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INVESTIGATION OF THE SOURCE OF A RADON ANOMALY, EAST OF BATCHELOR, RUM JUNGLE AREA, N.T.

by

D.C. STUART and A.T. WARNES

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SUMMARY

During reconnaissance radiometric surveys conducted by BMR in the Rum Jungle area during 1979, BMR located a strong radon anomaly near the prospective boundary between the Batchelor and Namoona Groups, 5 km east of Batchelor.

Additional work on this anomaly was undertaken jointly by BMR and Dampier Mining Company during 1980 in an attempt to locate the source of the anomaly and investigate radon transport mechanisms. This work comprised surface gamma-ray spectrometry, surface Alphameter (radon) surveys, magnetic surveys, laboratory assays of samples, and some qualitative down-hole gamma-ray spectrometry.

The additional surveys outlined a roughly circular radon anomaly associated with a smaller and less well defined apparent uranium anomaly. Studies of the variation of the radioelement concentration with depth, disequilibrium of surface rocks, and a comparison of alpha and gamma anomalies indicate that the source of the anomaly was not detected. These studies also suggest that the source of the anomaly could still be a buried concentration of uranium or radium located near the radon anomaly.

Additional work, including further studies of the disequilibrium and radioelement concentration of surface and subsurface rocks, ground water flow, and pattern drilling/logging, is required to evaluate properly the source of the radon anomaly.

INTRODUCTION

During August and October 1979, the Bureau of Mineral Resources (BMR) carried out reconnaissance radiometric surveys in the Rum Jungle area to evaluate instrumentation used in uranium exploration and to document the distribution of radioelements in the rocks and soils of the area (Stuart & Warnes, in prep.). Work undertaken included surface and down-hole gamma-ray spectrometry, surface alpha detection (radon) surveys, ground magnetics, and auger drilling. The work was carried out along 14 traverses as shown in Figure 1. During the course of this work a strong radon anomaly was detected on Traverse 3A, which is a graded fence line track located 5 km east of Batchelor on E.L. 1349, then held by Dampier Mining Company (Dampier).

The anomaly on Traverse 3A is of considerable interest as it is located close to the contact between Coomalie Dolomite and Masson (Golden Dyke) Formation, which is a stratigraphic position considered favourable for uranium mineralisation. Furthermore, as this radon anomaly was not associated with a strong gamma-ray anomaly at the surface, radon transport, perhaps from a body of buried uranium mineralisation, is possible. There is no obvious evidence of prior exploration work in the immediate area. However, a search through BMR records indicates the presence of a "3rd order" airborne uranium gamma-ray spectrometer anomaly (Beattie, 1971) which had not been ground checked.

The source of the radon anomaly was investigated by BMR in 1979 by the drilling and gamma spectrometer logging of two holes, one sited on the anomaly on Traverse 3A, and the other 100 m to the west. The depth of these holes was 23 m and 16 m respectively but logging indicated no significant increase in the level of gamma-radiation with depth. Further investigation of the source of the radon anomaly was

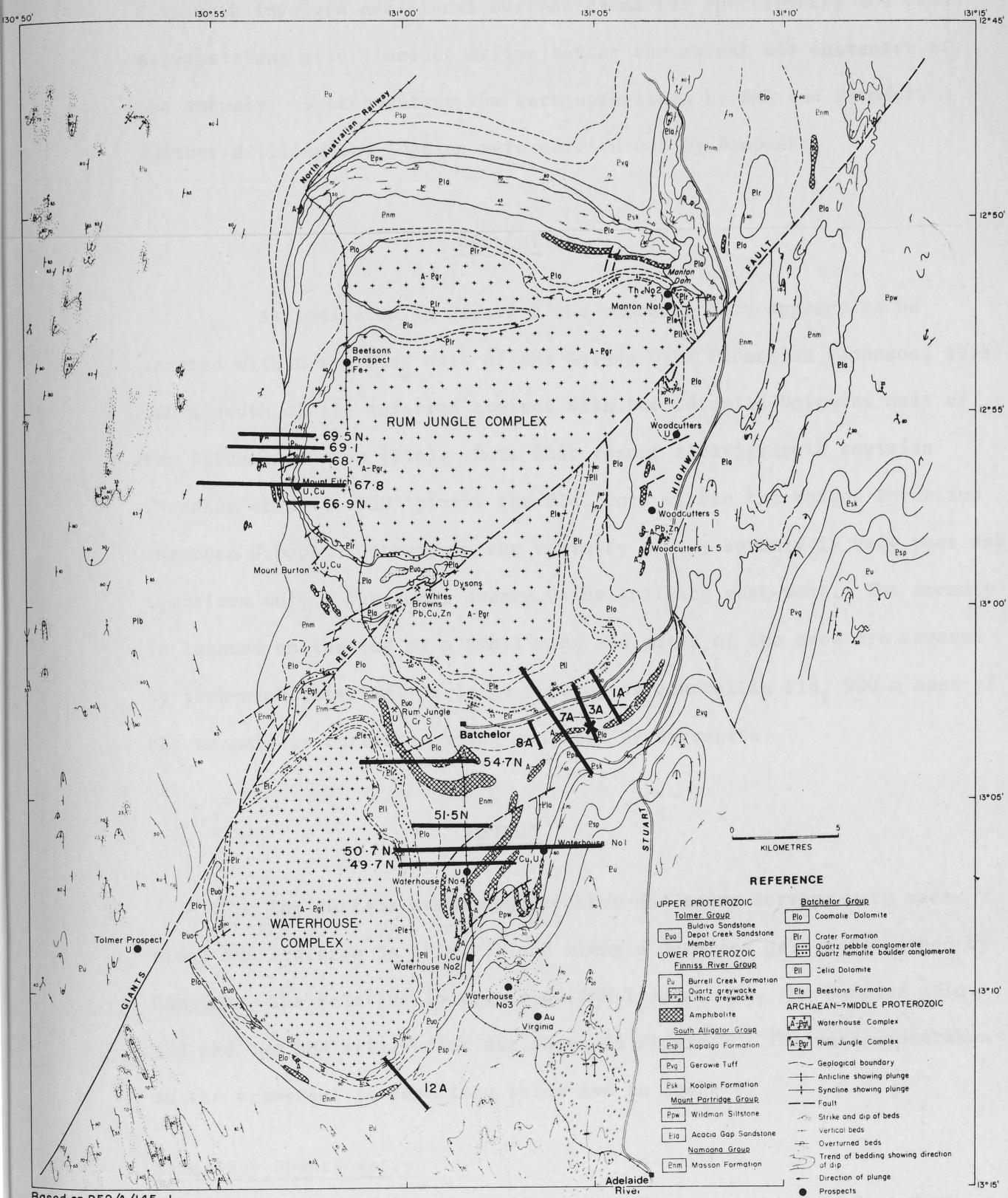

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Fig.1 LOCALITY MAP SHOWING BMR RECONNAISSANCE RADIOMETRIC TRAVERSES

undertaken jointly by BMR and Dampier during May and June of 1980. This work involved additional surface gamma-ray spectrometry and radon surveys along grid lines to define better the extent and character of the anomaly. Subsequent to the work undertaken by BMR and Dampier, further drilling and logging were carried out by Dampier.

GEOLOGY

As indicated in Figure 2 the radon anomaly appears to be located within the Pld_2 unit of the Golden Dyke Formation (Johnson, 1974), 100 m south of its inferred contact with the Coomalie Dolomite unit of the Batchelor Group (Plo). Note that recent stratigraphic revision (Needham et al., 1980) places the Pld_2 unit within the Masson Formation (Namoona Group). Outcrop in the vicinity of the anomaly is very poor and comprises only a few small quartz veins striking east-west. The anomaly is located on the top of a small rise and parts of the area are covered by iron-rich laterite. A large outcrop of quartzitic Pld_2 500 m east of the anomaly is currently being quarried as aggregate.

