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IMC DEVELOPMENT CORPORATION

Melbourne, Australia

Report No. 60

COMPLETION REPORT

PROSPECTING AUTHORITY 2681

KATHERINE URANIUM PROJECT

April, 1972

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INTRODUCTION

Prospecting Authority 2681 for an area of 170 square miles 20 miles north-east of Katherine (Figure 1) was granted to IMC Development Corporation on April 20, 1970, in response to an application dated February 3, 1970.

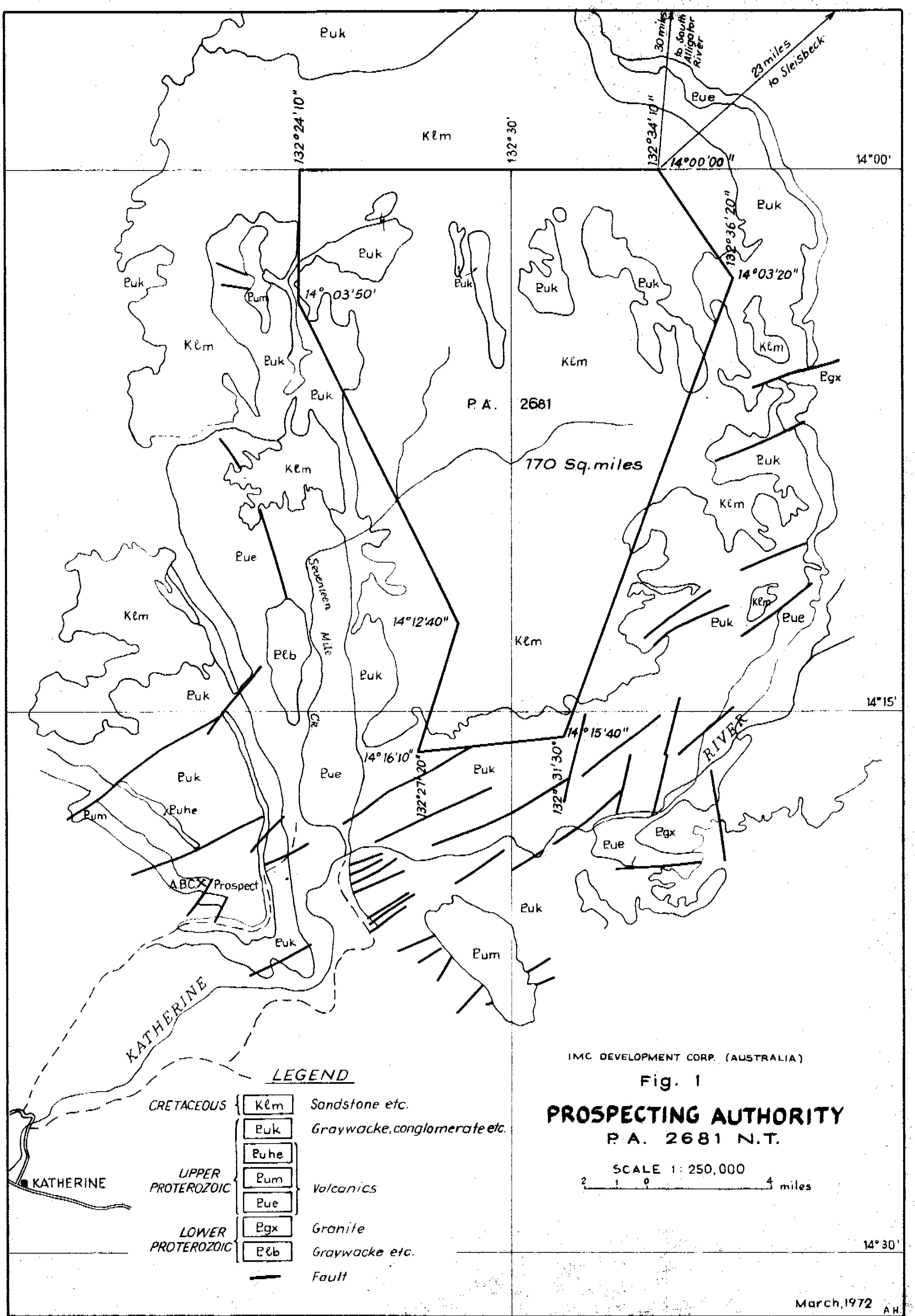
IMCDC acquired the authority primarily to prospect the Upper Proterozoic sediments and volcanics exposed north of Katherine Gorge for uranium deposits similar to those which have been found in Upper Proterozoic sediments and volcanics in the Westmoreland District of north-west Queensland.

In 1970 the company completed a ground geological and radiometric reconnaissance survey of the P.A. 2681 area and commissioned Aero Service (Aust.) Pty. Ltd. to make an airborne magnetic and gamma ray spectrometer radiometric survey over it.

The airborne survey was flown between June 14 and July 4, 1970. Compilations of the results were received by IMCDC in December, 1970. The radiometric compilations contained some inconsistencies and after a considerable amount of work by Aero Service and its sub-contractor, Engineering Computer Services Pty. Ltd., amended compilations of the radiometric data were received by IMCDC in March, 1972.

Neither the ground nor the aerial surveys located targets for detailed exploration, and the company decided to carry out further ground surveys in the 1971 field season to check the sources of the low intensity gamma radiation anomalies that were detected by the aerial survey in the previous year.

Field work was recommenced in May, 1971, but did not produce any information which led to further exploration by IMCDC. On September 30, 1971, the company requested that it be allowed to relinquish the Prospecting Authority and the authority was cancelled by the Administrator for the Northern Territory on October 20, 1971.



IMC DEVELOPMENT CORP. (AUSTRALIA)
Fig. 1
PROSPECTING AUTHORITY
P.A. 2681 N.T.
SCALE 1: 250,000
2 1 0 4 miles
LEGEND
CRETACEOUS
Klm Sandstone etc.
Puk Graywacke, conglomerate etc.
UPPER PROTEROZOIC
Puhe
Pum
Pue
Volcanics
LOWER PROTEROZOIC
Pgx Granite
Plb Graywacke etc.
Fault
P.A. 2681
170 Sq. miles
132°24'10"
132°30'
132°34'10"
14°00'00"
132°36'20"
14°03'20"
14°03'50'
14°12'40"
14°15'40"
14°16'10"
132°27'20"
132°31'30"
14°00'
14°15'
14°30'
30 miles to South Alligator River
23 miles to Sleisbeck
Seventeen Mile Cr.
KATHERINE RIVER
KATHERINE
ABCX Prospect
March, 1972
AH

GEOLOGY

The P.A. 2681 area is in the south-western corner of the uranium province extending from Katherine north to Darwin and east into the Arnhem Land Plateau. The principal uranium deposits so far found in the province occur in Lower Proterozoic metasediments and Archaean gneiss, but uranium mineralization is also known in Upper Proterozoic sediments and volcanics.

