DEPARTMENT OF
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BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

1975/89

**Aeromagnetic and Radiometric Survey of
Cobourg Peninsula, Alligator River and Mount Evelyn (part)
1:250 000 Sheet Areas**

Northern Territory 1971-1972

by

K.R. Horsfall & P.G. Wilkes

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SUMMARY

During parts of 1971 and 1972, BMR made an airborne magnetic and radiometric survey of the 1:250 000 map sheet areas of Cobourg Peninsula, Alligator River, and Mount Evelyn (northern half). The survey was designed to assist BMR's semi-detailed geological mapping and uranium investigations in the area. The survey was of a regional nature with east-west lines flown 150 m above the ground at a spacing of 1.5 km.

Interpretation of the magnetic data from Cobourg Peninsula shows a gradual deepening of the basement from about 100 m in the southeast corner of the Sheet to about 900 m in the northwest.

In Alligator River and the northern half of Mount Evelyn Sheet areas, many of the magnetic anomalies are of shallow or surface origin, and their correlation with geological units has been helpful in tracing these units beneath the extensive overburden which covers much of the area to the west and north of the Arnhem Land escarpment. The more magnetic of the geological units appear to be the Stag Creek Volcanics, Koolpin Formation, Koolpin Formation equivalent, Zamu Complex dolerite, and Oenpelli Dolerite.

The magnetic data show that the Nanambu Complex is only weakly magnetic with anomalies generally less than 30 nanoteslas. This complex is surrounded by rocks of Koolpin Formation equivalent and locally by Oenpelli Dolerite, both of which gave anomalies up to 300 nanoteslas. The magnetic interpretation indicated the likely existence of two further areas of Nanambu Complex to the north of the main mass, and these have been confirmed by shallow drilling. The Nimbuwah Complex has a very variable and complex magnetic expression, and it was not possible to determine its extent from the magnetic and radiometric data.

The Koolpin Formation equivalent exhibits a very variable magnetic expression with anomaly amplitudes ranging from less than 10 nanoteslas to

as high as 300 nanoteslas. This makes it difficult to trace its full extent and also to determine whether it is continuous with the Koolpin Formation.

Magnetic anomalies are associated with both the Zamu Complex dolerite and the Oenpelli Dolerite. Dolerites appear to be very much more widespread than was previously thought. It is considered that many of the surface exposures are parts of larger continuous bodies in the subsurface.

Areas of higher than average radioactivity have been identified from the radiometric results, and the predominant sources of the radioactivity - uranium, thorium, potassium, or mixed - have been interpreted.

The most intense radiometric anomalies were recorded over three known large uranium deposits (Ranger 1, Nabarlek, and Koongarra), Teague's dump in the South Alligator Valley, various granite masses, and Mount Basedow. The Jabiluka uranium deposit was not directly overflown by the BMR survey and appears to have been too far from the nearest line to be detectable.

On Cobourg Peninsula there is a correlation between areas of bauxitic laterite and thorium anomalies. At present it is not known in what mineral the thorium is present in the laterite.

In Alligator River and Mount Evelyn, 44 anomalies have been classified as 'uranium anomalies'. The host rocks for the 'uranium anomalies' are Nanambu Complex, Nimbuwah Complex, Koolpin Formation, Koolpin Formation equivalent, Masson Formation, Fisher Creek Siltstone, Mount Partridge Formation, and laterites associated with the volcanic members of the Kombolgie Formation.

Radiometric anomalies not related to uranium were analysed to determine the radiometric characteristics of various rock units.

1. INTRODUCTION

During 1971 and 1972, BMR made an airborne magnetic and radiometric survey of the 1:250 000 Sheet areas of Cobourg Peninsula, Alligator River, and the northern half of Mount Evelyn.

The main survey objectives were to complement the semi-detailed geological mapping undertaken by BMR between 1971 and 1974, and to assist the exploration for uranium in the Alligator Rivers uranium province.

The survey was flown in the periods September to November 1971 and June to September 1972. Survey lines were flown east-west at 150 m ground clearance with a 1.5 km spacing (Fig. 2). Variations in the Earth's magnetic field were recorded with a proton magnetometer, and radiometric measurements were obtained with a four-channel differential gamma-ray spectrometer using two sodium iodide detectors each 15 cm x 10 cm. All data were recorded only in analogue form.

A preliminary release of data was made in February 1973. This comprised magnetic contour maps and radiometric total-count profiles at 1:100 000 scale and flight-path maps at 1:250 000 scale. Figure 1 shows the locations of the 1:100 000 Sheet areas.

2. PREVIOUS GEOPHYSICAL SURVEYS

During the past 15 years many geophysical surveys have been made in the area by private exploration companies and BMR. The following notes briefly describe the relevant results of these surveys.

Magnetic and radiometric surveys

During 1957, BMR (Livingstone, 1958) conducted a radiometric survey in the South Alligator River region. Four radiometric anomalies were located near Spring Peak and nine anomalies in the Mount Basedow Range, east of Jim Jim Creek. The anomalies probably correspond to thorium-bearing sediments of the Mount Partridge Formation. Numerous radiometric anomalies were also recorded in connexion with the uranium mineralization along the South Alligator River Fault Zone.

In 1963 an aeromagnetic survey was flown in the Darwin/Pine Creek area by Adastra Hunting Geophysics Pty Ltd, under contract to BMR (Goodeve 1966). The magnetic contours revealed four distinct magnetic lineaments of considerable length, which were interpreted as being due to steeply dipping dykes. Extensive magnetic disturbance recorded over the Masson Formation was thought to be generated by alteration of its iron-rich components by underlying Cullen Granite.

Tipper & Finney (1966) described a BMR detailed aeromagnetic survey of part of the Mount Harris tinfield. The magnetic data indicate a zone of complex magnetic disturbance five to six kilometres wide skirting the Cullen Granite.

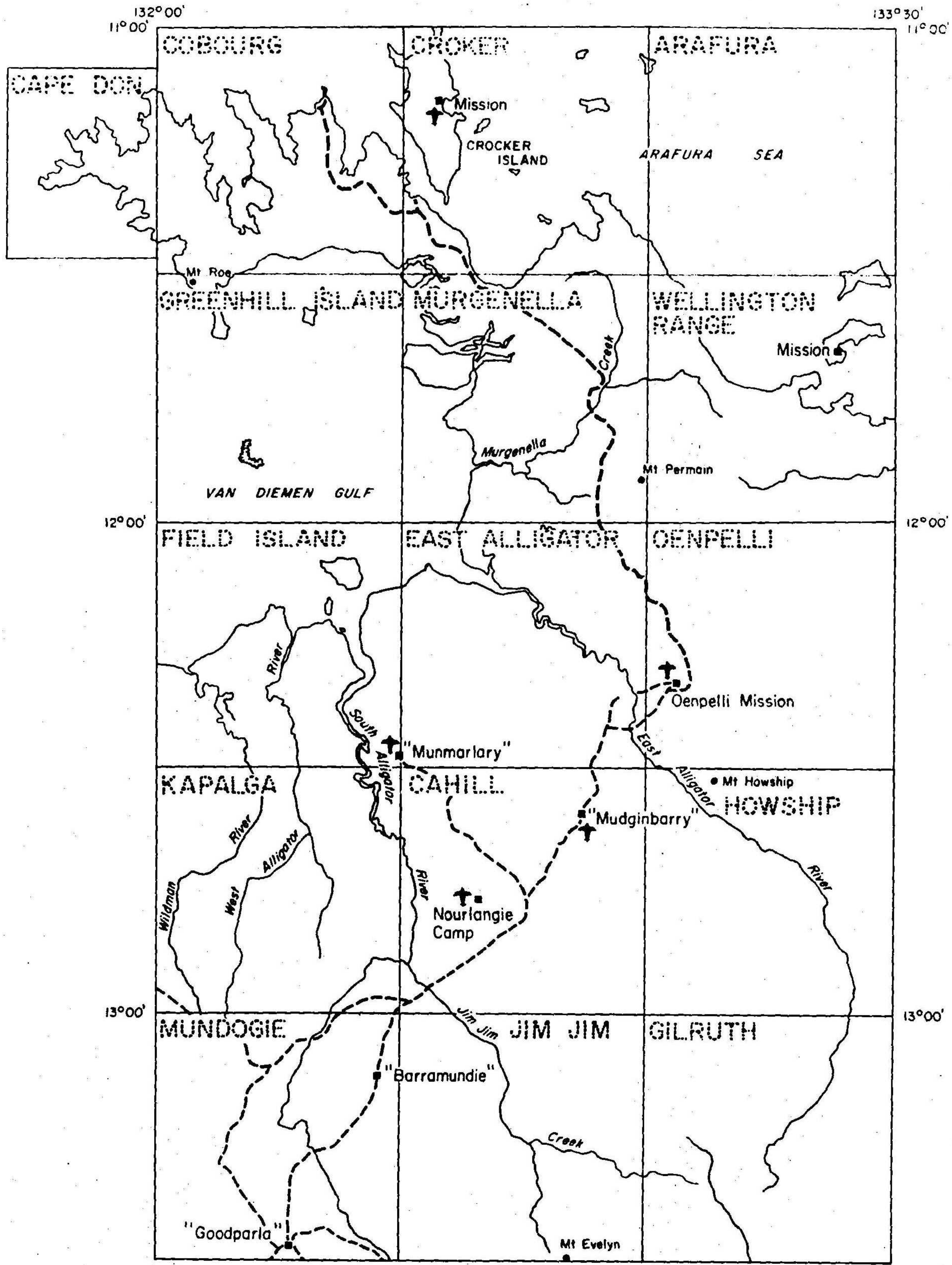
Two magnetic surveys (Shell Development, 1965; Flinders Petroleum, 1969) were conducted in the Cobourg Peninsula to obtain the depth to magnetic basement in the region of Upper Cretaceous sediments. Basement depths of 1000 m (Shell) and 300 m (Flinders) were obtained on the northern side of the Peninsula. It is thought that a sedimentary depression ranging from 450 m to 1000 m exists in Van Diemen Gulf (Shell Development, 1965; Flinders Petroleum, 1969;).

Gravity surveys

Whitworth (1970) described the results of part of the reconnaissance gravity survey of Australia. The results indicated a gravity high in association with the Jim Jim and Cullen Granites. The gravity results also indicated that the Jim Jim Granite may be more extensive than its mapped area.

3. GEOLOGY

Geological maps and Exploratory Notes have been published by BMR for the Cobourg Peninsula, Alligator River, and Mount Evelyn 1:250 000 Sheet areas.



AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

LOCALITY MAP

20 0 20 40 60 80 KILOMETRES

10 0 10 20 30 40 MILES

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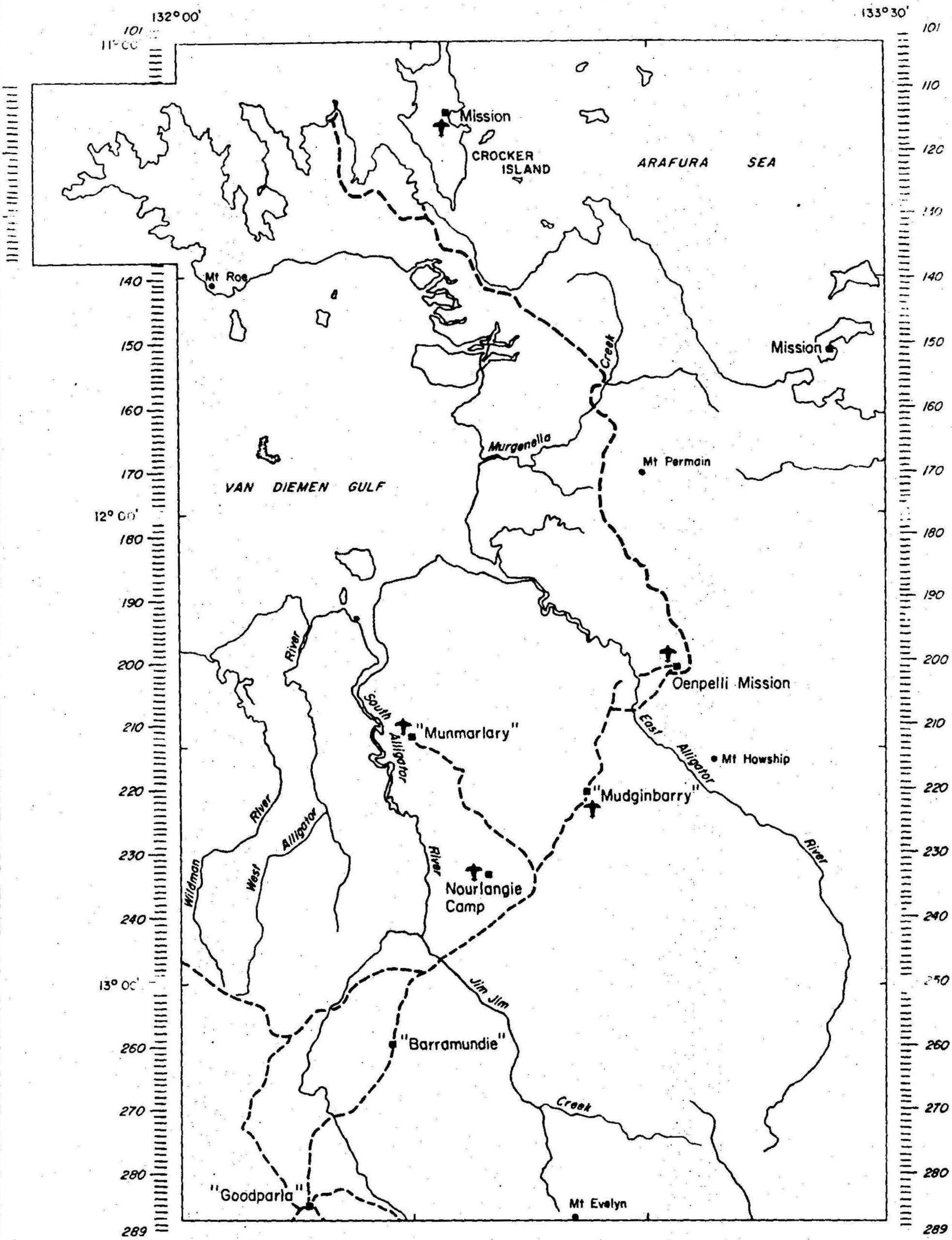
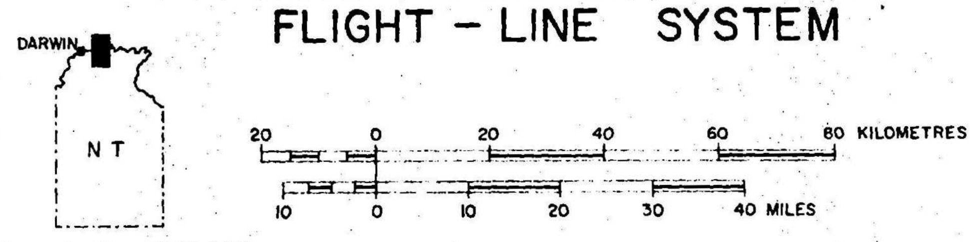
FIGURE 2



AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

FLIGHT – LINE SYSTEM



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For more detailed geological information reference should be made to:

Cobourg Peninsula: Hughes & Senior (1973), Hughes (1973), Senior & Smart (1974)

Alligator River and Mount Evelyn: Dunn (1962), Walpole (1962), Walpole et al. (1968), Needham and Smart (1972), Needham, Smart & Watchman (1975 a,b) Smart et al. (1974), and Needham (1974).

Cobourg Peninsula (Pl. 3)

The stratigraphy in Cobourg Peninsula is summarized in Appendix 1. The oldest rock unit exposed is the Nimbuwah Complex, in the southeast corner of the area. This has been locally intruded by the Oenpelli Dolerite, and is unconformably overlain by the Kombolgie Formation. During the Cretaceous, marine sediments accumulated on a basement surface that sloped gently to the north and west - the Bathurst Terrace. At the end of the Cretaceous, or during the early Tertiary, the area was uplifted and the Cretaceous sediments were lateritized. Shallow stratigraphic drilling (Hughes, 1973) in the southeastern part of the Cobourg Peninsula showed that the Cretaceous sediments thicken northwards from about 60 m at drill-hole 1 (9 km west of Mount Permain) to about 300 m at drill-hole 3 (on eastern shore of Mount Norris Bay). The drilling also indicated that Cainozoic deposits are less than 10 m thick.

Alligator River and Mount Evelyn north of 13°30'S (Pl. 4)

Plate 4 is a composite geological map. East of longitude 132°15'E, the geology is from Needham et al. (1973); west of longitude 132°15'E it is taken from Dunn (1962) and Walpole (1962). The stratigraphy in this area is summarized in Appendix 2. The table does not include the Burrell Creek, Golden Dyke, and Diljin Hill Formations, which have very limited outcrop in the survey area.

This area is part of the Pine Creek Geosyncline, the evolution of which was described by Walpole et al. (1968). Recent geological mapping by

BMR (1971-74) has modified some of the earlier ideas; the main reference for the later work is Smart et al. (1975). The principal modifications are:

1. The earlier workers considered that this area occupied a subsidiary eastern trough of the Pine Creek Geosyncline. It is now considered to lie within the major trough of the geosyncline, which is more extensive than was thought previously.
2. The rocks of Myra Falls Inlier, which were previously known as the Archaean Myra Falls Metamorphics, are now recognized as metamorphic equivalents of the Lower Proterozoic Koolpin Formation.
3. The Stag Creek Volcanics, previously considered to be Archaean, are now regarded as part of the Goodparla Group within the Lower Proterozoic sequence.
4. The earlier workers considered the Nimbuwah Complex and the Nanambu Granite to be either Archaean basement, or younger intrusive granites within the basement, on the eastern margin of the Pine Creek Geosyncline. The Nanambu Granite has now been renamed Nanambu complex and is regarded as a mantled gneiss dome formed by migmatization of Lower Proterozoic sediments around an Archaean basement high. The Nimbuwah Complex was formed predominantly by migmatization of Lower Proterozoic sediments, but some Archaean material was probably incorporated during its formation.

   The Complexes were previously described as mainly granitic; it is now known that a wide variety of other rock types are also present including migmatite, amphibolite, quartzite, and various gneisses and schists.

The following geological history is reproduced from Needham (1974).

An Archaean basement high (the 'Nanambu High') between the South and East Alligator Rivers was flanked and progressively covered by Lower Proterozoic sediments, first the Goodparla Group (Masson and Mount Partridge

Formations), and after these were folded, by the South Alligator Group (Koolpin Formation and equivalents, and Fisher Creek Siltstone). Differentiated dolerite of the Zamu Complex was then emplaced as numerous sills, mostly in the South Alligator Group. About 1800 m.y. ago the thick pile of sediment in the northeast of the area was extensively migmatized to form the Numbuwah Complex. During this process strata, probably including Archaean basement material, were uplifted and overthrust. Rocks were metamorphosed as far southwest as Jim Jim Creek. At the same time the Nanambu High was reactivated and partly migmatized, along with the flanking Lower Proterozoic sediments, to form the Nanambu Complex.

The Oenpelli Dolerite was emplaced as a series of ellipsoidal basin-shaped bodies, or lopoliths, at approximately the same level in the rock pile. Hybridization of the dolerite and country rock in the centre of the Nimbuwah Complex suggests that the dolerite was emplaced while the core of the complex was still hot. Melts formed in the root-zone of the Nimbuwah Complex became mobilized, and were intruded as anatectic granites at various levels within and outside the migmatite complexes. The Edith River Volcanics are about the same age, and are possibly comagmatic with the granites.

During the long period of erosion that followed, the area was levelled except for isolated ridges and hills of Oenpelli Dolerite and Mount Partridge Formation. These hills and ridges outlined wide shallow basins during the deposition of the Kombolgie Formation, and the formation was subsequently preferentially eroded along them, where the Kombolgie Formation was thinner.

The Kombolgie Formation was eroded to its present-day outline, mostly before Mesozoic time, predominantly by scarp retreat. Mesozoic terrestrial and littoral sediments covered all the Alligator Rivers area, but have subsequently been almost entirely removed, their breakdown products, along with colluvial material derived from the Kombolgie Formation, contributing to the extensive accumulation of Cainozoic sand over all low-lying areas. Extensive cappings of laterite developed over the low-lying areas mostly before deposition of Cainozoic sand. A Quaternary submergence resulted in extensive deposition of silt and clay in the major estuaries. A recent minor emergence is marked by incised channels in flood-plain deposits and incision of most creek courses.

Mineralization

Uranium. Most of the recent exploration for uranium in the Alligator Rivers area was initiated as a result of suggestions and recommendation by P.R. Dunn. Dunn had carried out most of the mapping of the Alligator Rivers area and in recent years he recognized certain broad similarities between this area, South Alligator uranium province to the south, and the Westmoreland uranium district on the NT/Queensland border.

All the uranium found so far has been restricted to Lower Proterozoic rocks. The laterite, soil, and alluvium cover make uranium exploration extremely difficult. Many of the uranium prospects and deposits found to date are close to the sandstone escarpment of the Kombolgie Formation. Some of the deposits or prospects which lie close to the western scarp are Ranger 1 and Ranger 3 (Peko-EZ), Nabarlek, Caramal, and Beatrice (Queensland Mines), Koongarra (Noranda), and Jabiluka (Pancontinental).

Lead. Lead mineralization is located at Namoona and Minglo in the southwest part of the area. At Namoona, galena and cerussite are widespread in the Masson Formation. In the Minglo area, galena and anglesite have been deposited in a shear zone formation as a result of contact metamorphism by the Cullen Granite.

Tin. A small tin occurrence has been recorded from the Myra Falls area, south of Oenpelli. Cassiterite, apatite, beryl, and copper minerals have also been noted in the area.

Iron. In the Black Jungle Range, west of Mundogie Hill, ferruginous laterites are developed on the Koolpin Formation. The underlying rocks are thought to contain disseminated pyrite. A similar area of superficial enrichment is found near Coirwong. At the headwaters of Nourlangie Creek a quartz hematite body crops out in the Fisher Creek Siltstone near its contact with the Jim Jim Granite.

Bauxite. Widespread laterite in the Cobourg Peninsula may be a source of economic bauxite deposits.

4. MAGNETIC RESULTS AND INTERPRETATION

The magnetic data are presented as total magnetic intensity contours in Plates 1 and 2. The contour interval is 10 nanoteslas (NT).

For the Cobourg Peninsula area the magnetic interpretation has been superimposed on the geology in Plate 3. For the Alligator River and Mount Evelyn areas they are shown separately - the geology in Plate 4 and the magnetic interpretations in Plate 5.

Zones of magnetic disturbance have been outlined and major positive or negative trends delineated. These have been correlated with the mapped geology, which has then been extrapolated into regions of surficial cover.

Cobourg Peninsula (Pls 1, 3)

The magnetic field over Cobourg Peninsula is a contrast between the disturbed areas in the southeast and the high-amplitude anomalies in the northwest.

Zone 1 outlines the migmatite zone of the Nimbuwah Complex; it is very disturbed and anomalies range up to 150 nT. The most likely cause of the anomalies is the dolerites in the Complex. These dolerites can be related to strong negative anomalies, which suggests that they may be reversely magnetized. Zone 1 extends northwest along the coast parallel to the postulated Grant Island Fault. This part of zone 1 outlines the northern extension of the Nimbuwah Complex.

The complex in this area consists mainly of granitoid and migmatitic rocks with occurrences of schist and gneiss. Geologists (Watchman, pers. comm.) have suggested that the area may have originally contained sills of dolerite which have been eroded, leaving small pockets of dolerite. Thus the magnetic pattern is due to a combined effect of several sources and no one source can be singled out from the others.

The areas designated as zone 2 are continuous with areas to the south in the Alligator River Sheet area. The BMR stratigraphic drill-hole, Cobourg Peninsula 1, has shown that chlorite-tremolite schist is present at a depth of 60 m (Hughes, 1973). The magnetic data suggest that this schist may be continuous with the Koolpin and Fisher Creek Formations, which are associated with magnetic anomalies in the Alligator Rivers region.

Zone 3 contains an anomaly due to a body deep-seated in the basement. Depth estimates place it at 3300 m below sea level.

Zone 4, near Danger Point, contains anomalies which range up to 2300 nT; the estimated depth of the source is between 300 and 700 m. The zone to the northeast is probably a continuation of the same anomaly. As the other large anomaly to the southwest is similar in shape, amplitude, and depth to source, it is thought to have a similar source.

The anomalies in the two zones of type 5 have a similar shape and strike direction. Their cause is not known.

Several depth-to-basement estimates have been made, and these are shown on the interpretation map. All depths have been corrected to mean sea level (M.S.L.).

Very generally, the basement is about 100 m below M.S.L. in the southeast with a gradual deepening to 900 m in the northwest. This agrees with results of the offshore work flown under the Petroleum Search Subsidy Act, in which the depth to basement between Cobourg Peninsula and Melville Island was estimated as about 1000 m below M.S.L. (Flinders Petroleum, 1969; Shell Development, 1965). Some depth estimates do not fit into the general pattern;

3300 m below M.S.L. in Mount Norris Bay obviously refers to a source deep within the basement.

Alligator River and Mount Evelyn (Pls 2, 5)

The pattern of magnetic anomalies in the Alligator River and Mount Evelyn Sheets (Pl. 2) is mainly associated with the Nanambu Complex and associated dolerites.

The Nanambu Complex consists of migmatite masses named the Jim Jim Mass (zone 10), Munmarlary Mass (zone 11), and Magela Mass (zone 12). Several other zones (e.g. 17) may also be due to migmatite masses.

The magnetic field over the masses is undisturbed, in contrast with the disturbed area bordering the masses - zones 6, 7, 8, 9, and 13. These disturbed regions have been used to define the boundaries of the masses.

The Magela Mass, zone 12, is well defined by zones 7 and 13, in which the magnetic disturbance is mainly due to Koolpin Formation equivalent.

The Munmarlary Mass, zone 11, is bounded on the east by zones 6 and 7 and on the west by zone 9, which can be correlated with Mount Partridge Formation. The northern boundary of zone 11 is difficult to define. BMR drill-hole EA9, 31 km NNE of Munmarlary homestead, intersected migmatite, probably part of the Munmarlary Mass.

South of the Munmarlary Mass is the Jim Jim Mass (zone 10) bounded by zones 8 and 7. Zone 8 is attributed mainly to dolerite in the form of steeply dipping bodies and Zamu Complex dolerite. The magnetic data suggest that the Munmarlary and Jim Jim Masses are connected. Geologists have not been able to confirm this because of the swampy ground between the masses.

Zones 2, 6, and 7 form continuous magnetic features through the area. The magnetic anomalies in zone 6 are mainly due to Koolpin Formation equivalent and dolerite.

In the part of zone 7 east of Mount Basedow, the rock types are mainly Koolpin Formation equivalent and Zamu Complex dolerite. Ranger 1 uranium deposit lies close to the edge of this zone, and the Koongarra deposit lies well within it.

Individual anomalies within the zone have amplitudes up to 300 nT. Farther south in zone 7, near Mount Partridge, the magnetic anomalies correspond with exposures of Zamu Complex dolerite.

Zones 17, because of their lack of magnetic features, may represent migmatite masses. Two BMR drill-holes, EA 10 and EA 11 in the northernmost zone 17, intersected Koolpin Formation equivalent at depth. This is apparently part of the Koolpin Formation equivalent found in zone 6. The anomalies in zone 13 are due to Koolpin Formation equivalent as confirmed by geological mapping.

Zones of type 9 can be correlated with the Mount Partridge Formation. Mount Basedow, which consists of Mount Partridge Formation, is included in zone 9.

Large sills of dolerite occur throughout the area. In the Kombolgie Sandstone some of the dolerites had been mapped as volcanics, but more recent mapping has changed this.

In general the magnetic response of dolerite is markedly different from that of the volcanics. Dolerite tends to give a larger anomaly and in some cases good linearity. Volcanics, on the other hand, commonly give small anomalies.

Using these criteria, zones 14, 15, and 16 have been interpreted as Oenpelli Dolerite. This was confirmed by the recent geological mapping and the magnetic zones may outline the subsurface extent of the bodies. Anomalies range up to 150 nT in these areas, and it is apparent that some of the dolerites may be reversely magnetized.

East and southeast of Oenpelli Mission are three zones designated as 18. These also correlate with the Oenpelli Dolerite and may define the edges of one large sheet. A profile along a 330° line across the area (Fig. 3) indicates a strong negative anomaly across the northern zone and a positive one over the southern zone. Normally a north-south profile over a flat-lying magnetic sheet would give a positive anomaly over the northern edge, a flat

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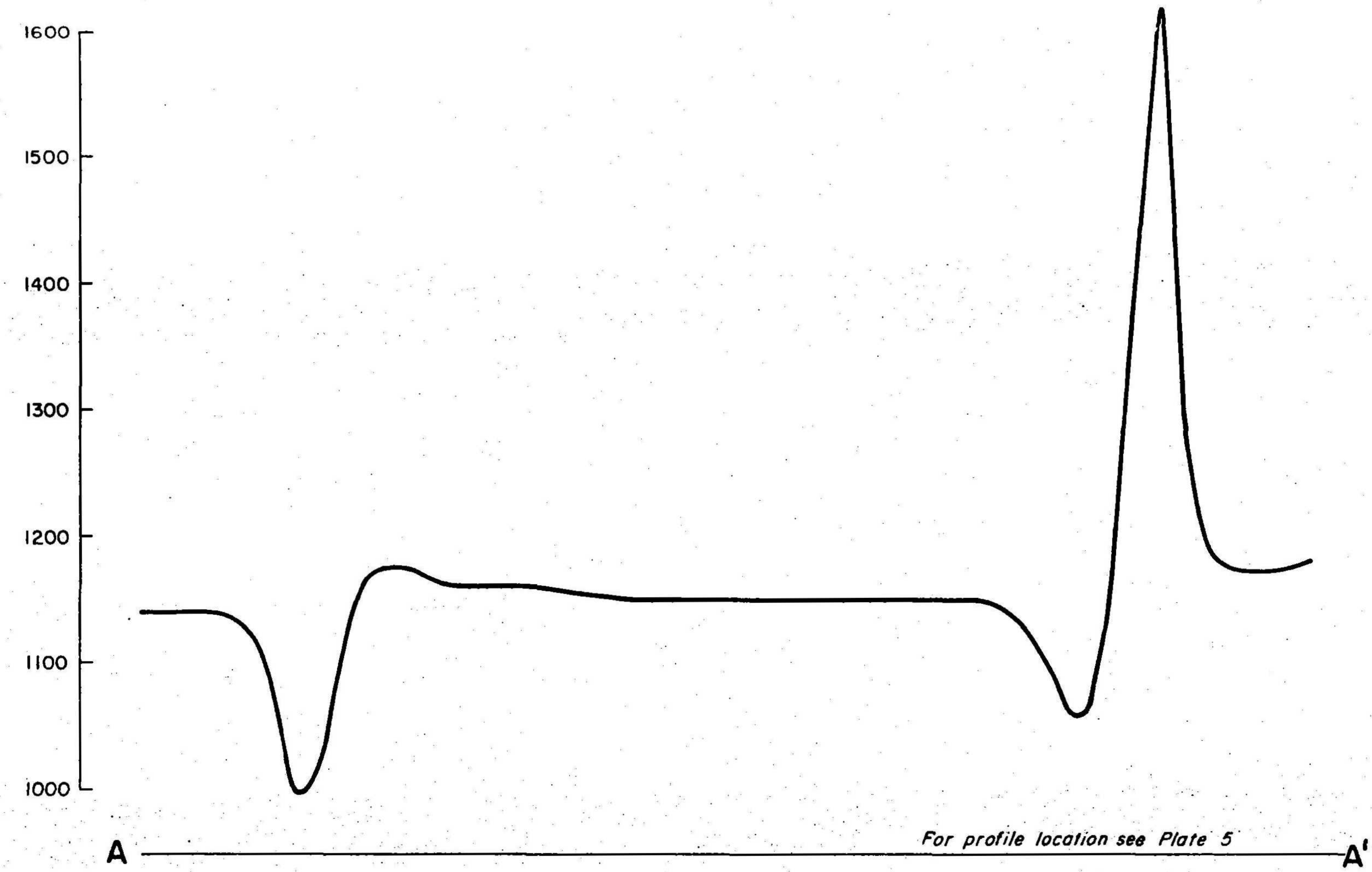

MAGNETIC PROFILE OVER OENPELLI DOLERITE IN N.E. ALLIGATOR RIVER

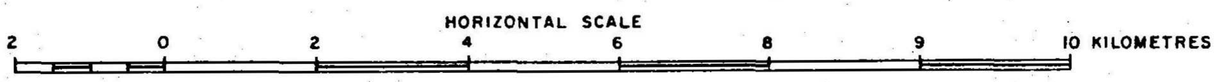

FIGURE 3

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field across the central portion of that sheet, and a negative anomaly over the southern edge. The situation here is opposite to this, and a reasonable explanation is that the dolerite is reversely magnetized. It seems that all other dolerites are reversely magnetized, giving negative anomalies where positive anomalies would normally be expected.

Zones 19, north and northwest of Nabarlek, are all obviously due to dolerite which is part of the Nimbuwah Complex (zone 1).

Interpretation of the magnetic data has indicated that the zone 19 10 km north of Oenpelli Mission is due to a source very near the surface and dipping at a low angle to the east. This suggests that a sill of dolerite may exist in this region and the magnetic anomalies reflect only the edges of it. It is possible that the dolerite extends under the Lower Proterozoic sediments.

The magnetic field over the Kombolgie Sandstone is generally undisturbed with the exception of linear anomalies ascribed to dolerites (zone 26) which are thought to have intruded the joints. The joints trend northeast, northwest, and east through the area. Depth determinations indicate that the anomalies are due to shallow sources in the sandstone. This leads to the conclusion that the dolerites postdate the sandstone.

In contrast with the undisturbed magnetic field over the Kombolgie Sandstone, zone 21 is quite distinctive. It has become obvious with the more recent mapping that the magnetic anomalies are due to the Oenpelli Dolerite which crops out in a few places. The dolerite is probably quite extensive under the Kombolgie Sandstone, and zone 21 outlines its probable extent. Also present are exposures of the Nungbalgarri volcanic member and the Gilruth volcanic member. As these are non-magnetic elsewhere, the magnetic disturbance is attributed to the dolerites. As mentioned above there is little magnetic effect associated with the Nungbalgarri volcanic member. This is demonstrated in the region 30 km east of Koongarra uranium prospect. An explanation for the low magnetic response over these volcanics is that they thin to the south and are only a few centimetres thick in places (Needham, pers. comm.).

Samples of the dolerites and volcanics have been collected from the survey area for measurement of magnetic susceptibility. The average susceptibility for the Zamu Complex dolerite was 65×10^{-6} cgs units and that for the Oenpelli Dolerite 1190×10^{-6} cgs units; the Nungbalgarri volcanic member varied widely, making a meaningful estimate of susceptibility difficult.

Several other zones interpreted as dolerite are 22, 23, 24, 25, and 30. Their disposition suggests that the dolerite once existed as extensive sills, now fragmented by erosion. One sheet may have extended from the eastern boundary of zone 21, along Deaf Adder Creek and then south along the Nourlangie Creek. Another sheet probably extended south from the vicinity of the Jim Jim Granite to encompass the zones of dolerite exposed in the south. Zones 28, 29, and 31 are thought to be due to Koolpin Formation, but there may be some influence from the dolerite as well.

The South Alligator River Fault zone (zone 32,) is characterized by anomalies of several hundred nanoteslas. Correlation of the magnetic contours with the detailed geology of Walpole et al. (1968) shows that the anomalies are due to the Stag Creek Volcanics.

Zone 33 can be correlated with the Plum Tree Volcanics.

Zone 34 represents the Cullen Granite and zone 36 can be correlated with the surrounding contact zone between the granite and the Masson Formation. In an aeromagnetic survey of an adjoining area (Goodeve, 1966), it was noted that the Cullen Granite is magnetically undisturbed, the few anomalies present being possibly due to small roof pendants of Lower Proterozoic sediments. Outcrops of Masson Formation farther north and east of this metamorphic region do not exhibit any magnetic anomalies. Therefore it is assumed that the anomalous field over the Masson Formation, zone 36, is due to its association with the Cullen Granite.

Zone 35 in the southeast is a weakly disturbed zone and can be correlated with the Mullaman Beds which are Lower Cretaceous ferruginous sandstone and conglomerate.

Several faults have been interpreted from magnetic data. Most, but not all, of these correspond with faults recognized in the geological mapping.

5. RADIOMETRIC RESULTS

Acquisition of data

The radiometric equipment used for this survey was a four-channel differential gamma-ray spectrometer with two 15 cm x 10 cm sodium iodide detectors. The four channels were set as follows:

Channel	Energy range (MeV)	Common name
1	0.84 - 3.00	'total-count channel'
2	1.30 - 1.60	'potassium channel'
3	1.60 - 1.90	'uranium channel'
4	2.40 - 2.80	'thorium channel'

All radiometric data were recorded in analogue form with a time constant of 3 seconds. A radar-altimeter record of ground clearance was recorded on the same charts as the radiometric data.

