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National Uranium Resource Evaluation

**Airborne Gamma-Ray Spectrometer
And Magnetometer Survey
Mitchell Quadrangle, South Dakota**

Final Report - Volume I

**Aero Service Division
Western Geophysical Company of America
Houston, Texas 77001**

April 1981

**PREPARED FOR U.S. DEPARTMENT OF ENERGY
Assistant Secretary for Resource Applications
Grand Junction Office, Colorado**

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AIRBORNE GAMMA-RAY SPECTROMETER
AND
MAGNETOMETER SURVEY

MITCHELL QUADRANGLE
SOUTH DAKOTA

FINAL REPORT
VOLUME I

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AERO SERVICE DIVISION
WESTERN GEOPHYSICAL COMPANY
OF AMERICA
HOUSTON, TEXAS

APRIL, 1981

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ASSISTANT SECRETARY FOR RESOURCE APPLICATIONS
GRAND JUNCTION OFFICE, COLORADO
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SUBCONTRACT NO. 80-449-L
PROJECT NO. IGO207-PROJECT A

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Figure 1
MITCHELL QUADRANGLE
INDEX MAP

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INTRODUCTION

During the months of June through October, 1980, Aero Service Division Western Geophysical Company of America conducted an airborne high sensitivity gamma-ray spectrometer and magnetometer survey over eleven (11) 2° x 1° NTMS quadrangles located in the states of Minnesota and Wisconsin and seven (7) 2° x 1° NTMS quadrangles in North and South Dakota. These include the Kenora, Roseau, International Falls, Quetico, Bemidji, Hibbing, Two Harbors, Brainerd, Duluth, Stillwater, and St. Paul quadrangles of Minnesota and Wisconsin. The quadrangles located within the North and South Dakota survey area include Devil's Lake, New Rockford, Jamestown, Aberdeen, Huron, Mitchell, and Sioux Falls. This report discusses the results obtained over the Mitchell map area.

Traverse lines were flown in an east-west direction at a line spacing of six (6) miles. Tie lines were flown north-south approximately twenty-four (24) miles apart. A total of 21,481 line miles of geophysical data were acquired, compiled, and interpreted during the survey, of which 1479 line miles are in this quadrangle.

This report is a result of work performed under Bendix Field Engineering Corporation Subcontract No. 80-449-L, Project No. IGO207-Project A, as part of the National Uranium Resources Evaluation. NURE is a program of the U. S. Department of Energy's Grand Junction, Colorado, office to acquire and compile geologic and other information with which to assess the magnitude and distribution of uranium resources and to determine areas favorable for the occurrence of uranium in the United States.

The data were reduced and compiled in accordance with the technical specifications of the contract as stated in BFEC 1200-C and BFEC 1250-A. The parameters used in the processing of the radiometric data have been substantiated in a previously submitted calibration report of the Douglas DC-3 installed airborne gamma-ray spectrometer system.

DATA ACQUISITION

Aircraft

The survey was conducted using a Douglas DC-3 fixed wing aircraft, registration N5000E, owned and operated by Aero Service Division Western Geophysical Company of America. The flight crew consisted of a pilot, a navigator and an electronic operator. Some of the more pertinent characteristics and specifications of the aircraft are listed below:

T A B L E I

<u>Aircraft Specifications and Characteristics</u>	
Aircraft	Douglas DC-3 - N5000E
Power Plant	2 ea. - Pratt Whitney - R1830-94 Engines, Twin Row, Radial - 1,350 H. P.
Allowable Gross Weight	26,900 lbs.
Empty Weight - Survey Configuration	23,000 lbs.
Avionics - Dual RT41A VHF Comm Transceiver	
Dual Collins 51V VOR/LOC/RMI Receiver	
Dual Collins Glide Scope Receiver	
1 KDM 705 DME	
1 KXP 750 Transponder	
1 618T3B H.F. Transceiver	
Sperry A-12 Autopilot System	
Bendix Doppler Navigation System	
Honeywell Radar Altimeter	
Cruise Airspeed	120 to 165 M.P.H.
Rate of Climb	1,200 f.p.m.
Service Ceiling	24,000 Feet
Fuel	100/130 Octane
Fuel Consumption	Approx. 100 Gal. Per Hour

Gamma-Ray Spectrometer System

The survey was carried out using Aero Service's HISENS A(irborne) G(amma)-R(ay) S(pectrometer) 3000F system, shown in block diagrammatic form in Figure 3, page 12.

Figure 3

DWN
CHKE
APVD

DATE
12/86

SIZE
B

REV	SHE

16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
----	----	----	----	----	----	----	---	---	---	---	---	---	---	---	---

The primary detector package consists of 14 logs of 4" x 4" x 15" of Polyscin®, NaI(Tl), each log hermetically sealed in a stainless steel container and coupled to a high quality photo-multiplier tube. The logs are assembled in 3 slabs of respectively 4, 4 and 6 logs each. Each slab is enclosed in a heated and thermally stabilized container. Total volume of the primary detector is 3360 cubic inches (55.06 liters). The upward looking (2π) detector consists of two 4" x 4" x 16" logs of Polyscin®, NaI(Tl), also hermetically sealed in a steel container and coupled to high quality photo-multiplier tubes. The two logs are enclosed as a slab in the same container that houses the slab of 6 logs of Polyscin®. The upward looking crystals are mounted on top of the 4π sensor, separated by a 0.75" slab of lead shielding, in order to obtain the prescribed shielding effect of 85% @ 3000KeV.

The preamplifiers, which with the photo-multipliers provide virtually the total signal amplification, are also enclosed in the thermally stabilized packages, to ensure maximum signal stability. The output of the preamplifiers is fed into the amplifiers, whose main function is to shape the incoming pulses into a bipolar gaussian form.

The mixer/router, the 50 MHz Wilkinson ramp analog to digital converter and the multi-channel analyzer of both the primary and 2π spectrometer systems are commercially available units, supplied by Canberra Industries. The data from the two spectrometers are output to the data controller, formed by a Hewlett Packard 21 MX minicomputer system, which stores the data, formats them, outputs them on tape and compares the tape recorded data with the data stored in memory. Additional data recorded on tape are radar altitude, barometric pressure, atmospheric temperature, magnetometer data, real time, gamma-ray spectrometer system live-time and other ancillary data such as additional navigational data. Two tape drives were employed and automatic switching between the two occurs as each tape ends. Additional ancillary equipment includes a cathode ray tube display, a Clevite Brush 6-channel analog recorder and a 35mm frame camera, triggered by the data controller at a preset interval.

Magnetometer

The magnetic sensor used for the survey was a Geometrics G-803 proton free-precession magnetometer, housed in a high-drag, fiberglass bird and towed approximately 100' behind and 25' below the aircraft, in order to assure reliable data with minimal aircraft compensation.

PRODUCTION SUMMARY

The 2° x 1° NTMS quadrangle of Mitchell, South Dakota, was surveyed as part of a subcontract covering eleven (11) quadrangles located in Minnesota and Wisconsin along with seven (7) quadrangles in North and South Dakota. The subcontract covered the flying of a total of 21,481 line miles of geophysical data, of which 1479 miles are in the Mitchell quadrangle.

The main base of operations of all survey flights was located between the two survey areas at Fargo, North Dakota.

The aircraft arrived on site on June 28, 1980. The first production flight was made on July 1, 1980, with the last flight being completed on October 25, 1980. Production operations within these survey areas were interrupted over the period of July 11, 1980, through August 10, 1980, during which time the aircraft was conducting a similar NURE program of airborne radiometric surveying over twelve (12) quadrangles located in northern Alaska. The aircraft and crew were on site, carrying out flight operations in the Minnesota, Wisconsin and Dakotas areas for a total of eighty-eight days. It was not possible to complete production flights on fifty-nine of these days. Twenty-two days were lost due to inclement weather or atmospheric conditions. Six days were lost due to electronic equipment maintenance and thirty-one days were lost due to aircraft maintenance including twenty-three days for multiple engine changes. A complete summary of daily flight operations is given in Table II, pages 16, 17, 18 and 19.

Production averaged 75.8 miles per hour of flight time. An average of 740.7 miles of data was acquired each actual production day. When computed over the total number of days on site, data acquisition averaged 244.1 miles per day.

Flight line directions and spacing for the Mitchell quadrangle were east-west traverse lines 6 miles apart and north-south tie lines flown at 24 mile intervals. The nominal terrain clearance for the survey was 400 feet. Figure 4 shows a histogram of the terrain clearance of the aircraft as recorded by the radar altimeter. The histogram takes into account all final samples in this quadrangle. The mean terrain clearance, as observed, is approximately 410 feet. The ground speed of the aircraft, as determined from the distances between samples based on their final X-Y positions, is depicted in graphic form in the histogram of Figure 5, page 21.

T A B L E II
Daily Production Summary

<u>DATE</u>	<u>BASE</u>	<u>ACTIVITY</u>	<u>FLIGHT NO.</u>
06/28/80	Fargo, North Dakota	Arrive Fargo	
06/29/80	Fargo, North Dakota	Weather	
06/30/80	Fargo, North Dakota	Aircraft maintenance	
07/01/80	Fargo, North Dakota	Production	4, 5
07/02/80	Fargo, North Dakota	Production	6
07/03/80	Fargo, North Dakota	Production	7
07/04/80	Fargo, North Dakota	Electronic maintenance	
07/05/80	Fargo, North Dakota	Production	8
07/06/80	Fargo, North Dakota	Weather	
07/07/80	Fargo, North Dakota	Aircraft maintenance and tests	9, 10
07/08/80	Fargo, North Dakota	Production	11, 12
07/09/80	Fargo, North Dakota	Production	13
07/10/80	Fargo, North Dakota	Electronic maintenance	
07/11/80	Fargo, North Dakota	Depart for Alaska	
07/12/80 to 08/09/80		Operations in North Slope airborne survey quadrangles	
08/10/80	Fargo, North Dakota	Arrive Fargo	31
08/11/80	Fargo, North Dakota	Aircraft maintenance	
08/12/80	Fargo, North Dakota	Aircraft maintenance	
08/13/80	Fargo, North Dakota	Aircraft maintenance	
08/14/80	Fargo, North Dakota	Aircraft test flight	32
08/15/80	Fargo, North Dakota	Production	33, 34
08/16/80	Fargo, North Dakota	Weather	
08/17/80	Fargo, North Dakota	Weather	
08/18/80	Fargo, North Dakota	Production	35
08/19/80	Fargo, North Dakota	Production	36

Daily Production Summary

<u>DATE</u>	<u>BASE</u>	<u>ACTIVITY</u>	<u>FLIGHT NO.</u>
08/20/80	Fargo, North Dakota	Weather	
08/21/80	Fargo, North Dakota	Weather	
08/22/80	Fargo, North Dakota	Production	37, 38
08/23/80	Fargo, North Dakota	Weather	
08/24/80	Fargo, North Dakota	Excessive radon	39, 40
08/25/80	Fargo, North Dakota	Weather	
08/26/80	Fargo, North Dakota	Production	41
08/27/80	Fargo, North Dakota	Aircraft maintenance	
08/28/80	Fargo, North Dakota	Aircraft maintenance	
08/29/80	Fargo, North Dakota	Aircraft test flight	42
08/30/80	Minneapolis, Minnesota	Aircraft engine change #1	
08/31/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/01/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/02/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/03/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/04/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/05/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/06/80	Minneapolis, Minnesota	Aircraft engine change #1	
09/07/80	Minneapolis, Minnesota	Aircraft test flight	44
09/08/80	Minneapolis, Minnesota	Aircraft engine change #2	
09/09/80	Minneapolis, Minnesota	Aircraft engine change #2	
09/10/80	Minneapolis, Minnesota	Aircraft test flight	45
09/11/80	Minneapolis, Minnesota	Aircraft maintenance	
09/12/80	Minneapolis, Minnesota	Aircraft maintenance	
09/13/80	Fargo, North Dakota	Ferry to Fargo	46
09/14/80	Fargo, North Dakota	Weather	
09/15/80	Fargo, North Dakota	Abort - Count rates too high	47
09/16/80	Fargo, North Dakota	Abort electronics	48
09/17/80	Fargo, North Dakota	Weather	49
09/18/80	Fargo, North Dakota	Production	50
09/19/80	Fargo, North Dakota	Production	51

Daily Production Summary

<u>DATE</u>	<u>BASE</u>	<u>ACTIVITY</u>	<u>FLIGHT NO.</u>
09/20/80	Fargo, North Dakota	Weather	
09/21/80	Fargo, North Dakota	Fog then production	52
09/22/80	Fargo, North Dakota	Aircraft Maintenance	
09/23/80	Fargo, North Dakota	Production and reflights	53
09/24/80	Fargo, North Dakota	Production then rain	54
09/25/80	Fargo, North Dakota	Electronic maintenance	
09/26/80	Fargo, North Dakota	Production and reflights	55
09/27/80	Fargo, North Dakota	Abort, electronics	56
09/28/80	Fargo, North Dakota	Electronic maintenance	
09/29/80	Fargo, North Dakota	Abort, excessive radon	57
09/30/80	Fargo, North Dakota	Production	58
10/01/80	Fargo, North Dakota	Production	59
10/02/80	Fargo, North Dakota	Weather	
10/03/80	Fargo, North Dakota	Production	60
10/04/80	Fargo, North Dakota	Production	61
10/05/80	Fargo, North Dakota	Production	62
10/06/80	Fargo, North Dakota	Production	63
10/07/80	Fargo, North Dakota	Production	64
10/08/80	Fargo, North Dakota	Abort, engine out	65
10/09/80	Fargo, North Dakota	Aircraft engine change #3	
10/10/80	Fargo, North Dakota	Aircraft engine change #3	
10/11/80	Fargo, North Dakota	Aircraft engine change #3	
10/12/80	Fargo, North Dakota	Aircraft engine test flight	66
10/13/80	Fargo, North Dakota	Reflights	67
10/14/80	Fargo, North Dakota	Weather	
10/15/80	Fargo, North Dakota	Weather	
10/16/80	Fargo, North Dakota	Weather	
10/17/80	Fargo, North Dakota	Weather	
10/18/80	Fargo, North Dakota	Aircraft maintenance	
10/19/80	Fargo, North Dakota	Production	68
10/20/80	Fargo, North Dakota	Production	69

Daily Production Summary

<u>DATE</u>	<u>BASE</u>	<u>ACTIVITY</u>	<u>FLIGHT NO.</u>
10/21/80	Fargo, North Dakota	Production and reflights	70
10/22/80	Fargo, North Dakota	Weather	
10/23/80	Fargo, North Dakota	Weather	
10/24/80	Fargo, North Dakota	Weather	
10/25/80	Fargo, North Dakota	Reflights	71
		Complete Airborne Operations	

AERC SERVICE
QUAD MITCHELL

TERRAIN CLEARANCE HISTOGRAM
JOB 624

NUMBER OF DATA POINTS

RADAR
ALTIMETER
FEET

-20-

Figure 4

AERC SERVICE QUAC MITCHELL

GROUND SPEED
JOB 624

HISTOGRAM

NUMBER OF DATA POINTS

1400 2800 4200 5600 7000 8400 9800 11200 12600 14000 15400

MILES
PER
HOUR

21/22

Figure 5

DATA REDUCTION

The data reduction process as used in the processing of the airborne gamma-ray spectrometer and magnetometer data obtained within the Department of Energy (DOE) National Uranium Resource Evaluation (NURE) program is shown in flow chart form in Figure 6, page 24.