In general, the uranium mineralization found in the province is associated with major north-west trending structures such as those marked by the Bulman Fault and by the South Alligator Fault. The P.A. 2681 area lies 15 miles north-east of the north-west trending flexure which forms the eastern margin of the Cambrian Daly River Basin.

The known uranium mineralization nearest the P.A. 2681 area is the ABC Prospect (Figure 1) where secondary mineralization occurs in a ten feet thick bed of tuff in the McAddens Creek Volcanics, at the intersection of two major fractures.

Most of the P.A. 2681 area is a plateau formed on a gently folded sequence of Upper Proterozoic sandstone, conglomerate and siltstone (the Kombolgie Formation) and interbedded volcanics (Edith River Volcanics, and the Henwood Creek and McAddens Creek Volcanic Members of the Kombolgie Formation) covered by thin remnants of Mesozoic sandstone and siltstone (the Mullaman Formation) and by a veneer of Tertiary to Recent sand (Plate 1).

The Upper Proterozoic sequence - especially in the southern part of the area - is traversed by several sets of well developed joints and faults. The airborne magnetic data show that some of these fractures are filled with continuations and repetitions of dolerite dykes exposed in the foothills to the plateau, and indicate that volcanic plugs may be present in the south-western part of the area (Plate 3 features 5, 5a and 5b).

THE AIRBORNE RADIOMETRIC AND MAGNETIC SURVEY

The area was surveyed at mean terrain clearances of 300 to 400 feet on flight lines approximately 1/5 of a mile apart. The equipment used included a Gulf R and D Mark III Fluxgate Magnetometer, a Hamner-Harshaw 3 crystal (total 325 cu. in.) 4 channel differential gamma ray spectrometer, and a Bendix Doppler Navigator. Records were taken on both an analog printout and in digital form on magnetic tape. The latter readings were taken every 1/40 nautical mile.

The following geophysical parameters were measured and recorded:

.. the total magnetic field corrected for diurnal and transient variations recorded at Katherine.

.. gamma radiation at the following levels -

. total radiation - 0.75 to 3.00 MeV

. radiation due to potassium - 1.36 to 1.56 MeV (K_{40} peak at 1.46 MeV)

. radiation due to uranium - 1.66 to 1.86 MeV (Bi_{214} peak at 1.76 MeV)

. radiation due to thorium - 2.52 to 2.72 MeV (Tl_{208} peak at 2.62 MeV).

Compilations of the results of the survey are presented in Plates 3 and 4. An analysis of the collection and presentation of the data by Mr. G.L. Barr in 1971 discusses some inconsistencies which exist between the radiometric data collected early and late in the survey (Barr, 1971).

GROUND SURVEYS

Ground geologic and radiometric surveys were made in 1970 and 1971 by J. Barrie, A.M. Cooney, M. Gordon and E. Donkin.

The numbered magnetic features on Plate 3 are related to the geology as follows:

.. Feature 1 is coincident with an outcrop of basalt with minor interbeds of tuff and rhyolite in the McAddens Creek Volcanic Member of the Kombolgie Formation.

.. Feature 2 is also related to the outcrop of the McAddens Creek Volcanics. The feature outlines the basin in the Upper Proterozoic sequence in the northern part of the P.A. 2681 area. Feature 2 terminates at its southern end along the dyke-filled fault located by feature 4.

.. Feature 3 is related to a fault or anticline in the Upper Proterozoic sequence.

.. Feature 4 is interpreted as being related to a fracture filled by a basic dyke.

.. Features 5, 5a and 5b are interpreted as volcanic plugs of basic volcanics.

.. Feature 6 is a horst of Upper Proterozoic volcanics between two major fractures.

.. Features 7 and 8 are faults filled with basic dykes. They are part of the fracture system which extends into the ABC Prospect area.

Radiometric data was obtained with a Thyac III scintillometer fitted with a GM489-55 gamma ray probe containing a 1¼ x 1½ inch sodium iodide crystal.

The usual gamma radiation levels over the principal lithologic units exposed in the P.A. 2681 area are listed in Table 1. These levels were consistent from day to day and from one part of the area to another.

Table 1. COMMON GAMMA RADIATION LEVELS OVER LITHOLOGICAL UNITS EXPOSED IN THE P.A. 2681 AREA

Lithology	Gamma Radiation (counts/minute)	Remarks
Edith River Volcanics	6000-8000	rock outcrop
McAddens Creek Volcanic Member	1500-2000	rock outcrop
Kombolgie Formation	1000-1500	rock outcrop
Cretaceous sediments	1500	rock outcrop
Laterite	2500-3000	savannah woodland (Figure 2)
Red sandy soil	2000-2500	scrubby savannah (Figure 3)
Brown sandy soil	1500-2000	scrubby woodland
Sandy, light brown soil	1000-1500	tall woodland
Black soil (alluvium)	2000	forest/swamp grass
Grey soil (alluvium)	1000-1500	forest/swamp grass

Radiometric anomalies numbered 5 through 14 on Plate 2 are areas of laterite. Ground traverses did not locate unusual radiation levels within the areas of laterite outcrop.

Figure 2. Savannah woodland on laterite.
Gamma range 2500-3000 cpm. (Photo: J. Barrie, 1971)

Figure 3. Scrubby savannah woodland on red sandy soil.
Gamma range 2000-2500 cpm. (Photo: J. Barrie, 1971)

Figure 4. Laterite (pisolitic ironstone) on Kombolgie Formation sandstone.
Gamma contrast (instrument on ground) -
laterite 4000-4500 cpm
sandstone 2500-3000 cpm (Photo: J. Barrie, 1971)

Figure 5. Twenty to thirty feet thick laterite in headwaters of creek on east side of P.A. area. (Photo: J. Barrie, 1971)

REFERENCES

BARR, G.L., 1971. Analysis of Data from an Aeroradiometric and Aeromagnetic Survey, Katherine, Northern Territory. School of Geology, University of Melbourne B.Sc. (Hons) Thesis.

Appendix 1

TECHNICAL REPORT

RADIOMETRIC SURVEY

KATHERINE AREA

AUSTRALIA

by

AERO SERVICE (Division of Litton Industries)

AIRBORNE SCINTILLOMETER EQUIPMENT

The aircraft instrumentation of prime concern to the radiometric survey consists of a Harshaw Spectrometer and a Honeywell (model DHG 9050-cs) radar altimeter.

Three sodium iodide crystals, each with its own photomultiplier tube, constitute the gamma ray sensor. The crystals are six inch diameter by four inches thick providing a total volume of 305 cubic inches.