On each flight, measurements were made of background radioactivity (of non-geological origin) and along a baseline flown at survey altitude. Background measurements were made by flying at 600 m above the ground and recording for several minutes. Background and baseline measurements were made before the first survey line and after the last line of each flight. Some of the northern lines over Cobourg Peninsula crossed considerable areas of sea. This provided up-dating information on the background levels during a flight. Background levels were calculated by interpolation between the 600 m measurements for lines which did not cross such areas of sea.

Presentation of data

Radiometric data have been presented in two forms: total-count profiles and anomaly maps.

'Total-count' radiometric profiles were produced at a horizontal scale of 1:100 000, by reduction from smoothed original records. The background radioactivity was subtracted during this process. As the reduction factor varies from line to line the profiles do not have a constant vertical scale. The average vertical scale is 135 counts/s/cm. Preliminary editions of these profiles, together with flight path maps at 1:250 000 scale, were released through the Australian Government Printer early in 1973. They are not presented in this Record.

Radiometric anomaly maps show the positions of selected anomalies and various numerical data related to count rates measured in channels 2, 3, and 4, together with a reference number. The reference number is derived from the flight-line number and a fiducial along the line; e.g. anomaly 2860/176 is the anomaly recorded with peak at fiducial 2860 on flight-line 176. Below the reference number four numbers are shown. The left-hand number is the peak 'total-count' count rate (in counts/s) above non-geological background. The three figures to the right are derived from adding the count rates in channels 2, 3, and 4 and expressing each of the individual count rates as a percentage of that sum. E.g. anomaly 988/288 has channel 1, 2, 3, and 4 count rates of 130, 34, 10, and 6 counts/s above non-geological background. The percentages work out as 68, 20, and 12 for channels 2, 3, and 4 respectively and these are the numbers shown on the map together with the reference number and the total-count figure of 130 counts/s. The source of each anomaly is shown symbolically. The method of determining the source is explained in the next section.

To facilitate comparison of results with other spectrometer systems, the spectrometer used in this survey has been calibrated against a radium-226 source and has a sensitivity of 58 counts/s/μR/h (counts per second per microroentgen per hour). This is the sensitivity of the 'total-count' channel. Use of this figure makes it possible to compare results with other such calibrated systems.

Principles of interpretation

From a study of the total-count radiometric profiles, together with the most recent BMR geological mapping, anomalies were selected for further analysis. The selection was made on the basis of local increases in total-count count rates over given rock units, and/or anomalous distribution of count rates between channels 2, 3, and 4. In practice a lower limit of about 50 counts/s (in total-count) above the local geological background has been used in anomaly selection. As background terminology is often a source of confusion, Figure 4 has been included to show how such terms have been used in this record. No strict mathematical definition of anomalies in terms of multiples of backgrounds and restricted widths has been used because it would be unnecessarily restrictive. In selection of anomalies, the radiometric records have been compared with the ground clearance record, to ensure that spurious anomalies generated by variation of ground clearance have been omitted as far as possible. A figure of 10 percent variation in total-count count rate per 15 metres of altitude variation has been used to estimate the correct amplitude of such anomalies. This percentage applies only to the geological component of measured radioactivity.

For each anomaly, peak count rates in all channels were measured and compared with the count rates over the adjacent area. From the peak data, percentage figures were calculated as explained under 'Presentation of data'. Each anomaly was then compared with a triangular diagram (Fig. 5) to assess the composition of its source. This diagram was used to divide anomalies into four groups based on their source content:

(1) Predominantly due to potassium

(2) Predominantly due to uranium

(3) Predominantly due to thorium

(4) Of mixed source, no component being particularly dominant.

The divisions within the triangular diagram are based on airborne measurements over known sources and on theoretical considerations.

The count-rates in each channel can be expressed by the following equations:

$$ch2 = K2 + aU3 + bTh4 \qquad (1)$$

$$ch3 = U3 + cTh4 \qquad (2)$$

$$ch4 = Th4 + dU3 \qquad (3)$$

where ch2, ch3, and ch4 are the count rates in channels 2, 3, and 4, respectively, after removal of non-geological background and after height correction to the standard terrain clearance (in this survey 150 m); K2, U3 and Th4 are the contributions from potassium to channel 2, from uranium to channel 3, and from thorium to channel 4 respectively.

The constants a, b, c, d are usually called the Compton Scattering coefficients or stripping ratios. Grasty & Darnley (1971) showed that these coefficients depend on source geometry and that their accurate determination requires conditions similar to those encountered in survey operation. These conditions have been simulated by the Geological Survey of Canada by using calibration pads 7.6 m square and 46 cm thick which contain known amounts of radioactive material. In Australia there is no similar facility and the accurate determination of the coefficients is difficult. For the equipment and survey parameters of this survey, approximate values for the coefficients would be:

$$a = 1.1 \qquad b = 0.75 \qquad c = 0.70 \qquad d = 0.04$$

The data from this survey have not been processed to produce outputs of K2, U3, and Th4 because:

(a) The data are not in digital form and therefore not amenable to bulk processing.

(b) The data have not been corrected for variations in terrain

SECTION OF IDEALIZED SPECTROMETER CHART

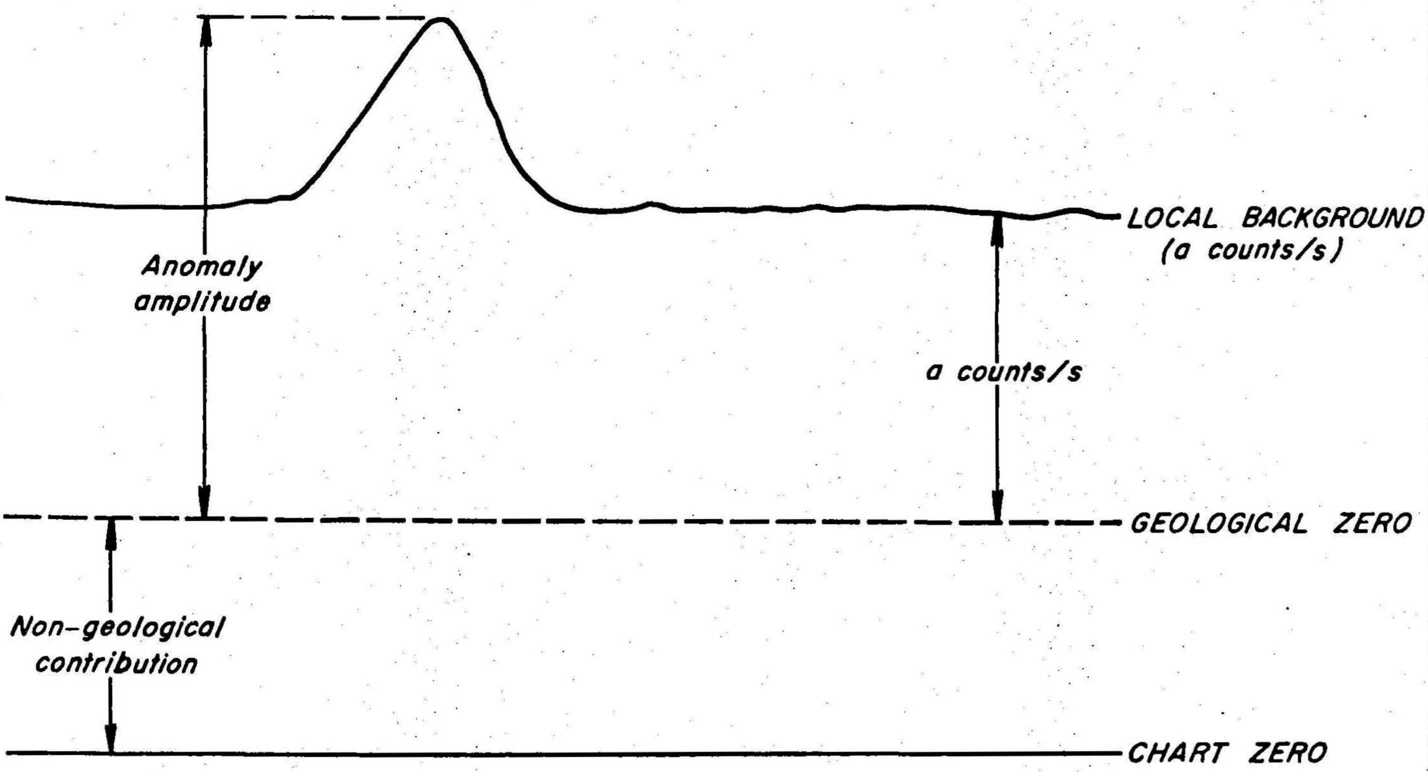
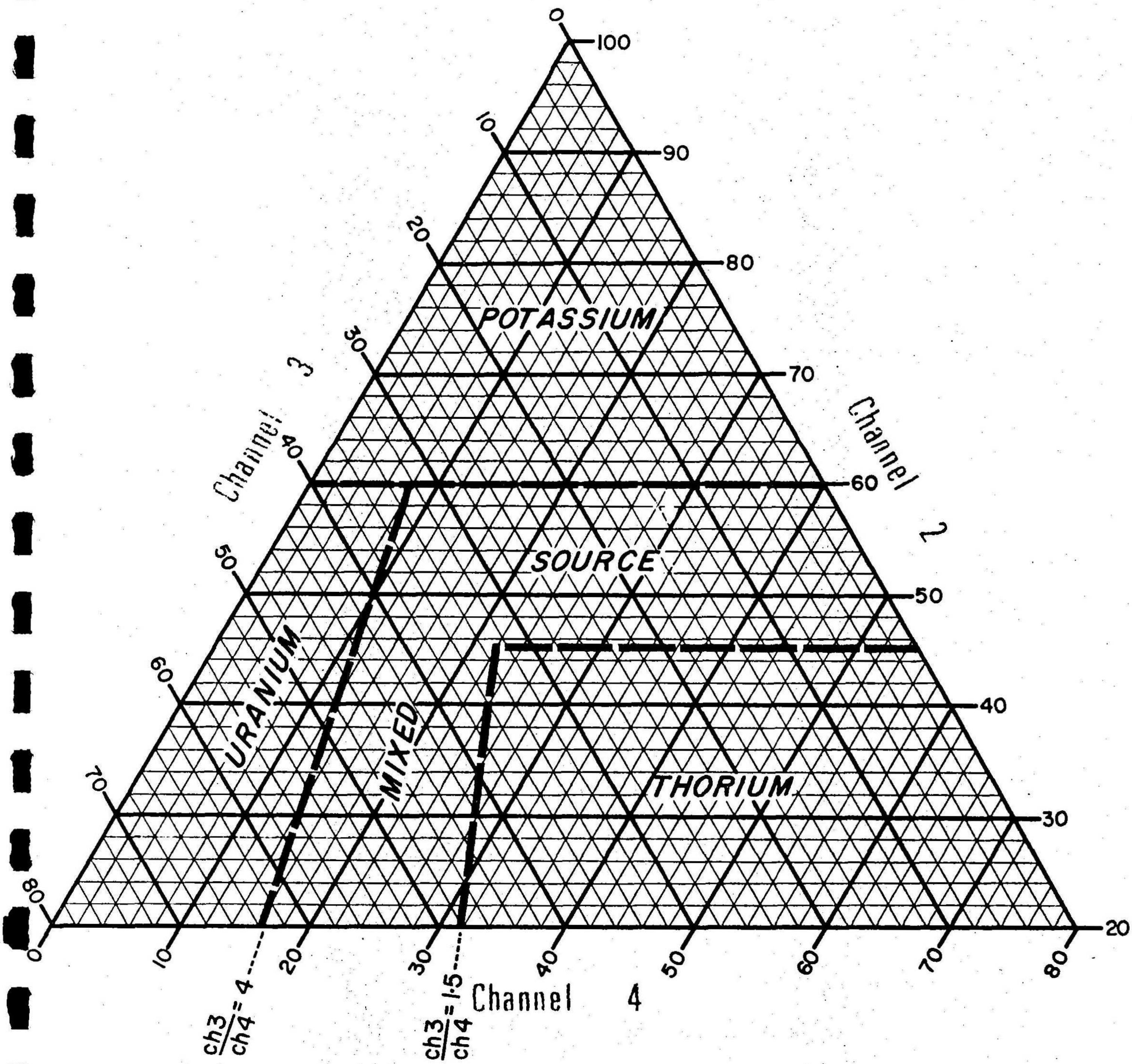


DIAGRAM TO ILLUSTRATE USE OF BACKGROUND TERMINOLOGY AS USED IN THIS RECORD



PERCENTAGE SUM DIAGRAM

clearance, as would be necessary before using equations (1), (2), and (3).

(c) The data have low statistical accuracy because of the low detector volume.

(d) Accurate values for the Compton Scattering coefficients are not known at present.

As comprehensive processing was not possible an alternative method of using triangular diagrams was used. In addition to providing useful visual displays it is also possible to derive approximate values for the Compton Scattering coefficients.

At various places in this Record the ch3/ch4 ratios have been converted to uranium-to-thorium ratios by means of the equation:

$$U/Th \simeq 0.5\ (ch3/ch4 - 0.70).$$

RESULTS - COBOURG PENINSULA (Pls. 3, 6)

The main radioactive zones in this area are covered by the 1:100 000 Sheets of Cape Don, Croker, Cobourg, and Wellington Range (Fig. 1). The only other Sheet with much land area is Murgenella, in which the radioactivity is low, as would be expected as it has extensive areas of marshland and very little outcrop. The most important results are as follows:

Correlation between thorium anomalies and areas of bauxitic laterite

Comparison of the Cobourg Peninsula-Melville Island geological map (1:250 000 scale) with a plot of radiometric anomalies shows a clear correlation between many of the thorium anomalies and areas of bauxitic laterite north of 11°15'S. The radiometric profile maps (1:100 000 scale) of Cape Don, Cobourg, and Croker show that in general the radioactivity increases towards the north. Figures 6 and 7 show the anomalies from these sheets plotted on triangular diagrams. These show that most of the anomalies fall well within the thorium area on the diagram. The following table shows the main numerical data for these anomalies.

Anomalies	Max. total-count amplitude counts/s	ch3/ch4 range	mean ch3/ch4
Northern mainland	200	0.7 - 1.5	1.1
Croker Island	150	0.7 - 1.4	1.0

The mean value of 1.0 to 1.1 for the ch3/ch4 ratio corresponds to a thorium-to-uranium ratio of about six. At the time of writing it is not known what causes the thorium anomalies or the reason for the correlation with the bauxitic laterite. It is possible that the thorium radioactivity could be due to the presence of zircon and/or monazite in the laterite.

XRF determinations of uranium and thorium content of samples from six sites on the coast gave uranium contents in the range less than 3 ppm up to 12 ppm (average about 5 ppm), and thorium contents in the range 35 to 54 ppm (average 42 ppm).

Anomalies in the Wellington Range area

A number of anomalously radioactive areas have been detected over the eastern part of the Wellington Range and adjacent areas. Radioactivity up to 260 counts/s (at anomaly 748/167) was recorded in the airborne data. Most of the anomalies in this area appear to be over Kombolgie Formation and are mainly due to thorium although a small number indicate mixed sources and potassium sources.

Anomaly 1456/164 was detected about 1 km north of the Black Rock uranium prospect. The prospect lies between lines 164 and 165 and was not detected by this survey. Anomaly 1456/164 indicated a thorium source with no anomalous uranium content.

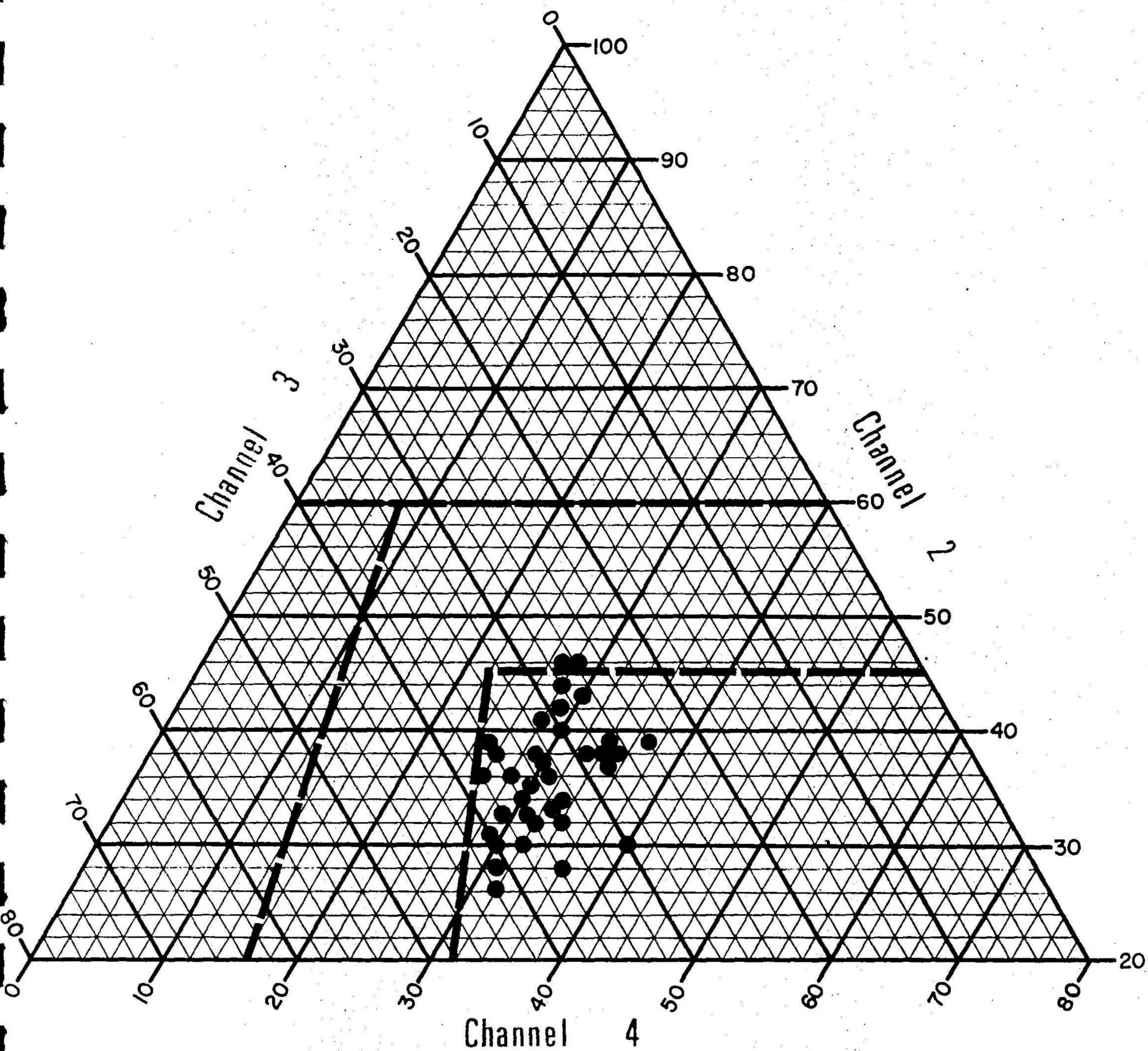
RESULTS - ALLIGATOR RIVER AND MOUNT EVELYN (Pls 5, 7)

Uranium anomalies

Anomalies have been classified as uranium anomalies if:

1. The ratio of the count-rate in the 'uranium channel' to that in the 'thorium channel' is four or greater; and

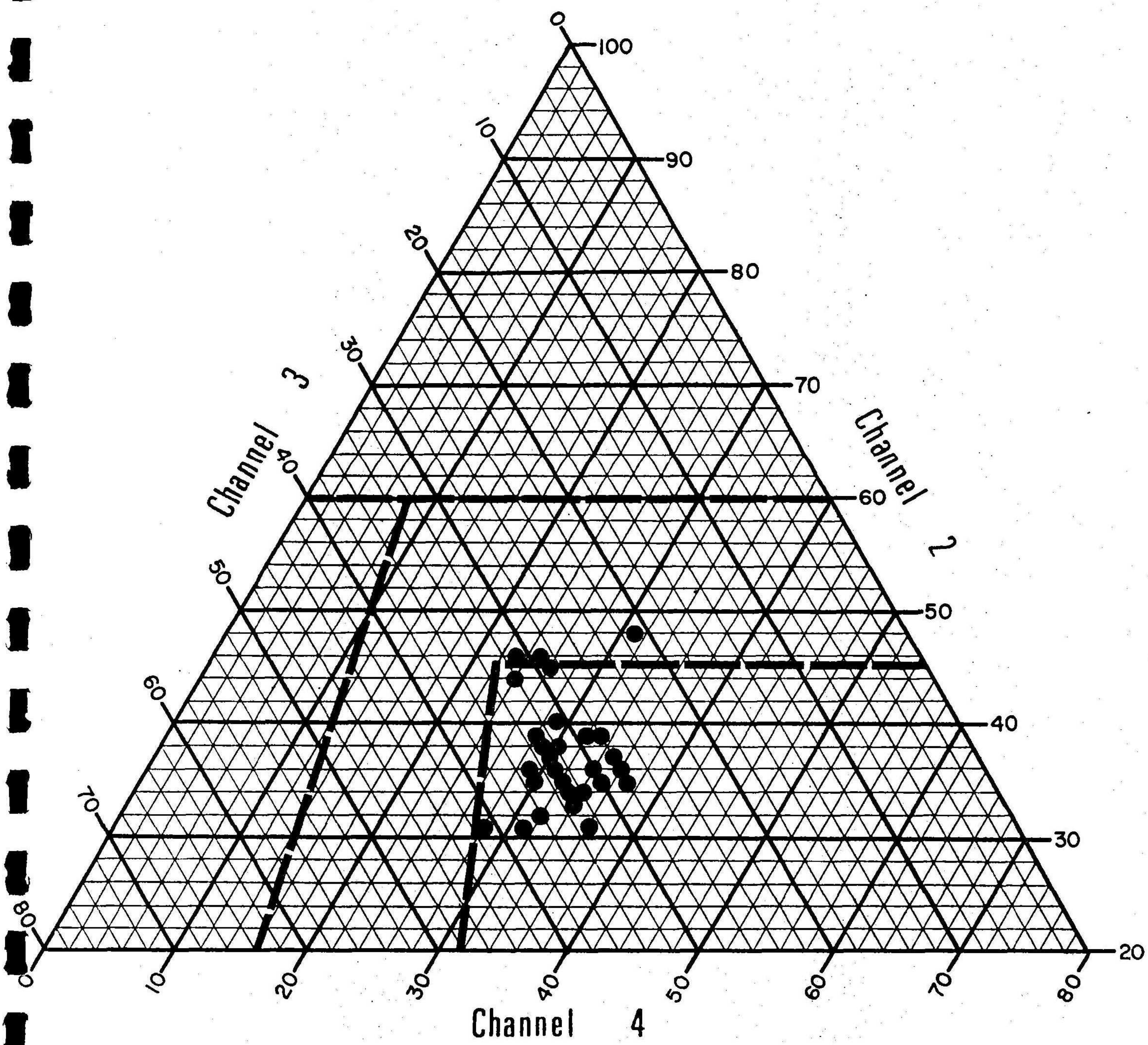
FIGURE 6



ANOMALIES OVER COBOURG PENINSULA
NORTHERN MAINLAND

(Based on G43-514A) *Record No. 1975/89* C53/B1-12A

FIGURE 7



ANOMALIES OVER CROKER ISLAND

2. Potassium is not the major contributor to the radioactivity.

With the above definition, 44 anomalies are classified in the uranium group. It should be noted that it is not possible from the airborne data alone to make any deductions about radioelement concentrations or areal extent of the sources of anomalies. The uranium anomalies are described in the following text in an order based on their location from north to south on the Alligator River and Mount Evelyn map sheets. Numerical and geological data together with copies of spectrometer records are given in Appendix 3.

Anomaly 2127/200.1. This is a high intensity anomaly (700 counts/s recorded over the Nabarlek uranium deposit of Queensland Mines Ltd. The anomaly is sharp and relatively narrow (half-height width = 8 seconds). The ch3/ch4 ratio is 14, which partly reflects the local geology in addition to the uranium mineralization. If allowance is made for the local geological background the ch3/ch4 ratio becomes about 20. The uranium indication was detected on only one flight-line, as would be expected as mineralization occurs over a strike length of only 270 m.

Anomaly 1595/206. This anomaly lies on flat ground about 4 km SSW from Cannon Hill airstrip. The source of the anomaly appears to be within sand overlying Kombolgie Formation. It is also close to a postulated extension of the Bulman Fault. The anomaly has an amplitude of 120 counts/s with a ch3/ch4 ratio of 4. The ch3/ch4 ratio of the surrounding area is about 2. This anomaly thus shows a local increase in the uranium-to-thorium ratio but is probably of little importance.

Anomalies 376/212, 370/216, 2063/217. These three anomalies are very similar and close together near the western boundary of the survey area. They are all of low intensity with total-count figures of less than 100 counts/s. They all appear to be located in Quaternary alluvium and to indicate minor local increases in the uranium-to-thorium ratio. It is considered unlikely that these anomalies are associated with mineralization.

Anomaly 1991/217. This low-intensity anomaly (90 counts/s) lies within the Munmarlary Mass of the Nanambu Complex. Only the Total-count and uranium channels show noticeable increases in count rate. The maximum ch3/ch4 ratio is low (4), but the anomaly probably warrants ground checking.

Anomaly 1055/215. This anomaly lies just inside the northern margin of the Magela Mass of the Nanambu Complex about 2 km east of the Ranger 4 prospect of Peko-EZ. The anomaly is of low intensity (90 counts/s) and has a ch3/ch4 ratio of about 6. The thorium channel count rate is very low (3 counts/s) hence the accuracy in determining the ch3/ch4 ratio is low; an error in measurement of $\pm$ 1 count/s in this channel would change the ratio from 4 to 8. The position - close to a prospect and close to the margin of the Complex - makes the anomaly worth further investigation. The position relative to the margin of the complex is important as most of the known uranium deposits and prospects lie within the outer zones of the migmatite complexes.

Anomaly 822/216. This anomaly is of very low intensity (40 counts/s) but has a high ch3/ch4 ratio of about 11. However, the thorium channel count rate is only 1 count/s and therefore the high ratio is suspect. The anomaly lies within Kombolgie Formation and adjacent to a large mass of Oenpelli Dolerite.

Anomaly 871/223. This anomaly was recorded over the 'Beatrice' uranium prospect of Queensland Mines Ltd. The total-count channel recorded 130 counts/s and channels 3 and 4 produced a ch3/ch4 ratio of 5. Drilling at this prospect failed to locate significant uranium mineralization at depth (de Ferranti, 1973).

Anomalies 1178/227.4, 1071/228.1, 1042/229, 645/230. These four anomalies were recorded over the Ranger 1 uranium deposit of Peko-Ez. The deposit was crossed by four flight-lines between Mount Brockman and Magela Creek, and one anomaly was recorded on each line. Anomalies 1178/227.4 and

1071/228.1 were particularly intense, with total-count values of 790 and 1460 counts/s respectively. Their ch3/ch4 ratios are about 15. If allowance is made for the local geological background the ch3/ch4 ratio is increased to over 20. Anomalies 1042/229 and 645/230 are less intense, with total-count values of 100 and 310 counts/s and ch3/ch4 ratios of 5 and 9 respectively.

Anomaly 2242/227. This anomaly lies near West Alligator River in the Kapalga area. The geological map (Pl. 4) shows this to be an area of Cainozoic cover with no outcrops. The anomaly is moderately intense (190 counts/s) and has a maximum ch3/ch4 ratio of 4. Over the surrounding area the ratio is about 1.5. The position of the maximum ch3/ch4 ratio is displaced from the total-count peak by about one fiducial (6 seconds).

Anomalies 1089/233 and 1616/238. Both these anomalies are located near Baroalba Creek, on the western side of Brockman Massif. Anomaly 1089/233 occurs in black soil about 2 km from the Kombolgie Formation; it is well defined and has a total-count intensity of 200 counts/s and a ch3/ch4 ratio of 16. It seems probable that the source of uranium in this anomaly is farther upstream, nearer to Brockman Massif. Anomaly 1616/238 is not as strong (100 counts/s), but this may have been due to the increased ground clearance as the aircraft would have been climbing to clear the Brockman Massif. Both these anomalies warrant further attention.

Anomalies 483/240 and 2822/241. Anomaly 2822/241 was recorded over the Koongarra uranium deposit of Noranda Australia. This anomaly shows well that, with the equipment and settings used in this survey, a uranium anomaly is characterised by:

(a) a high ch3/ch4 ratio.

(b) a ch2/ch3 ratio of about 1.

(c) a narrow, well defined anomaly in channels 1, 2, and 3.

This last characteristic is not always seen because the anomaly intensity can be markedly reduced by material overlying the source of radioactivity.

Anomaly 483/240 was recorded on the survey line to the north of Koongarra, and indicates that there may be more uranium close to the eastern side of Brockman Massif.

Anomalies 1682/238, 811/239, 827/239 and 2757/241. These four anomalies are on the top of the Arnhem Land Plateau and adjacent to an area of Nungbalgarri Volcanics. The anomalies are all of low intensity (less than 80 counts/s) but stand out quite distinctly above the low geological background of the Kombolgie Sandstone. The first three were visited in August 1973; Anomaly 1682/238 lies in a black soil area, and 811/239 and 827/239 within laterite. It is considered that the laterite is developed at the base of the Nungbalgarri Volcanic Member of the Kombolgie Formation. Ground measurements at these anomalies showed radioactivity up to 15 μR/h.

Anomalies 2147/248 and 1268/249. These two small anomalies are over and adjacent to a small outcrop of Masson Formation. Both show an increase in ch3/ch4 ratio from about 2.5 over the surrounding area to about 5 over the anomalies. However, the count rates in channel 4 are so low that these increases are of doubtful significance. For both anomalies the ch2/ch3 ratio is about 1.7.

Anomaly 1326/249. This very low-intensity anomaly (50 counts/s) would not have been selected except for its channel-3 response. It appears to be near or over an exposure of Koolpin Formation. The ch3/ch4 ratio is low (4) and this anomaly is probably of low significance.

Anomaly 557/251.1. This anomaly, on the Arnhem Land Plateau, was examined during August 1973 and found to be due to radioactivity in laterite probably developed at the base of the Nungbalgarri Volcanic Member. Ground measurements showed radioactivity up to 15 μR/h.

Anomalies 2980/255.3, 2984/255.3, 882/261.2, 898/261.2, 923/261.2, 1735/262.2, 1792/262.2, 1802/262.2, 1897/263.2, 1570/268.2, 758/269.2, 1389/273.2, 1405/273.2, 1409/273.2, 1414/273.2. This group of anomalies is situated high up on the Arnhem Land Plateau within the Kombolgie Formation in the southeast of the area. The anomalies recorded in the air were not particularly intense (up to 170 counts/s) but were distinctive above the very low background over the surrounding sandstone. Ten of them were visited during August 1973 and found to be associated with laterite. The radioactive laterite is developed down-slope from the base of a thin volcanic member within the Kombolgie Formation. This volcanic member was discovered during 1973 field work and is currently referred to as the Gilruth Volcanic Member. Photogeology and some brief field mapping indicate that all the anomalies in this group are within or near the laterite associated with the Gilruth Volcanic Member. This member is probably less than 5 m thick and consists of lateritized tuff and tuffaceous siltstone (Smart et al., 1974). Measurements on the ground showed radioactivity up to about 25 μR/h except for one anomaly (1570/268.2) where up to 170 μR/h was recorded. Airborne and ground measurements indicated high uranium-to-thorium ratios. Analysis of samples from this locality yielded 280 ppm uranium and 9 ppm thorium. The anomalies are thought to be only surface features and not of direct economic importance. If uranium is found in the laterite in significant concentrations it could assist the study of the original source or sources of uranium in the area.

Figure 8 is a triangular diagram showing all the anomalies associated with the volcanic members of the Kombolgie Formation. It shows all the anomalies (not just the uranium group) recorded over the areas where the latest BMR geological mapping shows outcrop of the Nungbalgarri and Gilruth Volcanic Members. The anomalies associated with the Nungbalgarri Volcanic Member are more widely distributed on the triangular diagram than those associated with the Gilruth Volcanic Member. The August 1973 field work indicated that many of the anomalies on top of the Arnhem Land Plateau are associated with laterites developed down-slope from the volcanic members rather than directly over them.

Anomaly 1287/273.2. This anomaly is located in the southeast of the Five Sisters Inlier which is an inlier of Fisher Creek Siltstone surrounded by Kombolgie Formation. The source of the anomaly is in phyllite of the Fisher Creek Siltstone. Ground measurements showed radioactivity up to about 55 μR/h. This anomaly coincides with a uranium prospect. Analysis of rock samples yielded 40 ppm uranium and 20 ppm thorium.

Anomaly 2203/264.2. This anomaly is apparently over a soil-covered or alluvial area about 1 km from Coirwong Creek. The geological map (Pl. 4) shows an outcrop of dolerite to the east and Koolpin Formation to the west. The anomaly was recorded for about 36 seconds along the flight-lines; this indicates that the radioactive zone is about 2 km wide. The count rates in channels 1, 2, and 3 are roughly twice those of the adjacent area, but the count rate in channel 4 is unchanged. This corresponds to a ch3/ch4 ratio increase from about 2 to 5.

Anomaly 1798/276.3. This anomaly is located in alluvial fill in the core of an eroded fold structure of Masson Formation. As it has low amplitude and involves only a minor increase in the uranium-to-thorium ratio, it is unlikely to be significant.

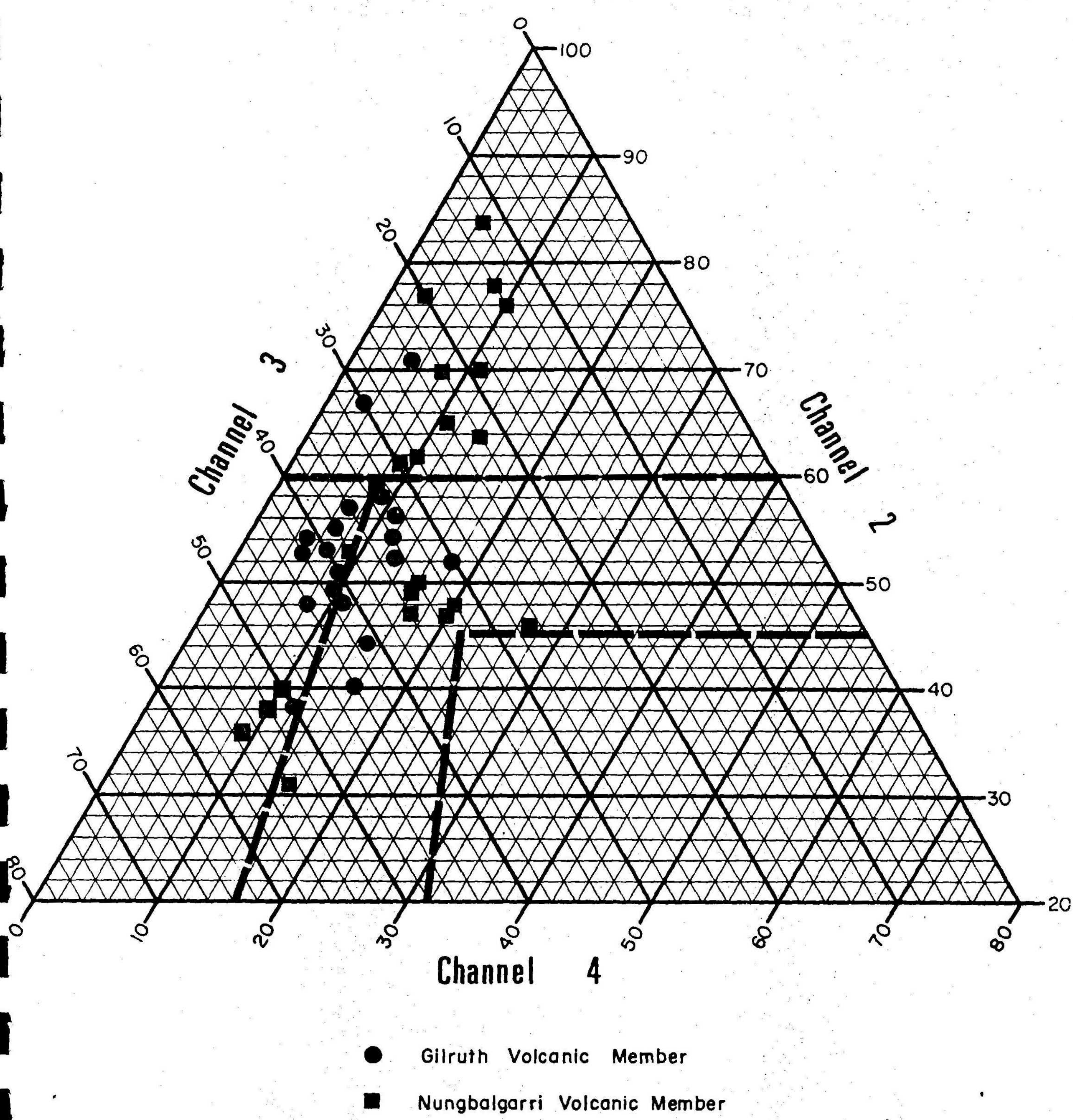
Anomaly 2052/286.2. This intense anomaly was recorded over the waste dump at Teagues uranium mine in the South Alligator Valley. The records went off scale in channels 1, 2, and 3; hence the amplitude was at least 600 counts/s in channel 1, and the ch3/ch4 ratio exceeded 3.5. Extrapolation of the records suggests that the total-count anomaly was about 1500 counts/s and the ch3/ch4 ratio about 6.