Upon arrival in the Houston office, the digital data are edited and a back-up tape is generally produced. The EDIT consists partly of a data quality check, enabling the elimination of single record spikes in any field, outside a specified preselected limit. The EDIT program further checks for data continuity and flags all data acquired at terrain clearances exceeding the survey specification. The EDIT further sums a preselected number of spectral records at the beginning and end of each survey line and fits a gaussian curve to diagnostic photopeaks, such as the Tl^{208} peak at 2614.5 KeV and the K^{40} peak at 1460 KeV for low altitude lines and the annihilation peak at 511 KeV and the K^{40} peak at 1460 KeV for high altitude lines. The position of these photopeaks is determined with an accuracy of better than 0.1 of a channel and is used to determine the exact position of the energy windows with regard to channel numbers. At the same time the calculated standard deviations of the fitted gaussian curves serve to obtain the system resolution at the photopeaks used. The window count rates are normalized for live time and are calculated as follows:

K	:	1362 KeV - 1566 KeV (Channel 114 → 130, @ 12 KeV/Channel)
U	:	1662 KeV - 1866 KeV (Channel 139 → 155, @ 12 KeV/Channel)
T	:	2406 KeV - 2826 KeV (Channel 201 → 235, @ 12 KeV/Channel)
T.C.	:	390 KeV - 2982 KeV (Channel 33 → 248, @ 12 KeV/Channel)
Cosmic	:	2994 KeV - 6138 KeV (Channel 250 → 512, @ 12 KeV/Channel)
$U_{2\pi}$	:	1662 KeV - 1866 KeV (Channel 139 → 155, @ 12 KeV/Channel)

The above channel numbers are valid only if system gain corresponds exactly to 12 KeV per channel and there is no zero shift.

The CORRECT program applies the background and cosmic corrections to the single record window count rates, corrects the data for Compton scatter and atmospheric radon, and normalizes the terrain clearance. Background count rates and cosmic factors were determined from high altitude test data acquired over the Pacific Ocean, offshore California.

Potassium Background	=	32.01 counts per second
Uranium Background	=	10.09 counts per second
Thorium Background	=	6.86 counts per second
Total Count Background	=	278.04 counts per second
2 π Bismuth Background	=	1.55 counts per second

Potassium Cosmic factor	=	0.20 c.p.s. per count 4 π cosmic
Uranium Cosmic factor	=	0.165 c.p.s./cps 4 π cosmic
Thorium Cosmic factor	=	0.22 c.p.s./cps 4 π cosmic
Total Count Cosmic factor	=	3.64 c.p.s./cps 4 π cosmic
2 π Bismuth Cosmic factor	=	0.0344 c.p.s./cps 4 π cosmic

The Compton scatter functions were determined from data obtained over the Grand Junction test pads, using the radiometric analysis of the bulk sample with natural water content.

$$\begin{aligned}
 T/U &= \tau = 0.076 \\
 U/T &= \alpha = 0.35 + 0.02 + 0.000076H \\
 K/T &= \beta = 0.44 \\
 K/U &= \gamma = 0.96
 \end{aligned}$$

The 2 π and 4 π uranium window count rates are related through the geometric or equivalency factor. For the present system, installed in the Douglas DC-3, this factor, $f = 6.0$. Part of the terrestrial radiation of energy higher than 1662 KeV - the lower threshold of the uranium window - is detected in the uranium window of the upward looking detector, due to incomplete shielding, skyshine and shine-around. This shine-through/shine-around effect is assumed to be a function of both the intensity of the terrestrial uranium and thorium radiation and of the aircraft terrain clearance. From multi-altitude data acquired over the Lake Mead Dynamic Test Range the shine-through/shine-around effect was determined for each altitude level. The data provided a best fit for a linear terrain clearance function as follows:

$$\text{shine-through/shine-around} = (0.05 - 3.8 \times 10^{-5}H) (U_{4\pi} + 0.35T_{4\pi})$$

The shine-through/shine-around corrected Biair Count rate is then:

$$U_{2\pi} c = \frac{U_{2\pi} - (U_{4\pi} + 0.35T) (0.05 - 3.8 \times 10^{-5}H)}{1 - 6.0 (0.05 - 3.8 \times 10^{-5}H)}$$

The shine-through/shine-around correction is applied to the $U_{2\pi}$ count rate at each single record. The single record $U_{2\pi}$ count rates are then averaged over 35 records to make them statistically compatible with the data of the primary system. The atmospheric radon correction is applied to both the $U_{4\pi}$ and the Total Count count rates. The equivalency factor for the $U_{4\pi}/U_{2\pi} = 6.0$, for Total Count/ $U_{2\pi}$ it is 61.75.

Within the CORRECT program the data are normalized to a common datum of 400 feet terrain clearance. An exponential formula is used, based on an air column reduced to a standard temperature and pressure of 0°C and 760mm Hg. (32°F and 29.92" Hg). The air absorption coefficients used are those derived from the multiple altitude flight over the Lake Mead Dynamic Test Range for thorium, potassium and Total Count. The air absorption factor for uranium is obtained by straight interpolation between the potassium and thorium air absorption factors. Their values are respectively:

$$\begin{aligned}\mu_K &= 2.71 \times 10^{-3} \text{ per foot} \\ \mu_U &= 2.56 \times 10^{-3} \text{ per foot} \\ \mu_T &= 2.15 \times 10^{-3} \text{ per foot} \\ \mu_{TC} &= 2.16 \times 10^{-3} \text{ per foot}\end{aligned}$$

The formula used for the altitude normalization is:

$$N_{400} = N_H \cdot e^{-\mu \left(400 - \frac{273}{273+t} \cdot \frac{P}{29.92} \cdot H \right)}$$

Where N_{400} , N_H are respectively the count rates at 400 feet and at altitude H, μ is air absorption factor, t is temperature in degrees Celsius and P is barometric pressure in inches Hg.

The last operation in the CORRECT program is the determination of statistical adequacy of the data. The criteria for adequacy of the data are based on the work of Lloyd A. Currie (op.cit.). A critical level is recognized, below which all observations made fail to detect a signal, i.e. 95% of all measurements fall within the "normal" distribution of "noise". The detection level is similarly defined as the level above which 95% of the measurements made fall within the normal Poisson distribution of "signal". Currie's critical level has been adopted as the count rate level below which data are inadequate. Data with count rates above the critical level but below

the detection level are considered marginal. Above the detection level data are considered adequate. For the single record data the formulas are then:

Count Rate ≤ 2.33 (Sum Corrections)^{1/2}: data inadequate

2.33 (Sum Corrections)^{1/2} < Count Rate $\leq 2.71 + 4.65$ (Sum Corrections)^{1/2}:
data marginal

Count Rate > $2.71 + 4.65$ (Sum Corrections)^{1/2}: data adequate

No ratios have been calculated involving inadequate data in either numerator or denominator. Ratios have been calculated when the data in the numerator are marginal, provided the data in the denominator are adequate.

The thorium, uranium and potassium data are subsequently averaged over 9 records in the SPECAVG program. The output is a spectrometer master tape containing both averaged and single record data.

Parallel with the radiometric data reduction process, the magnetic data are edited and processed. Using the recovered film intersections and the established ground identities, preliminary flight paths are prepared. The flight path is refined in the magnetic adjustment program until an accurate final flight path has been obtained. The reduced spectrometer data are then merged with the final X-Y position of the data points, the reduced magnetic data and the digitized geology, and a master tape is produced with data that pertain to each 2° x 1° NTMS quadrangle only. The REGROUP program then eliminates all duplicate line segments, inserts reflight segments where required, orders the remaining line segments and renumbers the fiducials of these segments such that the resulting line is directionally consistent with location sequential sample numbers. The renumbered fiducials increase from west to east for traverse lines and south to north for tie lines. A listing relating the renumbered fiducials to the original fiducial numbers as recorded in flight is included in this volume as Appendix N and can also be found in the back of Volume II. This listing gives both the line number as it appears on all final data and the line number as recorded in flight. Similarly, the start and end fiducials of each final line and/or line segment shown on the flight path base map are given along with the corresponding start and end fiducials as recorded in flight. When correlated with the final fiducial numbers, the original fiducials will increase sequentially for lines flown west to east or south to north and decrease for lines flown in the opposite

directions.

The following processing steps are STATANAL and HISTGRM. HISTGRM groups the radiometric data by geological cell units, determines the distribution of the data as normal or lognormal, calculates the mean (for normally distributed data) or the mode (for lognormal distributions) as well as the standard deviations. The results from HISTGRM are used in the STATANAL program, which calculates the signed standard deviation from the mean for each averaged sample for each of the six radiometric parameters. Its output is the Final Spectrometer Master Tape, from which the anomaly maps, the statistical analysis tape, the averaged record and single record reduced data tapes and listings, the flight path maps and the radiometric and magnetic profiles are produced.

High 2π uranium count rates were encountered during many of the data acquisition flights over this quadrangle. This resulted in correspondingly high atmospheric radon corrections to the 4π uranium data reducing this data to very low count rate levels which fell, for the most part, in the range of statistically marginal to inadequate data. The data of both the 4π and 2π acquisition systems were extensively tested and all possible system malfunctions were eliminated as the source of the high $U_{2\pi}$ count rates recorded in flight.

After consultation with BFEC, it was agreed that the fully corrected single record $U_{4\pi}$ data would be adjusted upward to levels corresponding to $U_{4\pi}$ concentrations obtained over those quadrangles bordering this area on the east and west. The normalization factors as applied to the data were obtained by comparing $U_{4\pi}$ data levels averaged over 200 samples at the east and west ends of the traverse lines with similar averages over the nearest lines within the adjacent quadrangles. The east and west end factors were in turn averaged to obtain the final normalization factor. After adjustment of the single record $U_{4\pi}$ count rates, the data were again tested for statistical adequacy and the two uranium ratios were re-computed. The data along the tie lines were adjusted in a similar manner using the normalized $U_{4\pi}$ data along the northernmost and southernmost traverse with this quadrangle.

The single record data were then averaged over 9 records using the SPECAVG program. All subsequent processing steps were then followed as outlined above.

DATA PRESENTATION

General

The final data are presented in four different forms: on magnetic tape; on microfiche; in graphic form as profiles and histograms; and in map form as anomaly maps, flight path maps, and computer printer maps.

The histograms and the multiparameter profiles are presented with the anomaly maps and flight path map in a separate bound volume. Complete data listings of both the reduced single record and the reduced averaged record data are found in the back of this report. The format of the printout of the microfiches and the format of the data files delivered on magnetic tape are in accordance with the specifications of the BFEC 1200-C and are described in appendices F through L of this report.

Radiometric Multiple-Parameter Stacked Profiles

The radiometric profiles have been prepared at the horizontal scales of 1:250,000 and 1:500,000 on an automated flatbed plotter. Displayed are from top to bottom: total magnetic intensity, IGRF removed, in gammas; radar altimeter, in feet; ratio of eT concentration in ppm/potassium concentration in %; ratio of eU/K; eU/eT ratio, atmospheric radon (BIAC) in counts per second, equivalenced to the 4π count rate; apparent concentration of terrestrial eT in ppm, apparent concentration of terrestrial eU in ppm; apparent concentration of potassium in %; "Total Count" count rate. Flags are indicated, where needed, below the base line of the corresponding parameter. A short flag indicates marginal data, including terrain clearances between 700 and 1000 feet, while a long flag indicates inadequate data. Fiducial markers are plotted every 200 records, along the top of the profile, every 10 records near the bottom.

The flight path and the geologic formations overflown along the line are shown on the bottom of both the radiometric and magnetic multiple-parameter stacked profiles below the lower fiducial markers. Six tiers of formation identifiers along with short markers on the flight line are used to indicate changes along the profile with the base of the identifier letters aligned with the corresponding marker. The first identifier found on the westernmost end of the profile applies to the start of the line and this formation continues until the next marker is encountered. Subsequent changes to the geology are similarly indicated along the profile.