The total count channel is set to cover the range from 0.75 to 3 mev. Radioactive Potassium 40 is detected directly by monitoring a 200 kev window centered on the peak at 1.46 mev. Radioactive Uranium is indirectly measured by monitoring a 200 kev window centered at 1.76 mev. The element whose peak occurs at this energy is Bismuth 214, one of the decay products of Uranium. Radioactive Thorium is also detected indirectly by measuring the counts from Thallim 208. A 200 kev window is centered 2.62 mev for this purpose.

The radar altimeter is used to allow the interpreter to distinguish anomalies due to radioactive differences from those due to structural differences. The resolution is one foot but the altimeter looks at a 30^{o} cone and senses the highest point inside the cone.

Data samples were taken every 152 feet.

AERO SERVICE SCINTILLOMETER PROGRAM AND PRODUCT DESCRIPTION

The scintillometer data on this job has been processed using a new computer program developed at Aero Service. This program is designed to perform a number of functions and we believe that the customer should fully understand the processing which has been carried out in order that the resulting data can be used most intelligently.

The first correction applied to the data is the reduction of the raw count infomation to a counts-per-second basis at each point. Aero Servise uses the output of the aircraft doppler radar to effect digital recording at equal intervals of ground distance. As a result the time between digital samples varies with ground speed. Since the scintillometer counting gates are kept open during the entire period, the sampling time varies with the aircraft speed. This is corrected in the computer by dividing the number of counts obtained in each interval by the length of that interval. Since airspeed variations of 10% are not uncommon this correction is a significant one and will in itself cause a significant difference between the raw D to A profiles recorded on the aircraft and those produced by the computer.

The second step is to make what are called stripping ratio corrections to the spectrometer data. As higher energy gamma rays propagate through the air and the scintillometer crysal itself some collide with particles of the medium and experience Compton scattering. The result of such collisions are gamma rays of less energy than the original. Thus then a certain fraction of the highest energy channel (thorium) are scattered into the lower energy channels (uranium and potassium) and a certain fraction of the uranium counts are scattered into the potassium. These fractions have been published in the literature and although there will be some variation from installation to installation we have adopted those values in the above report because of the similarity of our installation with the one discussed therein.

The third processing step is editing. This entails the removal of spurious bad values from both the scintillometer and the radar altimeter fields. These normally appear as spikes (isolated points) within the data and are removed and replaced by the mean value of the two adjacent points. The editing program also computes and prints out the mean value and standard deviation of each field in each line. Any points more than 2.5 standard deviations from the mean are also discarded, and replaced by the preceding value. It is possible once the editing is complete, and prior to the other processing steps, to plot all the data fields. One example of such a plot is included so that the customer can get a good idea of what the data looks like at this stage of the processing.

The fourth step in the program is to smooth the data so that actual anomalies can be seen and the effect of the statistical noise can be suppressed. The filter used on this data has a Gaussian envelope which drops to 1/e of the central value at the 11th point and encompasses a total of 81 points. It is assumed that the customer has a basic understanding of digital filtering. Two plots are supplied of the output of this phase of the program. These exhibit the results of two different filters. Based on the amplitude of the statistical noise the filter discussed above was chosen as most appropriate for the data at hand. Since digital filtering involves a weighted average of a number of points on either side of the point of interest, it is not possible to filter all the way up to the very ends of the line. Rather than lose those points on the end of the line, we save them in the filtering program by treating the ends of the line differently. After the main central part of the line has been smoothed, a third order polynomial is fit to the raw data on the end and also to the nearby smoothed points. In order to insure continuity with the already filtered data, the filtered points are assigned a heavier weight in the polynomial filting process. This allows the line to be filtered out to the end and none of the original points are thrown out. It should be noted however, that the data at the ends of the line is more questionable than the inboard data and peaks which exist entirely within the last forty points on a line should be only believed if verified by looking at the raw data.

The fifth step in the program is one which we have the option to use or not use. Its purpose is to correct the radiometric data for variations in the terrain to aircraft distance which can result from altitude variations of the aircraft or vertical structure in the terrain beneath the aircraft. The option to apply this correction was not exercised on this job. The reasons are discussed below.

Normally the assumption is that all radiation comes from the top foot of the terrain in the vicinity of the aircraft. Thus flying level over a rise would give an increase in the count rates due to the lesser distance between aircraft and source. Assuming one is looking for true radiometric differences as opposed to structure, the altitude correction would tend to reduce the magnitude of this anomaly, and if all the assumptions held might eliminate it completely. However, as a result of studying a number of profiles from the area of interest, the opposite of the basic assumption seems more true. That is, when the radar altimeter is higher (larger aircraft to ground distance) the scintillometer counts are also higher. The exact cause for this is not known to us because we have no geological information concerning the area. One hypothesis suggest itself; that the lows contain alluvial material carried to its present location by water. Regardless of the cause, the altitude correction as normally used would only amplify the differences which are correlated with structure, and has therefore been suppressed.

The sixth step is necessary for automatically determining the location and significance of anomalies along the profile. Aside from recognizing a peak in the data, there is the problem of determining whether or not the peak is significant. In order to do this two steps are required. First the height of the anomaly over the local background level must be calculated. Then the test of whether this height is significant or not must be made.

