Palaeozoic sequence; if so quite large thicknesses of prospective sediments may occur in areas where shallow basement depths are indicated. The latter possibility is unlikely, since no volcanic rocks have so far been observed in the Palaeozoic.

The basement contours deepen steeply to the southeast in SANDOVER RIVER across a northeast-trending line where a possible fault has been interpreted (Plate 5). There is an alternate explanation of this steep gradient. Since shallower anomalies mentioned above are not seen in the region of the trough to the southeast of SANDOVER RIVER, it could be concluded that the volcanic rocks forming the upper of the two magnetic horizons, previously referred to, have pinched out to the southeast. On the other hand, if there is a marked increase in the thickness of the sedimentary sequence, both magnetic horizons could still be present at depth. This latter hypothesis gains some support from the evidence for there being more than one magnetic horizon within the trough. The steep gradient of the depth contours along the northwest wall of the trough could well represent a fault with a throw of about 610 m.

The deep basement development in the southeast of SANDOVER RIVER is part of a large, irregularly-shaped depression extending into the southwest of URANDANGI and into adjoining corners of GLENORMISTON and TOBERMORY, where the magnetic basement is estimated to be at depth of 8000 ft (2440 m) below sea level. It was expected that Upper Proterozoic sediments would be developed in the trough, and Alliance Mulga No. 1 Bore appears to confirm this. Nevertheless, the aeromagnetic results suggest that this large depression holds more promise of oil acculumations than any other area surveyed in the Georgina Basin except the Toko Syncline.

This SANDOVER RIVER/URANDANGI Depression is separated in the southeast by an east-trending basement ridge from two smaller depressions known as the Tobermory and Glenormiston Depressions. These two depressions, where basement is postulated to be 8000 and 10 000 ft (2440 m and 3050 m) deep respectively, are separated by a small northeast-trending basement ridge. Netting Fence No. 1 bore was drilled near the southwestern margin of the Glenormiston Depression. Granite was encountered in the bore at a depth of 2010 m. This agrees fairly well with the basement depth estimate of about 6000 ft (1830 m) derived from the aeromagnetic profiles in this area.

There is a small magnetic basement depression estimated to be 6000 ft (1830 m) deep northeast of Tarlton Downs Homestead in TOBERMORY. BMR 12 bore was drilled to 1220 m on the eastern side of this depression, where aeromagnetic results suggest magnetic basement is at about 4000 ft (1220 m). BMR 12 penetrated 390 m of Middle Cambrian sediments and finished in these. The maximum known thickness of Middle Cambrian in the region is 457 m, so it is likely that the base of the Palaeozoic section occurs at less than 4500 ft (1370 m). The aeromagnetic results therefore suggest that little or no Upper Proterozoic section is present in this area, as this generally behaves magnetically in a manner indistinguishable from the Palaeozoic.

Gravity surveys

Gravity surveys were carried out in Western Queensland and southeastern Northern Territory by BMR from 1957 to 1961, including both ground traverses and helicopter reconnaissance surveys (Gibb, 1967; Barlow, 1966). Mines Administration Pty Ltd in 1959 carried out a semi-detailed gravity survey in Western Queensland covering parts of the Georgina Basin, on behalf of Papuan Apinaipi Petroleum Company Ltd (Papuan Apinaipi, 1960). The results of these surveys, which cover much of the Georgina Basin and part of the Great Artesian Basin, have been compiled in the form of a composite Bouguer anomaly map (Barlow, 1966) shown in Plate 6. In the following discussion the names of the gravity units are those revised by Vale (1965) except in cases where an author's name is quoted after the unit.

As noted by Gibb (1967) the Bouguer anomaly picture of the Georgina Basin immediately indicates that the eastern boundary of the Georgina Basin is well expressed as a distinct north-northwest gravity gradient which continues for more than 322 km along the western edge of the Cloncurry Regional Gravity High. Extending over an even longer distance is the northwest trend in contours which follows the southwest boundary of the basin. This trend, described by Lonsdale & Flavelle (1962), is expressed in the Caroline Gravity Ridge and also in the Hay and Huckitta Gravity Lows (Barlow, 1966) which accompany this gravity ridge on its north-eastern side. The region bounded by these trends forms the southern portion of the Georgina Basin.

In the southeast corner of the region, the Toko Gravity Trough is a well-expressed gravity low which suggests that the Toko Syncline extends well to the southeast of the outcrop area. This is bounded on the west by a gravity high named the Field Gravity Spur, which diverges from the Caroline Gravity Ridge. Farther north, an area of low gravity relief, the Tobermory Gravity Shelf, occupies nearly all of TOBERMORY and extends over considerable portions of the neighbouring 1:250 000 Sheet areas. The Tobermory Gravity Shelf is bounded on the northwest by the Sandover Gravity Low, which covers most of SANDOVER RIVER and is bounded on the west by the Ooratippra Gravity High, which occurs mainly on the eastern part of ELKEDRA.

The gravity relief in the western part of ELKEDRA is not pronounced, but there is evidence for the existence of a ridge of high values of gravity in the Davenport Range area. This ridge separates the Frew River Gravity Low (Barlow, 1966), in northern ELKEDRA and probably most of FREW RIVER, from the Ammaroo Gravity Depression centred on

HUCKITTA. This gravity depression is bounded on the southwest by the western extension of the Caroline Gravity Ridge.

The interpretation of gravity data in the Georgina Basin is complicated by the smallness of the expected density contrast between the Cambrian limestone and the basement (2.7 to 2.8 g/cm and 2.5 to 2.8 g/cm respectively). The densities of Proterozoic sediments, Upper Cambrian sandstone, and post-Cambrian sediments are lower, but in some cases only slightly lower than these. Further difficulties arise because of the existence of numerous local gravity anomalies, bounded by strong gravity gradients, in areas of outcropping Precambrian rocks. For this reason lateral density variations of considerable magnitude are thought to occur within the basement rock complex, composed of metamorphics into which numerous types of basic and acid igneous rock have been intruded. Moreover, the very dense dolomites of the region alternate with lighter sandstones, and these near-surface facies changes tend to mask effects caused by basement features.

Notwithstanding these difficulties, originating from complex lithology, the gravity data are of considerable value in delineating the geological margins of the Georgina Basin, in assessing the broader structure of the Basin, and in establishing major structural features associated with sedimentary rocks within the basin.

Comparison of aeromagnetic and gravity interpretations

Because of the considerable, though different, problems which apply to interpretation of the gravity and aeromagnetic results in the region, it is useful to compare the interpretations arrived at by these two methods, each of which serves as a check on the other.

The eastern margin of the Southern Georgina Basin is marked by a strong gravity gradient interpreted (Gibb, 1967) as the gravity expression of the western limit of the Precambrian Cloncurry Fold Belt under transgressive Palaeozoic sediments of the Georgina Basin. Aeromagnetic and gravity results are in good agreement in defining the eastern limit of the basin.

The distinct and persistent northwest gravity trend evident in the extensive zone of the Caroline Gravity Ridge and the group of gravity lows which accompany it to the northeast is tentatively interpreted as indicative of a major linear tectonic feature. In the westernmost portion of this gravity ridge the gravity highs are known to occur over outcropping Archaean rocks of the Arunta Complex. The gravity low north of the highs appears to be mainly caused by extensive intrusions of huge masses of granite into metamorphic rocks of Archaean age. As a whole, the distorted zone comprising the Caroline Gravity Ridge and the adjacent chain of gravity lows is interpreted as the gravity expression of a major basement ridge of raised Archaean rocks occurring on a line of tectonic weakness, into which liquid masses of various types of magma, but mainly of granite, have intruded. The northeastern limit of the Hay Gravity Low, adjacent and parallel to the Caroline Gravity Ridge, agrees well with magnetic basement contours in defining the southwestern margin of the Southern Georgina Basin.

The Tobermory Gravity Shelf covers a large part of TOBERMORY. It is interpreted as a region of generally shallow basement with depth to basement about 3000 ft (914 m), a figure which agrees well with magnetic basement depth estimates for the region.

The Sandover Gravity Low covers much of SANDOVER RIVER, but notably reaches its maximum intensities in the northern half of the Sheet area. It is interpreted as a somewhat depressed area containing Palaeozoic sediments of increased thickness. However, it has been suggested (Barlow, 1966) that the gravity minima in the northwestern and southwestern corners of SANDOVER RIVER, in association with the Ooratippra Gravity High, might be an expression of the margin of a high-standing complex of basement rocks rather than the result of sedimentary depressions.

Southeast of SANDOVER RIVER, where the aeromagnetic results suggest a deep sedimentary depression bounded on the northwest by a possible fault, the gravity values are similar to those on the Tobermory Gravity Shelf. In this area the most plausible gravity and aeromagnetic interpretations are in disagreement. However, Mulga No. 1 Bore in the southeast of SANDOVER RIVER indicated that the Ninmaroo Formation, Arrinthrunga Formation, and Marqua Beds were all considerably thinner than at BMR 12 in TOBERMORY, so that a northward extension of the Tobermory Gravity Shelf of shallow Proterozoic basement into this area seems likely.

There are two small gravity minima in the southwest of URANDANGI and northwest of Tobermory Homestead which are overlapped by larger areas of magnetic basement depression. These are likely areas of increased thickness of sediments. However, there is no gravity low corresponding to the Glenormiston magnetic depression north of Netting Fence No. 1 Bore. On the contrary the gravity results suggest an extension of the Tobermory Gravity Shelf into this area.

The Toko Syncline is well expressed in both gravity and aeromagnetic results. The Field River Gravity Spur runs parallel to the Toko Syncline on its southwest margin in MOUNT WHELAN and HAY RIVER, but to the north, in TOBERMORY and GLENORMISTON, the Spur fans out across the projected axis of the Toko Syncline. Consequently, the gravity data suggest that the Toko Syncline does not extend as a deeply depressed trough beyond the northwest corner of MOUNT WHELAN. Nevertheless, because of the high density of the Cambrian limestones, the gravity data would not exclude the possibility that a relatively shallow syncline with geologically mapped Cambrian sediments extends into the south-east of TOBERMORY. The gravity expression of the Toko Syncline in MOUNT WHELAN is much more pronounced here because of the lower density of the Middle and Upper Palaeozoic rocks.

The aeromagnetic results indicate a continuous though diminished magnetic basement depression from the Toko Syncline proper across the Field River Gravity Spur to the southeast corner of TOBERMORY. This magnetic depression is somewhat south of the mapped northwest extension of the Toko Syncline, so it is unlikely that it represents a sedimentary depression.

Seismic surveys

General. Apart from the short experimental seismic survey by BMR near BMR 12 Bore in 1964 as a prelude to reconnaissance surveying in the region, no previous seismic work had been conducted in the region of the Southern Georgina Basin where the 1965 survey was carried out. To the north of the survey area, BMR in 1961 carried out experimental and reconnaissance seismic work in the Undilla Basin northeast of Camooweal, Queensland (Robertson, 1963). A number of seismic surveys have been carried out in the southeast Georgina Basin. Papuan Apinaipi Petroleum Co Ltd and Phillips Petroleum Co conducted work in 1960-1961 in the Springvale, Boulia, and Toko Range areas (Phillips, 1961). Also in 1960 the South Australian Department of Mines conducted a seismic survey in the Great Artesian Basin in South Australia and in Queensland as far north as Boulia (Milton & Seedsman, 1961). In 1963 and 1964 surveys were done by BMR in SPRINGVALE, MOUNT WHELAN, and BEDOURIE (Robertson, 1965; Jones, 1965). In 1963 the French Petroleum Company (Aust.) Pty Ltd started a reconnaissance seismic survey which extended across the southern part of the Simpson Desert from South Australia to the Annandale-Sandringham region of Queensland. This survey was continued in 1964 as a semi-detailed seismic survey in the Bedourie area (French Petroleum Co., 1964).

'Undilla Basin' survey, 1961 (Robertson, 1963)

The BMR seismic survey in the 'Undilla Basin' in 1961 encountered a number of technical difficulties in applying the reflection and refraction seismic methods, owing to the occurrence of Middle Cambrian limestone and Camooweal Dolomite near the surface.

Reflection work in the area was difficult because of the large amount of surface noise generated by the shots and because the coherent noise waves generated have higher velocities and greater wave-lengths than in most areas with the result that multiple-geophone patterns of normal length are less effective in reducing them. Air-shot patterns were found to be quite effective in reducing high-frequency noise, particularly on the earlier part of the records.

It was considered, after experimentation, that single deep shots and patterns of shallow shots would both improve record quality if they were offset about the same distance (607 m) as the air-shots (Robertson, 1963). Patterns of holes about 46 m deep drilled on the traverse line were also considered effective, but extremely hard drilling conditions would make progress slow with deeper holes.

The refraction method generally depends for its success on the occurrence of a number of rock layers whose refraction velocities become successively greater with depth. In the 'Undilla Basin' refraction velocities of about 5180 m/s are recorded from the Cambrian limestone close to the surface. The surface limestones thus act as a screen preventing useful information from being obtained below them by refraction methods unless refractors occur with unusually high velocities (e.g. 6100 m/s). Such refractors were apparently recorded in the area, but it was not certain what they represented. The most likely interpretation is that they represent a horizon near the top of the Proterozoic section.

Seismic surveys of Boulia area (Phillips Petroleum Company, 1961)

In the work carried out by Phillips Petroleum Co, in the Netting Fence area (MOUNT WHELAN) of the Toko Syncline, split spreads of 290 m-290 m were used with 4 and 32 geophones per trace, 1 to 5 shot-holes per shot pattern, and shot-point spacing of between 0.4 km and 1.6 km. Correlation reflection shooting was reported to give satisfactory results where the surface outcrop was the Middle Ordovician Mithaka Shale, poor results over the Carlo Sandstone outcrops (only 6 shot-points shot), and entirely unsatisfactory results over the Lower Ordovician Ninmaroo carbonate rocks.

A well-defined structural high in Cambrian and Ordovician rocks was indicated around 22°55' south/138°02' east. The closed area covers about 5 km^2, and maximum closure is about 76 m. About 1980 m of section was suggested by seismic results. The seismic structure corresponds closely with a definite surface feature (Netting Fence Structure). Southeast of the above feature a uniform south dip, based on reliable data, persists through the area surveyed. The Netting Fence Structure was drilled in 1964, with the results already indicated (see Geology and Stratigraphic Drilling).

<u>Great Artesian Basin survey</u> (Milton & Seedsman, 1961)

The greater part of the S.A. Department of Mines seismic survey in 1960 was carried out south of Breadalbane, outside the area of interest of the present survey. One refraction line of interest, however, was shot at Boulia, north of the main survey, and a refractor of velocity 5490 m/s at depth 91 m was obtained, which was interpreted as representing early Palaeozoic carbonate rocks.

<u>Southeast Georgina Basin survey, 1963-1964</u>

(Robertson, 1965; Jones, 1965)

The main objectives of the seismic surveys carried out by BMR in the southeastern Georgina Basin in 1963 and 1964 were to investigate the possible extension of the Toko Syncline to the southeast beyond the Toko Range outcrop area, to attempt a tie between outcropping Upper Proterozoic sediments near the head of Sylvester Creek and supposed Upper Proterozoic sediments in Canary No. 1 bore, and to investigate shooting conditions and techniques required in areas where Lower Palaeozoic formations are covered by a thin section of Mesozoic and Tertiary sediments.

The investigation of the Toko Syncline was facilitated by the occurrence of a very good reflection which was identified by cores from holes on the eastern flank of the syncline in the Ninmaroo Formation. A sedimentary thickness of about 4570 m near the axis of the Toko Syncline was demonstrated. In the Toko Syncline, with the exception of areas which were probably very disturbed tectonically, good results were obtained using 5 to 7 holes per shot drilled in line along the traverse to a depth of 14 m, and 16 geophones per trace in line. The surface formations were Mesozoic to Recent in age and easy to drill.

On the other hand no reflections were obtained using similar techniques on outcropping Lower Palaeozoic formations east of Herbert Downs. It was found from there southwards that the Lower Palaeozoic sediments under thin cover do not contain persistent individual layers that can be used as reliable refraction markers over appreciable distances. It was concluded that the high-velocity layer mapped by the refraction method was associated with an unconformity. It was shown that it is possible to obtain reflections between Marion Downs and Canary, where there is a thin cover of about 100 metres of Mesozoic cover, using 5-hole shot patterns and 16 to 32 geophones per trace. It was also shown that sediments exist between Marion Downs and Canary, but poor results at a few places made correlation across this interval very difficult.

Pedirka-Annandale survey, 1963 (French Petroleum Company, 1964)

The results of the 1963 to 1964 seismic survey by the French Petroleum Co (Australia) Pty Ltd in the Bedourie area are similar to those obtained by BMR during the above surveys. The good-quality Ninmaroo reflection defines the southern extent of the Toko Syncline, and can be correlated up the eastern flank of the syncline to a possible north-trending boundary fault. This fault coincides with a steep gravity gradient with similar trend. To the east of the fault, reflections are confined mainly to the Mesozoic section, and only occasional deeper reflections from within the possible Palaeozoic section are obtained.

Experimental survey, Southeast Georgina Basin (Chenon, 1966)

The seismic survey of most immediate interest to the 1965 program is BMR's experimental seismic survey near BMR 12 (Cockroach) Bore, undertaken in the last four weeks of the 1964 field season as a necessary preliminary to the broader program of reconnaissance surveying to be carried out on large areas of outcropping Lower Palaeozoic sediments. The location of the 1964 experimental traverse is shown in Plate 4 near Traverse A. The main conclusions reached as a result of the experimental survey may be summarized as follows:

(a) The character of seismic noise in the test area was unusual; there was much incoherent high-frequency noise, but little low-frequency organized noise.

(b) Noise tests and tests of various shot and geophone arrangements indicated that the best solution for improving reflection quality was to use large areal patterns of holes and geophones (e.g. 25 holes and 32 geophones) designed to reduce random noise.

(c) The optimum shooting depth seemed to be about 9 m, or about a metre into the first high-velocity layer.

(d) Using the optimum shot and geophone arrangement determined, it was possible to obtain satisfactory reflections in the area tested, from depths of up to about 1220 to 1370 m, which probably represents the thickness of prospective sediments in this area.

(e) The records contained high-frequency signal and noise, so that high-pass filters for recording and playback had to be chosen carefully.

(f) Measurement of near-surface parameters indicated that the thickness of the weathered layer varied considerably over intervals of about a kilometre, despite only minor elevation changes.

(g) Drilling was very slow once the first layer of high-velocity material was reached.

4. OBJECTIVES AND PROGRAM

General objectives and proposed program

The broad objectives of the Southern Georgina Basin seismic survey in 1965 were twofold. Firstly, to develop successful reconnaissance techniques for use in the area, and secondly to obtain regional information on the Southern Georgina Basin which would assist in the interpretation of existing geological, gravity, and aeromagnetic data in the area, with particular reference to petroleum prospects.

As a result of the preliminary experimental work carried out in November 1964, it was hoped that, if the area tested was typical of the whole region, a suitable reconnaissance technique would be developed with little additional testing, in 1965. It was planned to test the effects of offset shooting, which was not done in 1964, by shooting expanded spreads. It was also planned to carry out further experimental work during the reconnaissance survey if (a) the results deteriorated, or (b) the surface conditions changed significantly. In the case of (a) it was planned to carry out a complete re-appraisal of all shooting parameters, while in the case of (b) it was planned to shoot noise profiles and carry out tests of modified shot/geophone arrangements with the object of improving results or economy.

It was proposed to pursue the objective of obtaining regional information by surveying a long reconnaissance seismic traverse across the southern part of the Georgina Basin approximately at right angles to the strike and following this with supplementary traverses whose priorities and locations would depend partly on the results of the main traverse. Five traverses were proposed with specific objectives in mind, although it was realized that it would not be possible to complete all of these traverses in 1965. It was considered that, if results warranted it, the proposed program or modifications of it might be continued in 1966 or at a later date.

Detailed objectives and proposed program

The detailed objectives of the survey and the seismic traverses proposed to achieve these objectives were as follows:

(a) To investigate the large depression in the magnetic basement southwest of Urandangi, and the Tobermory Depression, and the relation of these depressions to the Tobermory Gravity Shelf area, where both gravity and magnetic results suggest a shallower basement.

Traverse proposed from BMR 12 (Cockroach) bore to Urandangi (approximate distance 193 km) with time required 16 to 24 weeks.

(b) To investigate the northwest extension of the magnetic depression southwest of Urandangi, particularly its northwest boundary where the magnetic results suggest the possibility of a large fault. To resolve an apparent contradiction between the magnetic results and the gravity results; the former suggest that there is an increase in thickness of sediments northwest of the supposed fault whereas the latter suggest a decrease.

Traverse proposed from the Tobermory/ Urandangi Traverse (a) in the southeast corner of SANDOVER RIVER northwest at least to Gordon Creek near the centre of SANDOVER RIVER (approximate distance 92 km) with time required 8 to 12 weeks.

(c) To complete a tie from the southwestern end of Traverse (a) across areas of outcropping Upper and Middle Cambrian sediments to Proterozoic outcrops at the southwestern margin of the Basin.

Traverse proposed from BMR 12 bore to Precambrian outcrop area about 13 km south-east of Marqua (approximate distance 58 km) with time required 5 to 7 weeks.

(d) To investigate the magnetic and gravity depressions near Tarlton Downs and to complete a tie from Traverse (a) across the northern end of the Tarlton Range to granite in the vicinity of Arthur Creek.

Traverse proposed from BMR 12 bore to Arthur Creek (approximate distance 61 km) with time required 5 to 8 weeks.

(e) To investigate whether there is any thickening of sediments southeast of Tobermory in the area of the Tobermory Magnetic Depression and a small gravity low east of Tobermory.

Traverse proposed from Traverse (a) near Tobermory through Linda Downs (approximate distance 32 km) with time required 3 to 4 weeks.

Program carried out

In practice, drilling progress proved slower than anticipated and reflection results proved very difficult to obtain. Proposal (a) was commenced and about a half of the traverse was surveyed before slow progress and lack of results caused its abandonment. Several segments of traverse were surveyed in the Mulga Hill/Gordon Creek area to pursue the objectives of proposal (b) and to attempt a seismic tie to Alliance Mulga No. 1 bore. It was necessary to terminate the survey at the end of October, a month earlier than originally planned. There was insufficient time to carry out proposals (c) to (e).

5. RECORDING TECHNIQUES

Problems in obtaining seismic data

There were severe problems in recording useful seismic data in the survey area. The main problems were as follows.

1. Drilling was slow because of the widespread occurrence of hard shallow layers of limestone or dolomite.

2. Record quality was closely related to near-surface conditions: the depth, thickness, and lithology of near-surface layers, and the position of the

charges within layers of varying lithology. The record quality was highly variable over short distances as near-surface conditions changed.

3. Coherent and random shot-generated noise were both troublesome over the survey area.

The recording problems and the techniques developed in an effort to overcome them are discussed below in detail.

Drilling. In general, drilling presented considerable difficulties throughout the area, mainly because of the prevalence of hard layers of rock near the surface and because of the extreme variability of surface formations over short horizontal distances. The party was equipped with two Mayhew 1000 rigs and one lighter Carey rig. The Carey rig proved inadequate for drilling in the harder formations and was mainly used for advance exploratory drilling from the surface down to the first hard layer. The party frequently worked three shifts per day on the two Mayhew rigs. Drilling rates were very variable, but the average depth drilled per rig per 8½ hour shift was about 91 m. It was possible to drill with air on all traverses and it was only occassionally necessary to use water injection.

The locations of the various seismic traverses are shown in Plate 4. Drilling progress on Traverse A was frequently very slow, but in general it improved from west to east. As might be expected, drilling was most difficult where highly consolidated limestone or dolomite outcropped, as between SPs 197 and 200 and in the vicinity of SPs 257 and 258. On the rest of the traverse, formations presented an alternation of soft rocks, such as argillaceous sandstone, and often siliceous limestone. In general, drilling difficulties increased as the thickness and number of limestone beds increased.

The usual practice was to drill shot-holes about a metre into the first substantial hard layer encountered, so that the charges were placed within the hard rock. The average depth of shot-holes so drilled was about 9 m, although in isolated cases the soft formations extended much deeper. At SP 228 two holes were drilled to 46 m in sand, clay, and shale without encountering hard bands of carbonates.

Limestone cropped out in places on Traverse B and drilling was consequently very slow. The depth to the limestone increased towards the south. Average hole depth on this traverse was about 15 m. Where limestone was not present near the surface the drills encountered a succession of hard shale layers and plastic clay, which made necessary the use of water injection.

On Traverse C hard limestone was generally encountered within about 11 m of the surface. Above this, sand, clay, and hard shale were reported in the drill logs. The average depth of shot-holes was about 9 m, although at two shot-points it was possible to drill to 42 m and 59 m respectively without penetrating any very hard layers.

Surface conditions were similar on Traverse D, where the average shot-hole depth was about 6 m. Drilling conditions down to the hard limestone were a little easier on Traverse E as sandy sediments predominated over the harder shale beds. Shot-hole depth was fairly constant at about 6 m.

Variation of record quality with near-surface conditions. It soon became evident during the survey that, where hard limestones or dolomites were encountered by the drill rigs at shallow depths, a number of poor-quality reflections, often at times less than half a second, could be recorded using a high energy technique. Where the first high-velocity layer was deeper it was virtually impossible to obtain any reflections using conventional procedure.

Plate 15, which is the variable-area record section of Traverse A, shows the effect of surface conditions on reflection quality. The various near-surface layers derived from analysis of first-break refraction times are shown plotted above the cross-section. Consider that part of the traverse between SPs 258 and 271: between SP 258 and SP 265, where the high-velocity layer is close to the surface, some poor quality reflections are recorded; east of SP 265, where the high-velocity layer is much deeper, the records are of lower frequency and reflections are almost absent.

In consequence of these observations and the slow drilling progress the party's light Carey rig was used to drill one or two exploratory holes at each shot-point in advance of the main drilling crews to enable the selection of those portions of traverse where it appeared likely that reflection results could be obtained. The object was that drilling of shot-hole patterns, which was difficult and slow, could then be concentrated on the portions selected. Shallow refraction spreads, the same length as the normal reflection spreads and using one geophone per trace, were shot from each exploratory hole to assist in determining near-surface conditions.

The near-surface profile indicated by these shallow refraction spreads on Traverse A shows three main layers characterized by different velocity ranges. The surface layer, with a velocity range of 610 m/s to 910 m/s, appears to be continuous and not thicker than 27 m. Average thickness is only about 6 m. The high-velocity layer, with average velocities ranging from 4600 to 5490 m/s varies greatly in depth as well as in velocity. The intermediate layer, which is not always present, varies greatly in thickness over short distances. The average velocity of this layer over the entire length of Traverse A is about 1830 m/s. Between SPs 240 and 265 it seems to be absent, and the low-velocity layer rests directly on the high-velocity layer. East of SPs 265 and 266, where the various layers are interrupted by a minor fault, its thickness is 37 m. Six kilometres farther east, near SP 277, the intermediate layer reaches a maximum thickness of 11 m.

Single holes were also drilled at each shot-point along Traverses B, C, D, and E and were shot into 550 - refraction spreads on either side of the shot-point to provide information of near-surface layers.