Radioactive granites

The granite masses in the area all display anomalous radioactivity. These granites are:

1. Cullen Granite
2. Jim Jim Granite

FIGURE 8



ANOMALIES ASSOCIATED WITH THE VOLCANIC MEMBERS OF THE KOMBOLGIE FORMATION

3. Jim Jim Granite (South), about 20 km south of the main mass
4. A granite 7 km east of Nabarlek which is here referred to as the 'Nabarlek Granite'
5. Three granite masses which crop out 7 km east of Myra Falls, 8 km southeast of Myra Falls, and about 23 km south of Myra Falls. These are referred to here as the 'Tin Camp Granites'

The granites listed under 4 and 5 are not shown in the earlier mapping (Dunn, 1962), but are included in the preliminary geological maps produced by the Alligator River Geological Party (1971-1973). Similarly the names 'Nabarlek Granite' and 'Tin Camp Granites' have not yet been formally accepted.

Table 1 shows the main numerical data for these granites. Figures 9 and 10 display the various anomalies on triangular diagrams. The main conclusions are as follows:

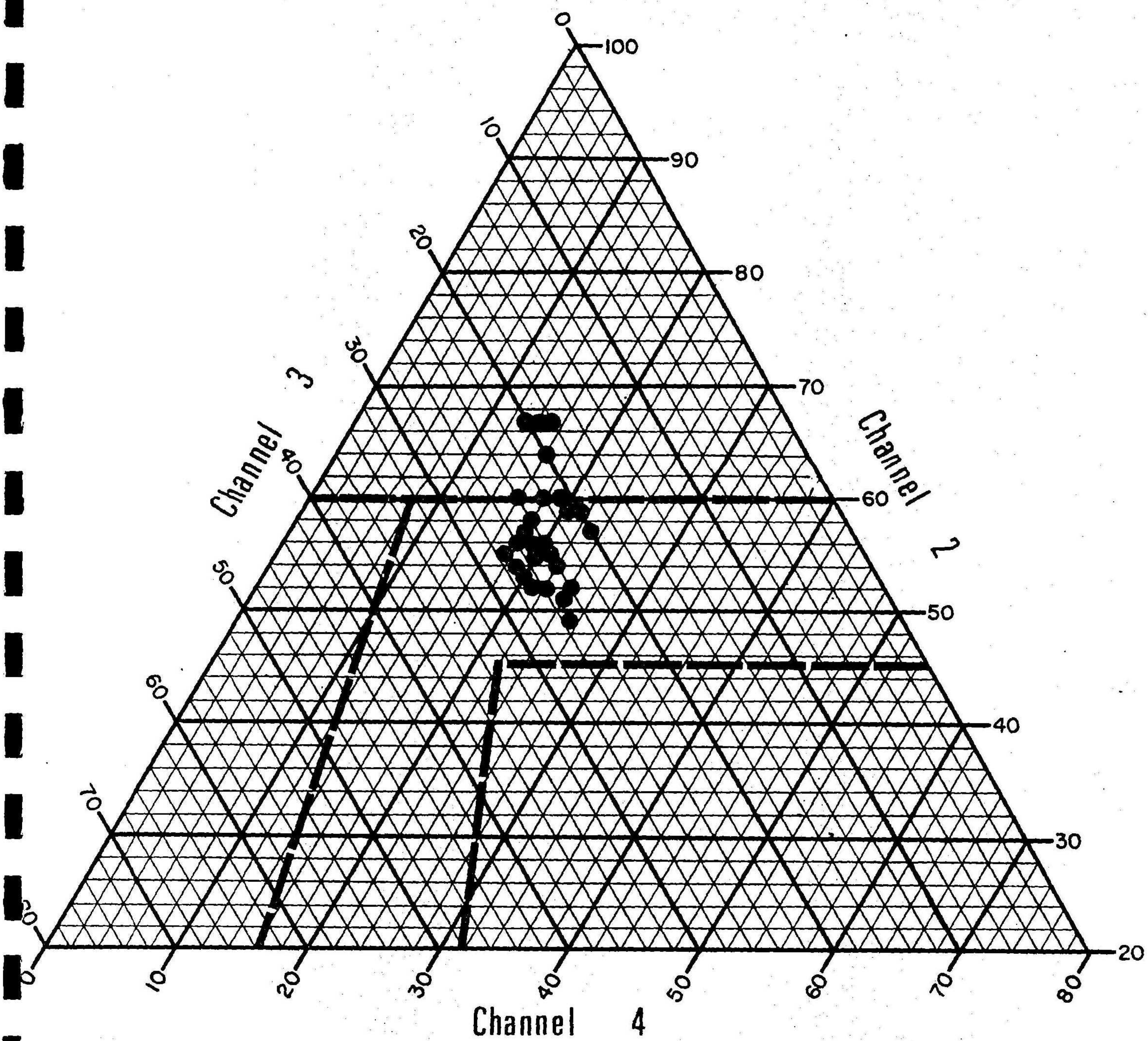
1. Cullen granite, of which only the northeastern part was covered by this survey, displays the highest radioactivity of any of the granites. It also appears to have the highest potassium content. The mean ch3/ch4 ratio corresponds to a thorium-to-uranium ratio of about four. Heier & Rhodes (1966) made laboratory gamma-ray analyses of rocks from the Cullen Granite. They reported that the uranium content was up to 12 ppm, thorium content up to 47 ppm and potassium up to 4.7 percent. The thorium-to-uranium ratios were in the range 3 to 13. The 1971-1972 airborne work showed that the highest radioactivity occurs over the outer part of the granite.
2. The airborne radiometric data from Jim Jim Granite and the granite 20 km south of it are very similar, both in total-count intensity and in source type. This latter granite is regarded as a southern extension of Jim Jim Granite and is here referred to as Jim Jim Granite south. A small number of ground measurements on each

TABLE 1 NUMERICAL DATA FOR ANOMALIES OVER GRANITES

Granite	Max. total-count intensity (counts/s)	Percentage sums: Channel 2 Range	Channel 2 Mean	Channel 3 Range	Channel 3 Mean	Channel 4 Range	Channel 4 Mean	ch3/ch4 Mean
Cullen (northeastern part)	450	49-67	56	18-27	24	13-26	20	1.2
Jim Jim	260	39-63	51	19-32	25	14-35	24	1.05
Jim Jim (south)	230	45-52	51	22-31	26	22-24	23	1.15
'Nabarlek' *	290	42-56	49	20-27	25	22-31	26	1.00
'Tin Camp' * north	300	53-55	54	28	28	17-19	18	1.55
south	150	43-47	45	33-37	35	19-21	20	1.75

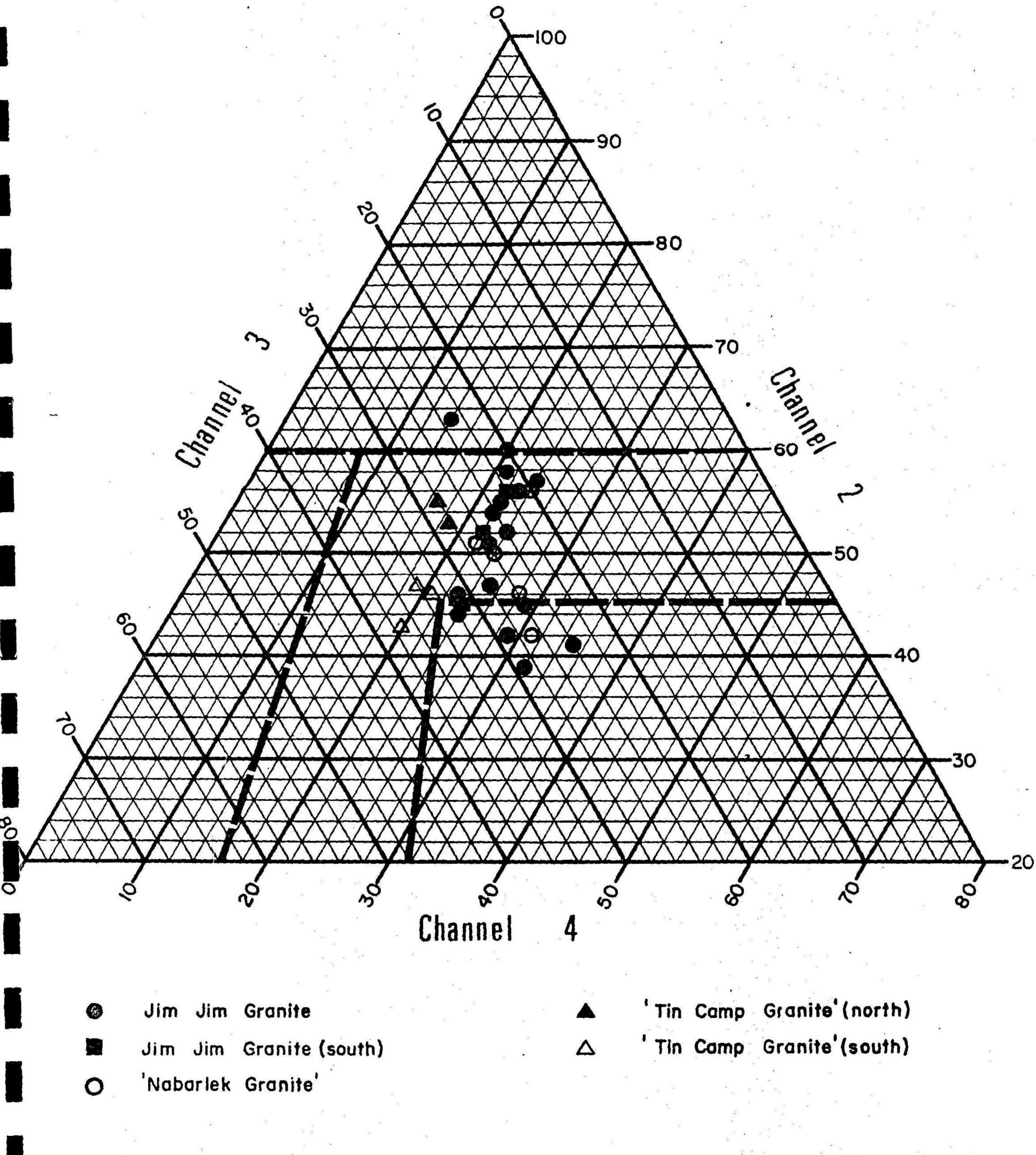
* Name not yet approved

FIGURE 9



ANOMALIES OVER CULLEN GRANITE

(Based on G43-514A) *Record No. 1975/89* D53/B1-34A



ANOMALIES OVER RADIOACTIVE GRANITES EXCLUDING CULLEN GRANITE

granite were made in 1973 and indicated radioactivity up to about 22 μR/h.

3. The results from the 'Nabarlek Granite' are very similar to those recorded over the Jim Jim Granite. The airborne data indicated thorium-to-uranium ratios of about six.

4. The three areas of outcropping 'Tin Camp Granite' seem to be somewhat different, both from each other and from the other granites. The two northern areas of outcrop seem to have higher potassium contents and higher thorium-to-uranium ratios than the southern area. The thorium-to-uranium ratios (about 2) over these granites are lower than those observed over the other granites. However, as the areal extent of outcropping 'Tin Camp Granite' is relatively small, these conclusions are based on a very limited amount of airborne data and should be treated with caution until any further work is done.

Mount Basedow

Radioactivity over Mount Basedow was detected by the 1957 BMR airborne survey (Livingstone, 1958). That survey showed a number of anomalous areas associated with the Mount Basedow range. Radiometric assays of rock samples taken from several of these areas indicated up to 0.03% U_3O_8. It was concluded that both uranium and thorium were present. The 1971-1972 survey indicated that the uranium content was low compared to thorium particularly at the southern end of the range. At the northern end the ratio is higher but here the radioactivity is predominantly due to potassium. The highest radioactivity recorded was 770 counts/s at anomaly 363/251.2. It is thought that the radioactivity is due to potassium and thorium in arkose and conglomerate of the Mount Partridge Formation.

Spring Peak

The 1957 BMR survey detected four anoamlies in the vicinity of Spring Peak. One of these was in an area where thorium-bearing arkose of the Mount Partridge Formation had previously been found, and from this it was inferred that all four anomalies were due to thorium. Interpretation of the 1971-1972 data suggests, however, that most of the radioactivity is due to potassium. The highest radioactivity recorded was 160 counts/s.

Groups of thorium anomalies

There are four main areas where thorium is the major contributor to the radioactivity. These are:

1. About 20 km northeast of Oenpelli Mission. This group is probably due to laterite.
2. In and adjacent to the northwestern part of the Magela Mass of the Nanambu Complex (Magnetic zone 12 Pl. 5).
3. About 10 km west and 15 km southwest of Mount Basedow, in Lower Proterozoic sediments.
4. In the southeast corner of the area, in sandstone and conglomerate of the Mullaman Beds.

Numerical data for these anomalies are shown in Table 2. Figure 11 is a triangular diagram showing anomalies from area 4. Of the four areas, area 4 has the highest radioactivity (up to 250 counts/s) and the highest thorium-to-uranium ratio (about 5).

South Alligator Valley and area to the northwest

Radiometric profiles across the Mundogie 1:100 000 Sheet area show a number of anomalous areas. These include the Cullen Granite (described above) and anomalies over outcrops of the following geological units:

(a) The Plum Tree Volcanic Member; east and southeast of Goodparla Homestead. (Anomalies 385/285.2; 2098/286.2; 1417/287.2; 1425/287.2)

(b) Fisher Creek Siltstone; on the east bank of the South Alligator River. (Anomalies 1090/273.2; 3094.274.2; 2416/275.2).

(c) Gerowie Chert; one area between Gerowie Creek and the South Alligator River (Anomalies 2406/275.2; 1766/276.3; 1768/276.3; 1775/276.3; 1085/277.3;

TABLE 2 NUMERICAL DATA FOR VARIOUS GROUPS OF THORIUM ANOMALIES

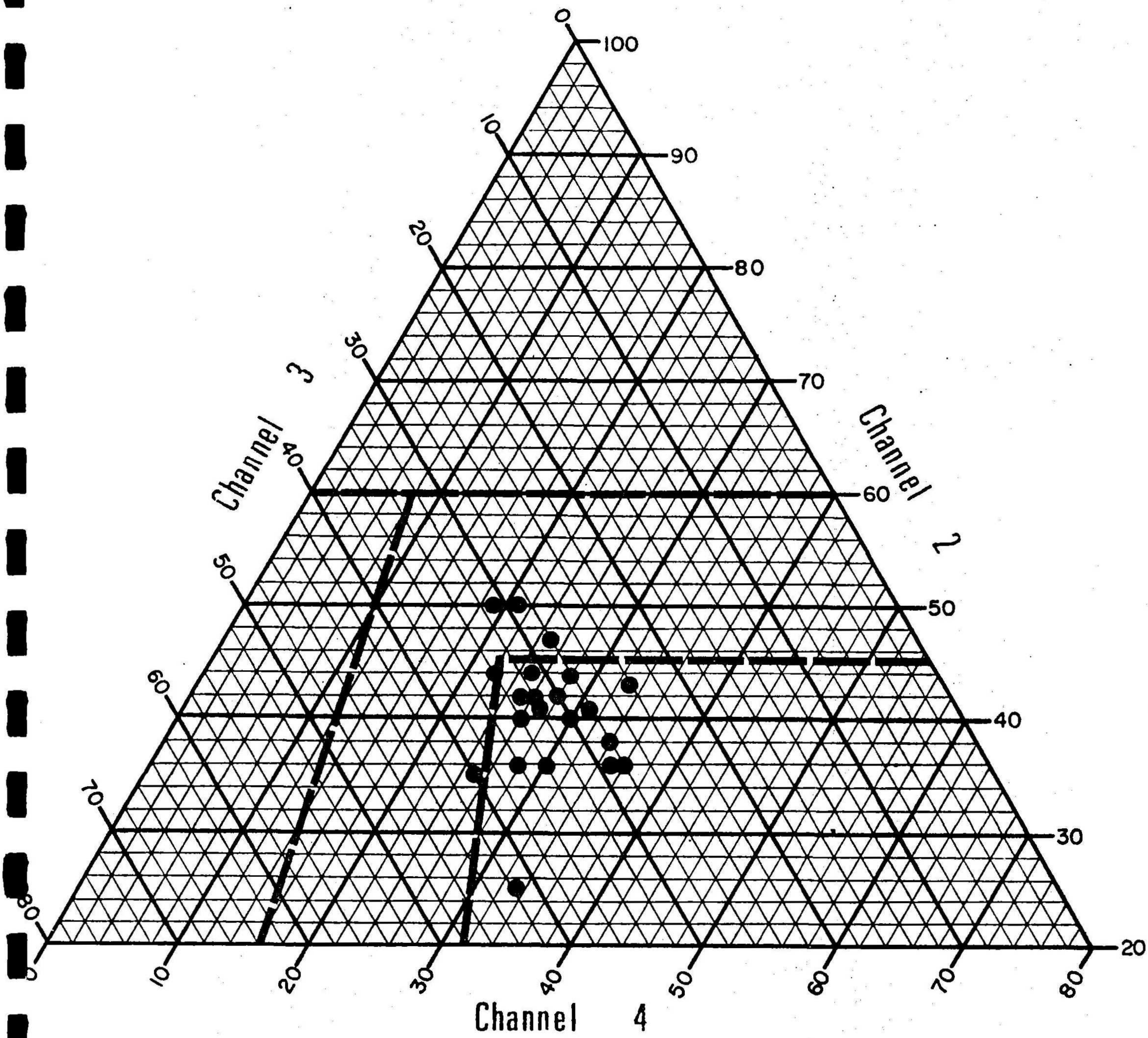
Area	Max. total-count intensity (counts/s)	Percentage sums						Mean ch3/ch4	Number of anomalies
		Channel 2		Channel 3		Channel 4			
		Range	Mean	Range	Mean	Range	Mean		
1	160	32-57	45	27-36	32	19-29	23	1.4	13
2	210	34-48	42	26-41	34	19-28	24	1.4	13
3	210	32-49	41	26-39	32	21-30	27	1.2	13
4	250	25-50	41	24-42	31	19-36	28	1.1	22

2231/278.2; 843/279.2); one area near Coirwong (Anomalies 2203/263.2; 2218/264.2; 2981/265.2; 2987/265.2; 2205/266.2; 2210/266.2).

(d) Koolpin Formation; in the Coirwong area (Anomalies 1162/252.1; 685/256.2; 688/256.2; 3422/257.3; 1195/261.2; 1198/261.2; 1405/262.2).

(e) Masson Formation; 18 km northwest of Coirwong (Anomalies 663/256.2; 3446/257.3; 3450/257.3; 1650/258.2; 1659/258.2); and two anomalies north of Namoona (1942/272.2 and 1948/272.2).

(f) Zamu Complex dolerite: anomaly 1078/277.3. Numerical data for these anomalies are summarized in table 3. Most of these anomalies are classified as mixed-source or potassium anomalies. The ch3/ch4 ratios are generally low. The highest mean ch3/ch4 ratio is 1.7 for anomalies in the Koolpin Formation. This corresponds to a thorium-to-uranium ratio of approximately 2.



ANOMALIES OVER THE MULLAMAN BEDS - GILRUTH AREA

TABLE 3 NUMERICAL DATA FOR VARIOUS ANOMALIES IN SOUTH ALLIGATOR VALLEY AND ADJACENT AREA

Geological unit	Max. total-count intensity (counts/s)	Percentage sums						Mean ch3/ch4
		Channel 2		Channel 3		Channel 4		
		Range	Mean	Range	Mean	Range	Mean	
Plum Tree Volcanic Member	230	57-67	61	17-28	23	13-19	16	1.4
Fisher Creek Siltstone	190	60-69	64	18-25	21	11-21	15	1.4
Gerowie Chert								
at Gerowie Creek	190	59-64	61	19-26	23	13-19	16	1.4
at Coirwong	180	48-66	58	17-32	24	16-22	18	1.3
Koolpin Formation	160	42-66	51	22-37	31	12-23	18	1.7
Masson Formation	210	51-69	58	19-35	25	12-20	17	1.5

6. CONCLUSIONS AND RECOMMENDATIONS

Many of the magnetic anomalies are of shallow or surface origin, and their correlation with geological units has been helpful in tracing these units below the extensive overburden which covers most of the area west and north of the Arnhem Land Plateau escarpment. The more magnetic of the geological units appear to be the Stag Creek Volcanics, Zamu Complex dolerite, Koolpin Formation equivalent, and Oenpelli Dolerite.

The magnetic data show that the Nanambu Complex is only weakly magnetic (anomalies generally less than 30 nT). The complex is surrounded by rocks of the Koolpin Formation equivalent and locally by Oenpelli Dolerite, both of which have stronger magnetic expression (anomalies up to 300 nT). Mapping these magnetic features permits indirect interpretation of parts of the margins of the complex. Magnetic interpretation has also indicated the likelihood of two further areas of Nanambu Complex north of the main ones, and this has been confirmed by drilling. The Nimbuwah Complex, however, has a very variable and complex magnetic expression, and its extent seems impossible to determine from the magnetic and radiometric data.

The Koolpin Formation equivalent has a very variable magnetic expression with anomaly amplitudes ranging from less than 10 nT (in the Myra Falls Inlier) to possibly as high as 300 nT (west of Koongarra).

Dolerite appears to be much more widespread than originally mapped. Magnetic anomalies are associated with both the Zamu Complex dolerite and the Oenpelli Dolerite. Interpretation of the magnetic data indicates that many of the surface exposures are parts of larger continuous bodies in the subsurface.

The airborne radiometric results have identified areas of above-average radioactivity, and provided an indication of the predominant sources of the radioactivity, i.e. whether due to uranium, thorium, or potassium.

The radiometric anomalies of highest amplitude were recorded over three of the major uranium deposits (Ranger 1, Nabarlek, and Koongarra), various uranium prospects, granite masses, and Mount Basedow (Mount Partridge Formation). The BMR survey did not fly directly over the Jabiluka uranium deposit, which appears to have been too far from the nearest line to be detectable.

Forty-five anomalies have been classified as 'uranium anomalies'. For this purpose a uranium anomaly was defined as one where the channel 3/channel 4 ratio was 4 or greater and potassium was not the major source. This value of channel 3/channel 4 ratio corresponds to a uranium-to-thorium ratio of about 1.6 assuming equilibrium in both the uranium and thorium decay series. The principal host rocks for the 'uranium anomalies' are Nanambu Complex, Nimbuwah Complex, Koolpin Formation equivalent, Mount Partridge Formation, and laterite associated with the volcanic members of the Kombolgie Formation.

All the granite masses are anomalously radioactive, potassium and thorium being the major sources. Similarly the high radioactivity of Mount Basedow is due mainly to potassium and thorium.

The sandstone of the Kombolgie Formation is very low in radioactivity. But laterites developed down-slope from the Nungbalgarri Volcanic Member and the Gilruth Volcanic Member are somewhat radioactive with moderately high uranium-to-thorium ratios. Laterites associated with the Gilruth Volcanic Member have generally higher uranium-to-thorium ratios than laterites associated with the Nungbalgarri Volcanic Member. It is considered likely, however, that these are only surface features and that the uranium has been concentrated in the laterite.

On Cobourg Peninsula good correlation exists between areas of bauxitic laterite and thorium enrichment. The thorium concentrations are high enough (up to 54 ppm in samples from six coastal sites) to be detectable in the radiometric measurements.

7. REFERENCES

DE FERRANTI, R.Z., 1973 - Aust. Miner. Ind. Ann. Rev. 1971.

DUNN, P.R., 1962 - Alligator River, NT - 1:250 000 Geological Series. Bur. Miner. Resour. Aust. explan. Notes SD/53-1.

FLINDERS PETROLEUM N.L., 1969 - Van Diemen Gulf aeromagnetometer survey OP-167 Northern Territory by Compagnie General du Geophysique. Bur. Miner. Resour. Aust. Petrol Search Subs. Acts Rep. (unpubl.)

GOODEVE, P.E., 1966 - Darwin/Pine Creek contract aeromagnetic survey 1963. Bur. Miner. Resour. Aust. Rec. 1966/101. (unpubl.)

GRASTY, R.L., & DARNLEY, A.G., 1971 - The calibration of gamma-ray spectrometers for ground and airborne use Geol. Survey of Canada Paper 71-17.

HEIER, K.S. & RHODES, J.M., 1966 - Thorium, uranium and potassium concentrations in granites and gneisses of the Rum Jungle Complex, N.T., Australia. Econ. Geol., 61 (3), 563-571.

HUGHES, R.J. & SENIOR, B.R., 1973 - Progress report on the geology of the Bathurst Island, Melville Island, Cobourg Peninsula and Fog Bay 1:250 000 Sheet areas, N.T. Bur. Miner. Resour. Aust. Rec. 1973/52 (unpubl.).

HUGHES, R.J., 1973 - Stratigraphic drilling, Cobourg Peninsula 1:250 000 Sheet area, N.T. Bur. Miner. Resour. Aust. Rec. 1973/196 (unpubl.).

KOULOMZINE, T.H., LAMONTAGNE, Y., & NADEAU, A., 1970 - New methods for the direct interpretation of magnetic anomalies caused by inclined dykes of infinite length. Geophysics, 34 (5), 812-830.

LIVINGSTONE, D.F., 1958 - Airborne radiometric survey of the South Alligator River region, N.T. Bur. Miner. Resour. Aust. Rec. 1958/70 (unpubl.).

NEEDHAM, R.S., 1974 - Recent Geological work in the Rum Jungle/Alligator Rivers Uranium Province, N.T. Abstract in - BMR Symposium, Canberra 30 April - 1 May, 1974: Abstracts - Bur. Miner. Resour. Aust. Rec 1974/35 .

NEEDHAM, R.S., & SMART, P.G., 1972 - Progress report of the Alligator River party, N.T. 1971. Bur. Miner. Resour. Aust. Rec. 1972/1 (unpubl.).

NEEDHAM, R.S., WILKES, P.G., SMART, P.G., and WATCHMAN, A.L., 1973 - Alligator Rivers region environmental fact-finding study. Geological and Geophysical Reports. Bur. Miner. Resour. Aust. Rec. 1973/208 (unpubl.).

NEEDHAM, R.S., SMART, P.G., & WATCHMAN, A.L., 1975a - Alligator River party N.T. Progress report, 1972 - Oenpelli Region. Bur. Miner. Resour. Aust. Rec. 1975/39 (unpubl.).

NEEDHAM, R.S., SMART, P.G., & WATCHMAN, A.L., 1975b - Alligator River Party N.T. Progress report, 1972 - Jim Jim Region. Bur. Miner. Resour. Aust. Rec. 1975/31 (unpubl.).

SENIOR, B.R., & SMART, P.G., 1974 - Explanatory notes of the Cobourg Peninsula and part Melville Island 1:250 000 sheet area (in press)

SHELL DEVELOPMENT (AUSTRALIA) PTY. LTD., 1965 - Report on airborne magnetometer survey over the Arafura Sea, Northern Australia. (O.P. 8, O.P. 86, O.P. 96, O.P. 127, O.P. 128) by Adastra Hunting Geophysics Pty Ltd. Bur. Miner. Resour. Aust. Petrol. Search Subs. Acts Report (unpubl.).

SMART, P.G., WILKES, P.G., NEEDHAM, R.S., & WATCHMAN, A.L., 1975 - The Geology and Geophysics of the Alligator Rivers region. A.I.M.M. Metals Volume (in press).

TIPPER AND FINNEY 1966 - Mount Masson Detailed Aeromagnetic Survey N.T. 1965. Bur. Miner. Resour. Aust. Rec. 1966/91 (unpubl.).

WALPOLE, B.P., 1962 - Mount Evelyn 1:250 000 Explan. Notes.

WALPOLE, B.P. CROHN, P.W., DUNN, P.R., & RANDAL, M.A. 1968 - Geology of the Katherine - Darwin Region, Northern Territory. Bur. Miner. Resour. Aust. Bull. 82, V. 1-2.

WHITWORTH, R., 1970 - Reconnaissance Gravity Survey of Part of Northern Territory and Western Australia, 1967. Bur. Miner. Resour. Aust. Rec. 1970/15. (unpubl.).

APPENDIX 1

STRATIGRAPHY OF THE COBOURG PENINSULA 1:250 000 SHEET AREA

(Adapted from Senior & Smart (1974))

Age	Rock unit	Maximum thickness (metres)	Lithology
Cainozoic			Sand, soil, silt, alluvium. Ferruginous to bauxitic pisolitic laterite. Coquina, calcarenite, minor conglomerate.
Upper Cretaceous	Bathurst Island Formation		Mainly sublabile sandstone, siltstone, and mudstone calcareous in part (lateritized in outcrop).
	Moonkinu Member	50	Sublabile sandstone, carbonaceous siltstone.
	Wangarlu Member	220	Mudstone, siltstone, minor sublabile sandstone, scattered nodular pyrite.
	Marligur Member	70	Quartzose sandstone, siltstone, and mudstone, micaceous and sparsely fossiliferous.
Carpentarian	Kombolgie Formation	250	Cross-bedded quartzose sandstone. Basal conglomerate beds of quartzite and vein quartz clasts.
Lower Proterozoic	Oenpelli Dolerite	10	Dolerite.
	Nimbuwah Complex		Granitoid and gneissic migmatite of granitic to granodioritic composition; lit-par-lit gneiss, amphibolite, minor schist, and quartzite.

APPENDIX 2

STRATIGRAPHY OF THE ALLIGATOR RIVER AND MOUNT EVELYN (NORTHERN HALF) 1:250 000 SHEET AREAS

(Adapted from Walpole (1962) and Needham (1974))

	Rock unit	Maximum thickness (metres)	Lithology	Remarks
Cainozoic	Alluvium		Soil, river and estuarine alluvial deposits	
	Superficial deposits		Laterite, sand, rubble, soil,and ferruginous deposits	
Lower Cretaceous	Mullaman Beds	60	Lateritized sandstone, conglomerate, and shale.	Flat-lying. Unconformably overlies Kombolgie Formation and Nimbuwah Complex
Adelaidean	Mudginberri and Maningkorrirr Phonolites	1.5	Phonolites and trachytic differentiates	Randomly oriented dyke swarms
Carpentarian	Kombolgie Formation	1600	Fair to poorly sorted coarse quartz sandstone, clayey sandstone, conglomerate, thin siltstone bands. Intercalated volcanics.	Maximum thickness 500 metres, north of 13°15'S
	*Gilruth Volcanic Member	3	Amygdaloidal basalt, tuff, tuffaceous siltstone, jasper.	
	Nungbalgarri Volcanic Member	60	Basalt flows, amygdaloidal, minor interbedded sediments.	
	Plum Tree Volcanic Member	350	Andesite, rhyolite, and dacite.	
	Kurrundie Member	130	Quartz greywacke with pebbles and bands of quartz conglomerate.	
Lower Proterozoic	? Edith River Volcanics	1200	Rhyolite, dacite, tuff.	
	? Cullen Granite		Biotite-hornblende granite	Anomalously radioactive

* Informal name

	Rock unit	Maximum thickness (metres)	Lithology	Remarks
Lower Proterozoic	?Jim Jim, *Nabarlek and *Tin Camp Granites		Altered biotite granite	Anatectic granites. Anomalously radioactive.
	*Oenpelli Dolerite	300	Differentiated dolerite sill, minor ophitic gabbro, gabbro pegmatite, and chilled margin.	
	Nimbuwah Complex		Granitoid and gneissic migmatite of granitic to granodioritic composition; lit-par-lit gneiss, amphibolite, minor schist and quartzite.	Predominantly migmatized Lower Proterozoic sediments.
	Nanambu Complex		Leucocratic granite and gneiss with minor schist, mantled by schist, gneiss, and quartzite.	Large core of partly migmatized Archaean crystalline rock surrounded by migmatized Lower Proterozoic sediments, predominantly Koolpin Formation equivalent.
	Zamu Complex		Dolerite and gabbro with diorite and syenite differentiates. Metamorphosed to metadolerite and amphibolite north of Graveside Gorge.	Numerous sills, folded to give appearance of NW trending dyke swarm.
South Alligator Group				
	Fisher Creek Siltstone	7000+	Siltstone, minor arenaceous siltstone. Metamorphosed to phyllite north of Graveside Gorge and schist north of Jim Jim Creek.	Transitionally overlies Koolpin Formation and Koolpin Formation equivalent.
	*Koolpin Formation equivalent	6000	Quartz mica schist, chlorite schist, carbonaceous schist, amphibolite.	Associated with uranium mineralization. Lateral equivalent of Koolpin Formation.

*Informal name.