METHOD

The surface gamma spectrometer and radon surveys were made along BMR Traverse 3A (Fig. 1) and along a detailed grid established by Dampier. The relative locations of BMR Traverse 3A, the Dampier grid, and the two BMR drill-holes are shown in Figure 2. The work undertaken on the traverses is described below and in Table 1.

Gamma-Ray Spectrometry

The gamma-ray spectrometer permits the concentration of the radioelements thorium, uranium and potassium to be determined through analysis of the gamma-rays emitted by the respective daughter products

TABLE 1. Summary of Work

METHOD	INSTRUMENT	TRAVERSE	COVERAGE	STATION SPACING (m)
Radon	Alphameter	3A	450S - 1400S	50
	(Alphanuclear Inc)	200E	400S - 1000S	100
		400W	300S - 700S	100
		600W	600S - 1000S	50
		700W	400S - 1000S	50
		800W	200S - 1000S	50
		850W	450S - 1000S	50
		900W	400S - 1000S	50
		950W	400S - 1000S	50
		1000W	200S - 1000S	50
		1050W	400S - 1000S	50
		1100W	400S - 1000S	50
		1200W	00 - 750S	50
		1600W	100N - 500S	50
Gamma-Ray	Geometrics	3A	450S - 1600S	50
	DISA-400A 4-channel	200E	400S - 1000S	1000
	Gamma-ray	400W	300S - 700S	50
	Spectrometer	600W	300S - 1000S	50
		700W	300S - 1000S	50
		800W	200S - 1000S	50
		850W	400S - 1000S	50
		900W	500S - 1000S	50
		950W	400S - 1000S	50
		1000W	100N - 1000S	50
		1050W	400S - 1000S	50
		1100W	100S - 1000S	50
		1200W	00 - 700S	50
		1400W	00 - 600S	50
		1600W	100N - 500S	50
Magnetic	Geometrics	900W	00 - 1000S	5
	G-816 Proton	1000W	400S - 1000S	5
	Precession	1050W	400S - 1000S	5
	Magnetometer using	700S	400W - 1400W	10
	2 m pole			