Along Traverse B the near-surface profile (Plate 16) shows a low-velocity layer with a velocity of 610 m/s resting directly on a relatively high-velocity layer with a velocity of 427 m/s. The low-velocity layer has an average thickness of 12 m. Plate 17 shows the surface conditions along both segments of Traverse C. Between SPs 2401 and 2409, the low-velocity layer (1220 m/s) lies directly on the 5490 m/s velocity layer. The average thickness of the 1220 m/s layer is about 12 m with a rapid thickening to 37 m under SP 2402. On the other segment of Traverse C (SPs 2359-2370) the surface profile indicates two main layers. The surface layer, with a velocity of about 760 m/s, is continuous and not thicker than 18 m and rests directly on a high-velocity (5180 m/s) layers.

Between SPs 2360 and 2362 a 210 m/s layer appears. This layer is approximately 76 m thick under SP 2361 and is thought to be a filled-in creek channel. Numerous creek channels were encountered crossing the traverse in this area (Plate 4).

The surface profile along Traverse D (Plate 18) again indicates two layers. A 610 m/s layer 9 m thick rests directly on the 5330 m/s high-velocity layers. Two minor faults are observed between SPs 3802 and 3804.

The shallow refraction shooting on Traverse E (Plate 20) indicated a low-velocity layer (610 m/s) with an average thickness of 6 m overlying a high-velocity layer whose average velocity along the traverse is 5180 m/s.

Noise tests to determine optimum geophone and shot-hole patterns and frequency filters

As useful reflection results were difficult to obtain, at least one noise spread was shot on each main segment of traverse to try to determine the reason for the poor results. The tests took place where the records were poor but not completely without evidence of reflected signal so that measurements obfboth the signal and noise could be made. Three comprehensive noise tests and a number of abbreviated tests were performed on Traverse A. Complete noise tests were also shot on each of the other traverses - Traverses B, C, D, and E. The aims were to determine whether the change in record quality was due to variations in noise intensity and character or to alterations of the signal owing to changing subsurface structural and lithological relations. Where seismic reflection results were poor it was hoped that analsis of the noise tests would help to indicate the reasons for the poor seismic record quality and thus assist in the design of an optimum recording technique.

The basic data were recorded on a consecutive sequence of spreads, with shot-to-geophone distance ranging from 31 m to 1340 m from a single shot-point location. Charge sizes and hole depths were those thought to be typical for the area. The recording spreads consisted of single 20-Hz geophones spaced at 6 m intervals. No AGC or frequency filtering were employed. The gains were adjusted from spread to spread to obtain readable records at all distances using constant charge. Before each noise test a gain calibration test was carried out which allowed record amplitudes in millimetres to be related to input voltage for any gain setting. As a result, noise record amplitudes could be converted to microvolts input and finally expressed in terms of decibels relative to an arbitrary event of 1 microvolt amplitude. The noise test tapes were played back using variable-area/wiggle-trace display both with and without AGC.

Noise tests, Traverse A. The variable-area time-distance profiles of noise tests performed on Traverse A are shown in Plate 7.

SP 228: In general the surface or near-surface noise recorded is in the medium frequency range (20-40 Hz) and is not very highly organized. Probably about 30 percent to 50 percent of the noise recorded could be regarded as coherent for the 6-m trace interval employed. The noise events were fairly evenly distributed in time after the first breaks and no distinct noise-free 'window' was observed. The more dominant interfering noise appears to have a wave-number distribution which peaks in the neighbourhood of 3 to 10 cycles per 1000 m (Plate 8). These waves have a definable set of properties extending over a limited range of values. They substantially destroy the continuity of any reflected energy with arrival times up to 0.6 s. Because of the dominance of the noise waves accurate signal measurements were difficult to make from data recorded with single geophones. The first refraction arrivals show a large increase in velocity from 2270 m/s at distances up to 177 m from the shot-point to 4720 m/s at greater distances. The overall noise level was about 25 to 40 dB above signal level.

Low-cut frequency filtering in subsequent pattern shooting was effective in slightly attenuating the lower frequencies of the noise trains, but playbacks with successively higher low-cut filters demonstrated that many components of the noise waves had frequencies of over 27 Hz (Plate 8) and were therefore impossible to filter out without severely filtering reflected energy which is dominant tin the 30-40 Hz band.

The noise cross-spreads (Plate 7) did not show any important transverse noise and consequently single lines parallel to the traverse were used throughout the area.

The plot of the frequency and wave-number distribution of the signal and noise is shown in Plate 8. These observations were made over a time range of 0.1 to 3.0 s and a recording distance of 31 m to 1340 m. The frequency measurements were made visually on wiggly-line records.

The measurements show that the signal and noise overlap in frequency, but are separated in wavelength. The plotted points for much of the more dominant noise appear to be localized in a particular region between the 4270 m/s and 6096 m/s velocity lines of the frequency/wave-number contour chart (Plate 8). It is evident that a complete separation of signal and noise cannot be achieved by frequency filtering alone. On the other hand the different wave-number distribution of the signal and coherent noise suggests that signal enhancement could be obtained by using spatial filters with a cut-off at about 3 cycles per 1000 m.

In addition to the coherent noise a certain amount of random noise was detected. This type of noise can be decreased by using a large multiplicity of holes and geophones distributed over a large surface. The value of theoretical improvement in signal-to-noise ratio which can be expected is given by the formula $S/N = (n \times m)^{\frac{1}{2}}$ where n = number of geophones and m = number of holes. For example, in changing the shot and geophone arrangement from

10 holes and 12 geophones per trace to 20 holes and 24 geophones per trave, there would be an improvement for the random noise of the order of:

$$\sqrt{\frac{20 \times 24}{10 \times 12}} = 2.0, \text{ or 6 decibels (dB).}$$

Such an improvement should be noticeable on a field record. In practice the shot and geophone patterns designed to attenuate coherent noise were duplicated by parallel patterns for the purpose of further reducing random noise.

Although the graphs in Plate 8 suggested that a spatial filter with a cut-off at about 3 cycles per 1000 m would have most effect in reducing coherent noise, hole and geophone spacings were chosen which resulted in a cut-off at 10 cycles per 1000 m in order to avoid excessive overlap of geophone groups and consequent ground mixing. It was considered that the cut-off value could be effectively increased on playback of the tapes with instrument mixing if desired. The shot and geophone arrangements employed in normal split spreads thus consisted of two rows of ten holes with 5-m spacing between holes and 46 m between rows and 24 geophones per trace in two rows of twelve with 4-m spacing between geophones and 9 m between rows.

The frequency filters used in the field were K18 and K160 for monitor and K33 and K92 on playback. The K filter settings have a slope of 18 dB/octave on both high-pass and low-pass sides.

SP 270: Observations show that at SP 270 the surface and near-surface noise has frequencies in the 10-40 Hz band and is more highly organized than the noise recorded at SP 228 (Plate 7). About 70 percent of the noise can be regarded as coherent for the 6 m trace interval used. The noise events were evenly distributed in time after the first breaks and no distinct noise-free 'window' was observed.

The Rayleigh wave, which shows dispersion, comes in strongly at 0.3 s 31 m from the shot and can be followed out to 1190 m from the shot at a time of 3.0 s. A noise event whose velocity varies from about 1520 to 2440 m/s with increasing distance from the shot is observed at a time of 0.2 s at 150 m and 0.8 s at 760 m from the shot. The overall noise level is about 20 dB above signal level.

Low-cut frequency filtering was effective in attenuating the lowest frequencies of the noise events, particularly the low-frequency (10-25 Hz) Rayleigh wave components. Reflected energy in this area was localized in the 25-55 Hz frequency band.

A small amount of organized transverse noise was detected on the cross-spread (Plate 7); it was predominantly of low frequency and low apparent velocity and would be readily attenuated by the frequency and spatial filters employed in normal reflection work.

Signal and noise overlap in frequency, but are separated in wave-number (Plate 8). The points plotted for noise on the frequency/wave-number contour map fall into two separate areas corresponding to either the low-velocity Rayleigh wave or the higher-velocity noise-wave group. The Rayleigh wave which has large wave-numbers (15-39 cycles per 1000 m) is centred on the 823 m/s velocity line while the higher-velocity waves with wave-numbers varying between 9 and 21 cycles per 1000 m lie mainly between the 1520 m/s and the 3050 m/s velocity lines.

It is apparent that a spatial filter with a cut-off of about 10 cycles per 1000 m would be effective in attenuating these two groups of noise events. In general, the noise recorded at SP 270 revealed similar characteristics to the noise observed at SP 228. This suggested that the shot/geophone arrangements should remain unchanged. A small amount of random noise was observed, but not as much as previously recorded at SP 228. The signal and noise spectrum (Plate 8) indicates that the optimum playback filter should also remain unchanged at K33-K92.

SP 370: Results of the noise test at SP 370 reveal that the noise in this particular area lies in the 15-50 Hz frequency band. About 40-60 percent of the noise is regarded as coherent. No noise-free 'window' was observed: both coherent and random noise appear evenly distributed in time after the first breaks. There are two main groups of noise events, with velocities of 1070 m/s and 2290 m/s. The noise level appears to be at least 30 dB above signal level.

Frequencies remain fairly constant with increasing time and distance. Low-cut frequency filtering was again effective to a certain extent in attenuating those noise waves with frequencies below 30 Hz. The optimum playback filter again appeared to be K33-K92. Reflection signal lies in the 35-60 Hz frequency band (Plate 8). A plot of the frequency distribution and the wave-number distribution shown in Plate 8 indicates that signal and noise overlap in frequency, but are separated in wave-number. However, there is some overlap near $k = 4.5$ cycles per 1000 m. A spatial filter with wave-number cut-off of about 6 cycles per 1000 m was indicated as suitable for separation of signal and noise. However, for field recording the shooting wave-number cut-off was retained as 10 cycles per 1000 m to avoid excessive geophone ground mixing.

The random noise recorded (Plate 7) appears to become more important beyond a recording distance of 610 m. The cross-spread, which was laid out perpendicular to the traverse from the shot, revealed the presence of some organized transverse noise, but this was not considered to be a serious problem (Plate 7).

Abbreviated noise tests were performed on Traverse A using the same technique employed in the comprehensive noise tests except that only two geophone spreads were used. Abbreviated noise tests were carried out at SPs 261, 262, and 350 (Plate 7). At each of these, shots were fired into two spreads laid out between 320 m and 610 m.

SP 261: The noise records obtained at this shot-point appear to be somewhat different from those obtained from the noise tests at SPs 228, 270, and 370. The records from SP 261 are of much lower amplitude, and this may partly account for the difference. The noise events down to 0.3 s are of high frequency (70 - 100 Hz) and below 0.3 s the noise is of much lower frequency. Two organized low-frequency events appear on both spreads. The earlier of the two events is modulated by the high frequencies which made picking difficult and not very reliable. However, the event can be followed from 0.26 s, 320 m from the shot, to 0.42 s, 610 m from the shot. This event has a velocity of 1830 m/s. The later organized event is the Rayleigh wave, its velocity measured over eight traces on the spread farthest from the shot is 980 m/s. Approximate arrival time of this wave is 0.6 s at the nearer geophones and its frequency is 22 Hz.

An event which occurs at 0.35 s between 470 m and 610 m is the most probable signal. Its frequency is 67 Hz and apparent velocity 11 600 m/s. It is notable that on subsequent pattern shooting in this area the best results were obtained at SP 261.

SP 262: The noise events recorded on the two records from near SP 262 were of different character from that recorded at SP 261. Frequencies were much lower, being in the range 30-40 Hz, and coherent noise immediately following the first breaks was stronger (Plate 7). This abrupt change in the frequency spectrum from one shot-point to another is probably due to the rapid deepening of the high-velocity limestone layer, from 1.8 m below the surface at SP 261 to at least 21 m below the surface at SP 263. The charge was placed in the hard limestone layer at SP 261 (at least 8 m thick at this point) whereas at SP 262 the charge was placed in soft limestone. The two spreads for this latter noise test were also laid out above a relatively thick layer of sand and clay. The less consolidated surface layers no doubt account for the low frequencies and more highly organized noise near SP 262. At SP 262 continuous alignments can be picked up to 0.4 s after the first breaks. These alignments have velocities of about 2130-2440 m/s, measured over a distance of 140 m on the spread farthest from the shot. Frequencies are about 33 Hz. Some difficulty is encountered in picking coherent events beyond 0.4 s. The noise beyond this time is predominantly incoherent for the 6-m trace interval used.

SP 350: This noise test, shot near Indeear bore (Plate 4), also consisted of two 140-m spreads laid out between 320 m and 610 m from the shot. The noise recorded is predominantly coherent over the recording range mentioned above. Strong organized noise alignments can be observed up to a time of at least 1.5 s (Plate 7). Frequencies are low (17 to 22 Hz) and velocities vary between 1220 and 1520 m/s.

In summarising the results of noise tests on Traverse A, although there are some differences in noise characteristics from shot-point to shot-point, these were not large enough to warrant marked changes in reflection recording techniques along the traverse.

Noise test, Traverse B. The variable area profile of the noise test performed at SP 1009 Traverse B is shown in Plate 9. The profile revealed a number of well organized noise events up to a time of 0.8 s. Energy decreases rapidly beyond a recording distance of 610 m. Frequencies vary between 20 and 50 Hz. One strong organized event, with a velocity of 3500 m/s and a frequency of 40 Hz, can be followed continuously from a time of 0.42 s to 0.7 s over a distance of 350 m on the four records farthest from the shot-point.

A few poor and discontinuous low-velocity events (490 m/s) which are probably components of the Rayleigh wave can be picked over the first three records nearest the shot. They extend over a time range of 0.7 s to 1.7 s and frequencies are about 22 Hz. The noise level measured over a recording distance of 31 m - 610 m from the shot is about 10 dB above signal level. Signal frequency varied between 35 Hz and 50 Hz. Low-cut frequency filtering was therefore likely to be effective in improving signal-to-noise ratio by attenuating low-frequency noise below 30 Hz.

Plate 10 illustrates the wave-number and frequency distributions of signal and noise. Signal and noise spectra overlap in frequency, but are separated in wave-number. It is apparent from the frequency/wave-number plot that a spatial filter with a cut-off of about 6 - 9 cycles per

1000 m would be necessary to attenuate the organized noise. The graph of frequency against wave-number on Plate 10 indicates that most of the noise events have apparent velocities between 2130 m/s and 6100 m/s.

In subsequent pattern shooting a spatial filter with a cut-off of 10 cycles per 1000 m was chosen with the same geophone arrangement used on Traverse A; that is, two rows of 12 geophones with geophones 4 m apart in line. The shot pattern, however, was reduced from two rows of 10 holes to 5 holes in line 12 m apart in order to increase the party's progress. Frequency filters used in the field were K18-K160 on monitor and K33-K92 on playback.

Noise Test Traverse C The noise test profile shot at SP 2368 is shown in Plate 9. About 80 percent of the noise recorded is considered coherent. Frequencies vary between 15 Hz and 55 Hz. The organized noise events are evenly distributed in time after the first breaks, and no noise-free 'window' is observed.

First breaks and first and second troughs have velocities varying from 5180 m/s to 6100 m/s. Two main groups of organized noise are revealed. The group of organized noise events which follow the first arrivals have velocities which vary between 3050 m/s and 4900 m/s. One component in particular, observed at a time of 0.3 s, 320 m from the shotpoint, can be followed out to 1340 m at a time of 0.5 s. The frequency of this event (40 Hz) showed little variation with distance. The second group of noise waves recorded is the low-velocity Rayleigh wave. Some components of this wave are quite strong and nearly continuous over the entire noise profile. The Rayleigh wave is disturbed by high-frequency wind noise on the three records farthest from the shot. The velocity varies from 1520 m/s near the shot (152 m) to 2130 m/s, 914 m from the shot. The frequency measured over the same distance decreases from 25 to 16 Hz. The cross-spread did not show any transverse noise.

The frequency and wave-number plots (Plate 10) show that the signal and noise overlap in frequency, but are separated in wave-number. The frequency/wave-number distribution contour map shows that most noise events have apparent velocities between 2300 m/s and 6100 m/s and frequencies between 20 - 50 Hz. The contour map also indicates that signal enhancement could be obtained by using a spatial filter with a cut-off in the region 4.5 to 9 cycles per 1000 m. It did not appear necessary to change the shot-hole and geophone patterns as chosen for Traverse B; that is, two rows of 12 geophones spaced 4 m apart and 5 holes in line 12 m apart.

Noise test, Traverse D. The noise test shot at SP 3810 (Plate 9) indicates that approximately 60 percent of the noise recorded was organized or coherent while the remaining 40 percent was random. Noise frequencies were generally higher than those recorded on previous traverses. The noise events have frequencies 60-100 Hz down to 0.7 s, and the frequencies at later times are considerably lower.

A few high-frequency organized events occur immediately after the first breaks. One event, in particular, can be followed nearly across the entire profile, its velocity increasing from 2195 m/s near the shot to 3500 m/s about 1130 m from the shot. Its frequency measured over the same recording distance was 70-80 Hz. Strong, organized low-frequency events appear on the five records nearest the shotpoint. Velocities increase from 1700 m/s, 31 m from the shot, to about 2100 m/s at 820 m from the shot. Frequencies are roughly 15-25 Hz. No significant organized transverse noise was recorded. No reflection signal appears on the noise test profile, even on the records replayed with AGC.

The shot/geophone arrangement adopted on Traverses B and C was again employed on Traverse D. The spatial filter cut-off was 9 cycles per 1000 m. In an attempt to improve the reflections of poor to fair quality recorded on the northern end of the traverse, the multiplicity of holes and geophones was increased to 20 holes (4 rows of 5) and 36 geophones per trace (3 rows of 12). However, there was only a slight improvement in reflection quality over the shot/geophone arrangement using 5 holes in line and 24 geophones per trace (2 rows of 12).

Noise test, Traverse E. The noise test shot from SP 4509 (Plate 9) shows a marked similarity in noise character and frequency to that recorded on Traverse D. A greater percentage of random noise was recorded on Traverse E. High-frequency noise events again immediately follow the first breaks down to 0.6 s. Two groups of organized noise are observed. A few high-frequency organized noise events appear close to the first breaks and can be picked only on the spreads most distant from the shot. One alignment, with a velocity of 2800 m/s and a frequency of 83 Hz, can be picked over recording distances of 610 m to 1340 m at times ranging from 0.3 s to 0.5 s respectively.

The low-frequency Rayleigh wave appears on all records along the profile. Measurements taken of one particular alignment in this wave group indicate an increase in velocity from 1400 m/s at 90 m to 2290 m/s at 1340 m from the shot. Its frequency decreases from 25 Hz over the same recording distance. No reflection signal was observed on the noise test records.

Collinear offset shooting, Traverse A

A number of shooting and recording arrangements were tied in an effort to improve results after shooting SP 204, Traverse A.

As the central traces on the 550-m split spread records appeared to be somewhat less disturbed by noise, 270-m split spreads were tried. However, improvement obtained was considered too slight to justify the extra work involved, particularly as it was necessary for the geophone groups to overlap one another to a considerable degree.

An expanded spread was shot centred at SP 261 (Plate 11) and it was found that the best offset distance for recording suitable events was in the range 1100 to 2200 m. Consequently, collinear offset shooting with the spread covering these distances from the shot was tried over an interval of about 10 km using five-hole shot patterns and 24 geophones per trace. It was found necessary to use charges of up to 191 kg per shot for this work. The subsurface between SPs 198 and 216 was covered twice by this method by shooting 'forward' and 'reverse' offset shots.

A few events were recorded within 0.5 s of the first breaks using this method, but unfortunately these appear to be either partly refracted events or reflections so confused by refracted events as to be almost unusable. The two cross-sections produced by shots in opposite directions showed little similarity in details both when placed in corresponding geophone positions and in similar subsurface coverage positions. This suggests that there may have been lenses or other bodies of discontinuous material between the surface and the main reflecting or refracting layers which interfered with the recording of continuous events.

6-fold CDP coverage, SPs 258 ^{2}/3 to 270, Traverse A

In an effort to improve results where some poor reflections had been recorded, six-fold multiple coverage was carried out on Traverse A between SPs 258 2/3 and 270. For this work the geophone spreads were laid out 2100 m away from the shot, the total length of the spread 180 m to 2290 m.

Five-hole shot patterns were employed, with 9-m spacings between holes. The geophone pattern was 24 geophones per trace in a single line, with 2.4-m spacings between geophones. Unfortunately the multiple-coverage work did not result in any improvement in reflection quality.

The common-depth-point stacked section is shown in Plate 12. The poor results may possibly have been due to the increased length of spread over that used for single coverage. An expanded spread shot centred at SP 261 (Plate 11) indicated that the reflection signal-to-noise ratio was best in the range 0 to 270 m from the shot and decreased considerably at larger distances.

Air-shooting

Some experimental airshots were recorded. In this method charges are detonated on poles in order to distribute the explosive shock wave-front over a large area of the ground surface, the aim being to see if there was any improvement over normal shot-hole patterns. The shots consisted of 13 or 20 5-kg charges placed on stakes, 6 m above the ground, and arranged in either a star after the method of Poulter (1950), or in rows parallel to the traverse (collinear pattern). On Traverse A, airshots were recorded at 15 shot-points between SPs 205 and 266. The shots were offset about 1200 m parallel to the traverse and Poulter and collinear patterns were used. At four shot-points comparisons were made with normal shot-hole patterns consisting of 2 rows of 10 holes spaced 4 m apart. For the Poulter pattern stakes were all 20 m apart. In collinear airshots 2 rows of 10 stakes were used with 6 m between stakes and rows spaced 50 m. In general the airshot records were poorer than the normal shot-hole records. Airshots were also recorded on Traverse C (SPs 2365-2367) and Traverse D (SPs 3819-3821) using similar airshot patterns to the above except that shots were offset perpendicular to the traverse a distance of 670 m and were recorded into a split-spread. Some poor reflections were recorded at SPs 3819-3821 at 0.3-0.4 s and at 1.0 s. On Traverse C, SP 2365, the airshot was better than a single-hole shot at the same offset. On Traverse D, SPs 3819-3821, comparison tests were made with four shooting arrangements (Plate 19): 5 holes in line depth 6 m, 20 holes depth 6 m, 100 holes depth 3-5 m, and airshots. The airshots were poorer than the shot-hole patterns. The comparison tests were limited but in general they indicated that airshots gave no improvement over normal shot-hole patterns. Airshots could, however, be advantageous in areas of difficult drilling.

6. SEISMIC DATA PROCESSING AND RESULTS

Data processing

Signal-to-noise ratio improvements by filtering and mixing. Two poor-quality seismic records, SPs 264 and 265, were chosen from Traverse A for experiments on various filtering and mixing arrangement in an attempt to improve the signal-to-noise ratio. These two shots were situated about one kilometre to the east of the fair-quality record at SP 261 (Plate 15). The frequency spectrum of the records at SPs 264 and 265 is lower than at SP 261 where an abbreviated noise test was performed (Plate 7). The noise and signal spectra in this poor-reflection area are probably more similar to those plotted for the noise test at SP 270 (Plate 8).

At the right hand end of Plate 9 variable-area records for SP 264 and 265 are shown for playback with a very wide frequency filter passband and no mixing (group a). It is seen that reflection signals are practically indiscernible amongst the noise. The next two groups of records (groups b and c) were played back using filter passbands of 31-100 Hz and 39-100 Hz, the filters having cut-off slopes of 12 dB per octave. It is seen that in both cases the filtering has resulted in a marked increase in signal-to-noise ratio, owing no doubt to the attenuation of low-frequency noise in a portion of the spectrum where reflection signal has only relatively minor components. As might be expected, the filter with cut-off at 39 Hz is seen to have been a little more effective than that with a cut-off at 31 Hz in attenuating low-frequency noise. However, there seems to be little difference in reflection quality between the two pairs of records. The plot of frequency against amplitude for SP 270 in Plate 8 indicates that above about 30 Hz there is too much overlap of signal and noise frequencies for frequency filtering to be very effective. It is probable that the filter with cut-off at 39 Hz results in significant signal attenuation as well as noise attenuation. It causes little or no improvement in signal-to-noise ratio compared with the filter with cut-off at 31 Hz. The fourth and fifth groups of records from the right in Plate 13 (groups d and e) show the results of the same frequency passbands with filter cut-off slopes at 24 dB per octave instead of 12 dB per octave. It is apparent that introduction of steeper filter slopes results in a small but significant increase in signal-to-noise ratio, because of greater attenuation of noise outside the reflection frequency range.

The six groups of records on the left hand side of Plate 13 (groups f to k) show, for each of the filter passbands employed the effects of various amounts of inter-channel mixing. The amount of mixing increases from right to left.

It is observed that the introduction of two-channel mixing (f and g) results in an enhancement of reflection signals, e.g. at about 0.4 s, as compared with similarly filtered unmixed records (d and e). With further mixing (h to k) the reflected events become still more marked, but is clear that multiples and other weak and possibly spurious events on the later portions of the records are also greatly enhanced by mixing. The question is to decide at which point the improvement of the reflected signals effected by mixing is counterbalanced by the introduction of spurious line-ups which look like reflections. It seems that in the record groups j and k the 7/6 graded mixing has enhanced spurious line-ups and perhaps weak multiples to an undesirable extent. Therefore part of the output of each of seven adjacent traces was combined to form one mixed trace, while six of these seven traces were used with another to form the next mixed trace, etc. The weighting factors of the seven traces to be mixed were graduated downwards from the centre traces to the outer traces. Perhaps the optimum amount of mixing is somewhere between the 2/1 graded mix and the 5/4 graded mix. SPs 258-271 were played out with 5/4 graded mix and without mixing, and the sections are shown in Plate 14. The improvement by mixing is apparent.

For the final display of results from Traverse A in variable-area cross-section form (Plate 15) an electric filter passband of 31-100 Hz was used with 24 dB per octave slopes. This filter was considered to retain maximum reflection character while sharply attenuating noise outside the reflection frequency range. A 5/4 graded mixing was employed, with the weighting of each five mixed traces in the proportions 10, 20, 40, 20, and 10 percent. The mixing had a similar effect to that which would be achieved by increasing the length of shot and geophone pattern, namely the attenuation of noise events with small wave-number. The noise tests showed this effect to be desirable.

Results

Traverse A. Reflection recording commenced on Traverse A at SP 200, close to BMR 12 (Cockroach) bore (see Plate 4). The shot and geophone arrangements used initially for normal split spreads were those suggested by the experimental work in 1964, namely four rows of five holes 9 m deep with 12-m spacing between holes and rows and 24 geophones per trace in four rows of six with 7-m spacing between geophones (the maximum allowed by the cables) and 9 m between rows. Only poor-quality reflections were obtained between SPs 200 and 204, the best one being a fairly high-frequency event (50-60 Hz) occurring at about 0.35 s, which is interpreted as a horizon corresponding to a pronounced velocity discontinuity known from BMR 12 (Plate 22) to occur near the boundary of the Arrinthrunga

Formation and the Marqua Beds at a depth of 830 m. A poor reflection also appears at about 0.5 s (Plate 15). It was unfortunate that BMR 12 was drilled no deeper than 1220 m. The field geologist believed basement (Upper Proterozoic) was reached before this depth whereas the reflection originated about 90 m below the base of the well (see Plate 3). Record quality deteriorated further to the northeast of SP 200 as the hard limestone layer became deeper (Plate 15).

