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AERIAL GAMMA RAY AND MAGNETIC SURVEY
FREMONT QUADRANGLE, NEBRASKA, IOWA
LINCOLN QUADRANGLE, NEBRASKA
MANHATTAN QUADRANGLE, KANSAS
HUTCHINSON QUADRANGLE, KANSAS

FINAL REPORT
VOLUME I

Prepared by:
geoMetrics
Sunnyvale, California
November 1977

Work Performed Under
Bendix Field Engineering Corporation
Grand Junction Operations, Grand Junction, Colorado
Subcontract 76-033-L
and
Bendix Contract EY-76-C-13-1664

Prepared for the
Department of Energy
Grand Junction Office
Grand Junction, Colorado 81501

DISCLAIMER STATEMENT

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ABSTRACT

Under the Department of Energy (DoE), National Uranium Resource Evaluation (NURE) Program, GeoMetrics, Inc. conducted a high sensitivity airborne radiometric and magnetic survey of the East Salina Basin Area (Kansas and Nebraska). The project area, the Hutchinson and Manhattan, Kansas 1:250,000 NTMS sheets and the Lincoln, Nebraska and Fremont, Nebraska and Iowa 1:250,000 NTMS sheets, consists of approximately 30,800 square miles (79,800 square kilometers). A total of 11,287 line miles (18,165 line kilometers) of high sensitivity radiometric and magnetic data were collected. Traverse lines were flown at a spacing of 3.125 miles (5 kilometers) in an east/west direction with tie lines flown in a north/south direction at a 18.375 miles (30 kilometers) separation. All data were collected utilizing a fixed wing aircraft, Grumman G-89, S2F Tracker (U.S. Registry No. N9AG), and over 3,500 cubic inches of NaI crystal detector (3,072 cubic inches in a downward looking configuration and 512 cubic inches in an upward looking configuration). Magnetometer data were collected utilizing a high sensitivity 0.25 gamma, proton magnetometer. Data were digitally recorded at 1.0 second intervals aboard the aircraft with navigation performed using both visual and doppler techniques. All field data were returned to GeoMetrics, Sunnyvale, California computer facilities for processing, statistical analysis and interpretation. As an integral part of this final report, other data are presented which include corrected profiles of all radiometric variables (total count, potassium, uranium, thorium, uranium/thorium, uranium/potassium, and thorium/potassium, ratios), magnetic data, radar altimeter data, barometric altimeter data, air temperature and airborne Bismuth contributions. Radiometric data presented are corrected for Compton Scatter, altitude dependence (data are all referenced to 400 foot mean terrain clearance) and atmospheric Bismuth. These data are presented in the form of strip charts as averaged one second samples using a 5 second moving average window (see Volume II of this report), microfiche (containing single record, averaged record and statistical analysis data), and digital magnetic tapes containing raw spectral data, single record data, averaged record data, and statistical analysis results. In addition, computer generated anomaly maps and interpretation maps are presented relating known geology or soil distribution to the corrected radiometric data.

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INTRODUCTION AND SUMMARY

INTRODUCTION

Under the U.S. Department of Energy (DOE), National Uranium Resource Evaluation (NURE) Program, GeoMetrics, Inc. conducted a high sensitivity airborne radiometric and magnetic survey of the Fremont, Lincoln, Manhattan, and Hutchinson NMTS 1:250,000 map sheets (see Figure 1), within the States of Kansas, Nebraska and Iowa. The objectives of the DOE/NURE program, of which this project is a small part, may be summarized as follows:

> "To develop and compile geologic and other information with which to assess the magnitude and distribibtion of uranium resources and to determine areas favorable for the occurrence of uranium in the United States...." (DOE)

As an integral part of the DOE/NURE Program, the National Airborne Radiometric Program is designed to provide systematic gamma ray reconnaissance information concerning the regional distribution of uraniferous materials within the United States.

All the data were collected utilizing a fixed wing aircraft, Grumman G-89, S2F Tracker (U.S. Registry No. N9AG). Compilation and interpretation of the data were performed at the GeoMetrics Sunnyvale, California, computer facility. This report covers the methodology and results of the project.

SUMMARY

This project area is located in the east-central portion of the Great Plains physiographic Province and encompasses approximately 30,800 square miles (79,800 square kilometers). A total of 11,287 line miles (18,165 line kilometers) of high sensitivity radiometric and magnetic data were collected. Traverse lines were flown at a spacing of 3.125 miles (5 Kilometers) in an east/west direction and tie lines were flown in a north/south direction 18.375 miles (30 kilometers) apart. In order to ensure high sensitivity radiometric and magnetic data, over 3,500 cubic inches of NaI crystal detector were utilized (3,072 cubic inches in a downward looking configuration and 512 cubic inches in an upward looking configuration). Magnetic data were collected utilizing a high sensitivity, 0.25 gamma, proton magnetometer. All data were digitally recorded at 1.0 second intervals aboard the aircraft. Inflight navigation was performed using both visual and Doppler techniques.

Major geological structures within the survey area include the Salina Basin on the west, the Forest City Basin on the east, and the intervening Nemaha Uplift. The Nemaha Uplift strikes approximately north-south along the eastern margin of

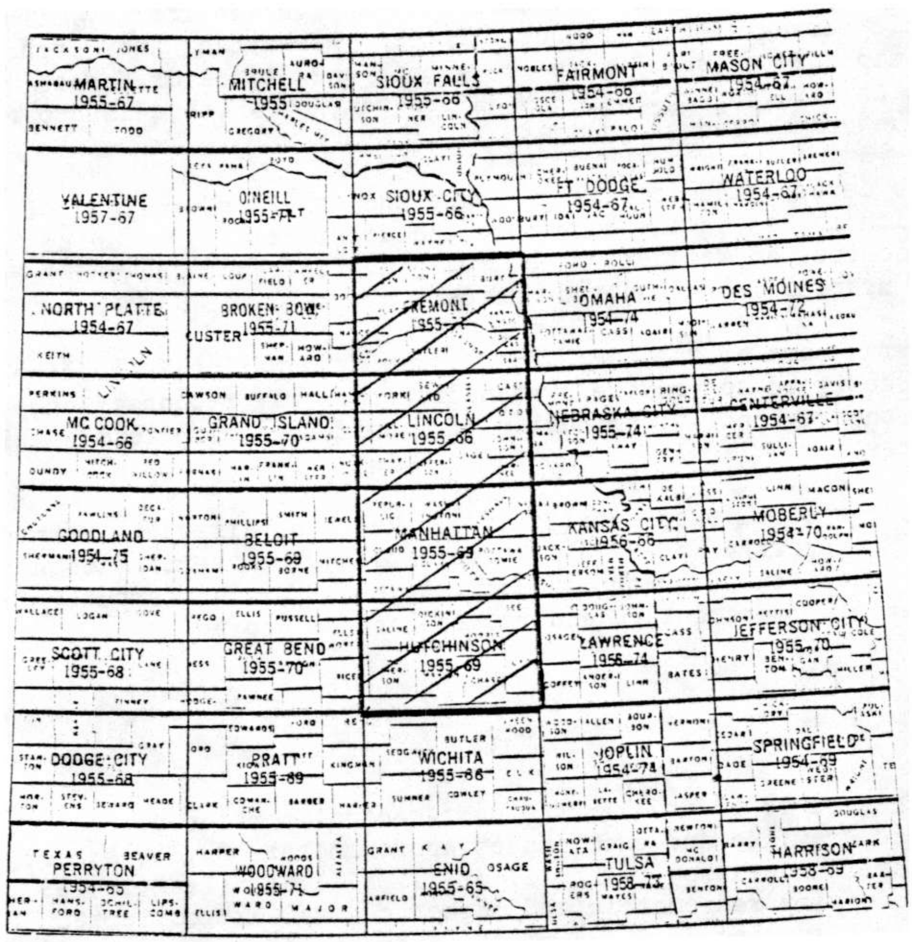


Figure 1. East Salina Basin Project Area

the Fremont and Lincoln quadrangles in Nebraska and veers south-southwest across the eastern and central parts of the Manhattan and Hutchinson quadrangles in Kansas. A less pronounced basement uplift, the Abilene Arch, diverges from the Nemaha Uplift and trends southwestward across the central Manhattan and north-central Hutchinson quadrangles. West of these structural highs, the basement surface and overlying sedimentary section dip gently westward to form the eastern flank of the Salina Basin. Rocks of Paleozoic and Mesozoic eras are represented in the primarily calcareous sediments of the basin. Unconformities are present at both the base of the Devonian and Pennsylvanian systems, the latter of the two being the more prominent. East of the Nemaha Uplift, a small portion of the western flank of the Forest City Basin (which blends into the Cherokee Basin to the south) is included within the Hutchinson quadrangle. The sedimentary sequence in the Forest City Basin is similar to that of the Salina Basin. The Sedgwick Basin occupies the western portion of the Hutchinson quadrangle.

Although the Salina Basin itself does not have known significant uranium occurrences, three formations which are present either as outcrops or underlying bedrock have been termed by DoE (1976) as favorable rock units for assessment of potential uranium resources. The first of these is the Marmaton formation which contains shales and sandstones of Pennsylvania age. It is potentially uraniferous outside the basin in the tri-state corner of southeastern Kansas (DoE, 1976). The second of these is the Cretaceous Dakota Sandstone, which, along the Front Ranges of Colorado is reported to contain uraniferous channel deposits. Last, the Pliocene Ogallala Group, which is widely distributed throughout the western Great Plains comprising several separate formations (Logn, 1939), is believed to be locally uraniferous in the Oklahoma Panhandle section of Texas. An equivalent unit (same name) occurs in the northwest Salina Basin area and locally overlies various Cretaceous units.

All field data were returned to the GeoMetrics, Sunnyvale, California, computer facilities for processing, statistical analysis, and interpretation. After processing, the data were correlated on a one-to-one basis with the geologic base maps. These data were then statistically evaluated to define those areas which were radiometrically anomalous relative to other areas within each similar lithology. For the Fremont and Lincoln quadrangles, only bedrock geologic maps (developed principally from well data) showing Quaternary sediment thickness were available. As a result, the anomaly maps for these quadrangles were derived from existing soils data. Anomaly maps, radiometric-magnetic data and profile data were evaluated individually and then integrated into a final interpretation map.

Other data integral to this final report, which include corrected profiles of all radiometric variables (total count, potassium, uranium, thorium, uranium/thorium, uranium/potassium, and thorium/potassium ratios), magnetic data, radar altimeter data, barometric altimeter data, air temperature, and airborne Bismuth contributions are presented as profiles. (See Volume II). Single record and averaged data are presented on microfiche at 1.0 second sample intervals, corrected for Compton Scatter, altitude dependence (data are all referenced to 400 foot mean terrain clearance) and atmospheric Bismuth. (See Volume II). Digital magnetic tapes are available containing raw spectral data, single record data, magnetic data, and statistical analysis results. In addition, computer generated anomaly maps and interpretation maps are presented which relate known geology to corrected radiometric data.

The balance of this report contains detailed descriptions of the data collection system, data processing procedures, statistical analysis and interpretation discussions summarizing each of the NTMS sheets.

DATA COLLECTION SYSTEM

AIRCRAFT

The project aircraft was a Grumman Tracker Model S2, (See Figure 2) Serial Number 3, U.S. Registration N9AG. The aircraft performance data as applicable to airborne geophysical surveys are described below:

Aircraft Empty		15,123 lbs.
Electronic Equipment		1,600 lbs.
Main Fuel Usable		3,108 lbs.
Auxilliary Fuel Usable		900 lbs.
Pilot		175 lbs.
Electronic Operator		175 lbs.
Maximum Gross Weight for Geophysical Survey Operation		21,081 lbs.
Maximum Allowable Aircraft Gross Weight		24,500 lbs.
Minimum Control Speed	85 KIAS at	24,500 lbs.
Safe Single Engine Speed	100 KIAS at	24,500 lbs.
Single Engine Rate of Climb at 120 KIAS	550 FPM at	23,000 lbs.
Single Engine Rate of Climb at 100 KIAS	390 FPM at	23,000 lbs.
Rate of Climb (2 Engines)	2000 FPM thru	5,000 ft.
120 KIAS at 23,000 lbs.	1200 FPM at	10,000 ft.

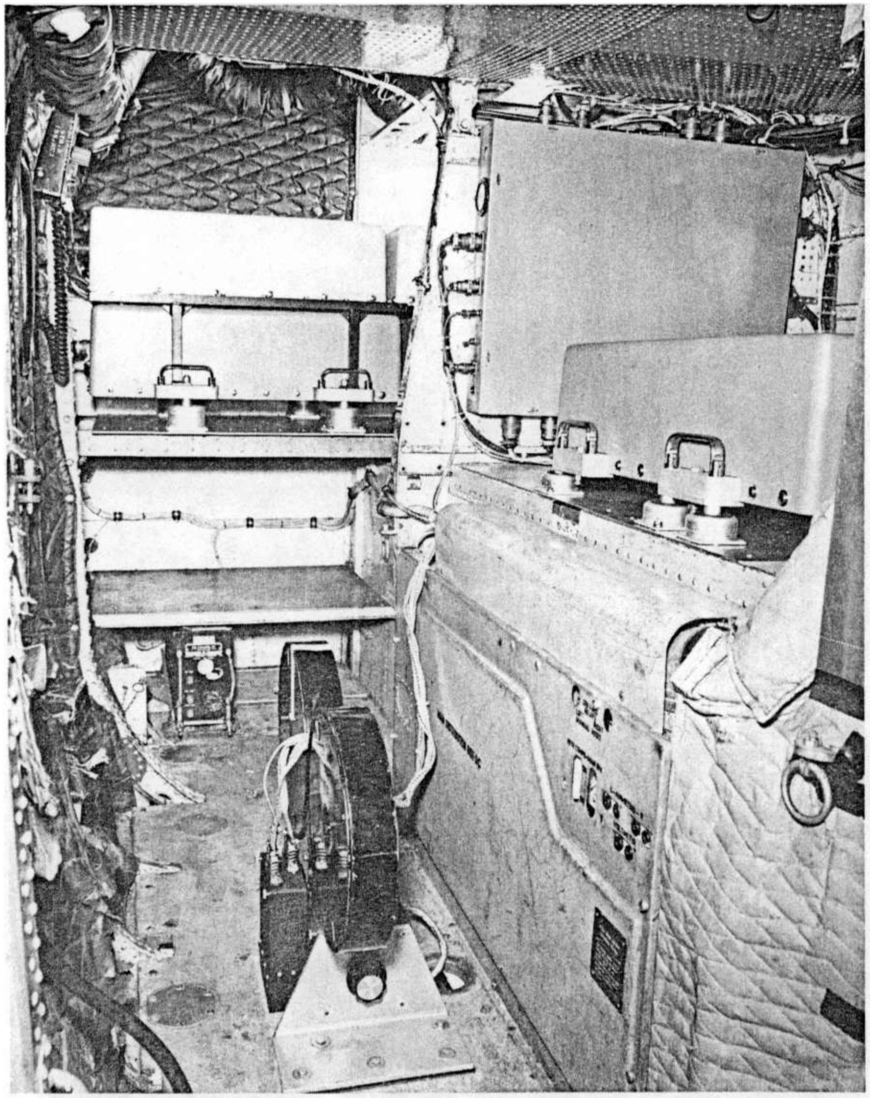
(KIAS = Knots Indicated Air Speed)

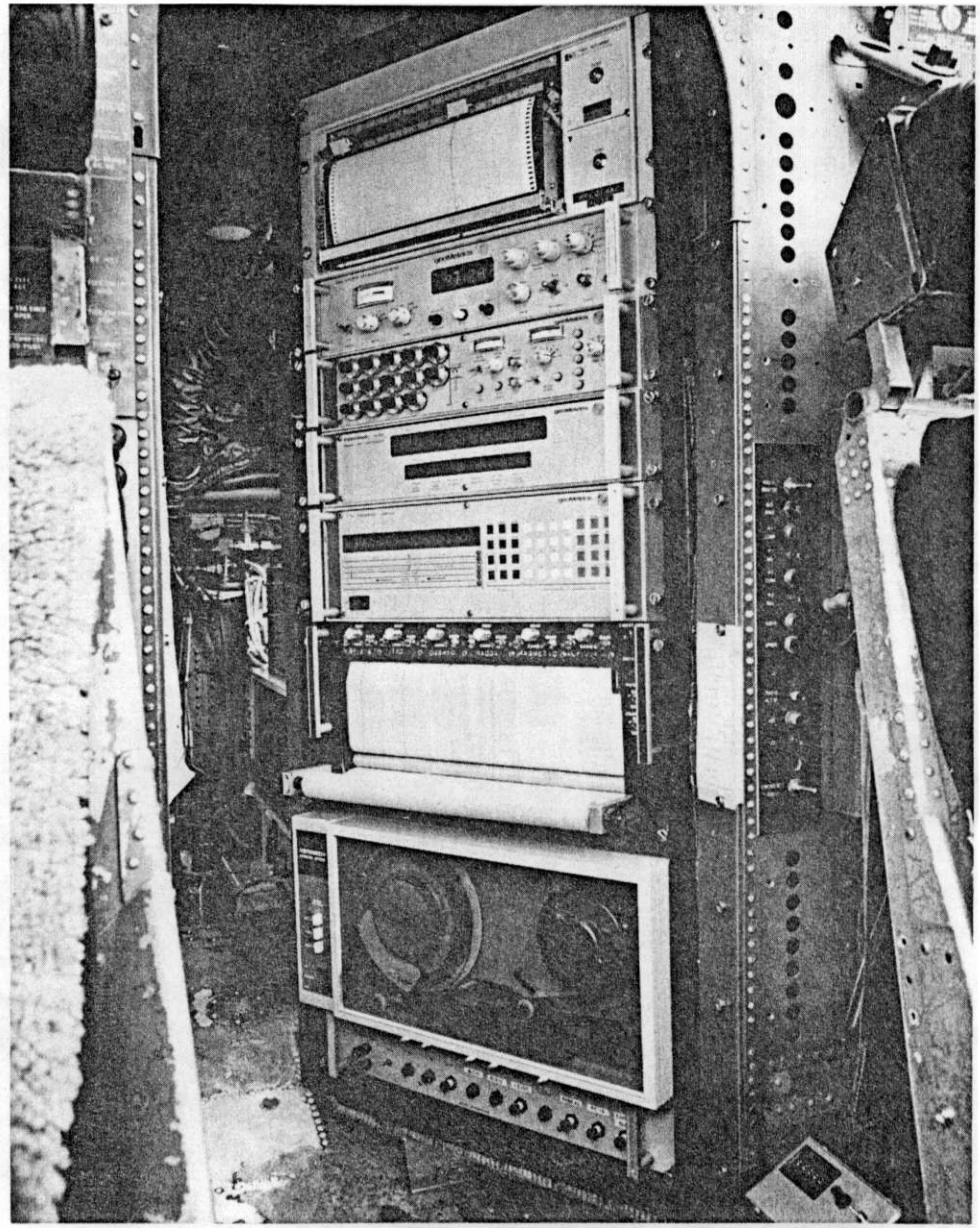
Cruise Configuration Stalling Speed at Gross Weight 21,000 lbs.
0^{o} Bank - 80 KIAS 45^{o} Bank - 96 KIAS

Usable Fuel	518 U.S. Gals.	3180 lbs. Mains
	150 U.S. Gals.	900 lbs. Auxiliary

400 pounds per hour at 1000 feet altitude and 120 KIAS at 23,000 lbs. gross wt. duration 10 hours plus, due to burn off and lower gross wt.

The S2 was originally designed and built by Grumman Aircraft Corporation for the U.S. Navy as a highly stable platform for carrying electronic instrumentation in the search of submarines from carrier bases and/or short landing fields. Since it was designed for magnetic surveillance, it is a "magnetically clean" aircraft and thus ideal for collecting magnetic data. Its performance and safety features make it ideal for low level, fixed-wing airborne geophysical survey work. There is virtually no other aircraft which can carry the adequate payload at the necessary constant low airspeeds and still maintain tight terrain clearance along with a wide envelope of safety.





Left: Grumman S2F Survey Aircraft. Upper right: Geophysical instruments: G-803 Magnetometer, GR-800 Spectrometer, G-714 Data System & Recorders. Upper left: NaI exSquare™ Crystal detectors—3,072 cu.in. (50.4 l) down, 512 cu.in. (8.4 l) up. Camera: Automax G2.