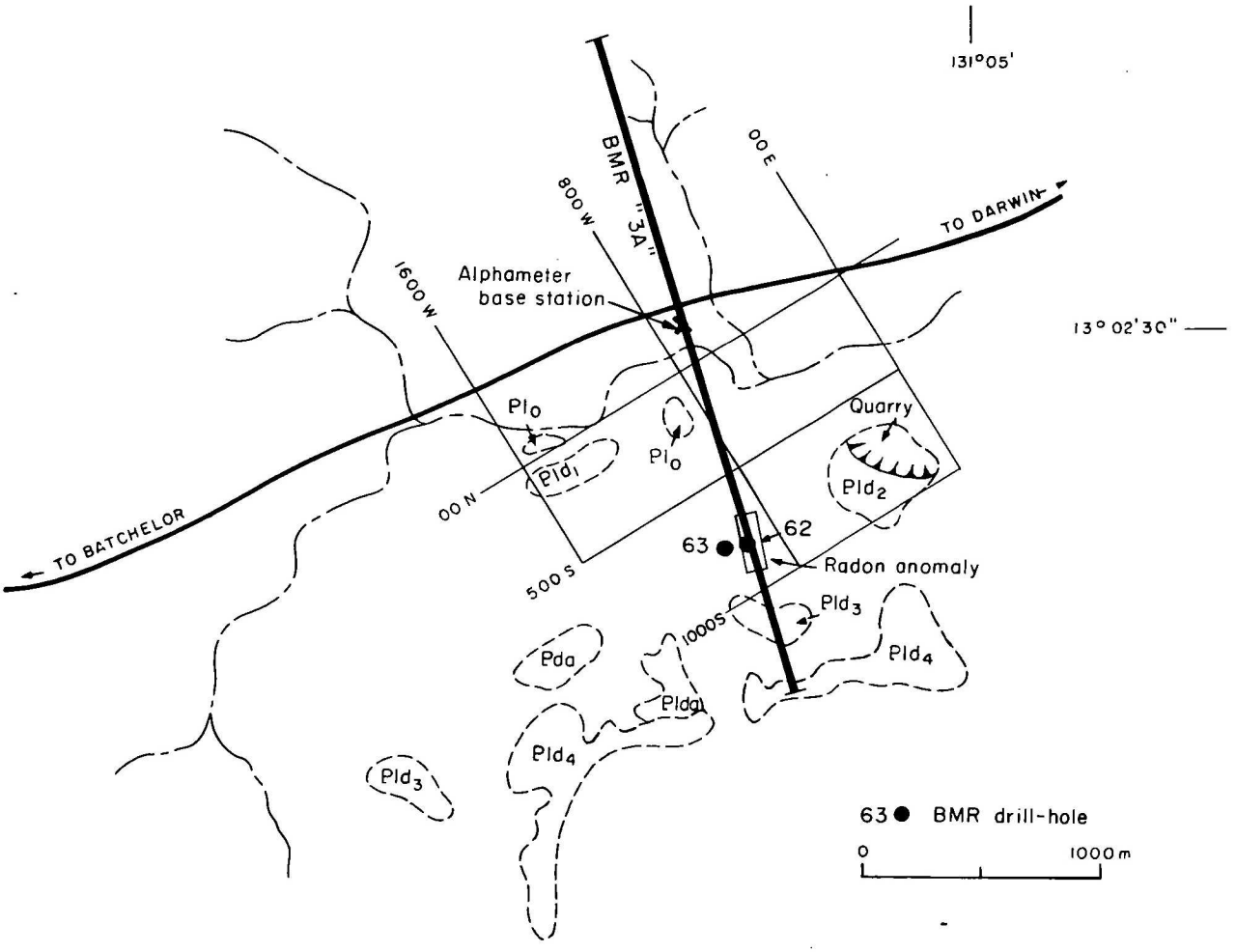

Fig. 2 DETAILS OF GEOLOGY AND GRIDS

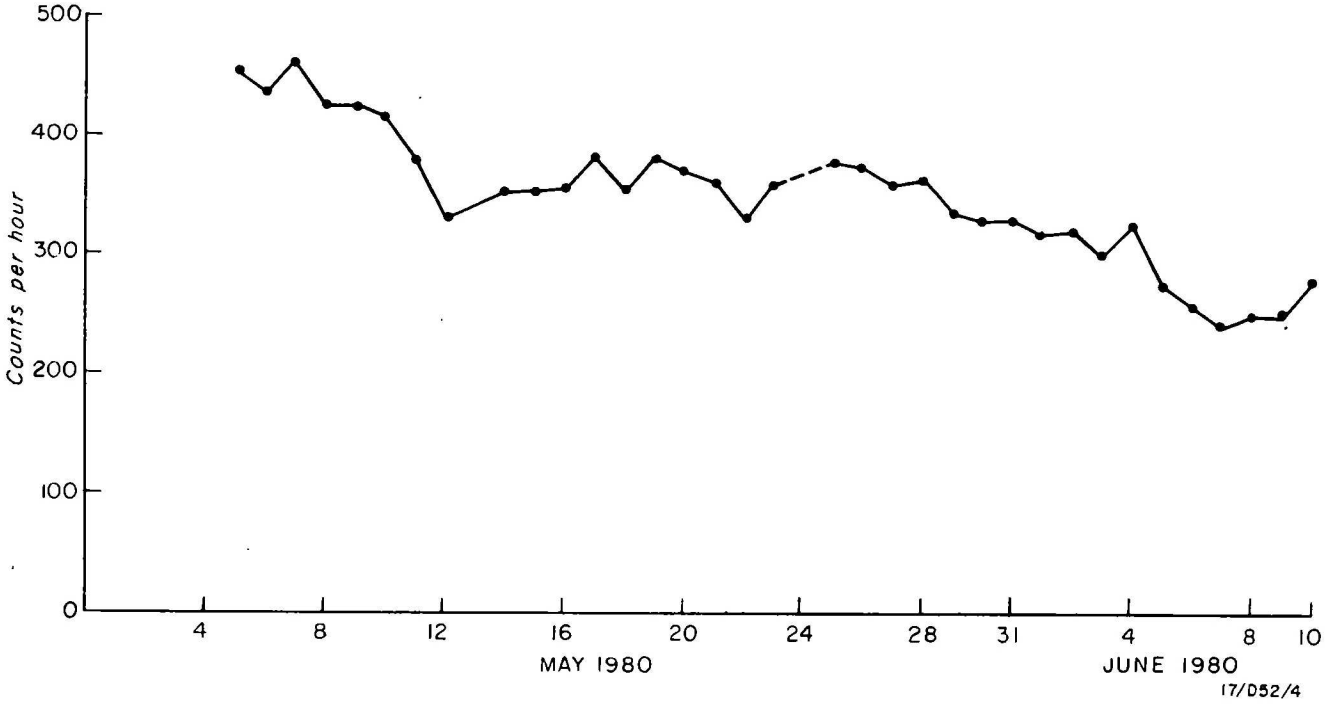

Fig. 3 BASE STATION ALPHAMETER RESPONSE

T1208, Bi214 and the radioisotope K40. As gamma-rays are totally absorbed by one metre or less of rock and soil, the method has a very limited depth of penetration.

Four-channel gamma-ray spectrometer readings were made above the surface with an Exploranium DISA-400A spectrometer, and in the boreholes with a Geometrics GR-410A spectrometer. Details of spectrometer make and type, crystal dimensions, energy windows, stripping ratios, and sensitivity and background constants used in the processing of the raw 4-channel data are presented in Appendix 1.

The derivations of radioelement concentrations from the survey data have been made with the assumption of secular equilibrium and the validity of the spectrometer calibration constants described in Appendix 1. However the spectrometer calibration constants (particularly those of the down-hole system) could not be determined accurately. Calibration constants for the DISA-400A spectrometer were determined at the Uplands pads at Ottawa, Canada. The GR-410 down-hole system was calibrated at the AMDEL pits in Adelaide and by comparison of down-hole logs and sample assays.

Surface gamma-ray measurements were made at 50 m intervals along traverses with the spectrometer detector supported on a tripod such that the detector was 60 cm above ground level. Down-hole spectrometer measurements were made at 1 m intervals in each hole. Owing to the need for long sampling times for the spectrometer measurements, continuous logging of the holes was not attempted. Typical sampling times were 2 minutes for surface measurements and 1 minute for down-hole measurements.

A comparison of the radioelement distribution at the surface and in the top few metres of soil was made at selected sites by lowering the probe of the DISA-400A spectrometer down shallow auger holes. No calibration constants are available for the quantitative analysis of these results.

Alphameter Radon Survey

The Alphameter indicates the alpha activity of soil gas at 0.3 m below the surface, and counting was carried out over a period of several days to average diurnal fluctuations in radon concentration caused by barometric pumping. The source of the alpha particles can be either the gaseous radionuclides Rn222 (radon derived from U-238) or Rn220 (thoron derived from Th232), and their immediate daughter products Po218 and Po216 respectively.

Although the presence of uranium or radium in the soils will lead to the liberation of radon into the soil gas it is conceivable that water or gas transport mechanisms may result in radon being introduced into the soil gas from buried deposits of uranium or radium.

Twenty-one Alphameters were used for the radon survey. Two were used as base monitors and the others were used to make surveys along traverses at 50 m or 100 m intervals. Each radon station was prepared by auger drilling a hole, having a diameter only slightly larger than that of the Alphameter, to a depth of 0.3 m. The Alphameters were then carefully lowered into the holes and left undisturbed for a period of 3 days during which counts were recorded on a daily basis. Where possible all the readings along a traverse were made in a short time interval. Laboratory tests indicated that the instruments were performing to specifications but calibration of instrument sensitivity was not possible.

The two base station Alphameters were located at 250N/700W (Dampier grid) well away from the radon anomaly recorded on BMR Traverse 3A. The average daily count rate recorded in the two Alphameters is shown in Figure 3, and indicates a steady decline from around 450 counts/hr in early May to around 300 counts/hr in June. The decline in count rate with time may reflect drying out of the ground over this period, or perhaps disruption to the normal soil gas flow after augering. However, as the background variations declined steadily and were much smaller than the anomaly recorded in the follow-up work, they can be ignored.

Magnetic Survey

A ground magnetic survey was carried out along several traverses using a Geometrics G816 proton precession magnetometer with a 2 m pole and a station spacing of 5 m. It was hoped that the magnetic data would provide information on the structure, stratigraphy, or surface weathering of the area.

ALPHAMETER SURVEY RESULTS

The results of the Alphameter survey are presented in contour form in Figure 4. The background count rate appears to be approximately 500 counts per hour, and two distinct anomalous zones are evident.

The most prominent anomaly has a maximum value of 7600 counts per hour (cph) at 800S/900W (Dampier grid). The 1000 cph contour indicates a roughly circular anomaly. However, more complex patterns in the 2000 cph and higher valued contours suggest north-south and east-west trends. The "average" values of the alpha count anomaly within the 2000 cph contour is approximately 3500 cph.

A second and unclosed anomaly is indicated along Traverse 600W, which is south of 800S and has a maximum value of over 4000 cph at 950S/600W. This anomaly occurs over a scree-covered area below an outcrop of quartzitic Masson Formation (Pld_2) which was being quarried for building aggregate.

Only background count rates were recorded on Traverse 200E.

SURFACE GAMMA SPECTROMETER SURVEY RESULTS

Results of the surface gamma spectrometer survey are shown as contours of apparent uranium (Ua) in Figure 5 and the ratio of apparent uranium to apparent thorium in Figure 6. The apparent thorium concentration throughout the survey area was fairly uniform, averaging approximately 14 ppm and ranging from 9 ppm to 18 ppm. Similarly the apparent potassium concentration averaged approximately 0.9% and ranged from 0.4% to 1.5%.

The apparent uranium results shown in Figure 5 indicate a background of 2 or 3 ppm Ua. Two distinct anomalies are observed to be centred on 750S/1050W and 950S/600W. The anomaly centred on 750S/1050W trends east-west between 1100W and 950W (150 m), and is roughly coincident with the Alphameter anomaly. Both the Alphameter and apparent uranium anomaly in this area appear to be truncated by the fence line. The uranium anomaly has a peak value of 15.8 ppm Ua at 750S/1050W. However, few values exceed 5 ppm Ua, and only the values at 750S/1050W and 950S/600W exceed 10 ppm Ua. The average value within the 5 ppm Ua contour centred on 750S/1050W is approximately 6 ppm Ua. The unclosed anomaly at 950S/600W also coincides with an Alphameter anomaly and has a maximum value of 14.5 ppm Ua at 950S/600W.