APPENDIX 3

URANIUM ANOMALIES:

NUMERICAL DATA

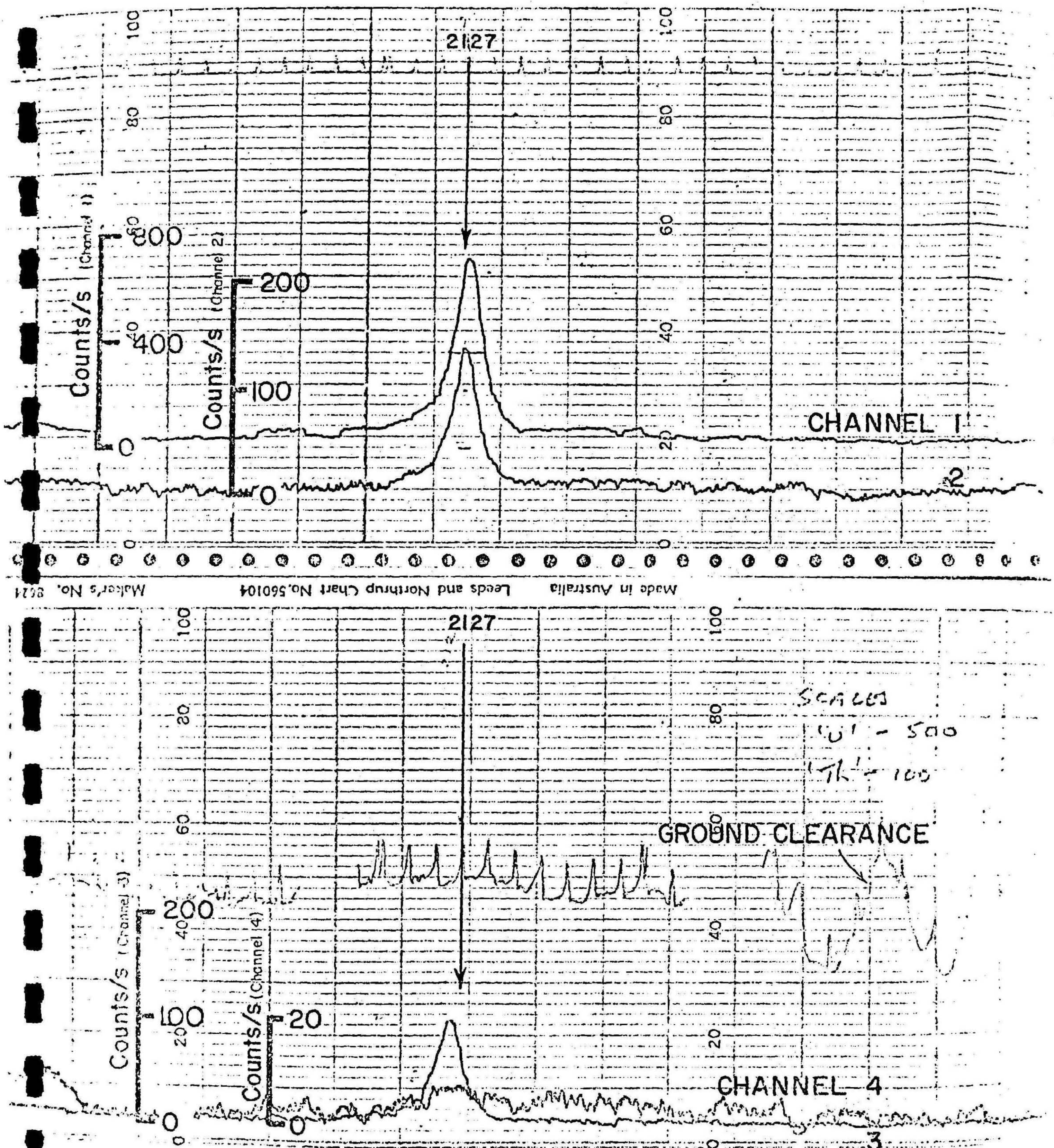
AND COPIES OF RADIOMETRIC RECORDS

Anomaly	Channel 1		Channel 2		Channel 3		Channel 4		Percentage sums			Geology and comments
	Max	b/g	Max	b/g	Max	b/g	Max	b/g	CH2	CH3	CH4	
1636/132.1	70	-	10	-	12	-	3	-	40	48	12	Quaternary alluvium
2127/200.1	700	20	136	6	101	4	8	3	56	41	3	Nabarlek uranium deposit Nimbuwah Complex.
1595/206	120	40	22	8	17	9	4	4	51	39	10	Koolpin Formation equivalent?
376/212	130	60	28	14	22	10	5	4	51	29	20	Quaternary alluvium
370/216	70	-	16	4	12	-	3	-	52	39	9	" " (close to outcrop of Mount Partridge Formation)
2063/217	90	30	20	6	13	-	3	-	55	37	8	" " "
1991/217	90	50	16	12	15	2	4	4	46	43	11	Nanambu Complex
1055/215	90	10	12	-	16	3	3	-	39	52	9	Nanambu Complex
822/216	40	30	8	6	12	4	1	1	38	57	5	Kombolgie Formation
871/223	130	40	26	6	15	4	3	2	59	34	7	Beatrice uranium prospect Nimbuwah Complex.
1178/227.4	790	40	146	8	116	5	7	4	54	43	3)	
1071/228.1	1460	40	271	8	221	5	14	4	53	44	3)	Ranger 1 uranium deposit
1042/229	100	30	36	8	15	5	3	3	67	28	5)	Koolpin Formation equivalent
645/230	310	40	56	8	50	6	5	3	50	45	5)	
2242/227	190	50	32	10	22	6	5	4	54	37	9	Quaternary alluvium
1089/233	200	40	44	8	38	5	3	2	52	45	3	Nanambu Complex

Anomaly	Channel 1 Max	Channel 1 b/g	Channel 2 Max	Channel 2 b/g	Channel 3 Max	Channel 3 b/g	Channel 4 Max	Channel 4 b/g	Percentage sums CH2	Percentage sums CH3	Percentage sums CH4	Geology and comments
1616/238	100	30	12	4	12	3	2	2	46	46	8	Koolpin Formation equivalent?
483/240	120	10	24	4	16	1	2	-	57	38	5	" " "
2822/241	345	40	60	10	56	5	5	4	50	46	4	Koongarra Uranium deposit. Koolpin Formation equivalent
1682/238	40	20	8	2	12	2	2	2	36	55	9	Kombolgie Formation (close to Nungbalgarri Volcanic Member)
811/239	40	10	18	2	13	1	3	-	53	38	9	" "
827/239	55	10	8	-	11	4	2	-	38	52	10	" "
2757/241	70	-	16	-	9	-	2	-	59	33	8	" "
2147/248	150	100	34	10	19	10	4	4	60	33	7	Masson Formation
1268/249	130	80	32	20	20	12	5	5	56	35	9	" "
1326/249	50	50	10	6	15	6	4	4	35	52	13	Koolpin Formation
557/251.1	40	20	8	2	14	4	4	2	31	54	15	Kombolgie Formation (close to Nungbalgarri Volcanic Member)
2980/255.3	80	20	16	6	11	3	2	1	55	38	7	Kombolgie Formation (close to Gilruth Volcanic Member)
2984/255.3	90	20	14	6	8	3	2	1	58	33	9	" "

Anomaly	Channel 1		Channel 2		Channel 3		Channel 4		Percentage sums			Geology and comments
	Max	b/g	Max	b/g	Max	b/g	Max	b/g	CH2	CH3	CH4	
882/261.2	100	30	18	6	15	3	4	1	48	41	11	Kombolgie Formation (close to Gilruth Volcanic Member)
898/261.2	70	10	6	4	8	1	2	1	38	50	12	" "
923/261.2	120	30	24	6	17	6	4	2	53	38	9	" "
1735/262.2	170	40	22	4	17	3	4	2	51	40	9	" "
1792/262.2	130	50	22	4	17	7	4	4	51	40	9	" "
1802/262.2	130	30	20	4	15	4	2	2	54	41	5	" "
1897/263.2	150	40	26	6	24	5	4	2	48	44	4	" "
1570/268.2	50	10	10	2	8	2	1	1	53	42	5	" "
758/269.2	110	20	20	4	16	3	2	2	53	42	5	" "
1389/273.2	90	20	26	4	9	1	2	1	71	24	5	" "
1405/273.2	150	30	40	14	18	4	2	2	67	30	3	" "
1409/273.2	100	30	20	10	12	3	3	1	57	34	9	" "
1414/273.2	90	30	16	10	12	3	2	1	53	40	7	" "
1287/273.2	150	70	30	16	29	10	5	3	47	45	8	Fisher Creek Siltstone Known prospect.
2203/264.2	160	80	32	16	19	7	5	4	57	34	9	Alluvium
1798/276.3	100	40	14	12	16	4	4	2	41	47	12	Alluvium
2052/286.2	600	40	170+	10	84+	5	24	4	-	-	-	Teagues Dump

Anomaly 2127/200·1



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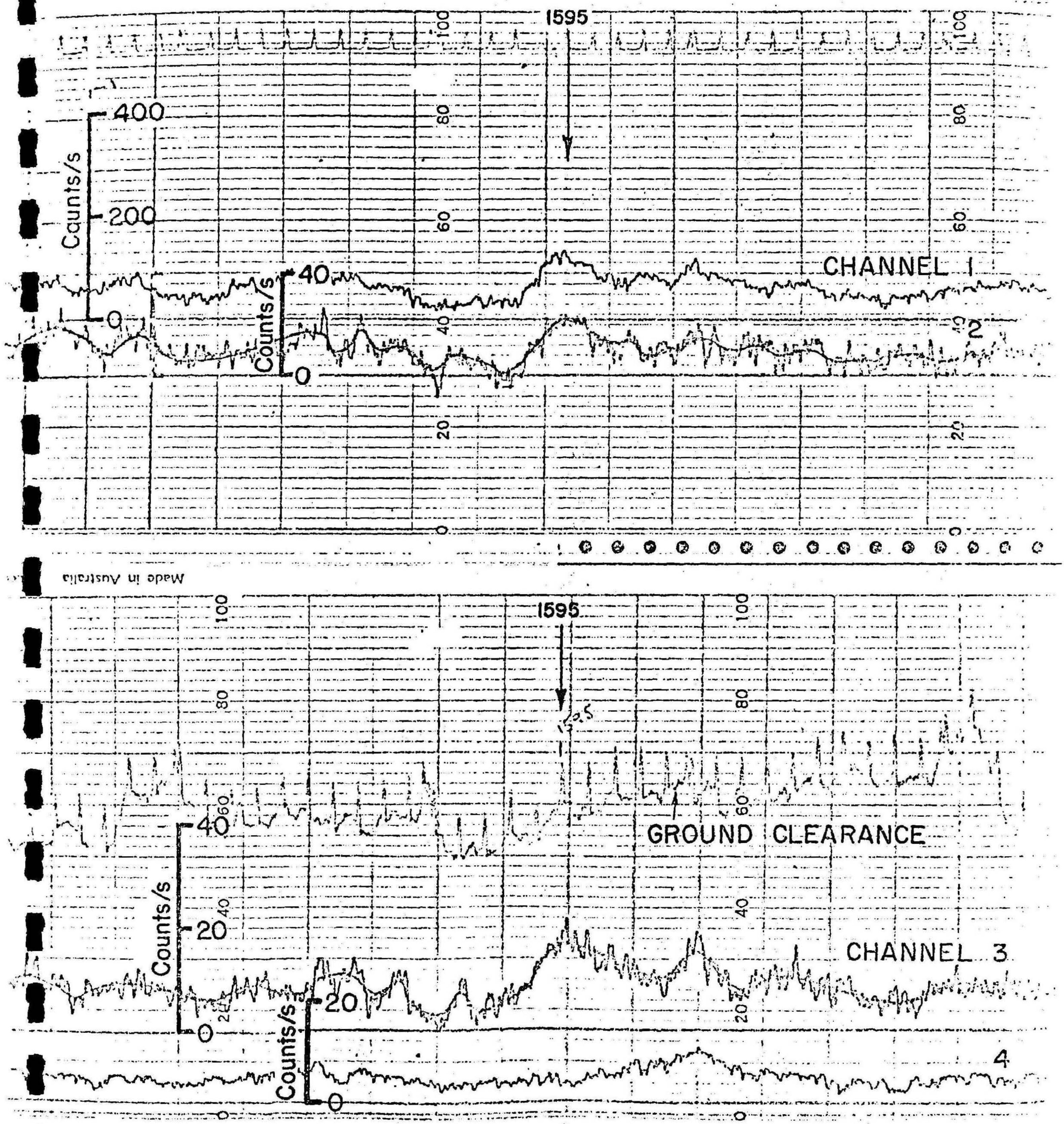
Anomaly 1595/206



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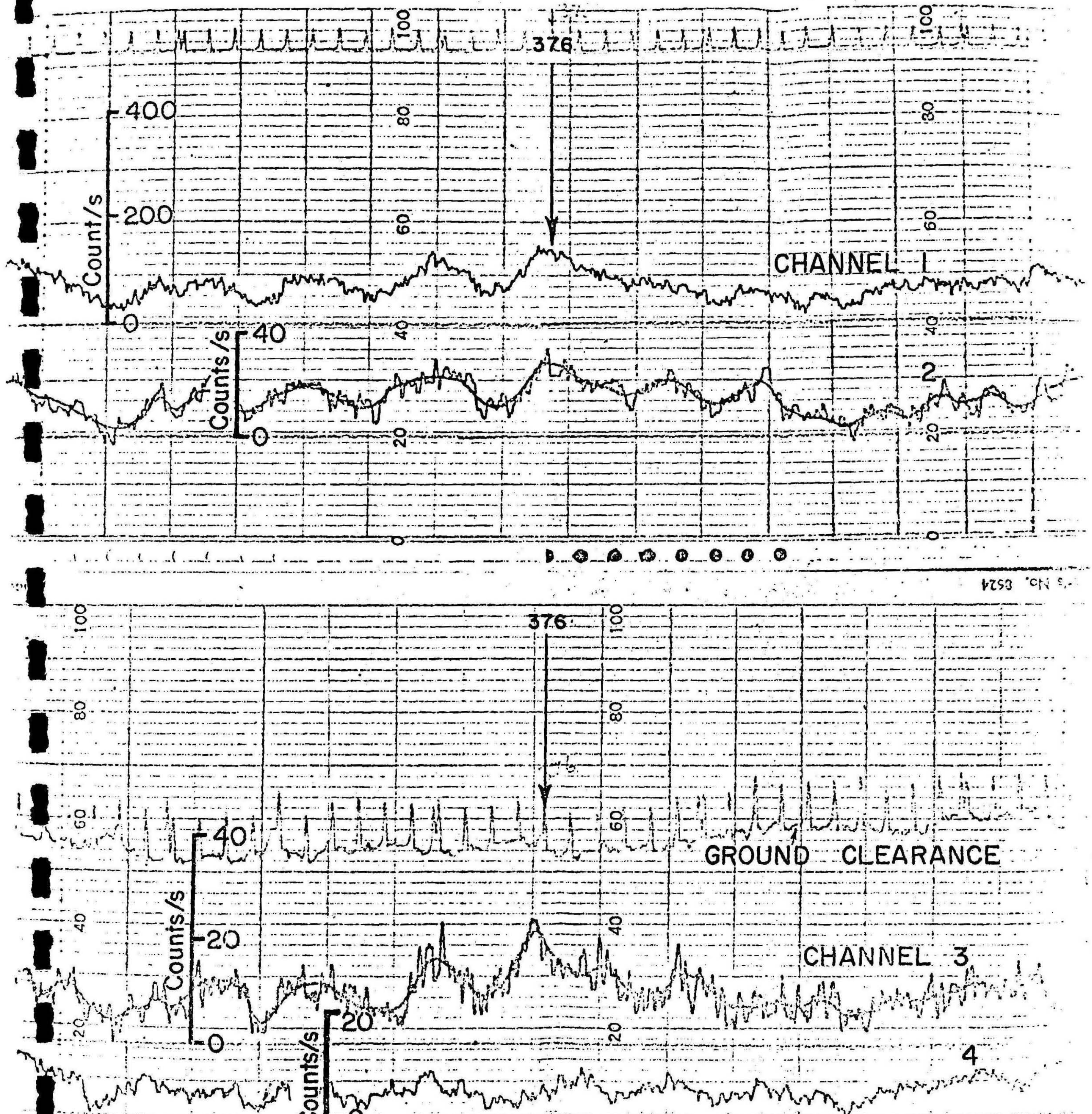

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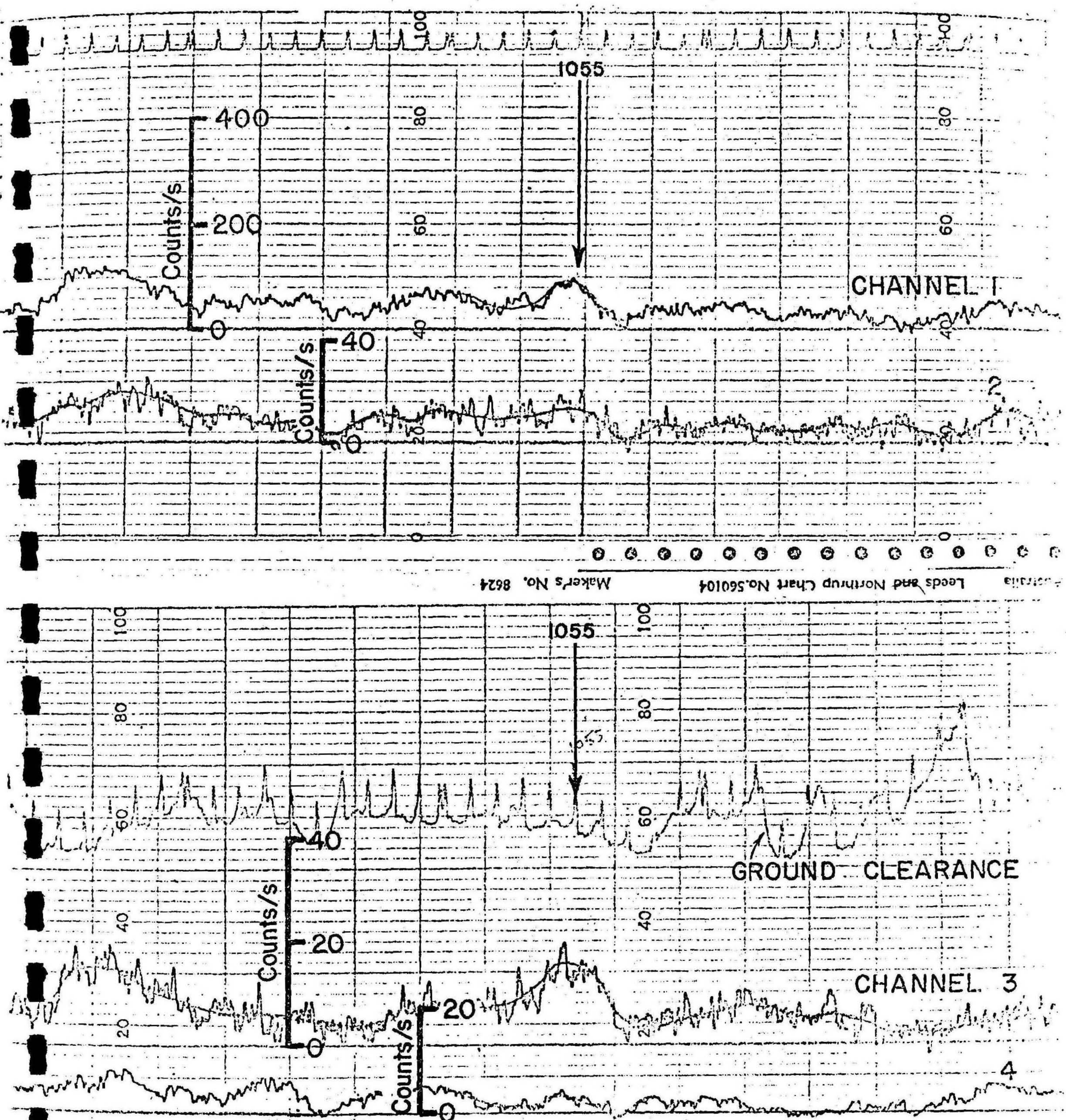

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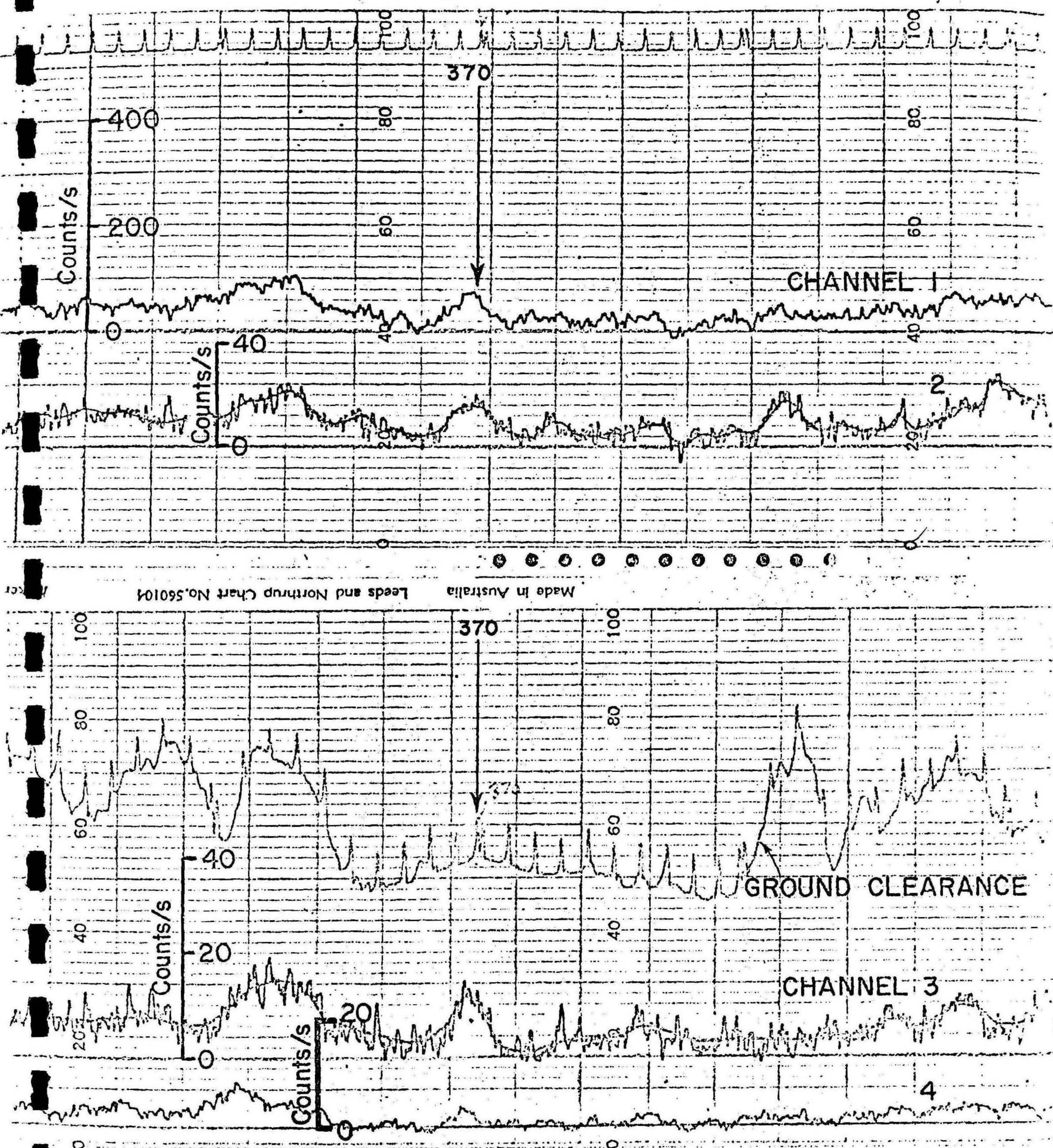
Anomaly 370/216



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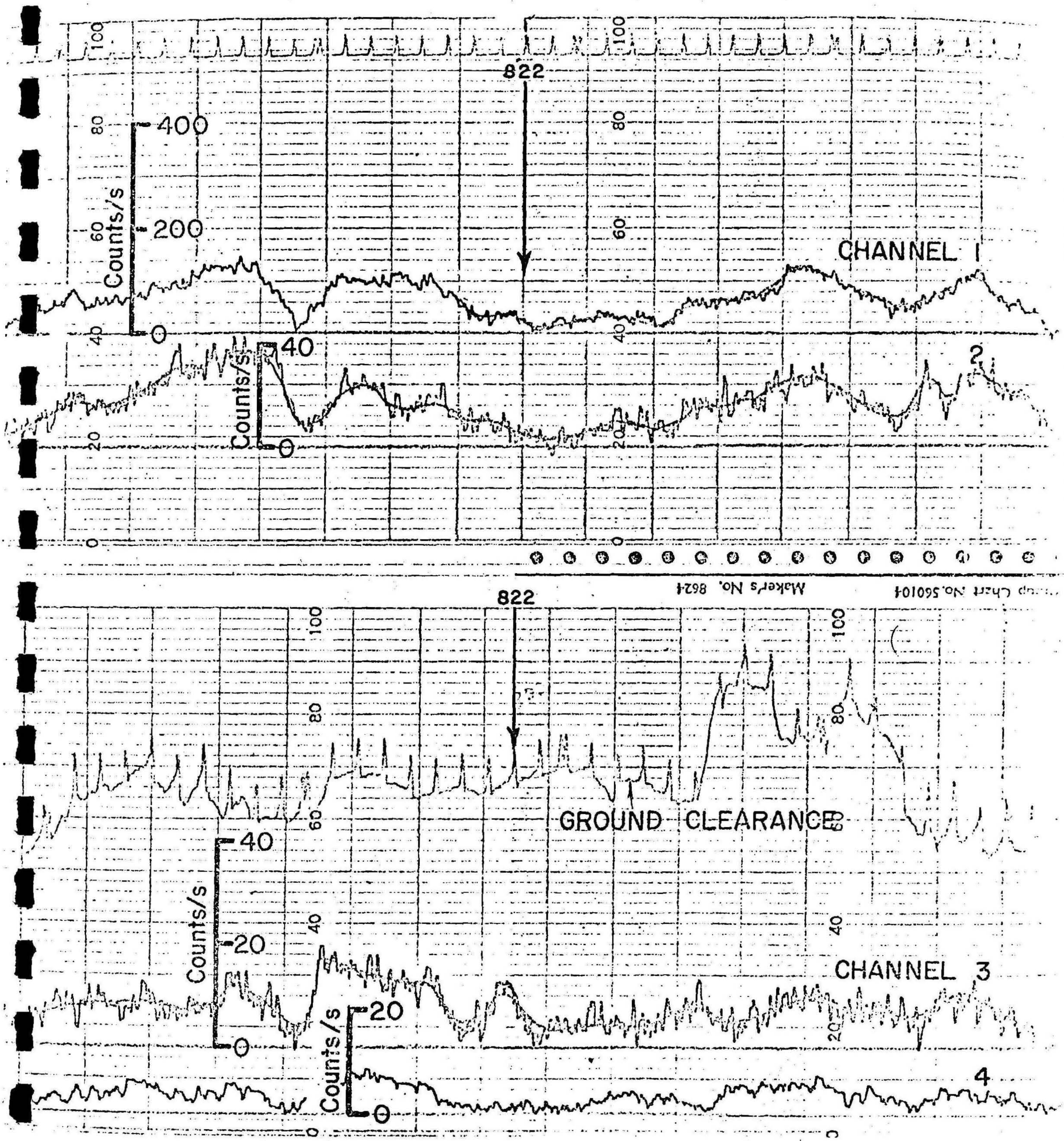

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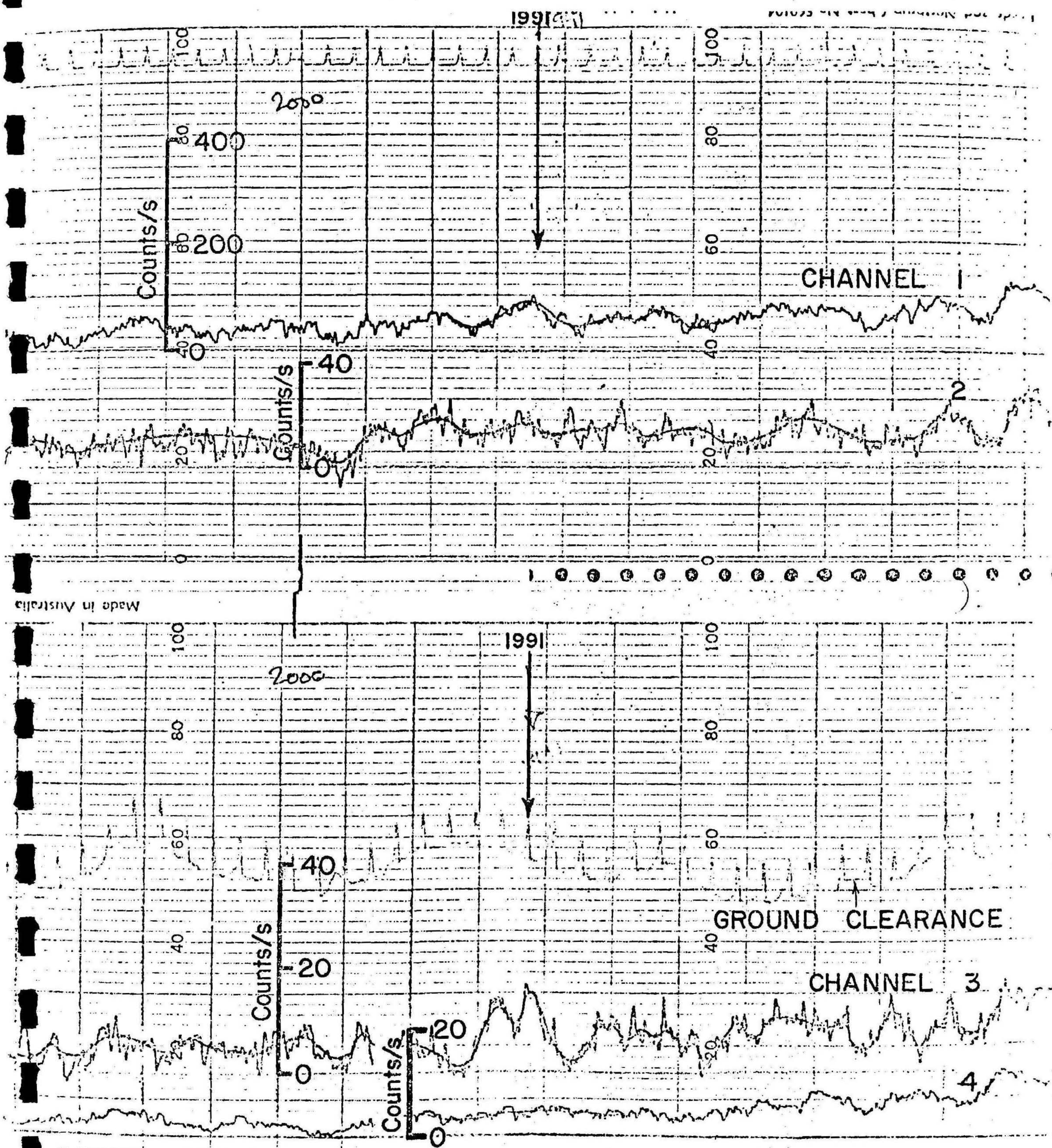

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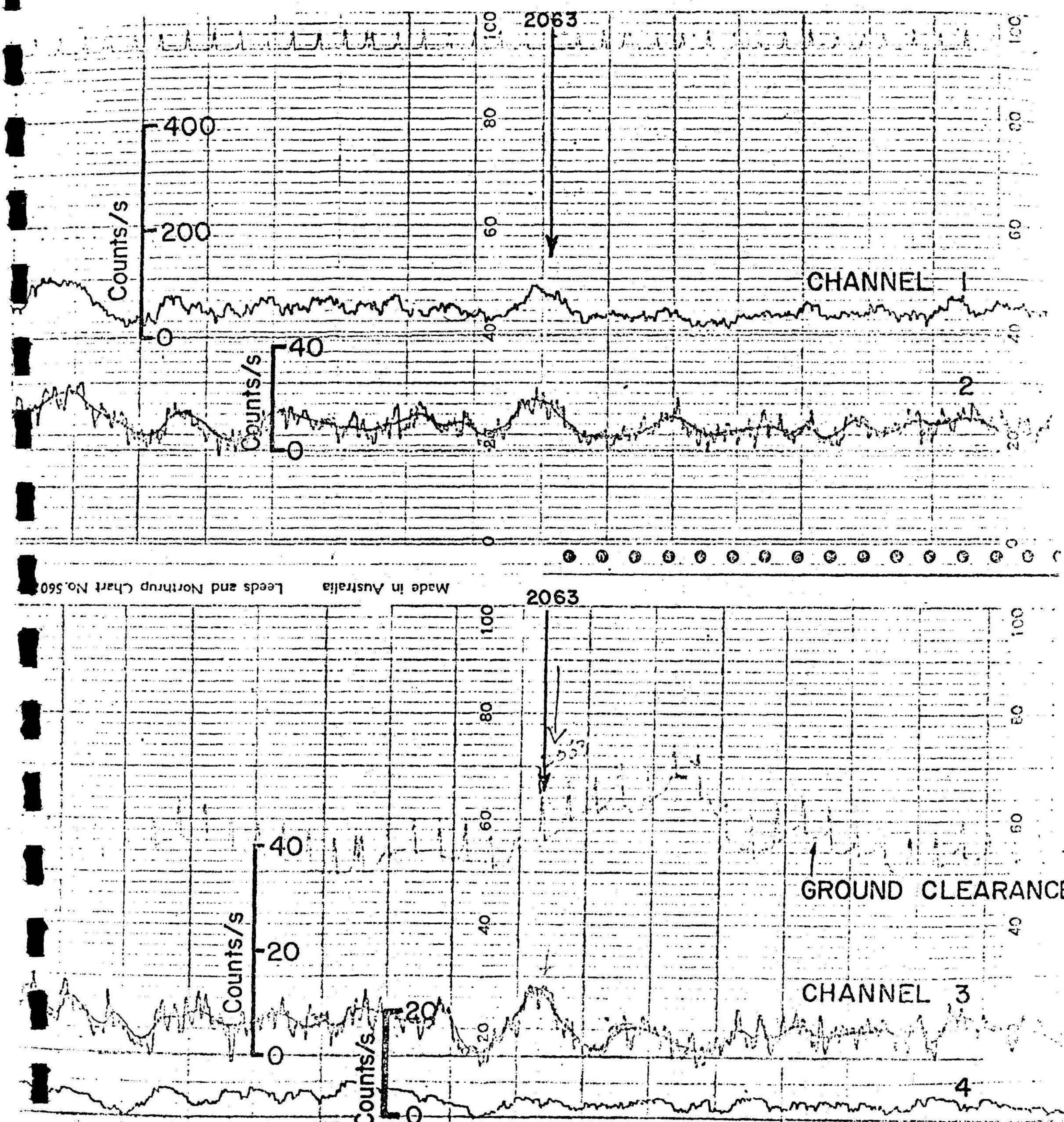
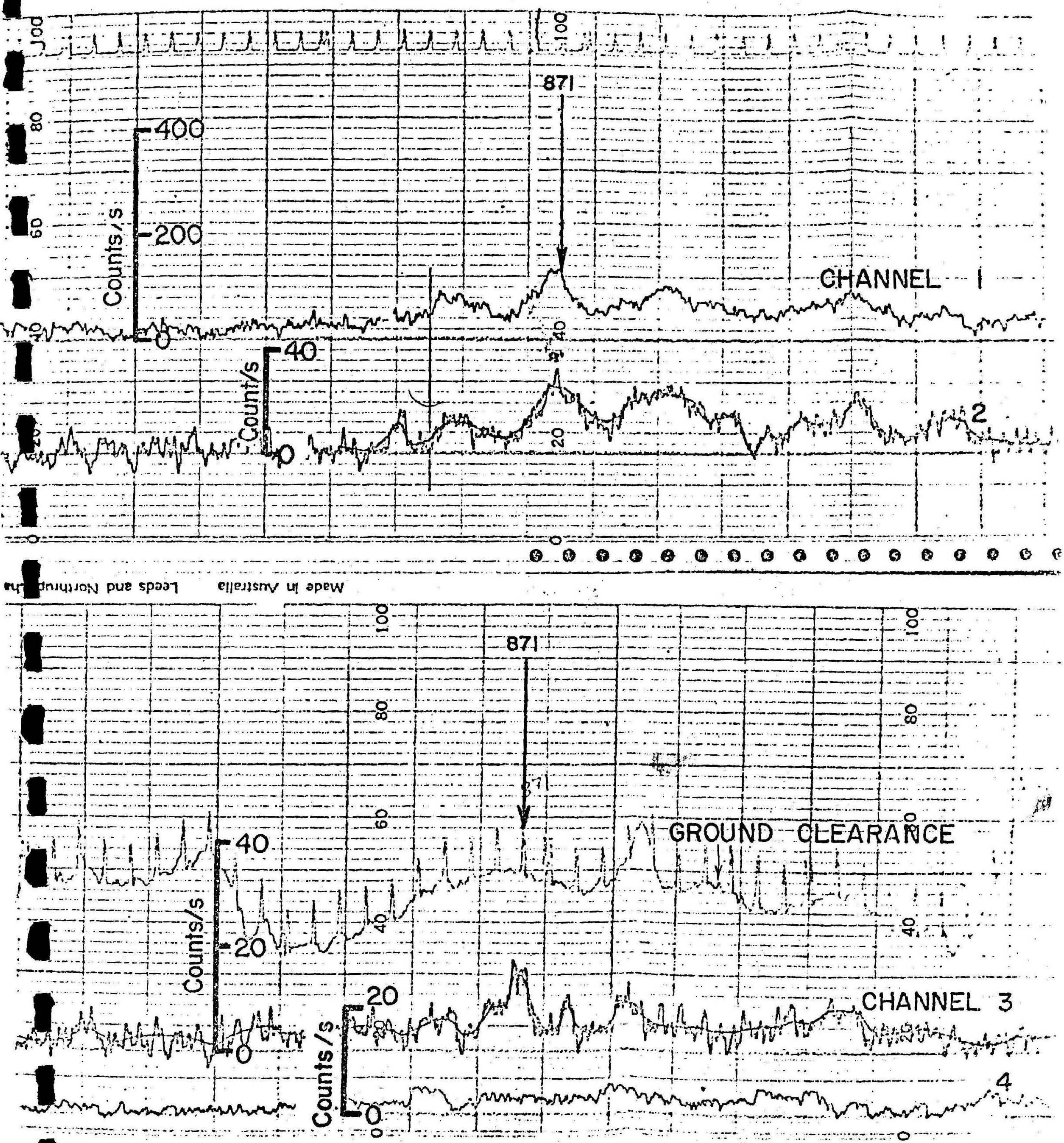