About 10 km northeast of BMR 12 bore, surface conditions became like those encountered during the preliminary survey in 1964, with consolidated carbonate rocks at depths of 6 to 9 m (Plate 15). Offset shooting was then abandoned and split-spread shooting resumed. It became evident where hard limestones or dolomites were encountered by the shot-hole rigs at shallow depths that a number of poor-quality reflections, mostly at times less than half a second, could be recorded using a high-energy technique. Where the first high-velocity layer was deeper it was virtually impossible to obtain any reflections using conventional means.

Of the 60 km of traverse between BMR 12 bore and No. 3 water bore to the northeast, 30 km was selected for reflection shooting using 550-m split spreads. Poor to fair reflections were recorded over portions totalling about 13 km of traverse, while the remaining portions were devoid of useful reflection results. It is notable that the best reflections were recorded near shot-points 260 and 261 where the high-velocity carbonate layer is at its shallowest depth.

Reflections obtained were mostly recorded in the first half second. They indicated little or no dip. Generally, two main reflection horizons can be followed over those portions of traverse where reflections were recorded. The first horizon is probably a reflection corresponding to the Arrinthrunga/Marqua boundary at 0.35 s (820 m). The second horizon, a probable basement (Upper Proterozoic) reflection, occurs at 0.5 s (1220 m). Another poor-quality reflection can be picked in places at times of about 0.26 s (61 m). This reflection is probably associated with a velocity discontinuity within the Arrinthrunga Formation (see Velocity Data, Plate 22).

The time interval between the two main horizons remained virtually constant at 150 milli seconds along the traverse. In some cases, poor-quality later events were recorded with reflection times up to 2 s or more (Plate 15).

The poor quality of results made it impossible to determine whether these later events were multiples or primary reflections. Likewise, it is impossible to estimate a maximum thickness for sediments in the area. On the basis that, where reflections were recorded they were usually observed up to at least 0.5 s, it appears that the minimum thickness of sediments along the traverse is about 1220 m, a fact already known at the southwestern end of the traverse from BMR 12 bore.

The easternmost segment of Traverse A, which extends over a distance of about 18 km from SP 350 to SP 383, was surveyed for the purpose of investigating an aeromagnetic 'low' centred southeast of Tobermory Homestead (Plate 4). Five kilometres of the traverse was shot for reflections near the Northern Territory/Queensland border, but then work on the traverse was abandoned because of lack of reflections (Plate 15).

Traverse B. Traverse B, about 6 km in length, was surveyed along the Northern Territory/Queensland border, a few kilometres south of Manners Creek homestead (see Plate 4).

A few poor shallow reflections were recorded on Traverse B at times of about 0.34 s and also a number of moderately strong deeper events with reflection times of up to 2.75 s (Plate 16). However, their importance is decreased by the lack of continuity between records. These deep events may indicate the presence of a deep Proterozoic sedimentary section in this area.

Traverse C. Traverse C (Plate 4) was surveyed in two segments, the southern segment for the purpose of allowing correlation of seismic results with the nearby Alliance Mulga Hill No. 1 bore and the northern segment to attempt seismic investigation of a gravity 'low'. However, the records from both segments were so devoid of useful reflections that neither of these aims was fulfilled (Plate 17).

A possible explanation for the lack of correlatable reflections in the area is provided by the sonic log from Mulga Hill No. 1 bore (Alliance, 1965). The occurrence of reflections of sufficient strength to be detected amongst the noise would depend on the existence of adequate velocity contrasts within the stratigraphic sequence. However, the sonic log indicates that there are no marked vertical velocity discontinuities in the area to a depth of about 790 m.

Traverse D. About 15 km of reflection profile was shot on Traverse D which extended southwards from Gordon Creek (Plate 4). It was surveyed in an attempt to find seismic evidence for the existence of a major fault postulated on the basis of aeromagnetic results (Plate 5). No useful reflections were recorded over the greater part of the traverse. However, some very poor reflections were recorded on the northern end of the traverse between SPs 3808 and 3819 (Plate 18). Reflection quality improved from SP 3819 to SP 3822 where a fair-quality reflection was recorded at about 0.24 s. Several other poor reflections were recorded at times up to 0.5 s. These reflections were also observed on the southern half of the record from SP 3823, which was the last shot-point on the traverse, but not on the northern half of the record.

Reflections in general indicated little or no dip. Termination of the reflections to the north on the record from SP 3823 was sufficiently abrupt to suggest that faulting occurs in this area. As mentioned previously a major fault with northeasterly trend had been postulated on aeromagnetic evidence to exist in this area (Plate 5). It is possible that Gordon Creek itself follows such a fault line.

SPs 3819, 3820, and 3821 at the northern end of Traverse D, originally shot with 5-hole patterns drilled into the hard limestone layer at about 6 m, were reshot for comparison using 20-hole patterns drilled to the same depths and also using airshot patterns (Plate 19). The results using 20-hole patterns were only very slightly better than those using five holes, while the airshots were noticeably poorer. At shot-points 3819, 3820, and 3821 one-hundred-hole patterns were drilled to the rig kelly depth of 5 m to test the effect of large numbers of energy sources located above the top of the first high-velocity layer. The results of the 100-hole patterns at shot-points 3819 and 3820 were poorer than the 5-hole patterns drilled about one metre deeper in order to place charges partly in the consolidated limestone layer (Plate 19). At SP 3821 the 100-hole pattern produced a record similar to the 5-hole pattern. It appears that in some cases the record quality depends strongly on the charges being placed in contact with the consolidated layer.

Traverse E. Traverse E consisted of 6 km of reflection profile surveyed near the centre of a large aeromagnetic 'low' in the southwestern corner of URANDANGI (Plate 4). The reflection shooting technique was similar to that used on the previous traverses. Using 5-hole shot patterns and 24 geophones per trace, the results were very poor. Only at SP 4511 were some reflections recorded (Plate 20). Poor events at about 0.5 s indicated gentle dips to the north.

7. CONCLUSIONS

In terms of new geological information obtained the survey proved very disappointing. The main conclusion to be drawn is a negative one, namely that in the region surveyed the seismic method indicated no areas where there might be considerable thicknesses of prospective oil-bearing sediments readily mappable by seismic means. This is a conclusion resulting mainly from the poor quality of seismic results obtained and it does not exclude the possibility that oil-bearing sediments occur in the area. However, the results throw some doubt on the likelihood that deep troughs of Palaeozoic sediments such as the Toko Syncline occur, since it is very likely that such troughs would have produced some persistent reflections.

The reflections which were recorded on Traverse A indicate little or no dip and were distributed similarly in time to those recorded near BMR 12 bore. The seismic results therefore tend to confirm indications from gravity results that there is a shelf area between BMR 12 and Tobermory. Alliance Mulga No. 1 bore to the north indicated that the Palaeozoic sediments were less than 610 m thick and are underlain by Upper Proterozoic sediments. No useful reflections were recorded in this area. However, 24 km northwest of Mulga No. 1, near Gordon Creek, fair reflections were recorded to about 0.5 s as in the vicinity of BMR 12. It is possible that 1220 m of Palaeozoic sediments may be present at Gordon Creel as at BMR 12. The seismic work indicated the likely presence of at least one fault in this area, but no indication could be obtained of this fault's magnitude or strike.

During the course of the survey a considerable amount of experimentation and testing was carried out to try to improve results and to determine the reasons for the poor results obtained. It was found that in general the best results were obtained where limestone or dolomite were encountered at shallow depths. Such areas can be readily located by shallow refraction shooting. It does not appear, then, that noise as a result of the presence of a surface layer with high velocity was the main reason for the poor reflections, although reflection of shot energy from the top of the high-velocity layer might have been a factor where the charge was not placed in the high-velocity layer. The main reason for lack of reflections is probably the absence of well defined velocity contrasts within the Upper Palaeozoic sediments.

Drilling on all traverses was slow and difficult. The poor signal-to-noise ratios generally observed require high multiplicity of energy sources and geophones. Since large shot-hole patterns are expensive, consideration should be given to the use of some other type of energy source, such as weight dropping or 'Vibroseis', for any future seismic surveys in the region. However, there is no certainty that methods using surface energy sources would be successful since the 1965 survey demonstrated that results were usually poor where the charges were not in contact with the first high-velocity layer. Air shooting is generally not as effective as hole shooting, but could be useful in areas of difficult drilling conditions where signal-to-noise ratio is better than on the traverses surveyed in 1965.

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APPENDIX A

Staff and Equipment

Staff

Party Leader	J.S. Davies
Geophysicist	P. Montecchi
Surveyors	J. Cameron P. Pullinen
Observer	R. Krege
Shooter	H. Pelz
Toolpusher	B. Findlay
Drillers	A. Zoska E. Cherry
Drilling Assistant, acting driller	E. Lodwick
Mechanics	T.H. Clark B. Ingram
Party clerk	S. Wright

Fourteen wages employees were also employed for the duration of the survey. These included cooking staff, field hands, and drill helpers.

Equipment

Seismic amplifiers	T.I. 8000 'Explorer'
Seismic oscillograph	S.I.E. TRO6
Magnetic recorder	Electro-Tech. DS7-7 PP7 Junction box
Geophones	E.V.S. 2B, 20 Hz (approx. 900), for reflection work
Cables	Vector 2000 ft and 1500 ft
Transceivers	Traeger T.M. 2(3) and Pye F.M. (3)
Recording truck	International AB120, 4 x 4 1 ton utility with BMR-Ansair cab

Shooting Truck	Bedford RLHC3, 4 x 4 with 600-gallon cylindrical tank
Drills	Two Mayhew 1000, one Carey shot-hole rig
Water tankers	Three Bedford RLHC3, 4 x 4 with 600-gallon cylindrical tanks.
	One Bedford RLHC3, 4 x 4 with 800-gallon flat tank.
Geophone trucks	Two Landrovers, LWB

Three more Landrovers, a one-ton utility, a three-ton supply truck, a workshop truck, an office caravan, a kitchen caravan, one electric generator mounted on a two-wheel trailer, and five four-wheel trailers completed the party's mobile equipment.

APPENDIX B

Table of Operations

General information

Sedimentary basin	Southern Georgina Basin
Area of survey	Tobermory, Sandover River, and Urandangi 1:250 000 Sheet areas
Camp sites near	Cockroach Waterhole, Gordon Creek
Established first camp	13 April 1965
Surveying commenced	13 April 1965
Drilling commenced	20 April 1965
Shooting commenced	20 April 1965
Kilometres surveyed	134
Topographic survey control	Division of National Mapping 4-mile series and airphotos. Department of Interior bench-marks, Queensland State datum
Total metres drilled	2997 (mainly 20- and 5-hole reflection patterns)
Explosive used	Geophex = 20 100 kg Ligdyn = 660 kg Ammonium nitrate = 290 kg
Datum level for corrections	152.4 m above sea level
Weathering velocities	600-900 m/s
Sub-weathering velocity	4600-5500 m/s
Method for weathering corrections	Up-hole times checked by first breaks
Source of velocity distribution	BMR 12 bore sonic log

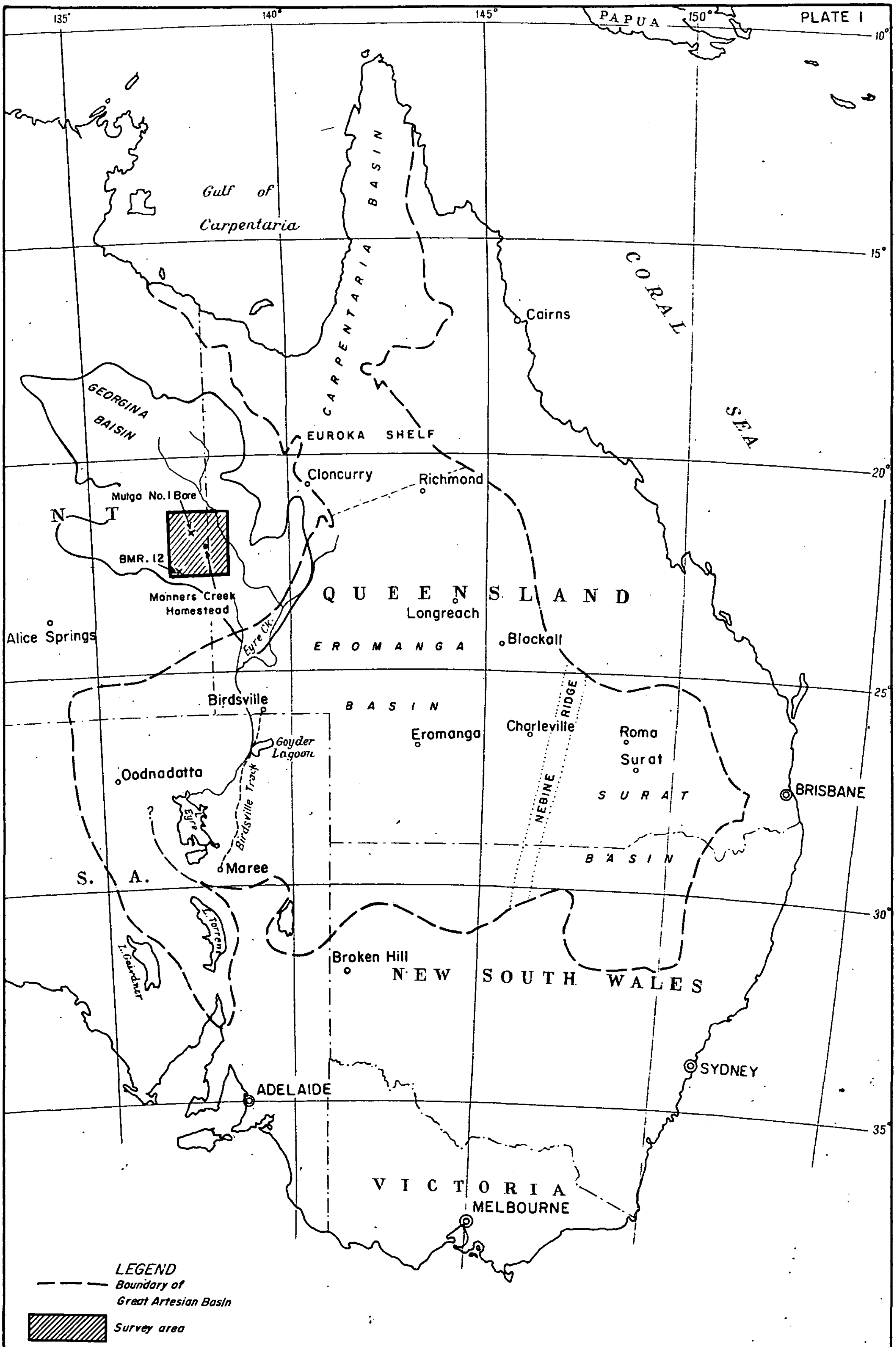
Reflection shooting data

Shot-point interval	550 m
Geophone group interval	46 m
Number of kilometres traversed	36

Number of shot-points fired	240
Common shooting depth	6-9 m
Usual recording filters	K18-K160
Usual playback filters	K33-K92
Common total charge per SP	45.4 kg (split spreads) 90.7 kg (offset shooting) 59 kg (air-shooting)

504789

PLATE I

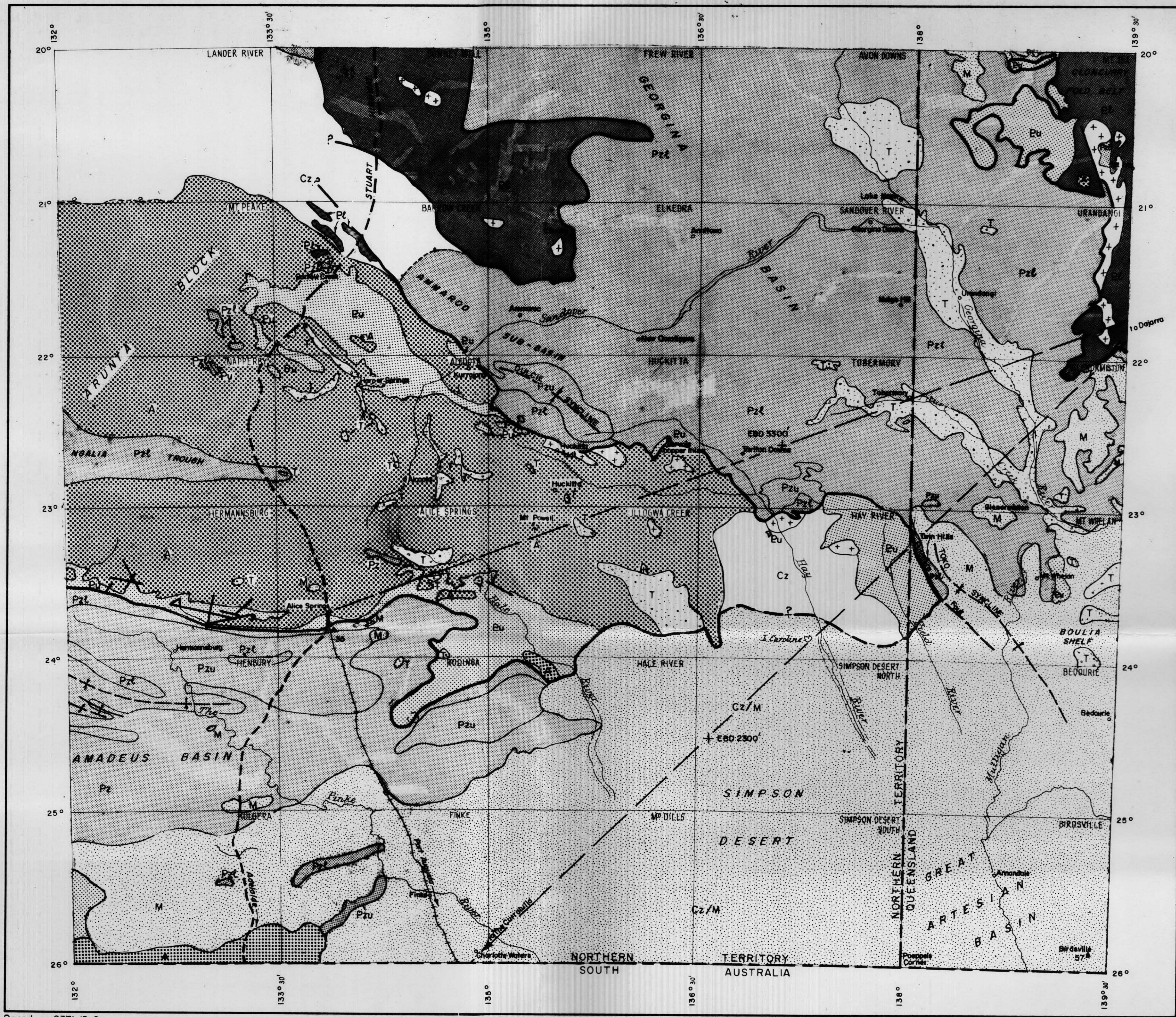


LOCALITY MAP

Record 1974/89

F53/B3-130A

504789 PLATE 2



Based on G371-12-0

Cz	Cainozoic	▲ 35	BMR gravity pendulum station
T	Tertiary	KULGERA	1 : 250,000 map area
Cz/M M	Mesozoic		Fault Fault, indefinite
Pz Pzu Pzl	Palaeozoic		Anticlinal axis
Pu	Upper Proterozoic		Synclinal axis
Pl	Lower Proterozoic		BMR aeromagnetic flight line
A	Archaean	+ EBD	Estimated basement depth
+ + +	Granite		Basin boundary (Precambrian against younger sediments)

REGIONAL GEOLOGY

0 20 40 60 80 100 120 140 160 180 200 km

Reference – Division of National Mapping 40 miles to 1 inch topographic map and BMR Tectonic map of Australia

COMPILED AND DRAWN MARCH 1961

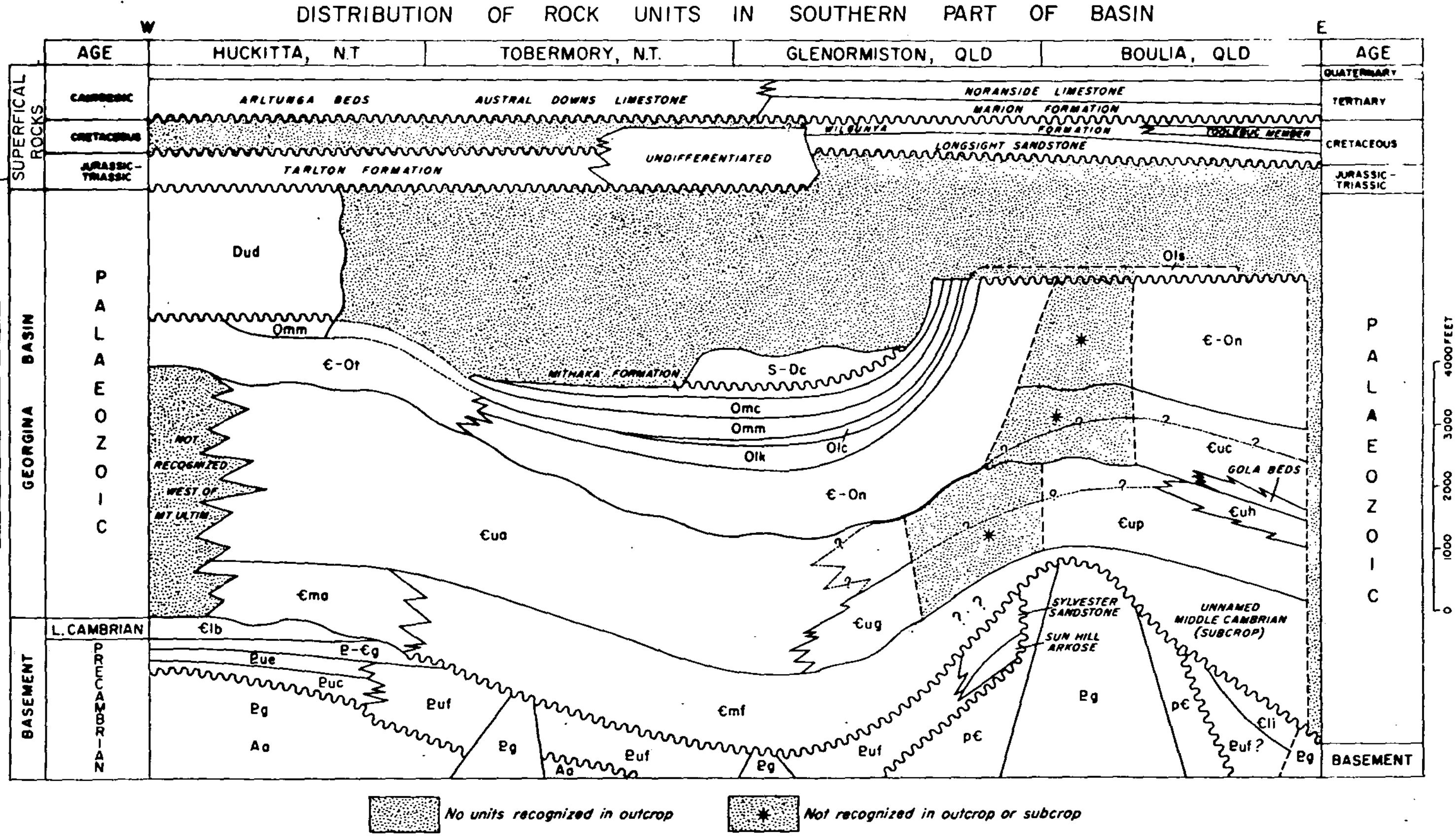
GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F53/B2-20

To Accompany Record No 1965/96 and Record No. 1974/89

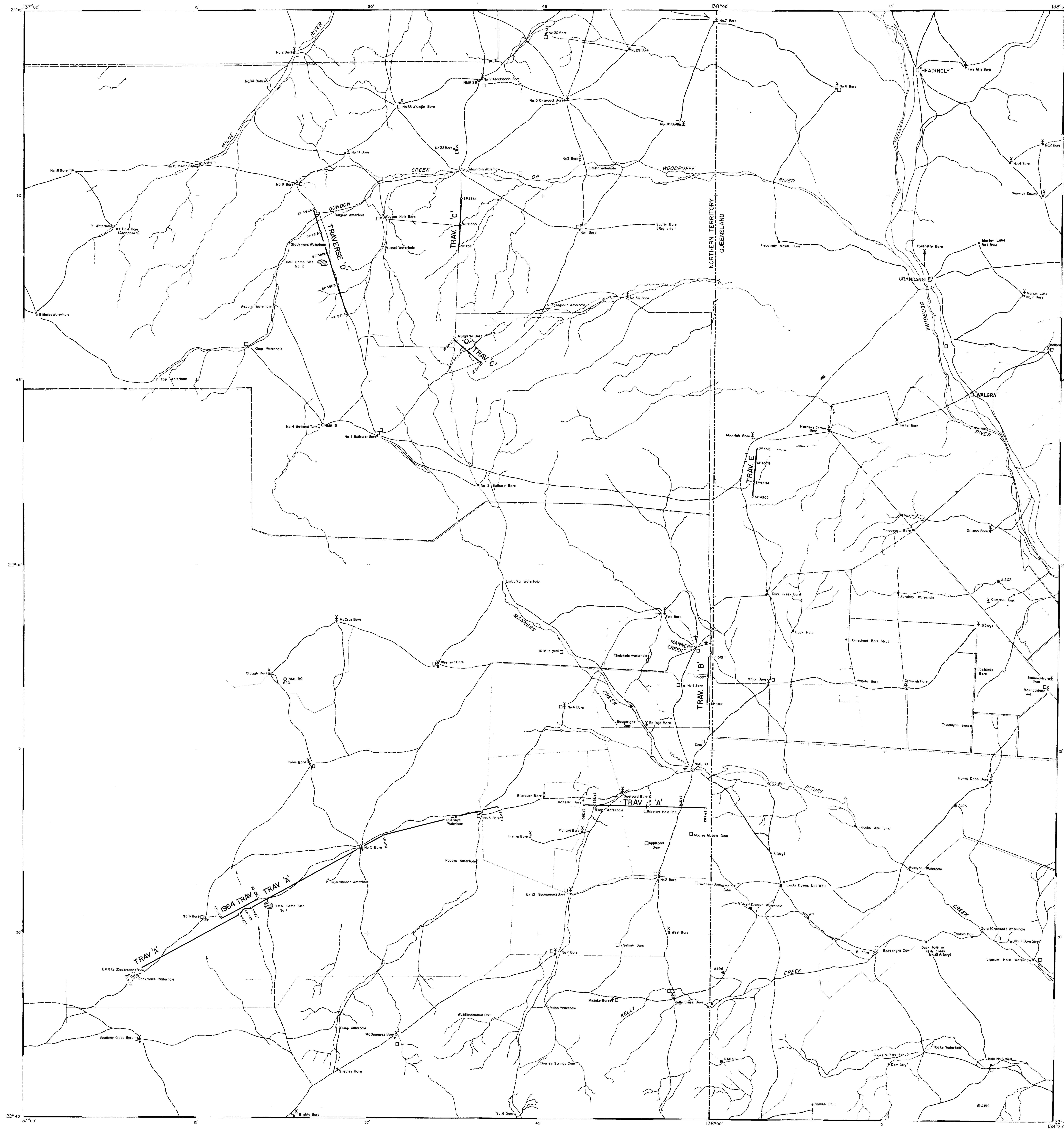
STRATIGRAPHIC UNITS IN THE SOUTHERN AND SOUTHEASTERN PART OF BASIN PLATE 3

Age	*Huckitta* *Formation*	*Thickness (m)*	*Tobermory-Glenormiston* *Formation*	*Thickness (m)*	*Boulia* *Formation*	*Thickness (m)*	*Southeastern Extension* *Formation*	*Thickness (m)*
U. Devonian	Dulcie Sst	630						
U. Silurian/ U. Devonian			Cravens Peak Beds	135+				
	Unconformity		*Unconformity*					
	Nora Fm	120+	Toko Group (Mithaka Fm (Carlo Sst (Nora Fm (Coolibah Fm	90+ 120 90 75				
			Disconformity					
L. Ordovician			Kelly Cr. Fm	165	Swift Fm	20+		
					Unconformity			
L. Ordovician/ U. Cambrian	Tomahawk Beds	240	Ninmaroo Fm	360	Ninmaroo Fm	750		
	Disconformity		*Disconformity*					
U. Cambrian	Arrinthrunga Fm	960	Arrinthrunga Fm	660	Chatsworth Lst	450	Undifferentiated. Subsurface only	920+ M. and U. Cambrian sediments in The Brothers 1
M. Cambrian	Arthur Cr. Beds	300	Marqua Beds	210+	Subsurface only	689 in Black Mt 1		
	Disconformity		*Unconformity*					
L. Cambrian/ Adelaidean	Mt Baldwin Fm	390	Field R. Beds	1800-2400				