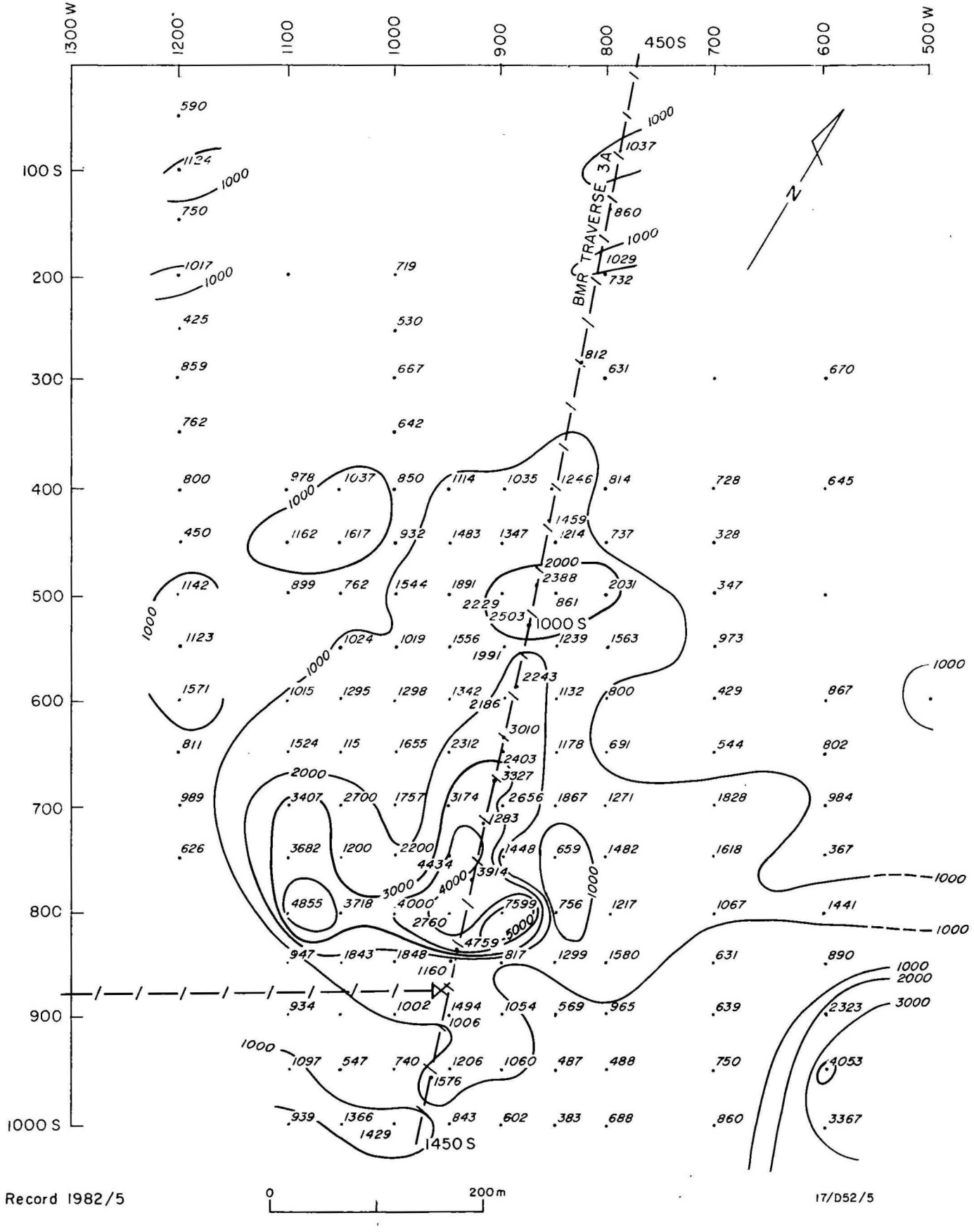

Fig. 4 ALPHAMETER RESULTS (COUNTS PER HOUR)

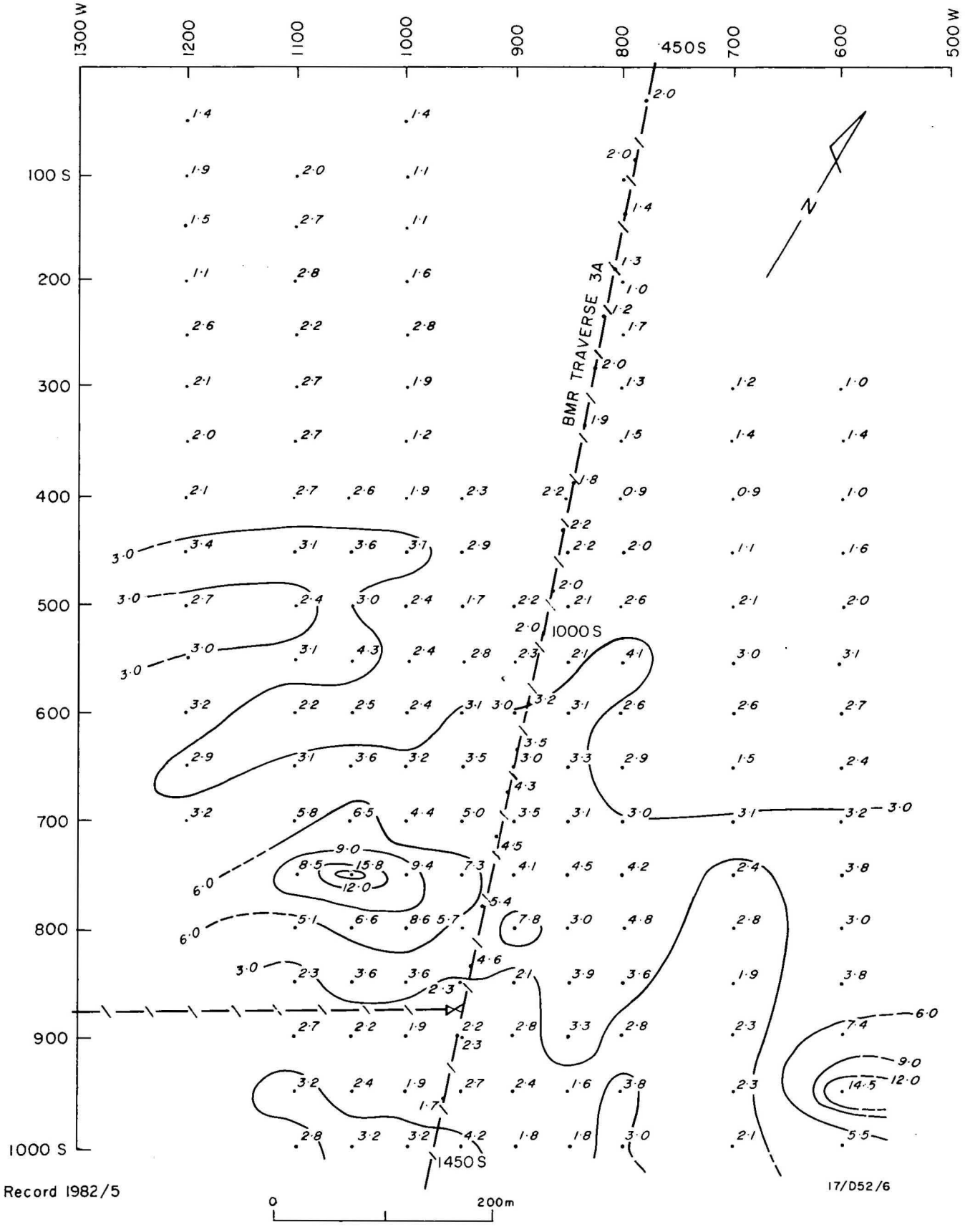

Fig.5 APPARENT URANIUM RESULTS (PARTS PER MILLION)