Anomaly 871/223



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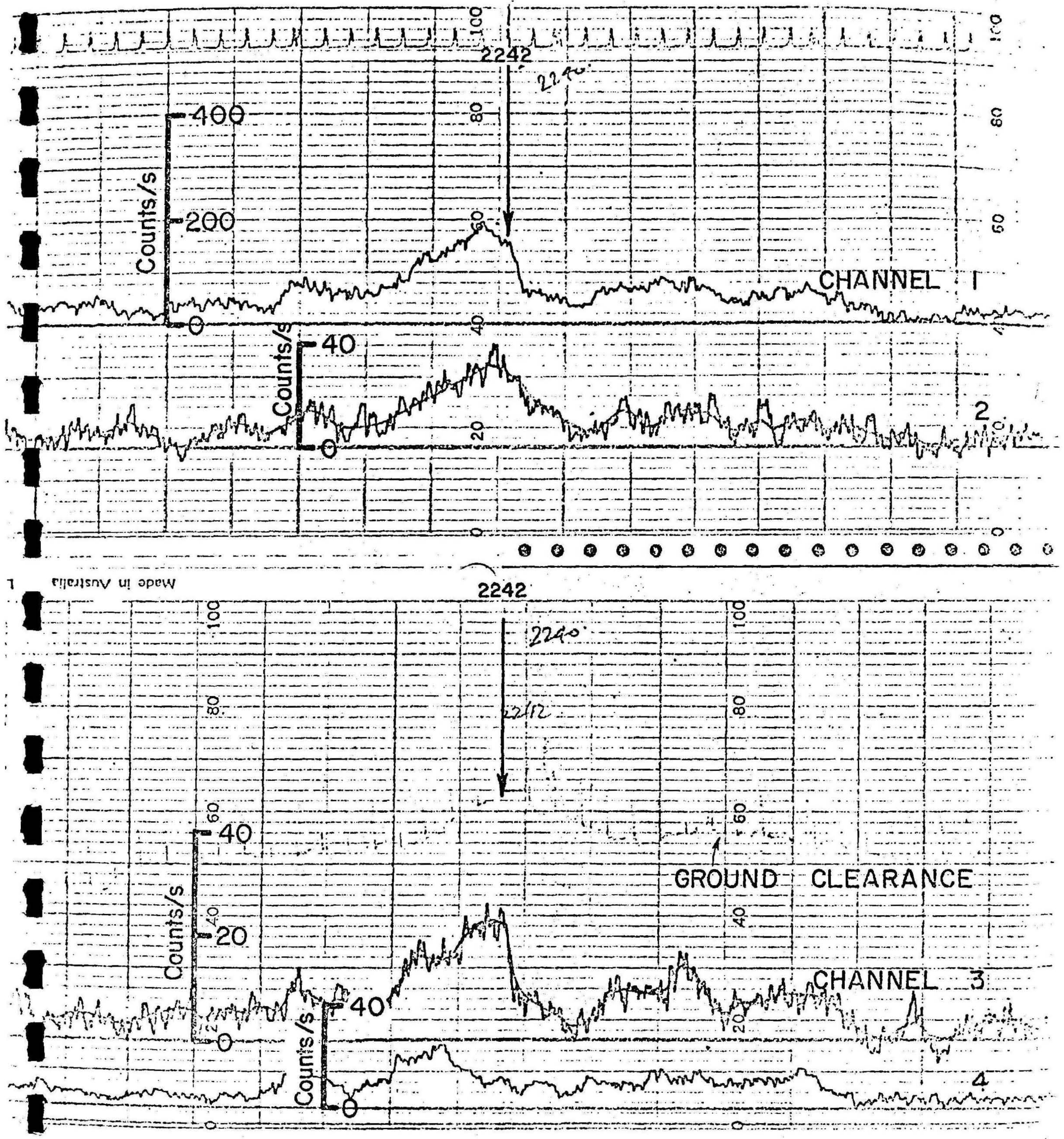
Anomaly 2242/227



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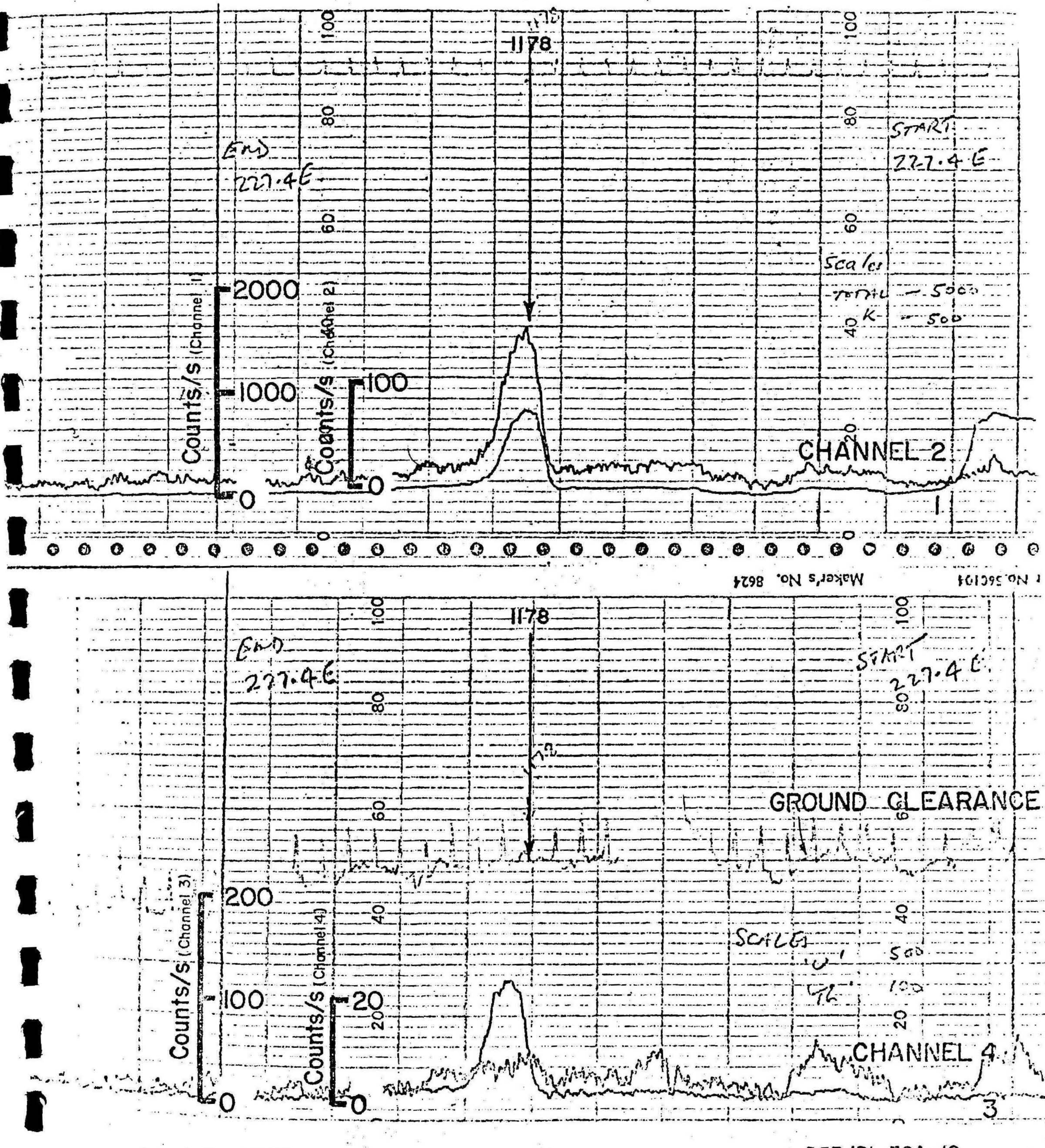
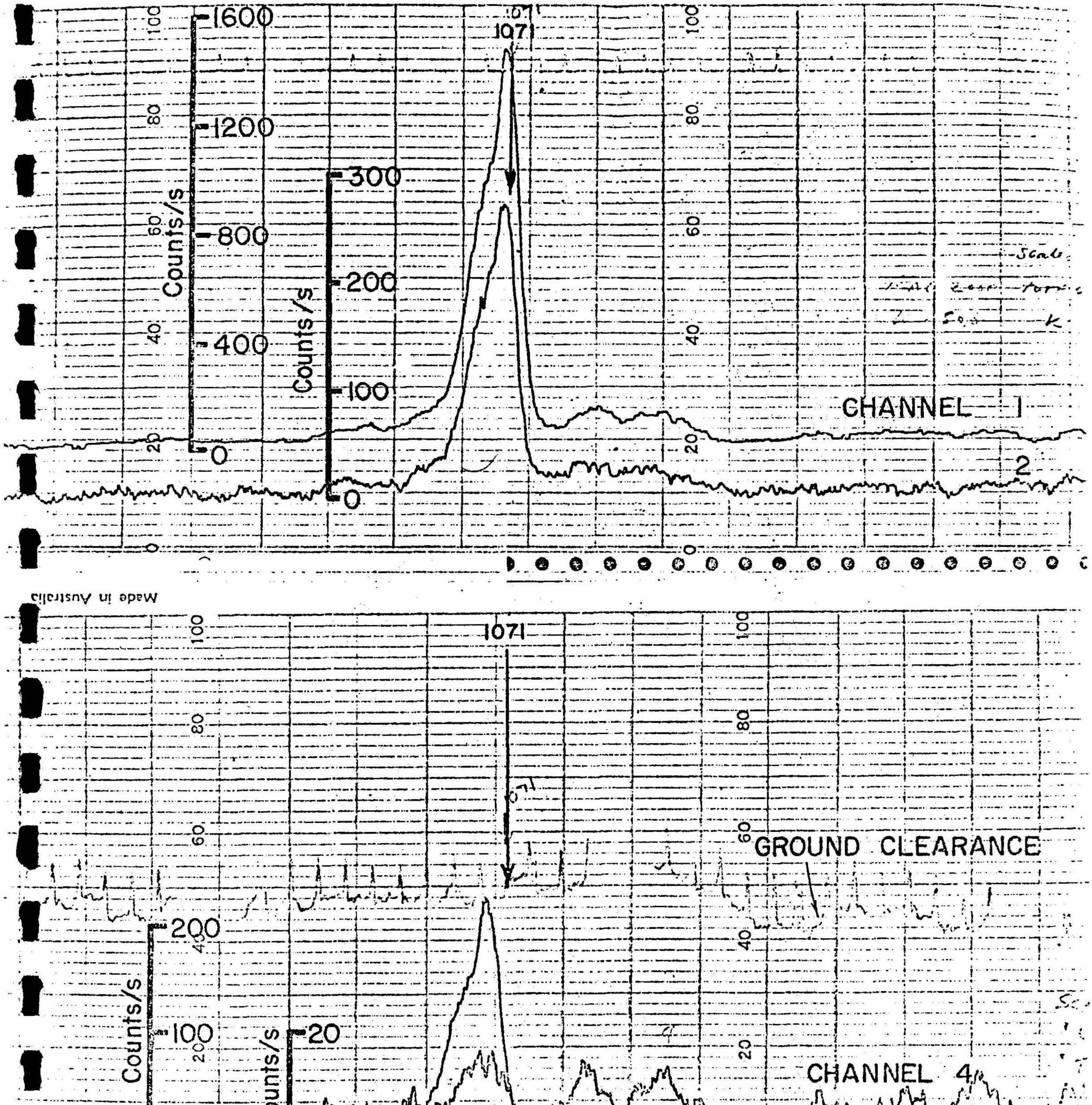
Anomaly 1178/227·4



Anomaly 1071/228·1



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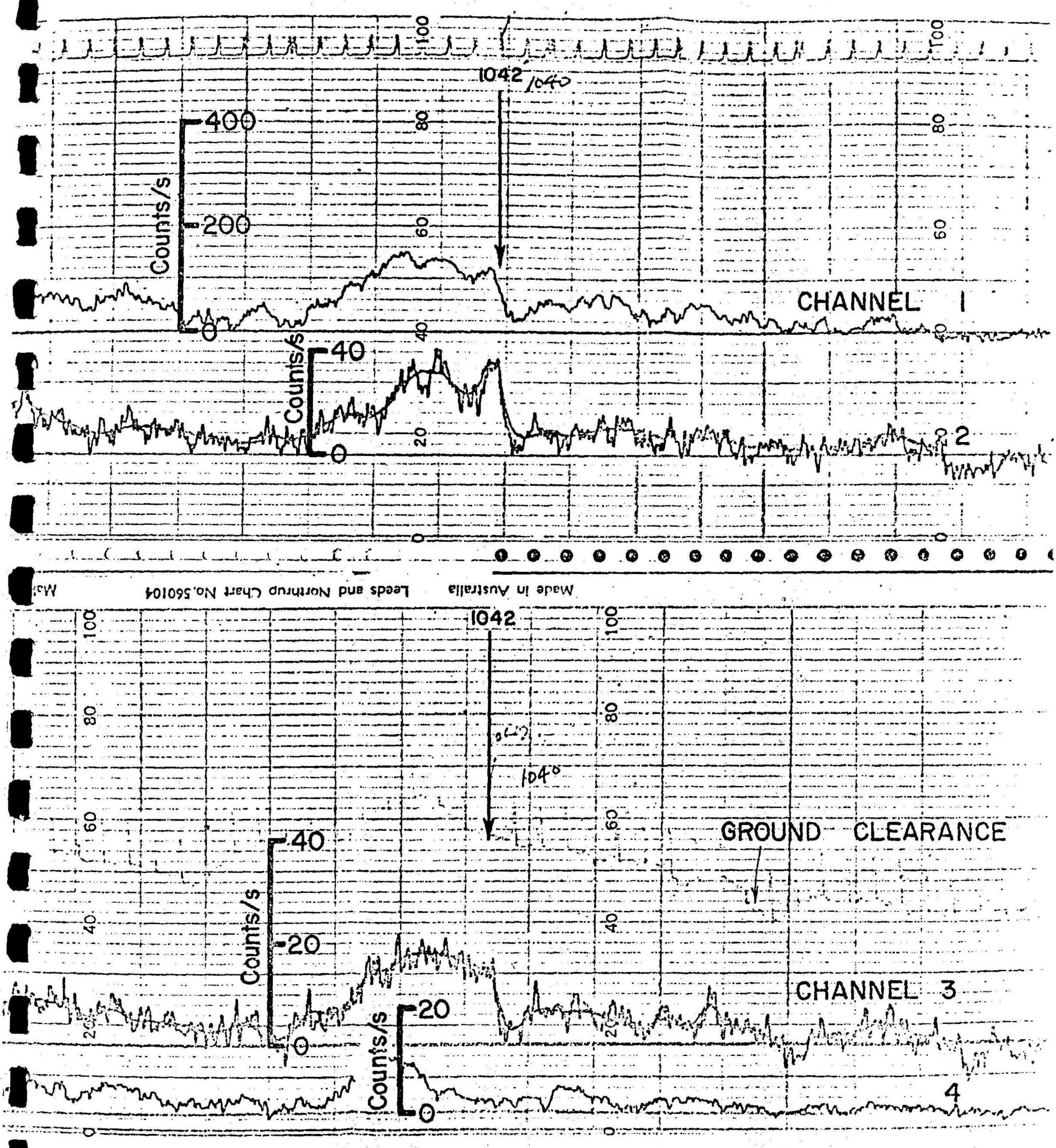

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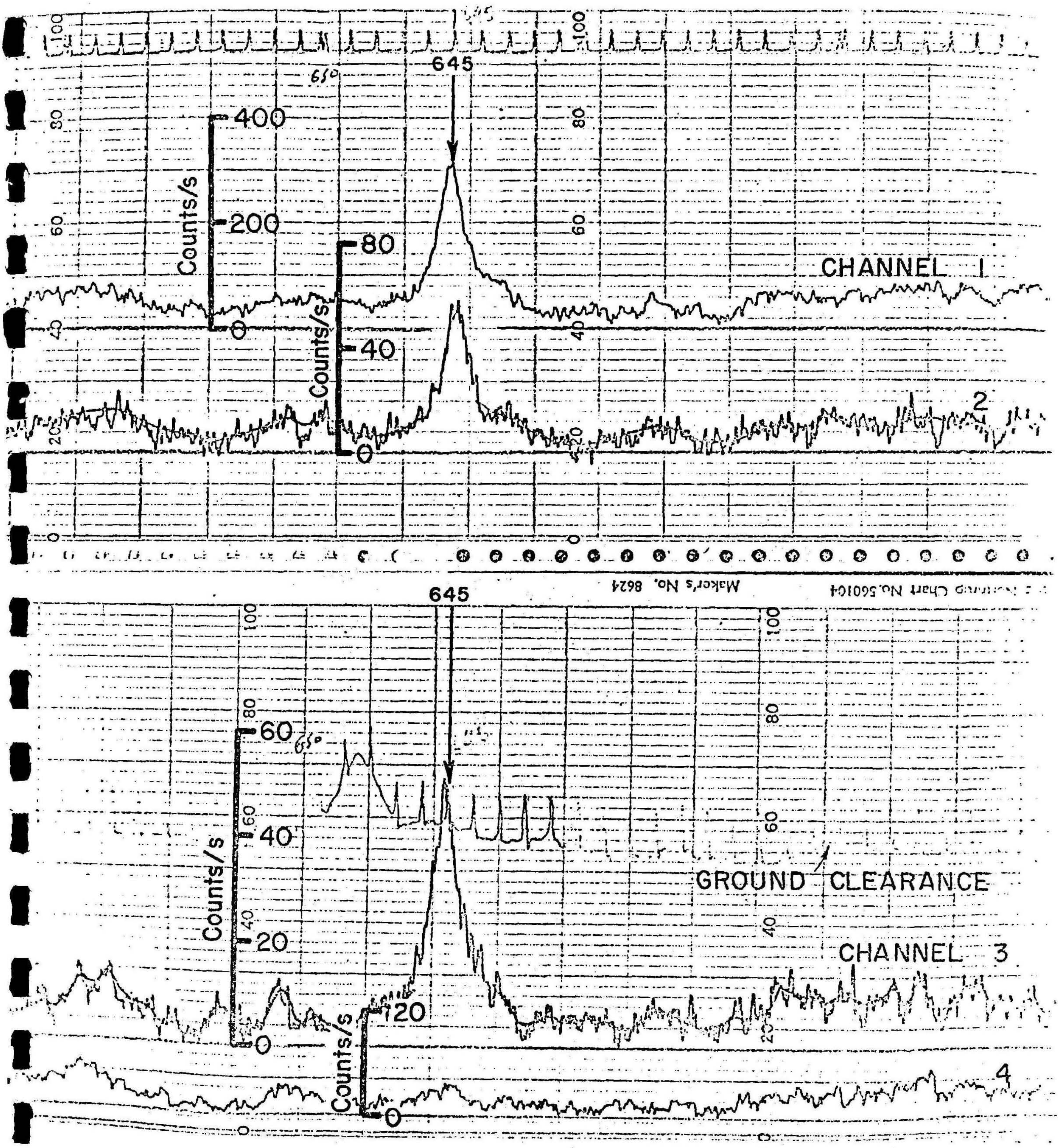

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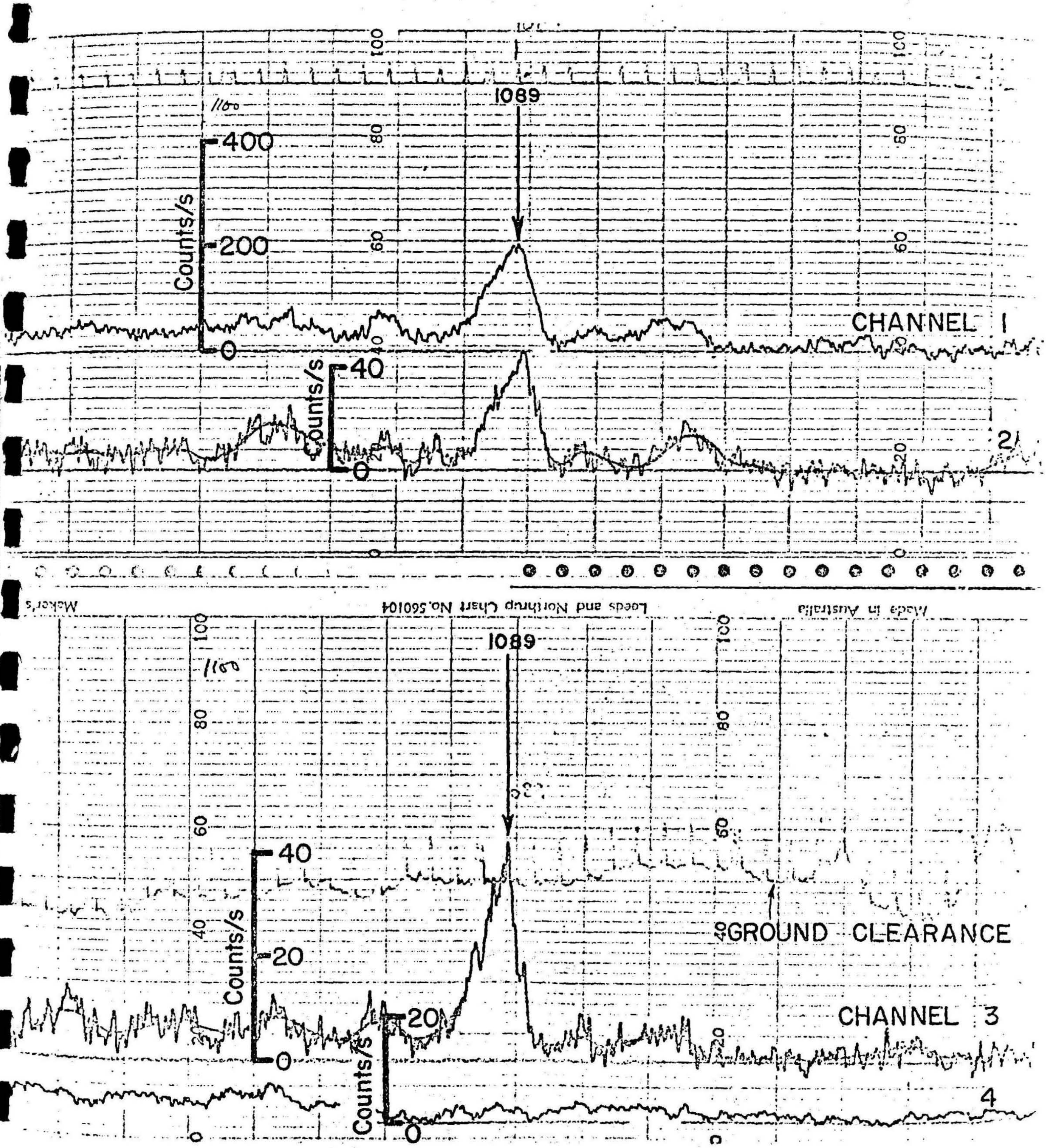

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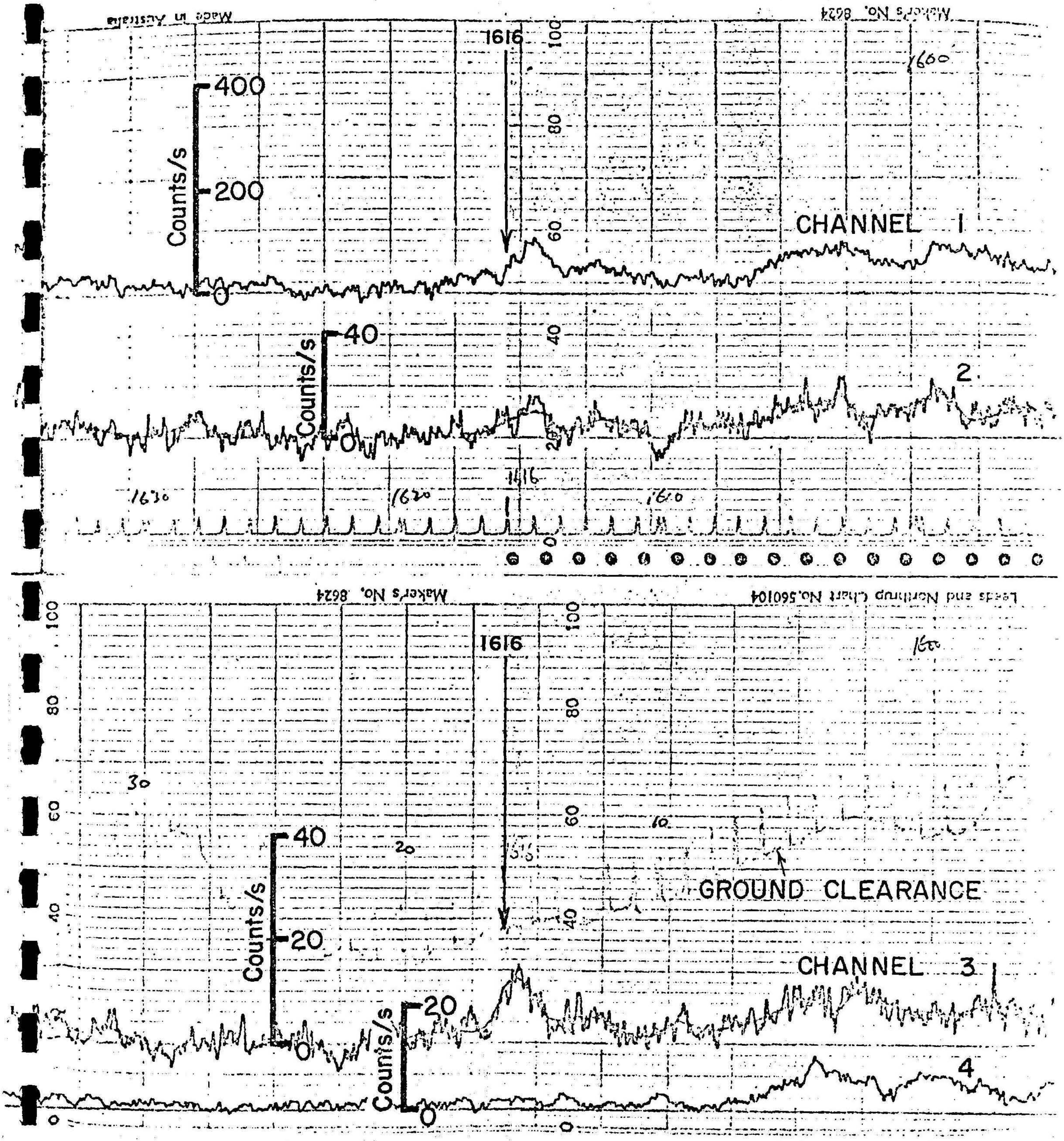
Anomaly 1616/238



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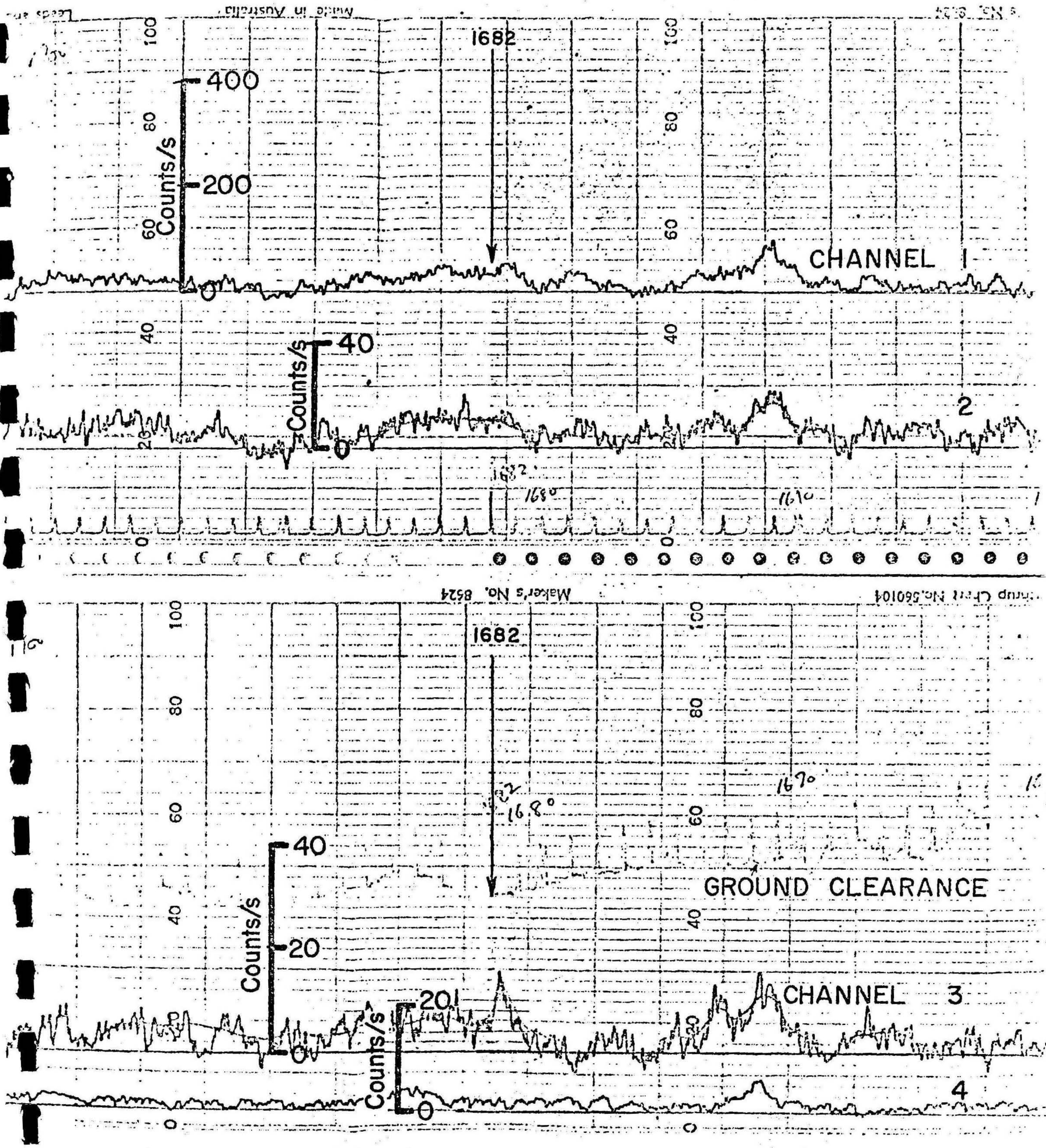
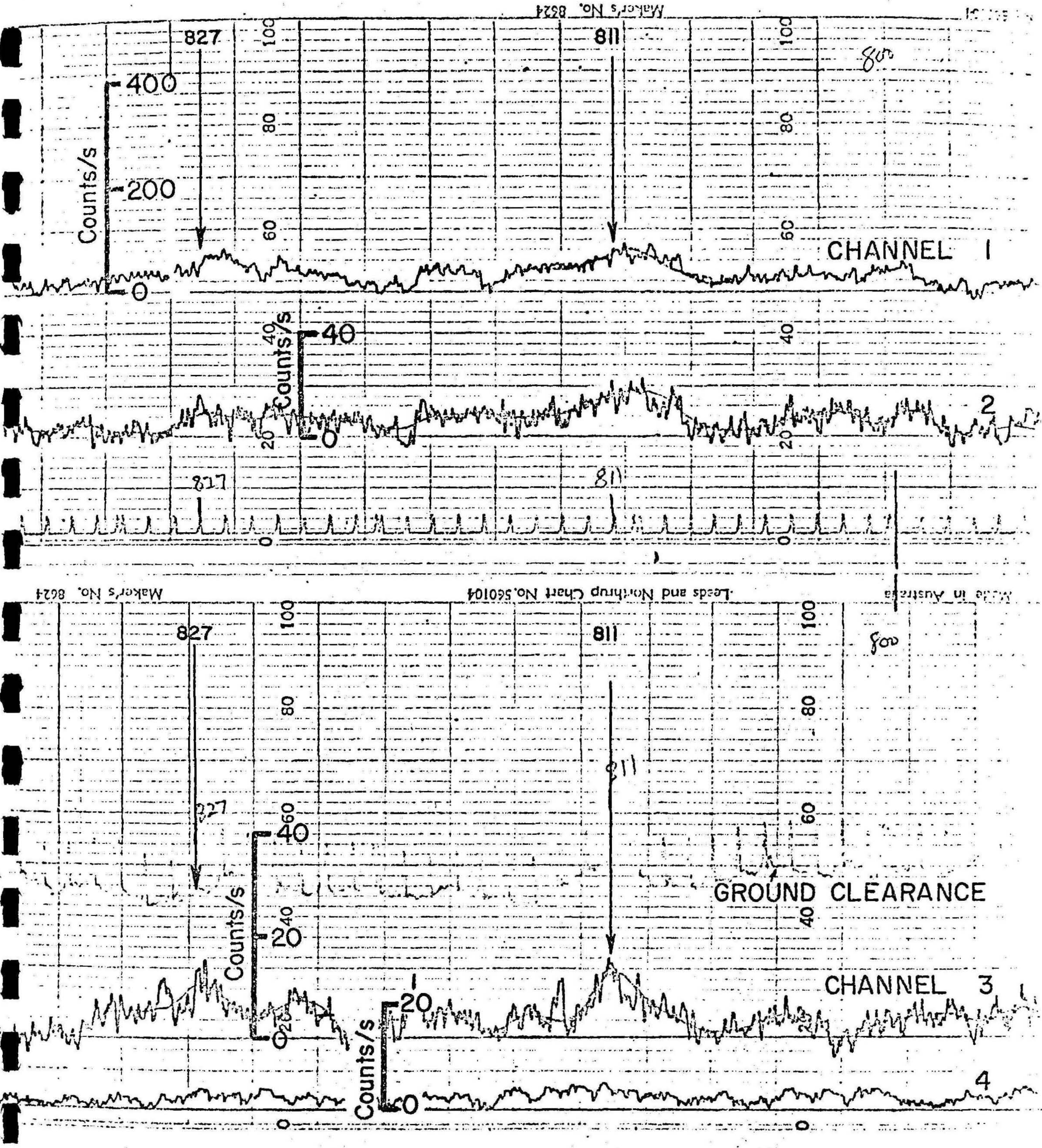
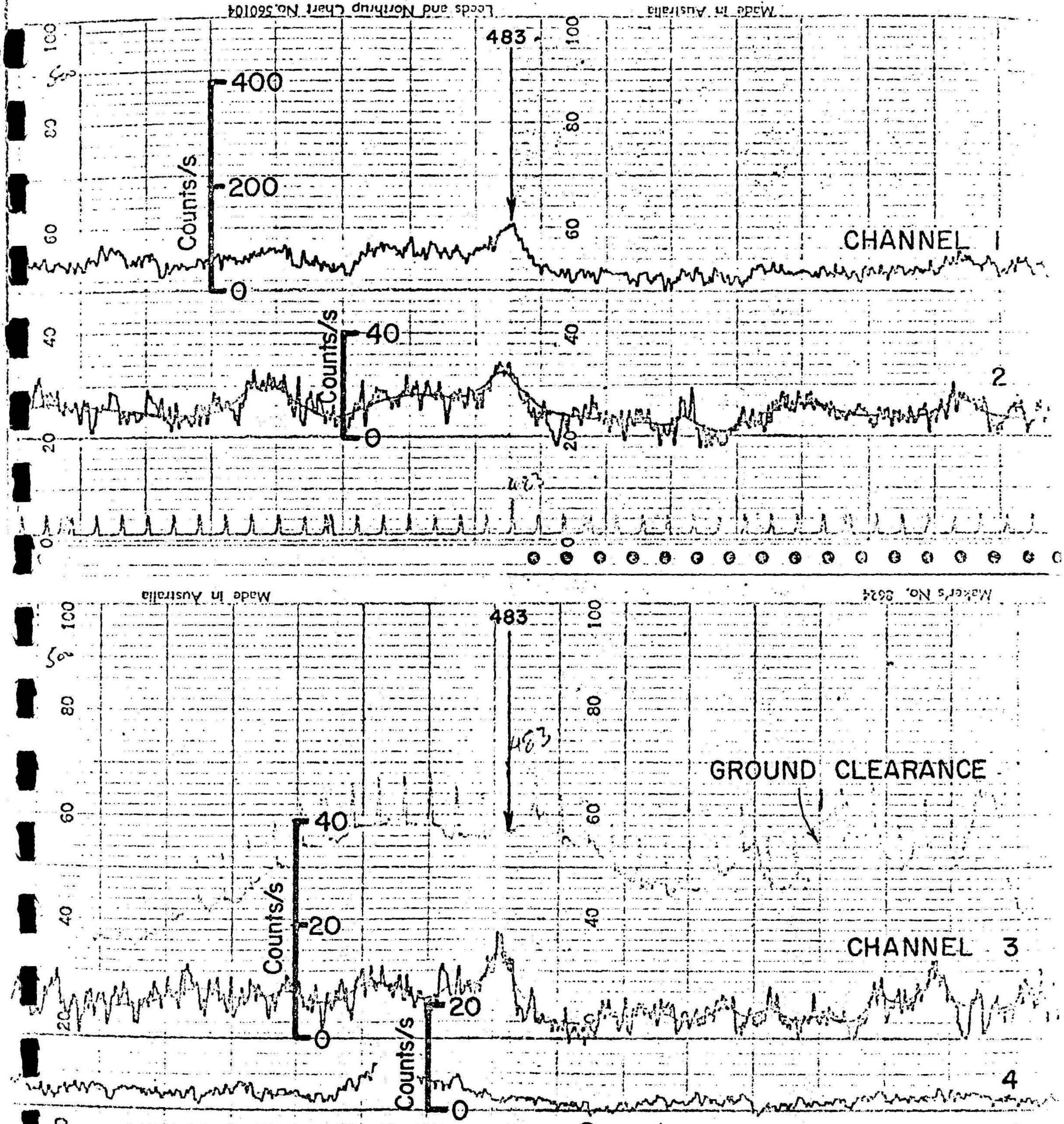