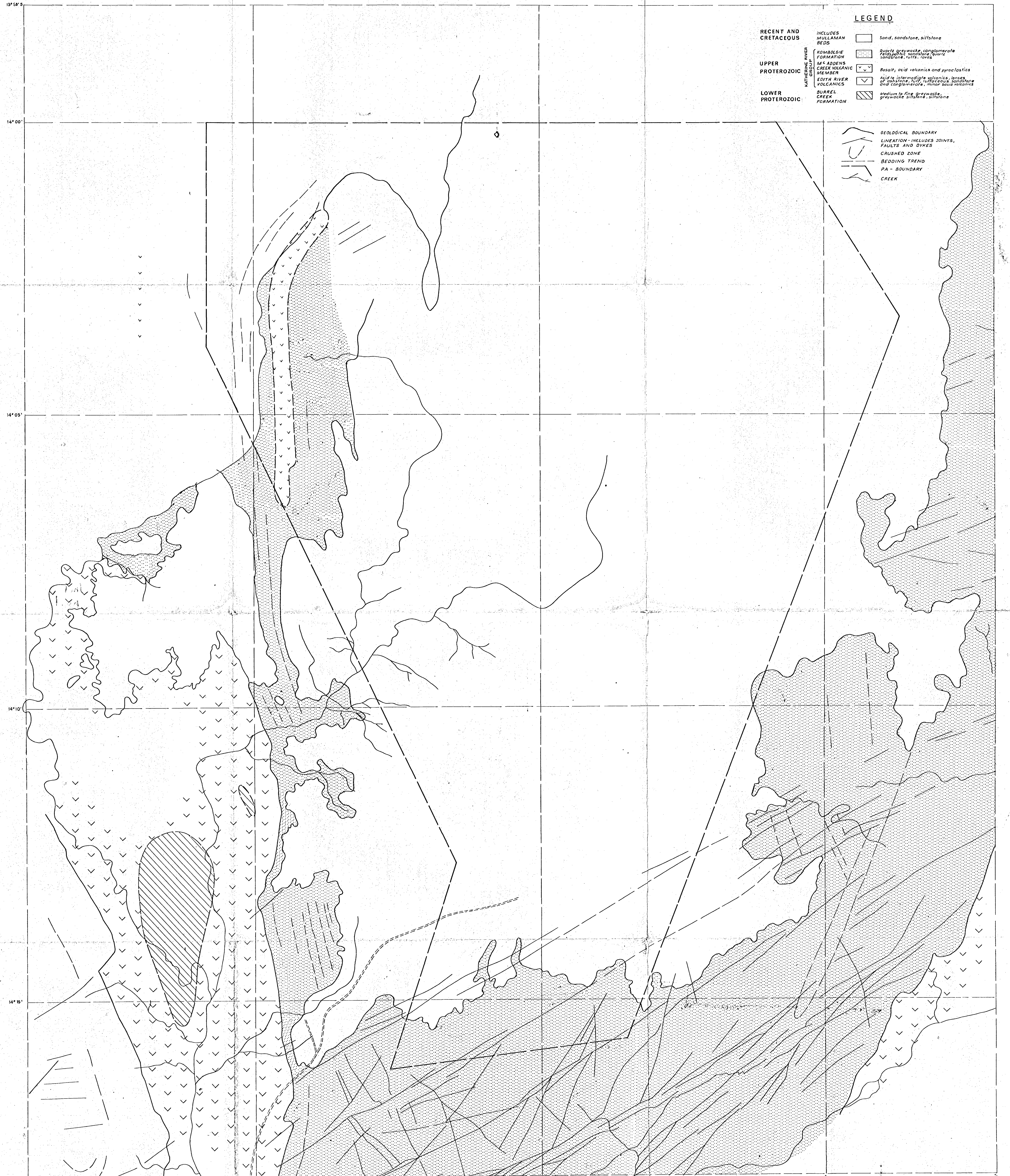
The local background is determined by fitting a fifth order polynomial to the "low side" of the data and removing this from the data along the line. This removes large scale regional trends and leaves only the more localized anomalies shown relative to a datum which represents the local background. This is illustrated by the final profiles which are being included for every line in this survey area. The amplitude of each anomaly is measured relative to this datum. The computer program locates each anomaly by examining the slope and curvature along the line.

After each is located, it is necessary to make an additional test for significance. If the signal to noise ratio were very large, then every anomaly could be considered significant but such is not the case. The significance of an anomaly must be predicated on the amplitude of the noise in the original data. We study the statistics of the data in all channels and computed standard deviations of the noise. These standard deviations are used to judge the significance of the anomalies shown in the final plots. That is, anomalies greater than sigma are judged significant and less than sigma not significant. There are cases in which human judgment, looking at the plotted curves, may disagree with this particular test, but this will vary from person to person and it is impossible to satisfy the subjective notions of a number of different observers in a single program. The computer program is conversely, always objective in its technique of analysis, insuring that all anomalies on all lines are judged by exactly the same criteria. The important point is that the user completely understand the processing steps and the tests applied so that the most intelligent use of the data can be made.

The seventh step is taking the anomalies judged significant in each data field in a line and deciding where the actual annotations should be made. For instance, if a significant anomaly is found at fiducial 1000 in the total count record and a significant anomaly is found at fiducial 1003 in the thorium data field, they are most likely from the same source and so only one annotation should really be made. The program resolves such closely spaced anomalies in various fields to a single value.

Annotations always include all four values, total count, uranium count, thorium count and potassium count. This is because some of the most diagnostic pieces of information are the ratios of the counts in different fields at a given point. Although annotations at each point include all four field values this does not imply that significant anomalies were found in all fields. The values from other fields are included in order that the interpreter can form all the ratios at a glance. In some cases the numerical values in the non-significant data fields go a few counts below the zero value due to the method used to fit the regional polynomial. These values are annotated on the map as zero values rather than small negative numbers. This is the only disagreement that should exist between the profile values and the annotations on the flight line map.

The annotations on the map are in the following order: Total count, Uranium count, Thorium count, and Potassium count. Profiles are plotted at a horizontal scale of 5016 ft/in and the vertical scale for each field is written directly on the plot. Start and end fiducials are ticked and plotted and a tick mark is placed at every 20 data point between them beginning with the first fiducial following the start fiducial with a zero in the least significant digit.