Figure 2

ELECTRONICS

The major components of the airborne data collection system are summarized below (shown pictorially in Figure 2 and schematically in Figure 3):

1. Gamma Ray Spectrometer, GeoMetrics GR-800, utilizing a dual 256 channel capability to provide spectral data in the 0.4 to 3.0 MeV range for both the downward looking and the upward looking crystal packages and coverage in the 3.0 to 6.0 MeV range for cosmic background.
2. Crystal Detector, GeoMetrics Model NaI-1000/CS consisting of 3072 cubic inches in the downward looking configuration and 512 cubic inches appropriately shielded in an upward looking configuration.
3. A GeoMetrics Digital Data Acquisition System, Model G-714 with "read-after-write" data verification, recording the following on magnetic tape:
    a) 512 channels of gamma ray spectrometer data
    b) Total magnetic intensity
    c) Fiducial number from data system/camera
    d) Manually inserted information, i.e., date, survey area, and flight line number
    e) Altitude from radar and barometric altimeters (by analog-to-digital conversion)
    f) Time in days, hours, minutes and seconds
    g) Outside air temperature
4. Magnetometer, GeoMetrics Airborne Model G-803, capable of 0.125 gamma sensitivity, but operated at 0.25 gamma sensitivity.
5. Radar Altimeter, Bonzer with a linear recording output, displaying an altitude range of 0 to 2500 feet.
6. Rosemont Barometric Altimeter with recording output and display.
7. Recording Thermometer for monitoring outside air temperature.
8. Tracking Camera, Automax 35 mm framing camera with wide angle lens to provide flight path recovery data.
9. Analog Recorder GeoMetrics MARS 6 to record the following data:
    a) Bi_{214} using a window about the 1.76 MeV peak from the downward looking system.
    b) Bi air background using a window about the 1.76 MeV peak from the upward looking system.
    c) Magnetometer

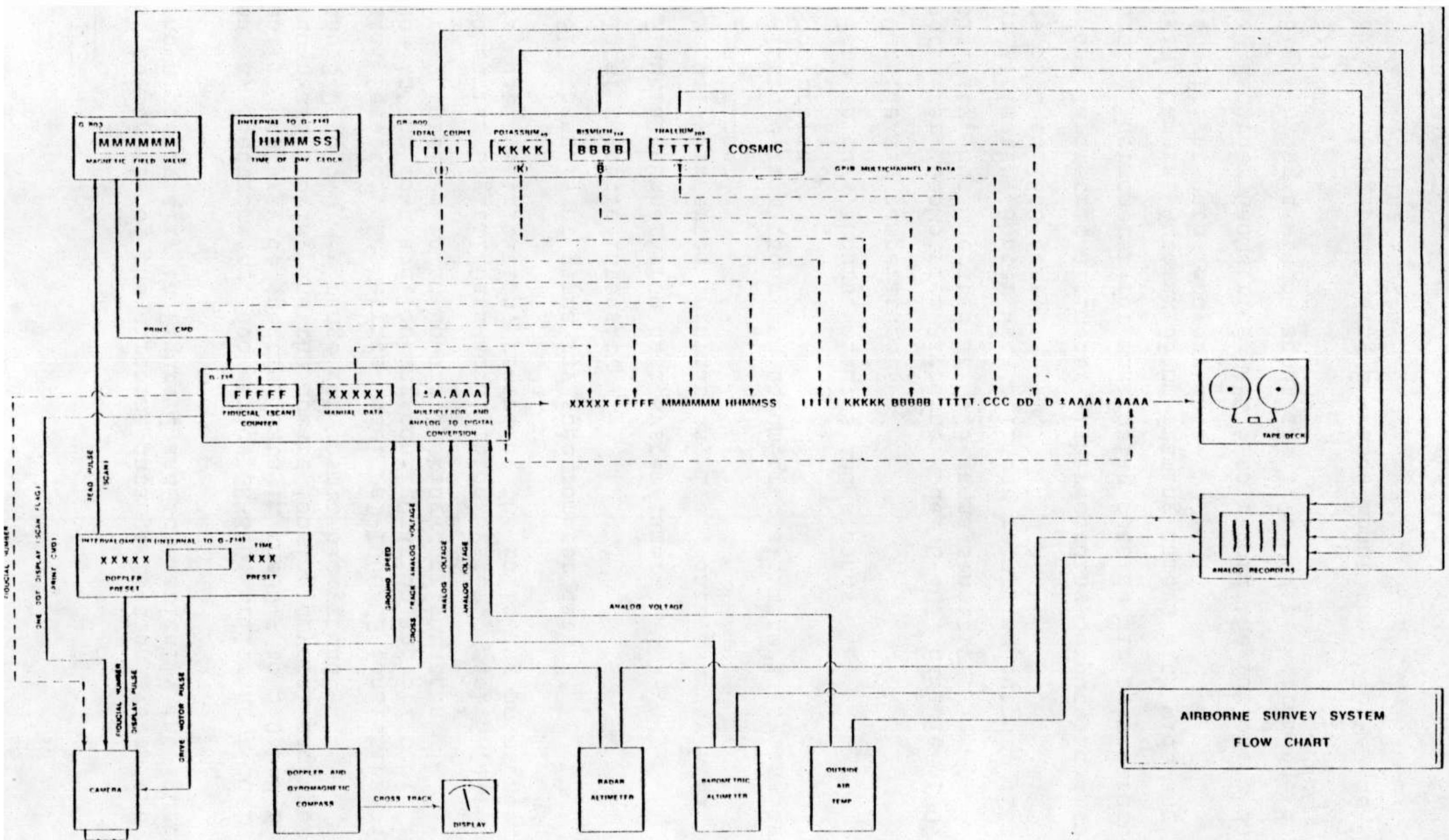

MMMMMM
MAGNETIC FIELD VALUE
HHMMSS
TIME OF DAY CLOCK
TOTAL COUNT
POTASSIUM
BISMUTH
THALLIUM
TTTT
COSMIC
GPIR MULTICHANNEL
PRINT CMD
FFFFF
FIDUCIAL (SCAN) COUNTER
XXXXX
MANUAL DATA
±A.AAA
MULTIPLEXOR AND ANALOG TO DIGITAL CONVERSION
XXXXX FFFFF MMMMMM HHMMSS
TAPE DECK
ANALOG RECORDERS
READ PULSE
XXXXX
DOPPLER PRESET
XXX
TIME PRESET
GROUND SPEED
CROSS TRACK ANALOG VOLTAGE
ANALOG VOLTAGE
FIDUCIAL NUMBER
DISPLAY PULSE
DRIVE MOTOR PULSE
CAMERA
DOPPLER AND GYROMAGNETIC COMPASS
CROSS TRACK
DISPLAY
RADAR ALTIMETER
BAROMETRIC ALTIMETER
OUTSIDE AIR TEMP
AIRBORNE SURVEY SYSTEM
FLOW CHART

FIGURE 3

d) Radar Altitude

e) Total count for downward looking system (0.4 to 3.0 MeV)

f) Event and time markers

10. HP 7128, two channel analog recorder to record the following data:

a) Outside air temperature

b) Barometric altimeter

c) Event and time markers

d) During pre and post flight calibrations, this recorder is used to plot full analog spectra for both the down and up crystal systems via the GR-800. Thus, a hard copy record of the data used for resolutions, drift, and other checks is available at all times (See Figure 4). This approach provides instant verification of system parameters.

OPERATIONS

DATA COLLECTION PROCEDURES

Operating Parameters/Sampling Procedures

This survey was conducted using data collection parameters summarized below:

1. Data sampling was performed by a time-based system using 1.0 second sample intervals.
2. The aircraft objective ground speed was 120 mph, and did not exceed 140 mph unless dictated by safety.
3. The downward looking crystal volume was 3,072 cubic inches, providing a range in V/v (i.e. crystal volume in cubic inches divided by ground speed in miles per hour), of between 25.6 (120 mph), and 22 (140 mph).
4. The volume of the upward looking crystal was 512 cubic inches.
5. All sensor data with analog output were digitally sampled at each data scan based upon the clock timing rate of 1.0 seconds. The data so collected are the instantaneous values of these parameters determined at the time of the data scan.

Navigation/Flight Path Recovery

Navigation was accomplished using a combination of visual and doppler navigation techniques. Flight lines were drawn on 1:62,500 scale county maps. The pilot/navigator utilized these maps to provide visual navigation features. The flight line was generally started and ended visually, while the doppler was used to fly a straight line between end points.

Simultaneously, a 35 mm tracking camera was used to record actual flight position. This camera's fiducial numbering system was directly synchronized to the digital recording system such that a one-to-one correlation between position and data could be made. Upon completion of a data collection flight, the 35 mm film was processed and actual flight path positions located on the 1:62,500 scale map sheets.

Infield System Calibration

Due to the complex nature of both the system and the resultant data interpretation, much emphasis was placed on infield calibration of the data collection system. The objective of this calibration was to ensure continuous high quality of the data collected. The daily calibration procedures used are set forth below as a summary check list:

A. Pre Flight

1. Use cesium sources (same positioning on crystals every day), peak each Photomultiplier tube/crystal using the digital split-window detector of the GR-800.

2. Run full cesium spectrum on analog recorder for both down and up looking crystals. Calculate the cesium resolution (see sample in Figure 4). Run spectrum out past the K_{40} peak on down crystals for centering evaluation of K_{40} peak.

3. Use thorium sources (same position every day) check upper end of spectrum in both up and down crystals - using the digital split window of the GR-800.

4. Run full thorium spectrum of down crystals on analog recorder. Check for centering of K_{40} and Th peaks in spectrum.

B. During Flight

1. Run test line at survey altitude (400 ft.), for approximately five miles, prior to production data collection (record both analog and digital).

2. Prior to production data collection, the above data are evaluated to ensure ±20% limits on total count - compared to first test flight from that base of operations.

3. During production data collection, monitor radon analog data for unusual increases. Visually correlate these with temperature and barometric pressure.

4. During production data collection, annotate operator logs with unusual features such as recently plowed fields, lakes, snow/rain showers, man-made features, etc., along with their fiducial numbers.

5. Upon completion of production data collection, re-fly test line at survey altitude (400 ft.). Record both analog and digital.

C. Post Flight

1. Verify test line total count within ±20% of first test line at that base of operations.

2. Using cesium sources (same position as pre-flight), run full cesium spectrum for both down and up crystals (allow it to record through the K_{40} peak in the down crystals).

3. Calculate the resolution of down and up crystal pack.

4. Determine shift, if any, in K_{40} peak position.

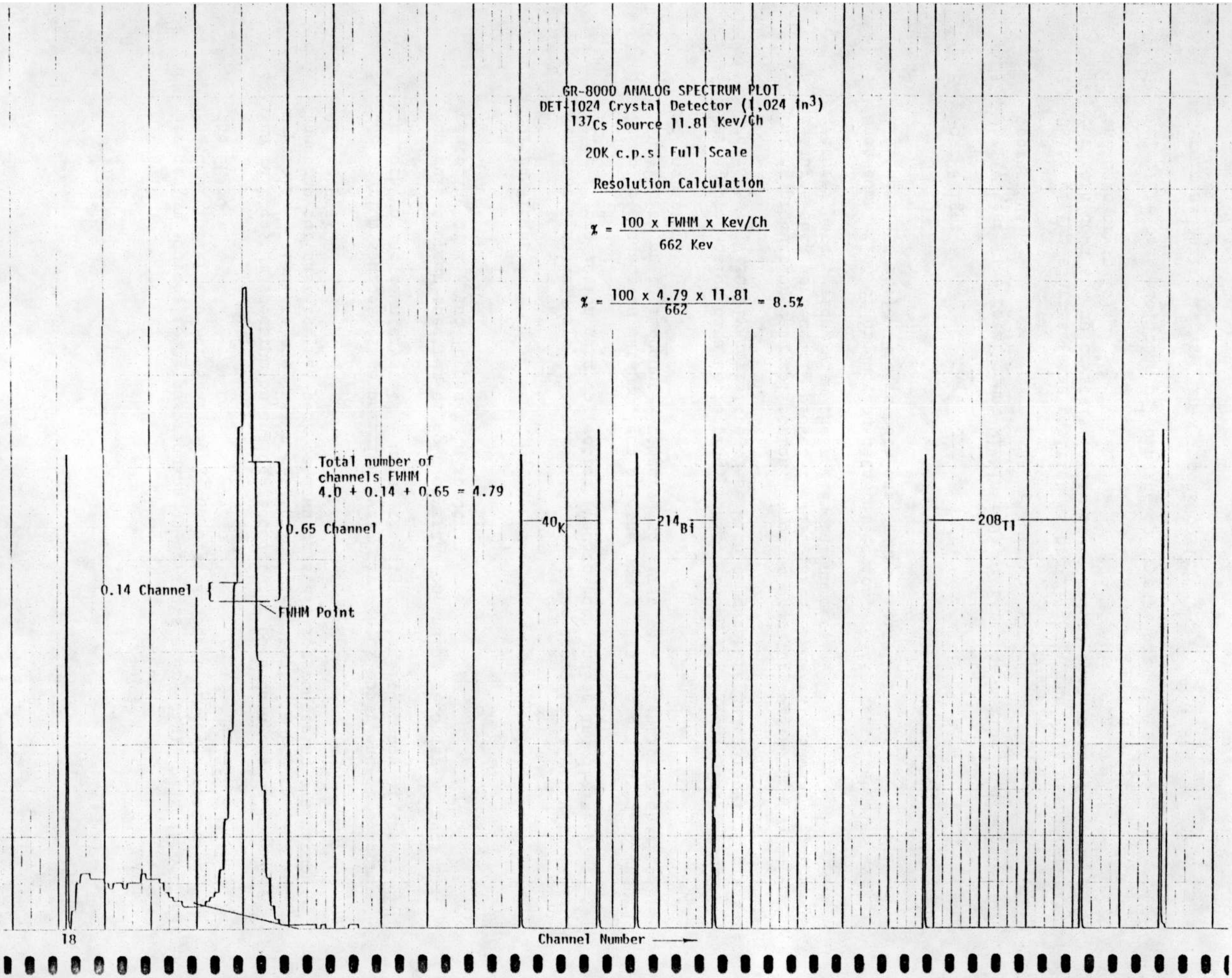

GR-800D ANALOG SPECTRUM PLOT
DET-1024 Crystal Detector (1,024 in³)
137Cs Source 11.81 Kev/Ch
20K c.p.s. Full Scale
Resolution Calculation
% = 100 x FWHM x Kev/Ch / 662 Kev
% = 100 x 4.79 x 11.81 / 662 = 8.5%
Total number of channels FWHM
4.0 + 0.14 + 0.65 = 4.79
0.65 Channel
0.14 Channel
FWHM Point
40K
214Bi
208Tl
18
Channel Number

Figure 4

PRODUCTION SUMMARY

Data collection for the East Salina Basin Project was initiated on 29 November 1976. From this date through 19 December 1976, the base of operations was Grand Island, Nebraska. Production during this time period was 8,078 line miles. Production ceased at this time due to prolonged weather problems. Data collection was again initiated on 15 February 1977 and was completed on 7 March 1977. During this time period 3,965 line miles were collected for a total in the project area of 11,943 line miles. Actual production data collection required 16 flights (days) for an average of 746 line miles per flight (per day). (See Appendix I, for a daily summary).

Throughout the survey an average ground speed of 130 mph was maintained. The objective altitude was 400 foot mean terrain clearance within an envelope of 200 to 700 feet. The average altitude was maintained at 429 feet mean terrain clearance. (Samples of the typical flight line distribution of ground speed and radar altimeter data are presented in Figures 5 and 6.) Overall, in excess of 99% of the data collected were within the specification limits.

ERDA -- EAST SALINA BASIN AREA -- FLIGHT FIVE-A

LINE NUMBER 4-0

RANGE	-99999.9	VALUE	0
RANGE	75.0	VALUE	0
RANGE	77.0	VALUE	0
RANGE	79.0	VALUE	0
RANGE	81.0	VALUE	0
RANGE	83.0	VALUE	0
RANGE	85.0	VALUE	0
RANGE	87.0	VALUE	0
RANGE	89.0	VALUE	0
RANGE	91.0	VALUE	0
RANGE	93.0	VALUE	0
RANGE	95.0	VALUE	0
RANGE	97.0	VALUE	0
RANGE	99.0	VALUE	0
RANGE	101.0	VALUE	0
RANGE	103.0	VALUE	5
RANGE	105.0	VALUE	0
RANGE	107.0	VALUE	0
RANGE	109.0	VALUE	0
RANGE	111.0	VALUE	0
RANGE	113.0	VALUE	0
RANGE	115.0	VALUE	0
RANGE	117.0	VALUE	0
RANGE	119.0	VALUE	5
RANGE	121.0	VALUE	4
RANGE	123.0	VALUE	50
RANGE	125.0	VALUE	111
RANGE	127.0	VALUE	300
RANGE	129.0	VALUE	513
RANGE	131.0	VALUE	615
RANGE	133.0	VALUE	495
RANGE	135.0	VALUE	377
RANGE	137.0	VALUE	241
RANGE	139.0	VALUE	140
RANGE	141.0	VALUE	86
RANGE	143.0	VALUE	19
RANGE	145.0	VALUE	11
RANGE	147.0	VALUE	0
RANGE	149.0	VALUE	0
RANGE	151.0	VALUE	0
RANGE	153.0	VALUE	0
RANGE	155.0	VALUE	0
RANGE	157.0	VALUE	0
RANGE	159.0	VALUE	0
RANGE	161.0	VALUE	0
RANGE	163.0	VALUE	0
RANGE	165.0	VALUE	0
RANGE	167.0	VALUE	0
RANGE	169.0	VALUE	0
RANGE	171.0	VALUE	0
RANGE	173.0	VALUE	0
RANGE	175.0	VALUE	0
RANGE	99999.9	VALUE	0

THE MINIMUM GROUND SPEED IS 102.52 MPH
THE MAXIMUM GROUND SPEED IS 145.95 MPH

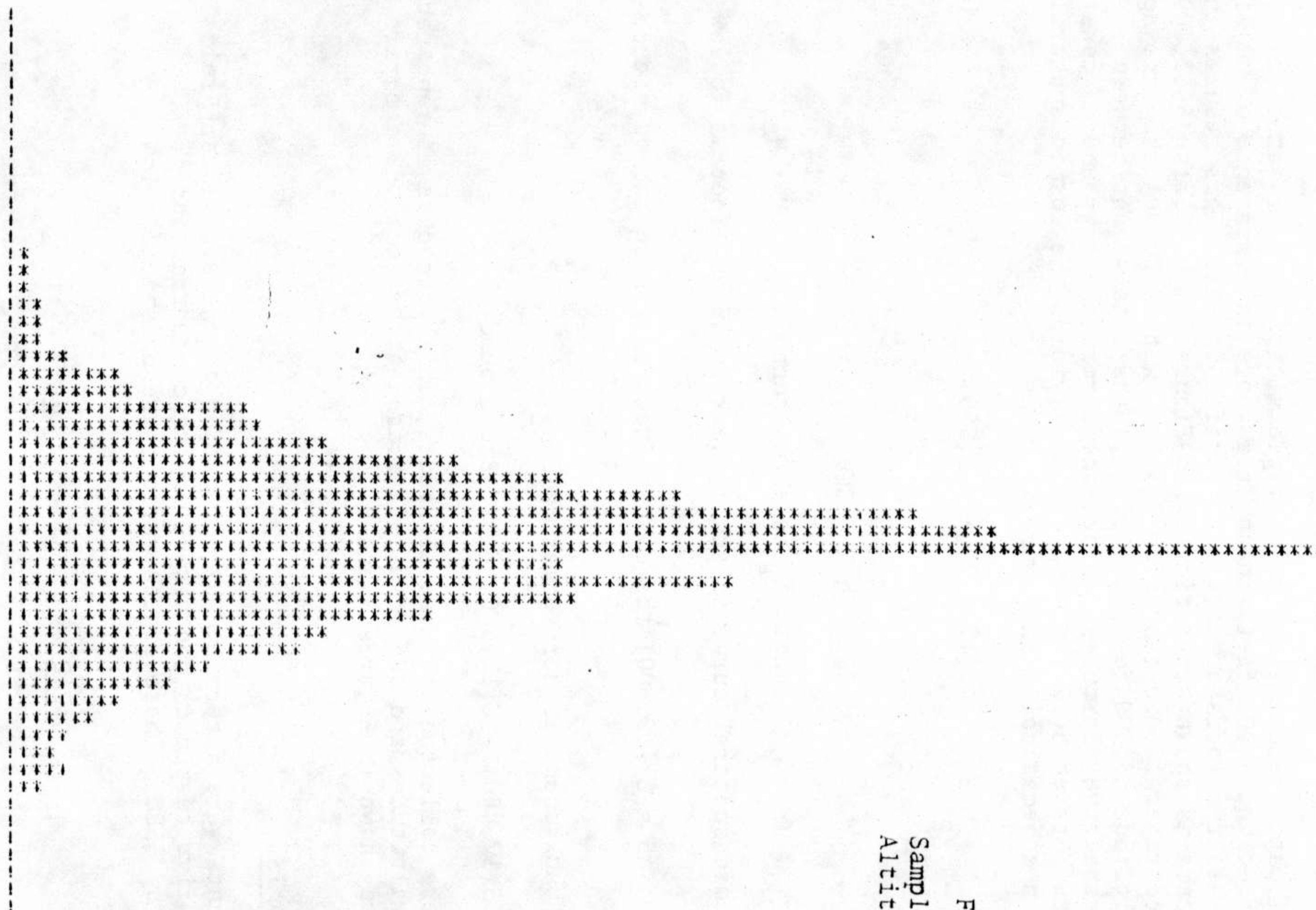
THE MEAN GROUND SPEED IS 131.92 MPH
THE STANDARD DEVIATION IS 4.47 MPH

Figure 5
Sample of Typical Ground Speed Distribution

ERDA -- EAST SALINA BASIN AREA -- FLIGHT TWELVE

LINE NUMBER 35-0

RANGE		VALUE	
RANGE	-99999.9	VALUE	0
RANGE	150.0	VALUE	0
RANGE	160.0	VALUE	0
RANGE	170.0	VALUE	0
RANGE	180.0	VALUE	0
RANGE	190.0	VALUE	0
RANGE	200.0	VALUE	0
RANGE	210.0	VALUE	0
RANGE	220.0	VALUE	0
RANGE	230.0	VALUE	0
RANGE	240.0	VALUE	0
RANGE	250.0	VALUE	0
RANGE	260.0	VALUE	0
RANGE	270.0	VALUE	0
RANGE	280.0	VALUE	2
RANGE	290.0	VALUE	2
RANGE	300.0	VALUE	2
RANGE	310.0	VALUE	3
RANGE	320.0	VALUE	5
RANGE	330.0	VALUE	6
RANGE	340.0	VALUE	13
RANGE	350.0	VALUE	30
RANGE	360.0	VALUE	36
RANGE	370.0	VALUE	71
RANGE	380.0	VALUE	78
RANGE	390.0	VALUE	98
RANGE	400.0	VALUE	143
RANGE	410.0	VALUE	177
RANGE	420.0	VALUE	213
RANGE	430.0	VALUE	292
RANGE	440.0	VALUE	318
RANGE	450.0	VALUE	429
RANGE	460.0	VALUE	174
RANGE	470.0	VALUE	231
RANGE	480.0	VALUE	182
RANGE	490.0	VALUE	131
RANGE	500.0	VALUE	100
RANGE	510.0	VALUE	88
RANGE	520.0	VALUE	61
RANGE	530.0	VALUE	46
RANGE	540.0	VALUE	28
RANGE	550.0	VALUE	20
RANGE	560.0	VALUE	15
RANGE	570.0	VALUE	9
RANGE	580.0	VALUE	12
RANGE	590.0	VALUE	5
RANGE	600.0	VALUE	0
RANGE	610.0	VALUE	0
RANGE	620.0	VALUE	0
RANGE	630.0	VALUE	0
RANGE	640.0	VALUE	0
RANGE	650.0	VALUE	0
RANGE	99999.9	VALUE	0



THE MINIMUM RADAR ALTMTR IS 278.00 FEET
THE MAXIMUM RADAR ALTMTR IS 591.00 FEET

THE MEAN RADAR ALTMTR IS 445.00 FEET
THE STANDARD DEVIATION IS 44.47 FEET

Figure 6
Sample of Typical
Altitude Distribution

SYSTEM CALIBRATION

AIRCRAFT AND COSMIC BACKGROUND

Full spectral data are collected at multiple altitudes over water (e.g. 12,000 feet, 8,000 feet and 4,000 feet) in an area where the existence of no airborne Bi_{214} can be assured (offshore over the Pacific Ocean). This results in separate spectra as shown schematically in Figure 7. We define S(12,000) to be the spectra at 12,000 feet from 0.4 MeV, with S(8,000) the same spectra at a lower altitude (8,000 feet) and $\Sigma C\ (h_i)$ the total count between 3.0 and 6.0 MeV at respective altitudes. Since the aircraft background is constant, the difference between S(12,000) and S(8,000) yields the cosmic spectral curve shape as shown schematically in Figure 7. Thus

$$S(12{,}000) - S(8{,}000) = \Delta S$$

and

$$\Sigma C_{12}\ (h_i) - \Sigma C_8\ (h_i) = \Delta C$$

Where h_i is each channel, .012 MeV wide

Then this cosmic spectral curve is scaled back to 12,000 feet as follows:

$$\frac{\Sigma C_{12}\ (h_i)}{\Delta C} \times \Delta S = C\ (12{,}000)$$ the Cosmic Spectrum (Shape and magnitude at 12,000 feet

The aircraft background is derived as follows:

$$S(12{,}000) - C(12{,}000) = \text{A/C Background}$$

Since data were collected at three altitudes, this procedure is repeated for each pair of altitudes and the results averaged to present the aircraft and cosmic spectra shown in Figures 8 and 9.