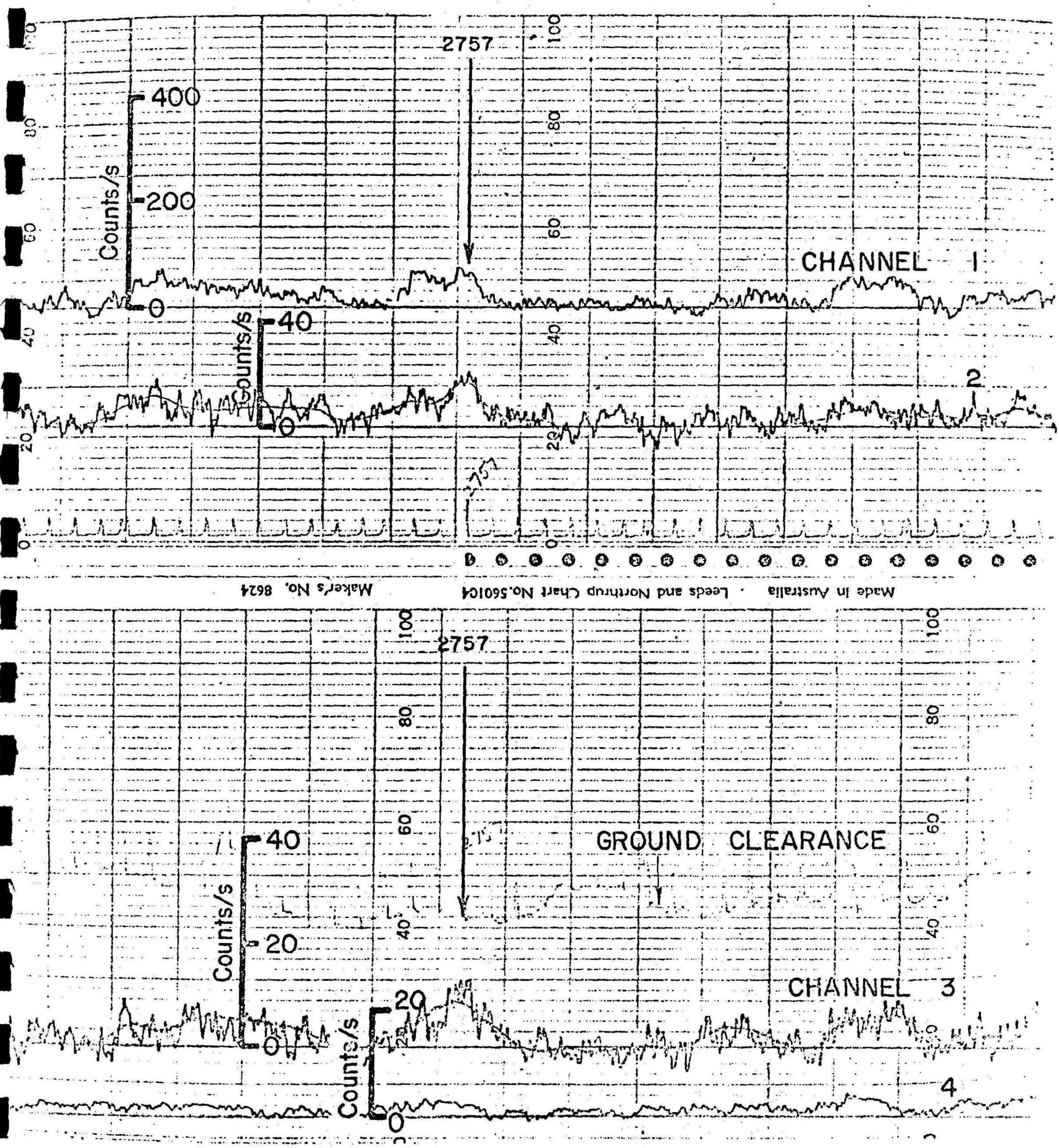
Anomalies 811,827/239

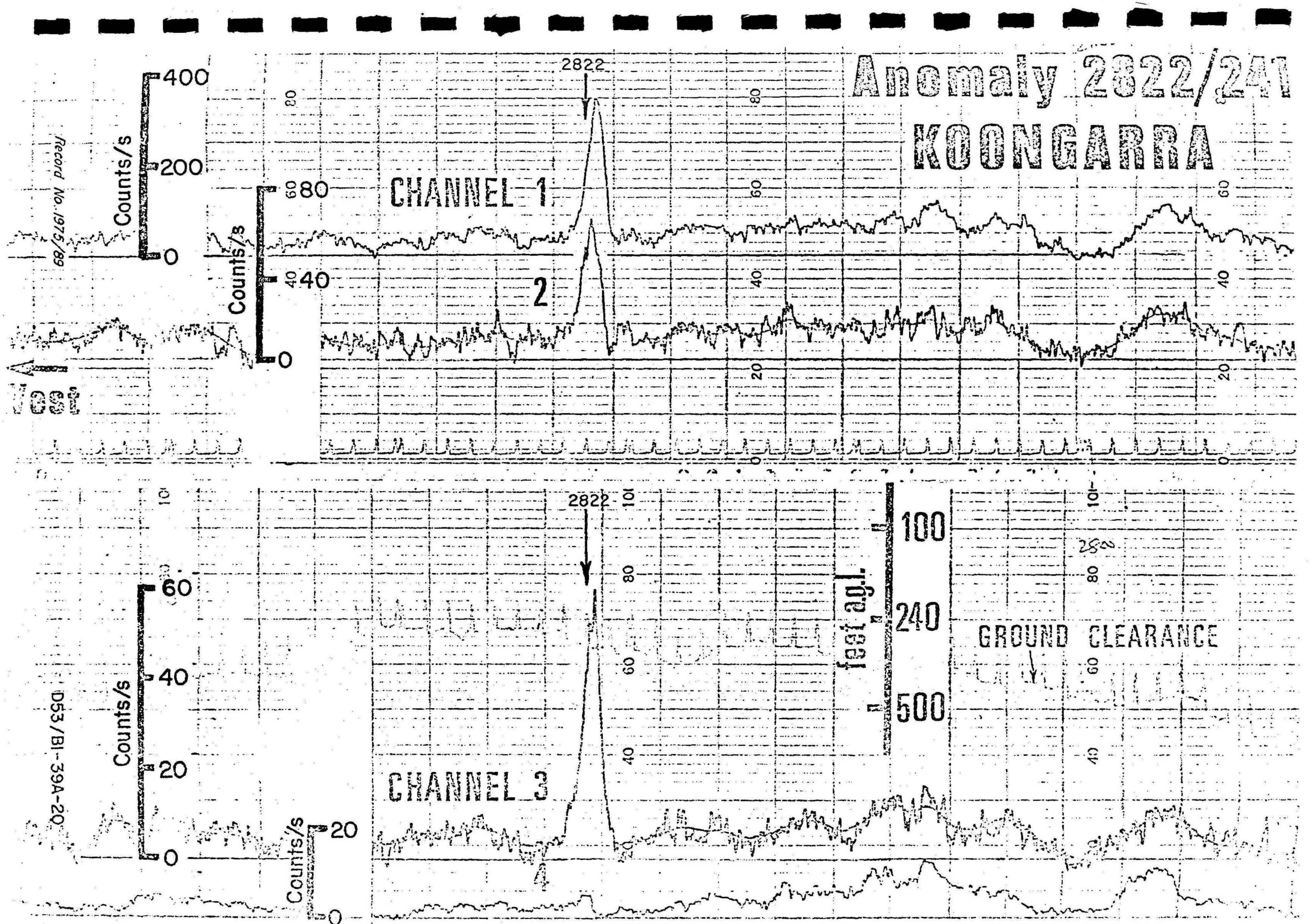


Anomaly 483/240



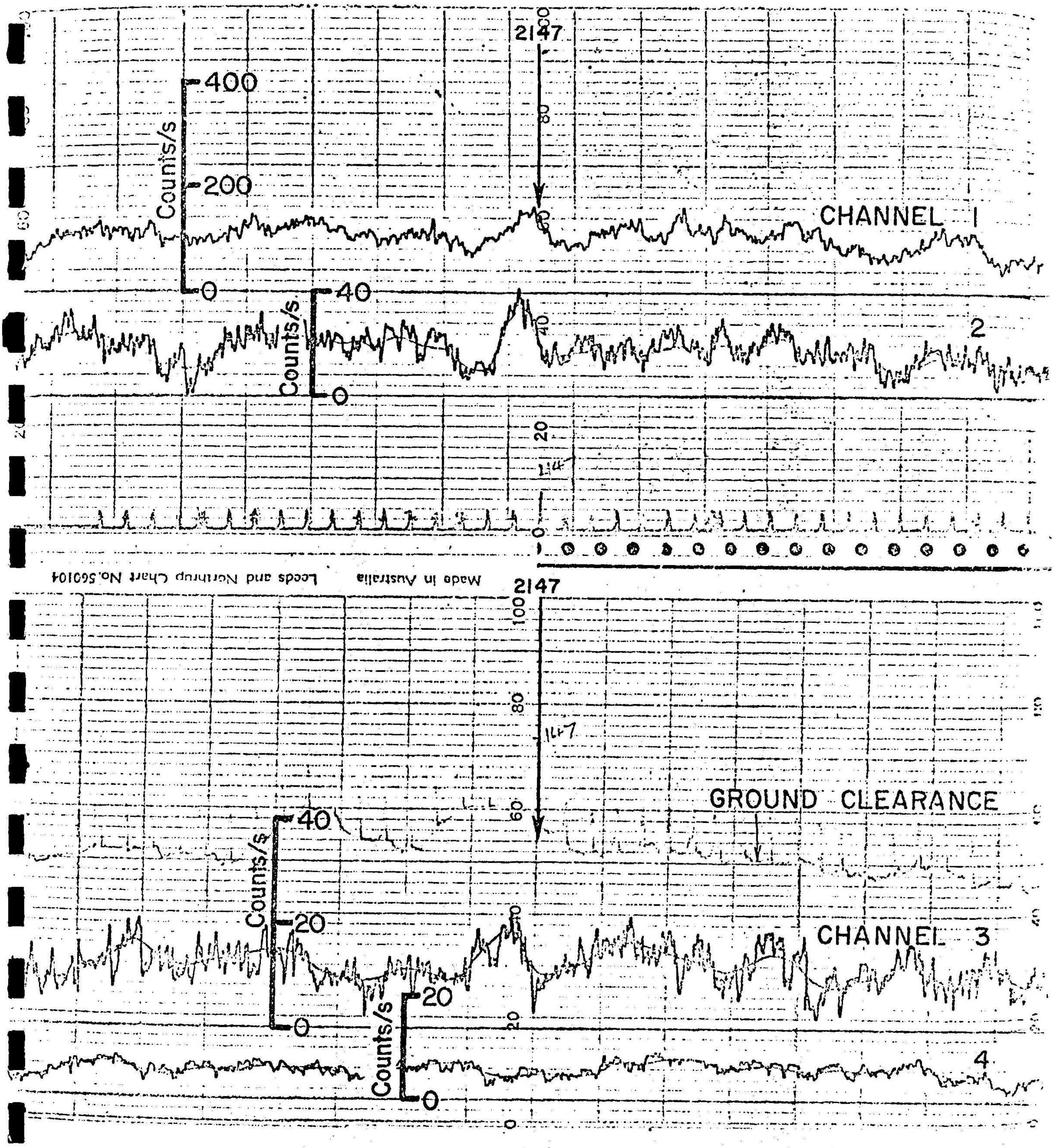
Anomaly 2757/241





Anomaly 2822/241
KOONGARRA
2822
CHANNEL 1
2
Counts/s
400
200
0
80
40
0
Record No. 1975/89
West
2822
CHANNEL 3
4
Counts/s
60
40
20
0
20
0
feet a.g.l.
100
240
500
GROUND CLEARANCE
D53/B1-39A-20

Anomaly 2147/248



Record No. 1975/89

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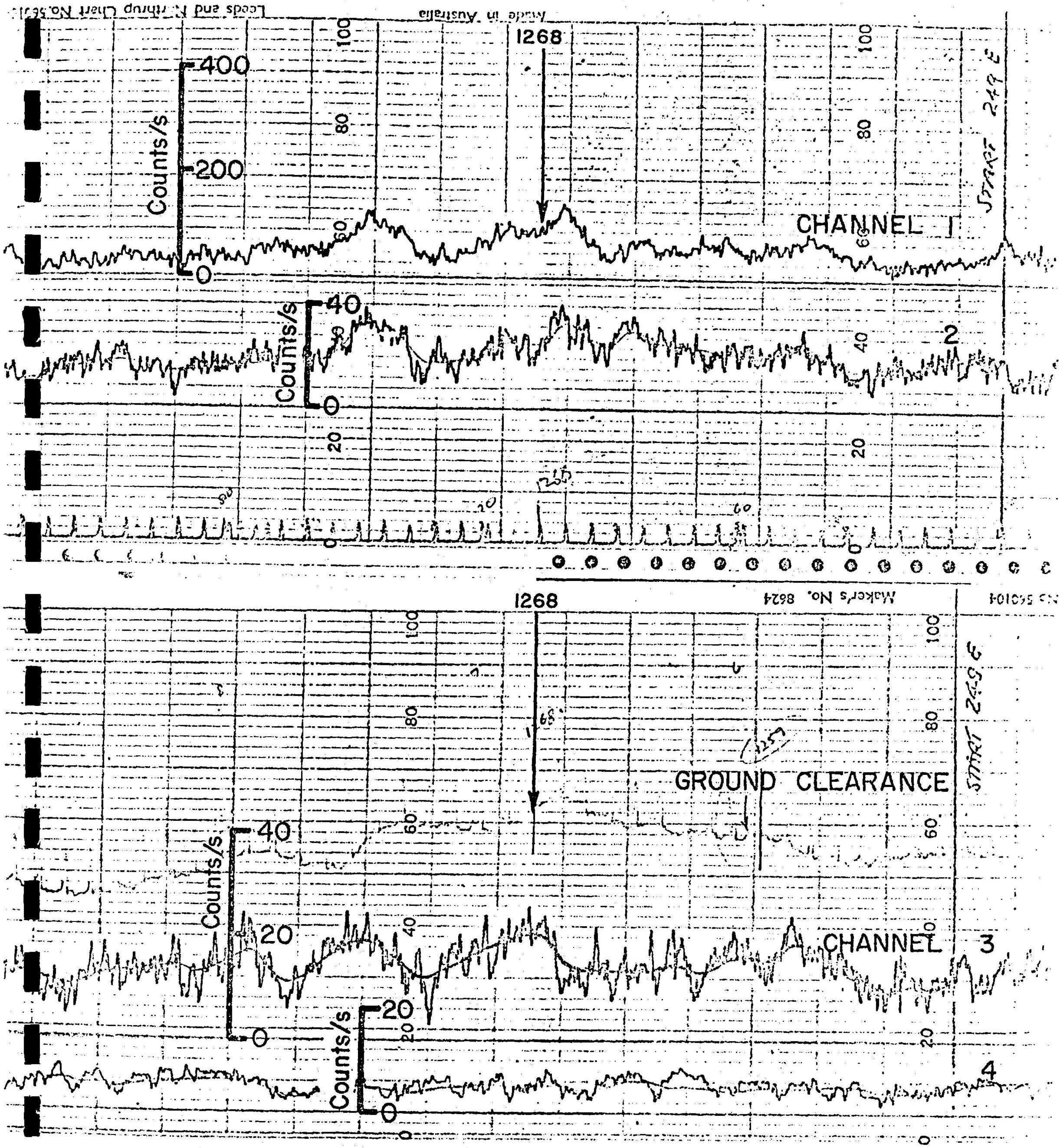
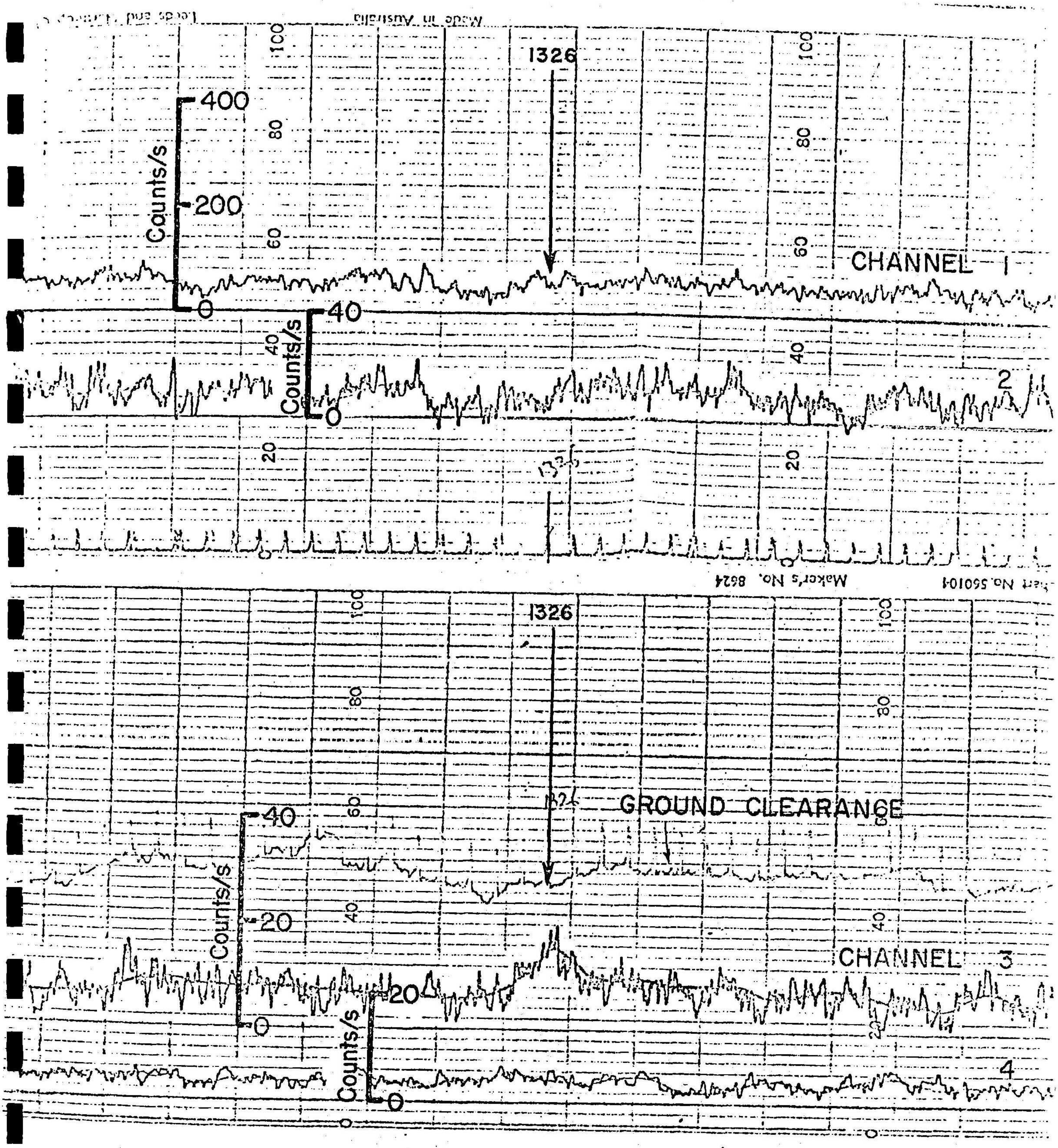
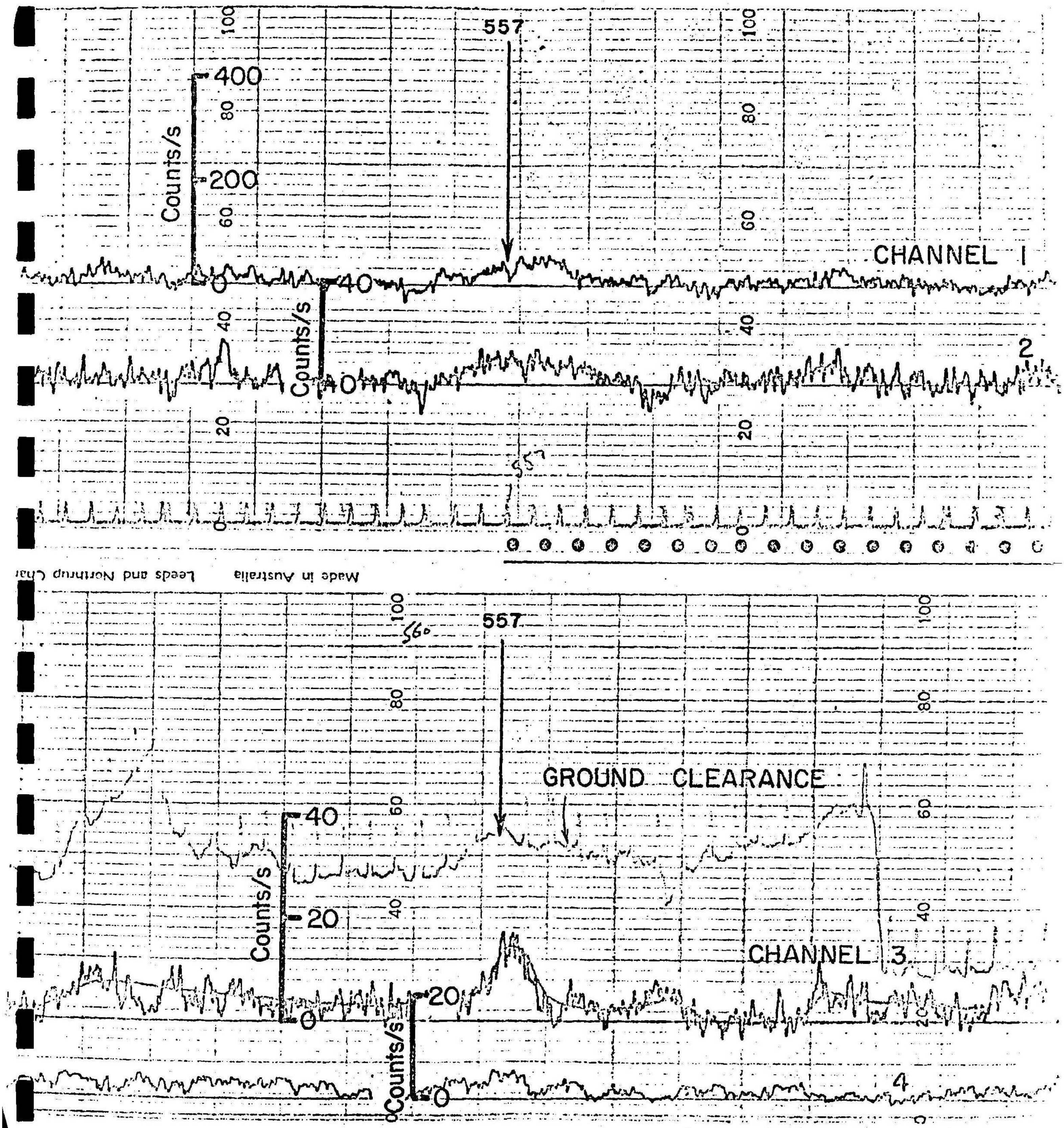
Anomaly 1268/249