Magnetic and Ancillary Parameter Stacked Profiles

The magnetic profiles have also been plotted at scales of 1:250,000 and 1:500,000 on an automated flatbed plotter. The plotting sequence of the profiles is, from top to bottom: barometric pressure at aircraft altitude in mm Hg; atmospheric ambient temperature in degrees Celsius, terrain clearance in feet; magnetic variations at base station, in gammas; total magnetic intensity, IGRF removed, plotted at 50 gammas per scale division. Fiducial markers are again plotted every 200 records along the top of the profiles, every 10 records near the bottom.

Histograms

Histograms have been prepared for the six radiometric parameters for each geologic cell unit of the NTMS quadrangle area. The horizontal scale of the plots is constant for each of the parameters. Frequency grouping has generally been done in 100 groups per full scale, although in some cases more groups may have been used for better definition. In all cases the vertical scale was normalized to the number of samples observed in the group with the highest sample frequency.

For each histogram the frequency distribution type (normal or lognormal) is listed, as well as the mean (or mode in case of lognormal distribution) and the signed standard deviations. Note that for both the normal and lognormal distribution curves the standard deviation is given in terms of the parameter value (K, eU, eT, eU/K, eU/eT and eT/K). The actual standard deviation is obtained by subtracting the mean parameter value from the +1 standard deviation figure in case of a normal distribution, by dividing the mode value into the +1 standard deviation figure in case of a lognormal distribution. In case of lognormal distribution curves the standard deviation is thus a multiplication factor.

Each histogram further lists the total number of samples observed in the geologic unit and the number of statistically adequate/marginal data samples in each parameter plot.

Anomaly Maps

The anomaly maps have been prepared at scales of 1:250,000 and 1:500,000 on an automated flatbed plotter. The fiducial numbers along the flight lines match those of the corresponding profiles. Positive signed deviations of the

mean are indicated by a plus sign to the north or west of the flight lines, while negative signed deviations are indicated by a minus, plotted to the south or east of the line. The number of pluses or minuses corresponds with the levels of standard deviation from the mean. To avoid crowding, standard deviation signs are calculated and plotted for every fifth sample only.

Computer Printer Maps

Computer printer plots are produced for the total field and the six radiometric channels. Upper and lower limits were chosen based on the minimum and maximum values of the gridded data. Ten intervals are represented by the contour values 0 to 9. A minus (-) or a plus (+) sign represents those values less than the lower limit or those values higher than the upper limit.

The interval for each integer contour is further divided into two groups. For those values less than .5, the contour is printed; e.g. for values 4.0 to 4.5, the value 4 is printed, while values of 4.6 through 4.9 are left blank.

GEOLOGY

General

The Mitchell quadrangle is located in southeastern South Dakota and includes the area between 43°N and 44°N latitude and between 98°W and 100°W longitude.

The geomorphology of this area is partially a product of glacial erosion and deposition, and erosion of Tertiary and Cretaceous strata. The Missouri River had its course effected by glacial advances, with the river in this quadrangle somewhat paralleling what was the terminus of a lobe of the upper Wisconsin ice sheet. Besides a deposit of lower Wisconsin glacial drift just west of the upper portion of the Missouri River, all of the morainal deposits within this quadrangle are situated east of the Missouri River. The Missouri River has dissected the terrain, cutting down to the oldest Cretaceous formation exposed in the quadrangle. East of the Missouri River, the topography is somewhat irregular, but generally slopes off to the east into the James River Basin. This basin is a broad lowland of gently undulating to relatively flat topography that is usually 200-300 feet lower elevation than the areas to the west.

There are numerous small lakes and ponds in this quadrangle within the morainal areas. Most of these lakes and ponds are seasonal. Intermittent springs and creeks drain this area generally to the east, where these systems eventually meet the James River.

West of the Missouri River the streams appear to display more of a dendritic drainage pattern. The smaller tributaries do show a preferential northwest-southeast orientation, probably following planes of weakness in the Cretaceous Pierre Formation. The White River, a major tributary of the Missouri River that enters from the west, displays entrenched meanders.

Stratigraphy

The geology of the area was compiled in 1980 by AAA Engineering and Drafting, Inc., Salt Lake City, Utah. The compilation was made using pre-existing data published by the South Dakota Geological Survey. This map delineates surface deposits of Quaternary and Tertiary age, along with formations of Upper Cretaceous age.

The surface lithology of the Mitchell quadrangle partially consists of glacial sediments and outcroppings of Upper Cretaceous, Oligocene, Pliocene and early Pleistocene formations. Cretaceous deposits of shale, marl, limestones and sandstones directly underlie the Cretaceous Niobrara Formation. Descriptions of the various geologic units mapped in this quadrangle are given below, beginning with the oldest.

Niobrara Formation (Kn)

This upper Cretaceous unit is found only in small exposures along the Missouri River. It consists of a medium- to dark-gray, calcareous marl with a lower section of gray-chalky, fossiliferous limestone rich in foraminifera.

Pierre Formation (Kp)

The upper Cretaceous Pierre Formation is comprised of blue-gray, calcareous to noncalcareous shale which locally contains marl zones and bentonite beds and frequently contains limestone concretions. Its lower zones are composed of bituminous shale rich in organic material.

Brule Formation (Tb)

The Oligocene Brule Formation contains clay, sandy tuffaceous silt and limestone concretions.

Undivided Bijou, Ash Hollow and Valentine Formations (Tbav)

The undivided unit of Pliocene age consists of arkosic, clayey, and tuffaceous sand and sandstone, opaline and limestone concretions, green clay, ash, and a basal conglomerate.

Herrick Formation (Qh)

This unit contains Pleistocene pre-glacial deposits of coarse arkosic sand. It is mapped predominantly to the south of the Missouri River.

Pleistocene Morainel Deposits (Qlwg, Qlwd, Quwg, Quwe)

These deposits include the lower Wisconsin Ground Moraine (Qlwg) containing till with some stratified drift, the lower Wisconsin Glacial Drift (Qlwd) composed of scattered boulders and minor till, and the upper Wisconsin Ground and End Moraines (Quwg, Quwe), chiefly till with some stratified drift.

The physical characteristics of the Wisconsin Stage tills are very similar to each other and distinguishing one till from another is very

difficult. Lateral changes within a single till are more conspicuous than changes between separate tills. Wisconsin tills possess weak fissility parallel to their surfaces, are less compact, and joints are less abundant or continuous as compared with older pre-Wisconsin till. Also, rock fragments of pebble, cobble and boulder size are more abundant in Wisconsin tills than in pre-Wisconsin tills. Boulders of the Wisconsin tills are described as numerous, large, and easily seen. The average thickness of the drift is 50 to 100 feet, but variations can range from over 300 feet to zero feet.

Unconsolidated Quaternary Deposits

These units include Pleistocene Lake Bed Deposits (Qlb) of silt and sand; gravel, sand and silt as Terrace Gravel (Qt) and sand and silt as Terrace Sand (Qts); undivided Outwash and Alluvium (Qoa) deposits of gravel, sand, silt, and clay; wind-deposited silt in Loess (Ql); and sand and silt in Colluvium (Qc). Also mapped within the quadrangle are Recent Alluvium (Qal) consisting of silt, sand and gravel along with Dune Sand (Qd).

Structure

The Mitchell quadrangle is more than half under glacial deposits and little structural information is revealed. It is known, however, that basement reaches a local structural high in this quadrangle. This high, the Sioux Uplift, located in the eastern half of this quadrangle, is separated from the Black Hills Uplift in western South Dakota by the Williston Basin.

INTERPRETATION

General

The airborne gamma-ray spectrometer survey is conducted in support of the Department of Energy's National Uranium Resource Evaluation (NURE) program. The primary purpose of the survey is regional resource evaluation as opposed to local anomaly identifications. The interpretation of the radiometric data is directed towards determining zones of possible depletion of uranium which may have served as possible uranium sources, outlining areas of regional enrichment in uranium and indicating the geological formations which are most likely to be mineralized within a possible uranium province.

The areas of possible uranium depletion/enrichment are outlined with the aid of anomaly maps, which have been previously described. Enrichment or depletion of uranium on a regional scale is assumed to have taken place if the U/T and U/K ratio values remain higher/lower than at least one standard deviation above/below the mean for a distance of at least a mile, provided the K, U and T count rates are at the same time not less than one standard deviation below the mean. One mile equals approximately 25 samples.

The probability of a geologic formation to be mineralized by a given element may be estimated from the dispersion of the geochemical distribution curve. The smaller the ratio of the standard deviation over the mean, the less the likelihood that an extremely high concentration of that element exists within that formation. Obviously, the opposite holds true as well.

The decision of both the "favorability" of a formation and of the presence of a regional geochemical anomaly is influenced to a large extent by the choice of the geological cell units used in the correlation of the radiometric and geologic data.

The radiometric parameters used in the present report are concentrations in parts per million of equivalent uranium and equivalent thorium and in percent of potassium and their ratios. The radiometric count rates of the Douglas DC-3 borne A.G.R.S. (Airborne Gamma-Ray Spectrometer) system were calibrated at the Lake Mead Dynamic Test Range against sources of known concentrations of potassium, uranium and thorium. The sensitivities of the A.G.R.S. system, normalized to 400 feet terrain clearance at standard temperature and pressure are:

<u>Radioelement</u>	<u>Count Rate</u>	<u>Concentration</u>
Potassium	96.42 cps	1%k
Uranium	12.02 cps	1ppm eU
Thorium	6.31 cps	1ppm eT

Geochemical Analysis

A total of 17 geologic units are recognized in the Mitchell quadrangle. The Niobrara Formation (Kn) crops out in only limited areas along the Missouri River and this unit was not sampled during the survey.

Histograms depicting the equivalent concentration distributions in the potassium, uranium, and thorium parameters, along with their comparative ratios, were prepared for each of the sixteen geologic units sampled plus a unit corresponding to water. A number of these units contain too few samples under their curves to permit reliable analysis. These include the units corresponding to Dune Sand (QD), Colluvium (QC), Terrace Sand (QTS), Lake Beds (QLB), and the Brule Formation (TB). The Pleistocene terrace gravel deposits (QT) occur in a number of areas of very limited extent and slight local inaccuracies in the flight path may have contributed to the irregular appearance of the distribution curves for this unit. The remaining geologic units all exhibit clean to fairly clean normal distribution curves for all six radiometric parameters.

Based on the relatively low ratios of the standard deviations to mean values for all of the geologic units, it is considered unlikely that a high concentration of either the uranium or thorium radioelement would exist within any of the units mapped in the Mitchell quadrangle.

Computer Printer and Anomaly Map Analysis

Computer printer maps of the total magnetic intensity and of the six radiometric parameters were prepared at a scale of 1:500,000 in addition to the radiometric anomaly maps of the area. The grid spacing of the computer printer maps is 2117 by 2170 meters. As a result, only broader features can be seen on these maps and high frequency events are generally not noticeable.

The total magnetic intensity map displays overall higher magnetization and high frequency anomalies in the eastern half of the quadrangle. The magnetics indicate a basement high to the east, with possible deepening to the west. This appears to agree with the known basement structure, the Sioux

TABLE III

LEGEND TO TOTAL FIELD MAP (GAMMAS)

CONTOUR VALUE	LOWER LIMIT	UPPER LIMIT
-		58700.0
0	58700.0	58780.0
1	58780.0	58860.0
2	58860.0	58940.0
3	58940.0	59020.0
4	59020.0	59100.0
5	59100.0	59180.0
6	59180.0	59260.0
7	59260.0	59340.0
8	59340.0	59420.0
9	59420.0	59500.0
+	59500.0	