SYSTEM CONSTANTS

System constants were determined by occupation of the DoE Walker Field Test Pads. These five test pads contained varying concentrations of K, U, and T as presented by BFEC. These concentrations are presented below:

PAD	K	U	T
Matrix	1.4%	2.2 ppm	6.3 ppm
K	5.2%	5.1 ppm	8.5 ppm
U	2.0%	30.7 ppm	9.2 ppm
T	2.0%	5.2 ppm	45.3 ppm
Mixed	4.1%	21.0 ppm	17.6 ppm

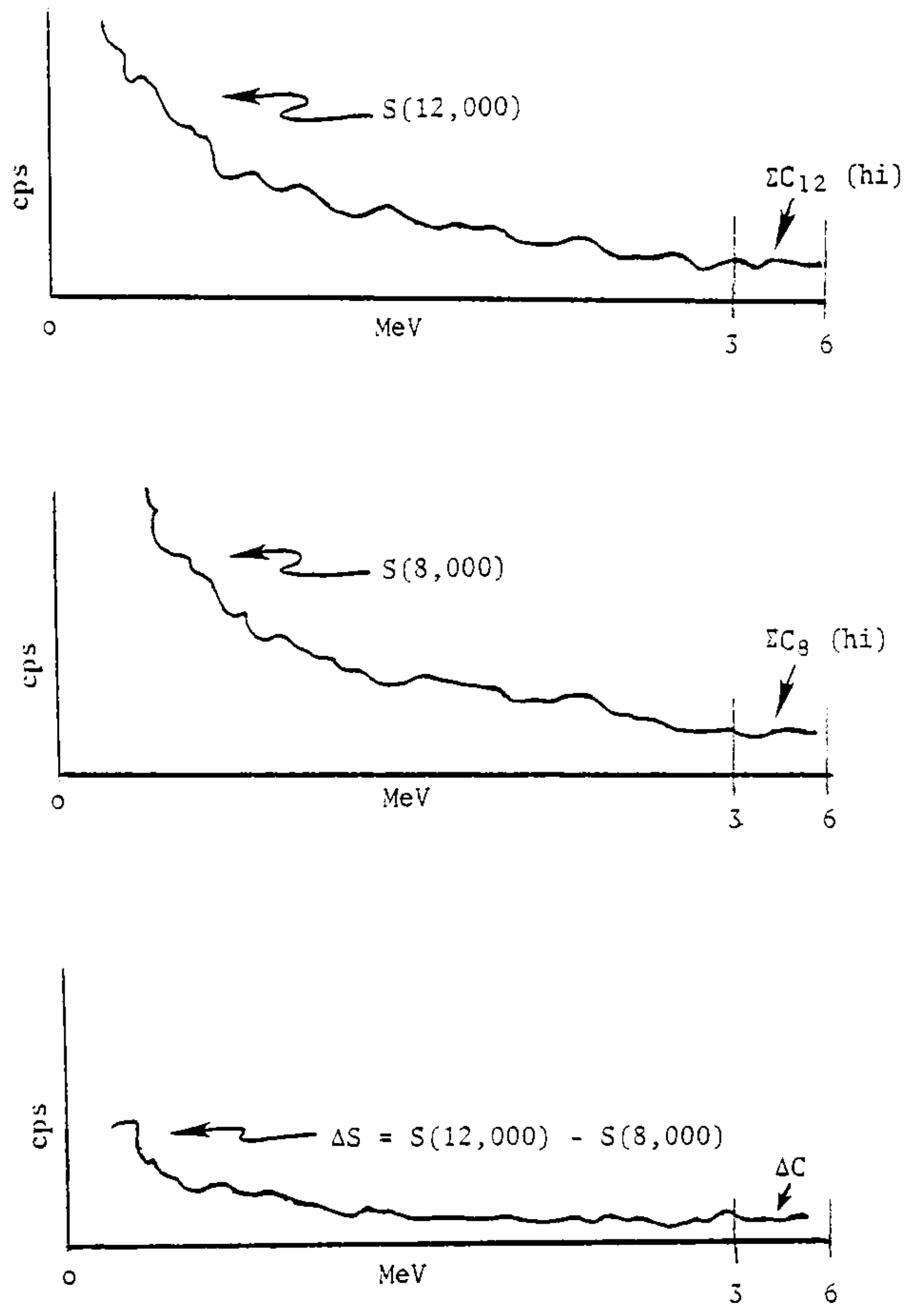


Figure 7 - Multiple altitude spectra schematic

DERIVED AIRCRAFT BACKGROUND SPECTRUM FROM PACIFIC OCEAN DATA

DOWNWARD-LOOKING CRYSTAL SPECTRUM FOR LINE AC BGD, DATED 111376

TC (0-6 MEV) 2134.49 TC (0.4-3.0 MEV) 1304.53 COSMIC (3-6 MEV) 0.00
U (1.12 MEV) 105.48 K (1.46 MEV) 107.38 U (1.76 MEV) 80.31 T (2.62 MEV) 11.83

AIRCRAFT BACKGROUND
DOWNWARD LOOKING CRYSTALS
3072 CUBIC INCHES
DATE: 13 NOVEMBER 1976

CH 0	(0.000 MEV)	0.000 CPS	
CH 1	(0.012 MEV)	0.000 CPS	
CH 2	(0.024 MEV)	0.000 CPS	
CH 3	(0.035 MEV)	0.000 CPS	
CH 4	(0.047 MEV)	0.000 CPS	
CH 5	(0.059 MEV)	0.000 CPS	
CH 6	(0.071 MEV)	0.000 CPS	
CH 7	(0.083 MEV)	0.000 CPS	
CH 8	(0.095 MEV)	0.000 CPS	
CH 9	(0.106 MEV)	0.000 CPS	
CH 10	(0.118 MEV)	0.000 CPS	
CH 11	(0.130 MEV)	0.000 CPS	
CH 12	(0.142 MEV)	0.000 CPS	
CH 13	(0.154 MEV)	0.000 CPS	
CH 14	(0.165 MEV)	0.000 CPS	
CH 15	(0.177 MEV)	0.000 CPS	
CH 16	(0.189 MEV)	0.000 CPS	
CH 17	(0.201 MEV)	0.000 CPS	
CH 18	(0.213 MEV)	41.587 CPS	
CH 19	(0.225 MEV)	65.548 CPS	
CH 20	(0.236 MEV)	68.564 CPS	
CH 21	(0.248 MEV)	63.207 CPS	
CH 22	(0.260 MEV)	62.849 CPS	
CH 23	(0.272 MEV)	61.692 CPS	
CH 24	(0.284 MEV)	57.919 CPS	
CH 25	(0.295 MEV)	53.586 CPS	
CH 26	(0.307 MEV)	51.306 CPS	
CH 27	(0.319 MEV)	51.807 CPS	
CH 28	(0.331 MEV)	55.618 CPS	
CH 29	(0.343 MEV)	53.704 CPS	
CH 30	(0.355 MEV)	46.971 CPS	
CH 31	(0.366 MEV)	36.410 CPS	
CH 32	(0.378 MEV)	31.721 CPS	
CH 33	(0.390 MEV)	27.477 CPS	
CH 34	(0.402 MEV)	25.847 CPS	TOTAL COUNT
CH 35	(0.414 MEV)	24.120 CPS	
CH 36	(0.426 MEV)	23.627 CPS	
CH 37	(0.437 MEV)	22.368 CPS	
CH 38	(0.449 MEV)	21.963 CPS	
CH 39	(0.461 MEV)	20.882 CPS	
CH 40	(0.473 MEV)	21.472 CPS	
CH 41	(0.485 MEV)	20.737 CPS	
CH 42	(0.496 MEV)	21.513 CPS	
CH 43	(0.508 MEV)	20.193 CPS	
CH 44	(0.520 MEV)	19.160 CPS	
CH 45	(0.532 MEV)	18.979 CPS	
CH 46	(0.544 MEV)	19.398 CPS	
CH 47	(0.556 MEV)	20.251 CPS	
CH 48	(0.567 MEV)	22.881 CPS	
CH 49	(0.579 MEV)	26.927 CPS	
CH 50	(0.591 MEV)	31.780 CPS	
CH 51	(0.603 MEV)	32.825 CPS	
CH 52	(0.615 MEV)	33.768 CPS	
CH 53	(0.626 MEV)	29.078 CPS	
CH 54	(0.638 MEV)	24.230 CPS	
CH 55	(0.650 MEV)	18.437 CPS	
CH 56	(0.662 MEV)	15.442 CPS	
CH 57	(0.674 MEV)	13.172 CPS	
CH 58	(0.686 MEV)	12.595 CPS	
CH 59	(0.697 MEV)	11.549 CPS	
CH 60	(0.709 MEV)	11.322 CPS	
CH 61	(0.721 MEV)	11.325 CPS	
CH 62	(0.733 MEV)	11.673 CPS	
CH 63	(0.745 MEV)	11.000 CPS	
CH 64	(0.756 MEV)	12.680 CPS	
CH 65	(0.768 MEV)	12.397 CPS	
CH 66	(0.780 MEV)	11.807 CPS	
CH 67	(0.792 MEV)	10.963 CPS	
CH 68	(0.804 MEV)	11.206 CPS	
CH 69	(0.816 MEV)	9.619 CPS	
CH 70	(0.827 MEV)	9.365 CPS	
CH 71	(0.839 MEV)	8.322 CPS	
CH 72	(0.851 MEV)	8.182 CPS	
CH 73	(0.863 MEV)	8.003 CPS	
CH 74	(0.875 MEV)	8.008 CPS	
CH 75	(0.887 MEV)	7.960 CPS	
CH 76	(0.898 MEV)	8.271 CPS	
CH 77	(0.910 MEV)	8.304 CPS	
CH 78	(0.922 MEV)	8.425 CPS	
CH 79	(0.934 MEV)	8.047 CPS	
CH 80	(0.946 MEV)	8.854 CPS	
CH 81	(0.957 MEV)	8.317 CPS	
CH 82	(0.969 MEV)	7.979 CPS	
CH 83	(0.981 MEV)	7.030 CPS	
CH 84	(0.993 MEV)	7.207 CPS	
CH 85	(1.005 MEV)	6.625 CPS	
CH 86	(1.017 MEV)	6.446 CPS	
CH 87	(1.028 MEV)	6.030 CPS	
CH 88	(1.040 MEV)	6.262 CPS	
CH 89	(1.052 MEV)	6.419 CPS	BISMUTH 214
CH 90	(1.064 MEV)	7.101 CPS	
CH 91	(1.076 MEV)	7.395 CPS	
CH 92	(1.087 MEV)	8.260 CPS	
CH 93	(1.099 MEV)	9.201 CPS	
CH 94	(1.111 MEV)	10.045 CPS	
CH 95	(1.123 MEV)	9.903 CPS	
CH 96	(1.135 MEV)	11.003 CPS	
CH 97	(1.147 MEV)	9.916 CPS	
CH 98	(1.158 MEV)	9.786 CPS	
CH 99	(1.170 MEV)	8.459 CPS	
CH 100	(1.182 MEV)	7.986 CPS	BISMUTH 214
CH 101	(1.194 MEV)	7.052 CPS	
CH 102	(1.206 MEV)	6.988 CPS	
CH 103	(1.217 MEV)	6.315 CPS	
CH 104	(1.229 MEV)	6.556 CPS	
CH 105	(1.241 MEV)	6.150 CPS	
CH 106	(1.253 MEV)	6.702 CPS	
CH 107	(1.265 MEV)	6.204 CPS	
CH 108	(1.277 MEV)	5.983 CPS	
CH 109	(1.288 MEV)	5.746 CPS	
CH 110	(1.300 MEV)	5.434 CPS	
CH 111	(1.312 MEV)	4.886 CPS	
CH 112	(1.324 MEV)	5.166 CPS	
CH 113	(1.336 MEV)	5.057 CPS	
CH 114	(1.347 MEV)	5.163 CPS	
CH 115	(1.359 MEV)	5.200 CPS	
CH 116	(1.371 MEV)	5.920 CPS	POTASSIUM 40
CH 117	(1.383 MEV)	5.993 CPS	
CH 118	(1.395 MEV)	6.748 CPS	
CH 119	(1.407 MEV)	6.476 CPS	
CH 120	(1.418 MEV)	7.341 CPS	
CH 121	(1.430 MEV)	7.090 CPS	
CH 122	(1.442 MEV)	7.950 CPS	
CH 123	(1.454 MEV)	7.644 CPS	
CH 124	(1.466 MEV)	7.587 CPS	
CH 125	(1.477 MEV)	7.378 CPS	
CH 126	(1.489 MEV)	6.975 CPS	
CH 127	(1.501 MEV)	5.870 CPS	
CH 128	(1.513 MEV)	6.375 CPS	
CH 129	(1.525 MEV)	5.380 CPS	
CH 130	(1.537 MEV)	4.772 CPS	
CH 131	(1.548 MEV)	3.911 CPS	
CH 132	(1.560 MEV)	3.971 CPS	POTASSIUM 40
CH 133	(1.572 MEV)	3.460 CPS	
CH 134	(1.584 MEV)	3.435 CPS	
CH 135	(1.596 MEV)	3.057 CPS	
CH 136	(1.608 MEV)	3.119 CPS	
CH 137	(1.619 MEV)	2.882 CPS	
CH 138	(1.631 MEV)	3.036 CPS	
CH 139	(1.643 MEV)	2.700 CPS	
CH 140	(1.655 MEV)	2.772 CPS	
CH 141	(1.667 MEV)	2.903 CPS	BISMUTH 214
CH 142	(1.678 MEV)	3.275 CPS	
CH 143	(1.690 MEV)	3.247 CPS	
CH 144	(1.702 MEV)	4.118 CPS	
CH 145	(1.714 MEV)	4.152 CPS	
CH 146	(1.726 MEV)	4.917 CPS	
CH 147	(1.738 MEV)	5.101 CPS	
CH 148	(1.749 MEV)	6.169 CPS	
CH 149	(1.761 MEV)	6.099 CPS	
CH 150	(1.773 MEV)	6.473 CPS	
CH 151	(1.785 MEV)	6.018 CPS	
CH 152	(1.797 MEV)	5.984 CPS	
CH 153	(1.808 MEV)	5.355 CPS	
CH 154	(1.820 MEV)	5.159 CPS	
CH 155	(1.832 MEV)	4.225 CPS	
CH 156	(1.844 MEV)	3.843 CPS	
CH 157	(1.856 MEV)	3.270 CPS	BISMUTH 214
CH 158	(1.868 MEV)	2.754 CPS	
CH 159	(1.879 MEV)	2.213 CPS	
CH 160	(1.891 MEV)	2.231 CPS	
CH 161	(1.903 MEV)	1.797 CPS	
CH 162	(1.915 MEV)	1.692 CPS	
CH 163	(1.927 MEV)	1.268 CPS	
CH 164	(1.938 MEV)	1.250 CPS	
CH 165	(1.950 MEV)	1.169 CPS	
CH 166	(1.962 MEV)	0.943 CPS	
CH 167	(1.974 MEV)	0.798 CPS	
CH 168	(1.986 MEV)	0.929 CPS	
CH 169	(1.998 MEV)	0.729 CPS	
CH 170	(2.009 MEV)	0.840 CPS	
CH 171	(2.021 MEV)	0.694 CPS	
CH 172	(2.033 MEV)	0.673 CPS	
CH 173	(2.045 MEV)	0.665 CPS	
CH 174	(2.057 MEV)	0.810 CPS	
CH 175	(2.068 MEV)	0.728 CPS	
CH 176	(2.080 MEV)	0.797 CPS	
CH 177	(2.092 MEV)	0.938 CPS	
CH 178	(2.104 MEV)	1.006 CPS	
CH 179	(2.116 MEV)	1.035 CPS	
CH 180	(2.128 MEV)	1.289 CPS	
CH 181	(2.139 MEV)	1.183 CPS	
CH 182	(2.151 MEV)	1.333 CPS	
CH 183	(2.163 MEV)	1.345 CPS	
CH 184	(2.175 MEV)	1.607 CPS	
CH 185	(2.187 MEV)	1.433 CPS	
CH 186	(2.199 MEV)	1.619 CPS	
CH 187	(2.210 MEV)	1.444 CPS	
CH 188	(2.222 MEV)	1.503 CPS	
CH 189	(2.234 MEV)	1.559 CPS	
CH 190	(2.246 MEV)	1.428 CPS	
CH 191	(2.258 MEV)	1.164 CPS	
CH 192	(2.269 MEV)	1.277 CPS	
CH 193	(2.281 MEV)	0.984 CPS	
CH 194	(2.293 MEV)	0.793 CPS	
CH 195	(2.305 MEV)	0.828 CPS	
CH 196	(2.317 MEV)	0.670 CPS	
CH 197	(2.329 MEV)	0.564 CPS	
CH 198	(2.340 MEV)	0.495 CPS	
CH 199	(2.352 MEV)	0.463 CPS	
CH 200	(2.364 MEV)	0.383 CPS	
CH 201	(2.376 MEV)	0.477 CPS	
CH 202	(2.388 MEV)	0.510 CPS	
CH 203	(2.399 MEV)	0.456 CPS	
CH 204	(2.411 MEV)	0.519 CPS	THALLIUM 208
CH 205	(2.423 MEV)	0.548 CPS	
CH 206	(2.435 MEV)	0.438 CPS	
CH 207	(2.447 MEV)	0.472 CPS	
CH 208	(2.459 MEV)	0.554 CPS	
CH 209	(2.470 MEV)	0.453 CPS	
CH 210	(2.482 MEV)	0.459 CPS	
CH 211	(2.494 MEV)	0.438 CPS	
CH 212	(2.506 MEV)	0.445 CPS	
CH 213	(2.518 MEV)	0.404 CPS	
CH 214	(2.529 MEV)	0.453 CPS	
CH 215	(2.541 MEV)	0.371 CPS	
CH 216	(2.553 MEV)	0.413 CPS	
CH 217	(2.565 MEV)	0.358 CPS	
CH 218	(2.577 MEV)	0.407 CPS	
CH 219	(2.589 MEV)	0.402 CPS	
CH 220	(2.600 MEV)	0.438 CPS	
CH 221	(2.612 MEV)	0.436 CPS	
CH 222	(2.624 MEV)	0.423 CPS	
CH 223	(2.636 MEV)	0.328 CPS	
CH 224	(2.648 MEV)	0.402 CPS	
CH 225	(2.660 MEV)	0.431 CPS	
CH 226	(2.671 MEV)	0.290 CPS	
CH 227	(2.683 MEV)	0.289 CPS	
CH 228	(2.695 MEV)	0.332 CPS	
CH 229	(2.707 MEV)	0.285 CPS	
CH 230	(2.719 MEV)	0.230 CPS	
CH 231	(2.730 MEV)	0.164 CPS	
CH 232	(2.742 MEV)	0.166 CPS	
CH 233	(2.754 MEV)	0.116 CPS	
CH 234	(2.766 MEV)	0.128 CPS	
CH 235	(2.778 MEV)	0.042 CPS	
CH 236	(2.790 MEV)	0.135 CPS	
CH 237	(2.801 MEV)	0.063 CPS	THALLIUM 208
CH 238	(2.813 MEV)	0.075 CPS	
CH 239	(2.825 MEV)	0.054 CPS	
CH 240	(2.837 MEV)	0.090 CPS	
CH 241	(2.849 MEV)	0.069 CPS	
CH 242	(2.860 MEV)	0.071 CPS	
CH 243	(2.872 MEV)	0.053 CPS	
CH 244	(2.884 MEV)	0.049 CPS	
CH 245	(2.896 MEV)	0.004 CPS	
CH 246	(2.908 MEV)	0.079 CPS	
CH 247	(2.920 MEV)	-0.005 CPS	
CH 248	(2.931 MEV)	0.036 CPS	
CH 249	(2.943 MEV)	0.077 CPS	
CH 250	(2.955 MEV)	0.040 CPS	
CH 251	(2.967 MEV)	0.057 CPS	
CH 252	(2.979 MEV)	0.038 CPS	
CH 253	(2.990 MEV)	0.037 CPS	
CH 254	(3.002 MEV)	0.073 CPS	TOTAL COUNT
CH 255	(3.014 MEV)	0.000 CPS	

Figure 8

DERIVED COSMIC SPECTRUM FROM PACIFIC OCEAN DATA

DOWNWARD-LOOKING CRYSTAL SPECTRUM FOR LINE COSMIC, DATED 111376

TC (0-6 MEV) 6979.32 TC (0.4-3.0 MEV) 4162.15 COSMIC (3-6 MEV) 1000.00
U (1.12 MEV) 210.06 K (1.46 MEV) 232.21 U (1.76 MEV) 191.52 T (2.62 MEV) 266.04