DISTRIBUTION OF ROCK UNITS IN SOUTHERN PART OF BASIN



Dud Dulcie Sandstone; S–Dc Cravens Peak Beds; Omm Nora Formation; Omc Carlo Sandstone; Olc Coolibah Formation; Olk Kelly Creek Formation Ols Swift Formation; €–On Ninmaroo Formation; €–Ot Tomahawk Beds; €ug Georgina Limestone; €uc Chatsworth Limestone; €uh O'Hara shale; €up Pomegranate Limestone; €ua Arrinthrunga Formation; €mf Marqua Beds; €ma Arthur Creek Beds; Cli Mount Birnie Beds; Clb Mount Baldwin Formation; P–€g Grant Bluff Formation; Pue Elyuah Formation; Puc Mount Cornish Formation; Puf Field River Beds; Pg Proterozoic granite undifferentiated; p€ Undifferentiated; Aa Arunta Complex

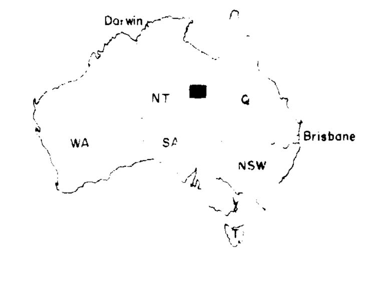


LEGEND

- State Boundary
- Track and Road
- River and Creek
- Fence
- Waterhole
- Waterbore
- Yard
- BMR Camp Site
- Landing Strip
- Oil Search Bore
- Seismic Traverse

5 0 5 10 15 20 KILOMETRES

SOUTHERN GEORGINA BASIN SEISMIC SURVEY 1965
POSITION OF TRAVERSES



Record 1974/89

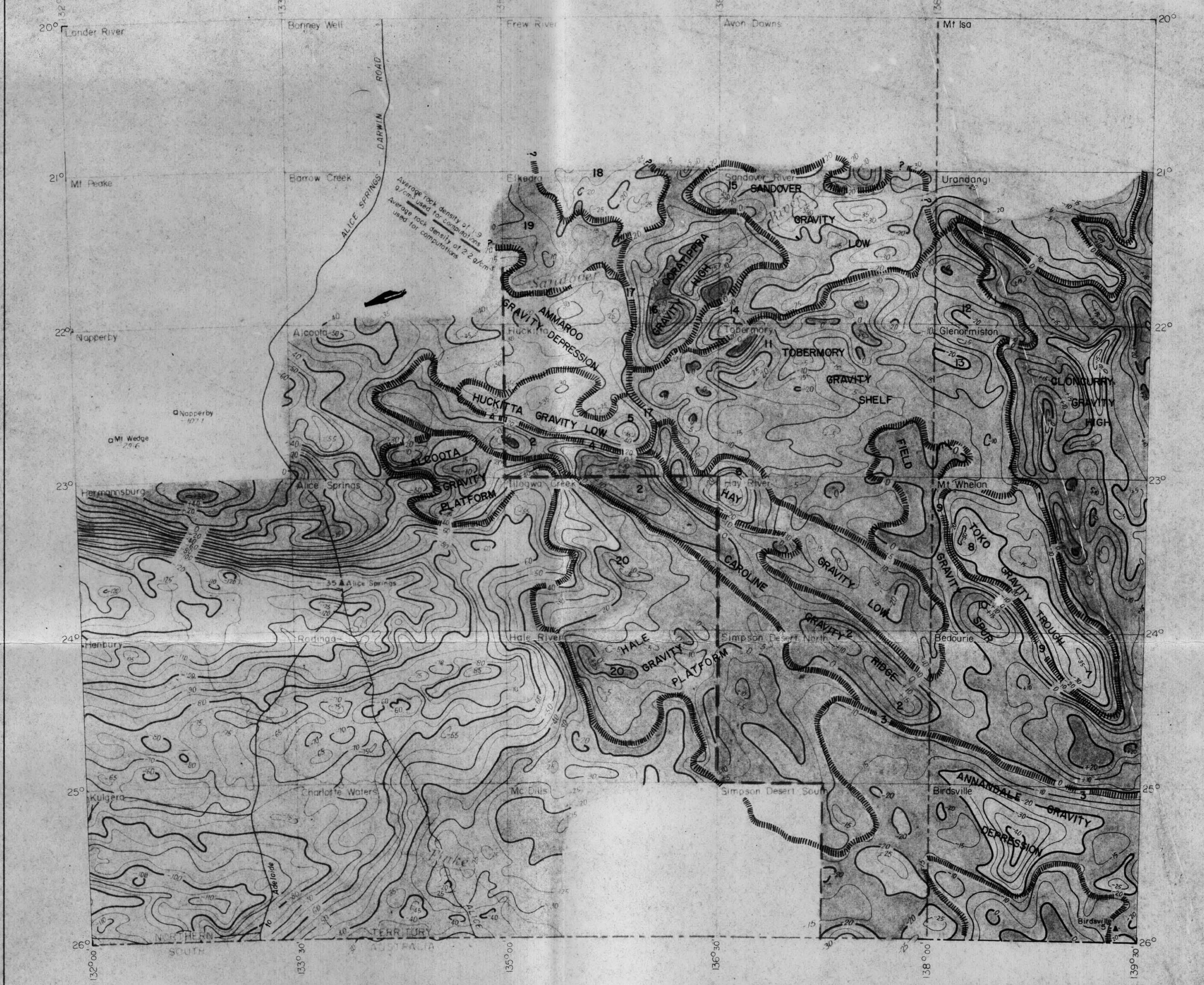
F53/B3-121

504789 PLATE 5

TO ACCOMPANY RECORD No. 1966/142

504789

PLATE 6



LEGEND

- Isogals, values in milligals
- ▲35 BMR gravity pendulum station
- BMR gravity reading at aerodrome
- Mt Isa BMR 1:250,000 gravity map area
- Gravity 'High'
- Gravity 'Low'
- 12 Gravity feature number
- Gravity province boundary

Bouguer Anomalies are based on the observed gravity values at BMR pendulum station:

No. 35 Alice Springs	978,653·7 milligals	
No. 54 Longreach	978,790·2	"
No. 55 Cloncurry	978,651·4	"
No. 56 Boulia	978,793·2	"
No. 57 Birdsville	979,003·7	"

Elevation datum: Queensland State

GEORGINA BASIN
RECONNAISSANCE GRAVITY SURVEYS USING HELICOPTERS
NT AND QLD, 1960-61

BOUGUER ANOMALIES

WITH SHADING EMPHASIS AND GRAVITY UNITS

20 0 20 40 60 80 100 120 140 160 180 200 km

Reference: Division of National Mapping 40 miles to 1 inch topographic map

Contour interval 5 milligals

RELIABILITY DIAGRAM

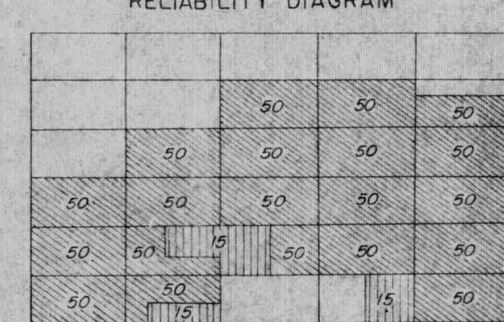
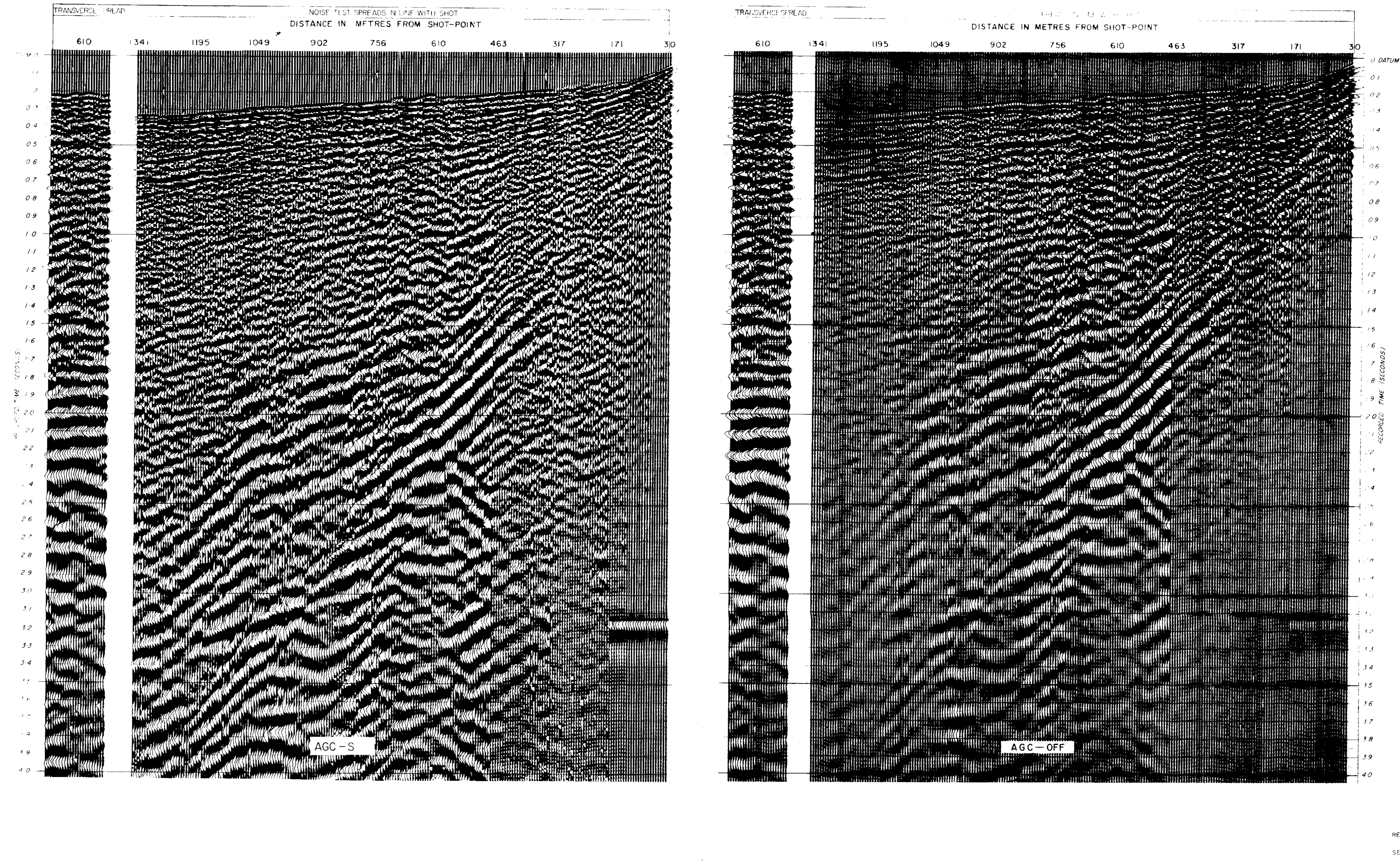


FIGURE IN EACH AREA DENOTES SQUARE MILES PER GRAVITY STATION.

G R A V I T Y	
SURVEY	METHOD
Helicopter by BMR	Regular grid coverage, air photography, barometric levelling.
Semi-detailed by Flamingo and Papuan Apinaipi	Helicopter traverses, conventional and barometric levelling.

COMPILED JUNE 1963

GEOPHYSICAL BRANCH, BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS F 53/B2-22-1
TO ACCOMPANY RECORD No. 1965/52
AND RECORD No. 1966/142
AND RECORD No. 1966/147
AND RECORD No. 1974/89



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: OUT

A.G.C.: OFF

Gain Initial: Various

Final:

Geophones: T.I.C. – 20c/s

Geophone pattern:

Single

Station Interval 6·1 m

Shot-hole pattern:

Single

Depth 9·1 m

Charge 4·5 kg

PLAYBACK INFORMATION

Filters: OUT

A.G.C.: OFF & S

	W/OUT AGC	WITH AGC
Gain Initial:	–40	–40
Final:	–40	–30
Trip delay:	0	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 100 200 300

0 146·5 293·0

Metres

SOUTHERN GEORGINA BASIN

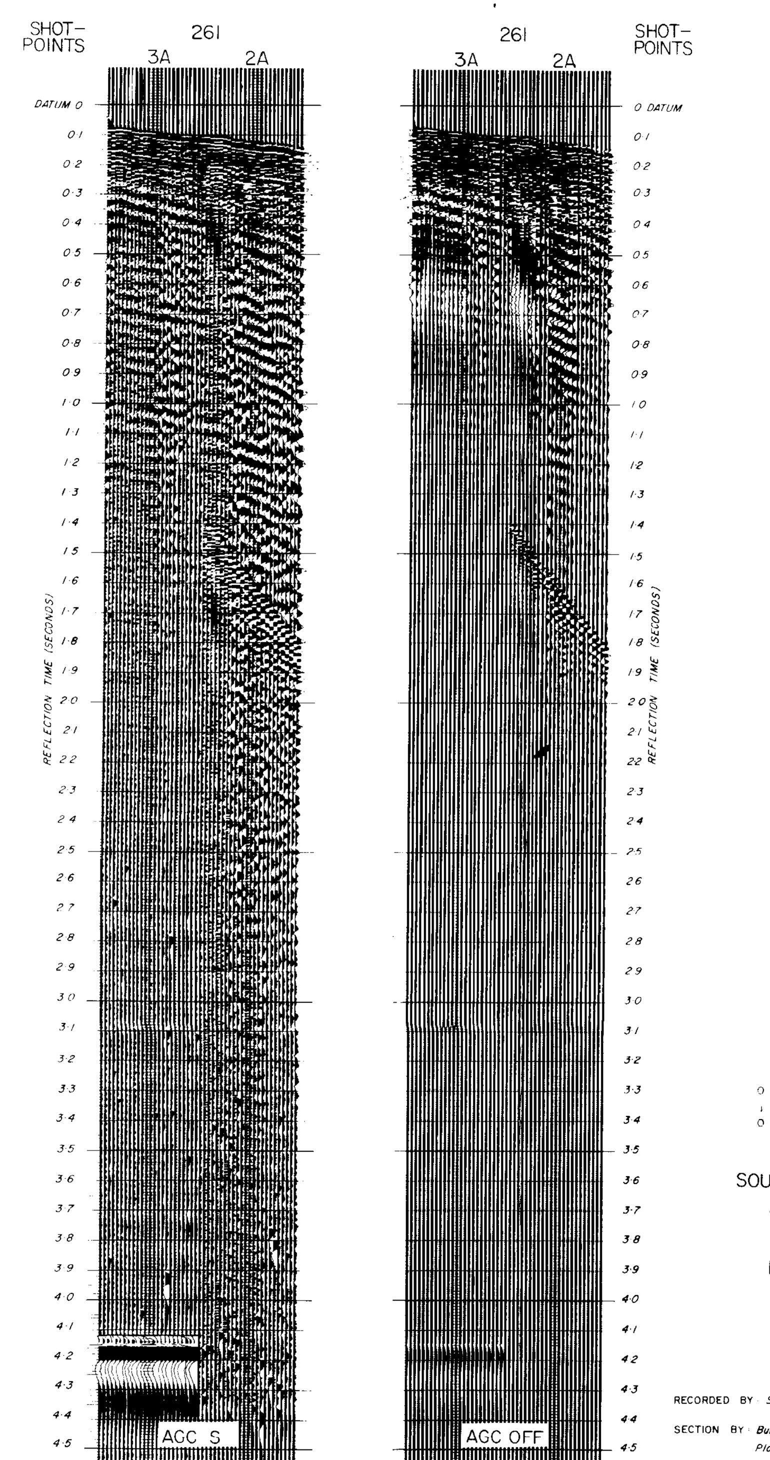
SEISMIC SURVEY, 1965

TRAVERSE A

NOISE TEST – SP228

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-114



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: Out

A.G.C.: Off

Gain Initial: Various

Final:

Geophones: T.I.C. – 20c/s

Geophone pattern:

Single

Station interval 6·1 m

Shot-hole pattern:

Single

Depth 9·1 m

Charge 4·5 kg

PLAYBACK INFORMATION

Filters: Out

A.G.C.: Off & S

	W/Out AGC	With AGC
Gain Initial:	–40	–40
Final:	–40	–30
Trip delay:	0	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 100 200 300

0 146·5 293·0

Metres

SOUTHERN GEORGINA BASIN

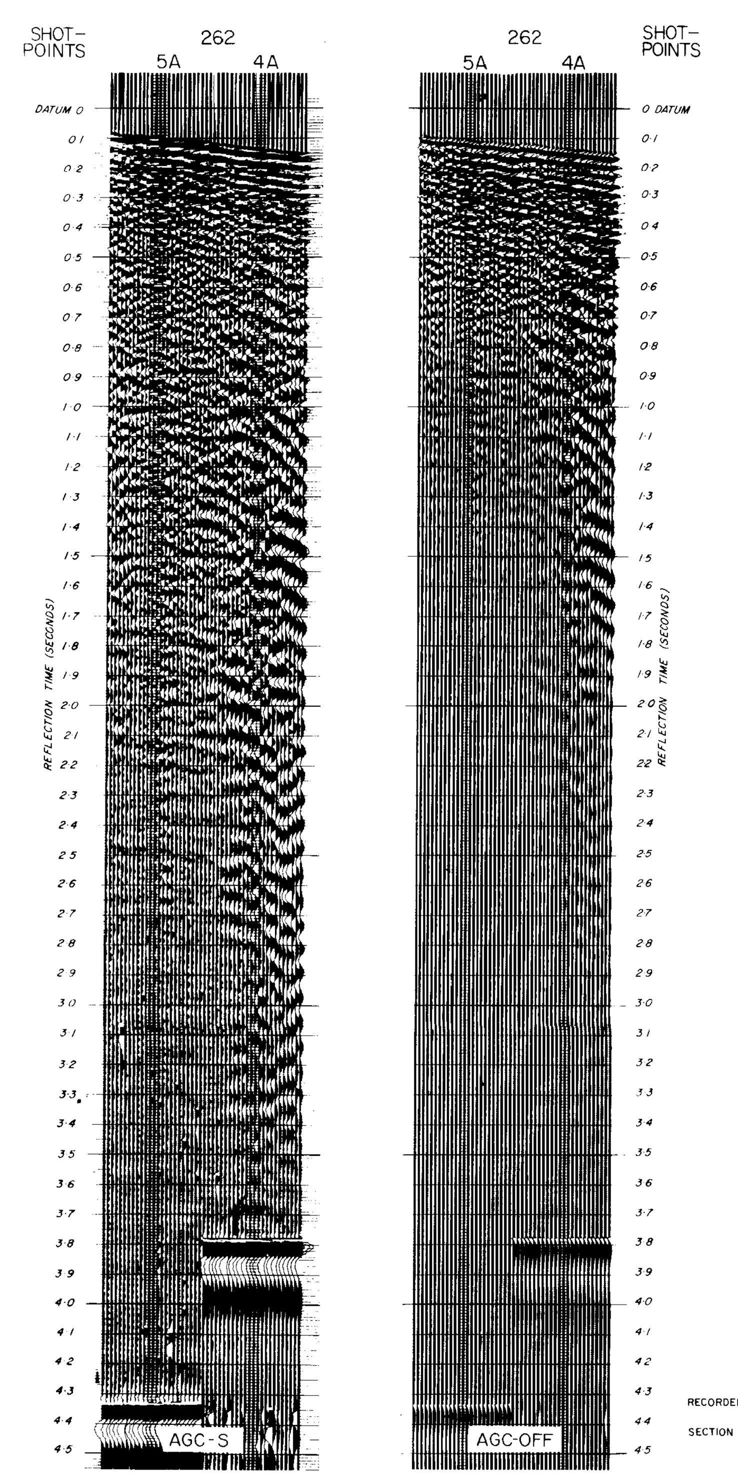
SEISMIC SURVEY, 1965

TRAVERSE A

NOISE TEST – SP 261

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-132



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: Out

A.G.C.: Off

Gain Initial: Various

Final:

Geophones: T.I.C. – 20c/s

Geophone pattern

Single

Station interval 6·1 m

Shot-hole pattern

Single

Depth 9·1 m

Charge 6·1 m

PLAYBACK INFORMATION

Filters: Out

A.G.C.: Off & S

	W/Out AGC	With AGC
Gain Initial:	–40	–40
Final:	–40	–30
Trip delay:	0	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 100 200 300

0 146·5 293·0

Metres

SOUTHERN GEORGINA BASIN

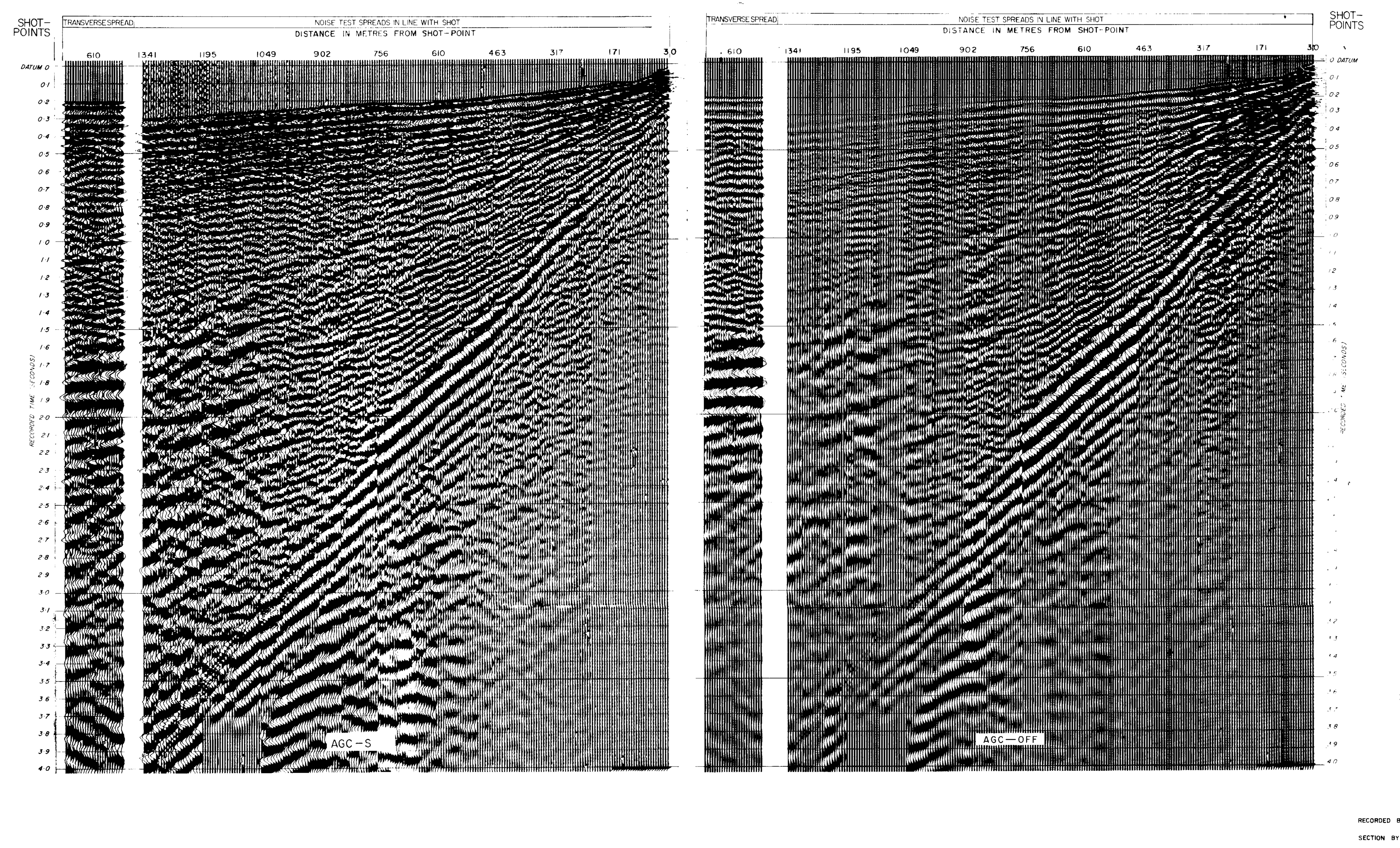
SEISMIC SURVEY, 1965

TRAVERSE A

NOISE TEST – SP 262

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-133



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: OUT

A.G.C.: OFF

Gain Initial: Various

Final:

Geophones: T.I.C. – 20c/s

Geophone pattern:

Single

Station Interval 6·1 m

Shot-hole pattern:

Single

Depth 9·1 m

Charge 4·5 kg

PLAYBACK INFORMATION

Filters: OUT

A.G.C.: OFF & S

	W/OUT AGC	WITH AGC
Gain Initial:	–40	–40
Final:	–40	–30
Trip delay:	0	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 100 200 300