GEOLOGICAL MAP
PA 2681

PLATE I

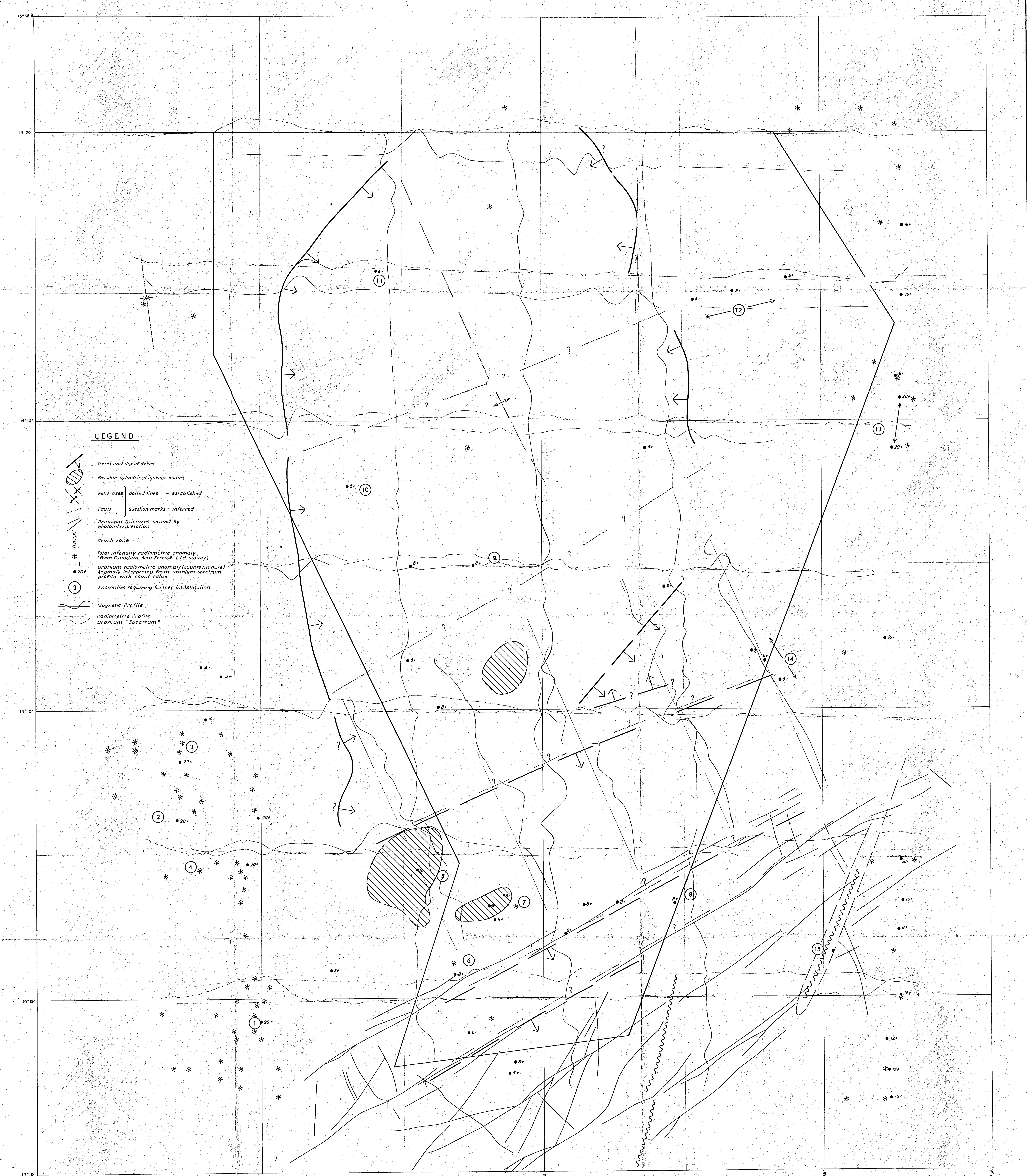
SCALE 1 : 50,000

0 .5 1 1.5 2 MILES
0 1 2 3 KILOMETRES

COMPILED BY A.M.C.

KATHERINE AREA
NORTHERN TERRITORY AUSTRALIA
IMC DEVELOPMENT CORPORATION

DRAWN BY A.H.



SUMMARY OF THE
GEOLOGICAL AND GEOPHYSICAL DATA
P.A. 2681

PLATE 2

SCALE 1: 50,000

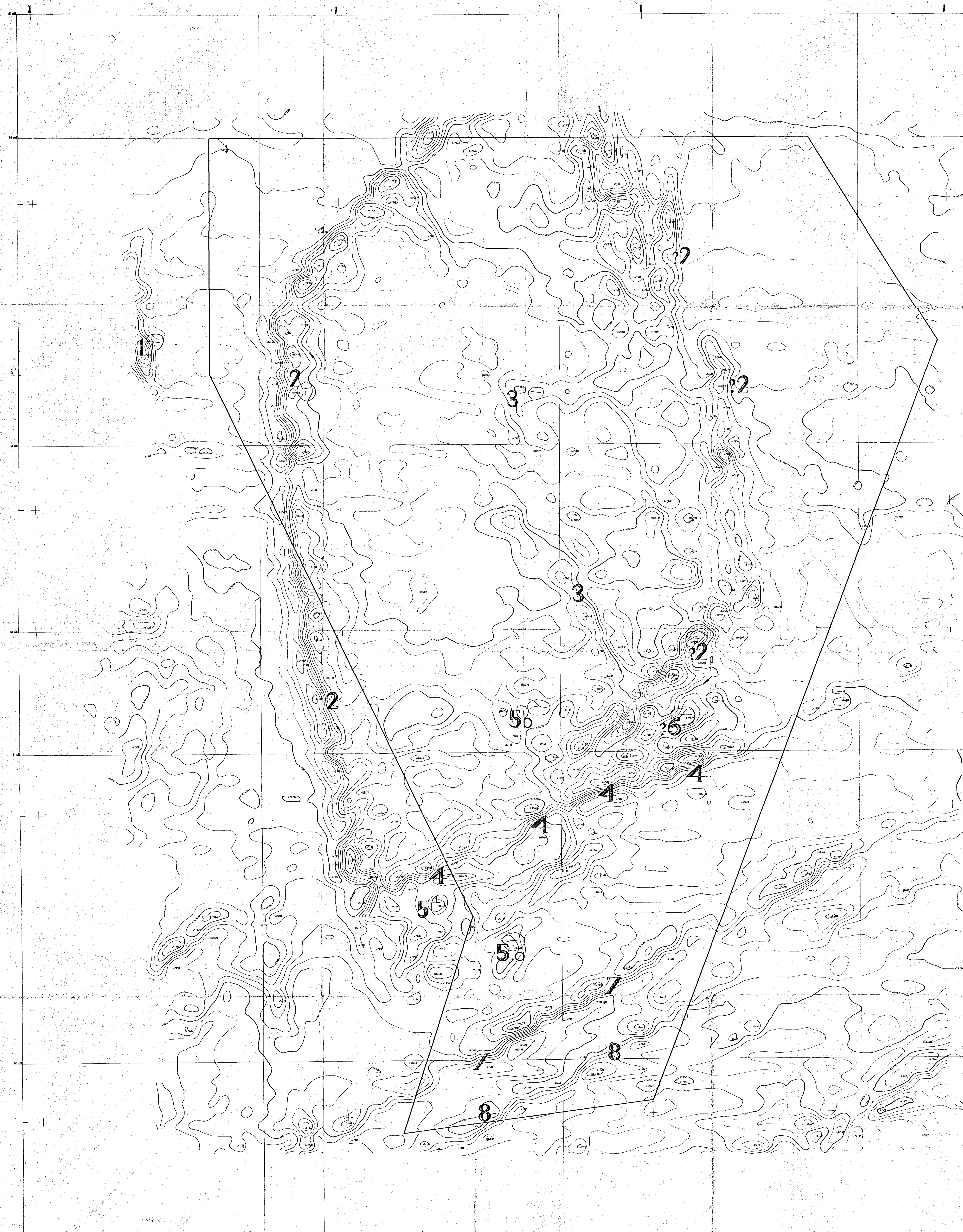
KATHERINE AREA
NORTHERN TERRITORY AUSTRALIA

IMC DEVELOPMENT CORPORATION

Compiled by A.M.C. from Canadian Aero Service Ltd. data
March 1971

CR 72/26

A1.