COSMIC SPECTRUM
DOWNWARD LOOKING CRYSTALS
3072 CUBIC INCHES
DATE: 13 NOVEMBER 1976

CH	Energy	CPS	
CH 0	(0.000 MEV)	0.000 CPS	
CH 1	(0.012 MEV)	0.000 CPS	
CH 2	(0.024 MEV)	0.000 CPS	
CH 3	(0.035 MEV)	0.000 CPS	
CH 4	(0.047 MEV)	0.000 CPS	
CH 5	(0.059 MEV)	0.000 CPS	
CH 6	(0.071 MEV)	0.000 CPS	
CH 7	(0.083 MEV)	0.000 CPS	
CH 8	(0.095 MEV)	0.000 CPS	
CH 9	(0.106 MEV)	0.000 CPS	
CH 10	(0.118 MEV)	0.000 CPS	
CH 11	(0.130 MEV)	0.000 CPS	
CH 12	(0.142 MEV)	0.000 CPS	
CH 13	(0.154 MEV)	0.000 CPS	
CH 14	(0.165 MEV)	0.000 CPS	
CH 15	(0.177 MEV)	0.000 CPS	
CH 16	(0.189 MEV)	0.000 CPS	
CH 17	(0.201 MEV)	0.000 CPS	
CH 18	(0.213 MEV)	172.114 CPS	
CH 19	(0.225 MEV)	170.889 CPS	
CH 20	(0.236 MEV)	154.059 CPS	
CH 21	(0.248 MEV)	137.509 CPS	
CH 22	(0.260 MEV)	135.134 CPS	
CH 23	(0.272 MEV)	122.587 CPS	
CH 24	(0.284 MEV)	118.613 CPS	
CH 25	(0.295 MEV)	105.747 CPS	
CH 26	(0.307 MEV)	104.835 CPS	
CH 27	(0.319 MEV)	102.027 CPS	
CH 28	(0.331 MEV)	86.543 CPS	
CH 29	(0.343 MEV)	84.171 CPS	
CH 30	(0.355 MEV)	80.732 CPS	
CH 31	(0.366 MEV)	78.379 CPS	
CH 32	(0.378 MEV)	85.291 CPS	
CH 33	(0.390 MEV)	78.825 CPS	
CH 34	(0.402 MEV)	81.419 CPS	TOTAL COUNT
CH 35	(0.414 MEV)	73.614 CPS	
CH 36	(0.426 MEV)	76.877 CPS	
CH 37	(0.437 MEV)	78.056 CPS	
CH 38	(0.449 MEV)	78.313 CPS	
CH 39	(0.461 MEV)	84.096 CPS	
CH 40	(0.473 MEV)	96.119 CPS	
CH 41	(0.485 MEV)	108.620 CPS	
CH 42	(0.496 MEV)	109.624 CPS	
CH 43	(0.508 MEV)	113.727 CPS	
CH 44	(0.520 MEV)	107.962 CPS	
CH 45	(0.532 MEV)	85.653 CPS	
CH 46	(0.544 MEV)	64.157 CPS	
CH 47	(0.556 MEV)	51.713 CPS	
CH 48	(0.567 MEV)	45.024 CPS	
CH 49	(0.579 MEV)	42.061 CPS	
CH 50	(0.591 MEV)	33.769 CPS	
CH 51	(0.603 MEV)	33.895 CPS	
CH 52	(0.615 MEV)	32.399 CPS	
CH 53	(0.626 MEV)	31.137 CPS	
CH 54	(0.638 MEV)	34.748 CPS	
CH 55	(0.650 MEV)	35.309 CPS	
CH 56	(0.662 MEV)	37.459 CPS	
CH 57	(0.674 MEV)	33.586 CPS	
CH 58	(0.686 MEV)	31.659 CPS	
CH 59	(0.697 MEV)	29.947 CPS	
CH 60	(0.709 MEV)	31.901 CPS	
CH 61	(0.721 MEV)	29.149 CPS	
CH 62	(0.733 MEV)	28.087 CPS	
CH 63	(0.745 MEV)	25.855 CPS	
CH 64	(0.756 MEV)	28.409 CPS	
CH 65	(0.768 MEV)	21.907 CPS	
CH 66	(0.780 MEV)	27.685 CPS	
CH 67	(0.792 MEV)	26.313 CPS	
CH 68	(0.804 MEV)	23.799 CPS	
CH 69	(0.816 MEV)	26.652 CPS	
CH 70	(0.827 MEV)	29.048 CPS	
CH 71	(0.839 MEV)	24.796 CPS	
CH 72	(0.851 MEV)	29.017 CPS	
CH 73	(0.863 MEV)	23.528 CPS	
CH 74	(0.875 MEV)	25.874 CPS	
CH 75	(0.887 MEV)	23.469 CPS	
CH 76	(0.898 MEV)	20.121 CPS	
CH 77	(0.910 MEV)	20.440 CPS	
CH 78	(0.922 MEV)	22.125 CPS	
CH 79	(0.934 MEV)	19.780 CPS	
CH 80	(0.946 MEV)	18.444 CPS	
CH 81	(0.957 MEV)	16.881 CPS	
CH 82	(0.969 MEV)	20.899 CPS	
CH 83	(0.981 MEV)	23.508 CPS	
CH 84	(0.993 MEV)	19.073 CPS	
CH 85	(1.005 MEV)	22.230 CPS	
CH 86	(1.017 MEV)	20.641 CPS	
CH 87	(1.028 MEV)	20.892 CPS	BISMUTH 214
CH 88	(1.040 MEV)	22.821 CPS	
CH 89	(1.052 MEV)	21.165 CPS	
CH 90	(1.064 MEV)	21.564 CPS	
CH 91	(1.076 MEV)	16.483 CPS	
CH 92	(1.087 MEV)	18.311 CPS	
CH 93	(1.099 MEV)	16.744 CPS	
CH 94	(1.111 MEV)	16.970 CPS	
CH 95	(1.123 MEV)	15.104 CPS	
CH 96	(1.135 MEV)	14.605 CPS	
CH 97	(1.147 MEV)	17.817 CPS	
CH 98	(1.158 MEV)	16.271 CPS	BISMUTH 214
CH 99	(1.170 MEV)	17.539 CPS	
CH 100	(1.182 MEV)	17.487 CPS	
CH 101	(1.194 MEV)	17.838 CPS	
CH 102	(1.206 MEV)	14.032 CPS	
CH 103	(1.217 MEV)	14.178 CPS	
CH 104	(1.229 MEV)	18.193 CPS	
CH 105	(1.241 MEV)	18.241 CPS	
CH 106	(1.253 MEV)	15.496 CPS	
CH 107	(1.265 MEV)	14.376 CPS	
CH 108	(1.277 MEV)	15.196 CPS	
CH 109	(1.288 MEV)	13.926 CPS	
CH 110	(1.300 MEV)	15.915 CPS	
CH 111	(1.312 MEV)	15.692 CPS	
CH 112	(1.324 MEV)	15.901 CPS	
CH 113	(1.336 MEV)	13.433 CPS	
CH 114	(1.347 MEV)	16.528 CPS	POTASSIUM 40
CH 115	(1.359 MEV)	15.344 CPS	
CH 116	(1.371 MEV)	14.014 CPS	
CH 117	(1.383 MEV)	15.029 CPS	
CH 118	(1.395 MEV)	13.883 CPS	
CH 119	(1.407 MEV)	14.397 CPS	
CH 120	(1.418 MEV)	10.884 CPS	
CH 121	(1.430 MEV)	16.133 CPS	
CH 122	(1.442 MEV)	10.102 CPS	
CH 123	(1.454 MEV)	12.505 CPS	
CH 124	(1.466 MEV)	15.394 CPS	
CH 125	(1.477 MEV)	10.998 CPS	
CH 126	(1.489 MEV)	14.253 CPS	
CH 127	(1.501 MEV)	12.642 CPS	
CH 128	(1.513 MEV)	15.434 CPS	
CH 129	(1.525 MEV)	12.116 CPS	
CH 130	(1.537 MEV)	13.989 CPS	POTASSIUM 40
CH 131	(1.548 MEV)	16.116 CPS	
CH 132	(1.560 MEV)	14.320 CPS	
CH 133	(1.572 MEV)	17.051 CPS	
CH 134	(1.584 MEV)	15.344 CPS	
CH 135	(1.596 MEV)	13.793 CPS	
CH 136	(1.608 MEV)	14.310 CPS	
CH 137	(1.619 MEV)	13.485 CPS	
CH 138	(1.631 MEV)	11.972 CPS	
CH 139	(1.643 MEV)	12.681 CPS	BISMUTH 214
CH 140	(1.655 MEV)	14.299 CPS	
CH 141	(1.667 MEV)	13.829 CPS	
CH 142	(1.678 MEV)	11.729 CPS	
CH 143	(1.690 MEV)	11.918 CPS	
CH 144	(1.702 MEV)	12.025 CPS	
CH 145	(1.714 MEV)	14.498 CPS	
CH 146	(1.726 MEV)	12.799 CPS	
CH 147	(1.738 MEV)	10.698 CPS	
CH 148	(1.749 MEV)	9.880 CPS	
CH 149	(1.761 MEV)	10.666 CPS	
CH 150	(1.773 MEV)	9.306 CPS	
CH 151	(1.785 MEV)	9.212 CPS	
CH 152	(1.797 MEV)	12.053 CPS	
CH 153	(1.808 MEV)	11.861 CPS	
CH 154	(1.820 MEV)	9.780 CPS	
CH 155	(1.832 MEV)	11.015 CPS	BISMUTH 214
CH 156	(1.844 MEV)	9.863 CPS	
CH 157	(1.856 MEV)	10.387 CPS	
CH 158	(1.868 MEV)	12.619 CPS	
CH 159	(1.879 MEV)	10.527 CPS	
CH 160	(1.891 MEV)	11.191 CPS	
CH 161	(1.903 MEV)	10.913 CPS	
CH 162	(1.915 MEV)	10.659 CPS	
CH 163	(1.927 MEV)	11.293 CPS	
CH 164	(1.938 MEV)	10.898 CPS	
CH 165	(1.950 MEV)	10.456 CPS	
CH 166	(1.962 MEV)	11.140 CPS	
CH 167	(1.974 MEV)	10.627 CPS	
CH 168	(1.986 MEV)	10.712 CPS	
CH 169	(1.998 MEV)	10.889 CPS	
CH 170	(2.009 MEV)	10.003 CPS	
CH 171	(2.021 MEV)	9.218 CPS	
CH 172	(2.033 MEV)	10.980 CPS	
CH 173	(2.045 MEV)	10.742 CPS	
CH 174	(2.057 MEV)	9.416 CPS	
CH 175	(2.068 MEV)	9.822 CPS	
CH 176	(2.080 MEV)	11.359 CPS	
CH 177	(2.092 MEV)	9.484 CPS	
CH 178	(2.104 MEV)	9.442 CPS	
CH 179	(2.116 MEV)	8.592 CPS	
CH 180	(2.128 MEV)	9.467 CPS	
CH 181	(2.139 MEV)	10.618 CPS	
CH 182	(2.151 MEV)	10.421 CPS	
CH 183	(2.163 MEV)	9.586 CPS	
CH 184	(2.175 MEV)	10.214 CPS	
CH 185	(2.187 MEV)	11.148 CPS	
CH 186	(2.199 MEV)	10.484 CPS	
CH 187	(2.210 MEV)	11.398 CPS	
CH 188	(2.222 MEV)	11.814 CPS	
CH 189	(2.234 MEV)	10.070 CPS	
CH 190	(2.246 MEV)	10.286 CPS	
CH 191	(2.258 MEV)	8.929 CPS	
CH 192	(2.269 MEV)	12.110 CPS	
CH 193	(2.281 MEV)	10.233 CPS	
CH 194	(2.293 MEV)	11.301 CPS	
CH 195	(2.305 MEV)	8.406 CPS	
CH 196	(2.317 MEV)	10.414 CPS	
CH 197	(2.329 MEV)	9.191 CPS	
CH 198	(2.340 MEV)	9.936 CPS	
CH 199	(2.352 MEV)	7.909 CPS	
CH 200	(2.364 MEV)	10.196 CPS	
CH 201	(2.376 MEV)	8.679 CPS	
CH 202	(2.388 MEV)	8.275 CPS	
CH 203	(2.399 MEV)	7.381 CPS	THALLIUM 208
CH 204	(2.411 MEV)	8.310 CPS	
CH 205	(2.423 MEV)	7.690 CPS	
CH 206	(2.435 MEV)	9.226 CPS	
CH 207	(2.447 MEV)	7.508 CPS	
CH 208	(2.459 MEV)	8.005 CPS	
CH 209	(2.470 MEV)	8.621 CPS	
CH 210	(2.482 MEV)	8.737 CPS	
CH 211	(2.494 MEV)	7.666 CPS	
CH 212	(2.506 MEV)	9.203 CPS	
CH 213	(2.518 MEV)	8.002 CPS	
CH 214	(2.529 MEV)	8.200 CPS	
CH 215	(2.541 MEV)	8.095 CPS	
CH 216	(2.553 MEV)	8.421 CPS	
CH 217	(2.565 MEV)	8.017 CPS	
CH 218	(2.577 MEV)	8.480 CPS	
CH 219	(2.589 MEV)	8.098 CPS	
CH 220	(2.600 MEV)	7.967 CPS	
CH 221	(2.612 MEV)	6.443 CPS	
CH 222	(2.624 MEV)	7.595 CPS	
CH 223	(2.636 MEV)	7.143 CPS	
CH 224	(2.648 MEV)	8.357 CPS	
CH 225	(2.660 MEV)	7.129 CPS	
CH 226	(2.671 MEV)	8.194 CPS	
CH 227	(2.683 MEV)	7.497 CPS	
CH 228	(2.695 MEV)	7.652 CPS	
CH 229	(2.707 MEV)	7.408 CPS	
CH 230	(2.719 MEV)	7.050 CPS	
CH 231	(2.730 MEV)	6.915 CPS	
CH 232	(2.742 MEV)	7.485 CPS	
CH 233	(2.754 MEV)	6.699 CPS	
CH 234	(2.766 MEV)	7.271 CPS	
CH 235	(2.778 MEV)	7.710 CPS	
CH 236	(2.790 MEV)	7.084 CPS	THALLIUM 208
CH 237	(2.801 MEV)	8.166 CPS	
CH 238	(2.813 MEV)	7.656 CPS	
CH 239	(2.825 MEV)	6.603 CPS	
CH 240	(2.837 MEV)	7.483 CPS	
CH 241	(2.849 MEV)	7.075 CPS	
CH 242	(2.860 MEV)	7.071 CPS	
CH 243	(2.872 MEV)	6.716 CPS	
CH 244	(2.884 MEV)	7.402 CPS	
CH 245	(2.896 MEV)	7.190 CPS	
CH 246	(2.908 MEV)	7.955 CPS	
CH 247	(2.920 MEV)	7.477 CPS	
CH 248	(2.931 MEV)	7.509 CPS	
CH 249	(2.943 MEV)	6.527 CPS	
CH 250	(2.955 MEV)	7.094 CPS	
CH 251	(2.967 MEV)	6.983 CPS	
CH 252	(2.979 MEV)	7.353 CPS	
CH 253	(2.990 MEV)	6.967 CPS	TOTAL COUNT
CH 254	(3.002 MEV)	6.443 CPS	
CH 255	(3.014 MEV)	1000.000 CPS	

Figure 9

Since the measurements were taken over a relatively short time period (4 hours), it was assumed that the matrix pad measurements contain not only the effects of the matrix pad itself, but also aircraft background (which is a constant), cosmic background (constant over the time period of interest), and all other local backgrounds (e.g., BiAir, etc.) effects. Thus, by subtracting the matrix pad count rates from the count rates in the four other pads, we have eliminated aircraft and cosmic background and BiAir effects for the four pads. The pad concentrations are then modified in a similar fashion by the subtraction of the matrix pad concentrations. Thus, the count rate data, after subtracting out the matrix pad count rate data can be related directly to the effects of the differential concentrations in the four pads (K, U, T and mixed). The differential concentrations in the pads are given in the table below:

PAD	K	U	T
K-Matrix	3.8%	2.9 ppm	2.2 ppm
U-Matrix	0.6%	28.5 ppm	2.9 ppm
T-Matrix	0.6%	3.0 ppm	39.0 ppm
Mixed-Matrix	2.7%	18.8 ppm	11.3 ppm

Considering the above, we now define a functional relationship using these data, which will provide a method of determining the calibration constants for the spectrometer system. These calibration constants are the sensitivities, in count rate per unit elemental concentrations, and the interactions which occur between the elemental channels in the system (Compton scatter coefficients, etc.).

Keeping in mind that we are dealing with the count rates corresponding to the concentrations presented in the last table, we define the following:

KC = uncorrected system count rate for the K channel

UC = uncorrected system count rate for the U channel

TC = uncorrected system count rate for the T channel

K = the percent differential concentration of potassium

U = ppm differential concentration of uranium

T = ppm differential concentration of thorium

We also define the following:

ζ_{kk} = sensitivity of KC to concentrations of K

ζ_{ku} = sensitivity of KC to concentrations of U

ζ_{kt} = sensitivity of KC to concentrations of T

ζ_{uk} = sensitivity of UC to concentrations of K

ζ_{uu} = sensitivity of UC to concentrations of U

ζ_{ut} = sensitivity of UC to concentrations of T

ζ_{tk} = sensitivity of TC to concentrations of K

ζ_{tu} = sensitivity of TC to concentrations of U

ζ_{tt} = sensitivity of TC to concentrations of T

We must now solve for the above nine variables to define the system's overall sensitivity. On the basis of an ideal situation, one would anticipate that some of these variables should be equal to 0. This is not totally the case, since we are dealing with a system which has less than infinite resolving power (e.g., the energies are smeared to some extent). Thus, a spectrum of a given element has a Gaussian shape rather than a pure line spectrum. Additionally, we are dealing with finite spectral windows, multiple peaked spectra, and pulse pile-up; all tend to couple each window's response to the other.

Using the foregoing, we can write nine equations, one set for each of the three (K, U and T) pads.

<u>K pad</u>

$$KC = \zeta_{kk}K + \zeta_{ku}U + \zeta_{kt}T$$

$$UC = \zeta_{uk}K + \zeta_{uu}U + \zeta_{ut}T$$

$$TC = \zeta_{tk}K + \zeta_{tu}U + \zeta_{tt}T$$

<u>U pad</u>

$$KC = \zeta_{kk}K + \zeta_{ku}U + \zeta_{kt}T$$

$$UC = \zeta_{uk}K + \zeta_{uu}U + \zeta_{ut}T$$

$$TC = \zeta_{tk}K + \zeta_{tu}U + \zeta_{tt}T$$

<u>T pad</u>

$$KC = \zeta_{kk}K + \zeta_{ku}U + \zeta_{kt}T$$

$$UC = \zeta_{uk}K + \zeta_{uu}U + \zeta_{ut}T$$

$$TC = \zeta_{tk}K + \zeta_{tu}U + \zeta_{tt}T$$

Separating these equations into consistent groups we get

$$(\text{K pad}) \quad KC = \zeta_{kk}K_k + \zeta_{ku}U_k + \zeta_{kt}T_k$$

$$(\text{U pad}) \quad KC = \zeta_{kk}K_u + \zeta_{ku}U_u + \zeta_{kt}T_u$$

$$(\text{T pad}) \quad KC = \zeta_{kk}K_t + \zeta_{ku}U_t + \zeta_{kt}T_t$$

Where K_k = concentration of K in K pad, K_u = concentration of K in U pad, and K_t = concentration of K in the T pad.

The equations can be expressed in matrix form

$$\begin{pmatrix} KC_k \\ KC_u \\ KC_t \end{pmatrix} = \begin{pmatrix} K_k & U_k & T_k \\ K_u & U_u & T_u \\ K_t & U_t & T_t \end{pmatrix} \cdot \begin{pmatrix} \zeta_{kk} \\ \zeta_{ku} \\ \zeta_{kt} \end{pmatrix}$$

Where the k, u and t subscripts represent the K, U and T pads.

In a similar manner we can write the other two matrix equations for UC and TC respectively.

$$\begin{pmatrix} UC_k \\ UC_u \\ UC_t \end{pmatrix} = \begin{pmatrix} K_k & U_k & T_k \\ K_u & U_u & T_u \\ K_t & U_t & T_t \end{pmatrix} \cdot \begin{pmatrix} \zeta_{uk} \\ \zeta_{uu} \\ \zeta_{ut} \end{pmatrix}$$

$$\begin{pmatrix} TC_k \\ TC_u \\ TC_t \end{pmatrix} = \begin{pmatrix} K_k & U_k & T_k \\ K_u & U_u & T_u \\ K_t & U_t & T_t \end{pmatrix} \cdot \begin{pmatrix} \zeta_{tk} \\ \zeta_{tu} \\ \zeta_{tt} \end{pmatrix}$$

In matrix form, these equations can be expressed in the general form of

$$\overline{A} = \overline{B} \cdot \overline{\zeta} \quad \text{or} \quad \overline{\zeta} = \overline{B}^{-1} \cdot \overline{A}$$

where $\overline{A}$ is the count rate matrix, $\overline{B}$ is the matrix of the known concentrations matrix, and $\overline{\zeta}$ the sensitivity matrix. We now have a functional relationship from which to derive all the sensitivity coefficients.

In order to calculate the concentrations in the unknown pad, we rewrite the equation as $\overline{B} = \overline{A} \cdot \overline{\zeta}^{-1}$ and define $\overline{\zeta}^{-1} = \overline{\Delta}$. Expanding we have:

$$\begin{pmatrix} K_m \\ U_m \\ T_m \end{pmatrix} = \begin{pmatrix} \Delta_{kk} & \Delta_{ku} & \Delta_{kt} \\ \Delta_{uk} & \Delta_{uu} & \Delta_{ut} \\ \Delta_{tk} & \Delta_{tu} & \Delta_{tt} \end{pmatrix} \begin{pmatrix} KC_m \\ UC_m \\ TC_m \end{pmatrix}$$

where the subscript m refers to the mixed pad. Expanding this in algebraic form we obtain the following set of equations:

$$K_m = \Delta_{kk} \left(KC_m + \frac{\Delta_{ku}}{\Delta_{kk}} UC_m + \frac{\Delta_{kt}}{\Delta_{kk}} TC_m\right)$$

$$U_m = \Delta_{uu} \left(UC_m + \frac{\Delta_{ut}}{\Delta_{uu}} TC_m + \frac{\Delta_{uk}}{\Delta_{uu}} KC_m\right)$$

$$T_m = \Delta_{tt} \left(TC_m + \frac{\Delta_{tu}}{\Delta_{tt}} UC_m + \frac{\Delta_{tk}}{\Delta_{tt}} KC_m\right)$$

where all count rates are observed values minus the matrix pads.

The terms in parenthesis in the above 3 equations are the "corrected stripped count rates" for the system. (These stripping coefficients are defined in terms of the S_{ij} in order to eliminate confusion with α, β, γ which are sometimes defined slightly differently). The results are defined as follows:

$$S_{ku} = \frac{\Delta_{ku}}{\Delta_{kk}} \quad \text{(effect of uranium on potassium)}$$

$$S_{kt} = \frac{\Delta_{kt}}{\Delta_{kk}} \quad \text{(effect of thorium on potassium)}$$

$$S_{ut} = \frac{\Delta_{ut}}{\Delta_{uu}} \quad \text{(effect of thorium on uranium)}$$

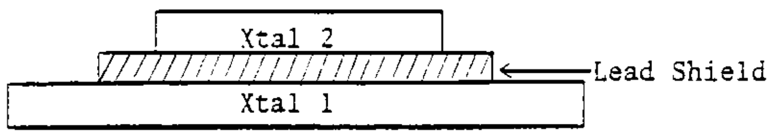
$$S_{uk} = \frac{\Delta_{uk}}{\Delta_{uu}} \quad \text{(effect of potassium on uranium)}$$

$$S_{tu} = \frac{\Delta_{tu}}{\Delta_{tt}} \quad \text{(effect of uranium on thorium)}$$

$$S_{tk} = \frac{\Delta_{tk}}{\Delta_{tt}} \quad \text{(effect of potassium on thorium)}$$

ATMOSPHERIC RADON CORRECTION

Consider the crystal configuration shown below:



Let 1 and 2 designate the down and up crystal respectively. The down crystal sees radiation rates of I_1 composed of the air signal I_a and the ground signal I_g plus aircraft and cosmic background.

therefore $\quad I_1 = I_g + I_a + A_1 + C_1$

Similarly, the up crystal sees the air signal and ground signal (both somewhat attenuated) plus an aircraft and cosmic background.

therefore $\quad I_2 = I_g + mI_a + A_2 + C_2$

Where m is the response to the air signal and ℓ is the % of the ground signal getting through to the up detector.

Using the test pad data, the factor ℓ can be determined. Consider the two previous equations. When we subtract the matrix pad data from the K, U, and T pad data, we have essentially set A_1, A_2, C_1, and C_2 and I_a equal to zero.

therefore: $\quad I_1 = I_g$

$\quad I_2 = \ell I_g$

or $\quad \ell = \dfrac{I_2}{I_1}$

Instead of using the count rates we can use the resultant sensitivities $1/\Delta_{uu}$ to determine ℓ for the elemental channel U.

$$\ell_u = \frac{1/\Delta_{uu\ (up)}}{1/\Delta_{uu\ (down)}}$$

It should be noted that due to "shine around" (since the shielding is not an infinite plane, the upward looking crystal responds to the surrounding terrain) on the test pads, as altitude increases, ℓ should decrease, thus $\ell = f(h)$.

Only the factor m remains to be determined. This unfortunately cannot be determined from test pad data. It can however be determined by flying over water (e.g. use of the Lake Mead over-water data).

Consider the equations for I_1 and I_2 again

$$I_1 - I_g + I_a + A_1 + C_1$$

$$I_2 = \ell I_g + mI_a + A_2 + C_2$$

Over water $I_g = 0$

We have A_1, A_2, C_1, and C_2 defined.

Removing the aircraft and cosmic background from the over water data and we are left with

$$I_1 = I_a$$

$$I_2 = mI_a$$

Since m is the shielding factor response to the air signal, we should have an air signal to "shield". Thus m is best determined if there is radon present.

Both up and down counting rates are corrected for aircraft and cosmic background and so we can solve the following two equations for I_a.

$$I_1 = I_g + I_a$$

$$I_2 = \ell I_g + mI_a$$

$$mI_a = I_2 - \ell I_g$$

but $I_g = I_1 - I_a$

then $I_a\ (m-\ell) = I_2 - \ell I_1$

or $$I_a = \frac{I_2 - \ell I_1}{m - \ell} = \text{Bi Air}$$

and I_a is then the Bi Air contribution from the surrounding air. This is then subtracted from the down looking U count resulting in corrected data.

DATA PROCESSING

DATA PREPARATION

The following sections summarize the techniques used for reduction and processing of the airborne data.

Field Tape Verification and Edit

The field data tapes containing the airborne data are read into the computer to verify the recording and data quality. Data recovery is essentially 100% from the field tapes. During this phase, statistics are generated summarizing the altitude (radar and barometric), ground speed and air temperature for each flight line. Simultaneously, the spectral peaks are evaluated for shifts using a centroid calculation and the particular windows peak channel. The data are also checked for correct scan lengths, proper justification of data fields within each scan and live time calculations are made. During this process, the desired window data fields are compared with the sum over the same windows in the spectra and then extracted from each scan and re-written as a reformatted copy tape.

The reformatted tape data are then edited, checked and corrected. The data for each flight line are then read (with aborted or unnecessary flight line data edited out) and each data variable is checked for consistency, data spikes, gradients, etc. Every correction suggested by the computer is evaluated by the data processing personnel prior to actual correction. Upon completion of this phase, the data on the output tape are "clean" and ready for subsequent correction of the radiometrics and magnetic tieing.

Flight Line Location

A single frame 35 mm camera is used for obtaining position recovery information. (Doppler systems are not generally used for primary navigation, but only as guides for flying straight lines and subsequently for interpolation along a line between photographically-determined fixes). The photo locations are spotted or transferred to a suitable base map and are digitized.