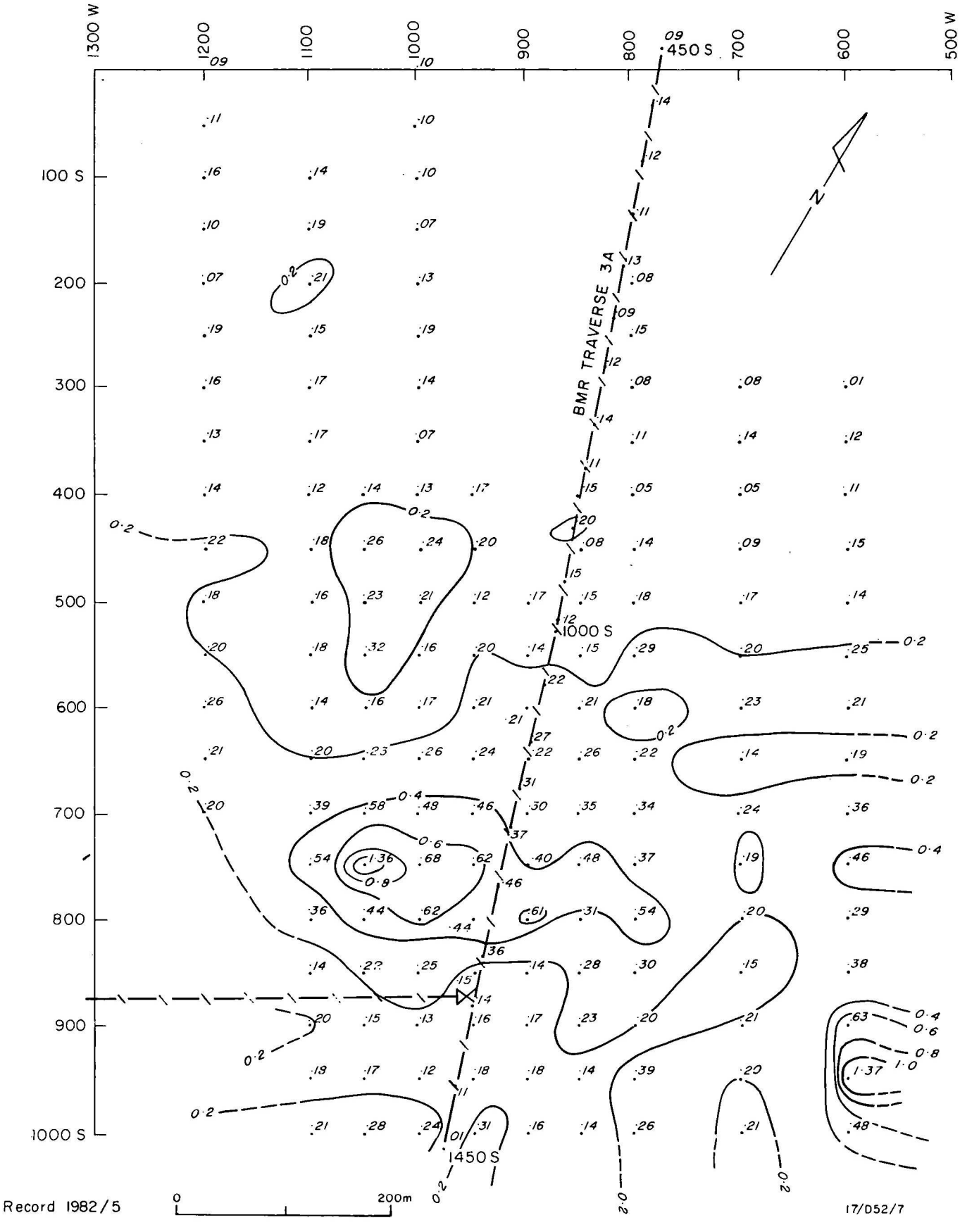

Fig 6. RATIO OF APPARENT URANIUM TO APPARENT THORIUM

The ratio of apparent uranium to apparent thorium measurements shown in Figure 6 has a similar pattern to the apparent uranium data. Background ratios are of the order of 0.1. A peak value of 1.3% is recorded at 950S/600W. However, this and the value of 1.36 recorded at 750S/1050W are the only values which exceed 1.0. The average value of the ratio anomaly within the 0.4 contour centred on 750S/1050W is approximately 0.6

Background values only were recorded on Traverse 200E.

DOWN-HOLE GAMMA SPECTROMETER RESULTS

Calibrated Probe

Down-hole spectrometer surveys were made in 1979 in auger holes PC62 and PC63 drilled to bedrock at stations 810S/923W and 760S/1025W respectively on the Dampier grid (Fig. 2). Apparent uranium and Alphameter results subsequently recorded at surface show anomalous concentrations of radioelements at the site of each hole. The logs were made with the roughly calibrated GBP-200 probe (Appendix 1) and the results are shown in Figure 7. The results from 0 to 5 m have not been included owing to the unknown effects of steel casing.

There does not appear to be any consistent trend in apparent uranium concentration with depth. However, the increase in apparent uranium concentration at 14 m in each hole may reflect some local enrichment due to water table movements or weathering effects. The values of 5-10 ppm Ua observed in hole PC62, and the values of 10-15 ppm Ua observed in hole PC63, roughly correspond to the surface apparent uranium values determined by gamma-ray spectrometry at the respective sites (5-6 pppm Ua at PC62, and 10-15 ppm Ua near PC63).

The results suggest that surface gamma spectrometer measurements reflect the bedrock concentration of radioelements. The results also suggest that the Alphameter anomalies are not caused by a local enrichment of uranium or radium at a shallow depth.

Uncalibrated Probe

A comparison of the radioelement distribution at the surface and in the top few metres of soil was made along Traverse 900W by lowering the DISA-400A probe down shallow auger holes 0.3 m deep. As no calibration constants were available for the probe in the hole the results which are shown in Figure 8 are the ratio of down-hole to surface apparent uranium measurements determined from the surface calibration data.

The relatively constant ratio across the traverse suggests that the concentration of uranium or radium at a shallow depth reflects the surface concentration of these radioelements. Note that the average ratio of 2.5 is consistent with the difference in source-detector geometry for the two measurements.

COMPARISON OF GAMMA SPECTROMETER AND CHEMICAL ASSAYS

A comparison of surface gamma-ray spectrometer assays with samples collected along Traverses 600W, 1050W and 900W is shown in Table 2. Results of the chemical assays are included as Appendix II. Uranium and thorium assays were made by XRF and potassium assays by AAS. Samples for laboratory assays were collected from the bottom of the Alphameter auger holes and averaged 200 g. Note that the radiometric and chemical assay samples are not identical. Hence, qualitative comparisons only are possible.