1 = MAGNETIC FEATURE

DECLINATION

INCLINATION

PLATE 3

AEROMAGNETIC TOTAL INTENSITY

P.A. 2681

CONTOUR INTERVAL 10 GAMMAS

SCALE 1 : 50,000

0 .5 1 1.5 2 MILES

0 1 2 3 KILOMETRES

KATHERINE AREA

NORTHERN TERRITORY, AUSTRALIA

IMC DEVELOPMENT CORPORATION

FLOWN AND COMPILED BY:

CANADIAN AERO SERVICE LTD. JUNE, DEC. 1970

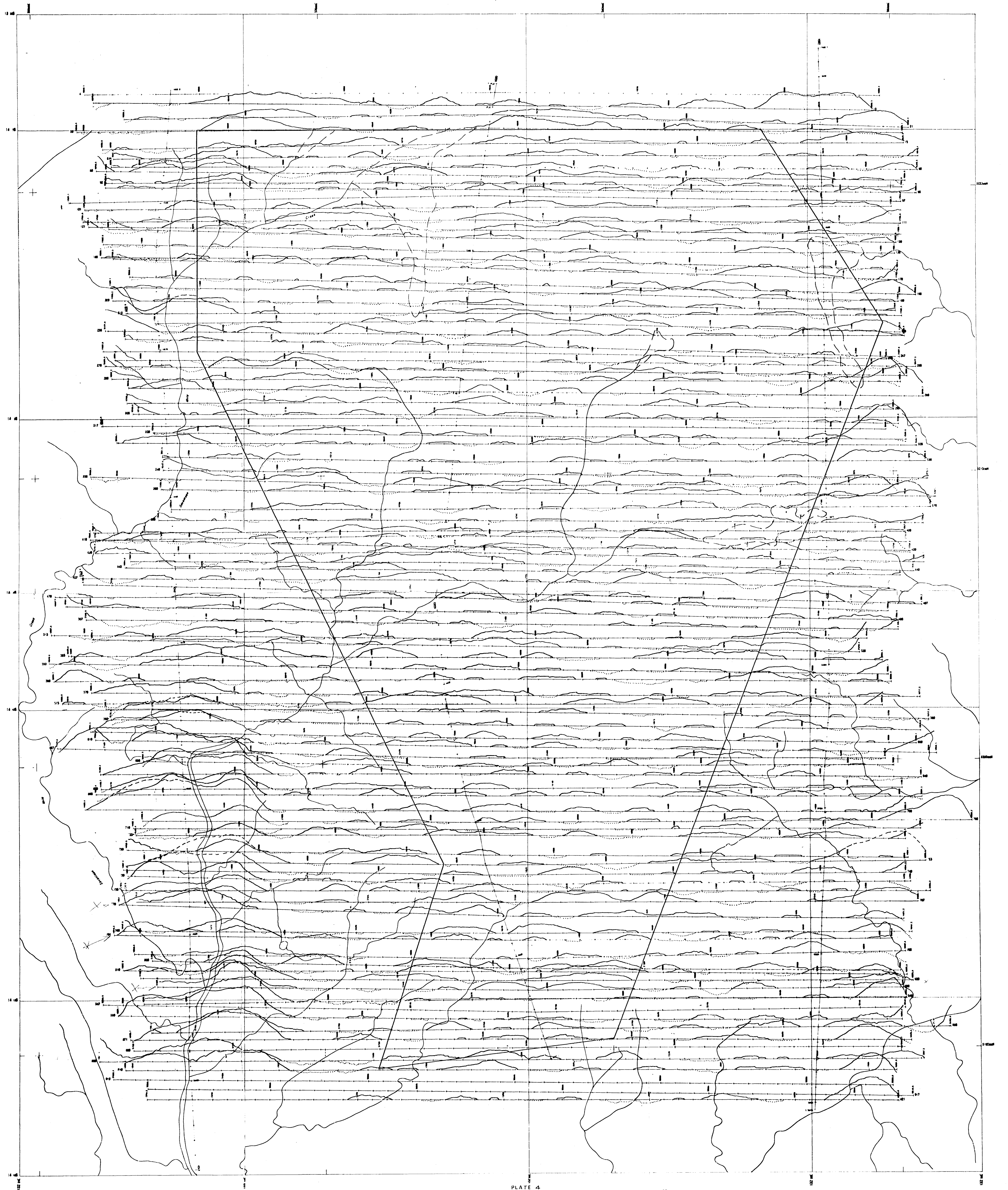


PLATE 4

PROFILES OF GAMMA RAY INTENSITIES IN THE URANIUM "SPECTRUM"

P.A. 2681

HORIZONTAL SCALE 1:50,000

0 .5 1 1.5 2 MILES

0 1 2 3 KILOMETRES

VERTICAL SCALE

0 4 8 12 16 20 30 40 50 counts /minute

KATHERINE AREA

NORTHERN TERRITORY, AUSTRALIA

IMC DEVELOPMENT CORPORATION

FLOWN BY :

CANADIAN AERO SERVICE LTD. JUNE, DEC. 1970

Compiled by A.H.
from profiles supplied by
Canadian Aero Service Febr. 1971

A C B

Please enlarge exactly "A-C" to "A-B"