0 146·5 293·0

Metres

SOUTHERN GEORGINA BASIN

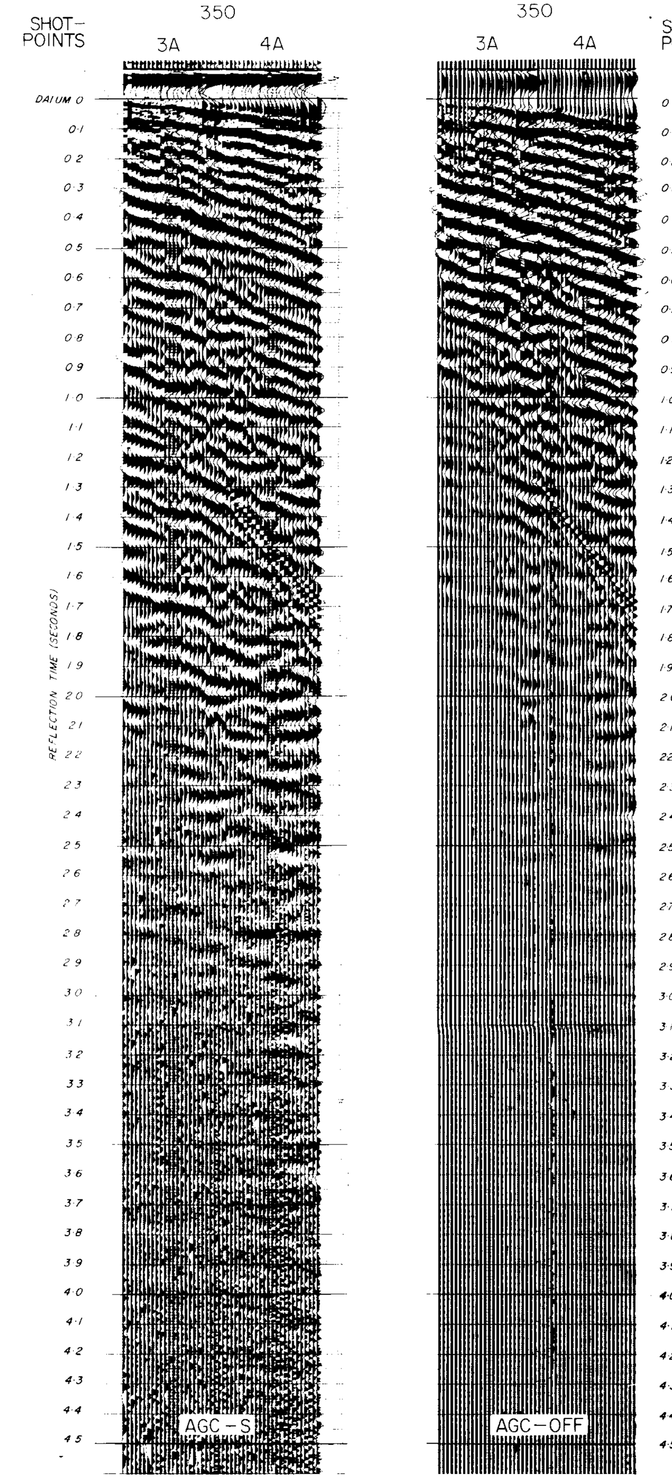
SEISMIC SURVEY, 1965

TRAVERSE A

NOISE TEST – SP270

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-115



CORRECTED RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: Out

A.G.C.: Off

Gain Initial: Various

Final:

Geophones: T.I.C. – 20c/s

Geophone pattern

Single

Station interval 6·1 m

Shot-hole pattern

Single

Depth 9·1 m

Charge 4·5 kg

PLAYBACK INFORMATION

Filters: Out

A.G.C.: Off & S

	W/out AGC	with AGC
Gain Initial:	40	40
Final:	–40	–30
Trip delay:	0	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 100 200 300

0 146·5 293·0

Metres

SOUTHERN GEORGINA BASIN

SEISMIC SURVEY, 1965

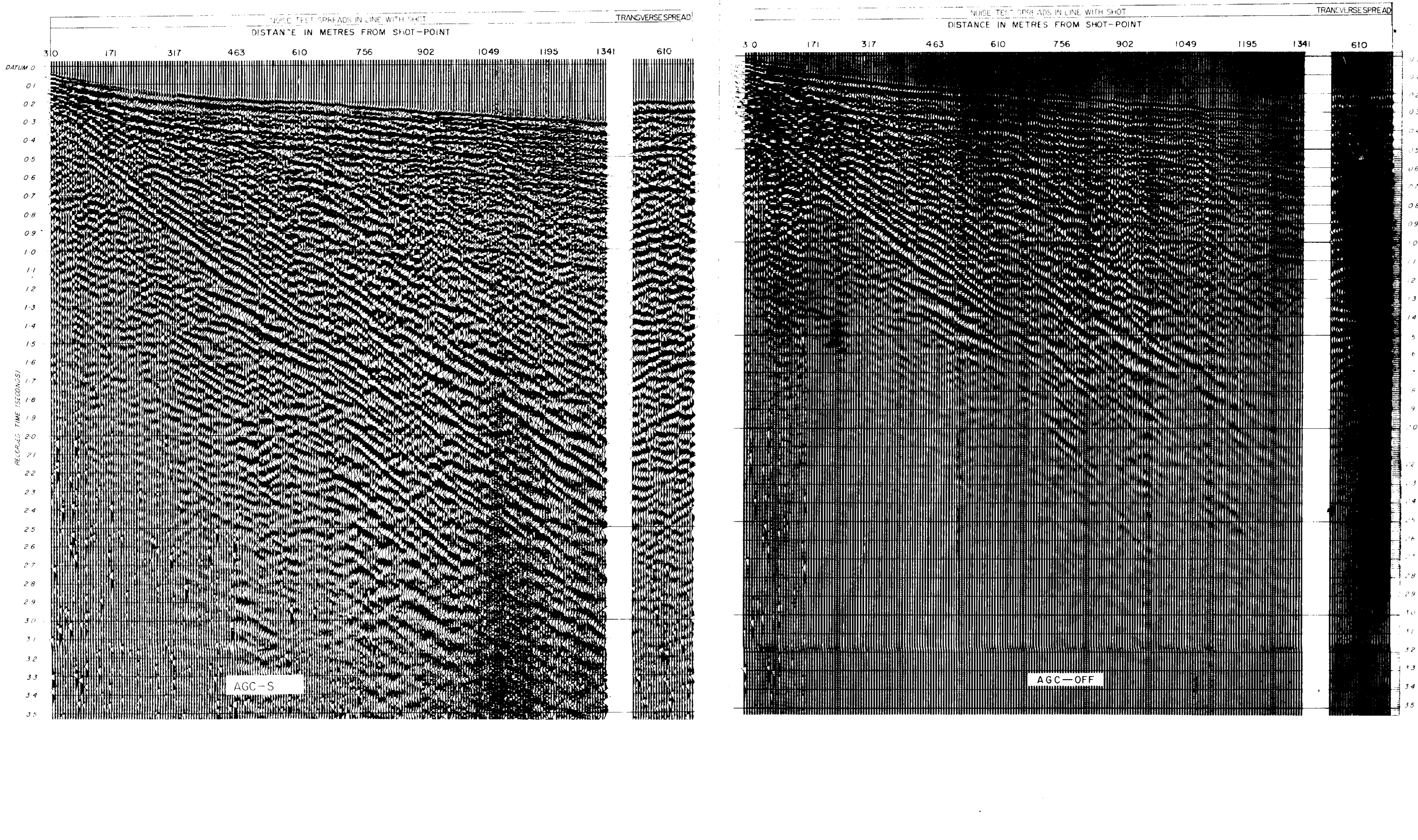
TRAVERSE A

NOISE TEST – SP 350

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42*

F53/B3-131



504789 PLATE 7

RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: OUT

A.G.C.: OFF

Gain Initial: Various

Final:

Geophones: T.I.C. – 20c/s

Geophone pattern:

Single

Station Interval 6·1 m

Shot-hole pattern:

Single

Depth 18·3 m

Charge 4·5 kg

PLAYBACK INFORMATION

Filters: OUT

A.G.C.: OFF & S

	W/OUT AGC	WITH AGC
Gain Initial:	–40	–50
Final:	–40	–30
Trip delay:	0	0

Compositing: Nil

VELOCITY INFORMATION

—

HORIZONTAL SCALE

0 100 200 300

0 146·5 293·0

Metres

SOUTHERN GEORGINA BASIN

SEISMIC SURVEY, 1965

TRAVERSE A

NOISE TEST – SP370

RECORDED BY: *Seismic Party No. 1*

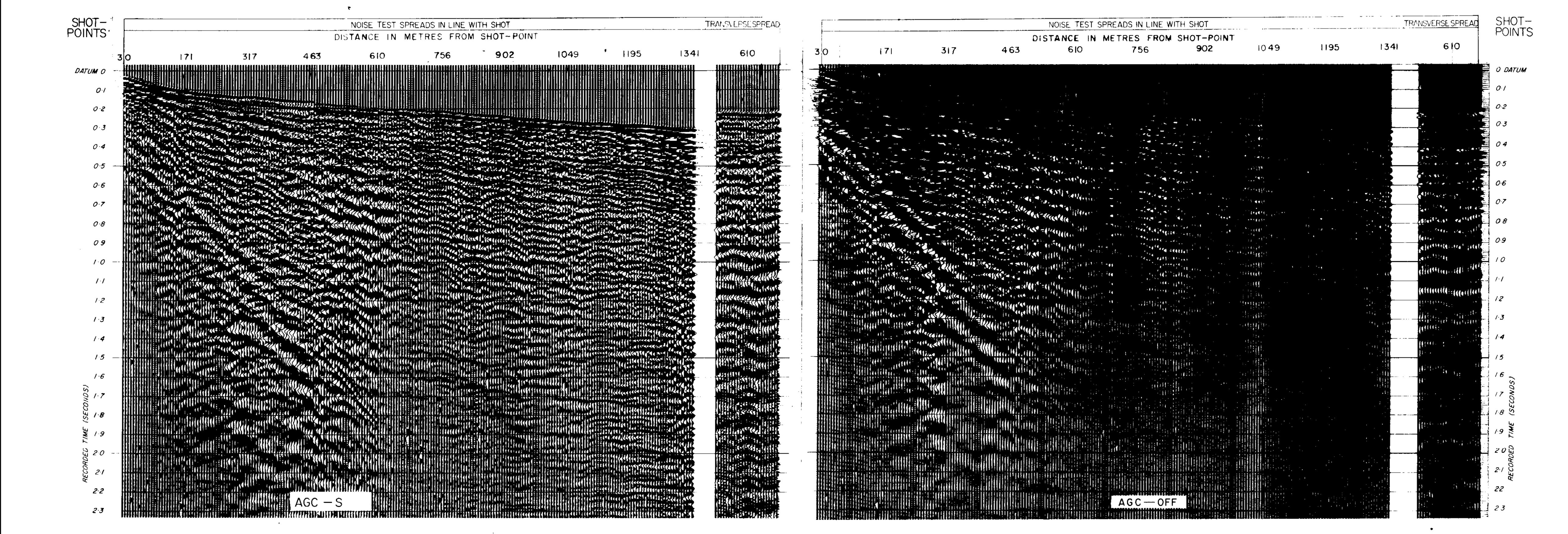
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-116

RECORD No. 1974/89

504789

STHN. GEORGINA BASIN, N.T. 1965

504789 PLATE 9



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : OUT
A.G.C. : OFF
Gain Initial : Various
Final :
Geophones : T.I.C.-20c/s
Geophone pattern :
Single
Station Interval 6·1m

Shot-hole pattern :
Single
Depth 18·3m
Charge 9·1kg

PLAYBACK INFORMATION

Filters : OUT
A.G.C. : OFF & S

	W/OUT AGC	WITH AGC
Gain Initial :	-40	-50
Final :	-40	-30
Trip delay :	0	0

Compositing : Nil

VELOCITY INFORMATION

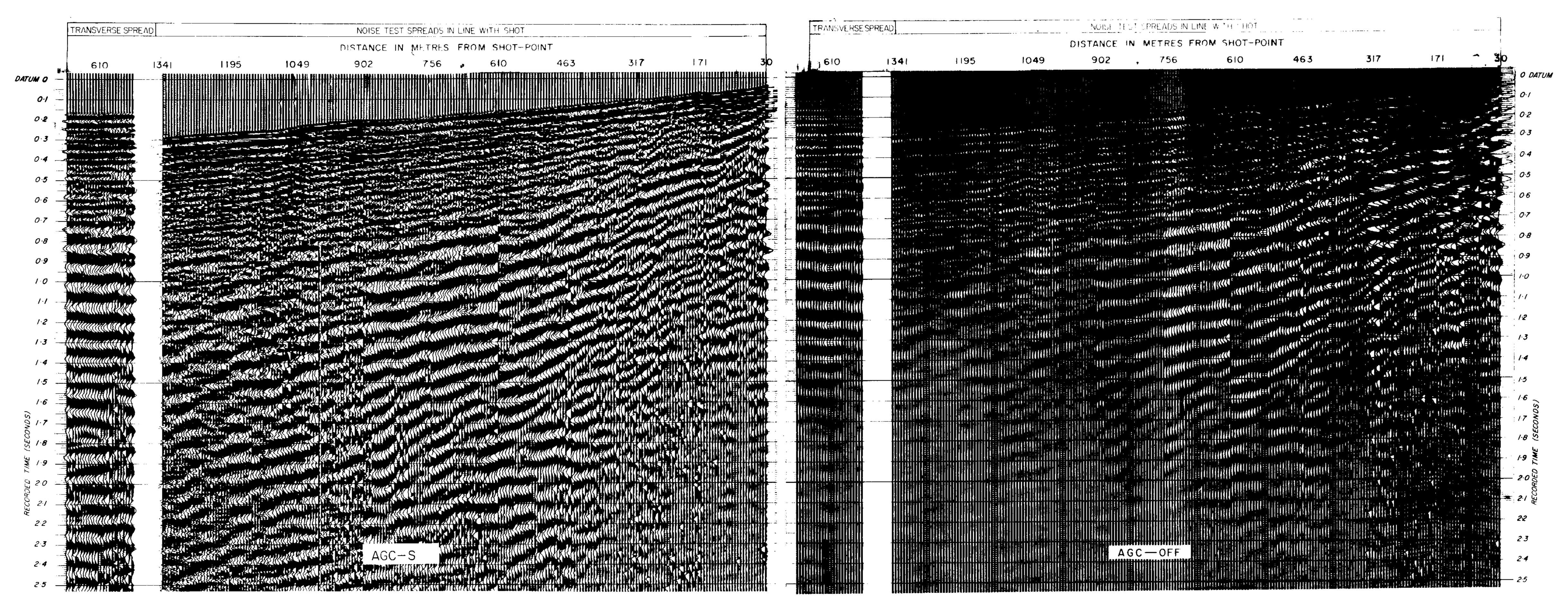
—

HORIZONTAL SCALE
0 100 200 300
0 146·5 293·0
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE B
NOISE TEST-SP1009

RECORDED BY : *Seismic Party No.1*
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-117



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : OUT
A.G.C. : OFF
Gain Initial : Various
Final :
Geophones : T.I.C.-20c/s
Geophone pattern :
Single
Station Interval 6·1m

Shot-hole pattern :
Single
Depth 15·2m
Charge 13·6kg

PLAYBACK INFORMATION

Filters : OUT
A.G.C. : OFF & S

	W/OUT AGC	WITH AGC
Gain Initial :	-40	-50
Final :	-40	-30
Trip delay :	0	0

Compositing : Nil

VELOCITY INFORMATION

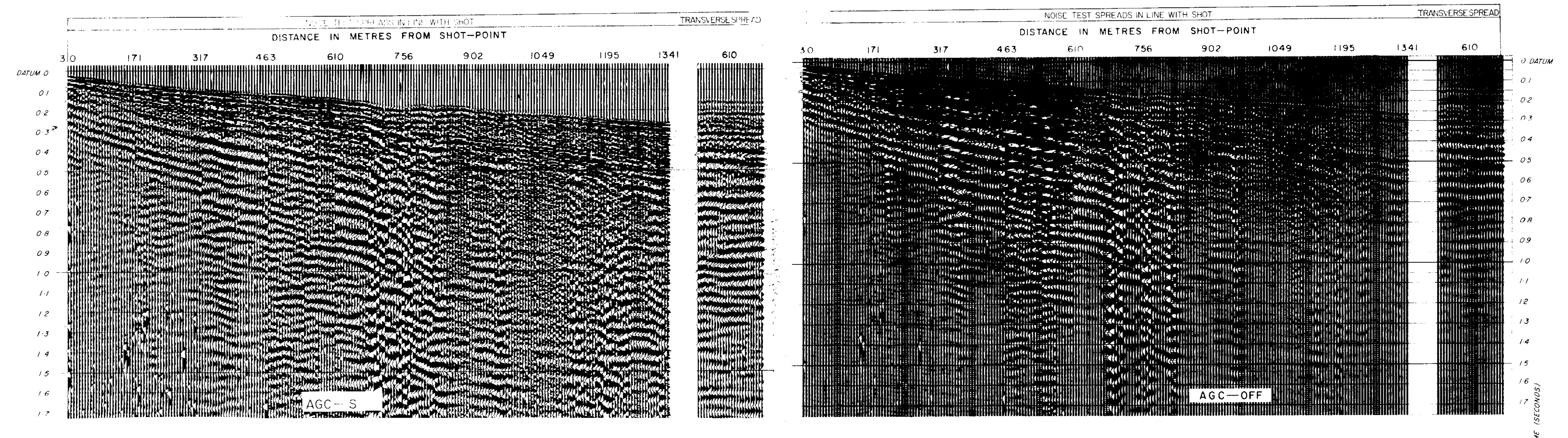
—

HORIZONTAL SCALE
0 100 200 300
0 146·5 293·0
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE C
NOISE TEST-SP2368

RECORDED BY : *Seismic Party No.1*
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-118



RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : OUT
A.G.C. : OFF
Gain Initial : Various
Final :
Geophones : T.I.C.-20c/s
Geophone pattern :
Single
Station Interval 6·1m

Shot-hole pattern :
Single
Depth 9·1m
Charge 9·1kg

PLAYBACK INFORMATION

Filters : OUT
A.G.C. : OFF & S

	W/OUT AGC	WITH AGC
Gain Initial :	-40	-50
Final :	-40	-30
Trip delay :	0	0

Compositing : Nil

VELOCITY INFORMATION

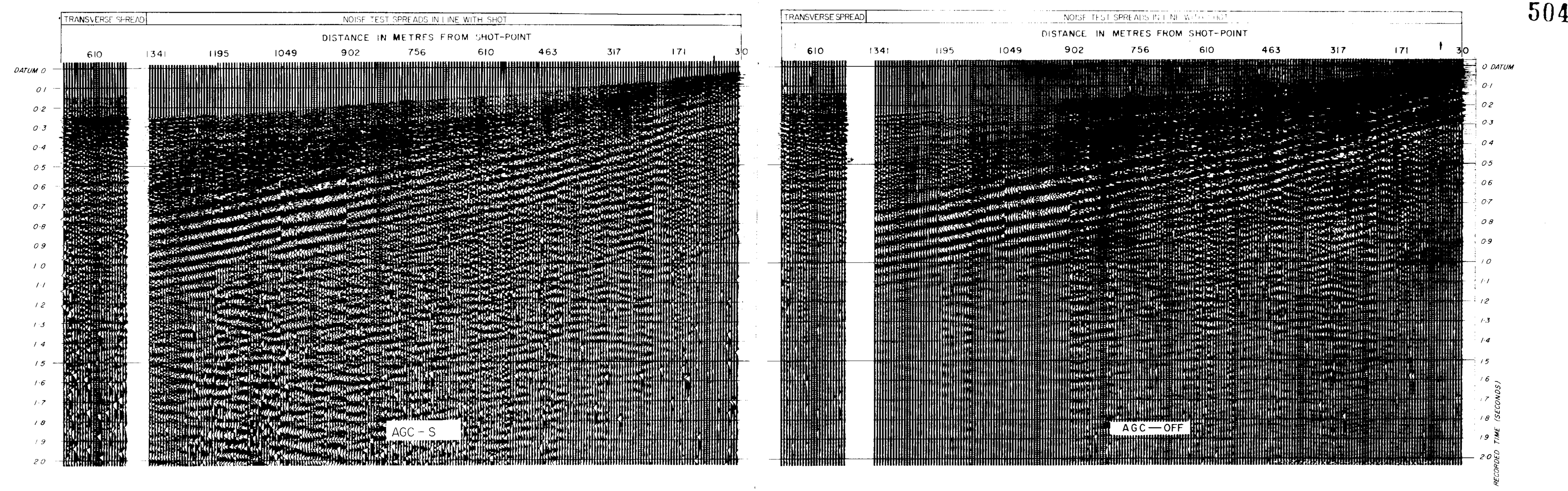
—

HORIZONTAL SCALE
0 100 200 300
0 146·5 293·0
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE D
NOISE-TEST-SP3810

RECORDED BY : *Seismic Party No.1*
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-119



NOISE TESTS
TRAVERSES B, C, D AND E

RECORD SECTION

RECORDING INFORMATION

Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : OUT
A.G.C. : OFF
Gain Initial : Various
Final :
Geophones : T.I.C.-20c/s
Geophone pattern :
Single
Station Interval 6·1m

Shot-hole pattern :
Single
Depth 7·6m
Charge 2·3kg

PLAYBACK INFORMATION

Filters : OUT
A.G.C. : OFF & S

	W/OUT AGC	WITH AGC
Gain Initial :	-40	-50
Final :	-40	-30
Trip delay :	0	0

Compositing : Nil

VELOCITY INFORMATION

—

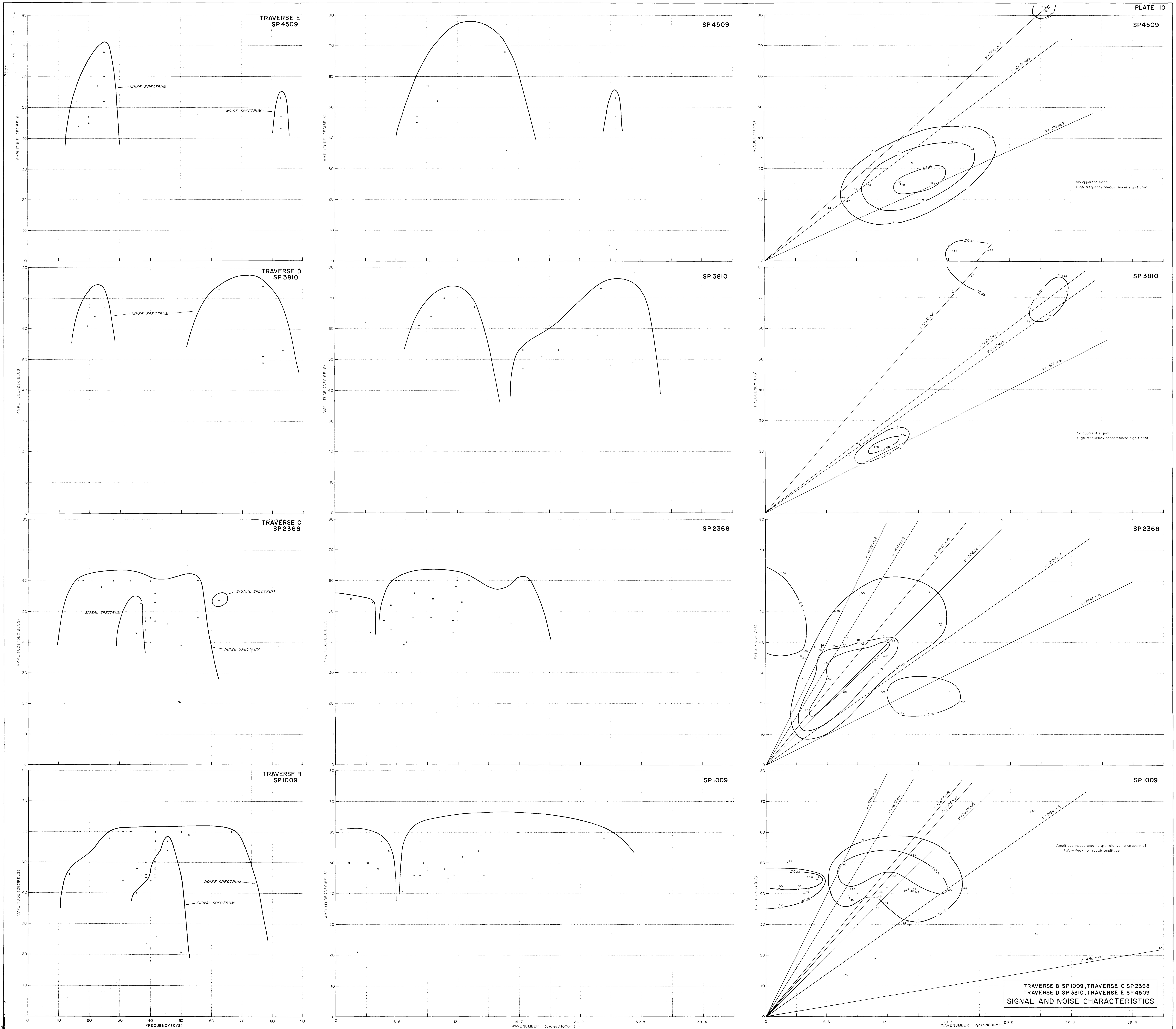
HORIZONTAL SCALE
0 100 200 300
0 146·5 293·0
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE E
NOISE TEST-SP4509

RECORDED BY : *Seismic Party No.1*
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-120
RECORD No. 1974/89

504789

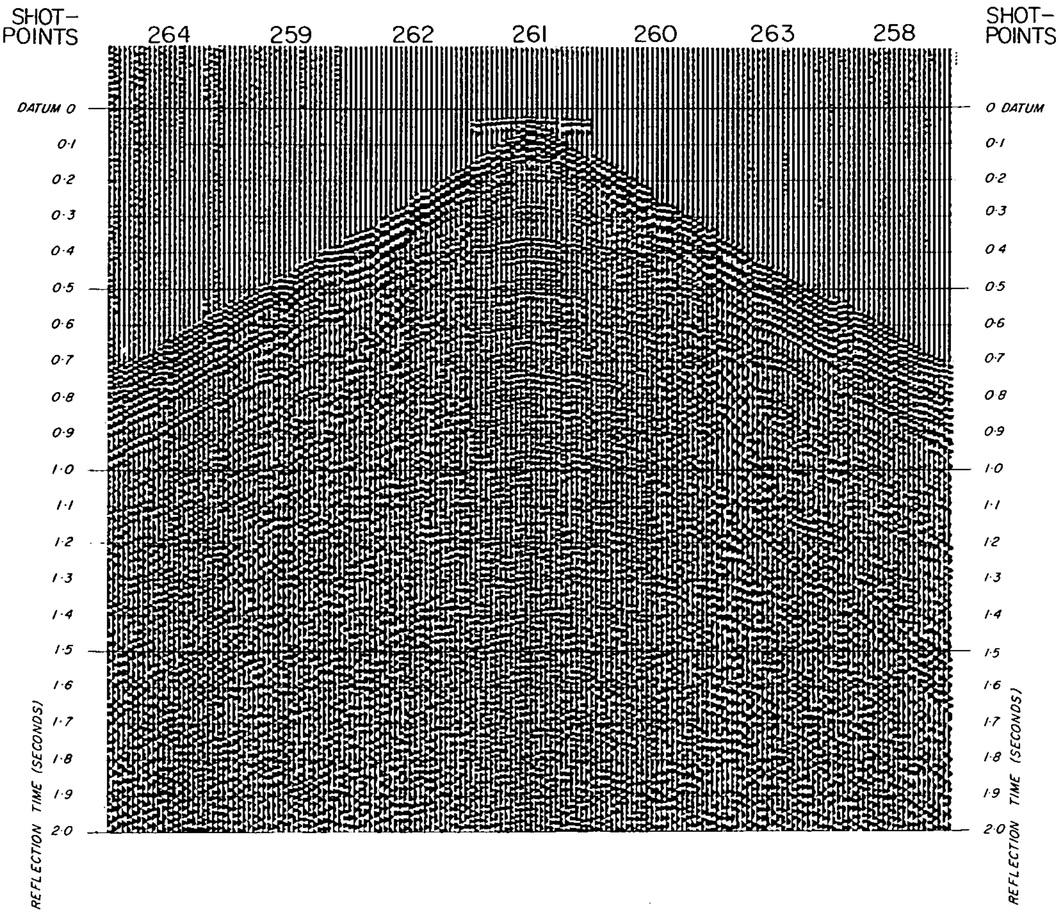


TRAVERSE B SP1009, TRAVERSE C SP2368
TRAVERSE D SP3810, TRAVERSE E SP4509
SIGNAL AND NOISE CHARACTERISTICS

504789

PLATE 11

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 8000 Explorer

Filters : K18-K160

A.G.C. : 1/1 125

Gain Initial : -67

Final : Max

Geophones : EVS 2B-20c/s

Geophone pattern :