The fiducial numbers of the spotted points along each line are logged and punched on Hollerith data processing cards. A computer program is used to check the consistency of these data using calculated intersections from tie line to tie line and from traverse to traverse. This program allows easy detection of keypunching and logging errors as well as potential flight path recovery errors.

A computer program then calculates the map location for each intersection and the beginning and end of each line based on the fiducial numbers and the control line/tie line grid. A computer plot is made of these locations to check against the field plot and correct editing information. This resulting location information is then merged with the geophysical data using the fiducial numbers as common reference.

RADIOMETRIC DATA REDUCTION

Reduction of these data was carried out utilizing system calibration constants as derived from over water flights, Lake Mead Dynamic Test Range, and the Walker Field Test Pads. The data reduction sequence used may be summarized as follows: (See Figure 10 for Flow Diagram)

1. Spectrum stabilization
2. Dead time correction
3. Aircraft and cosmic background correction
4. Compton stripping
5. Radon correction
6. Altitude correction
7. Data plots
8. Statistical analysis

Processing of the data were performed using the window energies given below:

Total count - 0.4 to 3.0 MeV

K - 1.32 to 1.64 MeV

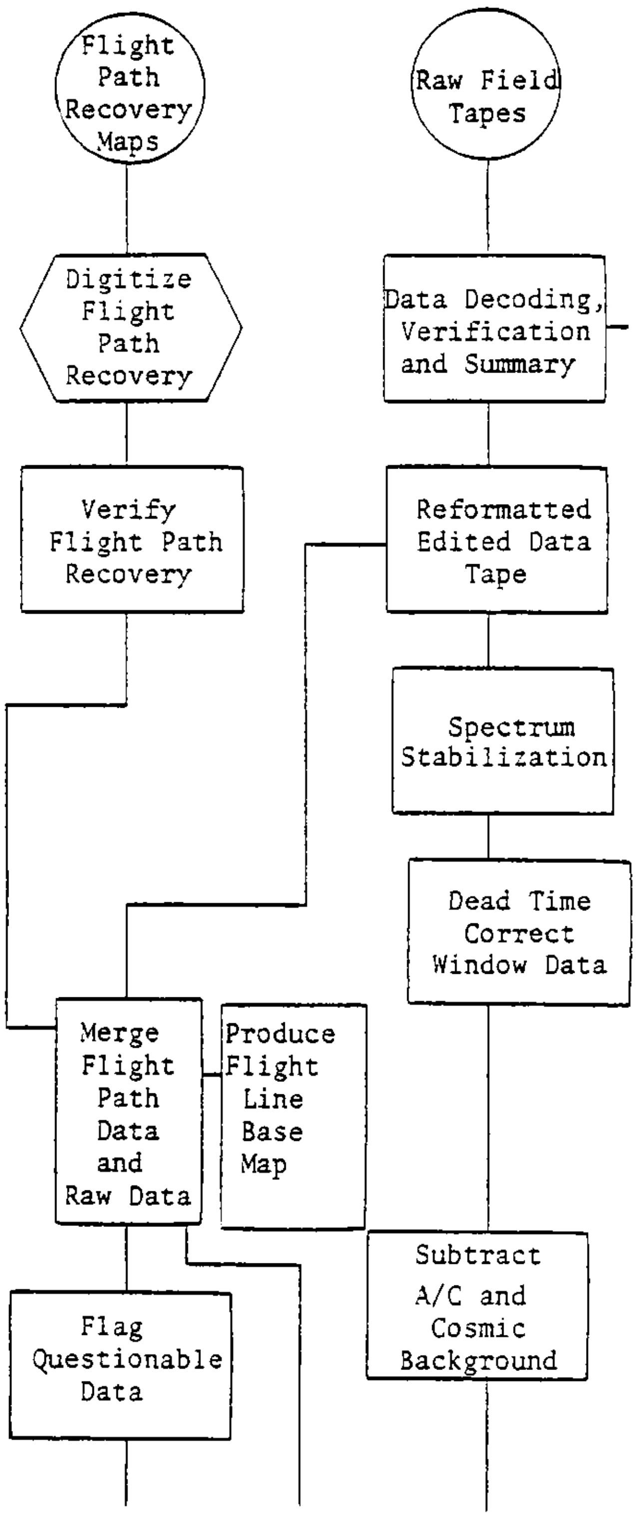
U - 1.05 to 1.32 MeV
1.64 to 2.41 MeV

T - 2.41 to 2.79 MeV

Cosmic - 3 to 6 MeV

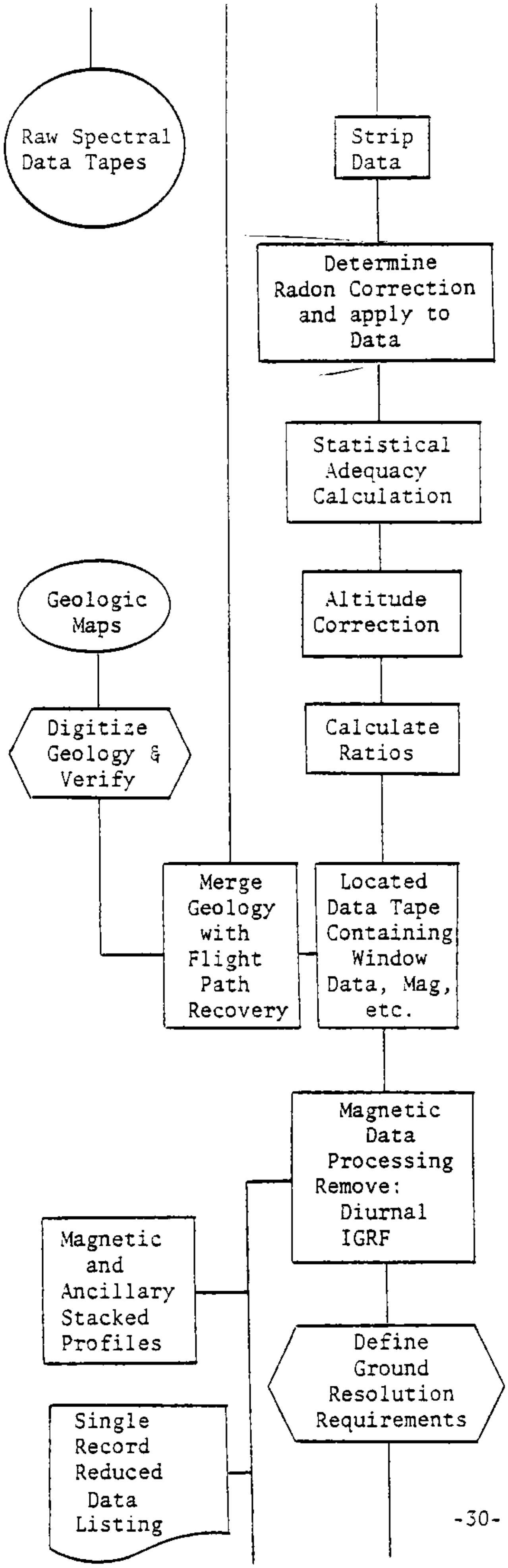
DATA PROCESSING FLOW DIAGRAM

Figure 10



This step performs the following:

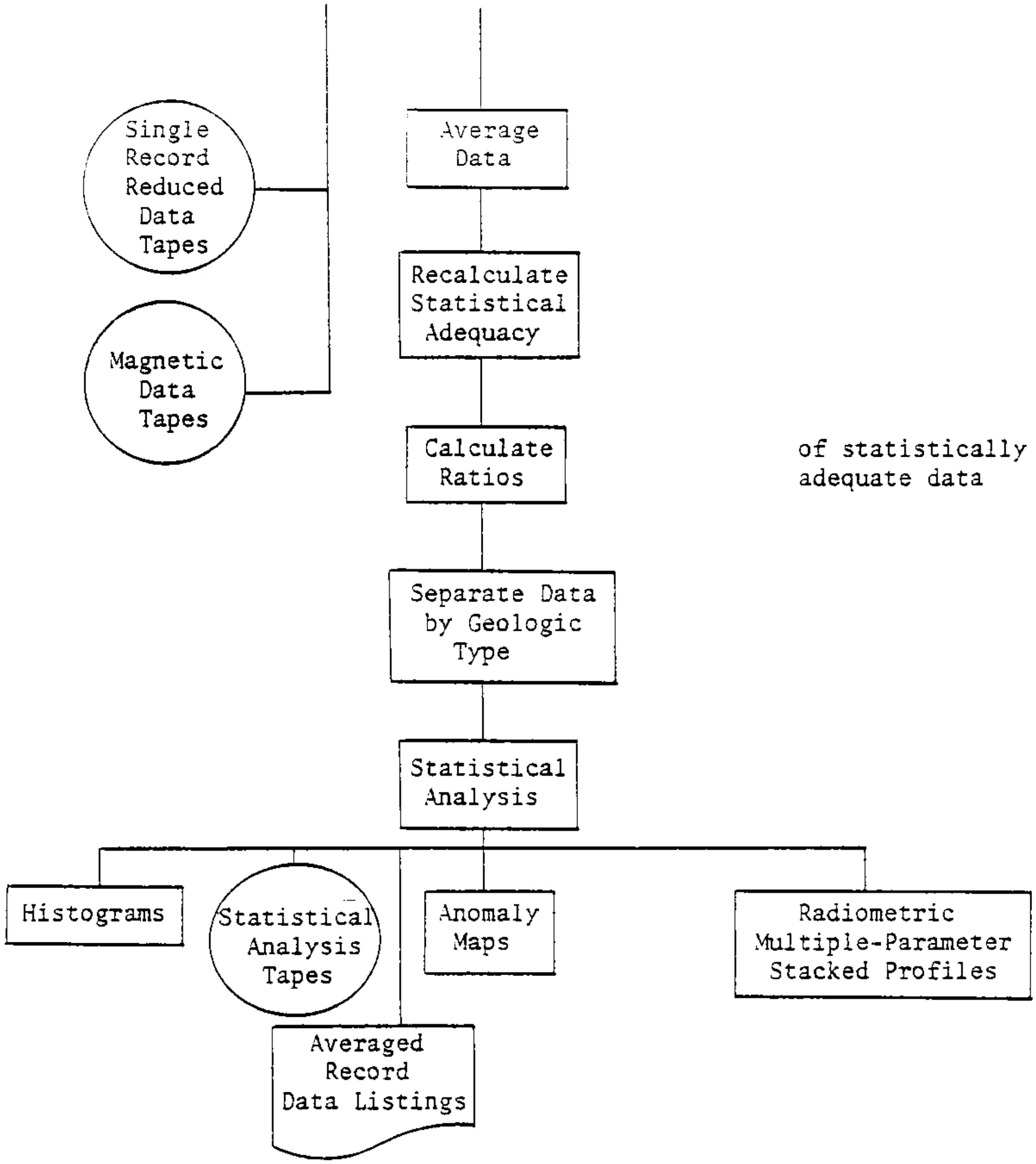
- System live time calculation
- Centroid calculation of K,U,T peaks stability determination
- Compares window output with spectral sums over windows
- Checks for spiking, etc.
- Produces line based statistics and histograms for ground speed, radar and barometric altitude, outside air temperature, cosmic up and down
- Edits data



Down crystals stripped with $S_{ut} = f\ (h)$ with all other factors constants. Up crystals stripped via down coupling factor.

Use crystal coupling equation to strip and determine radon to be subtracted from down looking crystal.

of statistically adequate data


Single Record Reduced Data Tapes
Magnetic Data Tapes
Average Data
Recalculate Statistical Adequacy
Calculate Ratios
of statistically adequate data
Separate Data by Geologic Type
Statistical Analysis
Histograms
Statistical Analysis Tapes
Averaged Record Data Listings
Anomaly Maps
Radiometric Multiple-Parameter Stacked Profiles

Aircraft and Cosmic background for the Fixed Wing Aircraft over these windows described above are summarized below:

AIRCRAFT BACKGROUND		COSMIC BACKGROUND*
T.C.	1304.53 cps	4.162 cps
K	144.49 cps	0.376 cps
U	312.51 cps	1.074 cps
T	11.83 cps	0.262 cps

* These are in cps per 1.0 cps in the 3-6 MeV window

The selected windows (pg. 28) were utilized in the downward and upward looking configuration. Compton corrections to the down data were made using the following constants:

S_{ku}	0.339
S_{kt}	0.171
S_{ut}	1.39
S_{uk}	0.53
S_{tu}	0.021
S_{tk}	-0.011

where the subscripts ij represent the influence of the j^{th} channel on the i^{th} channel.

All parameters except for S_{ut} are considered constants. S_{ut} was considered an altitude dependent parameter utilizing the following expression (after Grasty).

$S_{ut} = S_{ut_o} + 0.0076h$ where h is the altitude in hundreds of feet.

Altitude attenuation coefficients used are defined as follows:

μ_{TC} = (-0.00165) per foot

μ_K = (-0.00244) per foot

μ_U = (-0.00113) per foot

μ_T = (-0.00179) per foot

All radiometric data presented in the strip charts have been normalized to 400 feet mean terrain clearance using the expression

$$\exp\left[\mu_i \cdot (400-h)\right]$$

where h is the height in feet, and μ_i is the appropriate altitude attenuation coefficient. In cases where the altitude exceeds 1000 feet, the correction coefficients were limited to the 1000 foot value.

Bi Air calculations are made using the following expression:

$$Bi_{Air} = \frac{U_{up} - \ell \left(R_{us} + \frac{C'_{uk}}{C'_{uu}} R_{ks} + \frac{C'_{ut}}{C'_{uu}} R_{ts}\right)}{m - \ell}$$

where U_{up} = count rate from upward detectors

ℓ = crystal coupling constant

m = crystal geometric factor

C'_{uk}, C'_{ut}, C'_{uu} = stripping coeficients relating down data to up data

R_{us} = stripped uranium count rate - down system

R_{ks} = stripped potassium count rate - down system

R_{ts} = stripped thorium count rate - down system

The numerical values for the constant ℓ, m, C'_{uk}, C'_{ut}, and C'_{uu} are given below:

C'_{uk} = 0.03554

C'_{uu} = 0.05540

C'_{ut} = 0.1066

ℓ = 0.0666 - 0.0000318 (h), where h is in feet

m = 0.325 - 0.00005 (h), where h is in feet

These Bi Air data and the cosmic data are then averaged over a period of 25 seconds (using a running average operator 25 points wide). The resulting data are then removed, on a point by point basis, from the corrected window data.

MAGNETIC DATA REDUCTION

The magnetic data reduction processes are correction for diurnal variations, tieing to a common magnetic datum, and "de-trending" by subtracting the regional magnetic field as defined by the IGRF.

The diurnal magnetic field is monitored by a ground-based magnetometer that samples every four seconds at a sensitivity of one-quarter gamma. These data are recorded on magnetic tape along with the time for synchronization with the airborne data.

The diurnal data are edited to keep only those readings taken during flight time and to remove spikes and man-made magnetic events. They are displayed as profile data after editing to ensure that all corrections have been made. They are then merged with the airborne data, using time for synchronization, interpolated, and subtracted from the airborne magnetic data.

These diurnally corrected magnetic data are then processed by a tieing program that compares the magnetic differences at intersections of flight lines and tie lines. It calculates an individual magnetic field bias for each flight and tie line that will minimize the misties throughout the survey. These biases usually represent, after diurnal correction, systematic magnetic changes such as heading error, changes in location of the ground-based magnetometer, or changes in the airborne equipment. The biases are manually evaluated and selectively applied.

The 1975 IGRF (updated to the survey date) is then subtracted from the diurnally corrected, tied magnetic data yielding the reported residual magnetic field.

STATISTICAL ANALYSIS

STATISTICAL ADEQUACY TEST

The results of the data processing phase are single record samples (1.0 second sample interval). These data are then evaluated for statistical adequacy prior to altitude correction to ensure that they are significant within the context of the anticipated errors in count statistics. The statistical adequacy of a single data sample can be defined as the validity of that data sample to represent the actual count rate expected from the source being observed.

We can define three separate criteria for detection thresholds (ref. Currie, Analytical Chemistry, Vol. 40, No. 3, March, 1968) of which only one is directly applicable to our case; this is the critical level. The critical level is that level at which the decision is made that a signal is "detected". We thus define the "Statistical Adequacy" test level as being this critical level.

Setting of the actual levels in counts per second for each elemental window is difficult at best since a full analysis of all parameters is not known to a sufficient degree of certainty. However, in general, most of the errors which accumulate in the data can be ascribed to the corrections applied, if these corrections are a significant portion of the count rate. The corrections applied to these data are distributed in a Poisson manner and the following assumptions concerning them are made:

1. In the best case, the error propagation in each correction is cumulative (in the additive sense).
2. The sum of these corrections is also best represented by a Poisson distribution.
3. The uncertainty in the correction itself is equal to the square root of the correction applied.
4. This uncertainty is directly reflected in the corrected single record count rate.

With these assumptions in mind, the criterion for determining the statistical adequacy of a given data sample may be defined as follows:

> If a single record data sample exceeds 1.5 times the square root of the summed correction applied to that data sample, then that resultant data sample is considered to be statistically adequate.

During the course of the processing, all corrections applied to each data sample are retained. These corrections are then used as defined above to determine the statistical adequacy for each element in the single sample record. Any calculations using statistically inadequate data are also statistically inadequate (such as ratios calculated from statistically inadequate data).

The results of this statistical adequacy test are then utilized to determine an optimum interval over which the data should be averaged (e.g., 5 seconds or 7 seconds, etc.) in order to reduce the number of statistically inadequate samples to 5% or lower. In the case of this project, the resulting averaging sample interval was 5 seconds. This resulted in 97% or better of all data defined to be statistically adequate, exclusive of those data which were outside of altitude specifications. (The overall altitude specification was maintained at the 99% level).

HYPOTHESIS TESTING

It is generally accepted that correlations between radiometric parameters (count rates of K, U, T and their ratios and corresponding geology) can be described by normal (Gaussian) and log normal distributions. To date, the limited volume of data processed in this manner has neither proven nor disproven this hypothesis. It is felt however that once an adequate data base has been accumulated, more definitive results can be obtained. The East Salina Basin project necessarily represents a "small sample" of the possible variety of count rates associated with similar geologic units in the United States and the data are treated in a conventional manner, presented below.

All data (K, U, T and three ratios) are sorted in accordance with ground location and associated geologic type. They are then grouped such that each of the geologic types is represented by a distribution of count rates and ratios. A modified Chi Square testing scheme is utilized to evaluate the following two hypotheses:

1. The count rate distribution for a specified geologic type can be best represented by a normal distribution.

2. The count rate distribution for a specified geologic type can be best represented by a log normal distribution.

In addition to the Chi Square Test, all geological units are plotted as histograms and compared with the results of the hypothesis testing to clarify any ambiguities. Each radiometric parameter for a given geologic type is then classified as either a normal or log normal distribution. The measure of central tendency and dispersion for each of these distributions are then utilized as a basis for determining which data are anomalous within a given unit. A sample of such a histogram distribution is presented in Figure 11.

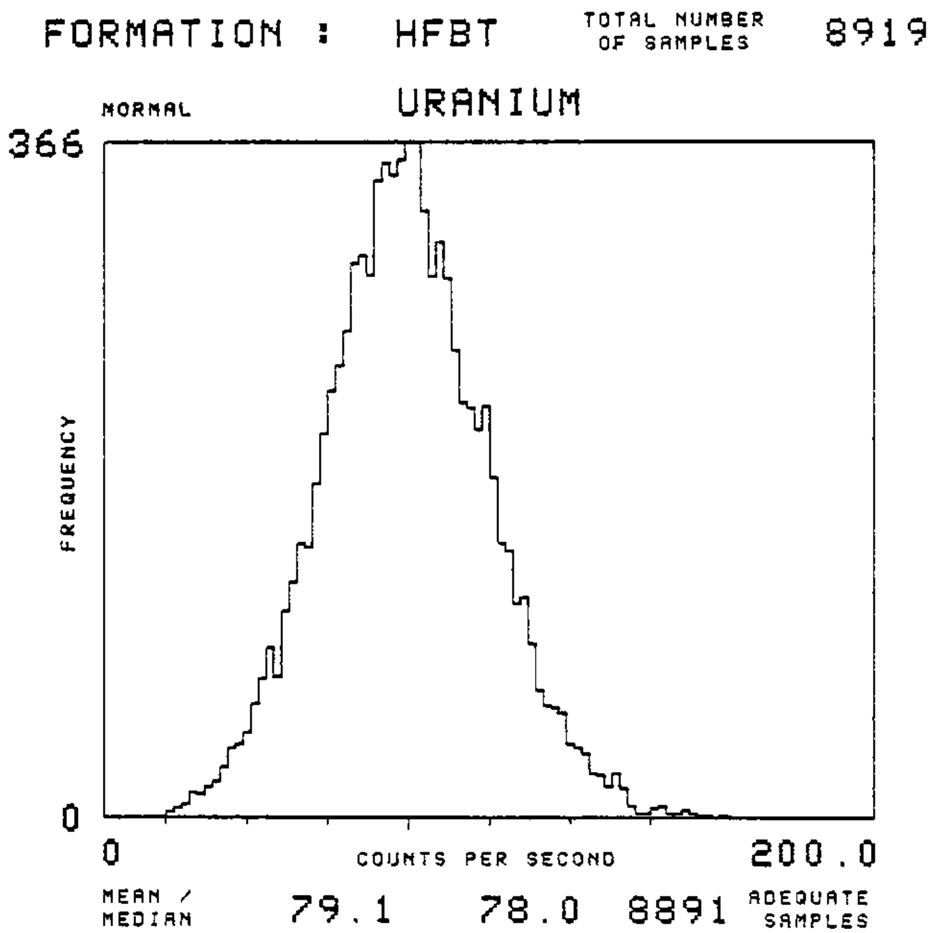


Figure 11. Sample Histogram

DATA PRESENTATION

GENERAL

Several other forms of data presentation are contained in this report. These include the uranium anomaly/interpretation maps and Pseudo-contour maps of potassium, uranium, thorium and magnetic data. These are integrated as part of the text in the interpretation section. In addition to these data, Volume II contains a group of data presented in the form of radiometric profiles, flight path recovery maps, anomaly maps and histograms. Microfiche data listings are contained in Appendix J of this volume and data tapes are available separately.

RADIOMETRIC PROFILES

Stacked profiles were prepared for the averaged data for each traverse and tie line. These stacked profiles, plotted at a linear scale of 1:250,000, contain the following parameters: corrected Total Count, corrected Potassium, corrected Uranium, corrected Thorium, U/TH, U/K and TH/K ratios, Bi Air, radar altimeter, and magnetometer data. Each of the stacked profile sheets contains a plot of the flight path superimposed on a geologic strip over which the aircraft flew. Included along these profiles are the fiducial numbers which correspond to flight path position as displayed on the flight path recovery maps. Each of the stacked profiles represents the data contained on the specific flight line within the boundaries of the specified NTMS Quadrangle sheet.

Radiometric traces on the stacked profiles contain an indicator showing those data which are statistically inadequate. These statistically inadequate data are marked by a small vertical tick at the sample location. The altitude profile has been limited in display to 1000 feet. A dashed line at the 700 foot level is presented to show those data which do not meet the altitude specifications. The vertical scale of each variable remains constant on all stacked profiles. When overranging occurs, the trace is stepped and the step labeled showing the actual value. A pictorial representation of such a stepping profile is shown in Figure 12. At the end of each stacked profile, a statistical summary of the minimum value, maximum value, mean, and standard deviation for that variable is presented.

Contained in Volume II of this report are an equivalent set of stacked profiles for each quadrangle, photographically reduced to an approximate scale of 1:500,000.