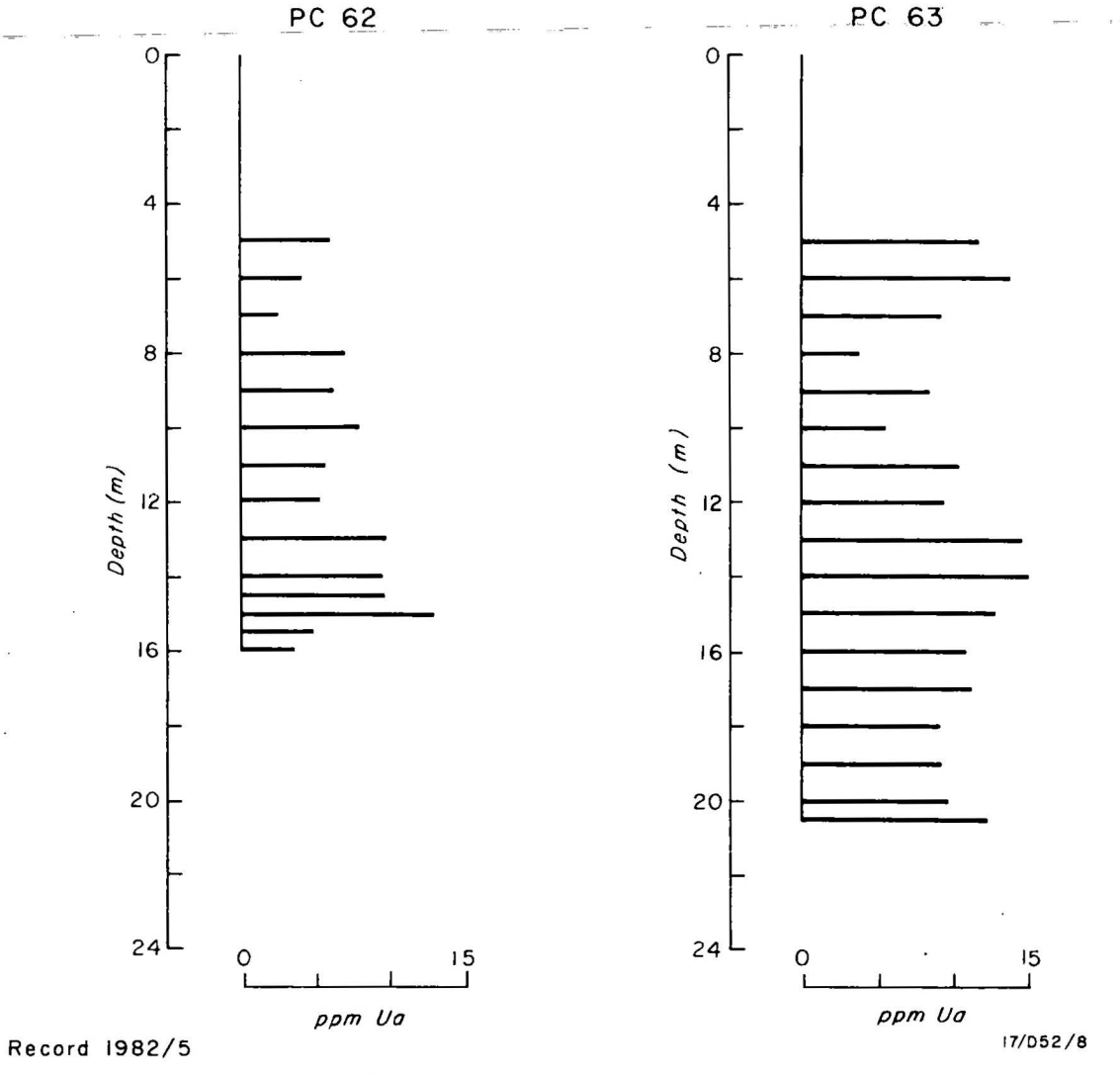

Fig.7 DOWNHOLE SPECTROMETER RESULTS

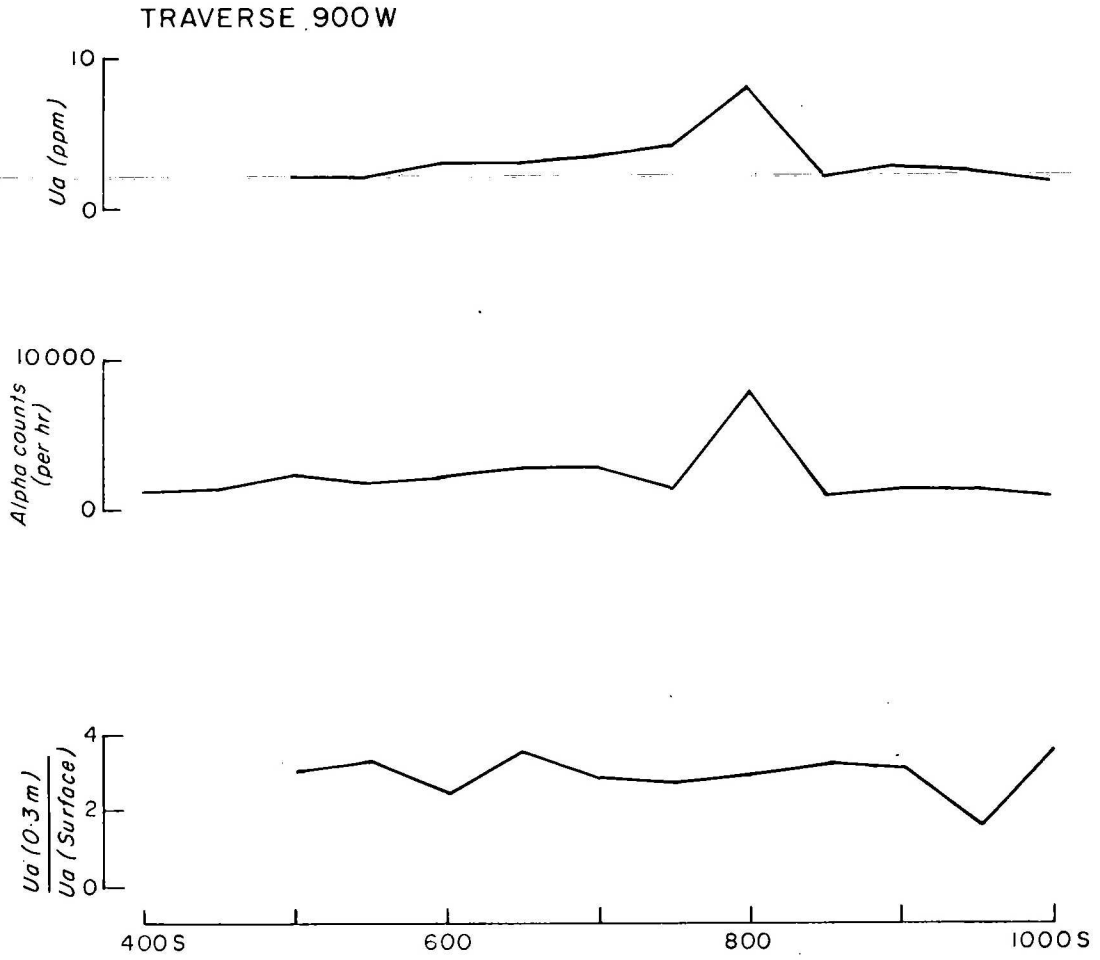

Fig 8 DOWN-HOLE SPECTROMETER RESULTS

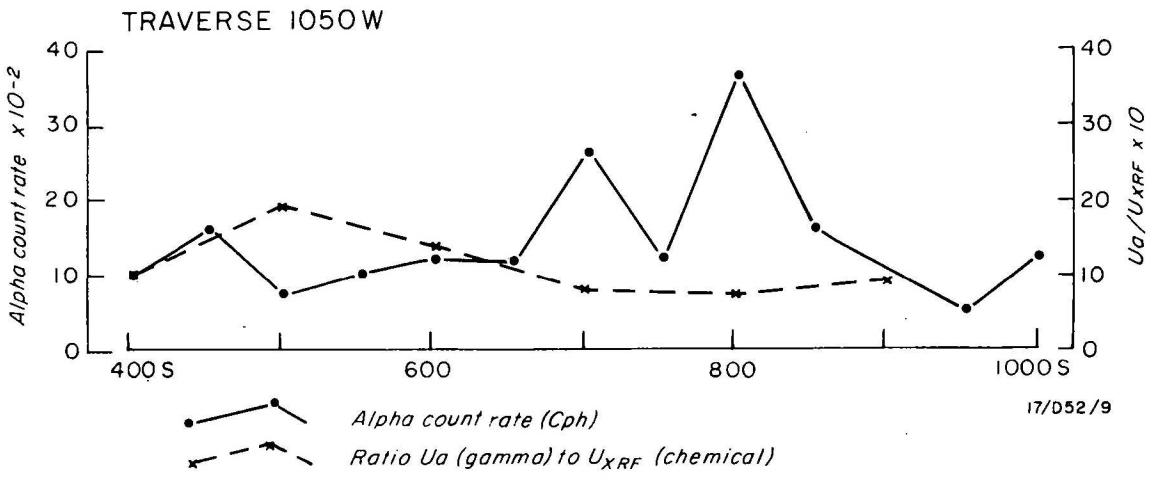

Fig.9 COMPARISON OF GAMMA AND CHEMICAL ASSAYS WITH RADON MEASUREMENTS

TABLE 2. Comparison of Gamma Spectrometer and Chemical Assays.*

LINE	STATION	THORIUM	URANIUM	POTASSIUM
600W	300S	1.24	0.71	1.1
	400S	0.47	0.71	1.1
	500S	0.71	3.3	1.3
	600S	0.81	5.4	1.2
	700S	0.65	4.6	1.2
	800S	0.88	1.8	1.3
	900S	0.84	0.87	0.66
	1000S	0.82	5.0	1.1
1050W	400S	0.77	1.0	1.1
	500S	0.83	2.0	0.62
	600S	0.74	1.4	0.87
	700S	0.37	0.82	0.54
	800S	0.49	0.76	0.84
	900S	0.51	0.96	0.91
900W	600S	0.47	0.19	0.31
	850S	0.24	0.78	0.43

* Values are the ratio of U, Th or K determined by gamma-ray spectrometry in the field to laboratory analyses of the corresponding element in auger samples collected at the spectrometer stations.

Although considerable scatter in the ratio of gamma to chemical assay is shown in Table 2, the results with one or two exceptions are in reasonable agreement given the different samples represented by the gamma and chemical assays. Few if any trends can be established. However, the thorium gamma assay is consistently lower than the chemical assay and suggests that calibration, equilibrium or sampling problems may be present. As