24/trace (2 rows of 12)

Geophones 4·3m apart

Rows 9·1m apart

Station interval 45·7 m

Shot-hole pattern :

5 holes in line

Holes 11·6 m

Depth 12·2 m – 14·6m

Charge 5 x 9·1kg

PLAYBACK INFORMATION

Filters : 2/31-2/100

A.G.C. : S

Gain Initial : -50

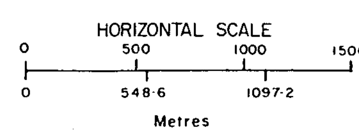
Final : -30

Trip delay : 0-0·7sec

Compositing : Nil

VELOCITY INFORMATION

—



SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE A

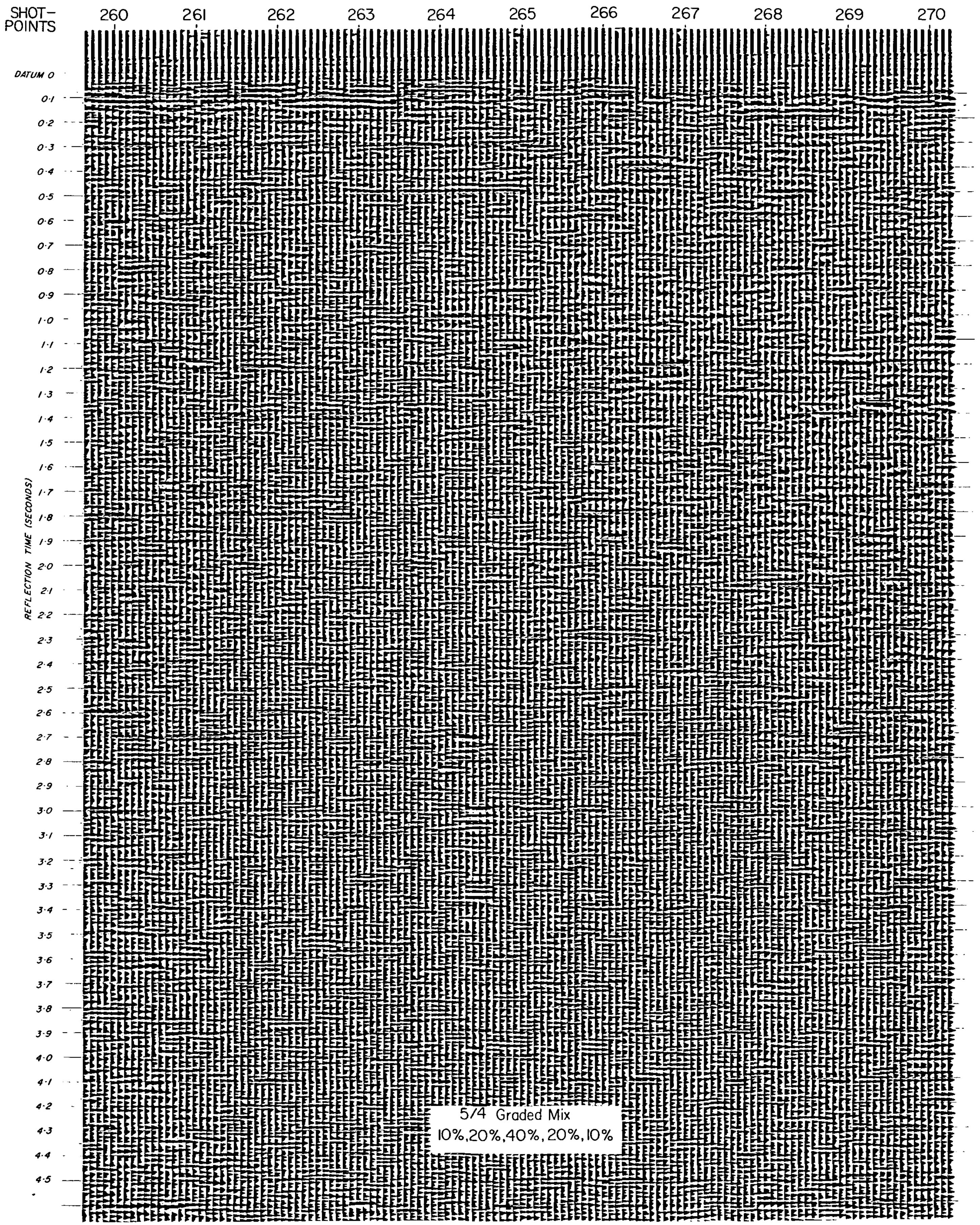
EXPANDED SPREAD

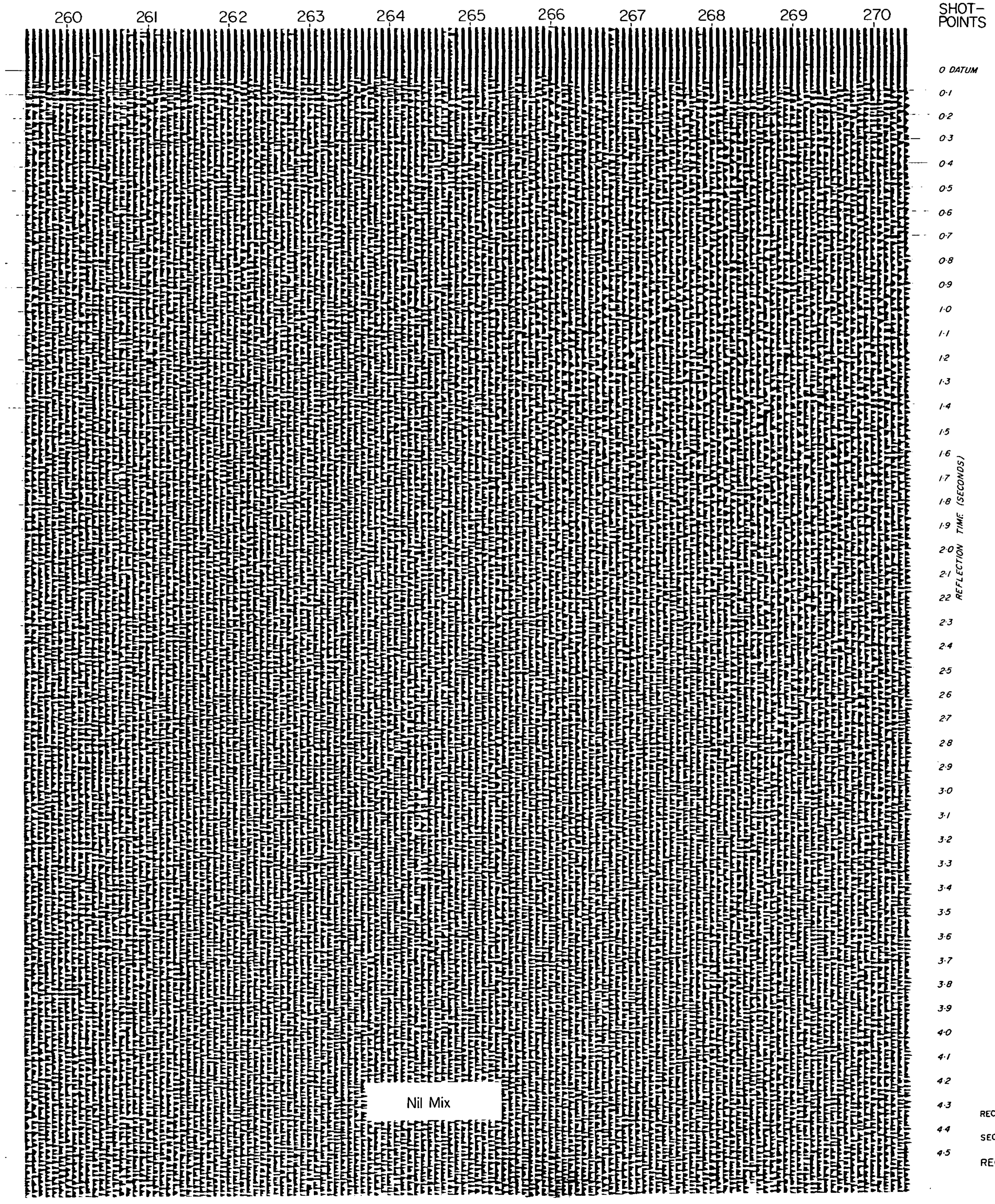
RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F53/B3-136A

RECORD No. 1974/89

504789 PLATE 12





CORRECTED RECORD SECTION

(3 FOLD CDP-NEAREST 12 TRACES TO SP)

RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 8000 Explorer

Filters : K33-K125

A.G.C. : 1/1 80

Gain Initial : -67 to -60

Final : Max

Geophones : EVS 2B-20c/s

Geophone pattern :

24/trace

Geophones 2·4 m apart

Station Interval 91·4 m

Shot-hole pattern :

5 holes

Holes 9·1m

Depth 6·1m-13·7m

Charge 5 x 9·1 kg

PLAYBACK INFORMATION

Filters : 1/31-1/100

A.G.C. : SS

Gain Initial : -60

Final : -20

Trip delay : 0

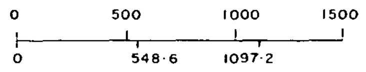
Compositing :

As indicated

VELOCITY INFORMATION

BMR 12 Sonic Log

HORIZONTAL SCALE



SOUTHERN GEORGINA BASIN

SEISMIC SURVEY, 1965

TRAVERSE A

CDP COVERAGE

SP 258 2/3 - SP 270

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42*

F53/B3-137

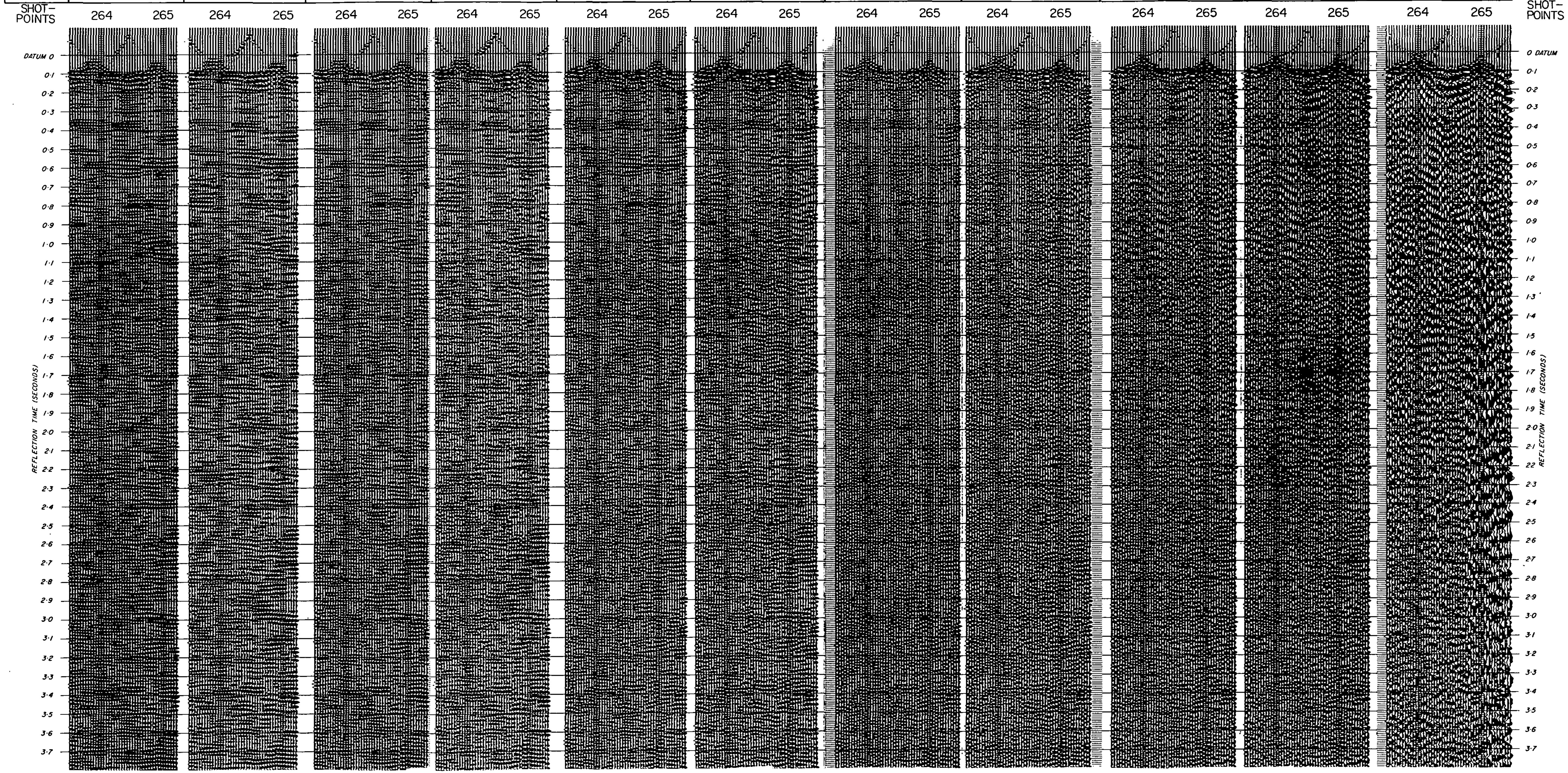
RECORD No. 1974/89

504789

PLATE 13

CORRECTED RECORD SECTION

FILTERS	$\frac{2}{39}-\frac{2}{100}$	$\frac{2}{31}-\frac{2}{100}$	$\frac{2}{39}-\frac{2}{100}$	$\frac{2}{31}-\frac{2}{100}$	$\frac{2}{39}-\frac{2}{100}$	$\frac{2}{31}-\frac{2}{100}$	$\frac{2}{39}-\frac{2}{100}$	$\frac{2}{31}-\frac{2}{100}$	$\frac{1}{39}-\frac{1}{100}$	$\frac{1}{31}-\frac{1}{100}$	Wide band
MIXING	7/6 Graded	7/6 Graded	5/4 Graded	5/4 Graded	2/1 Two channel	2/1 Two channel	Nil	Nil	Nil	Nil	Nil
FILTER SLOPE	24 db / octave	24 db / octave	24 db / octave	24 db / octave	24 db / octave	24 db / octave	24 db / octave	24 db / octave	12 db / octave	12 db / octave	—
REMARKS	Filter response peaked near frequency for max $\frac{S}{N}$ ratio (39 c/s)	Filter response peaked on frequency for max signal amplitude (31 c/s)	Filter response peaked near frequency for max $\frac{S}{N}$ ratio (39 c/s)	Filter response peaked on frequency for max signal amplitude (31 c/s)	Filter response peaked near frequency for max $\frac{S}{N}$ ratio (39 c/s)	Filter response peaked on frequency for max signal amplitude (31 c/s)	Filter response peaked near frequency for max $\frac{S}{N}$ ratio (39 c/s)	Filter response peaked on frequency for max signal amplitude (31 c/s)	Filter response peaked near frequency for max $\frac{S}{N}$ ratio (39 c/s)	Filter response peaked on frequency for max signal amplitude (31 c/s)	—



RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 8000 Explorer

Filters : K18 - K160

A.G.C. : 1/1 125

Gain Initial : -63

Final : Max

Geophones : EVS 2B - 20 c/s

Geophone pattern :
24 trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1 m apart
Station interval 45·7 m

Shot-hole pattern :
20 holes (2 rows of 10)
Holes 5·2 m apart
Depth 9·1 m - 10·7 m
Charge 20 x 2·3 kg

PLAYBACK INFORMATION

Filters : As indicated

A.G.C. : S

Gain Initial : -50

Final : -20

Trip delay : 0

Compositing :
As indicated

VELOCITY INFORMATION

BMR 12 Sonic log

HORIZONTAL SCALE

0 500 1000 1500

0 548·6 1097·2

Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE A

EFFECTS OF VARIOUS FILTERS AND MIXING ARRANGEMENTS ON THE SIGNAL TO NOISE RATIOS

RECORDED BY : *Seismic Party No. 1*

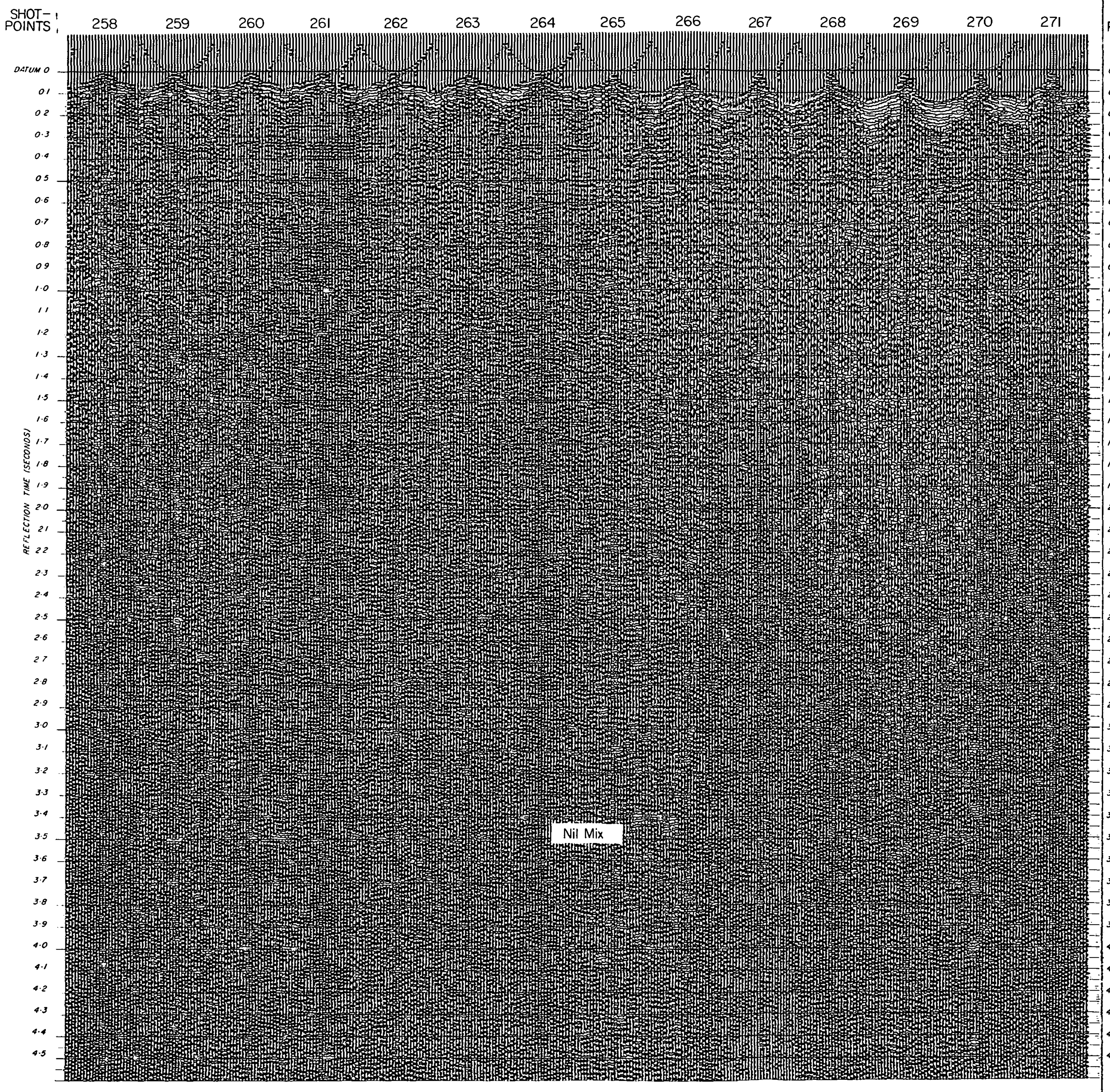
SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-129

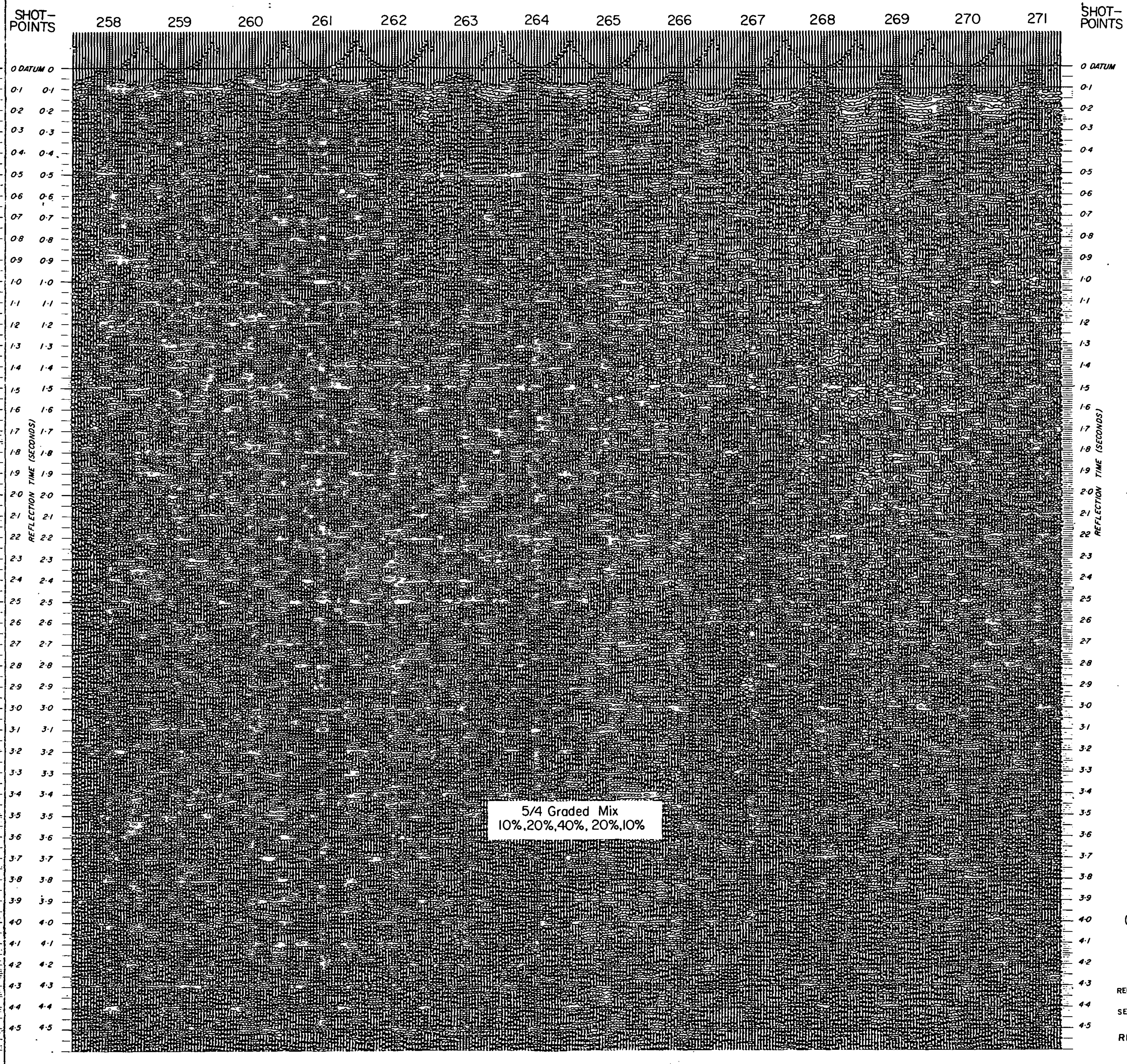
RECORD No. 1974/89

504789

PLATE 14

CORRECTED RECORD SECTION





RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 8000 Explorer

Filters : K18-K160

A.G.C. : 1/1 125

Gain Initial : -57 to -67

Final : Max

Geophones : EVS 2B-20 c/s

Geophone pattern :

24/Trace (2 rows of 12)
Geophones 4·3m apart
Rows 9·1m apart
Station interval 45·7m

Shot-hole pattern :

20 holes (2 rows of 10)
Holes 5·2m apart
Rows 45·7m apart
Depth 6·1m – 9·1m
Charge 20 x 2·3 kg

PLAYBACK INFORMATION

Filters : 2/31 – 2/100

A.G.C. : S

Gain Initial : -50

Final : -20

Trip delay : 0

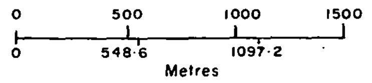
Compositing : 5/4 graded mix

10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION

BMR 12 Sonic log

HORIZONTAL SCALE



SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE A

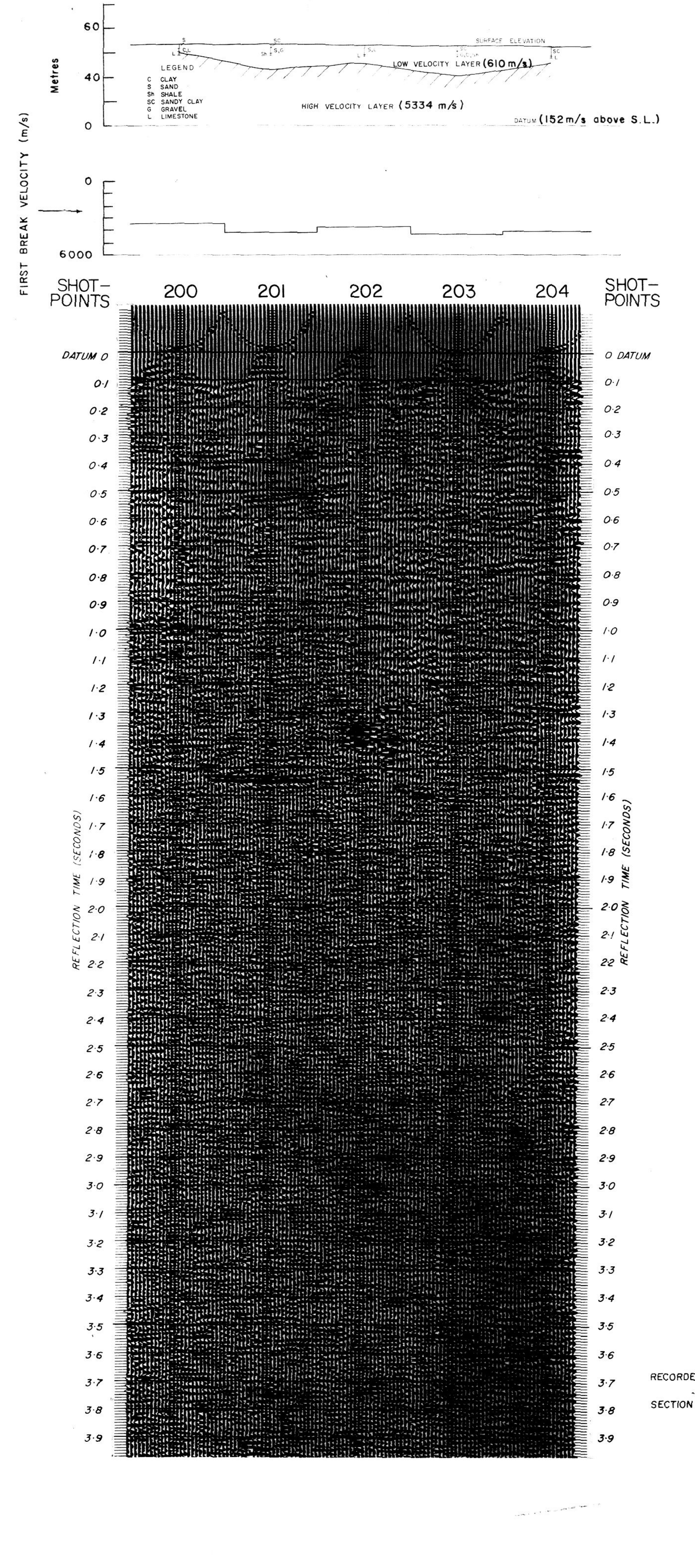
SP258-SP271

(COMPARISON OF MIXED AND UNMIXED SECTION)

RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-134

RECORD No. 1974/89



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : K22–K125
A.G.C. : 1/1 125
Gain Initial : –57 to –63
Final : Max
Geophones : EVS 2B–20c/s
Geophone pattern :
24/trace (4 rows of 6)
Geophones 6·7m apart
Rows 9·1m apart
Station interval 45·7m
Shot-hole pattern :
20 holes (4 rows of 5)
Holes 12·2 m apart
Rows 12·2 m apart
Depth 9·1 m
Charge 20 x 2·3 kg

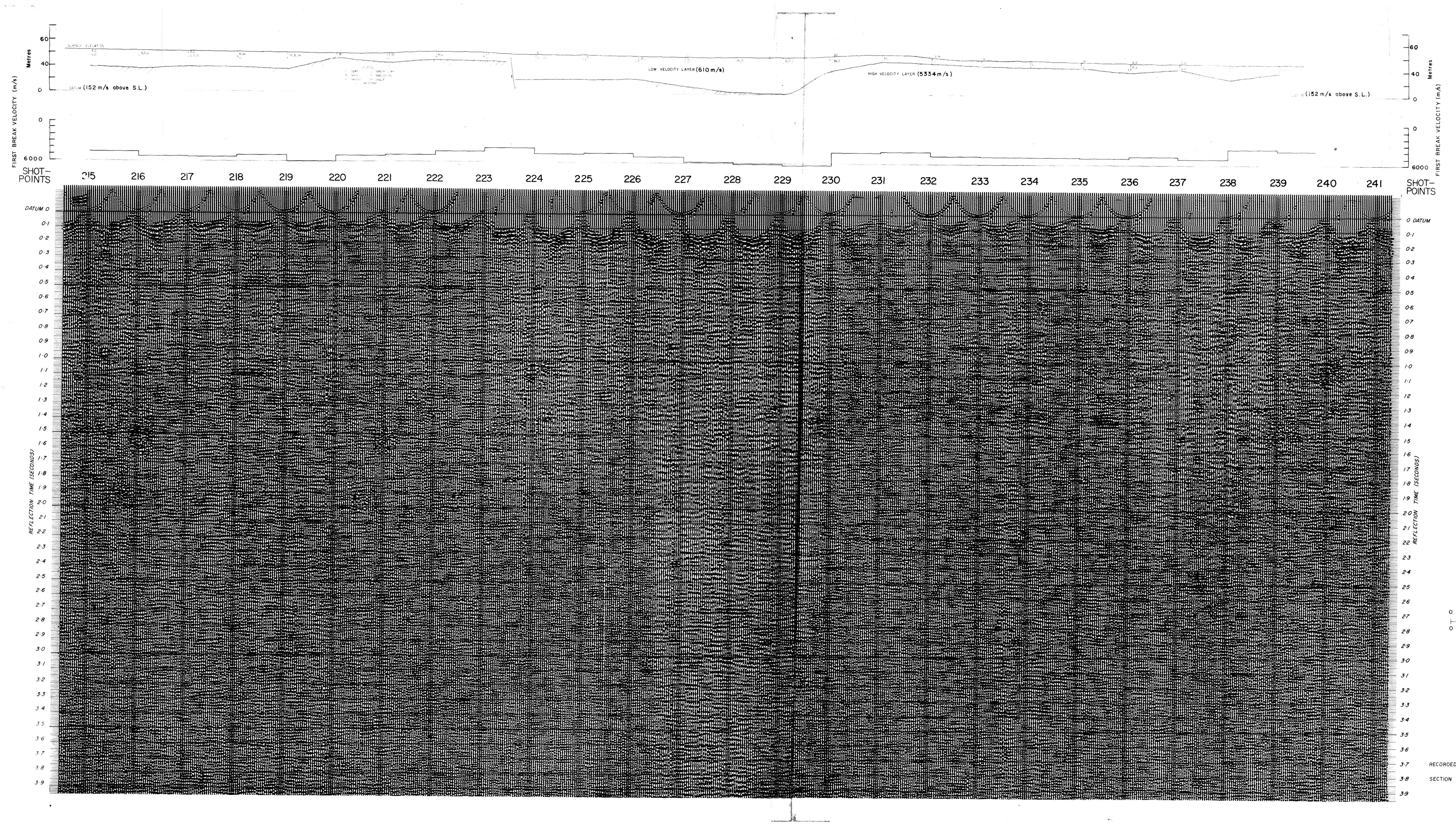
PLAYBACK INFORMATION
Filters : 2/31–2/100
A.G.C. : S
Gain Initial : –50
Final : –20
Trip delay : 0
Compositing : 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION
B.M.R. 12 Sonic Log

HORIZONTAL SCALE
0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE A
SP 200–SP 204

RECORDED BY : *Seismic Party No. 1*
SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42
F53/B3-124-1



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : K18–K160
A.G.C. : 1/1 125
Gain Initial : –57 to –67
Final : Max
Geophones : EVS 2B–20 c/s
Geophone pattern :
24/trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1m apart
Station interval 45·7m
Shot-hole pattern :
20 holes (2 rows of 10)
Holes 5·2m apart
Rows 45·7m apart
Depth 6·1m–9·1m
Charge 20 x 2·3 kg

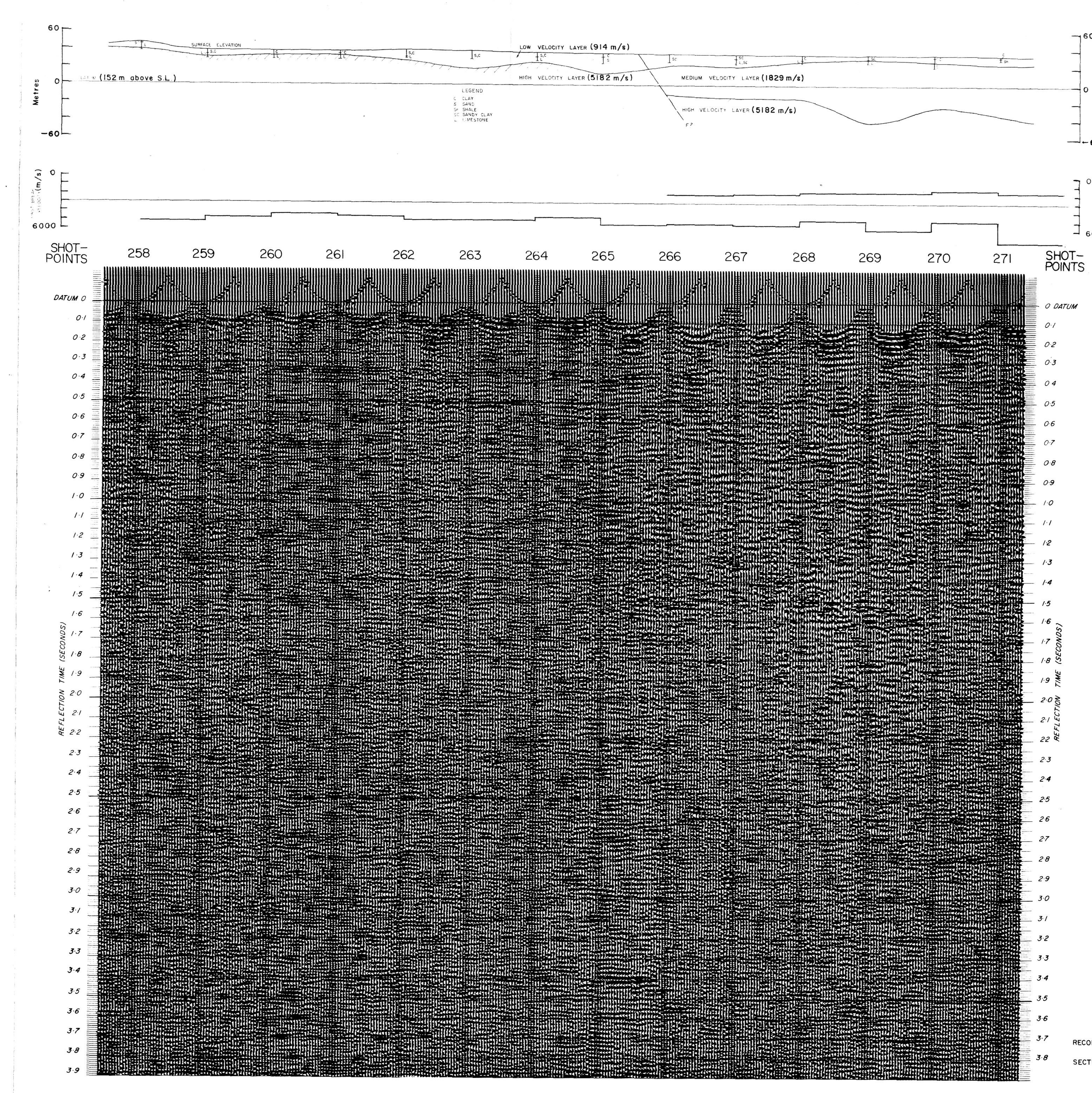
PLAYBACK INFORMATION
Filters : 2/31–2/100
A.G.C. : S
Gain Initial : –50
Final : –20
Trip delay : 0
Compositing : 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION
B.M.R. 12 Sonic Log

HORIZONTAL SCALE
0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE A
SP 215 – SP 241

RECORDED BY : *Seismic Party No. 1*
SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F53/B3-124-2



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : K18–K160
A.G.C. : 1/1 125
Gain Initial : –63
Final : Max
Geophones : EVS 2B–20 c/s
Geophone pattern :
24/trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1m apart
Station interval 45·7m
Shot-hole pattern :
20 holes (2 rows of 10)
Holes 5·2 m apart
Rows 45·7m apart
Depth 9·1 m
Charge 20 x 2·3 kg

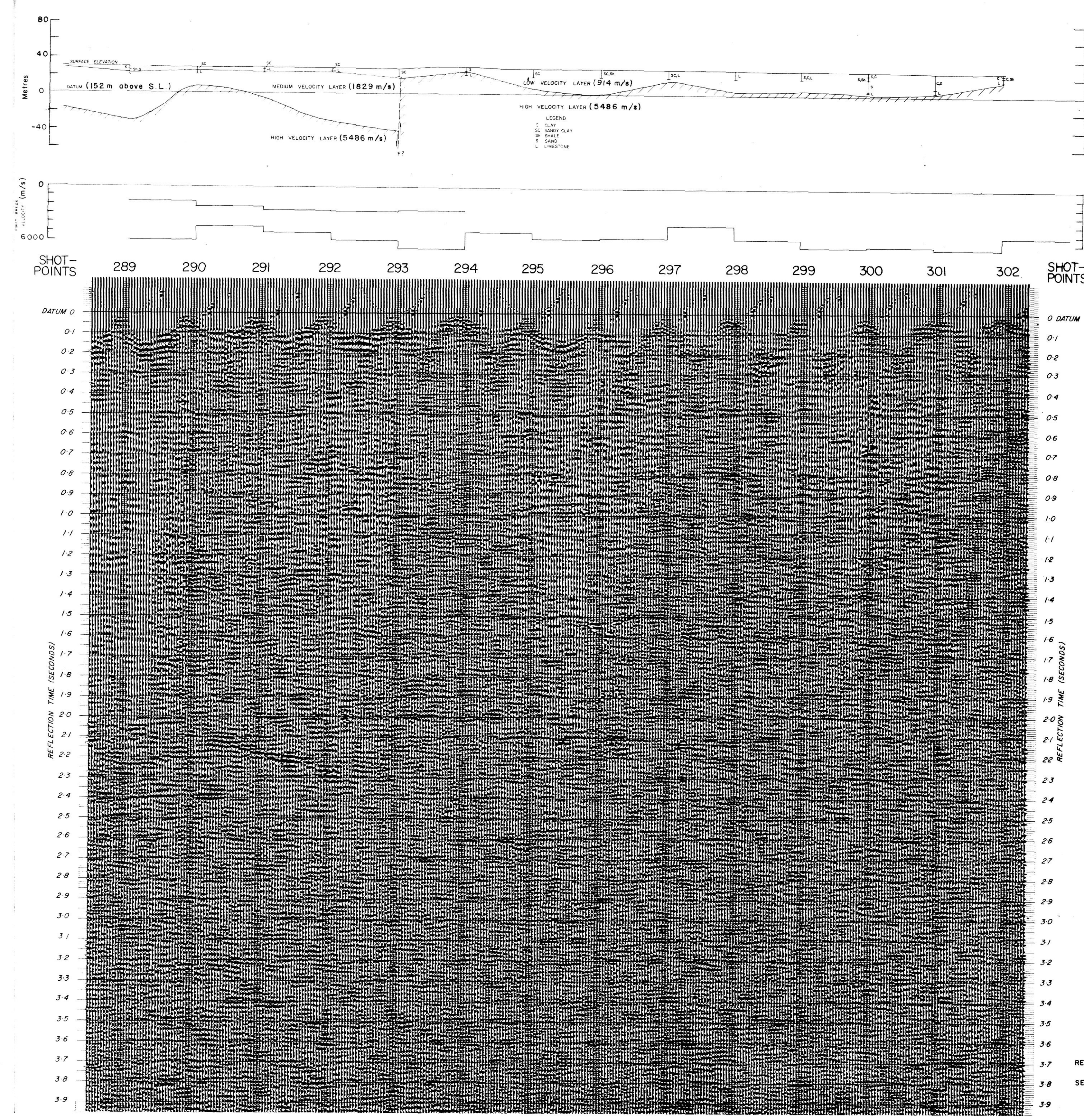
PLAYBACK INFORMATION
Filters : 2/31–2/100
A.G.C. : S
Gain Initial : –50
Final : –20
Trip delay : 0
Compositing : 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION
B.M.R. 12 Sonic Log

HORIZONTAL SCALE
0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE A
SP 258 – SP 271

RECORDED BY : *Seismic Party No. 1*
SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F53/B3-124-3



CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : K18–K160
A.G.C. : 1/1 125
Gain Initial : –60 to –63
Final : Max
Geophones : EVS 2B–20 c/s
Geophone pattern :
24/Trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1m apart
Station interval 45·7 m
Shot-hole pattern :
20 holes (2 rows of 10)
Holes 5·2 m apart
Rows 45·7m apart
Depth 9·1 m
Charge 20 x 2·3 kg

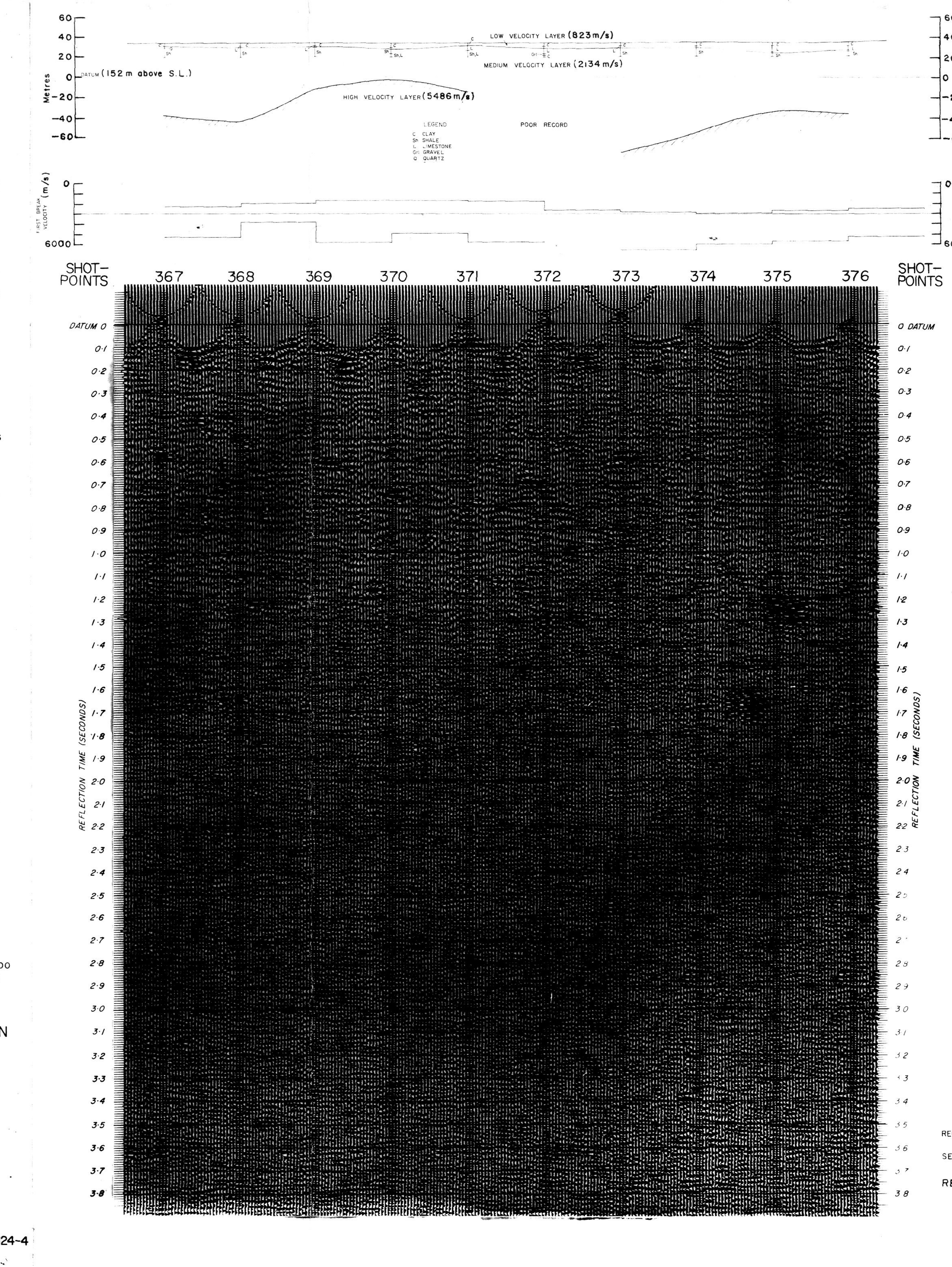
PLAYBACK INFORMATION
Filters : 2/31 –2/100
A.G.C. : S
Gain Initial : –50
Final : –20
Trip delay : 0
Compositing : 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION
BMR 12 Sonic log

HORIZONTAL SCALE
0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE A
SP 289 – SP 302

RECORDED BY : *Seismic Party No. 1*
SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42 F53/B3-124-4



504790

PLATE 15

CORRECTED
RECORD SECTION

RECORDING INFORMATION
Magnetic Recorder : DS7-7
Amplifiers : 8000 Explorer
Filters : K18–K160
A.G.C. : 1/1 125
Gain Initial : –67
Final : Max
Geophones : EVS 2B–20 c/s
Geophone pattern :
24/trace (2 rows of 12)
Geophones 4·3m apart
Rows 9·1m apart
Station interval 45·7m
Shot-hole pattern :
5 holes in line
Holes 9·1m apart
Depth 13·7m
Charge 5 x 9·1 kg

PLAYBACK INFORMATION
Filters : 2/31–2/100
A.G.C. : S
Gain Initial : –50
Final : –20
Trip delay : –0
Compositing : 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION
B.M.R. 12 Sonic Log

HORIZONTAL SCALE
0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE A

SP 367 – SP 376

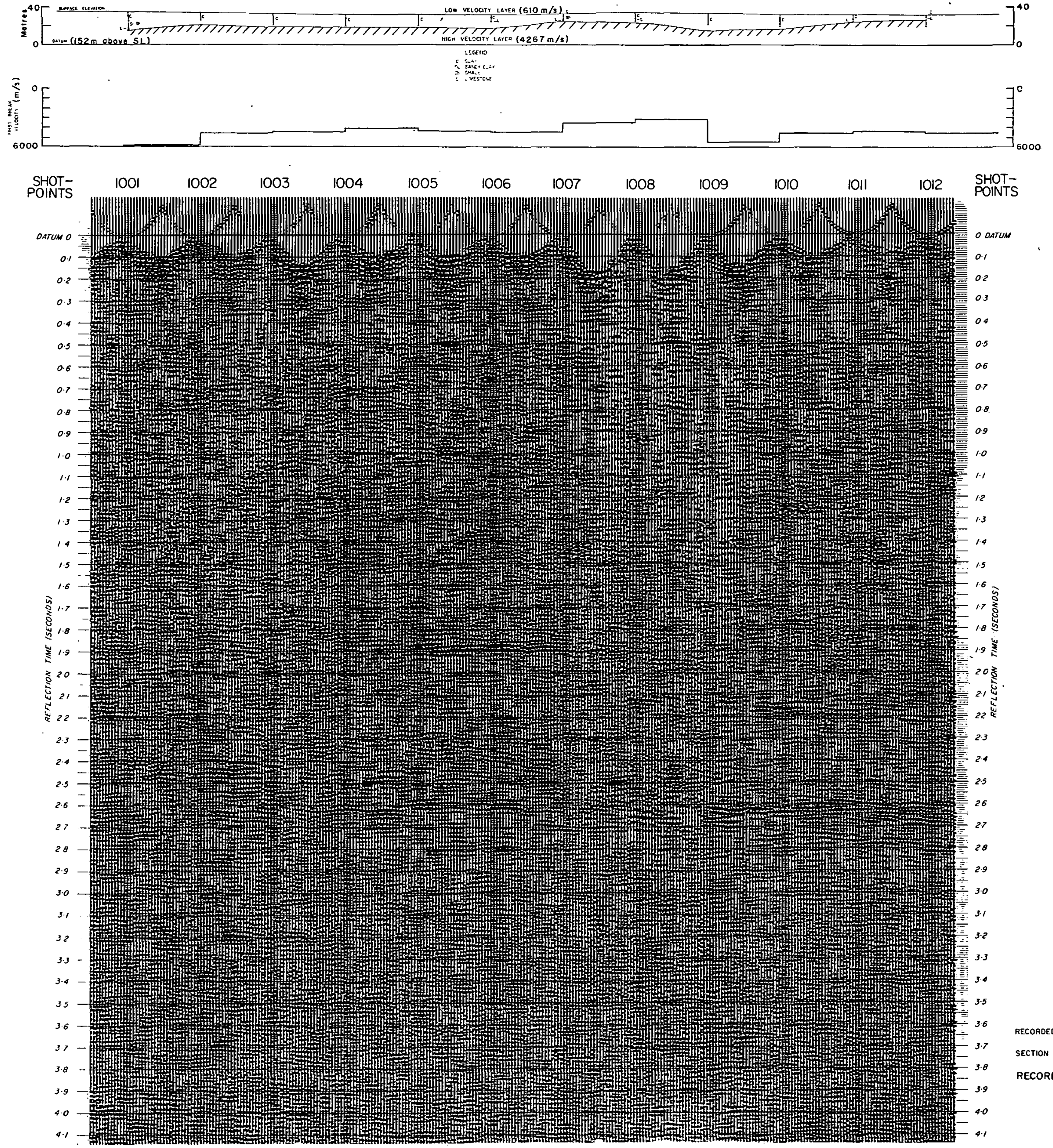
REFLECTION CROSS–SECTIONS SP200–376

RECORDED BY : *Seismic Party No. 1*
SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42
RECORD No. 1974/89
F53/B3-124-5

504789

PLATE 16

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: K18-K160

A.G.C.: 1/1 125

Gain Initial: -67

Final: Max

Geophones: EVS 2B-20 c/s

Geophone pattern:

24/Trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1 m apart
Station interval 45·7 kg

Shot-hole pattern:

5 holes in line
Holes 11·6 m apart
Depth 6·1-18·3 m
Charge 5 x 9·1 kg

PLAYBACK INFORMATION

Filters: 2/39-2/100

A.G.C.: S

Gain Initial: -50

Final: -20

Trip delay: 0

Compositing: 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION

B.M.R. 12 Sonic Log

HORIZONTAL SCALE

0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE B
SP 1001-SP 1012

REFLECTION CROSS-SECTION

RECORDED BY: *Seismic Party No. 1*

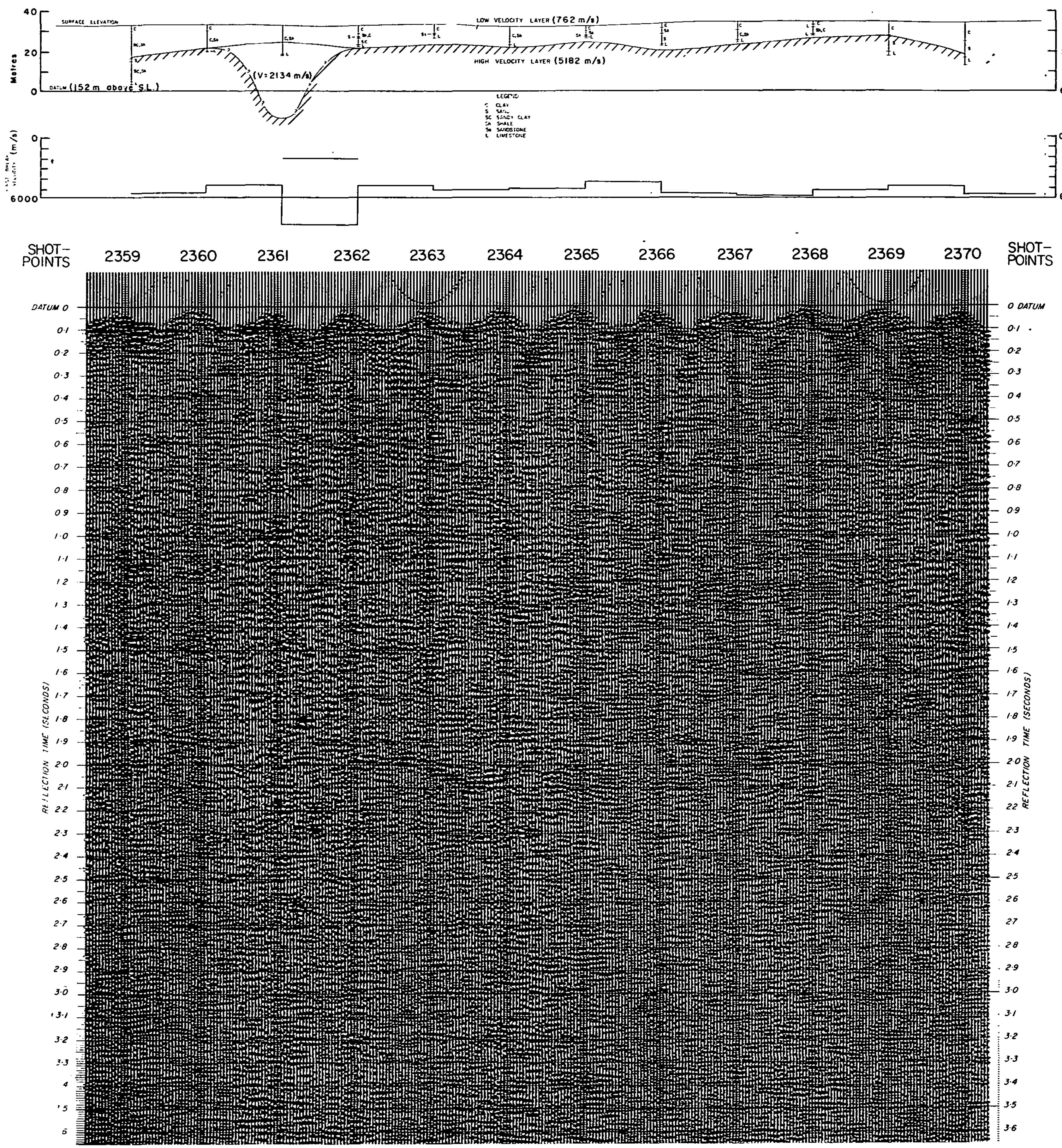
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-125