MITCHELL SOUTH DAKOTA TOTAL FIELD

X4= 417000.0

X3= 579560.0

Y4= 4878669.0

Y3= 4878669.0

.....+
.
.
.
66 44 00 33
6 5 4 4 11100 010 000000 0 111000 11 2344443322211 2 3 3322222 33333332.
.333 4 567654 45876 543333 44 5555554432222 344444 432 33210 1 1 0 0 1 1 1 234 4 3 2 2 33 3 32.
.33 4 56 654 45665 4 4 5 5 43 3 44 32 32 1 1 1 1 1 23 4 4 3 2 2 3 333 .
.23 45 6 54 4 44 333 4 5 555 43 3 3333 3 2 1 1 000 1 2 3 333 2 2 3 3 2 .
.2 3 4 444 3333333 3 3333 4 4 3333 3 3 4443 2 111 0 0 11 000 1 2 2 222 2222 33 2 .
.2 222 222222222222 3 4 44 3 3455543 10 0 1 1 0 0 1 2 2 2 333 2 2 33 2 .
.11 2 2 2 3 3 3456543 22 1 0 0 1 0 0 1 2 22 23 3 2 2 33 2 .
.1 2 2 3 3455542 2 2 1 0 0 0 0 1 22 2 2 22 3333 3 2 .
.1 22222 2 3 3 3 3 3 2 111 2 3322210000 0000 1 1 2 2 2 34444 3 2 .
.222 2 2 3 33 3 3 3 2 1 1 2 3 33321 1 1 1 1 2 2 3 44 4 3 2 .
.222 2 2 2 3 3 3 3 2 1 1 23 4444321 1 1 1 1 1 2 3 444 3 2 .
.2 2 22 3 3333 3 32 1 1 23 4 554321 1 1 1 1 1 2 3333333 2 .
.1 2 22 2 22222 3 3 2 1 2 34 5 54321 11 00 1 111 2 3 .
.1 22 22 3 3 22222 2 3 455 54321 1111 0 0 00 1 2 3 .
.11 2 333 2 2 3 44 33 2 23 4 566 5321 1 2 1 0 0 1 222222 33 .
.11 2 3 3 2 2 3 44 333 22 3 4 566 53211 1 2 1 0 0 1 2 3 3 .
.1 2 33 2 2222 2 3 4 4 33 33 4 55554332 1 1 1 0000000 1 2 3333 3 .
.1 2 222 222 222 2 3 4 444 33 444444 222211 11 111 2 3333333 3333 444444 .
.1 2 2 3 3 22222222 3 4 44444444443 3333 3333322222 11 1 22222 2 3 333 44 555554 .
.1 2 2 3 3 3 4 433 3 4444433 22 11 2333 22 3 444444 4 55 666 55 .
.11 222 222 1 2 2 2 3 4 4 4443 4 5 543 2 2 3333333333 44 5 6 777776 .
.1 22 22 2 1 1 2 33 2 2 3 4 555555544 4444 3 22 22 3 444444 555 6 77 8887 .
.11 2 2 1 1 2 3 3 2 2 3 4 5 6 776 5 4 3 2 22 3 45555555 55 6 77 88 88 .
.11 2 2 1 1 2 3 3 2 2 3 4 5 6 77 65 44 3 2222 345 666 5555 66 7 8 9999999 .
.1 2 3 3332211 2 3 3 2 22 3 4 5 6 77 65 44 33 333333 4566 666 66 7 8 99 + .
.1 2 3 333 332 2 2222 333 3 22 3 4 5 6 666 5 4 333333 444 5 66 66666 77 8 99 + .
.1 2 3444 3 22 3 3 2 2 3 4 44 5 5 44 444444 55 66 7 88 99 + .
.1 2 34 4 3 3 3 3 2 2 3 4 4 4 5 5555 444 5555555 66 77 88 99 + .
.1 2 34 4 3 3332 3 3 2 2 3 4 44 5 555555555 6666666 7777777 88 99 + .
.1 2 3 4 33 3 3 333 2 3 4 55 66666666666 6666 77 88 99 + .
.22222222 33 3 4 5555 66 7 6666666666 7777777 77 88 9 9 + .
.22 22222 3 4 5 6 77 777777777777777 777 8888 9 9 + .
.2 2 2 2 2 3 4 5 6 7 8888888 8888 8 9 9 + .
.11 2 2222 2 3 4 5 6 7 8 99 88 8 8 8 8888 8 9 9 + .
.11 22 3 4 5 6 66 7 89 9 8 8 9 9 + .
.11 2 3 4 5 6 7 8 9 9 8 8 9 9 + .
.11 2 3333333 4 5 6 7 8 9 9 88 8 9 99 + .
.11 2 222 3 4 5 6 7 89 9 8 777777 8 9 99 + .
.11 2 2 2 3 4 55 6 77 8 9 9 8 7 7 77 8 9 999 9 + .
.11 2 2 2 3 4 5 555 6 7 8 888 7 7 8 9 999 9999999 + .
.11 2 2 333 4 4 5 6 7 777777 7 7 8 8 9 999999 + .
.11 2 333 333 4 4 5 6 6666 7 7 6 6 6 6 7 77 8 8888 + .
.11 2 3333 3 3 4 4 5 6 6 6 7 77 6 6 7 8 888888 7 .
.11 2 3 3 3 3 3 4 4 5 5 6 6 6 6 7 77 6 6 7 776 .
.11 2 3 3 3 3 3 4 5 555 6 66666 6 7 7 7777 6 .
.1111 2 3 33 3 3 3 3 3333 4 5 6 666 6 7 7777 666 .
.00 1 2 3 333 2 3 3 4 444 5 5555 6 6 666 66 5 .
.00 1 2 33 2 3 3 3 4 4 4 444 5 66 66 6 6 6666 6 6 5 .
.00 1 11111111 2 222 33 222222 3 3333 222222 3 4 4 33 3 4 4 5 5 6 6 6 6 5 6 6666666666 55 6 6 555555 .
.000000 1 1111111 1 2 2222 222222 3 3 5 5
.....+
X1= 417000.0 X2= 579560.0
Y1= 4758000.0 Y2= 4758000.0

Figure 7

TABLE IV

LEGEND TO POTASSIUM AVERAGE MAP (PERCENT)

<u>CONTOUR VALUE</u>	<u>LOWER LIMIT</u>	<u>UPPER LIMIT</u>
-		0.90
0	0.90	1.00
1	1.00	1.10
2	1.10	1.20
3	1.20	1.30
4	1.30	1.40
5	1.40	1.50
6	1.50	1.60
7	1.60	1.70
8	1.70	1.80
9	1.80	1.90
+	1.90	

X3= 579560.0

Y3= 4878669.0

$$\dots + E$$

X2= 579560.0

Y2= 4758000.0

TABLE V

LEGEND TO URANIUM AVERAGE MAP (PPM)

CONTOUR VALUE	LOWER LIMIT	UPPER LIMIT
-		1.10
0	1.10	1.33
1	1.33	1.56
2	1.56	1.79
3	1.79	2.02
4	2.02	2.25
5	2.25	2.48
6	2.48	2.71
7	2.71	2.94
8	2.94	3.17
9	3.17	3.40
+	3.40	

URANIUM AVERAGE

X3= 579560.0

Y3= 4878669.0

x2= 579560.0

$$Y2 = 4758000.0$$

TABLE VI

LEGEND TO THORIUM AVERAGE MAP (PPM)

CONTOUR VALUE	LOWER LIMIT	UPPER LIMIT
-		3.80
0	3.80	4.30
1	4.30	4.80
2	4.80	5.30
3	5.30	5.80
4	5.80	6.30
5	6.30	6.80
6	6.80	7.30
7	7.30	7.80
8	7.80	8.30
9	8.30	8.80
+	8.80	

MITCHELL SOUTH DAKOTA THORIUM AVERAGE

$$Y_3 = 4878669.0$$
$$Y2 = 4758000.0$$

TABLE VII

LEGEND TO URANIUM/POTASSIUM RATIO MAP

<u>CONTOUR VALUE</u>	<u>LOWER LIMIT</u>	<u>UPPER LIMIT</u>
-		0.80
0	0.80	0.98
1	0.98	1.16
2	1.16	1.34
3	1.34	1.52
4	1.52	1.70
5	1.70	1.88
6	1.88	2.06
7	2.06	2.24
8	2.24	2.42
9	2.42	2.60
+	2.60	

URANIUM/POTASSIUM RATIO

X3= 579560.0

Y3= 4878669.0

```

+ ..... +
X1=  417000.0                                X2=  579560.0
Y1=  4758000.0                                Y2=  4758000.0

```

TABLE VIII

LEGEND TO URANIUM/THORIUM RATIO MAP

<u>CONTOUR VALUE</u>	<u>LOWER LIMIT</u>	<u>UPPER LIMIT</u>
-		0.190
0	0.190	0.225
1	0.225	0.260
2	0.260	0.295
3	0.295	0.330
4	0.330	0.365
5	0.365	0.400
6	0.400	0.435
7	0.435	0.470
8	0.470	0.505
9	0.505	0.540
+	0.540	

URANIUM/THORIUM RATIO

$\cdot x_3 = 579560.7$

$$Y_3 = 4878669.0$$

Figure 12

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X2= 579560.0

$$Y2 = 4758000.0$$

TABLE IX

LEGEND TO THORIUM/POTASSIUM RATIO MAP

CONTOUR VALUE	LOWER LIMIT	UPPER LIMIT
-		3.20
0	3.20	3.50
1	3.50	3.80
2	3.80	4.10
3	4.10	4.40
4	4.40	4.70
5	4.70	5.00
6	5.00	5.30
7	5.30	5.60
8	5.60	5.90
9	5.90	6.20
+	6.20	

```
X3= 579560.0
Y3= 4878669.0
```

Figure 13
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Uplift, located in the eastern half of the sheet. A ridge of anomalously high magnetics extends from just south center of the eastern sheet boundary to the west, southwest. Near the center of the quadrangle it apparently realigns itself to a more north, northeasterly trend and may terminate near the center of the northern sheet boundary. The overall magnetic intensity averages approximately 59,100 gammas.

The radiometric response, as shown on the computer printer maps for uranium, thorium and potassium is relatively low over much of this area, averaging on the order of 2.5 ppm eU, 6.8 ppm eTh and 1.5% K. All three parameters attain relatively higher levels of equivalent concentrations along with relatively fair to good ratio support over a broad zone trending east-west in the southern portion of the sheet, trending more northwesterly to the west, and smaller zones north of the center in the northwestern sector of the quadrangle. Most of the areas of higher concentration in the south central, western and northwestern portions of the quadrangle lie over either the Pierre Formation (Kp) or the undivided Bijou, Ash Hollow, and Valentine Formations (Tbav), giving suggestion to an intermittent zone of uranium enrichment within and/or possibly between these two formations. Within these areas, concentrations can exceed 2.7 ppm eU, 7.3 ppm eTh, and 1.6% K. Other areas of significant concentrations of uranium, thorium and occasionally potassium are associated with upper Wisconsin Ground Moraine (Quwg), upper Wisconsin End Moraine (Quwe), lower Wisconsin Ground Moraine (Qlwg), and Herrick Formation (Qh). There is one area where uranium and thorium concentrations and the U/T ratio are high, on traverse 1630 near fiducial 3300, and an area of high uranium and potassium concentrations and U/K ratio, on traverse 1690 near fiducial 4450. Uranium may have been concentrated in some mapped and unmapped, though suspected, alluvial deposits along drainage channels originating in morainal deposits. Other zones exhibiting anomalous responses in either of the two ratios are the result of low thorium and/or potassium concentrations.

Using the criteria outlined in the general section on interpretation, a total of 9 uranium anomalies have been outlined on the interpretation map. Many of the 9 uranium anomalies consist of anomalous responses of only one of the two uranium/potassium and uranium/thorium ratios, with the other ratio being normal and with only very weak to moderate expression on the uranium

anomaly map. These anomalies include zones 4, 5, 6, 7, 8 and 9. They are considered to have been adequately described in the anomaly listing of Appendix B and are not further discussed in this report.

Anomaly 1 has some support on the profiles and weak to moderate U/K and U, and weak U/Th response. The following two anomalies have noteworthy expression on the profiles. Anomaly 2, on traverse 1620 over alluvium (Qal) has moderate to good U/Th, weak to good U/K, and weak to moderate U response. It is easily visible on the profile. Anomaly 3, on tie line 5030 coinciding with undivided outwash and alluvium (Qoa) and minor amounts of upper Wisconsin end moraine (Quwe), has weak to moderate U, with weak U/K and U/Th responses. The anomaly is very easily seen on the profile, but appears to be narrow in extent.

The most significant anomalies are in zones 2 and 3. These may be indicative of local uranium enrichment, but are felt not to represent promising targets for further investigation.

0 10 20
STATUTE MILES

AERO SERVICE

LEGEND
③ URANIUM ANOMALY NO. 3

INTERPRETATION MAP
MITCHELL QUADRANGLE
U.S. DEPARTMENT OF ENERGY

FIGURE 14
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SELECTED REFERENCES

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A P P E N D I X A

Geologic Legend

GEOLOGIC LEGEND

<u>Aero Symbol</u>	<u>Map Symbol</u>	<u>Description</u>
QD	Qd	Recent dune sand
QAL	Qal	Recent alluvium
QC	Qc	Pleistocene to Recent colluvium
QL	Ql	Pleistocene loess
QOA	Qoa	Undivided Pleistocene outwash and alluvium
QTS	Qts	Pleistocene terrace sand
QT	Qt	Pleistocene terrace gravel
QLB	Qlb	Pleistocene lake beds
QUWG	Quwg	Upper Wisconsin ground moraine
QUWE	Quwe	Upper Wisconsin end moraine
QLWG	Qlwg	Lower Wisconsin ground moraine
QLWD	Qlwd	Lower Wisconsin glacial drift
QH	Qh	Herrick Formation
TBAV	Tbav	Undivided Pliocene Bijou, Ash Hollow, and Valentine formations
TB	Tb	Oligocene Brule Formations
KP	Kp	Upper Cretaceous Pierre Formation
—	Kn	Upper Cretaceous Niobrara Formation
W		Water

A P P E N D I X B

List of Geologic Units by Anomaly

List of Geologic Units by Anomaly

<u>Anomaly</u>	<u>Geologic Unit</u>	<u>t-traverse tl-tie line</u>	<u>Fiducial</u>	<u>Brief Description</u>
1	Kp	t-1610	2380	weak to moderate U/K and weak U/Th response, some evidence on profiles
2	Qal	t-1620	5660	moderate to good U/Th, weak to good U/K, and weak to moderate U response, easily visible on profiles
3	Qoa Quwe	tl-5030	12510	weak to moderate U, with weak U/K and U/Th responses, very easily seen on profile
4	Qoa	t-1640	12765	weak U/Th anomaly, U/Th and U response visible on profile
5	Kp	t-1690	4380	weak U/Th and U response, weakly visible on profile
6	Tbav.	l-1710	12670	weak to moderate U and U/K response, visible on profile
7	Tbav	t-1710	13220	weak to moderate U and U/K response, visible on profile
8	Kp	tl-5020	175	weak to moderate U/K, and weak U response, visible on profile
9	Kp	t-1710	14265	weak U/K and U response, possibly visible on profile

A P P E N D I X C

List of Anomalies by Geologic Unit

List of Anomalies by Geologic Unit

<u>Formation</u>	<u>No. of Samples</u>	<u>No. of U. Anomalies</u>	<u>No. of Th. Anomalies</u>
Qd	25	-	-
Qal	610	1	-
Qc	6	-	-
Ql	332	-	-
Qoa	2027	2	-
Qts	26	-	-
Qt	197	-	-
Qlb	4	-	-
Quwg	7797	-	-
Quwe	8202	1	-
Qlwg	800	-	-
Qlwd	2770	-	-
Qh	667	-	-
Tbav	3203	2	-
Tb	111	-	-
Kp	7735	4	-
Kn	—	-	-