MAGNETIC PROFILES

A set of profiles containing the magnetic data (corrected, with IGRF removed), barometric altimeter data, radar altimeter, diurnal monitor data, and temperature data are presented at a linear scale of 1:250,000. Each of the stacked profiles contains a plot of the flight path superimposed on the geology over which the aircraft flew.

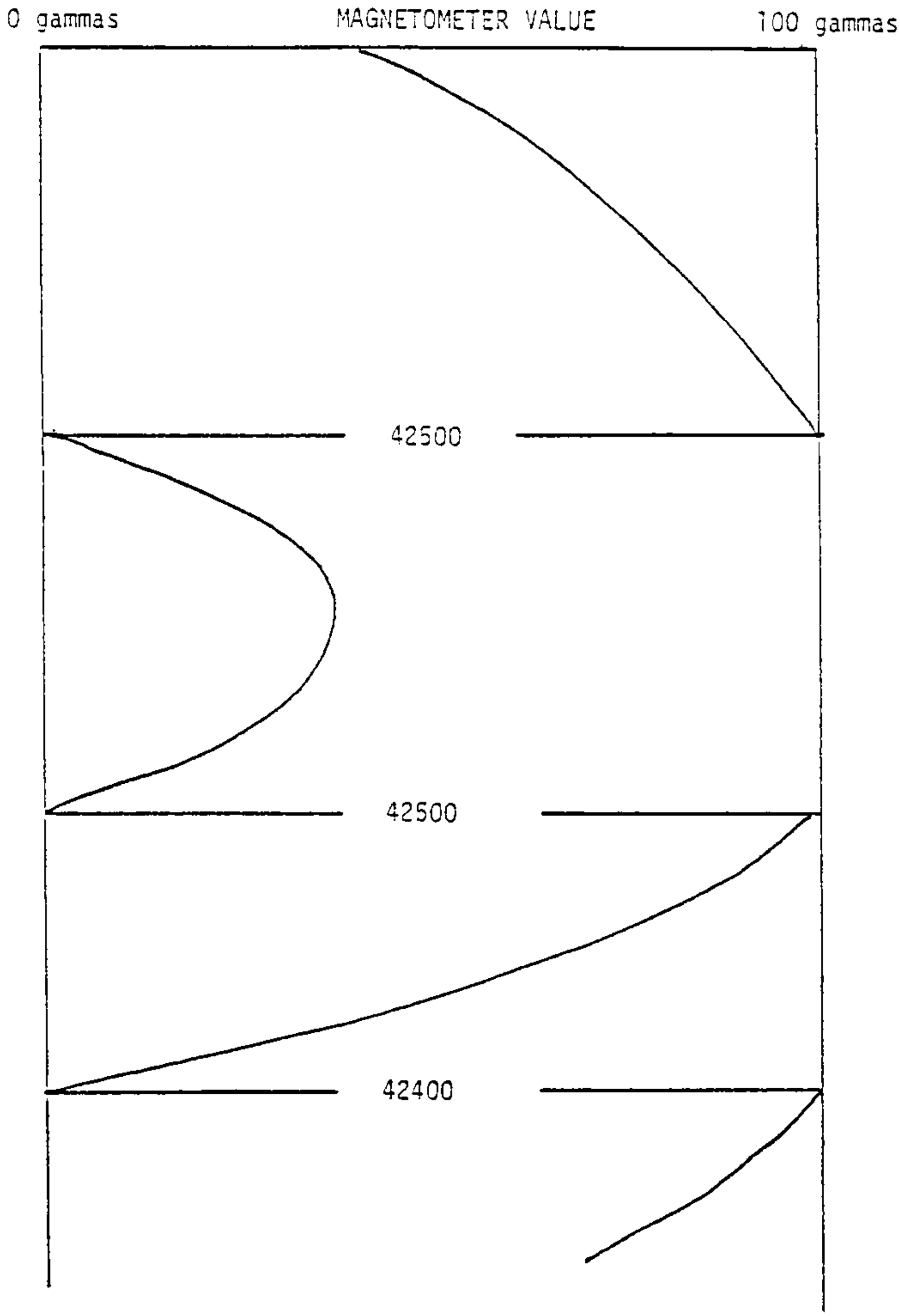


Figure 12 Plotter Step Value Labeling

FLIGHT PATH MAPS

For each of the NTMS quadrangle sheets covered by this survey, a flight path position map is presented at a scale of 1:250,000. The actual flight path has been superimposed on the geologic quadrangle maps. Flight lines and tie lines are annotated along with fiducial numbers of located positions. Reduced scale, 1:500,000, copies of these can be found in Volume II of this report.

ANOMALY MAPS

Gamma ray anomaly maps have been prepared for each NTMS quadrangle included in this survey. The six anomaly maps generated represent the following parameters: potassium, uranium, thorium, and U/TH, U/K, and TH/K ratios. The data contained in each map represent only those data which are considered statistically adequate. This automatically excludes all data collected over water or data which falls outside of altitude specifications (i.e., altitude greater than 700 and less than 200 feet). The symbolism on each of the six maps is identical. A circle represents every fifth data point (this was selected since the data had been averaged over a 5 second interval). The small boxes adjacent to each of the circles represents one standard deviation from the mean for that specific data sample. In order to determine whether the data shown are represented by positive or negative standard deviations, consider each map with north pointing away from the viewer. For east/west lines (traverse lines) positive standard deviations lie above or to the north of the traverse lines with negative below or to the south. On the north/south lines (tie lines) positive standard deviations are to the left of the viewer or to the west, with negative standard deviations to the right or to the east.

These maps were generated at a scale of 1:250,000 for each NTMS sheet and are superimposed on the corresponding geologic map. In addition, these anomaly maps are presented in Volume II of this report at a reduced scale of approximately 1:500,000.

HISTOGRAMS

Computer generated histograms showing the count rate distribution for each of the six gamma ray parameters measured and calculated as a function of geologic units are presented in Volume II of this report. Information contained on these histograms includes the distribution type (normal or log normal), the mean and median of the histogram distribution, the standard deviation as calculated about the mean, and the total number of samples from which the distribution was derived.

DATA LISTINGS

Single record reduced and averaged record (statistical analysis) data listings have been prepared as microfiche. The microfiche are contained in Volume I of this report as Appendix J. Each of the single record and averaged record data listings are presented for the data contained in a single quadrangle. The data contained in the single record data listings are summarized below:

1. Fiducial number

2. Quality - this defines the results of statistical adequacy testing for altitude, potassium, uranium, and thorium. A value of 0 indicates the data are statistically adequate. A value of 1 indicates that the data are statistically inadequate. Data collected in excess of 700 and less than 200 feet are considered statistically inadequate).

3. Time - time presented in hours, minutes and seconds.

4. Altitude - altitude presented in feet above terrain.

5. LAT/LONG - latitude and longitude presented in terms of decimal degrees.

6. Magnetic field expressed in residual gammas.

7. Geology - code representing geologic units.

8. K, U, T - count rate of corrected K, U, T data.

9. U/Th, U/K, Th/K - calculated ratios of the various parameters.

10. Total Count - corrected total count data (0.4 to 3.0 MeV).

11. COS - downward looking cosmic count rate in the 3-6 MeV channel.

12. Uair - atmospheric Bi-214 count rate.

13. Temperature - outside air temperature in degrees centigrade.

14. Press - barometric pressure in inches of mercury.

The averaged record (statistical analysis) data listings are summarized below:

1. Fiducial number

2. Quality - this defines the results of statistical adequacy testing for altitude, potassium, uranium, and thorium. A value of 0 indicates the data are statistically adequate. A value of 1 indicates that the data are statistically inadequate.

3. LAT/LONG - latitude and longitude presented in terms of decimal degrees.

4. Magnetic field expressed in residual gammas.

5. Geology - code representing geologic units.

6. K, U, T - count rate of corrected K, U, T data and the integer number of (±) standard deviations from the mean.

7. U/Th, U/K, Th/K - calculated ratios of the various parameters, and the integer number of (±) standard deviations from the mean.

8. Total Count - corrected total count data (0.4 to 3.0 MeV).

9. COS - downward looking cosmic count rate in the 3-6 MeV channel.

10. Uair - atmospheric Bi-214 count rate.

DATA TAPES

Data tape files have been generated for each of the 1:250,000 NTMS quadrangle sheets. The tapes are IBM compatible and recorded on 9 track EBCDIC at 800 BPI. Four separate sets of data tapes are presented: raw spectral data tapes; single record reduced data tapes; statistical analysis tapes; and magnetic data tapes. Detailed descriptions of the data tape formats are presented in Appendix H.

DATA INTERPRETATION

METHODOLOGY

The stated objective of the NURE Program is to evaluate the uranium potential of the United States. In support of this objective, high sensitivity radiometric and magnetic airborne surveys have been implemented to obtain reconnaissance information concerning the regional distribution of uraniferous materials.

Thus, the major portion of this interpretation has been oriented toward the detection of anomalously high concentrations of uranium minerals. To accomplish this, the profile data were located by geological units (as described previously), histograms were produced and statistical analysis performed. Each variable for each rock type was examined for the central tendency for that distribution; that is, the counts most frequently observed over that particular rock unit and variable. No Chi Square tests were performed on rock units having less than 20 statistically adequate samples. For many rock units the best estimate of central tendency for a particular variable was the median and not the arithmetic mean. In no case was the mode used as the measure of central tendency unless it was coincident with the median. Each central record of a 5 sample average was plotted with its corresponding standard deviation and the anomaly map for that variable.

For this interpretation, minimum requirements for a valid uranium anomaly are defined as follows:

1. Ten consecutive corrected Bi_{214} samples lying two standard deviations above the mean (median). (Actually two samples from anomaly maps since every fifth point is plotted.)

... and ...

2. Ten consecutive U/Th ratios lying two standard deviations above the mean (median).

3. The U/Th ratio defined in (2) must have a corresponding thorium value lying at least greater than minus one standard deviation below the mean. If the thorium sample is less than one standard deviation below the mean, the U/Th ratio is considered questionable.

At the same time, the potassium, thorium, uranium, residual magnetic, and altitude channels were each plotted as a pseudo contour map and overlain on the geologic map and corresponding statistical anomaly map. General trends and average absolute counting rates could thus be easily and quickly determined and compared with the associated geological and statistical trends. Only the long period signals within each variable would show any continuity from line to line (on a five kilometer line spacing) and thus only the regional trends will appear on these maps. By overlaying each map on the altimeter map, areas of questionable altitude could be immediately discarded from further interpretation. The pseudo contour maps provide excellent information for outlining the broad geochemical trends (e.g., see map in Figure 14).

Each quadrangle's stacked profiles were overlain on the corresponding geologic map and anomaly maps to further delineate trends and to allow a more detailed analysis of individual anomalies. Since the interpretation was concentrated on detection of anomalous uranium, subtle geological trends as reflected in the gamma ray profiles were only examined in a cursory manner. Even this brief examination of the profiles clearly indicated that the spectrometer system was highly sensitive to changes in gross lithology (even in areas of low counting rates). Thus radiometrics have a real potential for performing general surficial geochemical mapping/analysis on a geologic formation (or soil) basis as opposed to merely radioactive mineral "anomaly hunting".

The Lincoln and Fremont quadrangles contain few bedrock outcrops (Burchett et al, 1972; Burchett et al, 1975). Both quadrangles are almost completely covered by alluvial, glacial or periglacial, and loessial surface materials upon which the present day soils have developed. As the airborne gamma ray signal is predominantly a function of surficial material, maps based on the distribution of soil associations were utilized for both data display and statistical compilation.

Soil distribution maps were available on a county basis at scales which varied from 1:190,080 to 1:24,500. Individual county maps were photographically reduced to a common base scale (1:250,000) and transferred to a master quadrangle map. During the transfer process, soils units were aggregated into soil associations based on parent material, description, topographic distribution and geographical relationships. Discrepancies in registration between maps of varying ages were partially resolved during the aggregation. (See Appendices A and C)

Due to the long time period (60 years, 1916 to 1976) over which the individual soil maps were produced and the subsequent diversity of units and descriptions, an all encompassing soil association across the quadrangles was not produced. In many cases a soil association terminates at a political boundary. Adjustments were made to fit (spatially) associations at these boundaries although the individual names were retained within each county. Further, where possible, similar soil associations were created by appropriate aggregation between the various counties.

As many of the physical characteristics of the various soil units (those sensed by radiometrics) are similar, the original distinctions were made on the subsoil characteristics. This is reflected in the results of the statistical tests, which were generally more conclusive due to smaller standard deviation (ie less variability) than tests performed using outcropping geological base maps to the south in Kansas.

It is believed that the overall effectiveness of the statistical interpretation technique is not adversely affected by the above circumstances, although the number of units to be treated multiplies rapidly.

Base maps for the Hutchinson and Manhattan quadrangles were compiled from unpublished blueline copies of 1:250,000 hand drawn geologic maps (anonymous, undated) used by the Kansas Geological Survey for compilation of the 1:500,000 state map sheet (Kansas Geological Survey, 1964). Although the lithologic distributions were reasonably clear, unit designations were not. These were derived from the state map sheet. The formational contacts were redrafted on mylar and carefully checked against the state map to assure that unit names and distributions were compatible. The cooperation of the Kansas State Geological Survey in obtaining these maps is greatly appreciated.

FREMONT QUADRANGLE

The Salina Basin underlies approximately 95 percent of the Fremont Quadrangle and becomes progressively shallower to the northeast. The northern extension of the Nemaha Uplift occupies only a small region on the eastern margin of the basin's eastern edge. Two parallel normal faults trend northeast towards the Fremont quadrangle from the westerly adjacent Cambridge Arch, but are not shown to enter it (Tectonic map of U.S.). Above the essentially unknown Precambrian basement lies a sequence of mostly calcareous Paleozoic, Mesozoic and Tertiary sedimentary rocks. These rocks are generally homoclinal as displayed on the bedrock geology map (Burchett et al, 1975).

Surficial material (loess, glacial, drift, etc.) mantles even more bedrock within this quadrangle than the Lincoln quadrangle to the south. The few existing outcrops lie mostly along the Platte River in the southeast corner with a very few in the northeast corner. Thus the bedrock geology map of Burchett et al (1975) is drawn almost entirely from well and sub-surface data. The youngest units (Pliocene Ogallala Formation) subcrop in the northwest. The section gets progressively older diagonally across the quadrangle to the southeast corner where the oldest unit (the Pennsylvanian Marmaton Group) occurs. Appendix A presents a description of the bedrock unit's lithologies. Above the bedrock lie various materials of either glacial drift, loess or alluvial origin. The soils which have developed on these materials are believed to affect the radiometrics to the exclusion of bedrock materials. In only a few reported instances do the soils include contributions of bedrock material.

INTERPRETATION DISCUSSION AND RESULTS (FREMONT)

The resultant uranium anomaly-magnetic interpretation map is shown in Figure 13. Uranium anomalies are summarized in Table 1. Figures 14 through 17 present the pseudo-contour maps prepared for a regional overview. (Tables 2 and 3 provide the print character value for these maps.) Geologic unit information based on subsurface data is presented in Appendix A with the soil association symbologies and descriptions. Statistical tables for these soil associations which cite the distribution type, measure of central tendency and standard derivation data are displayed in Appendix B.

In general, the Fremont sheet is characterized by low counting rates in all channels and relatively uniform ratios indicating reasonable geochemical homogeneity. Refer to the following list displaying the equivalent geochemical concentrations of each soil association present in the quadrangle:

Soils	Mean % K	Mean PPM EU	Mean PPM ET
ABHY	1.34	1.33	5.84
ABHYON	1.63	1.51	7.03
BF	1.88	1.54	8.84
BFMD	1.79	1.68	8.58
BSB	1.37	1.49	7.44
BST	1.21	1.13	6.61
BT	1.52	1.72	7.38
C	1.44	1.45	7.47
CB	1.31	1.58	7.56
COCLKN	1.65	1.58	7.84
CSIWN	1.33	1.15	4.96
CSL	1.69	1.30	5.52
CSLS	1.57	1.33	6.60
CSLWB	1.63	1.41	6.86
CSMPWN	1.63	1.31	6.72
CYCZ	1.53	1.79	7.56
GBEWB	1.54	1.43	6.07
H	1.68	1.65	7.84
HB	1.72	1.68	8.30
HBHL	1.46	1.73	7.22
HCRBT	1.55	1.72	7.56
HFBT	1.54	1.57	7.72
HGE	1.61	1.73	8.30
HHD	1.54	1.63	7.63
HLHD	1.72	1.53	7.66
HLJ	1.59	.99	5.96
HO	1.59	1.70	6.90
HWY	1.36	1.29	7.53
K	1.63	1.66	8.03
LCLRV	1.47	1.47	6.87
LCLWN	1.83	1.39	8.00
LLLWB	1.54	1.44	6.95
LLS	1.54	1.06	5.20
LPSA	1.31	.76	4.63
LUKGLT	1.67	1.53	7.53
LUVO	1.60	1.57	7.30
M	1.66	1.66	8.01
MD	1.64	1.46	8.04
MDBF	1.74	1.71	8.35
MDK	1.72	1.68	8.16
MDNRBF	1.69	1.61	8.20
MDNRCF	1.85	1.66	8.87
MNCF	1.51	1.75	7.83
MNI	1.38	1.51	7.20
MPO	1.44	1.54	7.35
MUH	1.43	1.37	7.32
NRCFMD	1.77	1.77	8.43
NRMDJ	1.66	1.73	8.13

Soils	Mean % K	Mean PPM EU	Mean PPM ET
NWOR	1.61	1.29	5.75
PLLEAL	1.67	1.48	5.76
POI	1.48	1.66	7.75
PS	1.21	1.47	6.98
SACA	1.46	1.38	6.13
SB	1.48	1.48	7.68
SBLWN	1.38	1.34	5.66
SC	1.55	1.52	7.96
SF	1.58	1.66	7.64
SM	1.63	1.85	8.30
SMN	1.57	1.65	7.80
THMDLY	1.63	1.22	6.09
THME	1.67	1.11	5.17
V	1.54	.88	4.44
VTH	1.55	1.07	4.90
W	1.68	1.69	
WB	1.59	1.69	7.72
WBCSSA	1.13	1.36	5.04
WBL	1.34	1.56	7.35
WK	1.31	1.57	7.44
WN	1.41	.88	4.15
WO	1.61	1.26	4.98
WOHL	1.73	1.50	7.53
WOJ	1.62	1.64	7.40
WWBHL	1.57	1.64	7.86
ZLSWN	1.58	1.31	6.92
S	1.37	1.57	7.52

Minor perturbations in counting rates of the four channels might be due to exposed glacial erratics or unmapped outcrops since there are poor correlations with the few mapped outcrops. It is also possible that small local excursions may be attributable to agriculture and the application of phosphates and other fertilizers, or anomalous local accumulation of clays or organics capable of scavenging U or Th from solution in the surface layer.

The similarity of radiometric statistics and therefore, geochemical variation, for all the soil associations of the quadrangle seems remarkable and is possibly related to the origin of the dominant parent material loess (see previous list). The Ogallala Group in the Sand Hills region of north central Nebraska is believed (Logn 1968) to be the principal source of both the local sand dunes (and such soil units as the Valentine) and the loessal materials distributed across Nebraska and Western Kansas. The finer sediments (silt and clay and very fine sand) were selectively removed by combined wind, pluvial, and fluvial action leaving behind residual sand dunes. In essence, the Ogalla Group consists of a number of formations of varying geographic distribution and composition (in part a function of underlying or source material) which supplied some material to glacial drift and served with the drift as a source for subsequent reworking and development of loess and dune sand during intervals of aeolian activity. In addition to masking bedrock geology, the winnowing and distributive processes which selectively mobilized only the finer material to form the loess also acted to produce the radiometric homogeneity exhibited by these data.

The pseudo-contour maps (all channels) display a rough correlation between upland and bottomland values. In general, the central portion of river valleys characterized by units such as the Cass-Lamoure-Wabash are relative lows in contrast to the adjacent upland slopes typified by units such as the Marshall (M). Further, one can discern distinct count variations at some of the soil association boundaries, indicating some variation in overall geochemistry. Since most of the soil associations are not derived from parent bedrock materials, there is a marked lack of correlation between the soil and bedrock maps. Similarly, the bedrock geology pattern and basement interpretation as derived from the magnetic contour map are quite different.

In all, some 22 locations have been noted in the tables and the anomaly interpretation maps. Only uranium anomaly #1 is at all extensive. The others were included only to evaluate possible intra-unit correlations. Count rates are so low as to preclude any of the locations, including anomaly #1, from being directly representative of economic occurrence. There are no "Preferred Anomalies" within this quadrangle.

Neither the structural province (almost entirely Salina Basin) nor bedrock map correlate well with the low grade anomalies. However, the Ogallala formation in the northwest corner of the map underlies the only statistically substantial anomaly (#1) indicated.

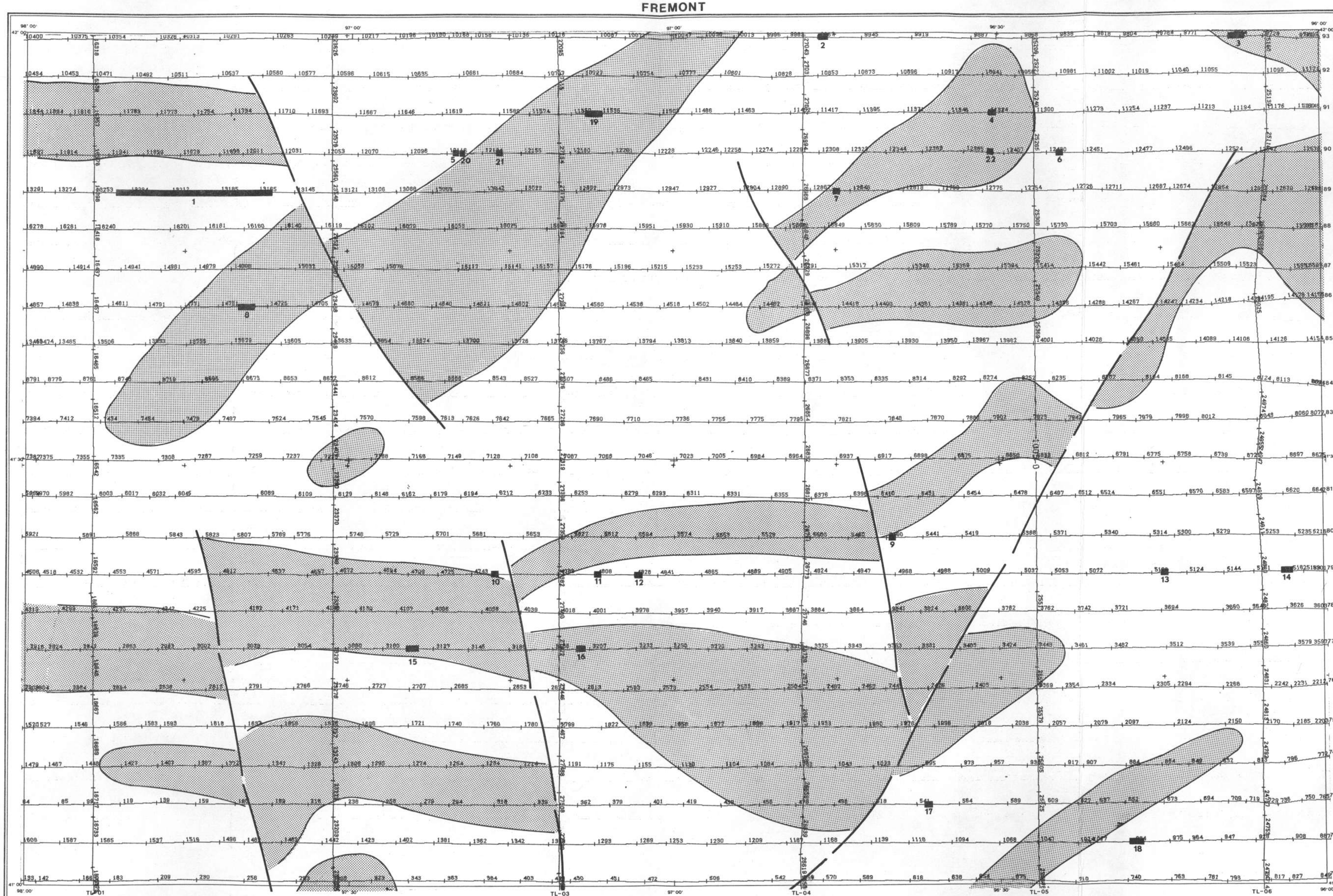
Anomaly #1 on line 89 occurs within the Marshall, a silt loam upland association in Madison and Boon counties, which at that location overlies the Ogallala formation Maximum expression is three standard deviations above the mean. Maximum count rates of 154 counts/second and 44 counts/second imply eU and eTh values of 3.2 ppm and 6.7 ppm respectively. These are not very high. On the other hand, the Marshall association (as mapped) is a widespread multi-county category, and further is a component of many other associations.