Anomaly 1326/249



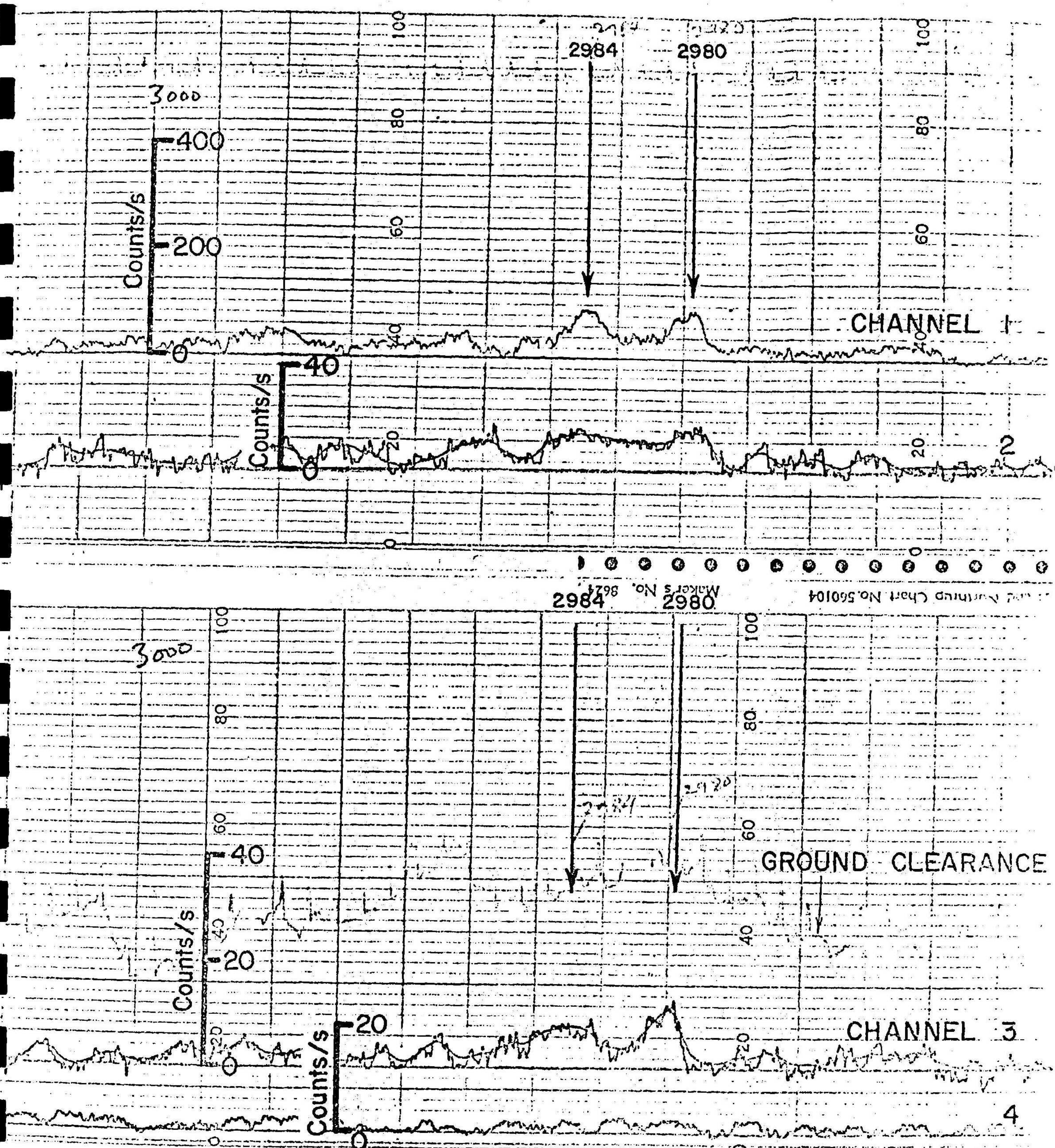
Anomaly 557/251·1



Record No. 1975/89

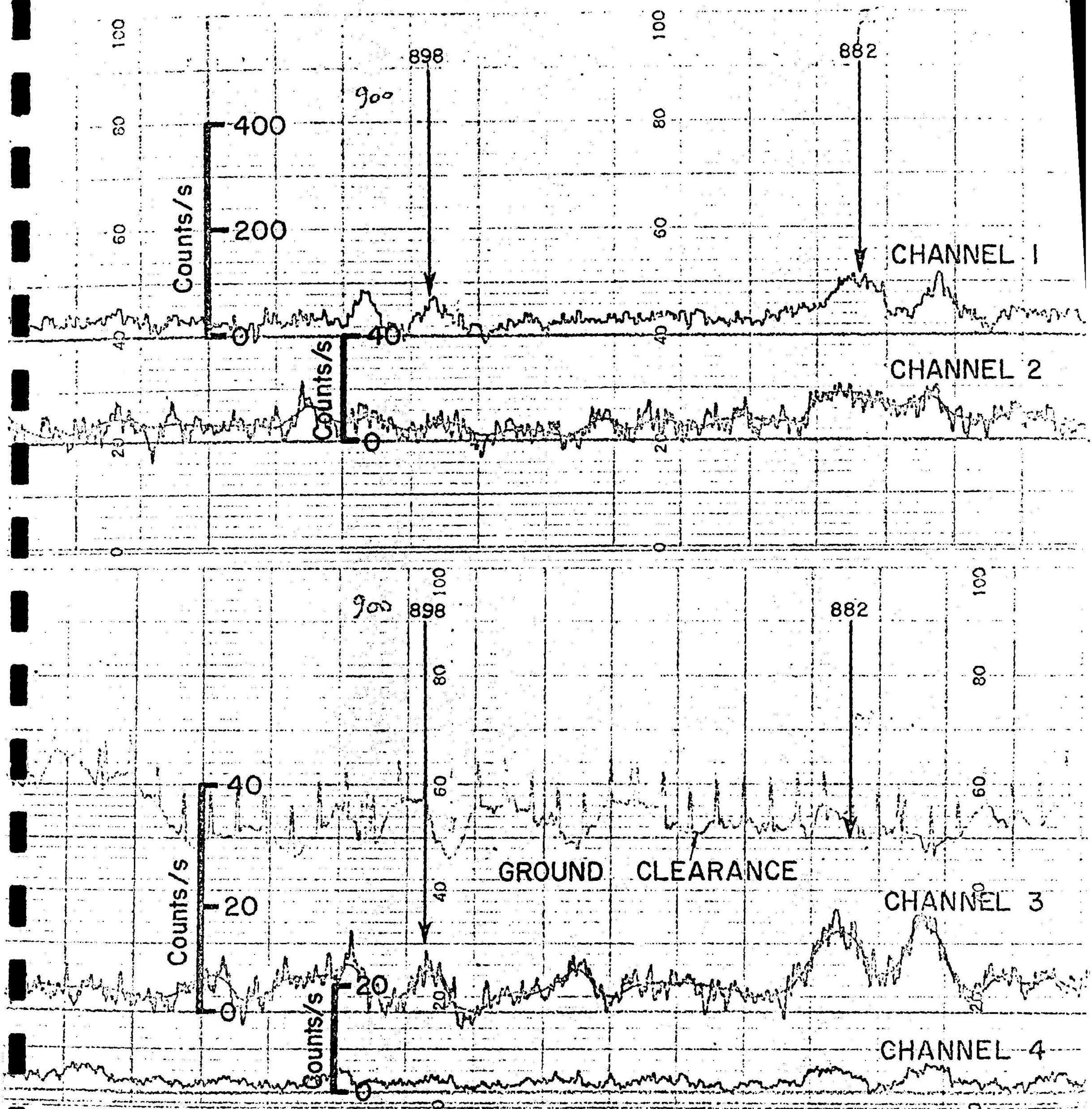
D53/B1-39A-24

Anomalies 2980,2984/255·3

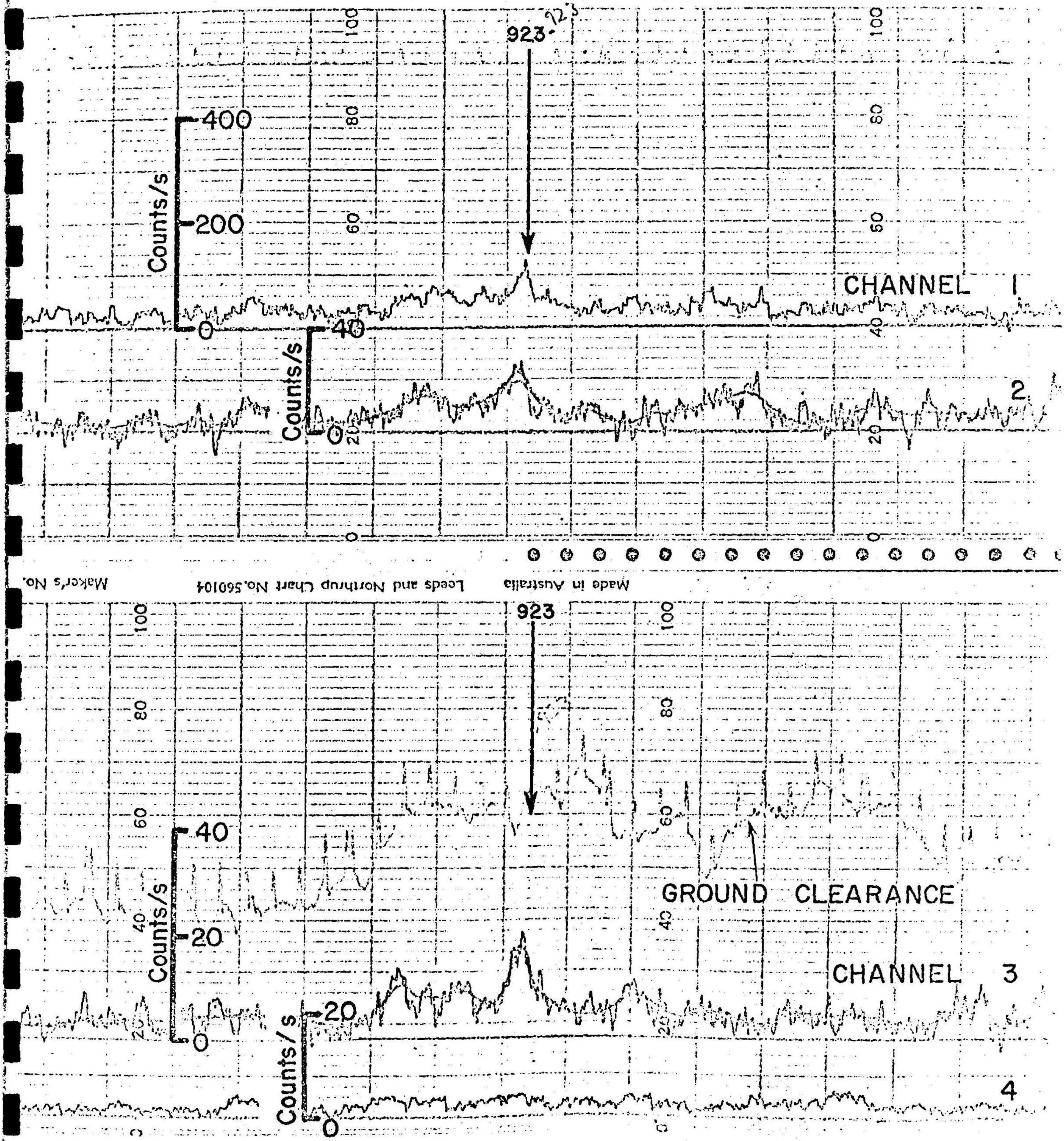


D53/BI-39A-25

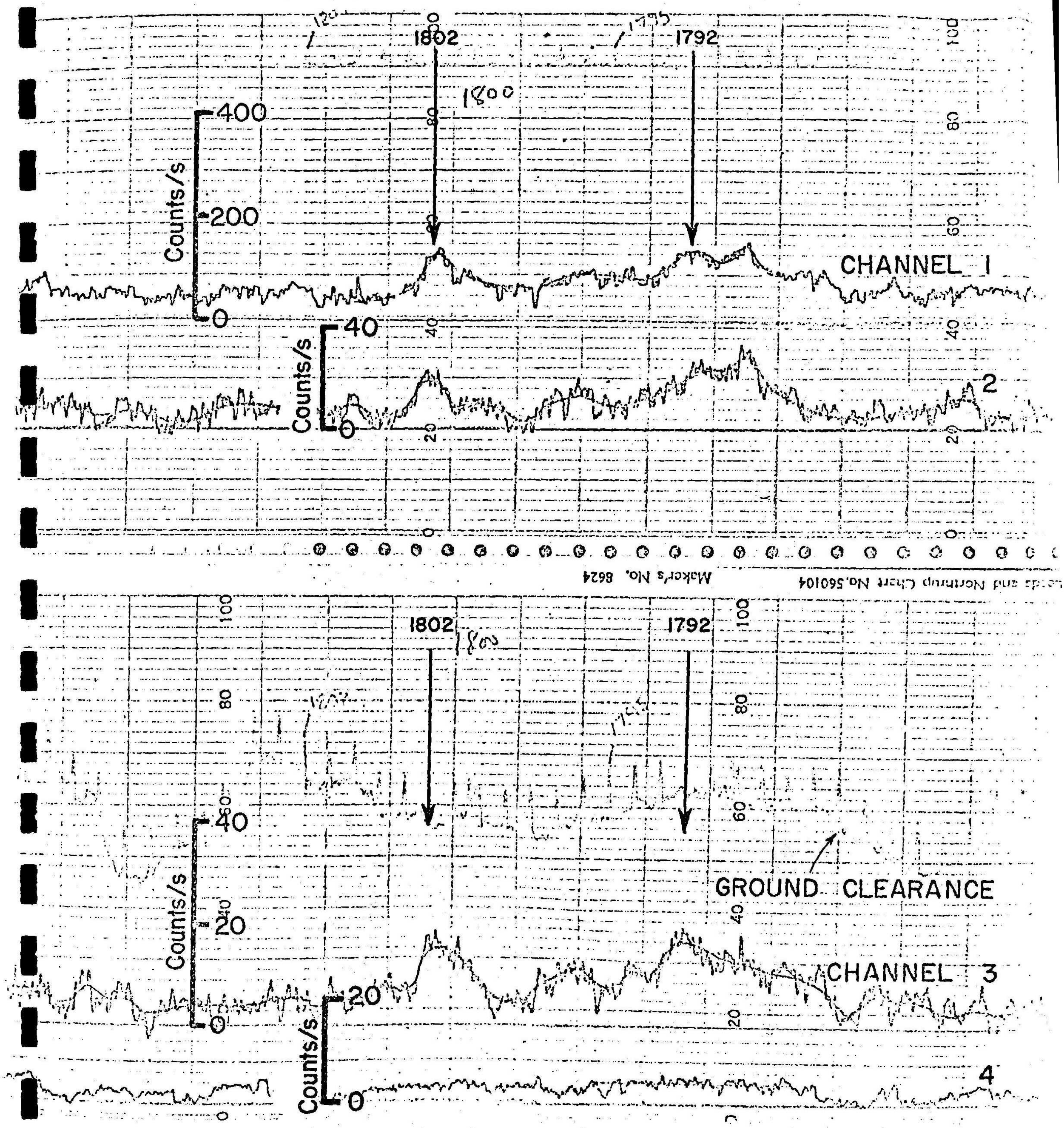
Anomalies 882,898/261·2



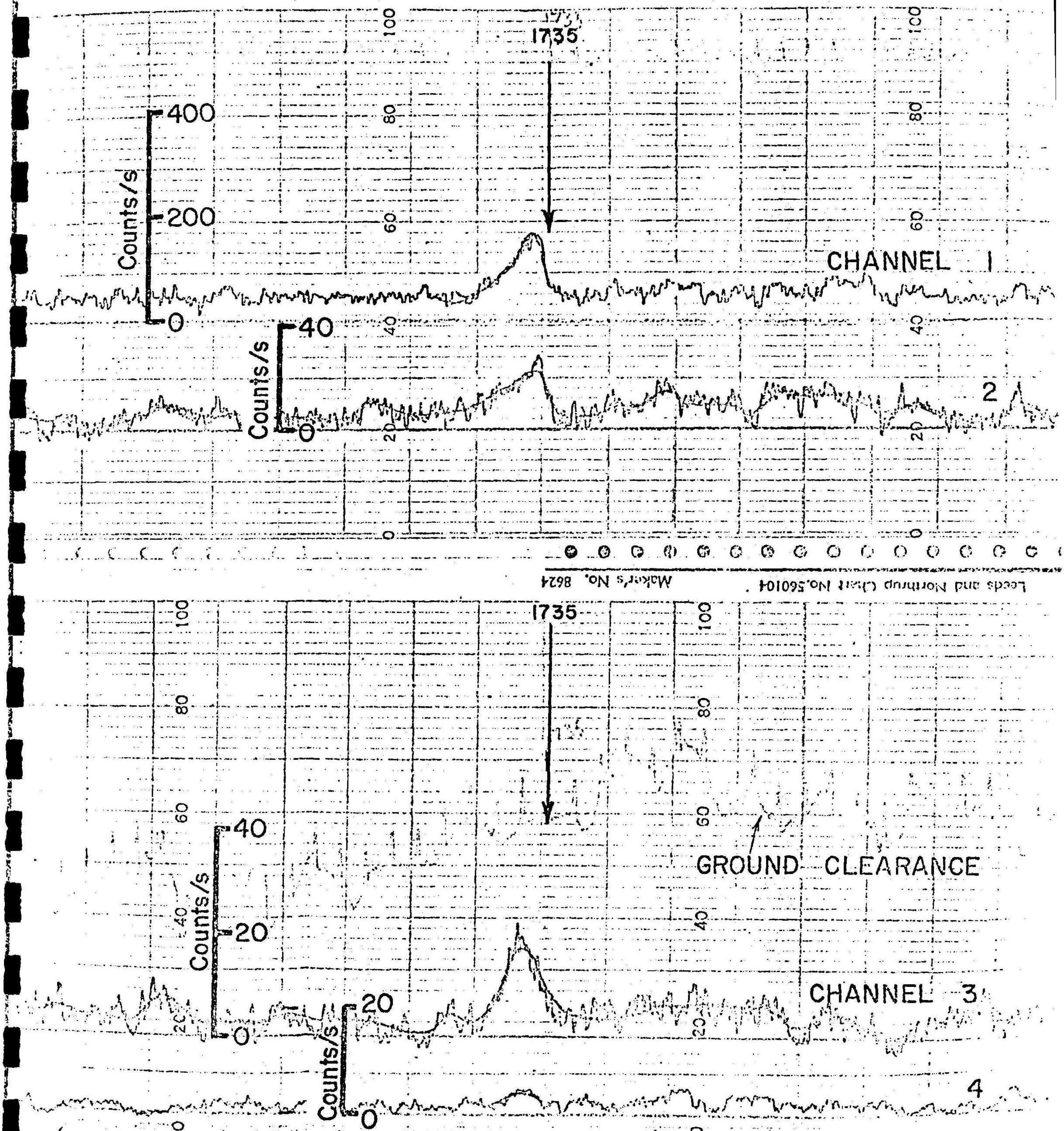
Anomaly 923/261·2



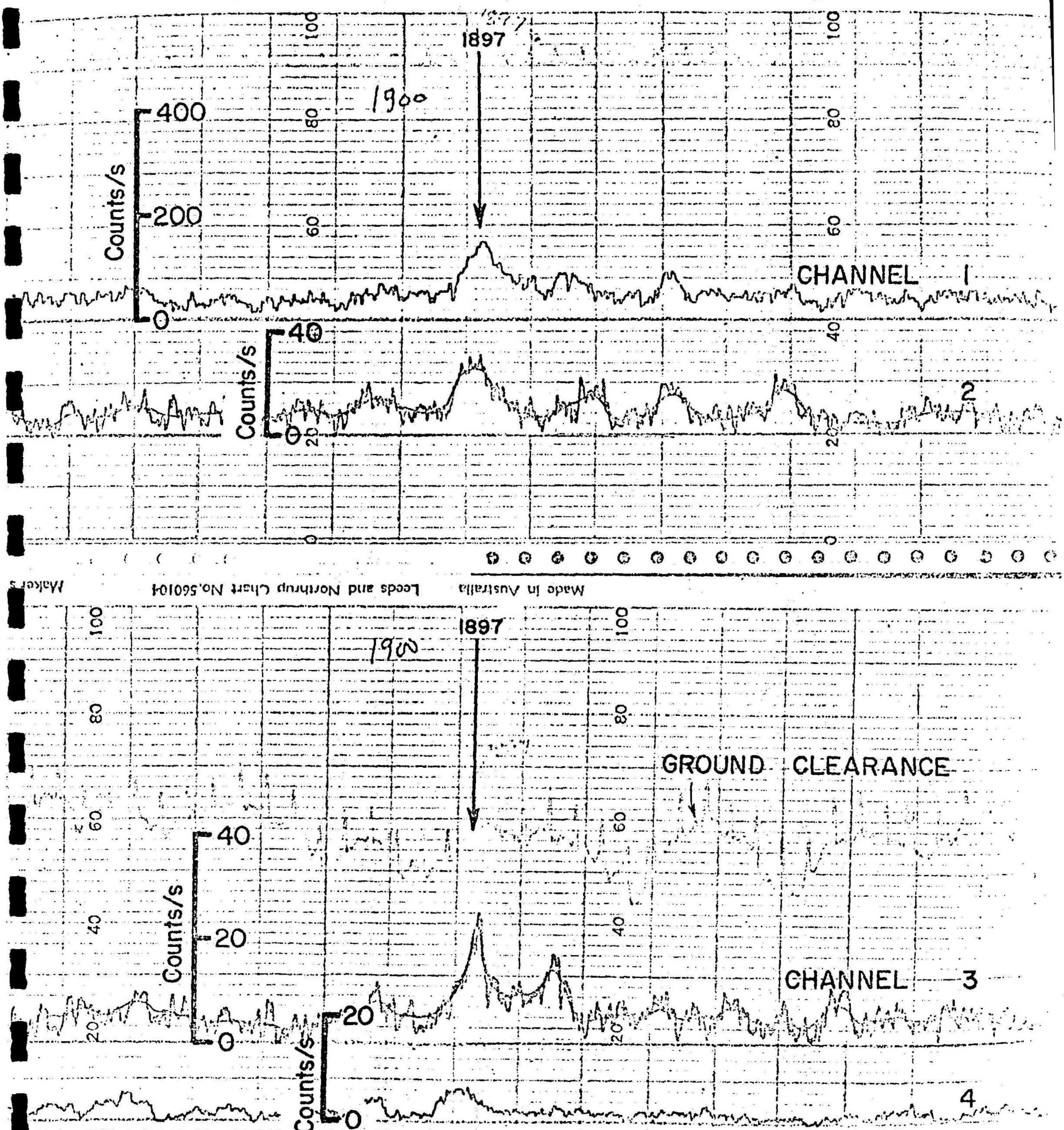
Anomalies 1792,1802/262·2



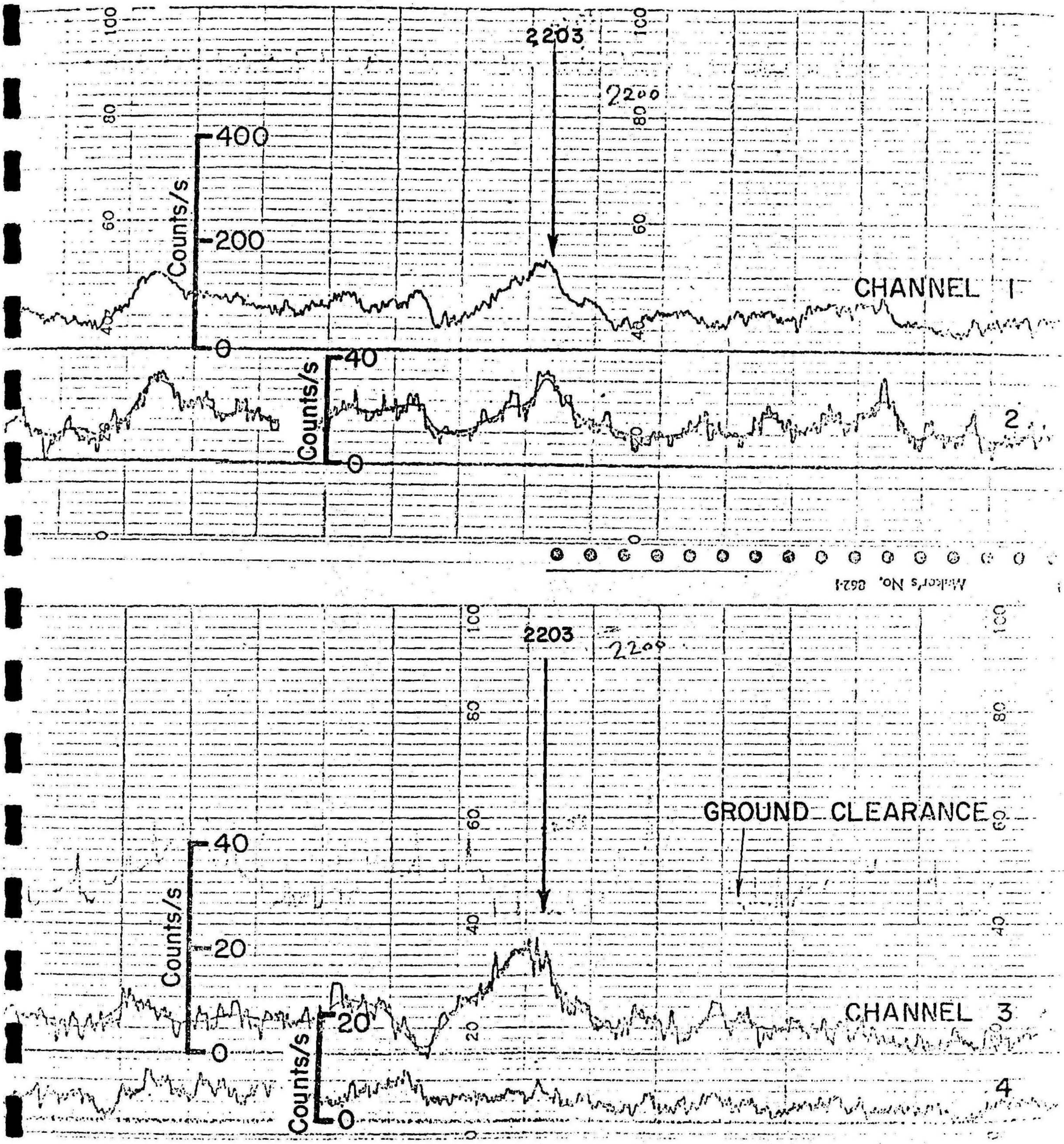
Anomaly 1735/262·2



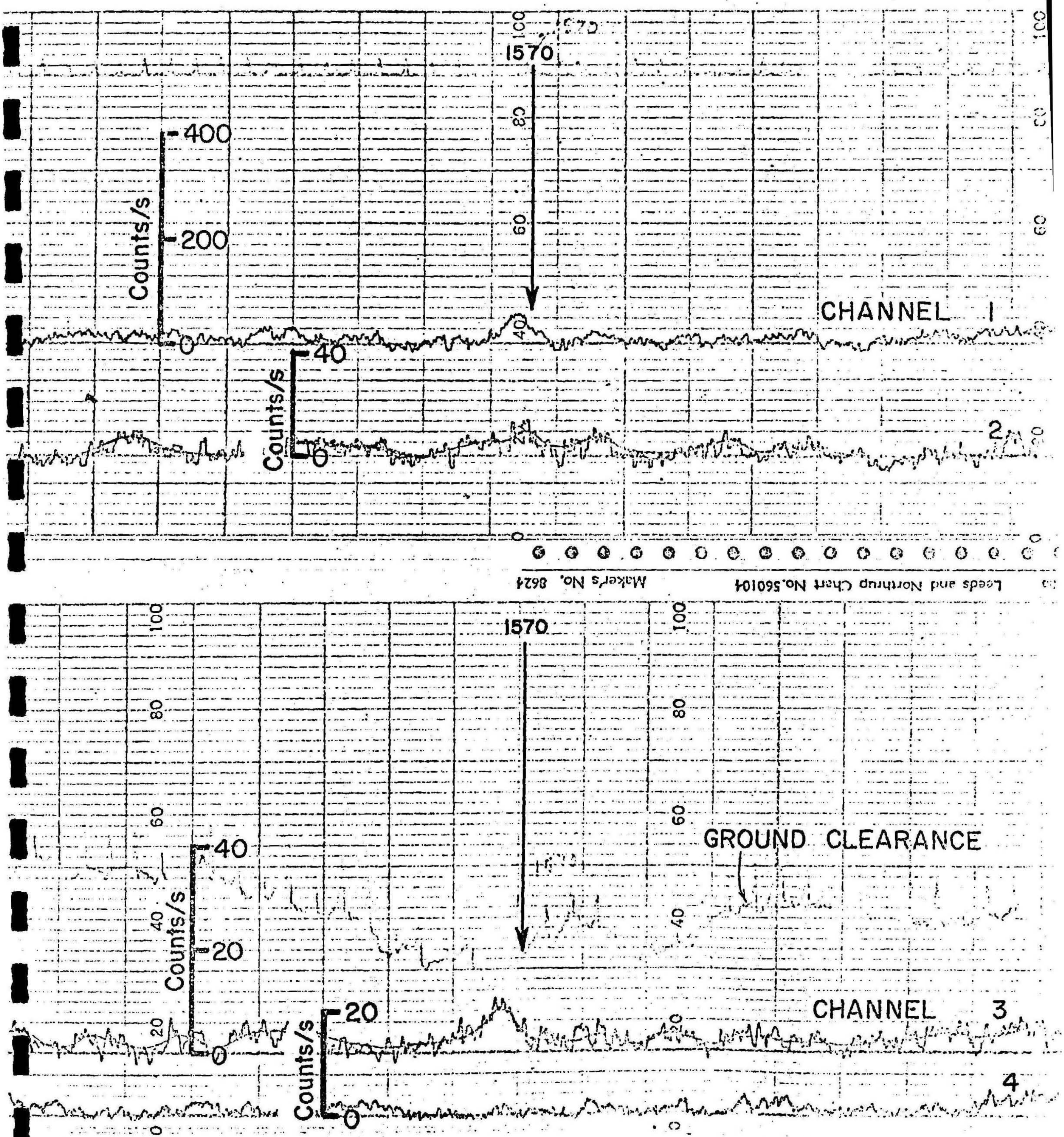
Anomaly 1897/263·2



Anomaly 2203/264·2



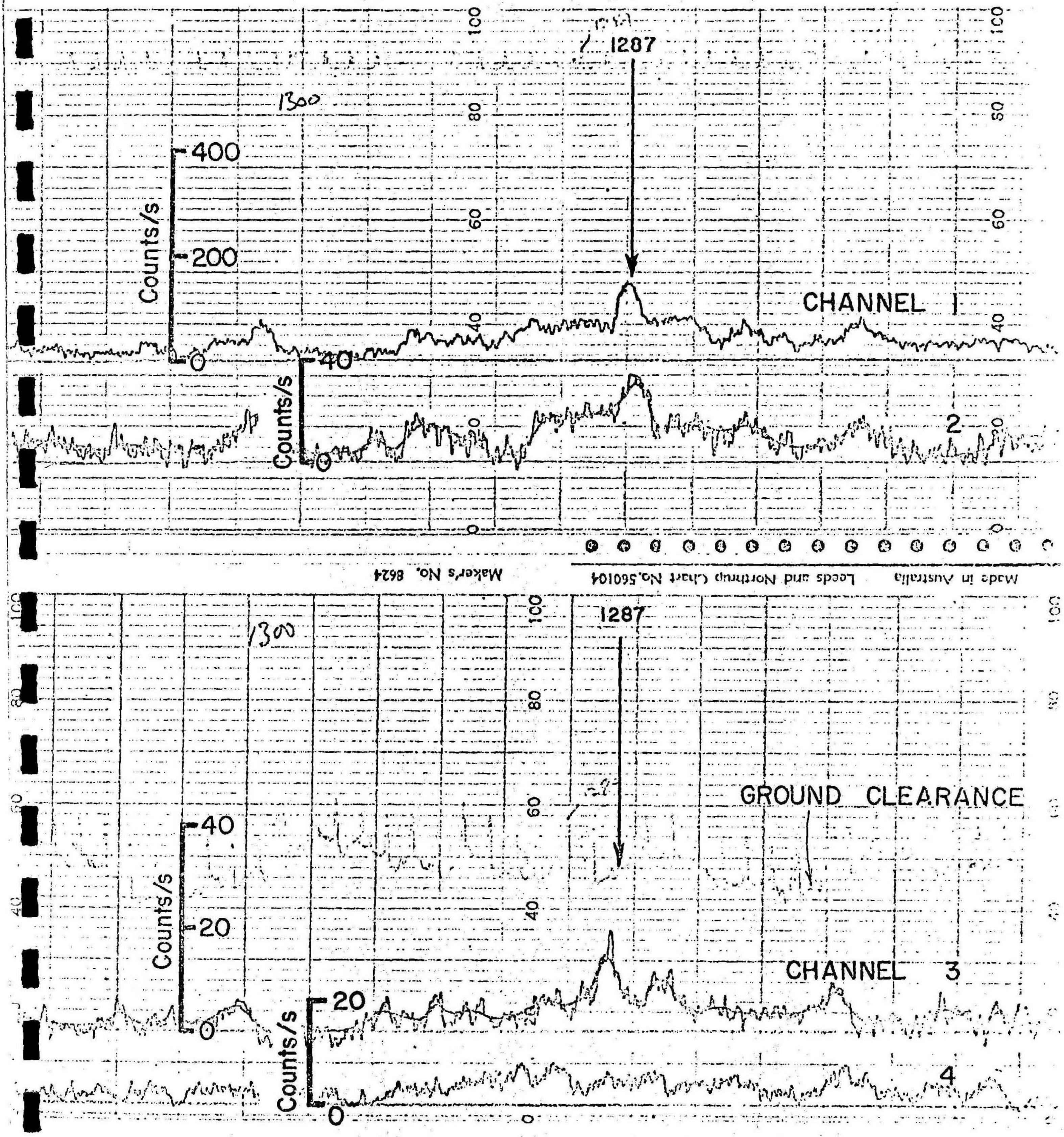
Anomaly 1570/2682



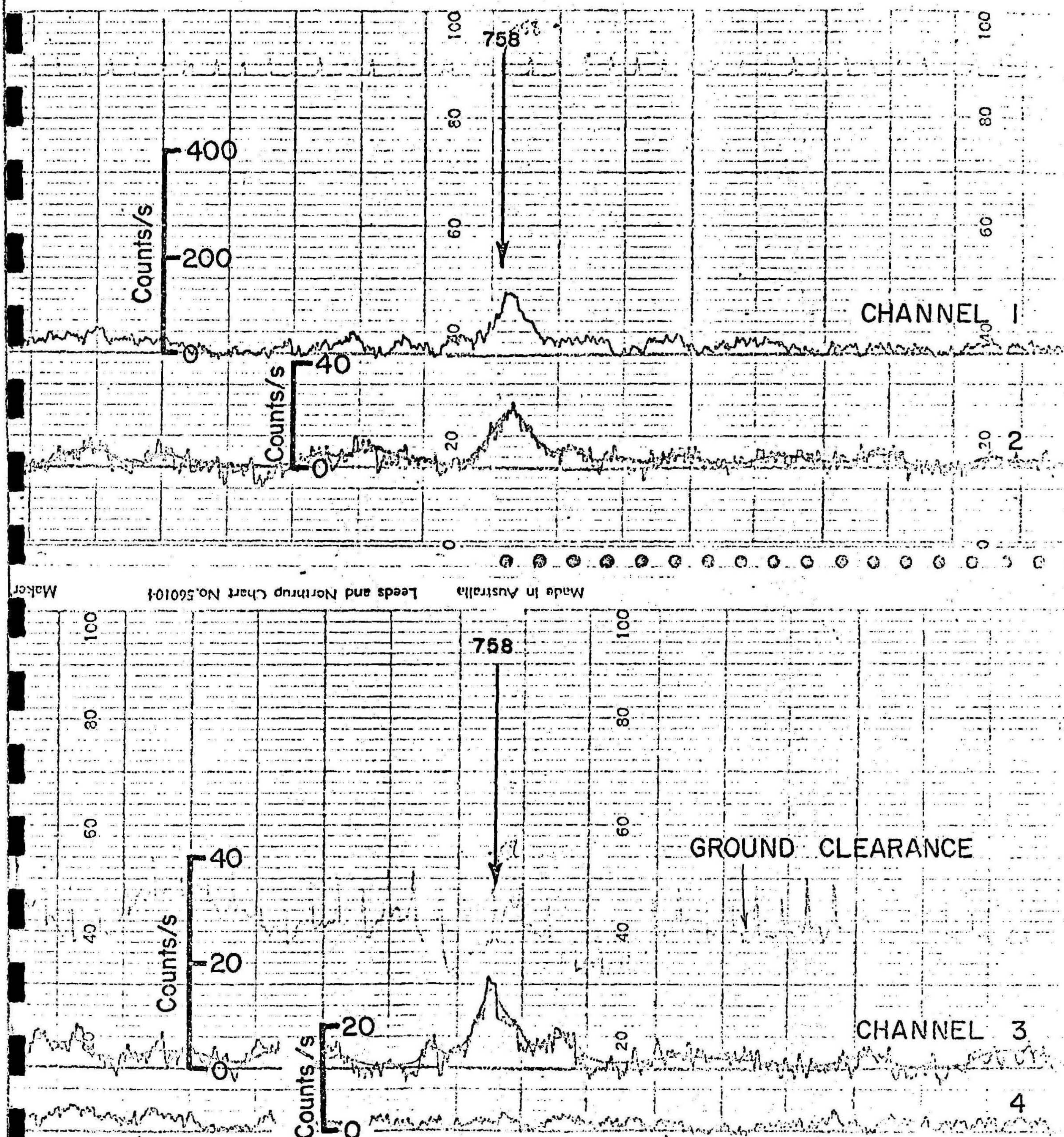
Record No. 1975/89

D53/BI-39A-32

Anomaly 1287/273·2



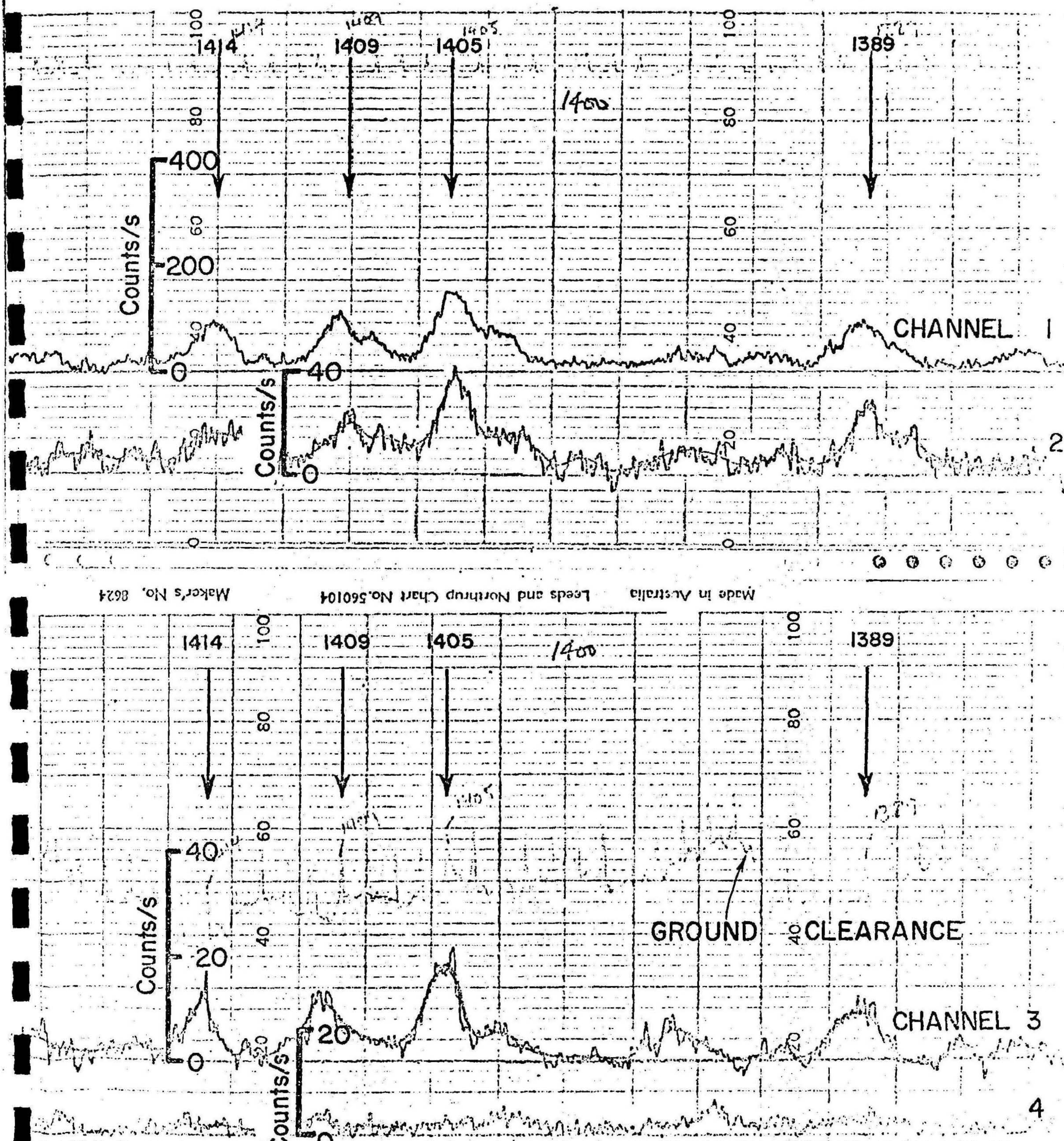
Anomaly 758/269·2



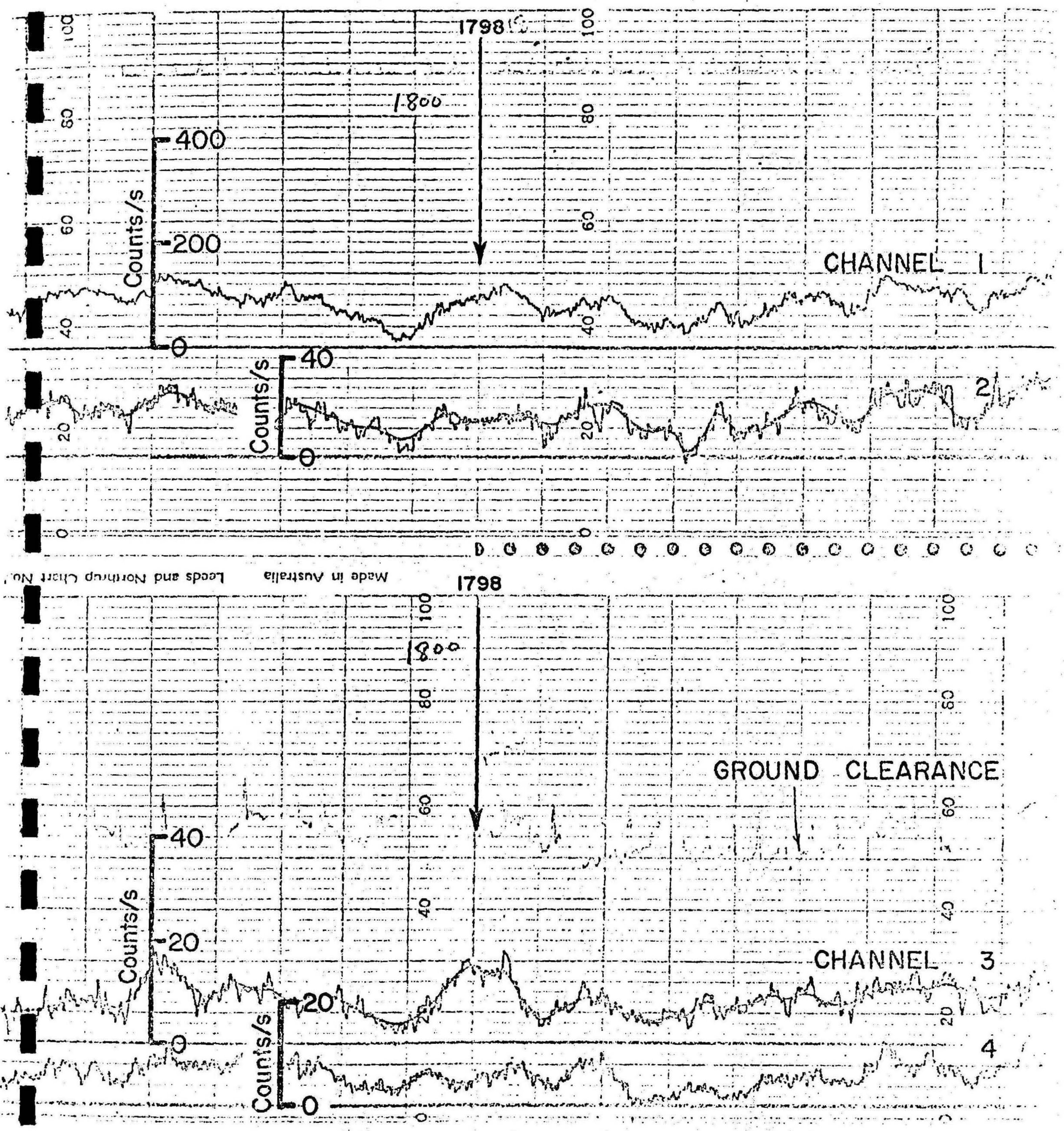
Record No. 1975/89

D53/B1-39A-33

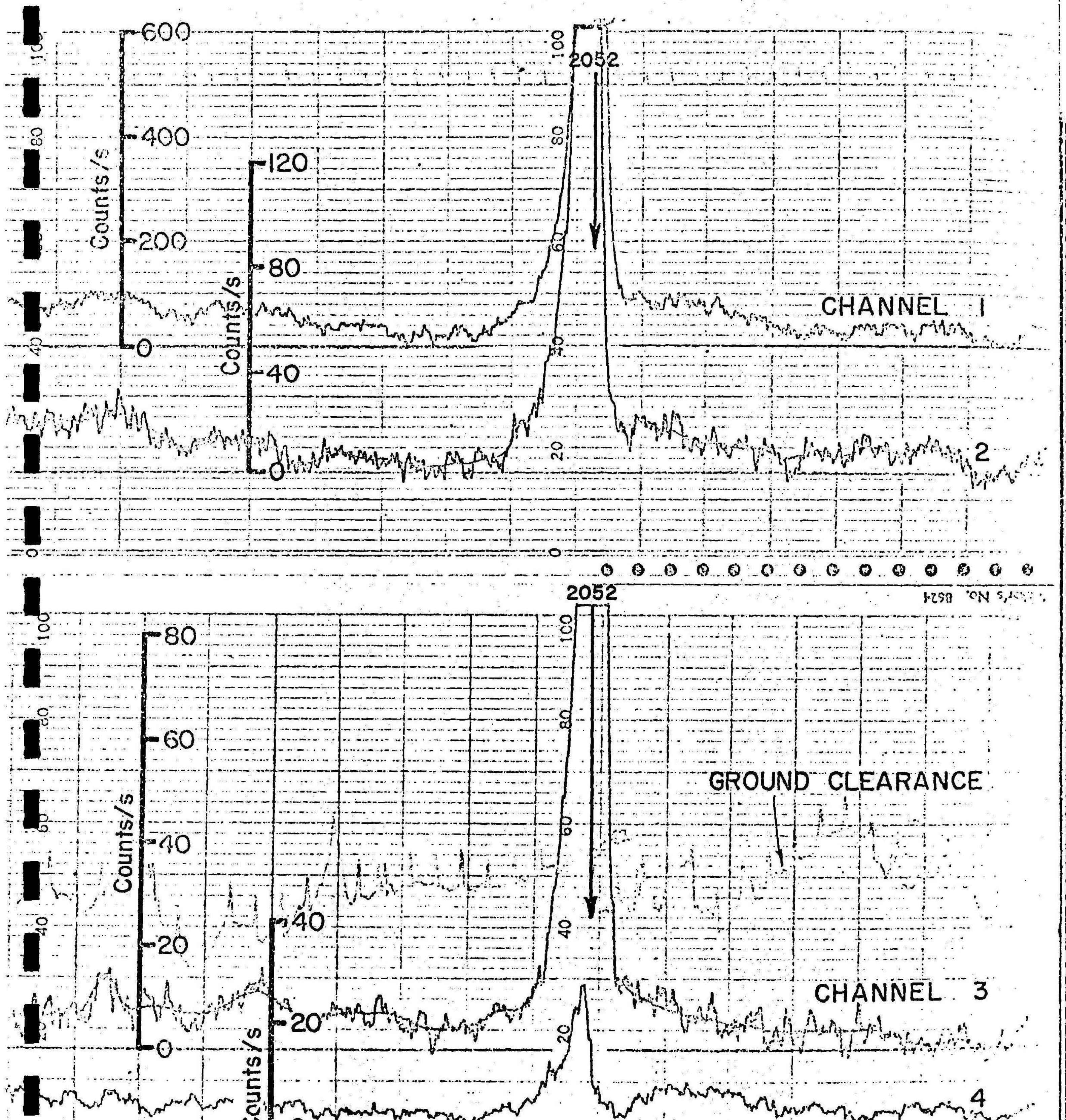
Anomalies 1389,1405,1409,1414/2732



Anomaly 1798/276·3



Anomaly 2052/286·2



APPENDIX 4

Operational Details

Personnel

Party Leader:	K. Horsfall
Geophysicists:	B. Wyatt
	R. Taylor (1971)
	P. Wilkes (1972)
Draftsmen:	I. O'Donnell
	A. Parvey (1971)
	T. Kimber (1972)
Technical Staff:	M. Johnson
	D. Park
	J. Walker (1971, 1972 Part Only)
	P. Mendrinos (1972 Part Only)
Pilots (TAA):	First Officer Joel (1971)
	First Officer Manning (1972)