A P P E N D I X D

Mean Radiometric Values by Geologic Unit

MEAN VALUE BY GEOLOGIC MAP UNIT

MITCHELL

QUAD

LINE 1600

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.49	2.25	21.67	0.306	1.602	5.267
QLWD	0.48	1.82	21.78	0.252	1.287	5.122
QT	0.41	2.14	19.75	0.362	1.726	4.819
W	0.24	1.48	11.23	0.535	2.590	5.039
QAL	0.35	2.05	16.52	0.385	1.904	4.949

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QL	0.51	2.48	20.91	0.329	1.816	5.666
QC	0.50	1.91	21.95	0.251	1.333	5.319
QUWG	0.45	2.31	20.99	0.340	1.686	5.027
CCA	0.39	2.22	19.48	0.391	1.773	4.624
QUWE	0.38	2.22	19.71	0.389	1.729	4.502

LINE 1610

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.49	2.75	22.17	0.372	1.905	5.184
W	0.19	1.62	9.69	0.627	3.669	5.787
QLWD	0.49	2.56	22.07	0.349	1.782	5.149
QUWE	0.39	2.77	20.01	0.488	2.135	4.475

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
CLWG	0.48	3.28	20.16	0.448	2.516	5.605
QUWG	0.45	2.59	20.85	0.380	1.907	5.068
CCA	0.40	2.66	19.69	0.452	2.078	4.688

LINE 1620

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.47	2.19	22.28	0.308	1.516	4.952
QLWD	0.49	1.95	21.75	0.262	1.380	5.279
QAL	0.37	3.11	19.02	0.591	2.630	4.620
QT	0.39	2.54	19.88	0.447	1.987	4.567

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
W	0.31	1.79	16.15	0.372	1.826	4.901
QUWG	0.44	2.47	20.64	0.372	1.840	4.995
CCA	0.37	2.33	18.67	0.418	1.927	4.677
QUWE	0.41	2.36	20.13	0.385	1.793	4.707

LINE 1630

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.42	1.62	18.90	0.259	1.333	5.171
QLWD	0.44	2.42	19.48	0.365	1.911	5.286
QAL	0.43	2.10	18.75	0.320	1.713	5.352
W	0.28	2.47	11.88	0.637	3.767	5.884
QQA	0.39	2.26	18.87	0.387	1.822	4.749

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QT	0.45	2.01	18.73	0.293	1.638	5.635
CLB	0.41	2.45	20.99	0.393	1.793	4.582
QUWG	0.49	2.84	21.39	0.382	2.030	5.324
QUWE	0.44	2.50	20.38	0.375	1.891	5.068

MEAN VALUE BY GEOLOGIC MAP UNIT

MITCHELL

QUAD

LINE 1640

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.50	2.13	23.41	0.282	1.404	4.993
QLWC	0.49	2.22	21.45	0.303	1.583	5.313
QAL	0.51	2.07	20.05	0.270	1.623	6.015
W	0.20	1.50	11.55	0.548	3.025	6.023

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QLWG	0.51	3.02	22.24	0.390	2.086	5.377
QOA	0.33	2.37	16.78	0.488	2.207	4.563
CUNG	0.45	2.48	20.37	0.367	1.856	5.111
QUWE	0.40	1.69	18.35	0.278	1.411	5.135

LINE 1650

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.48	2.16	22.42	0.298	1.495	5.038
QLWC	0.48	1.76	20.99	0.248	1.324	5.326
QAL	0.19	1.22	8.91	0.410	2.720	6.516
W	0.25	1.12	16.01	0.357	2.102	6.020

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QLWG	0.51	2.29	22.39	0.298	1.577	5.333
CUNG	0.48	2.63	21.57	0.364	1.881	5.213
QUWE	0.46	2.28	20.77	0.329	1.687	5.138
QOA	0.42	2.31	18.86	0.359	1.878	5.254

LINE 1660

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.46	2.07	22.48	0.298	1.432	4.845
QL	0.45	2.27	21.50	0.336	1.624	4.906
TBAV	0.43	2.61	21.38	0.408	1.879	4.630
QAL	0.43	1.92	17.98	0.319	1.718	5.515
QOA	0.48	1.99	21.08	0.278	1.461	5.274

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
W	0.24	1.00	9.40	0.451	2.484	5.399
QLWG	0.51	2.43	22.18	0.318	1.685	5.365
CUNG	0.47	2.42	20.96	0.344	1.773	5.179
QUWE	0.45	2.12	20.72	0.311	1.573	5.091

LINE 1670

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
KP	0.46	2.12	22.04	0.304	1.488	4.923
QT	0.45	2.75	21.04	0.400	2.001	4.992
QAL	0.39	1.95	21.08	0.332	1.543	4.577
QL	0.51	2.37	23.76	0.308	1.529	5.004
QUWE	0.45	2.38	20.36	0.354	1.800	5.144

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.54	2.18	20.52	0.269	1.631	6.204
W	0.25	1.41	13.09	0.472	2.878	5.384
CUNG	0.49	2.31	21.48	0.315	1.654	5.305
QOA	0.43	2.75	19.75	0.434	2.138	5.019

MEAN VALUE BY GEOLOGIC MAP UNIT

PITCHELL

QUAD

LINE 1680

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.47	1.66	23.48	0.245	1.103	4.705
KP	0.51	2.36	23.95	0.307	1.510	5.323
QT	0.49	2.22	26.32	0.295	1.283	4.344
QL	0.48	1.58	23.85	0.217	1.020	4.708
QDA	0.42	1.82	19.51	0.288	1.426	4.972

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QAL	0.39	0.25	18.08	0.041	0.204	4.992
W	0.19	0.0	6.17	0.0	0.0	7.084
QUWG	0.46	2.11	20.68	0.303	1.577	5.222
QUWE	0.44	1.97	19.85	0.299	1.529	5.161

LINE 1690

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.39	1.86	24.88	0.329	1.143	3.582
KP	0.52	2.85	25.84	0.364	1.702	4.725
QAL	0.49	2.80	24.28	0.383	1.813	4.798
QT	0.61	2.17	27.26	0.233	1.214	5.185
QUWE	0.41	1.61	18.22	0.260	1.367	5.267

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
CH	0.42	2.18	27.99	0.341	1.192	3.491
W	0.28	2.43	13.71	0.717	3.664	4.916
QUWG	0.50	2.77	22.88	0.361	1.845	5.145
COA	0.45	2.39	21.14	0.376	1.770	4.912

LINE 1700

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.42	2.02	24.56	0.330	1.263	3.940
QAL	0.44	2.33	24.47	0.346	1.478	4.210
KP	0.49	2.12	25.79	0.289	1.268	4.422
TB	0.53	2.15	23.64	0.267	1.396	5.271
QH	0.49	2.00	28.28	0.275	1.087	4.001
QUWE	0.49	2.38	22.15	0.330	1.674	5.101

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
CT	0.52	2.27	29.68	0.295	1.164	4.110
W	0.18	1.29	9.44	0.344	1.743	5.070
QUWG	0.52	2.25	24.12	0.291	1.449	5.027
CL	0.58	2.25	25.51	0.257	1.397	5.357
COA	0.47	1.95	20.31	0.271	1.477	5.417

LINE 1710

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.48	2.16	25.87	0.299	1.277	4.328
TB	0.37	1.95	23.08	0.341	1.289	3.725
KP	0.49	2.19	25.16	0.294	1.348	4.590
QAL	0.47	2.46	24.37	0.348	1.558	4.537
QC	0.34	1.96	22.31	0.379	1.325	3.506
QTS	0.34	2.19	23.55	0.424	1.421	3.362

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QT	0.49	1.93	26.81	0.261	1.115	4.270
CH	0.49	2.22	28.49	0.300	1.207	4.049
W	0.20	1.76	7.74	0.485	2.614	4.925
QUWG	0.53	2.35	24.48	0.298	1.482	5.009
QUWE	0.50	2.49	22.82	0.332	1.691	5.152
COA	0.44	2.14	22.30	0.325	1.471	4.602

MEAN VALUE BY GEOLOGIC MAP UNIT

MITCHELL

QUAD

LINE 5000

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QTS	0.39	2.27	24.00	0.385	1.458	3.798
QAL	0.47	2.38	25.65	0.336	1.431	4.312
KP	0.53	2.60	25.74	0.327	1.559	4.832

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.36	2.14	23.78	0.410	1.382	3.481
CLWD	0.54	2.24	25.16	0.276	1.369	4.986
W	0.51	2.61	28.51	0.345	1.409	4.108

LINE 5010

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QH	0.45	2.00	27.50	0.296	1.134	3.846
KP	0.52	2.37	23.85	0.307	1.547	5.126
QT	0.52	2.02	26.60	0.258	1.170	4.591
QAL	0.54	1.78	26.78	0.225	1.026	4.672
TBAV	0.54	2.36	25.31	0.296	1.446	4.939

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
W	0.34	1.54	13.88	0.291	2.009	7.217
CLWG	0.58	2.49	25.08	0.283	1.521	5.418
CUWG	0.56	2.52	24.34	0.298	1.591	5.362
QCA	0.51	2.10	22.31	0.272	1.454	5.359
CLWD	0.56	2.17	24.75	0.260	1.356	5.281

LINE 5020

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
TBAV	0.51	2.61	22.77	0.339	1.765	5.225
KP	0.44	2.60	18.93	0.407	2.208	5.464
W	0.25	1.59	13.94	0.668	3.363	5.256
QCA	0.44	2.86	20.27	0.436	2.162	5.012

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QAL	0.30	2.10	14.76	0.547	2.929	5.391
CUWG	0.48	2.76	20.91	0.383	2.033	5.345
CUWE	0.45	2.53	20.37	0.370	1.910	5.198

LINE 5030

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
QUWG	0.51	2.64	22.49	0.341	1.807	5.332
QCA	0.43	2.49	20.55	0.385	1.867	4.922

UNIT	E THOR	E URN	POT PCT	U/TH	U/K	TH/K
CUWE	0.45	2.43	22.53	0.358	1.651	4.668
W	0.34	1.84	13.01	0.360	2.331	6.509

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A P P E N D I X E

Standard Deviation Table

MITCHELL

QUAD

FORMATION QD

DATA	SAMPLES	MEAN		-3	-2	-1	+1	+2	+3
E THORIUM	25	7.34	NORMAL	6.27	6.63	6.99	7.70	8.06	8.42
E URANIUM	25	1.83	NORMAL	1.39	1.53	1.68	1.97	2.12	2.27
POTASSIUM	25	1.42	NORMAL	1.23	1.29	1.35	1.48	1.54	1.60
EU/K	25	1.21	NORMAL	0.77	0.92	1.06	1.36	1.51	1.66
EU/ETH	25	0.24	NORMAL	0.15	0.18	0.21	0.26	0.29	0.32
ETH/K	25	4.94	NORMAL	3.88	4.23	4.58	5.29	5.64	5.99

FORMATION QAL

DATA	SAMPLES	MEAN		-3	-2	-1	+1	+2	+3
E THORIUM	610	6.65	NORMAL	2.56	3.93	5.29	8.02	9.38	10.75
E URANIUM	601	2.27	NORMAL	0.23	0.91	1.59	2.95	3.63	4.31
POTASSIUM	610	1.41	NORMAL	0.57	0.85	1.13	1.69	1.97	2.25
EU/K	601	1.58	NORMAL	-0.10	0.46	1.02	2.14	2.70	3.25
EU/ETH	601	0.34	NORMAL	0.01	0.12	0.23	0.44	0.55	0.66
ETH/K	601	4.53	NORMAL	1.87	2.76	3.64	5.41	6.30	7.19

FORMATION QC

DATA	SAMPLES	MEAN		-3	-2	-1	+1	+2	+3
E THORIUM	6	4.95	NORMAL	3.96	4.29	4.62	5.28	5.61	5.94
E URANIUM	6	1.87	NORMAL	0.99	1.28	1.58	2.17	2.46	2.76
POTASSIUM	6	1.44	NORMAL	1.32	1.36	1.40	1.47	1.51	1.55
EU/K	6	1.23	NORMAL	0.61	0.82	1.02	1.44	1.64	1.85
EU/ETH	6	0.37	NORMAL	0.18	0.24	0.31	0.43	0.49	0.55
ETH/K	6	3.05	NORMAL	2.43	2.64	2.85	3.26	3.47	3.68

FORMATION QL

DATA	SAMPLES	MEAN		-3	-2	-1	+1	+2	+3
E THORIUM	332	7.22	NORMAL	4.58	5.46	6.34	8.10	8.58	9.86
E URANIUM	332	2.12	NORMAL	0.98	0.76	1.44	2.80	3.48	4.16
POTASSIUM	332	1.48	NORMAL	1.05	1.19	1.34	1.63	1.77	1.92
EU/K	332	1.39	NORMAL	-0.05	0.43	0.91	1.87	2.35	2.83
EU/ETH	332	0.29	NORMAL	0.01	0.10	0.20	0.38	0.48	0.57
ETH/K	332	4.60	NORMAL	2.82	3.42	4.01	5.20	5.79	6.39

MITCHELL

QUAD

DATA	SAMPLES	MEAN		FORMATION		QQA				
				-3	-2	-1	+1	+2	+3	
E THORIUM	2027	5.91	NORMAL	2.34	3.53	4.72	7.10	8.28	9.47	
E URANIUM	2024	2.30	NORMAL	0.35	1.00	1.65	2.95	3.61	4.26	
POTASSIUM	2027	1.24	NORMAL	0.80	0.94	1.09	1.39	1.54	1.69	
EU/K	2024	1.80	NORMAL	0.15	0.70	1.25	2.35	2.90	3.45	
EU/ETH	2024	0.39	NORMAL	0.00	0.13	0.26	0.52	0.64	0.77	
ETH/K	2024	4.48	NORMAL	2.41	3.10	3.79	5.17	5.86	6.55	