indicated in Figure 9, it seems possible that there is a reduction in the ratio of the apparent uranium (gamma) to chemical assay in the vicinity of high alpha counts. This effect might reflect an increase of from 1.5 to 2 times in the rate of radon emanating from rocks in the vicinity of the radon anomalies and a subsequent loss of gamma-emitting daughter products. Assuming this to be so, the suggested 1.5 to 2 times increase in emanation rate could partly explain why the radon anomaly is 2-3 times greater than the apparent uranium anomaly. Clearly more work is required before this hypothesis can be accepted.

MAGNETIC SURVEY

No useful information was obtained from the magnetic survey. In particular, high frequency noise was evident along all traverses and no geological boundaries or units were discernible.

DISCUSSION

Comparison of Alphameter and Gamma-Spectrometer Results

A comparison of the ratio of the Alphameter and gamma spectrometer anomalies centred near 750S/1000W is shown in Table 3. The ratio of the alpha counts anomaly to background is at least twice as large as the ratio of Ua or Ua:Tha to their respective backgrounds. This observation

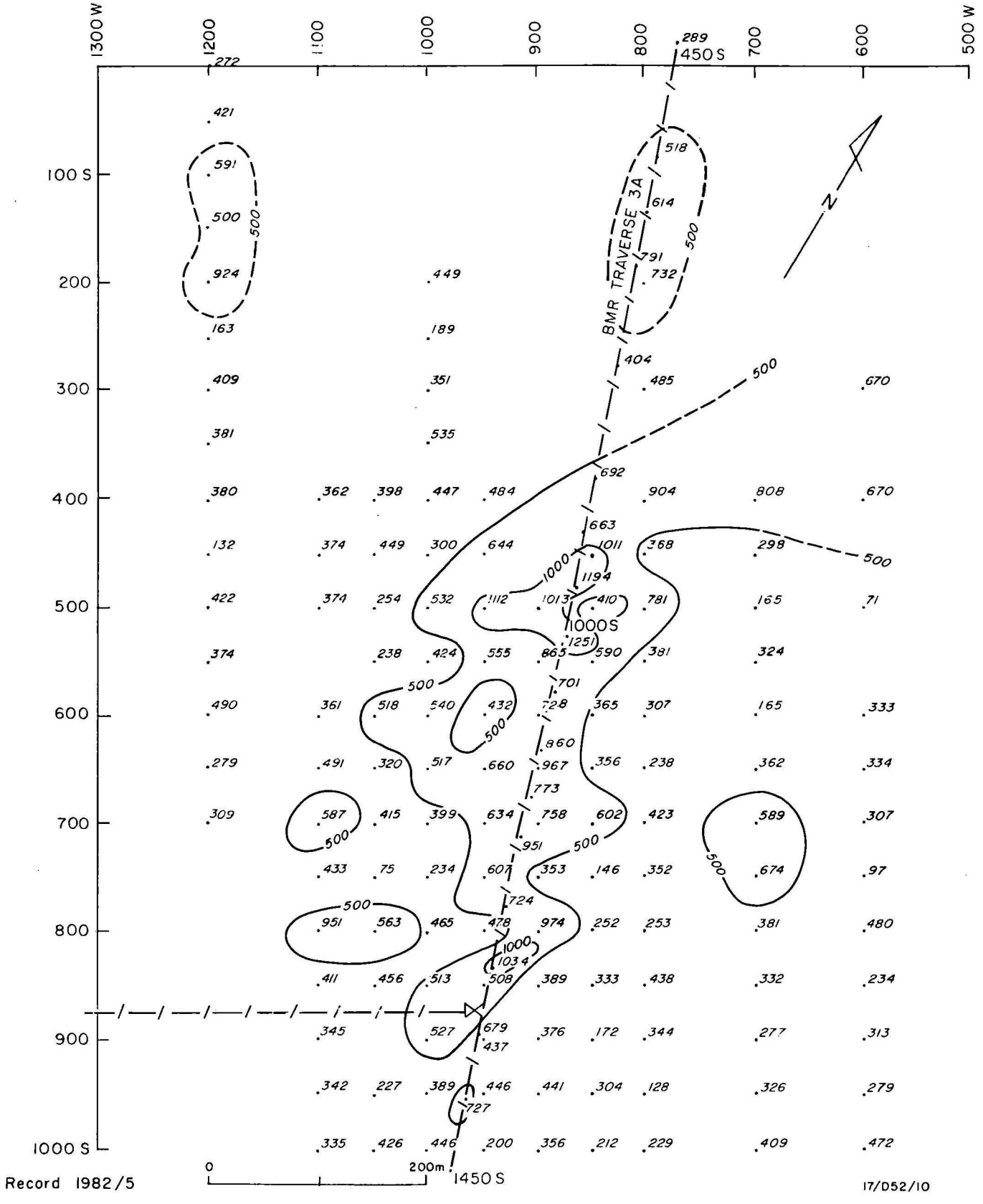

Fig. 10 RATIO OF ALPHA COUNTRATE TO APPARENT URANIUM

TABLE 3. Comparison of Alphameter and Gamma Spectrometer Results.