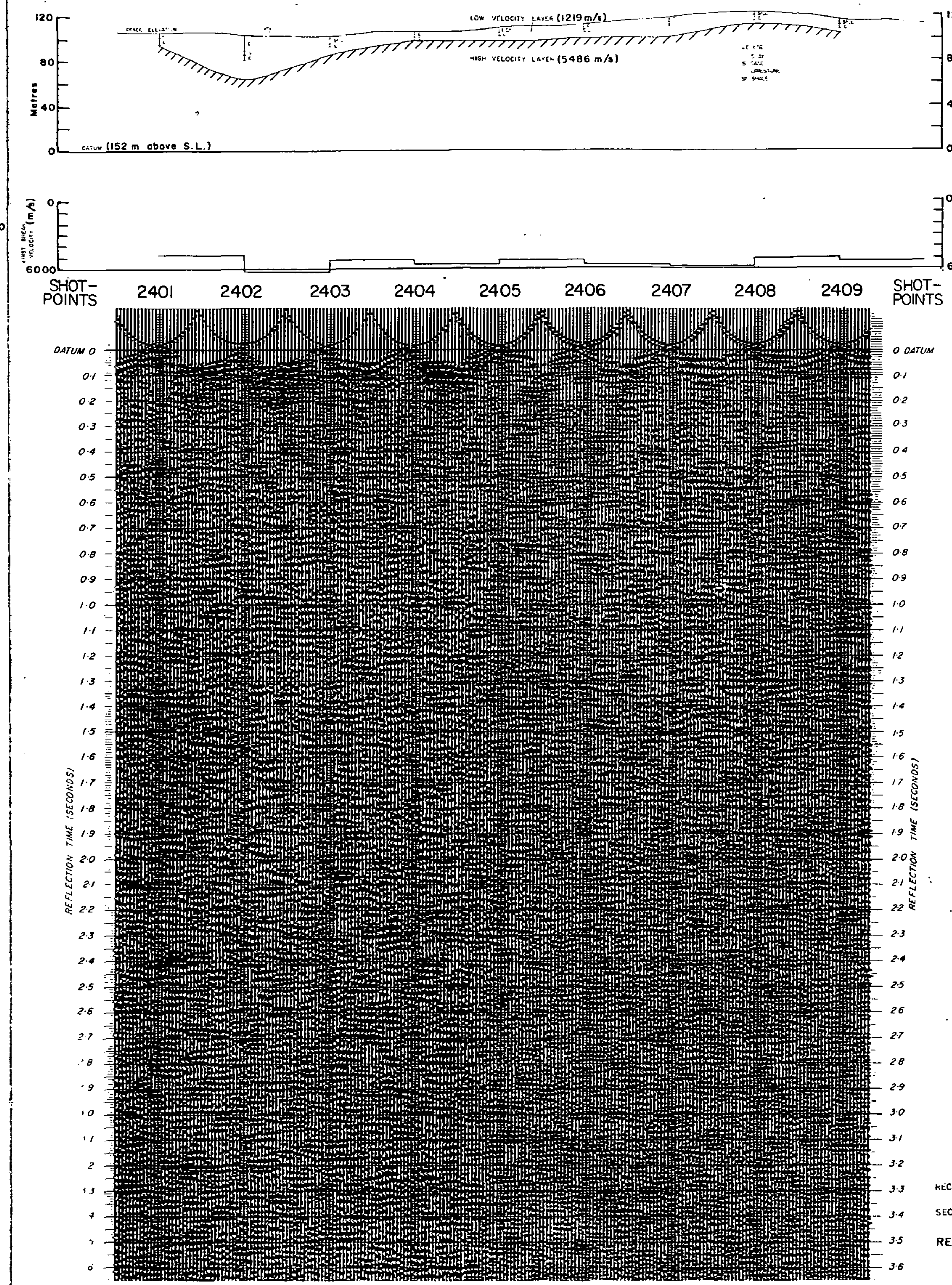
RECORD No. 1974/89

504789

PLATE 17

CORRECTED RECORD SECTION





RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 8000 Explorer

Filters : K18-K160 (SP2359-2370)
K18-K125 (SP2401-2409)

A.G.C. : 1/1 125

Gain Initial : -67

Final : Max

Geophones : EVS 2B-20c/s

Geophone pattern :

24/Trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1 m apart
Station interval 45·7 m

Shot-hole pattern :

5 holes in line
Holes 11·6 m apart
DEPTH 12·2-54·9 m (SP 2359-2370)
6·1-9·1 m (SP.2401-2409)
Charge 5x9·1 kg

PLAYBACK INFORMATION

Filters : 2/31-2/100

A.G.C. : S

Gain Initial : -50

Final : -20

Trip delay : 0

Compositing : 5/4 graded mix
10% 20% 40% 20% 10%

VELOCITY INFORMATION

B.M.R. 12 Sonic log

HORIZONTAL SCALE

0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965

TRAVERSE C

SP2359-SP2370
SP2401-SP2409

REFLECTION CROSS-SECTION

RECORDED BY : *Seismic Party No.1*

SECTION BY : *Bureau of Mineral Resources*
Playback Centre SIE MS 42

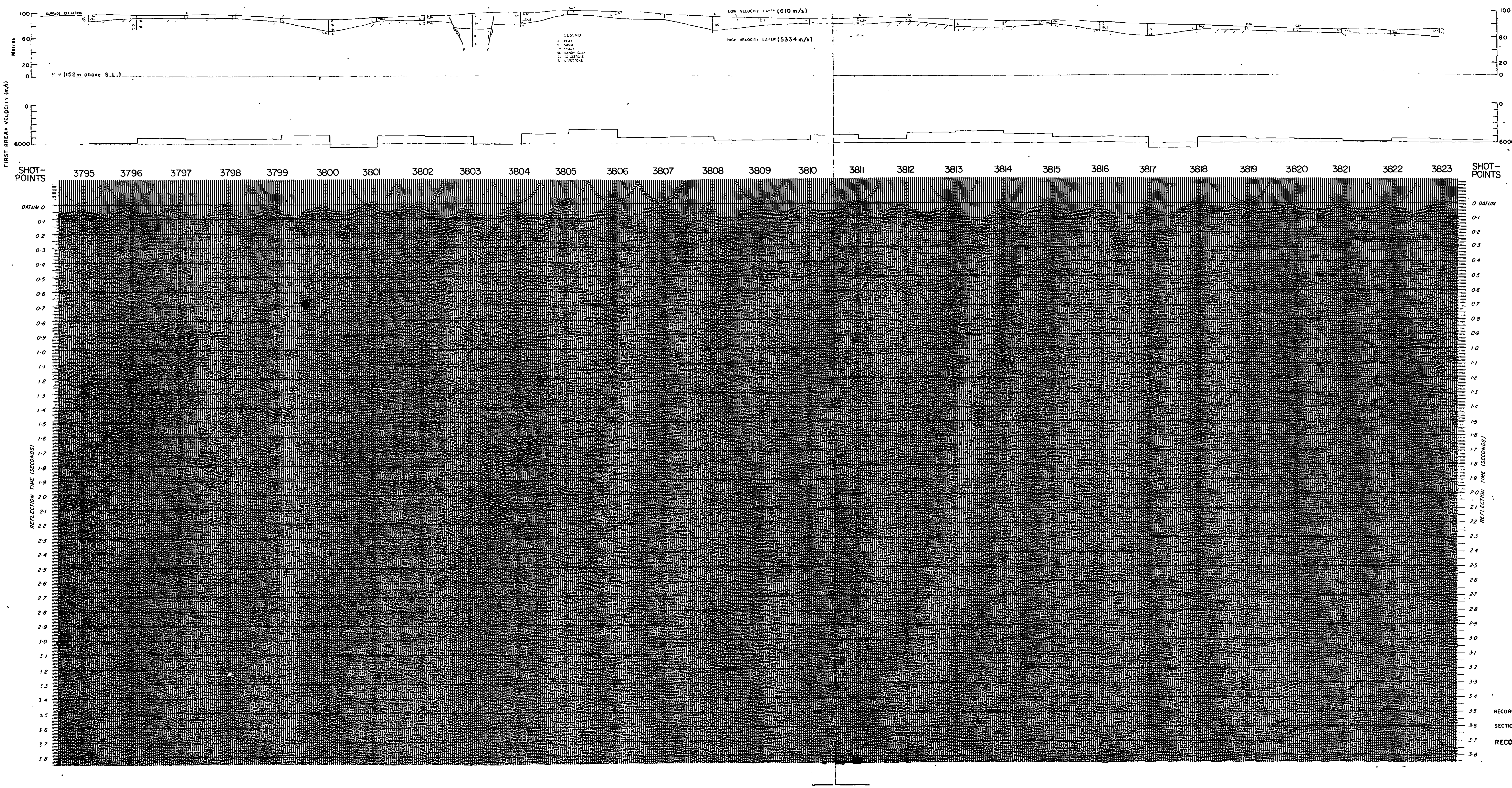
RECORD No. 1974/89

F53/B3-126

504789

PLATE 18

CORRECTED
RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder: DS7-7

Amplifiers: 8000 Explorer

Filters: K18–K160

A.G.C.: 1/1 125

Gain Initial: −67

Final: Max

Geophones: EVS 2B–20 c/s

Geophone pattern:

24/Trace (2 rows of 12)
Geophones 4·3 m apart
Rows 9·1 m apart
Station interval 45·7 m

Shot-hole pattern:

5 holes in line
Holes 11·6 m apart
Depth 5·2–10·7 m
Charge 5x9·1 kg

PLAYBACK INFORMATION

Filters: 2/39–2/100

A.G.C.: S

Gain Initial: −50

Final: −20

Trip delay: 0

Compositing: 5/4 graded mix
10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION

BMR 12 Sonic log

HORIZONTAL SCALE

0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE D
SP 3795–SP 3823

REFLECTION CROSS-SECTION

RECORDED BY: *Seismic Party No. 1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-127

RECORD No. 1974/89

504789

CORRECTED RECORD SECTION

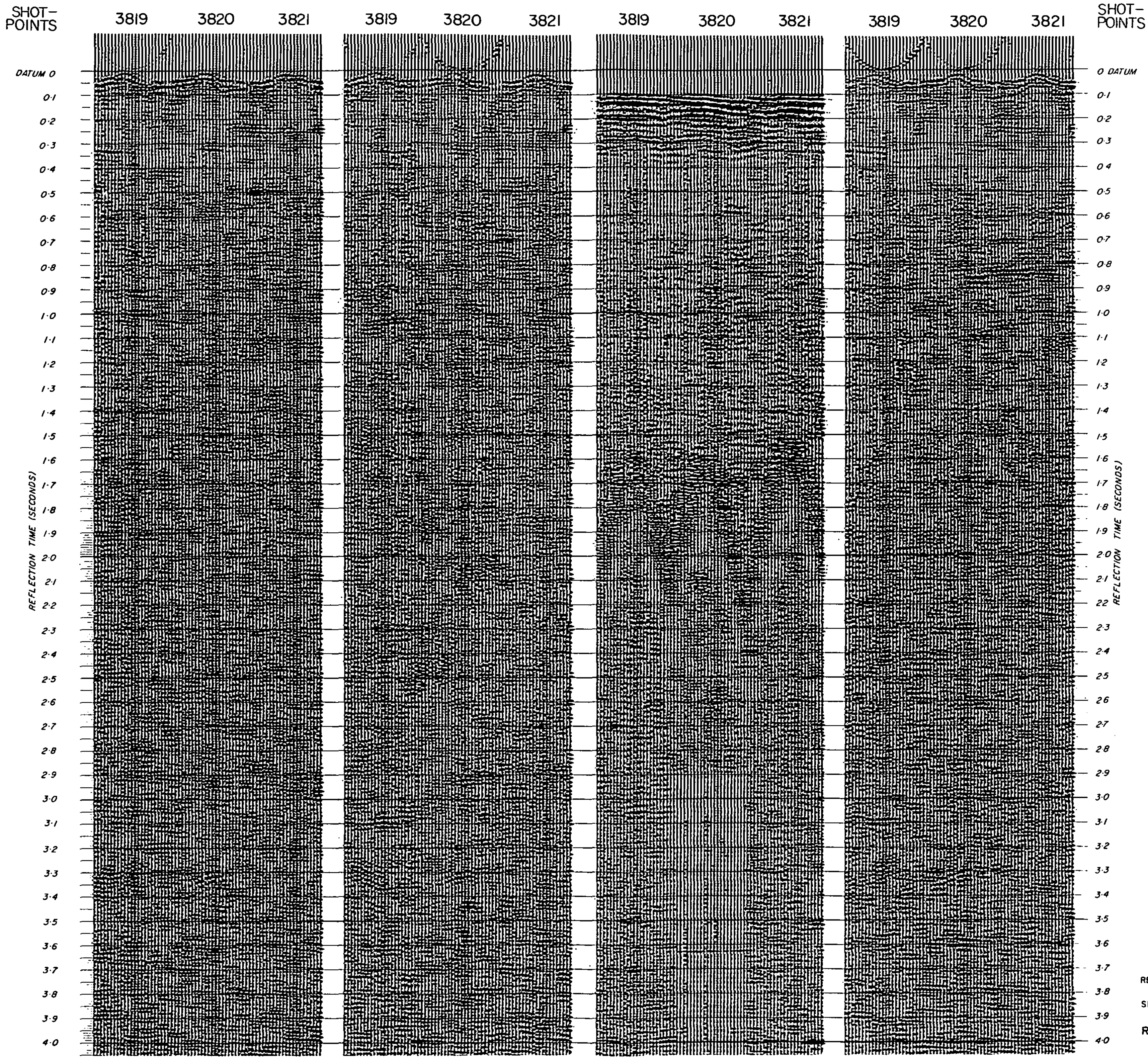
PLATE 19

5 holes in line
Holes 11·6 m apart
Charge 5 x 9·1 kg
Depth 3·7–9·1 m
24 geophones / trace (2 rows of 12)
Geophones 4·3 m apart

20 holes (4 rows of 5)
Holes 11·6 m apart
Rows 12·2 m apart
Charge 20 x 2·3 kg
Depth 3·7–9·1 m
36 geophones / trace (3 rows of 12)
Geophones 4·3 m apart

Airshots (610m ⊥ traverse)
Charge 13 x 4·5 kg
36 geophones / trace (3 rows of 12)
Geophones 4·3 m apart

100 holes (10 rows of 10)
Holes 6·1 m apart
Rows 6·1 m apart
Charge 100 x 0·4 kg
Depth 3·0–4·6 m
36 geophones / trace (3 rows of 12)
Geophones 4·3 m apart



RECORDING INFORMATION

Magnetic Recorder : DS7–7
Amplifiers : 8000 Explorer
Filters : K18–K160, K22–K125
A.G.C. : 1/1 125
Gain Initial : –47 to –67
Final : Max
Geophones : EVS 2B–20c/s
Geophone pattern :
As indicated

Shot-hole pattern :
As indicated

PLAYBACK INFORMATION

Filters : 2/39 – 2/100
A.G.C. : S
Gain Initial : –50
Final : –20
Trip delay : 0
Compositing : 5/4 graded mix
10% 20% 40% 20% 10%

VELOCITY INFORMATION

B.M.R. 12 Sonic Log

HORIZONTAL SCALE

0 500 1000 1500
0 548·6 1097·2
Metres

SOUTHERN GEORGINA BASIN
SEISMIC SURVEY, 1965
TRAVERSE D
(COMPARISON TESTS WITH VARIOUS SHOOTING ARRANGEMENTS)

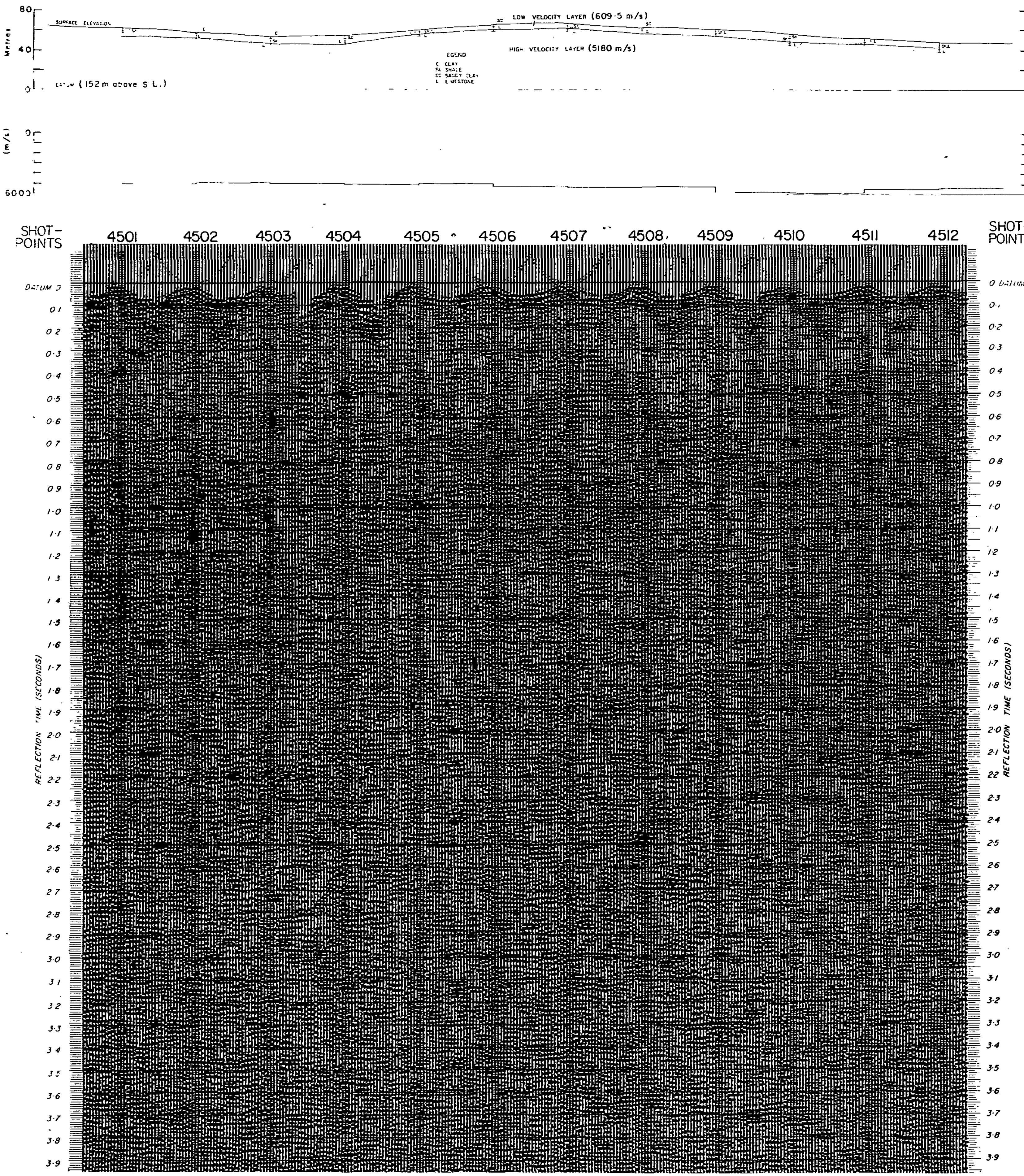
REFLECTION CROSS-SECTION

RECORDED BY: *Seismic Party No.1*
SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-135A
RECORD No. 1974/89

504789

PLATE 20

CORRECTED RECORD SECTION



RECORDING INFORMATION

Magnetic Recorder : DS7-7

Amplifiers : 8000 Explorer

Filters : K18-K160

A.G.C. : 1/1 125

Gain Initial : -67

Final : Max

Geophones : EVS 2B-20c/s

Geophone pattern :

24/trace(2 rows of 12)

Geophones 4·3 m apart

Rows 9·1 m apart

Station interval 45·7 m

Shot-hole pattern :

5 holes in line

Holes 11·6 m apart

Depth 6·1m-9·1m

Charge 5 x 9·1 kg

PLAYBACK INFORMATION

Filters : 2/39-2/100

A.G.C. : S

Gain Initial : -50

Final : -20

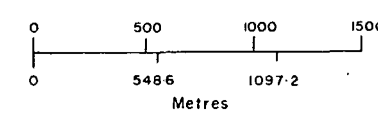
Trip delay : 0

Compositing : 5/4 graded mix 10%, 20%, 40%, 20%, 10%

VELOCITY INFORMATION

B.M.R. 12 Sonic Log

HORIZONTAL SCALE



SOUTHERN GEORGINA BASIN

SEISMIC SURVEY, 1965

TRAVERSE E

SP4501-SP4512

REFLECTION CROSS-SECTION

RECORDED BY: *Seismic Party No.1*

SECTION BY: *Bureau of Mineral Resources Playback Centre SIE MS 42* F53/B3-128

RECORD No. 1974/89

504780

PLATE 21

BMR 12 (COCKROACH) WELL

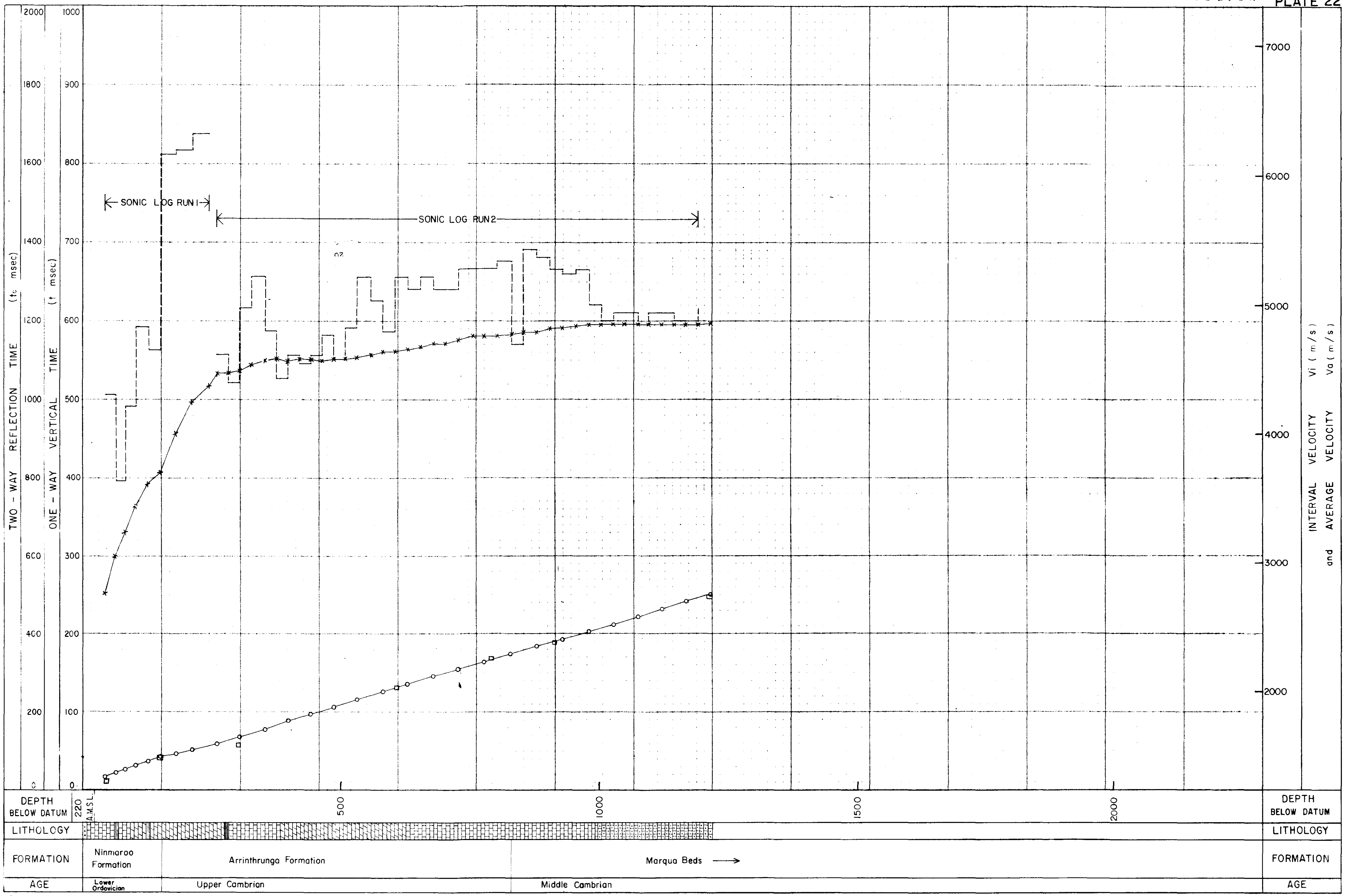
SONIC LOG

TO ACCOMPANY RECORD No. 1966/131
AND RECORD No. 1974/89

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics

E53/B3-111

504789 PLATE 22



(Based on G 85/3-20)

- □ Time / depth from well velocity survey
- —o— Time / depth curve from sonic log
- Interval velocity (Vi)
- —x— Average velocity (Va)

LITHOLOGY

Sandstone · Siltstone · Shale · Limestone · Dolomite · Sandy limestone and calc. sandstone

VELOCITY AND TIME VERSUS DEPTH

AREA BMR 12 (COCKROACH) WELL, GEORGINA BASIN

Basis SONIC LOG AND WELL VELOCITY SURVEY 1964

TO ACCOMPANY RECORD No. 1966/131 AND RECORD No. 1974/89

Geophysical Branch, Bureau of Mineral Resources, Geology and Geophysics F53/B3-100