DATA	SAMPLES	MEAN		FORMATION		QTS				
				-3	-2	-1	+1	+2	+3	
E THORIUM	25	5.36	NORMAL	3.31	3.99	4.68	6.04	6.73	7.41	
E URANIUM	25	2.15	NORMAL	1.09	1.44	1.80	2.50	2.86	3.21	
POTASSIUM	25	1.54	NORMAL	1.35	1.41	1.47	1.60	1.66	1.73	
EU/K	25	1.33	NORMAL	0.65	0.88	1.11	1.56	1.79	2.02	
EU/ETH	25	0.39	NORMAL	0.16	0.24	0.31	0.46	0.54	0.61	
ETH/K	25	3.27	NORMAL	1.92	2.37	2.82	3.72	4.18	4.63	

DATA	SAMPLES	MEAN		FORMATION		QT				
				-3	-2	-1	+1	+2	+3	
E THORIUM	197	6.91	NORMAL	3.76	4.81	5.86	7.96	9.02	10.07	
E URANIUM	197	2.04	NORMAL	0.60	1.08	1.56	2.52	3.00	3.48	
POTASSIUM	197	1.55	NORMAL	0.65	0.95	1.25	1.85	2.16	2.46	
EU/K	197	1.29	NORMAL	-0.11	0.36	0.83	1.76	2.23	2.70	
EU/ETH	197	0.29	NORMAL	0.03	0.12	0.20	0.38	0.47	0.56	
ETH/K	197	4.23	NORMAL	2.02	2.75	3.49	4.96	5.70	6.43	

DATA	SAMPLES	MEAN		FORMATION		QLB				
				-3	-2	-1	+1	+2	+3	
E THORIUM	4	6.00	NORMAL	4.24	4.83	5.41	6.59	7.18	7.77	
E URANIUM	4	2.37	NORMAL	2.03	2.14	2.26	2.48	2.60	2.71	
POTASSIUM	4	1.35	NORMAL	1.10	1.18	1.27	1.44	1.52	1.60	
EU/K	4	1.64	NORMAL	1.15	1.32	1.48	1.81	1.97	2.14	
EU/ETH	4	0.37	NORMAL	0.21	0.27	0.32	0.43	0.48	0.53	
ETH/K	4	4.28	NORMAL	3.65	3.86	4.07	4.48	4.69	4.90	

MITCHELL

QUAD

DATA	SAMPLES	MEAN		FORMATION		QUWG			
				-3	-2	-1	+1	+2	+3
E THORIUM	7796	7.06	NORMAL	4.37	5.27	6.17	7.96	8.86	9.75
E URANIUM	7787	2.42	NORMAL	0.58	1.19	1.81	3.04	3.65	4.27
POTASSIUM	7796	1.40	NORMAL	0.98	1.12	1.26	1.54	1.68	1.82
EU/K	7787	1.66	NORMAL	0.24	0.72	1.19	2.13	2.60	3.08
EU/ETH	7787	0.33	NORMAL	0.05	0.14	0.24	0.43	0.52	0.62
ETH/K	7787	4.78	NORMAL	2.88	3.51	4.15	5.41	6.04	6.68

DATA	SAMPLES	MEAN		FORMATION		QUWE			
				-3	-2	-1	+1	+2	+3
E THORIUM	8202	6.35	NORMAL	3.51	4.45	5.40	7.29	8.24	9.18
E URANIUM	8183	2.18	NORMAL	0.26	0.90	1.54	2.82	3.46	4.10
POTASSIUM	8202	1.31	NORMAL	0.91	1.05	1.18	1.44	1.58	1.71
EU/K	8183	1.59	NORMAL	0.09	0.59	1.09	2.09	2.59	3.09
EU/ETH	8183	0.33	NORMAL	0.02	0.12	0.23	0.44	0.55	0.65
ETH/K	8183	4.58	NORMAL	2.68	3.31	3.94	5.21	5.84	6.47

DATA	SAMPLES	MEAN		FORMATION		QLWG			
				-3	-2	-1	+1	+2	+3
E THORIUM	800	7.99	NORMAL	5.23	6.15	7.07	8.91	9.83	10.75
E URANIUM	800	2.54	NORMAL	0.68	1.30	1.92	3.16	3.79	4.41
POTASSIUM	800	1.51	NORMAL	1.06	1.21	1.36	1.66	1.81	1.96
EU/K	800	1.62	NORMAL	0.14	0.64	1.13	2.11	2.60	3.09
EU/ETH	800	0.31	NORMAL	0.03	0.12	0.22	0.40	0.49	0.59
ETH/K	800	5.02	NORMAL	3.26	3.84	4.43	5.61	6.19	6.78

DATA	SAMPLES	MEAN		FORMATION		QLWD			
				-3	-2	-1	+1	+2	+3
E THORIUM	2770	7.18	NORMAL	4.68	5.51	6.34	8.01	8.84	9.67
E URANIUM	2766	2.13	NORMAL	0.33	0.93	1.53	2.73	3.33	3.92
POTASSIUM	2770	1.41	NORMAL	0.91	1.08	1.25	1.58	1.75	1.92
EU/K	2765	1.44	NORMAL	0.05	0.51	0.98	1.91	2.38	2.84
EU/ETH	2765	0.25	NORMAL	0.02	0.11	0.20	0.38	0.46	0.55
ETH/K	2765	4.82	NORMAL	2.87	3.52	4.17	5.47	6.12	6.77

MITCHELL

QUAD

DATA	SAMPLES	MEAN		FORMATION		QH				
				-3	-2	-1	+1	+2	+3	
E THORIUM	666	7.05	NORMAL	3.85	4.92	5.58	8.11	9.18	10.25	
E URANIUM	666	2.01	NORMAL	0.31	0.88	1.44	2.57	3.13	3.70	
POTASSIUM	666	1.83	NORMAL	1.39	1.54	1.68	1.97	2.11	2.26	
EU/K	666	1.02	NORMAL	-0.07	0.30	0.66	1.39	1.75	2.11	
EU/ETH	666	0.27	NORMAL	0.02	0.10	0.19	0.36	0.44	0.53	
ETH/K	666	3.55	NORMAL	1.38	2.12	2.86	4.33	5.07	5.81	

DATA	SAMPLES	MEAN		FORMATION		TRAV				
				-3	-2	-1	+1	+2	+3	
E THORIUM	3158	6.46	NORMAL	0.71	2.63	4.54	8.37	10.29	12.21	
E URANIUM	3177	1.95	NORMAL	-0.08	0.60	1.27	2.63	3.31	3.99	
POTASSIUM	3158	1.59	NORMAL	1.14	1.29	1.44	1.75	1.90	2.05	
EU/K	3177	1.15	NORMAL	-0.13	0.29	0.72	1.57	2.00	2.42	
EU/ETH	3177	0.30	NORMAL	-0.03	0.08	0.15	0.41	0.52	0.63	
ETH/K	3177	3.77	NORMAL	0.37	1.50	2.64	4.91	6.04	7.18	

DATA	SAMPLES	MEAN		FORMATION		TB				
				-3	-2	-1	+1	+2	+3	
E THORIUM	111	6.50	NORMAL	0.30	2.37	4.44	8.57	10.64	12.70	
E URANIUM	109	1.96	NORMAL	0.30	0.86	1.41	2.51	3.06	3.61	
POTASSIUM	111	1.50	NORMAL	1.11	1.24	1.37	1.63	1.76	1.89	
EU/K	109	1.22	NORMAL	0.21	0.55	0.88	1.56	1.89	2.23	
EU/ETH	109	0.25	NORMAL	0.05	0.13	0.21	0.37	0.45	0.53	
ETH/K	109	4.05	NORMAL	0.51	1.69	2.87	5.23	6.41	7.60	

DATA	SAMPLES	MEAN		FORMATION		KP				
				-3	-2	-1	+1	+2	+3	
E THORIUM	7727	7.22	NORMAL	4.36	5.31	6.26	8.17	9.13	10.08	
E URANIUM	7695	2.21	NORMAL	0.26	0.91	1.56	2.86	3.51	4.16	
POTASSIUM	7727	1.52	NORMAL	0.95	1.14	1.33	1.71	1.89	2.08	
EU/K	7694	1.39	NORMAL	0.01	0.47	0.93	1.85	2.31	2.77	
EU/ETH	7694	0.30	NORMAL	0.02	0.11	0.20	0.39	0.48	0.58	
ETH/K	7694	4.52	NORMAL	2.51	3.18	3.85	5.18	5.85	6.52	

MITCHELL

QUAD

DATA	SAMPLES	MEAN		FORMATION		W				
				-3	-2	-1	+1	+2	+3	
E THORIUM	243	0.83	LOGNORMAL	0.08	0.17	0.38	1.82	3.98	8.74	
E URANIUM	379	0.82	LOGNORMAL	0.17	0.28	0.48	1.40	2.38	4.06	
POTASSIUM	214	0.11	LOGNORMAL	0.01	0.02	0.04	0.26	0.63	1.53	
EU/K	157	1.70	LOGNORMAL	0.29	0.52	0.94	3.07	5.57	10.08	
EU/ETH	164	0.36	LOGNORMAL	0.10	0.15	0.23	0.55	0.85	1.31	
ETH/K	157	5.08	LOGNORMAL	1.70	2.45	3.53	7.32	10.55	15.21	