CR 72/26 Plate 4

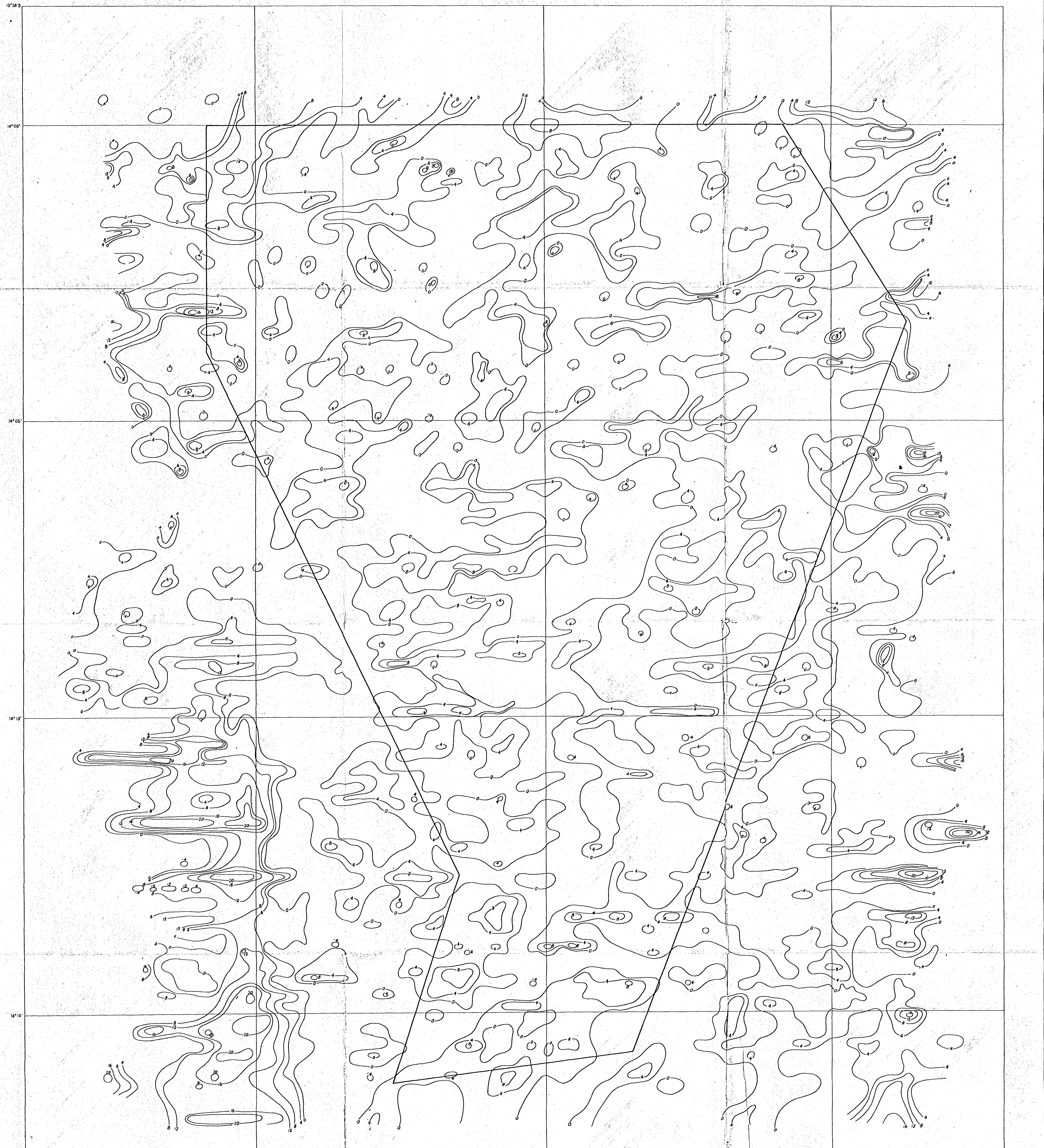


PLATE 5

ISORADS OF GAMMA RAY INTENSITIES IN THE URANIUM "SPECTRUM"

P.A. 2681

SCALE 1:50,000

0 ·5 1 1·5 2 MILES
0 1 2 3 KILOMETRES

CONTOUR INTERVAL - 4 COUNTS/MINUTE

CR 72/26

KATHERINE AREA
NORTHERN TERRITORY AUSTRALIA

IMC DEVELOPMENT CORPORATION

FLOWN BY
CANADIAN AERO SERVICE LTD. JUNE, DEC. 1970

Compiled by A.M.C.
from analysis of gamma ray intensity profiles in the Uranium spectrum supplied by Canadian Aero Service
Febr. 1971

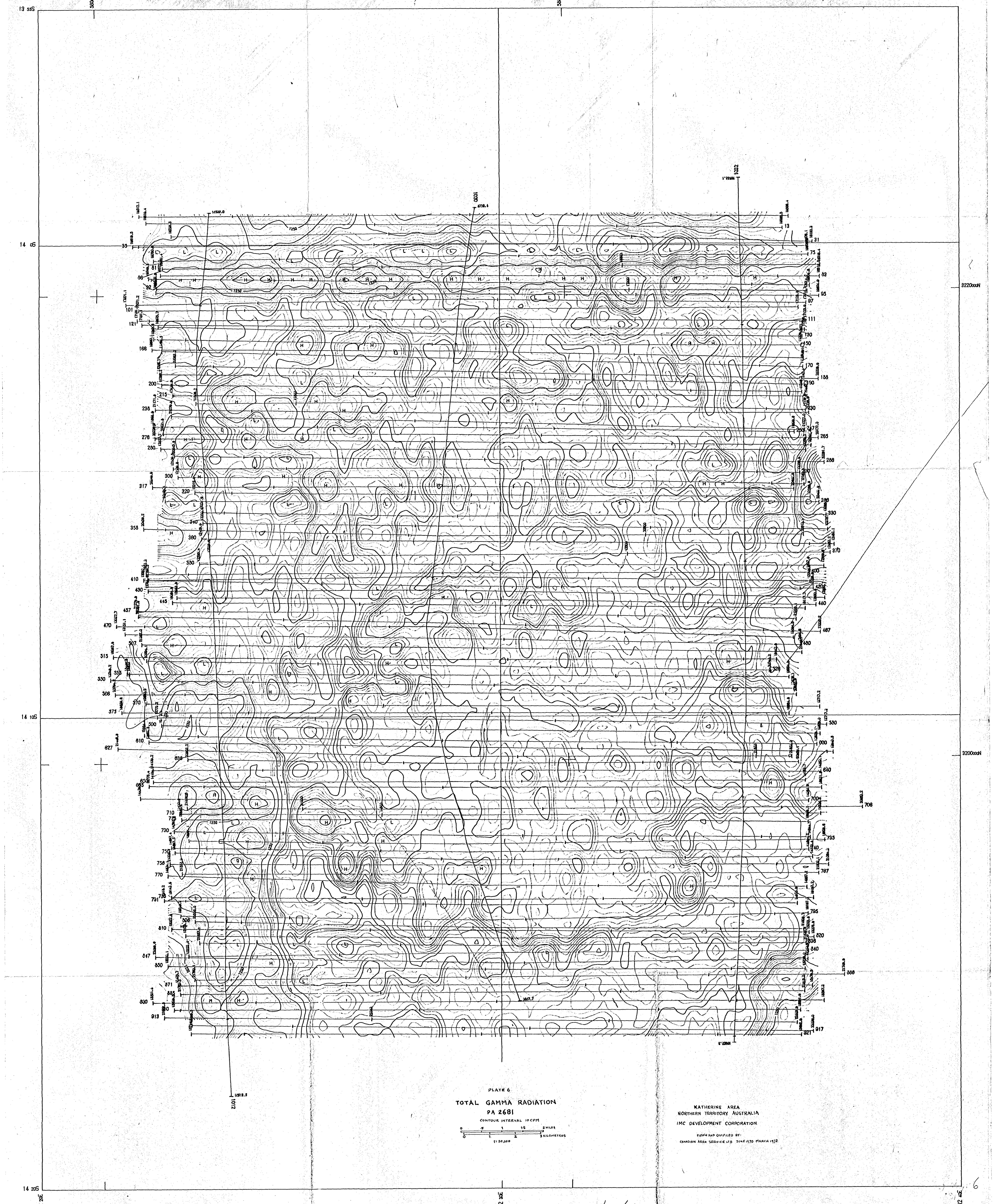
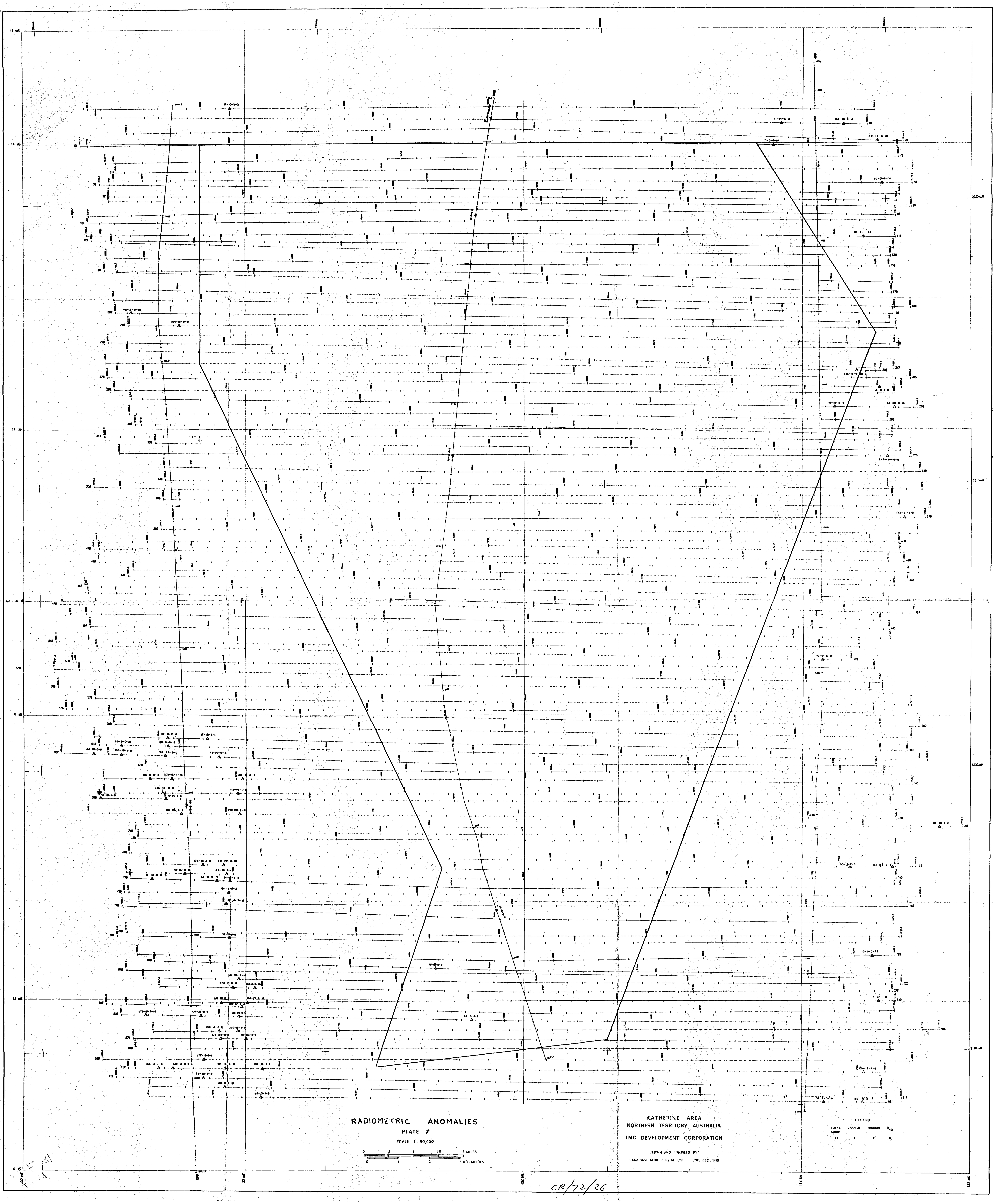