Quantity	Background	Peak Amplitude / Background	Average Anomaly Amplitude / Background	Extent of* Anomaly
$\frac{Ua}{Tha}$	0.2	6.8	3	200 m x 100 m
Ua	2.0 (ppm)	7.9	3	200 m x 100 m
alpha counts	500 (cph)	15.2	7	300 m x 100 m

*$\frac{Ua}{Tha}$ anomaly defined by 0.4 contour (Figure 6).

Ua anomaly defined by 5.0 ppm contour (Figure 5).

Alphameter anomaly defined by 2000 cph contour (Figure 4).

suggests that the increase in alpha activity cannot be entirely attributed to the increase in apparent uranium concentration observed by the gamma spectrometer in the surface rocks along an east-west trend through 750S. However, as suggested by Figure 9, it is possible that the anomaly may be partly due to increased emanation of radon from the rocks containing a higher intrinsic uranium concentration.

Also note that the areal extent of the alpha anomaly is considerably greater than that of the gamma anomaly. This observation is consistent with the transport of radon from depth or laterally. All anomalies appear to be truncated in the east by the fence line which was BMR Traverse 3A. A comparison of the ratio of alpha counts per hour to the measured value of Ua in ppm was also made and is shown in Figure 10. Although this ratio proved to be fairly erratic on a station-to-station basis, an increase in the ratio is observed in the vicinity of the alpha anomaly observed along BMR Traverse 3A. The ratio has a background value of approximately 300 counts per hour per ppm Ua, and a maximum value of 1251 counts per hour per ppm Ua was obtained at station 1000S on BMR Traverse 3A. By way of comparison Mutton and Stuart (1984) report ratios of about 140 cph per ppm Ua at the Austatom prospect in the Alligator Rivers area of the Pine Creek Geosyncline. It is interesting to note that an increase in the ratio of alpha counts to apparent uranium was not observed over the alpha count anomaly on Traverse 600W. The prominent trend of high ratio values along BMR Traverse 3A is difficult to explain. It is possible that grading of the ground surface along this track has enhanced the rate of radon accumulation or emanation.

The relatively high alpha count to apparent uranium ratio observed over the alpha count anomaly detected on BMR Traverse 3A further supports the contention that the anomaly cannot be entirely attributed to

surface concentrations of radium or uranium. However, the rather erratic changes in the ratio and the odd association with the graded fence line track highlight the difficulty of using Alphameter measurements for quantitative analysis.

Comparison of Surface and Down-hole Results

Insufficient data are available to study this association properly. However, the results from two drill-holes and the qualitative measurements in shallow auger holes along Traverse 900W suggest that the apparent concentration of uranium at depth is directly reflected by surface concentrations.

Possible Sources of the Radon Anomaly

The relatively high alpha count anomaly compared with the uranium anomaly (Table 3), and the apparent reflection of the subsurface radioelement concentration in surface measurements, suggest that the radon anomaly cannot be directly related to the apparent concentration of uranium (i.e. Bi214) in the near-surface rocks. However, the comparison of chemical and gamma assay data (Fig. 9) suggests that the radon anomaly can be at least partly attributed to higher radon emanation from surface rocks, as such an effect should contribute to the disequilibrium anomaly which appears to occur in the vicinity of the radon anomaly.

Hence, no definitive evidence for the source of the radon anomaly was obtained during the survey. Nonetheless it still seems possible that the radon has been transported from depth or laterally, to concentrate in a roughly circular pattern centred on 1000W/750S (Fig. 4). The truncation of the radon anomaly by the fence line track, the abnormal association of the alpha count/apparent uranium ratio data with the fence line track, and the high radon concentration observed near

the quarry at 600W/950S (Fig. 4), are all factors pointing to the accumulation of radon-rich ground waters in distinct channels or depressions in the surface. However, as similar depressions do not produce radon anomalies elsewhere in the Rum Jungle area (Stuart & Warnes, in prep.), the results might suggest the presence of an abnormal uranium or radium source nearby.

Possible Follow-up Work

The available data on disequilibrium of the surface rocks, association between surface and bedrock radioelement concentration, and the possible influence of groundwater flow, are too limited to permit an adequate study of the possible sources of the radon anomaly. Hence, further studies of these factors are necessary to assist in the interpretation of the existing radiometric data. Following such studies the value of a pattern drilling/logging program could be assessed if additional exploration is considered warranted.

CONCLUSIONS

Extensive surface gamma spectrometer and Alphameter surveys have failed to locate the source of the radon anomaly detected on a reconnaissance BMR traverse 5 km east of Batchelor. The surveys also demonstrate the difficulty of using information on radon distribution for quantitative interpretation.

However, the results of these surveys have shown the radon anomaly to be limited in extent and to be associated with a relatively small apparent uranium anomaly. The available information on the variation of radioelement concentration with depth, the disequilibrium of surface samples, and a comparison of alpha and gamma spectrometer anomalies still leave unanswered the question of whether the radon has a surficial or

bedrock source. Nonetheless, the uniqueness of this anomaly in the Rum Jungle area, and the apparent influence of ground water as a transport mechanism, lend support to the possibility that a buried concentration of uranium or radium could be the source of the radon.

To evaluate the source of this anomaly properly additional studies of the disequilibrium of surface rocks, association between surface and bedrock radioelement concentration, and the possible influence of ground water flow are required. On the basis of these studies, the justification for a pattern drilling/logging program could be determined.

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APPENDIX I. DETAILS OF GAMMA-RAY SPECTROMETER INSTRUMENTS

	Ground Spectrometer				Down-hole Spectrometer			
TYPE (SERIAL NUMBER)	DISA-400A portable 4-channel differential spectrometer (No. AE-071)				GR-410A 4-channel differential spectrometer (No. 2849)			
MANUFACTURER	Geometrics/Exploranium				Geometrics/Exploranium			
DETECTOR	NAL-21				GBP-200			
NaI (Tl) XTAL DIMENSIONS (VOLUME)	7.6 x 7.6 cm (350 cm^3)				7.6 x 3.5 cm (73 cm^3)			
STRIPPING RATIOS	0.65, 0.80, 1.10, 0.06				2.85(?), 3.45(?), 1.15(?), 0.02(?)			
SYSTEM DEADTIME					14×10^{-6} sec.			
CHANNEL	1	2	3	4	1	2	3	4
Window (MeV)	>0.4	1.36-1.56	1.66-1.86	2.42-2.82	0.5-3.0	1.36-1.56	1.66-1.86	2.46-2.78
Principal Isotope	-	K-40	Bi-214	Tl-208	-	K-40	Bi-214	Tl-208
Background (cpm)	570	19	11	7.5	-	-	-	-
Sensitivity Constant	660 cpm/URh^{-1}	170 cpm/%Ka	19 cpm/ppm Ua	8 cpm/ppm Tha	250 $cpm/\mu Rh^{-1}$	70(?) cpm/%Ka	6.9(?) cpm/ppm Ua	0.9(?) cpm/ppm Tha

APPENDIX II. CHEMICAL ASSAYS*, TRAVERSES 600W, 1050W AND 900W.

LINE	STATION	THORIUM (ppm)	URANIUM (ppm)	POTASSIUM %
600W	300S	10	1.4	0.62
	400S	20	1.4	0.40
	500S	20	0.6	0.47
	600S	16	0.5	0.46
	700S	14	0.7	0.41
	800S	12	1.7	0.47
	900S	14	8.5	1.28
	1000S	14	1.1	1.08
1050W	400S	18	2.6	0.86
	500S	16	1.5	0.96
	600S	22	1.8	1.23
	700S	30	7.9	1.73
	800S	30	8.7	1.93
	900S	28	2.3	1.16
900W	600S	30	16.0	2.10
	850S	65	2.7	2.10

*Uranium and thorium determined by XRF, potassium by AAS.