A P P E N D I X F

Format, Single Record Data Listing

REC NO.	LAT	LONG	RESID HAG GAMMA	TERR CL FEET	FLG	GEOL UNIT	CUSH CPS	II CPS	AIM TOTAL COUNT CPS	FLG	ETH PPM	FLG	EU PPM	FLG	K PCT	FLG	LU/ETH	EU/K	ETH/K	TEMP CELCIUS	BAKU PRES MMHG
5079	64.0086	-160.9193	55305	763	MAR	W	31	1	-12	NAU	-1.1	NAU	-0.5	NAU	0.0	NAU	0.0	0.0	0.0	12.7	746.8
5080	64.0087	-160.9189	55305	751	MAR	W	20	1	36	MAR	0.0	NAU	0.1	NAU	0.1	NAU	0.0	0.0	0.0	12.7	747.1
5081	64.0087	-160.9176	55305	741	MAR	W	26	1	4	NAU	0.2	NAU	0.1	NAU	-0.1	NAU	0.0	0.0	0.0	12.7	747.4
5082	64.0088	-160.9160	55305	730	MAR	W	35	1	-60	NAU	0.0	NAU	0.3	NAU	-0.1	NAU	0.0	0.0	0.0	12.7	747.7
5083	64.0088	-160.9154	55305	722	MAR	W	26	1	-4	NAU	-2.7	NAU	2.3		-0.4	NAU	0.0	0.0	0.0	12.7	748.0
5084	64.0089	-160.9144	55305	712	MAR	W	20	1	-12	NAU	0.5	NAU	-1.7	NAU	0.0	NAU	0.0	0.0	0.0	12.7	748.1
5085	64.0099	-160.9131	55305	702	MAR	W	23	1	37	MAR	0.0	NAU	0.4	NAU	-0.3	NAU	0.0	0.0	0.0	12.7	748.5
5086	64.0090	-160.9121	55305	691		W	22	1	50		0.3	NAU	-0.1	NAU	0.0	NAU	0.0	0.0	0.0	12.7	748.8
5087	64.0091	-160.9109	55305	680		W	23	1	46		0.3	NAU	0.0	NAU	-0.0	NAU	0.0	0.0	0.0	12.7	749.1
5088	64.0092	-160.9099	55305	673		W	17	1	72		0.6	MAR	0.3	NAU	-0.3	NAU	0.0	0.0	0.0	12.8	749.3
5089	64.0092	-160.9087	55305	668		W	20	1	156		-1.6	NAU	0.7	MAR	-0.0	NAU	0.0	0.0	0.0	12.8	749.4
5090	64.0093	-160.9075	55304	666		W	32	1	113		0.0	NAU	0.6	MAR	0.0	NAU	0.0	0.0	0.0	12.8	749.4
5091	64.0093	-160.9064	55304	667		W	30	1	247		-0.2	NAU	0.6	MAR	0.1	NAU	0.0	0.0	0.0	12.8	749.3
5092	64.0094	-160.9052	55304	671		W	29	1	343		0.2	NAU	1.1		0.3		0.0	4.0	0.0	12.8	749.2
5093	64.0094	-160.9042	55304	679		W	23	1	659		2.9		-0.8	NAU	0.8		0.0	0.0	3.5	12.8	748.9
5094	64.0095	-160.9030	55304	683		W	34	0	965		3.2		1.4		0.8		0.5	1.9	4.1	12.9	748.5
5095	64.0096	-160.9017	55305	647		KS	24	0	1208		8.6		0.0	NAU	0.5		0.0	0.0	18.3	12.9	748.1
5096	64.0096	-160.9007	55305	663		KS	12	0	945		2.5		1.7		0.5		0.7	3.5	5.2	12.9	747.8
5097	64.0098	-160.8995	55305	655		KS	20	0	831		3.0		1.5		0.6		0.5	2.8	5.5	12.9	747.6
5098	64.0098	-160.8985	55305	657		KS	22	0	759		2.2		1.4		0.3		0.8	5.1	8.1	12.9	747.1
5099	64.0099	-160.8973	55305	665		KS	29	0	699		1.7		2.0		0.5		1.1	4.4	4.1	12.9	746.5
5100	64.0100	-160.8962	55305	679		KS	28	0	610		0.5	NAU	1.3		0.4		0.0	3.7	0.0	12.9	746.1
5101	64.0100	-160.8950	55305	697		KS	26	0	581		2.2		0.5	MAR	0.3		0.2	1.6	7.0	12.9	746.0
5102	64.0101	-160.8940	55304	518		KS	35	0	512		1.3		-0.2	NAU	0.3		0.0	0.0	4.2	12.9	745.7
5103	64.0101	-160.8928	55304	540		KS	20	0	677		2.1		1.0		0.2		0.5	5.6	11.2	12.8	745.5
5104	64.0102	-160.8918	55305	569		KS	26	0	579		1.7		1.2		0.1	MAR	0.7	12.6	17.6	12.8	745.9
5105	64.0103	-160.8905	55304	608		KS	21	-1	611		3.2		3.1		0.0	NAU	1.0	0.0	0.0	12.8	745.6
5106	64.0103	-160.8895	55303	614		KS	16	-1	551		3.7		0.2	NAU	0.3		0.0	0.0	11.1	12.8	745.5
5107	64.0104	-160.8883	55304	595		KS	37	-1	488		1.6		2.4		0.7	MAR	1.5	18.6	12.5	12.8	745.4
5108	64.0105	-160.8873	55302	575		KS	22	-1	510		0.2	NAU	1.3		0.3		0.0	5.1	0.0	12.8	745.3
5109	64.0106	-160.8860	55304	552		KS	28	-1	437		0.0	NAU	1.0		0.1	MAR	0.0	9.0	0.0	12.8	745.2
5110	64.0107	-160.8848	55305	332		KS	25	-1	405		0.5	NAU	1.1		0.3		0.0	4.0	0.0	12.8	745.1
5111	64.0107	-160.8838	55305	514		KS	25	-1	379		1.0	MAR	-0.1	NAU	0.3		0.0	0.0	3.0	12.8	744.7
5112	64.0108	-160.8826	55305	501		KS	35	-1	325		0.5	MAR	1.4		0.1	MAR	2.5	13.6	5.5	12.8	744.5
5113	64.0108	-160.8816	55305	490		KS	20	-1	411		0.0	NAU	1.1		0.0	NAU	0.0	0.0	0.0	12.8	744.3
5114	64.0109	-160.8803	55305	481		KS	22	-1	417		1.0		1.0		0.1	MAR	1.0	12.7	12.9	12.8	744.3
5115	64.0110	-160.8791	55305	477		KS	28	-1	517		0.8	MAR	1.1		0.3		1.3	4.0	3.1	12.8	744.1
5116	64.0110	-160.8781	55304	479		KS	17	0	616		1.4		0.7		0.5		0.5	1.4	2.8	12.8	744.0
5117	64.0111	-160.8769	55304	486		KS	23	0	623		4.3		0.8		0.6		0.2	1.4	7.0	12.8	743.9
5118	64.0111	-160.8759	55303	493		KS	22	0	607		2.5		1.5		0.1		0.6	10.2	17.5	12.8	744.0
5119	64.0112	-160.8746	55303	500		KS	21	0	693		3.5		0.5	MAR	0.5		0.2	1.1	7.4	12.8	744.2
5120	64.0113	-160.8734	55303	509		KS	22	-1	633		2.2		2.6		0.3		1.2	8.6	7.2	12.8	744.2
5121	64.0113	-160.8724	55302	516		KS	30	-1	636		3.7		0.2	NAU	0.3		0.0	0.0	10.9	12.8	744.5
5122	64.0113	-160.8712	55302	519		KS	25	-2	777		5.1		1.5		0.3		0.3	9.9	20.2	12.8	744.9
5123	64.0113	-160.8701	55302	518		KS	26	-2	658		3.8		0.9		0.4		0.2	2.2	9.0	12.8	745.1
5124	64.0113	-160.8689	55302	517		KS	32	-2	718		0.8	MAR	1.9		0.7		2.1	2.8	1.3	12.8	745.6
5125	64.0113	-160.8677	55302	523		KS	32	-2	763		2.7		2.2		0.2		0.8	13.0	16.0	12.8	746.1
5126	64.0114	-160.8667	55302	541		KS	25	-1	781		3.2		1.3		0.6		0.4	2.4	5.9	12.8	746.4
5127	64.0114	-160.8654	55301	554		KS	26	-1	736		1.1	MAR	2.6		0.3		2.2	8.2	3.8	12.9	746.8
5128	64.0114	-160.8644	55300	574		KS	23	-1	668		3.2		0.2	NAU	0.4		0.0	0.0	7.4	12.9	747.1
5129	64.0114	-160.8632	55300	592		KS	21	0	640		2.4		3.5		-0.0	NAU	1.4	0.0	0.0	12.9	747.3
5130	64.0113	-160.8620	55300	606		KS	14	0	696		1.9		1.9		0.3		1.0	7.1	6.9	12.9	747.3
5131	64.0113	-160.8609	55302	617		KS	27	0	595		1.4		0.7	MAR	0.3		0.5	2.4	4.4	13.0	747.7

SINGLE RECORD DATA LINE 240 PAGE 1

FINISHED OUTPUTTING LINE 240

LINE 220 FIDS 2935 TJ 4865 OUTPUT TO SRRD TAPE

A P P E N D I X G

Format, Average Record Data Listing

A P P E N D I X H

Format, DOE SINGLE RECORD REDUCED DATA TAPE

DOE SINGLE RECORD REDUCED DATA TAPE

Line	Character Number			
Number	12345678901234567890123456789012345678901234567890123456789012			
1	02 0978	(DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)		
2				
3	SINGLE RECORD REDUCED DATA TAPE			
4				
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)			
6				
7	ITEM	FORMAT	DESCRIPTION	
8	1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION	
9	2	A20	NAME OF SUBCONTRACTOR	
10	3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)	
11	4	I1	NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR THIS QUADRANGLE	
12				
13	5	I1	AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM	
14	6	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR FIRST SYSTEM	
15				
16	7	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN CPS PER PERCENT K FOR FIRST SYSTEM	
17				
18	8	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT U	
19				
20	9	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT TH	
21				
22	10	I6	BLANK FIELD (999999)	
23	11	F6.3	4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM	
24	12	F6.3	2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM	
25	13	I3	NUMBER OF CHANNELS (0-3 MEV) IN 4 PI SYSTEM FOR FIRST AERIAL SYSTEM	
26	14	I3	NUMBER OF CHANNELS (0-3 MEV) IN 2 PI SYSTEM FOR FIRST AERIAL SYSTEM	
27				
28	15-24	(SAME)	REPEAT OF ITEMS 5-14 FOR SECOND AERIAL SYSTEM	
29	*	*	*	
30	*	*	*	
31	*	*	*	
32	85-94	(SAME)	REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM	
33	95	I3	NUMBER OF FLIGHT LINES ON THIS TAPE	
34	96	I4	FIRST FLIGHT LINE NUMBER ON THIS TAPE	
35	97	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE	
36	98	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT-LINE DATA WAS COLLECTED	
37				
38	99-101	I4,6, &3	REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ON THIS TAPE	
39	*	*	*	
40	*	*	*	
41	390-392	I4,6, &3	REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS TAPE	
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				

Line	Character Number
Number	12345678901234567890123456789012345678901234567890123456789012

52	FORMAT FOR SINGLE RECORD REDUCED DATA RECORD (THIRD THRU LAST BLOCK)		
53			
54	ITEM	FORMAT	DESCRIPTION
55	1	I1	AERIAL SYSTEM IDENTIFICATION CODE
56	2	I4	FLIGHT LINE NUMBER
57	3	I6	RECORD IDENTIFICATION NUMBER
58	4	I6	GMT TIME OF DAY (HHMMSS)
59	5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
60	6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
61	7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
62	8	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY
63			TO ONE DECIMAL PLACE IN GAMMAS
64	9	A8	SURFACE GEOLOGIC MAP UNIT CODE
65	10	I4	QUALITY FLAG CODES
66	11	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL POTASSIUM
67			(K-40) TO ONE DECIMAL PLACE IN PERCENT K
68	12	F4.1	UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL
69			PLACE IN PERCENT K
70	13	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL URANIUM
71			(BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
72	14	F4.1	UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL
73			PLACE IN PPM EQUIVALENT U
74	15	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL THORIUM
75			(TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
76	16	F4.1	UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL
77			PLACE IN PPM EQUIVALENT TH
78	17	F6.1	URANIUM-TO-THORIUM RATIO TO ONE DECIMAL PLACE IN
79			PPM EQUIVALENT U PER PPM EQUIVALENT TH
80	18	F6.1	URANIUM-TO-POSTASSIUM RATIO TO ONE DECIMAL PLACE IN
81			PPM EQUIVALENT U PER PERCENT K
82	19	F6.1	THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN
83			PPM EQUIVALENT TH PER PERCENT K
84	20	F8.1	GROSS GAMMA (0.4-3.0 MEV) COUNT RATE TO ONE DECIMAL
85			PLACE IN COUNTS PER SECOND
86	21	F6.1	UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL
87			PLACE IN COUNTS PER SECOND
88	22	F5.1	ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL
89			PLACE IN PPM EQUIVALENT U
90	23	F4.1	UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION
91			TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
92	24	F4.1	OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN
93			DEGREES CELSIUS
94	25	F5.1	OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG

A P P E N D I X I

Format, DOE RAW SPECTRAL DATA TAPE

DOE RAW SPECTRAL DATA TAPE

Line Character number
Number 12345678901234567890123456789012345678901234567890123456789012

```

1  01 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2
3  RAW SPECTRAL DATA TAPE
4
5  FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK ON TAPE)
6
7  ITEM      FORMAT  DESCRIPTION
8  1         A40     QUADRANGLE NAME AS PROJECT IDENTIFICATION
9  2         A20     NAME OF SUBCONTRACTOR
10 3         I4      APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11 4         I1      AERIAL SYSTEM IDENTIFICATION CODE
12 5         A20     AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER
13 6         I3      BFEC CALIBRATION REPORT NUMBER
14 7         F6.3    4PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
15                PLACES IN SECONDS
16 8         F6.3    2PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL
17                PLACES IN SECONDS
18 9         I3      NUMBER OF CHANNELS (0-3 MEV) FOR 4PI SYSTEM
19 10        I3      NUMBER OF CHANNELS (0-3 MEV) FOR 2PI SYSTEM
20 11        I3      NUMBER OF FLIGHT LINES ON THIS TAPE
21 12        I4      FIRST FLIGHT LINE NUMBER ON THIS TAPE
22 13        I6      FIRST RECORD NUMBER OF FIRST FLIGHT LINE
23 14        I3      JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE WAS
24                COLLECTED
25 15-17     I4,6 &3 REPEAT OF ITEMS 12-14 FOR SECOND FLIGHT LINE ON THIS
26                TAPE
27 *         *             *
28 *         *             *
29 *         *             *
30 306-308   I4,6 &3 REPEAT OF ITEMS 12-14 FOR 99TH FLIGHT LINE ON THIS
31                TAPE
32
33  FORMAT FOR RAW SPECTRAL DATA RECORD (THIRD THRU LAST BLOCK ON TAPE)
34
35  ITEM      FORMAT  DESCRIPTION
36  1         I1      AERIAL SYSTEM IDENTIFICATION CODE
37  2         I4      FLIGHT LINE NUMBER
38  3         I6      RECORD IDENTIFICATION NUMBER
39  4         I6      GMT TIME OF DAY (HHMMSS)
40  5         F8.4    LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
41  6         F8.4    LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
42  7         F6.2    TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
43  8         F7.1    TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE
44                IN GAMMAS
45  9         A8      SURFACE GEOLOGIC MAP UNIT CODE
46  10        I4      QUALITY FLAG CODES
47  11        F4.1    OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN
48                DEGREES CELSIUS
49  12        F5.1    OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
50  13        F5.3    LIVE TIME COUNTING PERIOD TO THREE DECIMAL PLACES IN
51                SECONDS

```

Line	Character Number																					
Number	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2
52	14																					
53																						
54	15																					
55	16																					
56	*																					
57	*																					
58	*																					
59	270																					

A P P E N D I X J

Format, DOE STATISTICAL ANALYSIS DATA TAPE

DOE STATISTICAL ANALYSIS DATA TAPE

Line	Character Number											
Number	1	2	3	4	5	6	7	8	9	0	1	2
1	03 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)											
2												
3	STATISTICAL ANALYSIS DATA TAPE											
4												
5	FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)											
6												
7	ITEM	FORMAT		DESCRIPTION								
8	1	A40		QUADRANGLE NAME AS PROJECT IDENTIFICATION								
9	2	A20		NAME OF SUBCONTRACTOR								
10	3	I4		APPROXIMATE DATE OF SURVEY (MONTH, YEAR)								
11	4	I1		NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR THIS QUADRANGLE								
12												
13	5	I1		AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM								
14	6	A20		AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR FIRST SYSTEM								
15												
16	7	F6.1		NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN CPS PER PERCENT K								
17												
18	8	F6.1		NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL URANIUM (B1-214) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT U								
19												
20	9	F6.1		NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT TH								
21												
22	10	I6		BLANK FIELD (999999)								
23	11	F6.3		4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM								
24												
25	12	F6.3		2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM								
26												
27	13	I3		NUMBER OF CHANNELS (0-3 MEV) IN 4 PI SYSTEM FOR FIRST AERIAL SYSTEM								
28												
29	14	I3		NUMBER OF CHANNELS (0-30 MEV) IN 2 PI SYSTEM FOR FIRST AERIAL SYSTEM								
30												
31	15-24	(SAME)		REPEAT OF ITEMS 5-14 FOR AERIAL SYSTEM								
32	*	*		*								
33	*	*		*								
34	*	*		*								
35												
36	85-94	(SAME)		REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM								
37	95	I3		NUMBER OF FLIGHT LINES ON THIS TAPE								
38	96	I4		FIRST FLIGHT LINE NUMBER ON THIS TAPE								
39	97	I6		FIRST RECORD NUMBER OF FIRST FLIGHT LINE								
40	98	I3		JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS COLLECTED								
41												
42	99-101	I4,6 &3		REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ONE THIS TAPE								
43												
44	*	*		*								
45	*	*		*								
46	*	*		*								
47												
48	390-392	I4,6 &3		REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS TAPE								
49												
50												
51												