PLATE 6
TOTAL GAMMA RADIATION
PA 2681
CONTOUR INTERVAL 10 CPM
0 ·5 1 1·5 2 MILES
0 1 2 3 KILOMETRES
1:50,000
KATHERINE AREA
NORTHERN TERRITORY AUSTRALIA
IMC DEVELOPMENT CORPORATION
FLOWN AND COMPILED BY:
CANADIAN AERO SERVICE LTD JUNE 1970 MARCH 1972
3220000N
3200000N

CR/72/26


RADIOMETRIC ANOMALIES
PLATE 7
SCALE 1:50,000
0 .5 1 1.5 2 MILES
0 1 2 3 KILOMETRES
KATHERINE AREA
NORTHERN TERRITORY AUSTRALIA
IMC DEVELOPMENT CORPORATION
FLOWN AND COMPILED BY:
CANADIAN AERO SERVICE LTD. JUNE, DEC. 1970
LEGEND
TOTAL COUNT
URANIUM
THORIUM
K40
22
4
2
0
CR/72/26

IMC DEVELOPMENT CORPORATION

OCTOBER, 1970, MONTHLY REPORT
PROSPECTING AUTHORITY 2681 (KATHERINE GORGE)

Work Completed

Canadian Aero Service Ltd. continued its compilation of the data obtained from the airborne radiometric and magnetic survey carried out in June.

Work to check and understand the unusual inverse correlation between gamma radiation intensity and terrain clearance has prolonged the completion of this compilation past the expected date.

Expenditure

Salaries	$397.54
Materials	19.49
Expenditure on Fixed Assets	44.93
Other Expenses	746.84
Contractors, Consultants, etc.	3.10
	$1,211.90

Total expenditure April 21-October 31, 1970, is $33,246.20.

November Programme

Details of further work in the area depend on the radiometric data to be supplied by Canadian Aero Service Ltd.

PWP/RdeS

IMC DEVELOPMENT CORPORATION

NOVEMBER, 1970, MONTHLY REPORT
PROSPECTING AUTHORITY 2681 (KATHERINE GORGE)

Work Completed

Canadian Aero Service Ltd. continued its compilation of the data obtained from the airborne radiometric and magnetic survey carried out in June.

Work to check and understand the unusual inverse correlation between gamma radiation intensity and terrain clearance has prolonged the completion of this compilation past the expected date.

Expenditure

Materials	$105.71
Other Expenses	93.70
Contractors, Consultants, etc.	546.50
	$745.91

Total expenditure April 21-November 30, 1970, is $33,992.11.

December Programme

Details of further work in the area depend on the radiometric data to be supplied by Canadian Aero Service Ltd.

PWP/RdeS

IMC DEVELOPMENT CORPORATION

DECEMBER, 1970, MONTHLY REPORT
PROSPECTING AUTHORITY 2681 (KATHERINE GORGE)

Work Completed

The final Canadian Aero Service Ltd. compilation of the radiometric results from the June airborne survey have been received, and are being examined to locate any targets for further exploration in 1971.

Expenditure

No expenditure was incurred during the month.

January Programme

The exploration programme in the authority area is to be reviewed thoroughly before any further significant expenditure is incurred on this project.

PWP/RdeS