Equipment

Aircraft:	Aero Commander (VH-BMR)
Magnetometers:	Airborne - Proton-precession MNS-2 coupled to Moseley 7100B recorder
	Ground - Proton-precession MNS-1 coupled to Esterline Angus recorder.
Gamma-ray Spectrometer:	Detector - Two Harshaw 15 cm x 10 cm thallium activated NaI crystals optically coupled to photo-multipliers.
	Electronics - Hamner modules
	Stabilization - Cs-137
	Recorders - Two Speedomax Mark 3 3-channel

Radar Altimeter:	Bonzer TRN-70 with output coupled to one Speedomax recorder
Camera:	Vinten 35 mm with wide angle lens
Timer:	BMR solid state

Equipment Settings

Magnetometer Sensitivities:	Airborne 4/40 gammas/cm
	Ground 9 gammas/cm
Spectrometer Sensitivities:	Channel I - 100 counts/s/cm
	Channel 2 - 20 counts/s/cm
	Channel 3 - 10 counts/s/cm
	Channel 4 - 10 counts/s/cm
Spectrometer time constants:	3secs all channels
Recorder Chart Speeds:	Moseley 7100, 5 cm/min
	Esterline Angus 15 cm/h
	Speedomax Mk3 5 cm/min

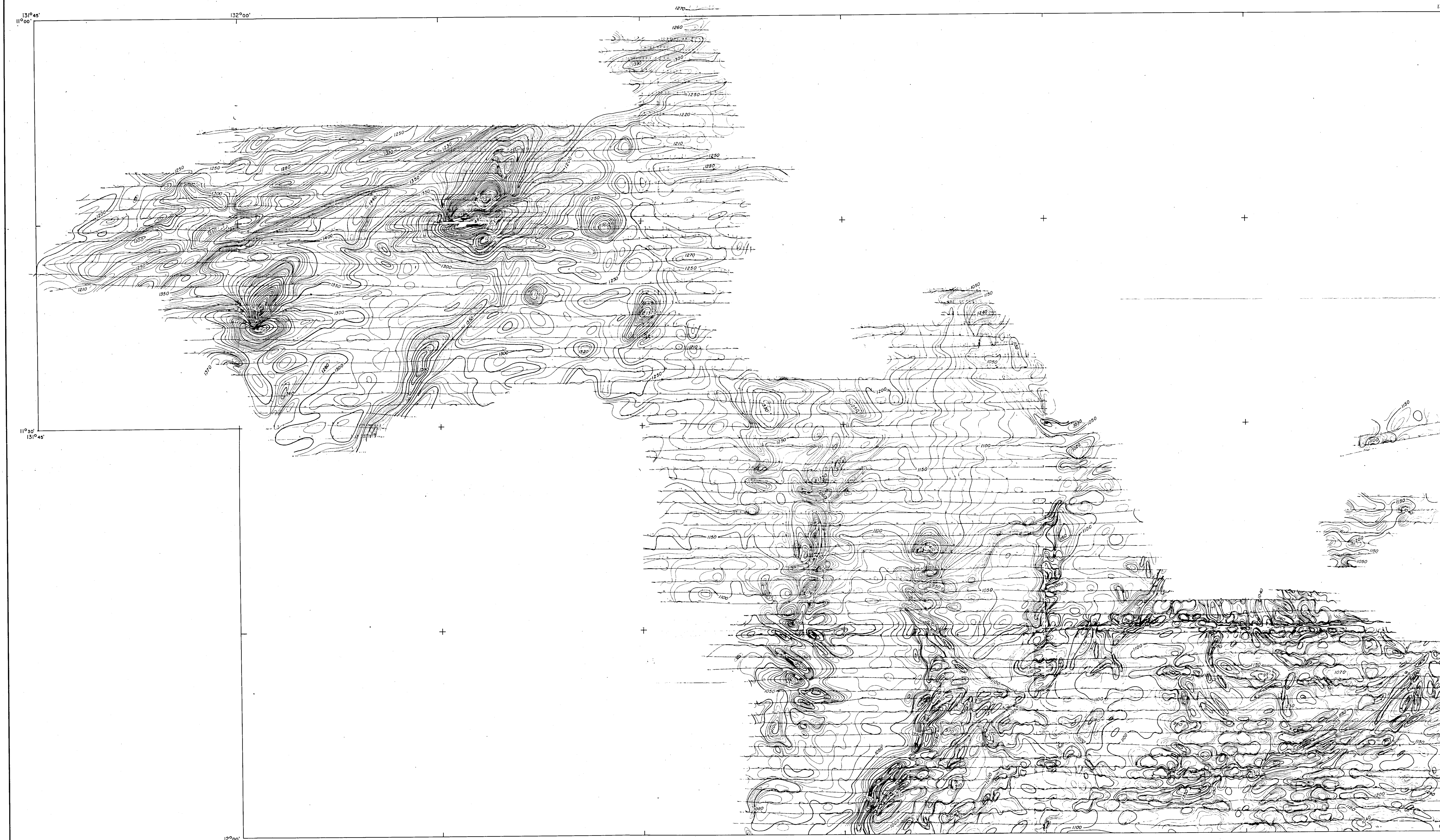
Survey Details

Height:	Nominally 150 m above ground level
Line Spacing:	Nominally 1.5 km
Traverse Direction:	East-west

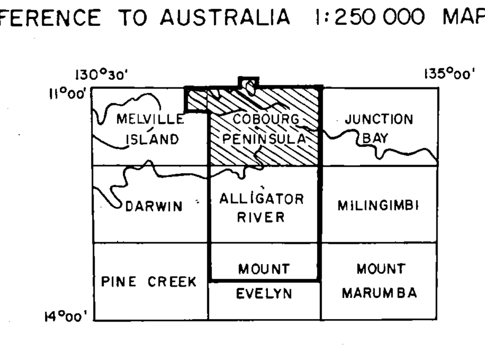
AUSTRALIA 1:250 000

COBOURG PENINSULA
NORTHERN TERRITORY

PLATE I



REFERENCE TO AUSTRALIA 1:250 000 MAP SERIES



AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

PRELIMINARY TOTAL MAGNETIC INTENSITY

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

MILES 5 0 5 10 15 MILES

CONTOUR INTERVAL 10 NANOTESLAS

EXPLANATORY NOTES

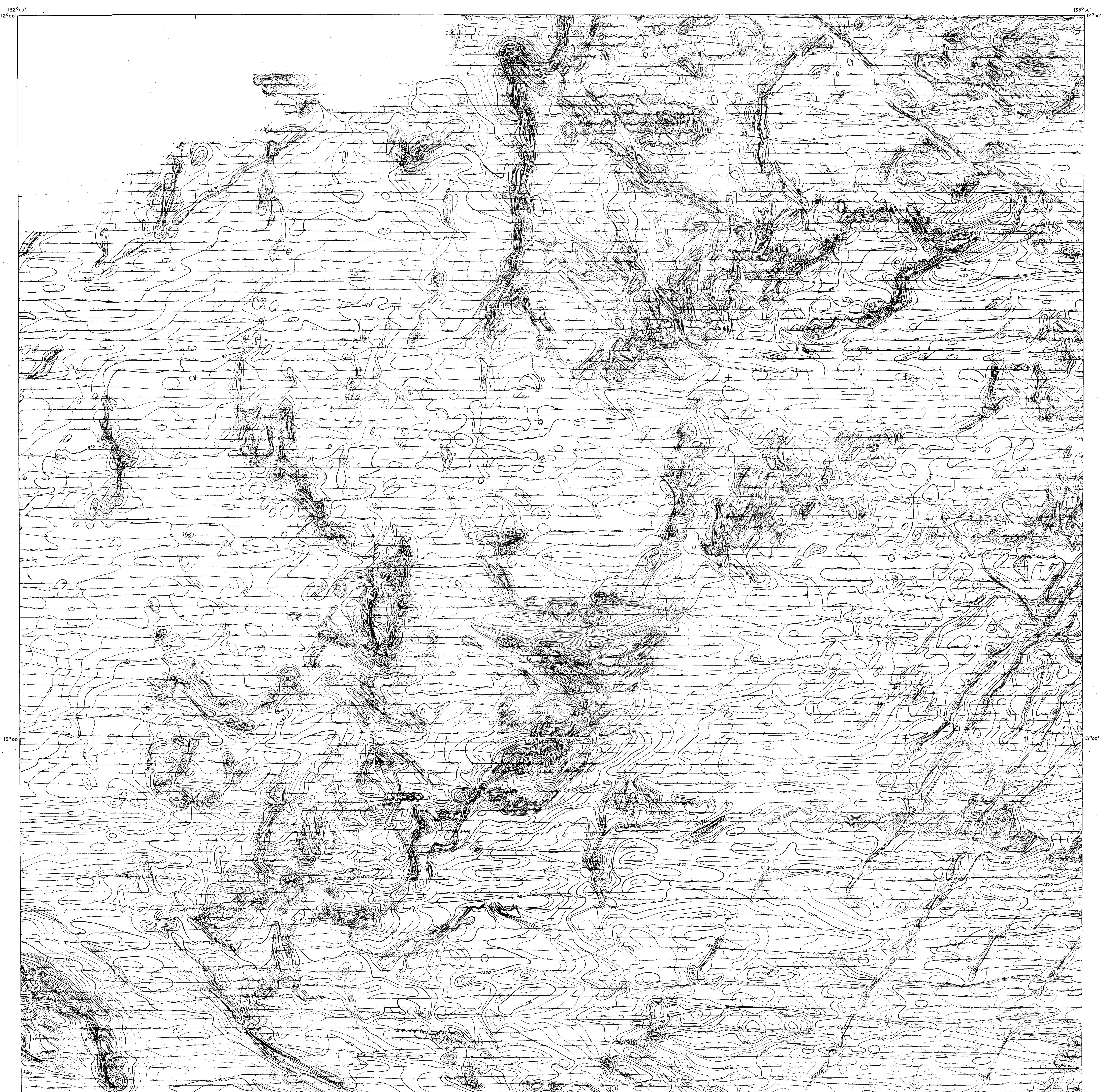
This map was compiled from an airborne magnetic survey made by the Bureau of Mineral Resources in 1971/72 The survey aircraft flew at a height of 150m above ground level along lines spaced 1·5 km apart.
The total magnetic intensity has been corrected for regional gradient.

Record No. 1975/89

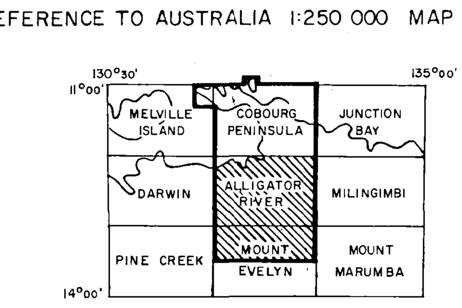
C53/B1-10

ALLIGATOR RIVER - MOUNT EVELYN (NORTH)

NORTHERN TERRITORY



REFERENCE TO AUSTRALIA 1:250 000 MAP SERIES



AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

PRELIMINARY TOTAL MAGNETIC INTENSITY

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

MILES 5 0 5 10 15 MILES

CONTOUR INTERVAL 10 NANOTESLAS

EXPLANATORY NOTES

This map was compiled from an airborne magnetic survey made by the Bureau of Mineral Resources in 1971/72. The survey aircraft flew at a height of 150m above ground level along lines spaced 1·5 km apart. The total magnetic intensity has been corrected for regional gradient.

Record No. 1975/89

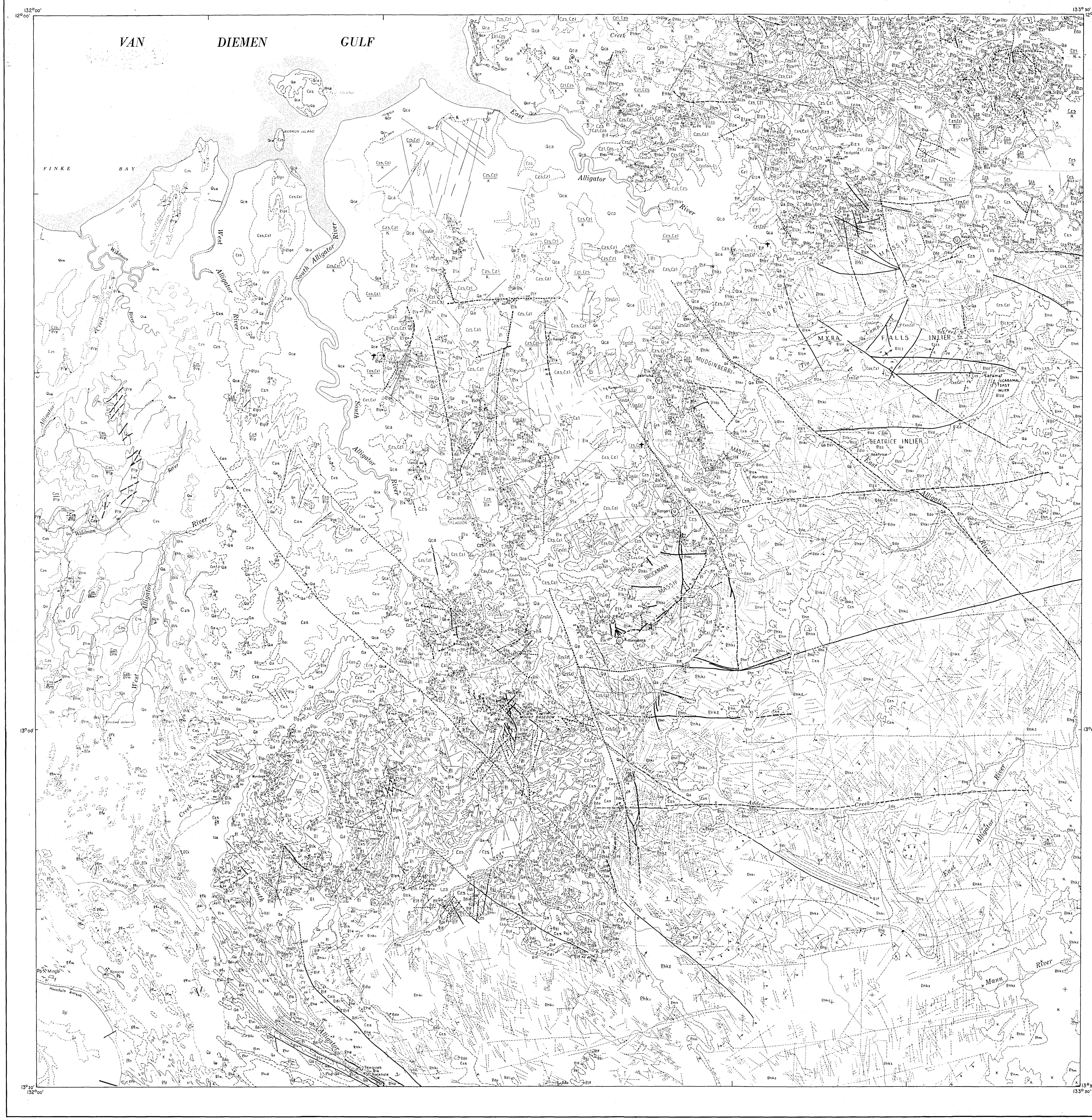
D53/B1-27

AUSTRALIA 1:250 000

COBOURG PENINSULA
NORTHERN TERRITORY

ALLIGATOR RIVER – MOUNT EVELYN (NORTH)

NORTHERN TERRITORY



GEOLOGICAL LEGEND

Era	Period	Unit	Symbol	Description
CAINOZOIC	QUATERNARY		Qca	Silt, mud, coastal alluvium
			Qcr	Sand, shelly sand, coastal sand ridges
			Qa	Silt, clay, sand, soil; terrestrial alluvium
			Czs	Unconsolidated sand, clayey sand
			Czl	Laterite; ferricrete, mottled zone
MESOZOIC	LOWER TO UPPER CRETACEOUS		K	Fossiliferous, poor. sorted quartzose sandstone, mudstone, siltstone and conglomerate
PROTEROZOIC	ADELAIDEAN	Mudginberri Phonolite *		Phonolite dykes
	CARPENTARIAN	Katherine River Group: McKay Sandstone	Ꝑhm	Ferruginous, flaggy to blocky, fine to medium sandstone, feldspathic sandstone, blocky white quartz sandstone
		Katherine River Group, Kombolgie Formation: Gilruth Volcanic Member *	Ꝑhg	Tuffaceous siltstone, siltstone, minor amygdaloidal basalt, jasperite
			Ꝑhk2	Quartz sandstone, minor conglomerate and siltstone; cross-bedded, ripple marked
		Nungbalgarri Volcanic Member *	Ꝑhn	Basalt, amygdaloidal in places, interrelated siltstone and tuffaceous sediments
			Ꝑhk1	Quartz sandstone, conglomerate, minor siltstone; cross-bedded, ripple marked
		Plum Tree Volcanic Member	Ꝑhd	Andesite with minor amygdaloidal volcanics, minor tuffaceous sediments
		Kurrundie Member	Ꝑhr	Purple quartz greywacke with pebbles and bands of quartz conglomerate
		Edith River Volcanics	Ꝑhe	Rhyolite, dacite, pyroclastic breccio-conglomerate
		Cullen Granite	Ꝑgc	Biotite-hornblende granite
			Ꝑlg	Pink biotite granite, altered; anomalously radioactive
		Jim Jim Granite	Ꝑgj	
		Oenpelli Dolerite *	Ꝑdo	Porphyritic, ophitic and granophyric dolerite; syenite differentiates
	LOWER PROTEROZOIC	Nanambu Complex	Ꝑlx	Schist, gneiss, minor granitoid migmatite
		Ninbuwah Complex: Granitoid Core	Ꝑlz1	Homogeneous, foliated to non-foliated, hornblende-biotite granitoid migmatite
		Migmatite Zone	Ꝑlz2	Hornblende-biotite granitoid migmatite; complex interpenetration fabrics
		Lit-par-lit Gneiss Zone	Ꝑlz3	Lit-par-lit gneiss, banded gneiss, augen gneiss
		Transitional Zone	Ꝑlz4	Isoclinally folded, schist, gneiss, feldspathic, some leucosome bands
		Zamu Complex	Ꝑdi	Dolerite, metadolerite, amphibolite
		Sth Alligator Group	Ꝑl	Undivided sediments
		Fisher Creek Siltstone	Ꝑlf	Siltstone, phyllite, minor quartzite
		Koolpin Formation and equivalent	Ꝑlk	Siltstone, phyllite, quartzite, carbonate rock, chert bands
		Goodparla Group: Golden Dyke Formation	Ꝑld	Chert, quartz siltstone, dolomite, minor carbonaceous pyritic siltstone with chert lenses, bands and nodules
		Coirwong Greywacke	Ꝑlc	Quartz greywacke, with conglomerate lenses
		Mount Partridge Formation	Ꝑlp4	Feldspathic quartzite, micaceous quartzite, quartzite
			Ꝑlp3	Phyllite, minor schist
			Ꝑlp2	Conglomerate, feldspathic sandstone, arkose, minor slate
			Ꝑlp1	Slate, phyllite, minor meta-arkose
		Mundogie Sandstone Member	Ꝑlu	Sandstone, conglomerate, minor slate and siltstone
		Stag Creek Volcanics	Ꝑlv	Altered basalt and basalt-agglomerate
		Masson Formation	Ꝑlm	Quartz greywacke, carbonaceous siltstone, calcareous siltstone, conglomerate

* Name not yet approved

Geological boundary
Anticline, showing plunge
Syncline, showing plunge
Fault, (D,U indicates relative movement down, up)
Fault; high angle reverse
Fault, inclined
Fault, showing relative horizontal movement
Fault, with slickenside

Where location of boundaries, folds and faults is approximate line is broken; where inferred, queried; where concealed boundaries and folds are dotted, faults are shown by short dashes

Plunge of minor anticline
Plunge of minor syncline
Plunge of fold axis
Plunge added to trend line
Dome
Strike and dip of strata
Prevailing strike and dip of strata
Vertical strata
Horizontal strata
Overturned strata
Curving dip
Dip 5°–15°
Dip 15°–45°
Trend lines
Joint pattern
Lineament
Dip slope
Prevailing dip of strongly deformed strata
Generalised strike and dip of undulating strata
Strike and dip of joints
Strike and dip of joints, unmeasured
Strike and dip of foliation
Strike and dip of foliation, unmeasured
Vertical foliation
Strike and dip of cleavage
Strike and dip of cleavage, unmeasured
Vertical cleavage
Apparent dip of cleavage on bedding plane
Strike of bedding and cleavage coincident
Strike and dip of bedding with vertical cleavage
Lineation on bedding
Foliation with plunge of lineation
Platy flow, inclined
Platy flow, vertical
Platy flow, horizontal

Direction of sedimentation x-cross stratification
Direction of sedimentation, sense unknown
Macrofossil locality
Dyke or vein, q-quartz ph-phonolite d-dolerite

Minor mineral occurrence
Unworked deposit
Prospect
Mine, minor

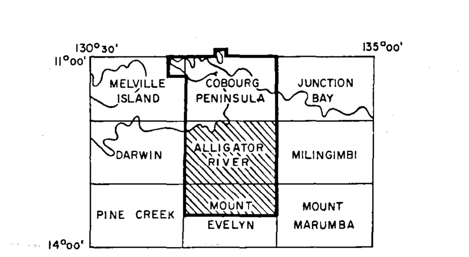
Au	Gold
Cu	Copper
Pb	Lead
Sn	Tin
U	Uranium
Zn	Zinc

Geology east of longitude 132°15' after Alligator Rivers Region Enviromental fact-finding study (Needham et al, 1973) West of 132°15' geology after BMR Alligator River, first edition 1962 and BMR Mount Evelyn, first edition 1963.

TOPOGRAPHICAL LEGEND

Road or track
Named place
Homestead
Aerodrome or landing ground
River or creek
Lake
Hill feature

REFERENCE TO 1:250 000 MAP SERIES



AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

GEOLOGY

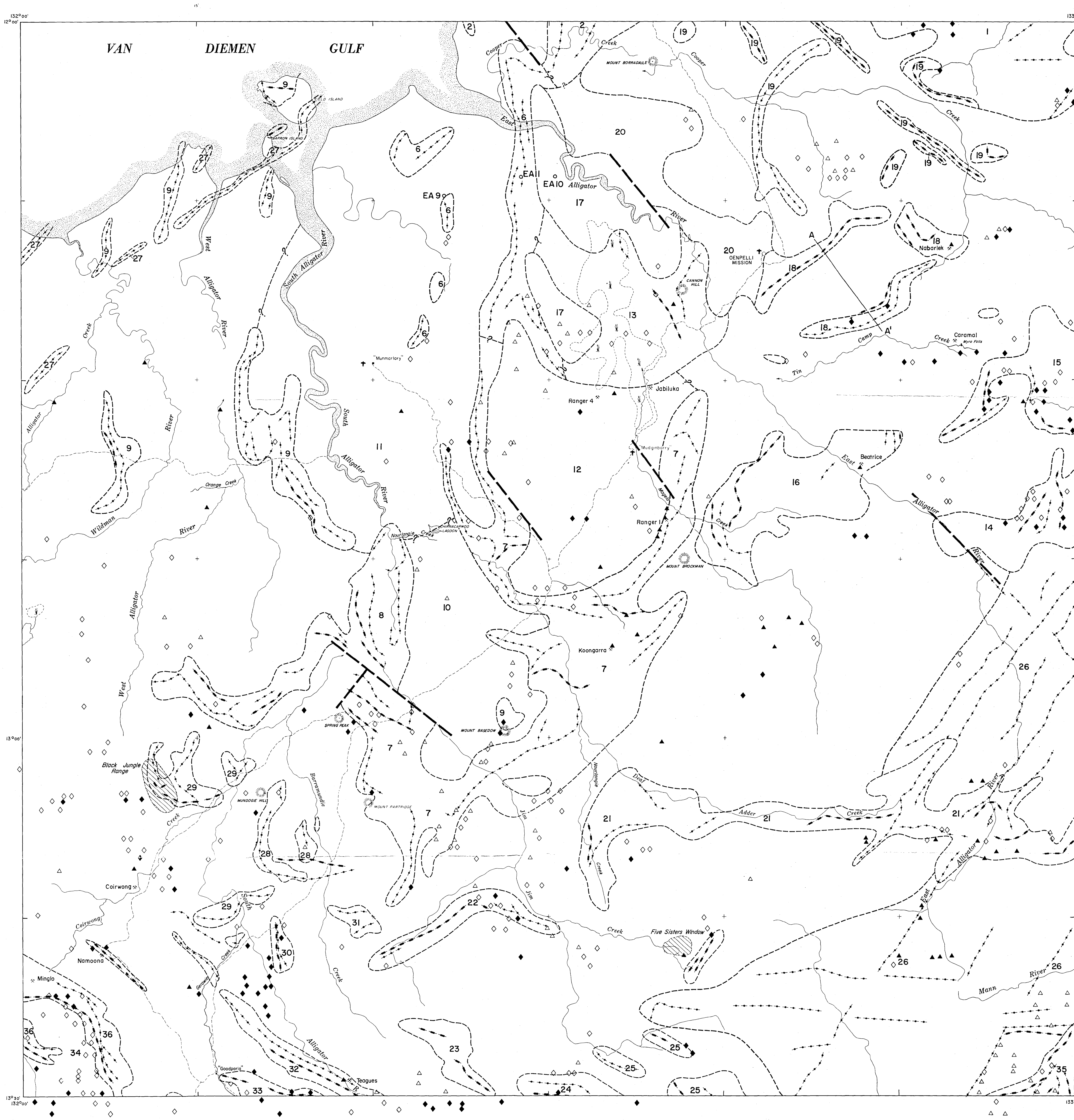
KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

MILES 5 0 5 10 15 MILES

AUSTRALIA 1:250 000

ALLIGATOR RIVER – MOUNT EVELYN (NORTH)

NORTHERN TERRITORY



REFERENCE TO 1:250 000 MAP SERIES

MELVILLE ISLAND	COBOURG PENINSULA	JUNCTION BAY
DARWIN	ALLIGATOR RIVER	MILINGIMBI
PINE CREEK	MOUNT EVELYN	MOUNT MARUMBA

TOPOGRAPHICAL LEGEND

- Road or track
- Named place
- Homestead
- Aerodrome or landing ground
- Mine or prospect
- River or creek
- Lake
- Swamp
- Saltpan or claypan
- Hill feature

AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

GEOPHYSICAL INTERPRETATION

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

MILES 5 0 5 10 15 MILES

MAGNETIC LEGEND

- (25) Magnetic zone
- Positive magnetic trend
- Negative magnetic trend
- Interpreted fault
- Drill hole

RADIOMETRIC LEGEND

- ◆ Anomaly predominantly due to potassium
- ▲ Anomaly predominantly due to uranium
- △ Anomaly predominantly due to thorium
- ◇ Anomaly of mixed source

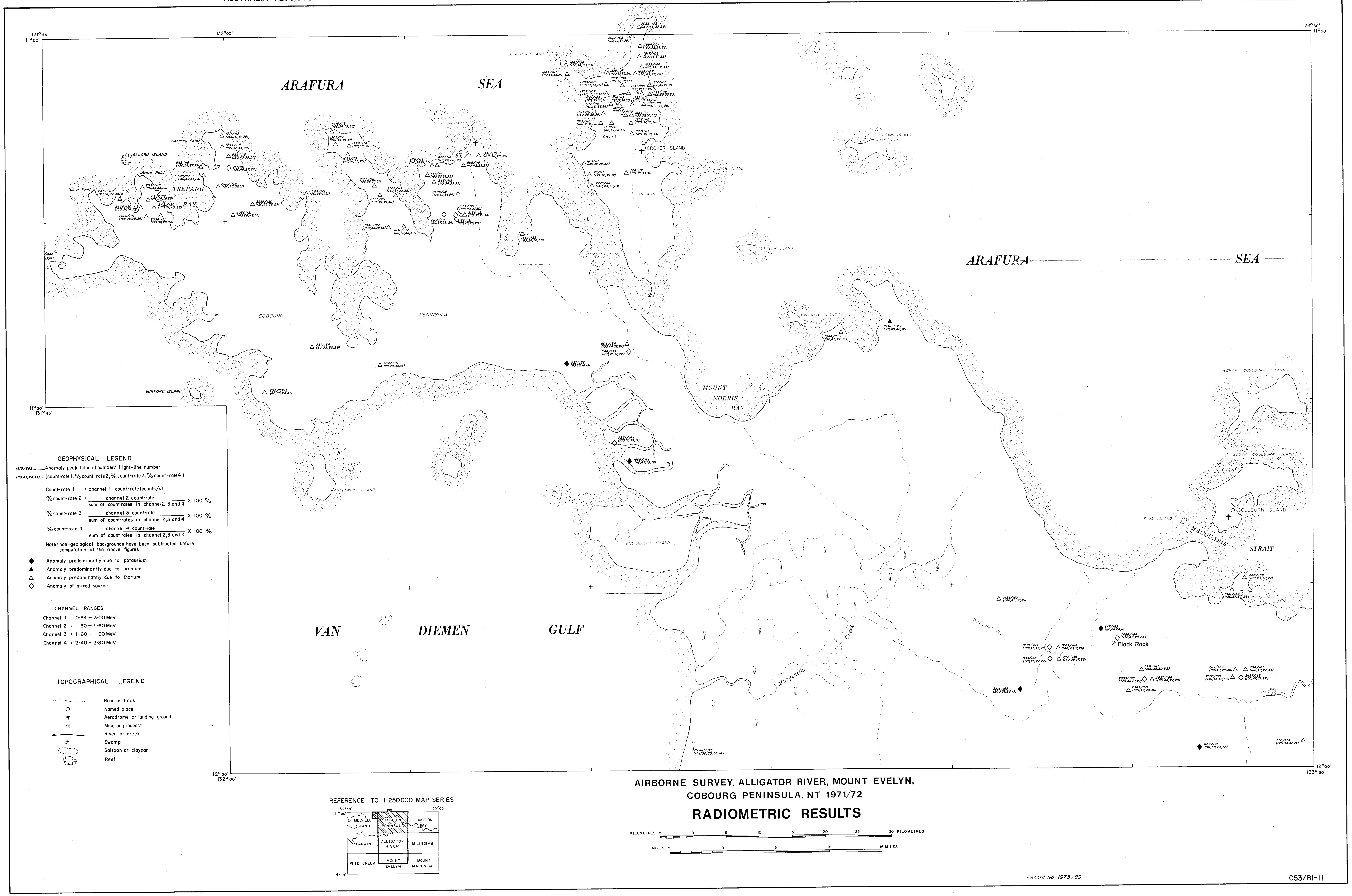
Record No. 1975/89

AUSTRALIA 1:250,000

COBOURG PENINSULA

NORTHERN TERRITORY

PLATE 6

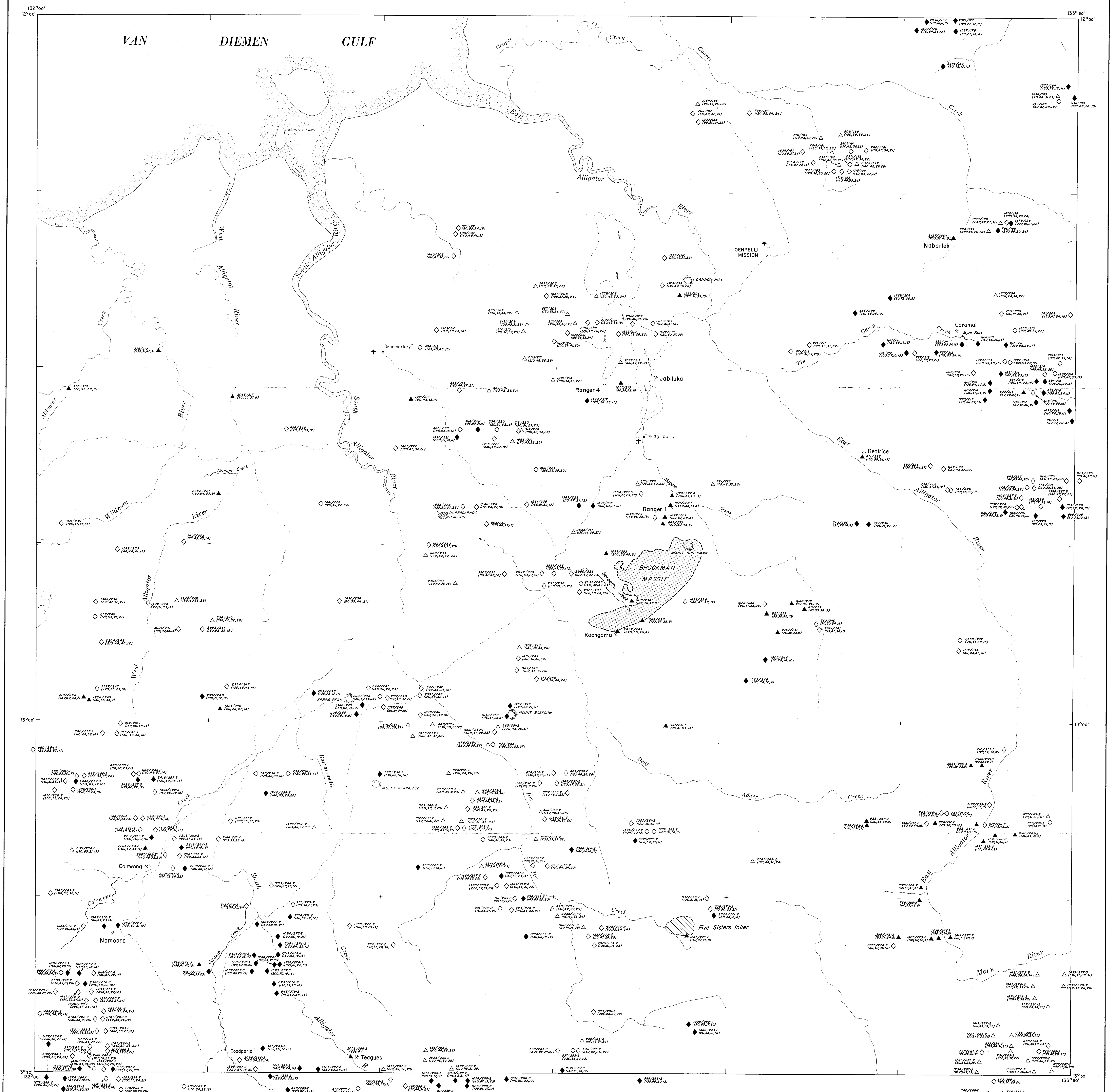


AUSTRALIA 1:250,000

ALLIGATOR RIVER – MOUNT EVELYN (NORTH)

NORTHERN TERRITORY

PLATE 7



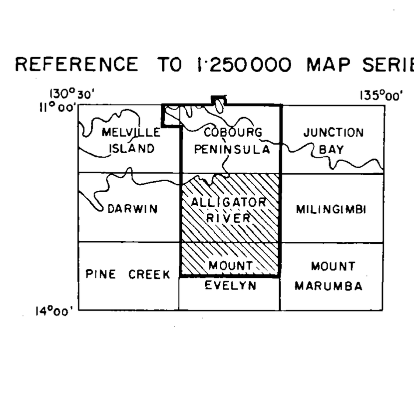
AIRBORNE SURVEY, ALLIGATOR RIVER, MOUNT EVELYN, COBOURG PENINSULA, NT 1971/72

RADIOMETRIC RESULTS

KILOMETRES 5 0 5 10 15 20 25 30 KILOMETRES

MILES 5 0 5 10 15 MILES

REFERENCE TO 1:250000 MAP SERIES



TOPOGRAPHICAL LEGEND

- Road or track
- Named place
- Homestead
- Aerodrome or landing ground
- Mine or prospect
- River or creek
- Lake
- Swamp
- Saltpan or claypan
- Hill feature

GEOPHYSICAL LEGEND

1815/282 .... Anomaly peak fiducial number/ flight-line number

(110, 43,24,33)......... (count-rate 1, % count-rate 2, % count-rate 3, % count-rate 4)

Count-rate 1 : channel 1 count-rate (counts/s)

$$\%\text{count-rate 2} : \frac{\text{channel 2 count-rate}}{\text{sum of count-rates in channel 2,3 and 4}} \times 100\ \%$$

$$\%\text{count-rate 3} : \frac{\text{channel 3 count-rate}}{\text{sum of count-rates in channel 2,3 and 4}} \times 100\ \%$$

$$\%\text{count-rate 4} : \frac{\text{channel 4 count-rate}}{\text{sum of count-rates in channel 2,3 and 4}} \times 100\ \%$$

Note: non-geological backgrounds have been subtracted before computation of the above figures

- ◆ Anomaly predominantly due to potassium
- ▲ Anomaly predominantly due to uranium
- △ Anomaly predominantly due to thorium
- ◇ Anomaly of mixed source

CHANNEL RANGES

Channel 1 : 0·84 – 3·00 MeV

Channel 2 : 1·30 – 1·60 MeV

Channel 3 : 1·60 – 1·90 MeV

Channel 4 : 2·40 – 2·80 MeV

Record No 1975/89

D53/B1-30