Line Character Number
 Number 12345678901234567890123456789012345678901234567890123456789012

52 FORMAT FOR STATISTICAL ANALYSIS DATA RECORD (THIRD THRU LAST BLOCK)

53	ITEM	FORMAT	DESCRIPTION
54	1	I1	AERIAL SYSTEM IDENTIFICATION CODE
55	2	I4	FLIGHT LINE NUMBER
56	3	I6	RECORD IDENTIFICATION NUMBER
57	4	I6	GMT TIME OF DAY (HHMMSS)
58	5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
59	6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
60	7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
61	8	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY
62			TO ONE DECIMAL PLACE IN GAMMAS
63	9	A8	SURFACE GEOLOGIC MAP UNIT CODE
64	10	I5	QUALITY FLAG CODES
65	11	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL POTASSIUM
66			(K-40) TO ONE DECIMAL PLACE IN PERCENT K
67	12	F4.1	UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL
68			PLACE IN PERCENT K
69	13	F5.1	POTASSIUM STANDARD DEVIATION FROM THE MEAN TO ONE
70			DECIMAL PLACE AND ALGEBRAICALLY SIGNED
71	14	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL URANIUM
72			(BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
73	15	F4.1	UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL
74			PLACE IN PPM EQUIVALENT U
75	16	F5.1	URANIUM STANDARD DEVIATION FROM THE MEAN TO ONE
76			DECIMAL PLACE AND ALGEBRAICALLY SIGNED
77	17	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL THORIUM
78			(TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
79	18	F4.1	UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL
80			PLACE IN PPM EQUIVALENT TH
81	19	F5.1	THORIUM STANDARD DEVIATION FROM THE MEAN TO ONE
82			DECIMAL PLACE AND ALGEBRAICALLY SIGNED
83	20	F8.1	GROSS GAMMA (0.4-3.0 MEV) COUNT RATE TO ONE DECIMAL
84			PLACE IN COUNTS PER SECOND
85	21	F6.1	UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL
86			PLACE IN COUNTS PER SECOND
87	22	F5.1	ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL
88			PLACE IN PPM EQUIVALENT U
89	23	F4.1	UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION
90			TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
91	24	F6.1	AVERAGED URANIUM-TO-THORIUM RATIO TO ONE DECIMAL
92			PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
93	25	F5.1	URANIUM-TO-THORIUM RATIO STANDARD DEVIATION FROM THE
94			MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
95	26	F6.1	AVERAGED URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL
96			PLACE IN PPM EQUIVALENT U PER PERCENT K
97	27	F5.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM
98			THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY
99			SIGNED
100	28	F6.1	AVERAGE THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL
101			PLACE IN PPM EQUIVALENT TH PER PERCENT K
102	29	F5.1	THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM
103			THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY
104			SIGNED
105			

A P P E N D I X K

Format, DOE STATISTICAL ANALYSIS SUMMARY DATA TAPE

DOE STATISTICAL ANALYSIS SUMMARY DATA TAPE

Line	Character Number
Number	1234567890123456789012345678901234567890123456789012

1 05 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODE)

2
3 STATISTICAL ANALYSIS SUMMARY TAPE (OR FILE)

4
5 FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)

6			
7	ITEM	FORMAT	DESCRIPTION
8	1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
9	2	A20	NAME OF SUBCONTRACTOR
10	3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11	4	I6	NUMBER OF GEOLOGIC MAP UNITS USED FOR THIS
12			QUADRANGLE

13
14 FORMAT FOR STATISTICAL ANALYSIS SUMMARY DATA RECORD (THIRD THRU LAST
15 BLOCK)

16			
17	ITEM	FORMAT	DESCRIPTION
18	1	A8	SURFACE GEOLOGIC MAP UNIT IDENTIFYING CODE
19	2	I6	TOTAL RECORDS FOR GEOLOGIC MAP UNIT
20	3	I6	NUMBER OF POTASSIUM RECORDS COMPUTED FOR GEOLOGIC
21			UNITS
22	4	F6.1	POTASSIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE
23			IN PERCENT K
24	5	F6.1	POTASSIUM CONCENTRATION STANDARD DEVIATION TO ONE
25			DECIMAL PLACE IN PERCENT K
26	6	A3	POTASSIUM CONCENTRATION DISTRIBUTION CODE
27	7	I6	NUMBER OF URANIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
28	8	F6.1	URANIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE
29			IN PPM EQUIVALENT U
30	9	F6.1	URANIUM CONCENTRATION STANDARD DEVIATION TO ONE
31			DECIMAL PLACE IN PPM EQUIVALENT U
32	10	A3	URANIUM CONCENTRATION DISTRIBUTION CODE
33	11	I6	NUMBER OF THORIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
34	12	F6.1	THORIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN
35			PPM EQUIVALENT TH
36	13	F6.1	THORIUM CONCENTRATION STANDARD DEVIATION TO ONE
37			DECIMAL PLACE IN PPM EQUIVALENT TH
38	14	A3	THORIUM CONCENTRATION DISTRIBUTION CODE
39	15	I6	NUMBER OF URANIUM-TO-THORIUM RATIO RECORDS COMPUTED
40			FOR GEOLOGIC UNIT
41	16	F6.1	URANIUM-TO-THORIUM RATIO MEAN TO ONE DECIMAL PLACE
42			IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
43	17	F6.1	URANIUM-TO-THORIUM RATIO STANDARD DEVIATION TO ONE
44			DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT
45			TH
46	18	A3	URANIUM-TO-THORIUM RATIO DISTRIBUTION CODE
47	19	I6	NUMBER OF URANIUM-TO-POTASSIUM RATIO RECORDS
48			COMPUTED FOR GEOLOGIC UNIT
49	20	F6.1	URANIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE
50			IN PPM EQUIVALENT U PER PERCENT K

Line	Character Number																															
Number	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2

51	21	F6.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE
52			DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
53	22	A3	URANIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE
54	23	I6	NUMBER OF THORIUM-TO-POTASSIUM RATIO RECORDS
55			COMPUTED FOR GEOLOGIC UNIT
56	24	F6.1	THORIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE
57			IN PPM EQUIVALENT TH PER PERCENT K
58	25	F6.1	THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE
59			DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
60	26	A3	THORIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE

A P P E N D I X L

Format, DOE MAGNETIC DATA TAPE

DOE MAGNETIC DATA TAPE FORMAT

Line Character Number
 Number 1234567890123456789012345678901234567890123456789012

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1 04 0978 (DATA TAPE TYPE AND FORMAT SPECIFICATION DATE CODES)
2
3 MAGNETIC DATA TAPE
4
5 FORMAT FOR TAPE IDENTIFICATION BLOCK (SECOND BLOCK)
6
7 ITEM      FORMAT  DESCRIPTION
8 1         A40     QUADRANGLE NAME AS PROJECT IDENTIFICATION
9 2         A20     NAME OF SUBCONTRACTOR
10 3        I4      APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
11 4        I3      NUMBER OF FLIGHT LINES ON THIS TAPE
12 5        I4      FIRST FLIGHT LINE OF THIS TAPE
13 6        I6      FIRST RECORD NUMBER OF FIRST FLIGHT LINE
14 7        I3      JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS
15                COLLECTED
16 8        F8.4    LATITUDE OF GROUND BASE STATION TO FOUR DECIMAL
17                PLACES IN DEGREES FOR FIRST FLIGHT LINE
18 9        F8.4    LONGITUDE OF GROUND BASE STATION TO FOUR DECIMAL
19                PLACES IN DEGREES FOR FIRST FLIGHT LINE
20 10-14    (SAME)  REPEAT OF ITEMS 5-9 FOR SECOND FLIGHT LINE ON THIS
21                TAPE
22 *        *              *
23 *        *              *
24 *        *              *
25 495-499  (SAME)  REPEAT OF ITEMS 5-9 FOR 99TH FLIGHT LINE ON THIS
26                TAPE
27
28 FORMAT FOR MAGNETIC DATA RECORD (THIRD THRU LAST BLOCK)
29
30 ITEM      FORMAT  DESCRIPTION
31 1         I1      AERIAL SYSTEM IDENTIFICATION CODE
32 2         I4      FLIGHT LINE NUMBER
33 3         I6      RECORD IDENTIFICATION NUMBER
34 4         I6      GMT TIME OF DAY (HHMMSS)
35 5        F8.4    LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
36 6        F8.4    LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
37 7        F6.1    TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
38 8        F5.1    OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
39 9         A8      SURFACE GEOLOGIC MAP UNIT CODE
40 10        F7.1    TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE
41                IN GAMMAS
42 11        F7.1    RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY
43                TO ONE DECIMAL PLACE IN GAMMAS
44 12        F7.1    DIURNAL MAGNETIC INTENSITY VARIATION TO ONE DECIMAL
45                PLACE IN GAMMAS
46 13        F7.1    MAGNETIC DEPTH-TO-BASEMENT TO ONE DECIMAL PLACE
47                IN METERS (IF REQUIRED)

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A P P E N D I X M

Reduced Calibration and Test Line Data

Reduced Calibration and Test Line Data

<u>Date</u>	<u>Flight</u>	<u>Res. Thor.</u> <u>583</u>	<u>Res. Thor.</u> <u>2615</u>	<u>Low Preflight</u> <u>Alt. T.C. 2π</u>	<u>Low Postflight</u> <u>Alt. T.C. 2π</u>
09/18/80	50	5.1%	9.8%	400' 2120 5	400' 2180 6
09/19/80	51	5.1%	9.8%	400' 2520 9	400' 2400 10
10/04/80	61	5.0%	9.3%	400' 2640 9	400' 1920 9
10/05/80	62	N/A	N/A	400' 2220 10	400' 2350 11

N/A = NOT AVAILABLE

A P P E N D I X N

Renumbered to Original Fiducial Correlations

MITCHELL QUADRANGLE

LINE 1600 FLOWN AS LINE 1600
MAP FIDUCIALS 14938 TO 17342 CORRESPOND TO ORIGINAL FIDUCIALS 17342 TO 14938

LINE 1610 FLOWN AS LINE 1618
MAP FIDUCIALS 2299 TO 4665 CORRESPOND TO ORIGINAL FIDUCIALS 4665 TO 2299

LINE 1620 FLOWN AS LINE 1620
MAP FIDUCIALS 4932 TO 7268 CORRESPOND TO ORIGINAL FIDUCIALS 7268 TO 4932

LINE 1630 FLOWN AS LINE 1630
MAP FIDUCIALS 2379 TO 4751 CORRESPOND TO ORIGINAL FIDUCIALS 4751 TO 2379

LINE 1640 FLOWN AS LINE 1648 AND 1640
MAP FIDUCIALS 10500 TO 12299 CORRESPOND TO ORIGINAL FIDUCIALS 10500 TO 12299
MAP FIDUCIALS 12300 TO 12974 CORRESPOND TO ORIGINAL FIDUCIALS 10500 TO 9825

LINE 1650 FLOWN AS LINE 1650
MAP FIDUCIALS 12706 TO 15101 CORRESPOND TO ORIGINAL FIDUCIALS 15101 TO 12706

LINE 1660 FLOWN AS LINE 1668
MAP FIDUCIALS 20135 TO 22608 CORRESPOND TO ORIGINAL FIDUCIALS 22608 TO 20135

LINE 1670 FLOWN AS LINE 1670
MAP FIDUCIALS 40 TO 2384 CORRESPOND TO ORIGINAL FIDUCIALS 2384 TO 40

LINE 1680 FLOWN AS LINE 1680
MAP FIDUCIALS 10616 TO 12872 CORRESPOND TO ORIGINAL FIDUCIALS 12872 TO 10616

LINE 1690 FLOWN AS LINE 1690 AND 1692
MAP FIDUCIALS 3245 TO 5243 CORRESPOND TO ORIGINAL FIDUCIALS 5243 TO 3245
MAP FIDUCIALS 5244 TO 5607 CORRESPOND TO ORIGINAL FIDUCIALS 19347 TO 18983

LINE 1700 FLOWN AS LINE 1700
MAP FIDUCIALS 15272 TO 17712 CORRESPOND TO ORIGINAL FIDUCIALS 17712 TO 15272

LINE 1710 FLOWN AS LINE 1710 AND 1711
MAP FIDUCIALS 12537 TO 14553 CORRESPOND TO ORIGINAL FIDUCIALS 14553 TO 12537
MAP FIDUCIALS 14554 TO 14903 CORRESPOND TO ORIGINAL FIDUCIALS 2785 TO 2435

LINE 5000 FLOWN AS LINE 5001
MAP FIDUCIALS 5430 TO 7027 CORRESPOND TO ORIGINAL FIDUCIALS 7027 TO 5430

LINE 5010 FLOWN AS LINE 5018
MAP FIDUCIALS 8276 TO 9911 CORRESPOND TO ORIGINAL FIDUCIALS 9911 TO 8276

LINE 5020 FLOWN AS LINE 5020
MAP FIDUCIALS 43 TO 1652 CORRESPOND TO ORIGINAL FIDUCIALS 1652 TO 43

LINE 5030 FLOWN AS LINE 5032
MAP FIDUCIALS 11447 TO 11921 CORRESPOND TO ORIGINAL FIDUCIALS 11921 TO 11447