Two general trends are present on the magnetic contour map. The first, dominant trend occurs mainly in the eastern half of the map and strikes northeast-southwest. Anomalies range up to 1,000 gammas. The second trend occurs mainly in the west-southwest portion of the map and strikes roughly east-west. The two trends appear to generally blend together rather than meeting in an abrupt offset.

The zone of magnetic anomalies in the southwest and south-center is interpreted as having its source in two extensive basement rock systems, striking east-west. They have variable apparent susceptibilities, relatively high, and by further inference are likely to be of relatively mafic bulk composition. The east-west rock systems appear offset by a complicated set of transverse interpreted faults, mainly striking north-south. The apparent displacement along these faults is mainly left-lateral, the eastern portion of each anomaly having shifted northward relative to the western portion.

Discernible faulting affecting the basement complex trends mainly north-south or northwest-southeast, although one major northeast-southwest fault inferred to the south in the Lincoln quadrangle, continues into the eastern half of the Fremont quadrangle. The degree of sedimentary involvement is not known.

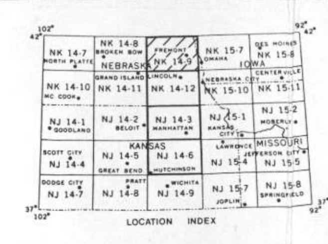
FREMONT



SCALE 1:500,000

MILES

KILOMETRES



INTERPRETATION MAP

EAST SALINA BASIN AREA

U.S. DEPARTMENT OF ENERGY

INFERRED MAGNETIC FAULTS

INFERRED MAFIC BASEMENT ROCK

RADIOMETRIC ANOMALIES

APPROXIMATE AXIS OF BASEMENT

SURVEY AND COMPILATION BY:

geoMetrics

TABLE I

FREMONT

URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Soil Type	Number of Data Samples (X5) With Defined σ																	
				-5σ	-4σ	-3σ	-2σ	-1σ	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ	9σ	10σ	11σ	12σ
1	U	89	M							11	30	3									
2	U	93	$M_dN_rB_f$							3	3										
3	U	93	$A_bH_yO_n$							5	3										
4	U	91	M, W_b								2										
5	U	90	V							4	1										
6	U	90	M								2										
7	U	89	$M_dN_rB_f$, $C_oC_lK_n$							6	1	1									
8	U	86	WOH_l, C_sLW_b							4	3										
9	U	80	SF							4	2										
10	U	79	C_sL							4	1	1									
11	U	79	C_sL							1	2										
12	U	79	C_sL							3	3										
13	U	79	SM							2	3										
14	U	79	M_nC_f							1	4										
15	U	77	C_yC_z								2										
16	U	77	M, B_t							2	2										
17	U	73	SM_n							1	2										
18	U	72	G_bEW_b							2	3										
19	TH	91	M_dK							2	4										
20	TH	90	V							1	3										
21	TH	90	V, C_sLW_b							4	2										
22	TH	90	W								2										

TABLE 2

Print Character Values For
Pseudo-Contour Maps - K, U, T

Print Character	Value (cps)
0	Less than 50
Blank	50 - 75
1	75 - 100
Blank	100 - 125
2	125 - 150
Blank	150 - 175
3	175 - 200
Blank	200 - 225
4	225 - 250
Blank	250 - 275
5	275 - 300
Blank	300 - 325
6	325 - 350
Blank	350 - 375
7	375 - 400
Blank	400 - 425
8	425 - 450
Blank	450 - 475
9	475 - 500
Blank	Greater than 500

FREMONT

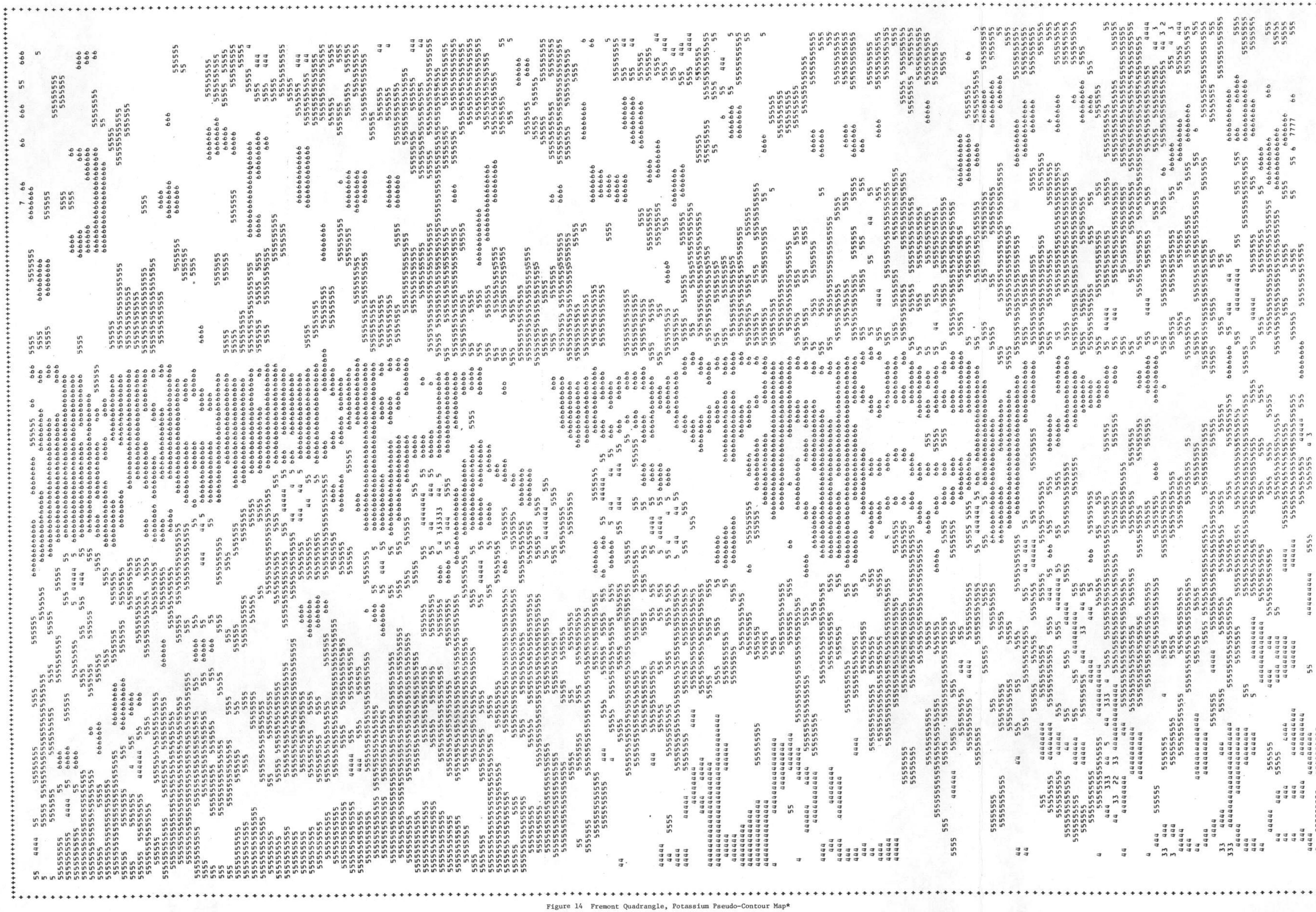


Figure 14 Fremont Quadrangle, Potassium Pseudo-Contour Map*

FREMONT

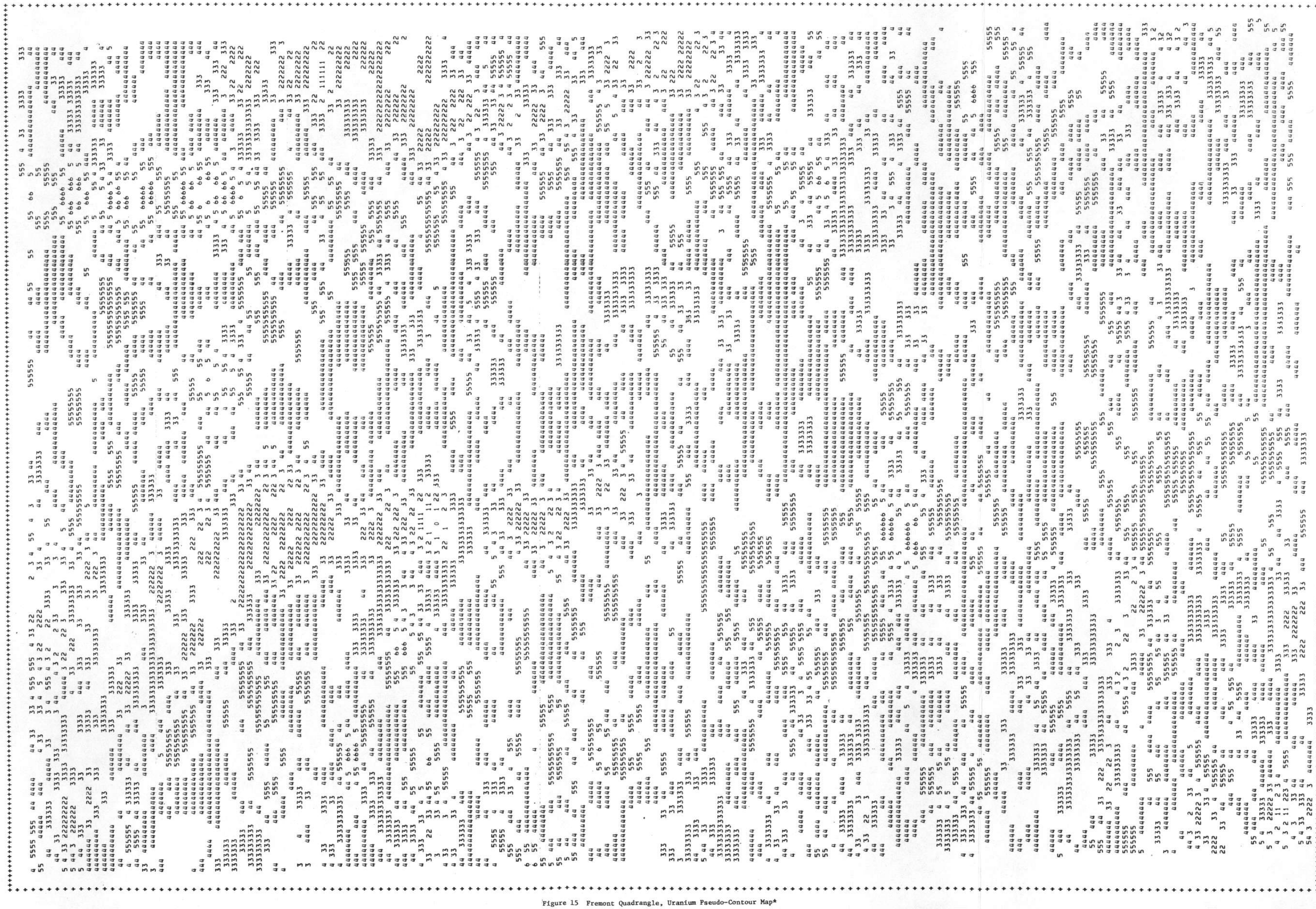


Figure 15 Fremont Quadrangle, Uranium Pseudo-Contour Map*

FREMONT

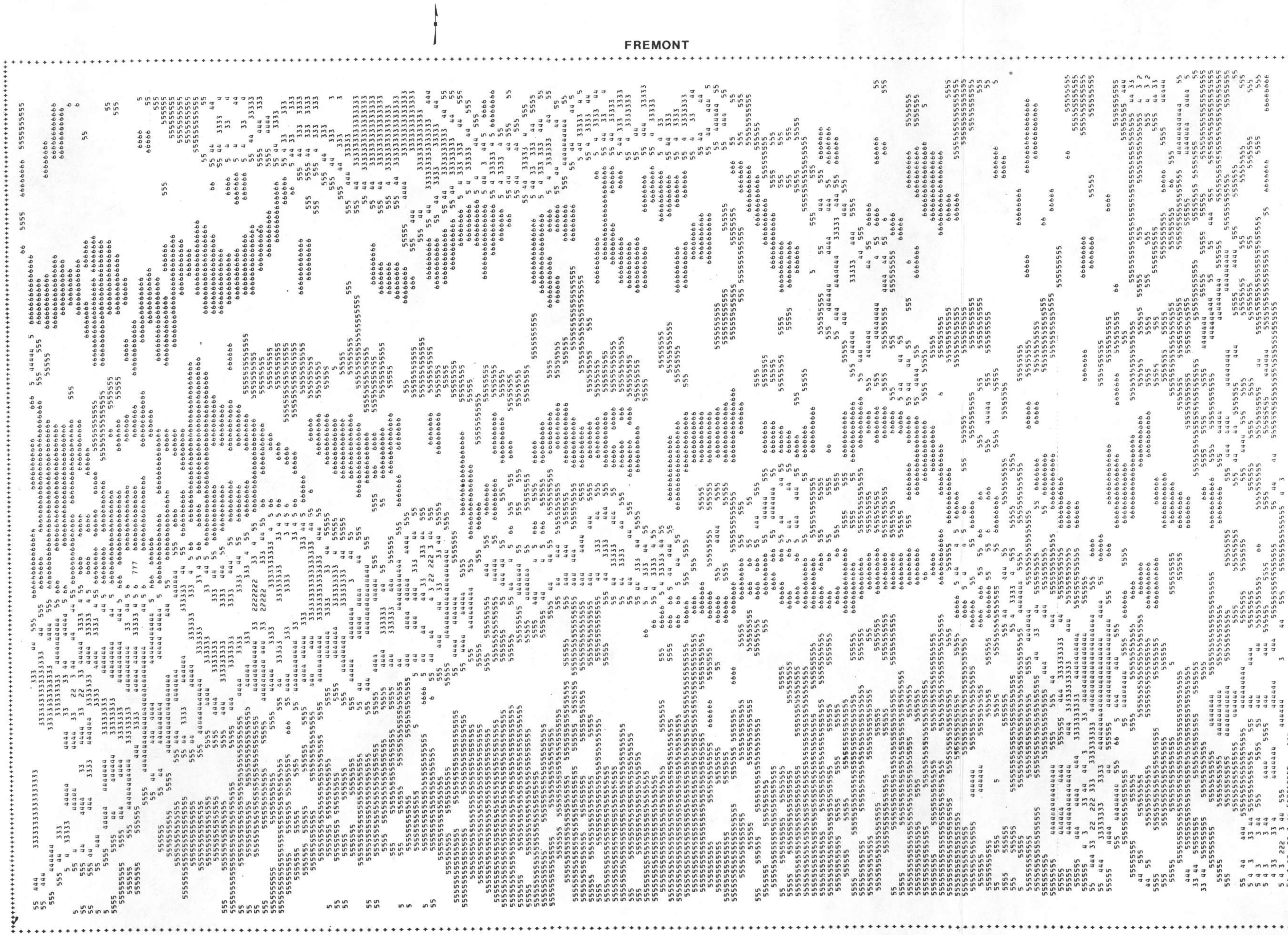


Figure 16 Fremont Quadrangle, Thorium Pseudo-Contour Map*

FREMONT

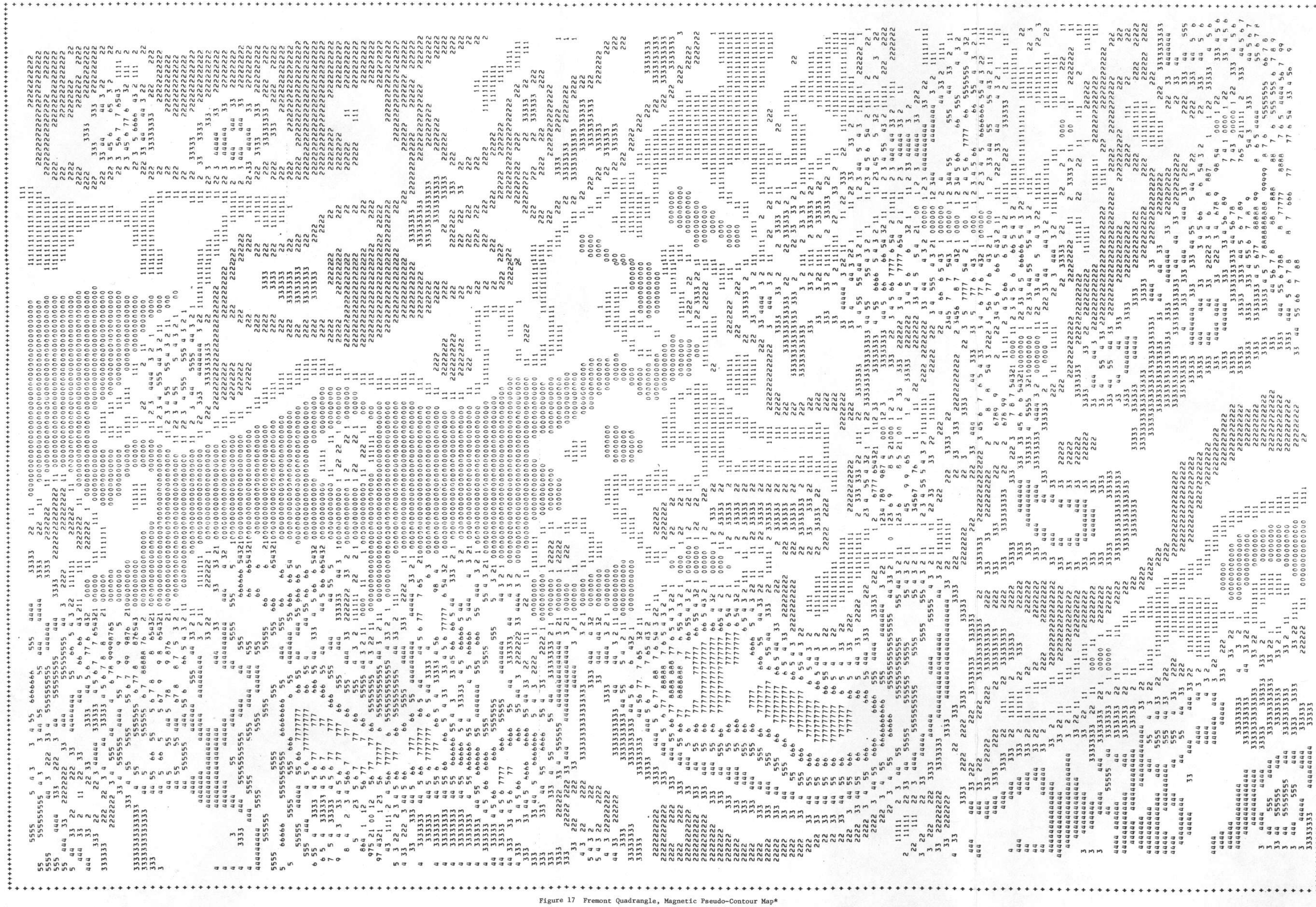


Figure 17 Fremont Quadrangle, Magnetic Pseudo-Contour Map*

LINCOLN QUADRANGLE

Two major geological structures lie within the Lincoln Quadrangle. The first, and largest, is the eastern edge of the northeast-southwest trending Salina Basin which covers the western 2/3 of the quadrangle. The basin deepens to the southwest to a maximum of 2,000 plus feet. It is bordered on the east by the second major geologic structure comprising the possible confluence of the axis of the Abilene Arch and the Nemaha uplift. The Nemaha uplift is bordered by normal faulting (paralleling the NE/SW uplift axis) on the extreme eastern edge of the quadrangle where the basement deepens into the Forest City Basin. Several regional basement faults, such as the Thurman-Wilson fault, extend into the northeast corner of the quadrangle across the Nemaha uplift.

Virtually the entire quadrangle is mantled with soils derived from Pleistocene loess, glacial drift, and alluvium. Outcrops occur predominantly along river bluffs in the southern and eastern portions of the quadrangle. Thus, knowledge of underlying formations stems mostly from well data (Burchett et al, 1972). Above the basement complex lies a nearly homoclinal sequence of Paleozoic and Mesozoic sediments ranging in age from Pennsylvanian to Cretaceous. In general, the younger sediments lie in the western 2/3 of the quadrangle, coterminous with the Salina Basin, while the Permian and Pennsylvania materials seem to be characteristic of the underlying formations over the Abilene Arch/Nemaha uplift. The rocks shown in the bedrock map (Burchett et al, 1972) include limestone units interbedded with sandstone and shale units.

INTERPRETATION DISCUSSION AND RESULTS (LINCOLN)

The resultant uranium anomaly-magnetic interpretation map is shown in Figure 18. Uranium anomalies depicted are summarized in Table 4. Figures 19 through 22 present the pseudo-contour maps prepared for regional overview (symbolism is the same as shown in Tables 2 and 3). All soils/geologic symbol definitions are presented in Appendix C. Statistical tables defining the distribution type, measure of central tendency and standard deviation data for these rock types are shown in Appendix D.

Throughout the Lincoln quadrangle, the corrected radiometric counting rates are very low. A brief examination of the following table of mean equivalent geochemical concentrations clearly demonstrates the lack of variability among soil types:

TABLE 3

Print Character Value For
Pseudo-Contour Maps - Magnetic

Print Character	Fremont/Lincoln Map Value (gammas)	Manhattan/Hutchinson Map Value (gammas)
0	Less than -750	Less than -700
Blank	-750 - -675	-700 - -650
1	-675 - -600	-650 - -600
Blank	-600 - -525	-600 - -550
2	-525 - -450	-550 - -500
Blank	-450 - -375	-500 - -450
3	-375 - -300	-450 - -400
Blank	-300 - -225	-400 - -350
4	-225 - -150	-350 - -300
Blank	-150 - -75	-300 - -250
5	-75 - 0	-250 - -200
Blank	0 - 75	-200 - -150
6	75 - 150	-150 - -100
Blank	150 - 225	-100 - -50
7	225 - 300	-50 - 0
Blank	300 - 375	0 - 50
8	375 - 450	50 - 100
Blank	450 - 525	100 - 150
9	525 - 600	150 - 200
Blank	Greater than 600	Greater than 200

Soils	Mean % K	Mean PPM EU	Mean PPM ET
CRS	1.45	1.56	8.53
WB	1.62	1.83	8.26
CS	1.54	1.75	8.64
P	1.54	1.87	8.67
WYPA	1.64	1.95	9.04
WY	1.50	1.74	8.86
WWBSA	1.84	1.77	8.67
WWBS	1.62	1.81	8.53
WWBHL	1.65	1.64	8.02
WWBCS	1.79	1.79	8.56
WK	1.69	1.79	9.02
WBLCS	1.44	1.53	7.70
WBL	1.39	1.42	7.16
W	1.52	1.52	7.41
SC	1.70	1.68	8.33
SBBMR	1.60	1.85	8.73
S	1.41	1.47	7.75
PS	1.40	1.29	7.42
PMYB	1.37	1.60	8.36
NC	1.35	1.47	7.84
MRB	1.64	1.90	9.13
M	1.44	1.56	7.65
LCSG	1.35	1.76	8.92
LCHV	1.06	1.74	8.26
LC	1.25	1.40	6.35
KPWK	1.27	2.07	8.18
KNJWB	1.46	1.69	8.41
JME	1.89	1.83	8.75
HWY	1.59	1.51	7.80
HGWBN	1.89	2.10	9.80
HGE	1.82	1.91	8.92
HFBT	1.65	1.66	8.14
HC	1.75	1.79	8.95
HBMUCS	1.81	1.92	8.81
HBJ	1.60	1.80	8.43
HBHL	1.58	1.72	7.98
GEH	1.80	1.91	9.60
GEJN	1.83	2.14	8.49
G	1.76	1.83	8.86
CRPA	1.64	1.82	9.09
CRMY	1.75	1.99	9.33
CRHBT	1.85	2.05	9.46
CRFBT	1.83	1.86	9.30
CRBT	1.80	1.93	9.3
CB	1.38	1.43	7.83
C	1.89	1.91	9.15
BST	1.25	1.09	6.97
BNKPSG	1.44	1.71	8.49
BNKP	1.25	1.90	8.38

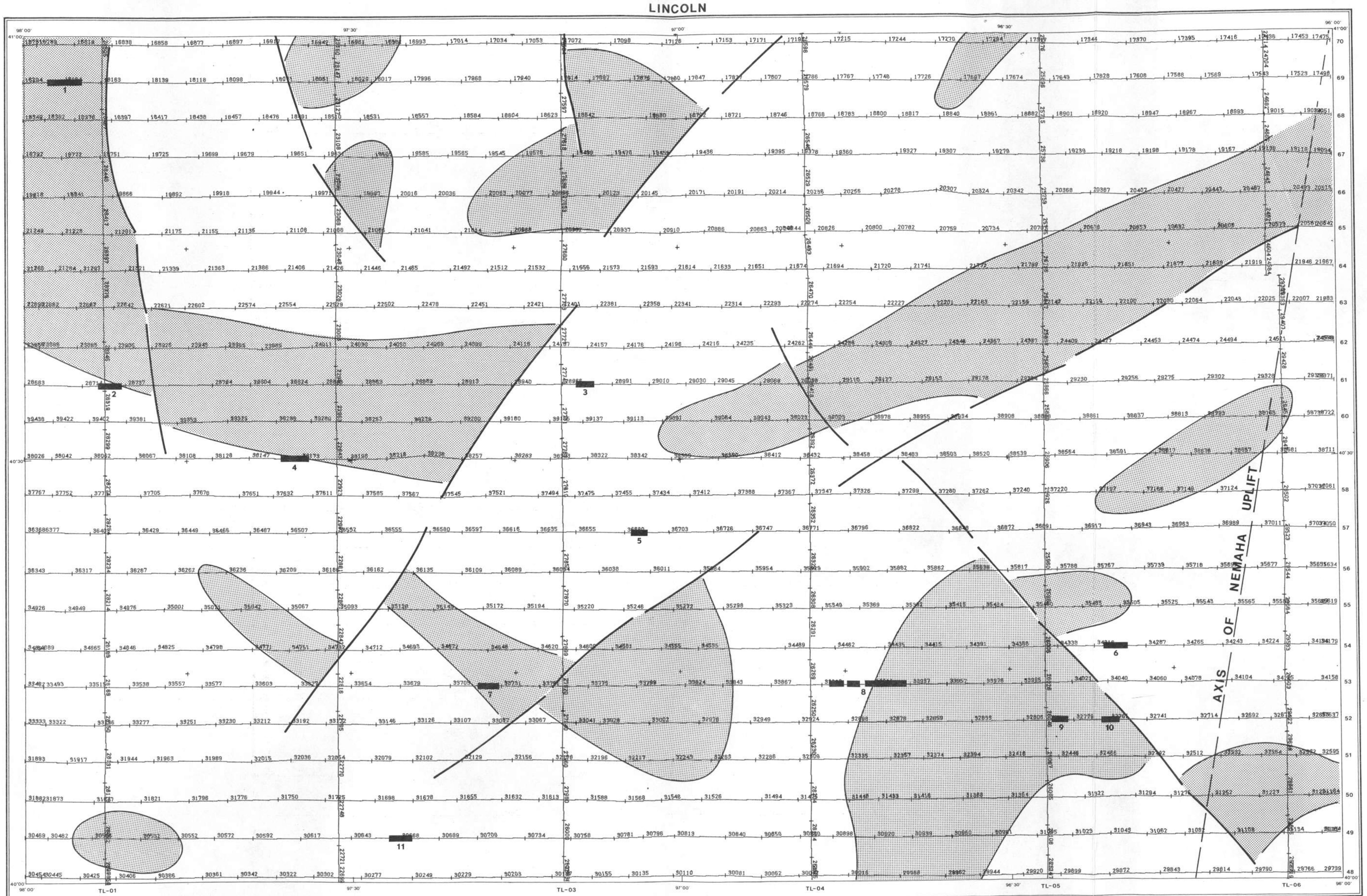
TABLE 4

LINCOLN

URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Soil Type	Number of Data Samples (X5) With Defined σ																
				-5σ	-4σ	-3σ	-2σ	-1σ	0	1σ	2σ	3σ	4σ	5σ	7σ	8σ	9σ	10σ	11σ	12σ
1	U	69	HFB_t							3	7	1								
2	U	61	HFB_t							4	2	1								
3	U	61	HC							3	3									
4	U	59	G							5	2	1								
5	U	57	C_rFB_t							2	2									
6	U	54	CS							8	3									
7	U	54	H_bH_l/G_eJ_n							15	7	2								
8	U	53	W_yPA							12	12	5	1							
9	U	52	PM_yB							4	3									
10	U	52	PM_yB							5	2									
11	U	49	$H_bM_uC_s$							4	2									

No "preferred" anomalies within the Lincoln Quadrangle.



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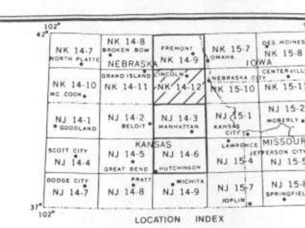


INTERPRETATION MAP

EAST SALINA BASIN AREA

U.S. DEPARTMENT OF ENERGY

SURVEY AND COMPILATION BY:

geoMetrics

INFERRED MAGNETIC FAULTS

INFERRED MAFIC BASEMENT ROCK

RADIOMETRIC ANOMALIES

APPROXIMATE AXIS OF BASEMENT

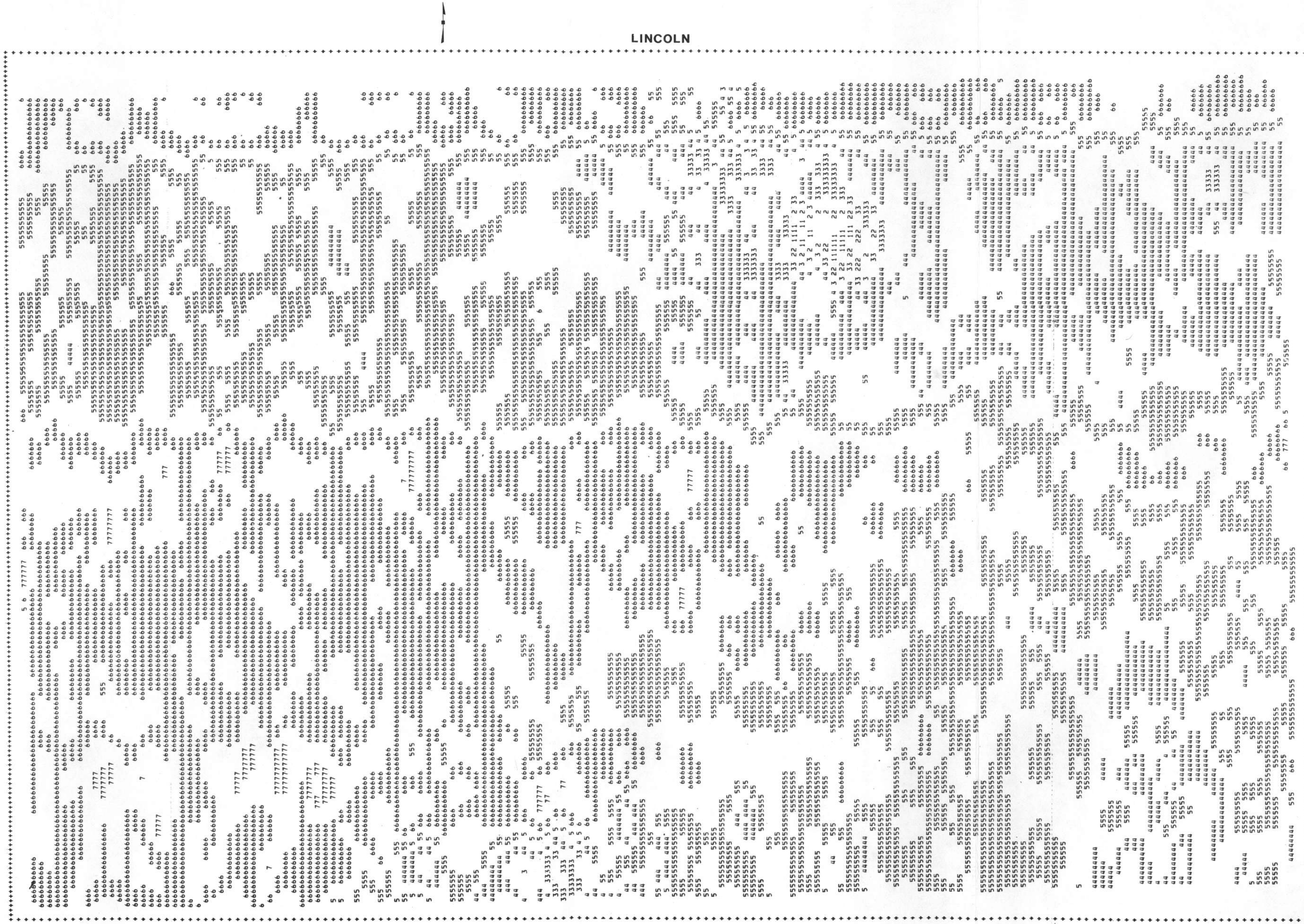


Figure 19 Lincoln Quadrangle, Potassium Pseudo-Contour Map*

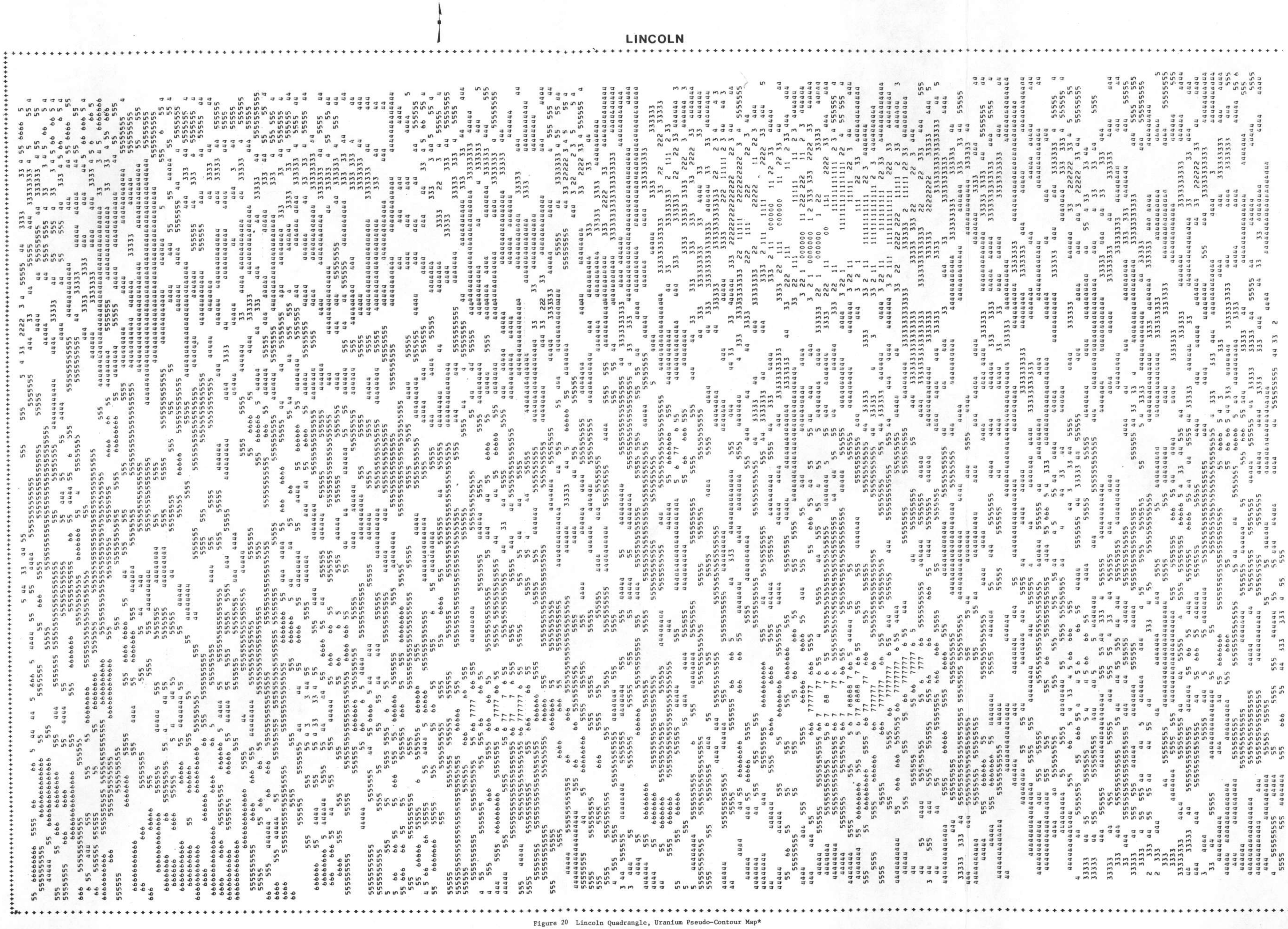


Figure 20 Lincoln Quadrangle, Uranium Pseudo-Contour Map*

LINCOLN

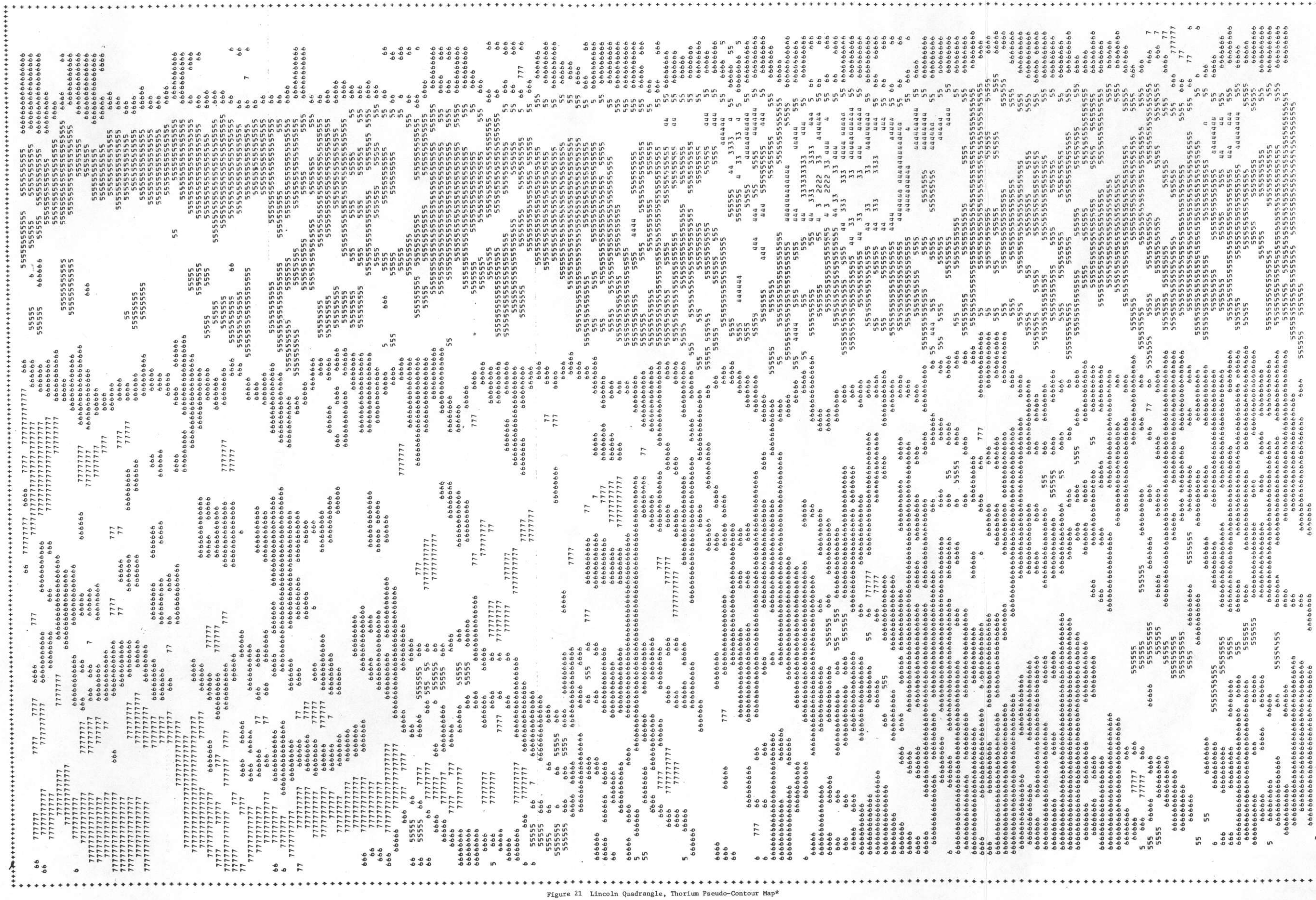


Figure 21 Lincoln Quadrangle, Thorium Pseudo-Contour Map*

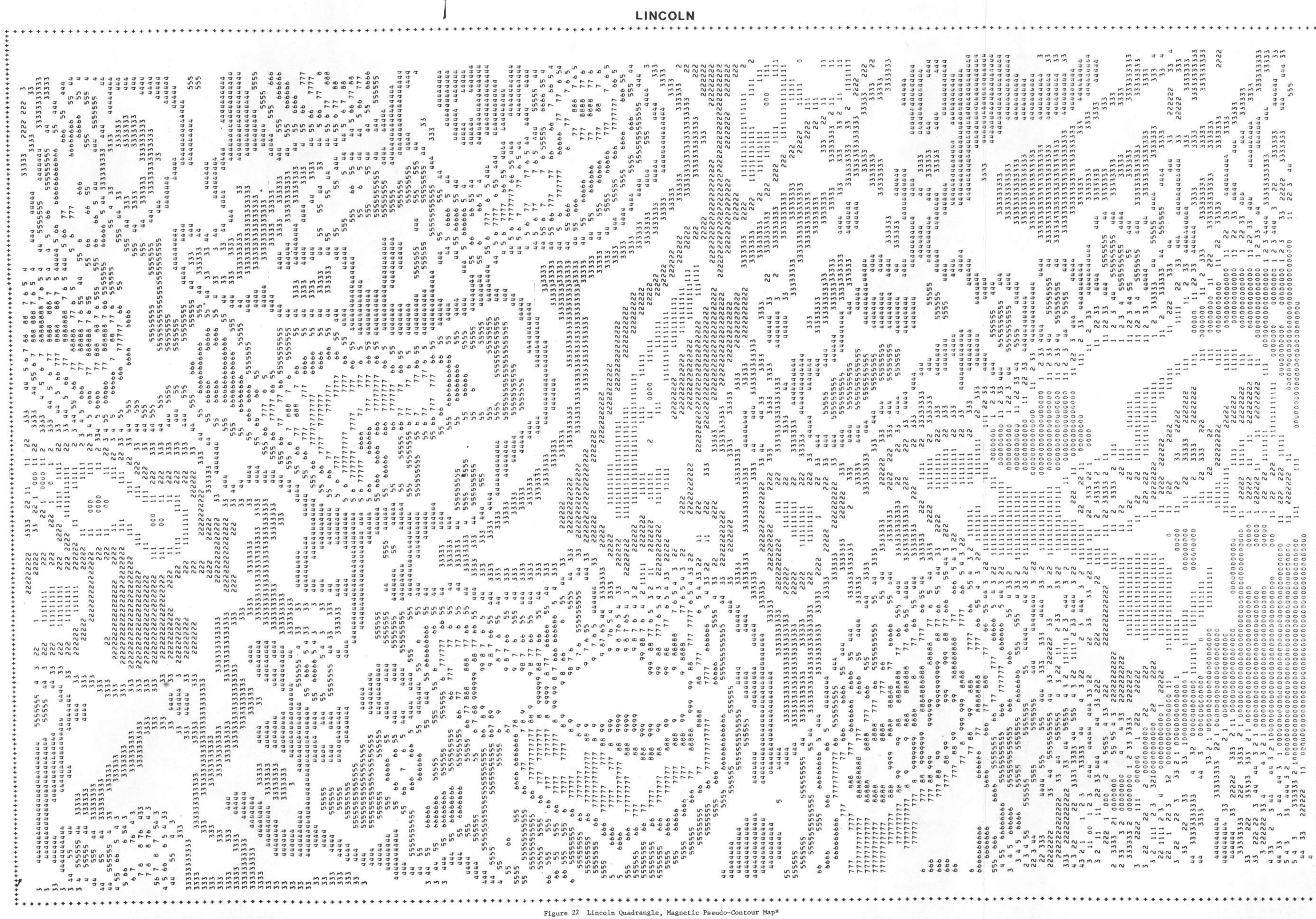


Figure 22 Lincoln Quadrangle, Magnetic Pseudo-Contour Map*

A few minor Bi 214 anomalies are noted that are associated with exposures of the lower Cretaceous Dakota sandstone in the northeastern corner of the quadrangle. As a generality, slightly higher count rates are present in the southwestern portion of the quadrangle on all three radiometric channels. The highest Bi 214 count rates are in the south center of the map over the town of Beatrice and north of Fairbury (location of anomalies 7 and 8, respectively). There is no obvious correlation with mapped soil units. Underlying bedrock units are Dakota sandstone, Greenhorn Limestone and Graneros shale and lower Permian Chase group. The maximum count rate recorded on the bismuth 214 channel is 160 counts per second; on the thallium 208 channel it is 70 counts per second, and on the potassium 40 channel it is 140 counts per second.

Other than this, no discernible radiometric pattern is present that can be related to the surficial soils or rock units mapped on the Lincoln quadrangle. This implies that the geochemistry of the soils is fairly uniform, and that the soils are completely developed with gradual lateral variation rather than abrupt transition between soil/rock types.

Eleven Bismuth 214 anomalies are displayed that meet the minimum criteria for recognition; ten consecutive samples exceeding the mean or median by at least two standard deviations supported by comparable and consistent values on the pertinent ratios. Of the eleven, anomalies 7 and 8 are the most interesting. None are likely to be economic concentrations as they barely meet the minimum criteria and their count rates are low.

The magnetic contour pattern displayed across the Lincoln quadrangle is dominated by large, irregularly shaped anomalies. Although their irregular shapes contribute to many local deviations, they are generally oriented east-west in the central and western part of the quadrangle and northeast-southwest in the east. Amplitudes are typically hundreds of gammas, with a few in excess of one thousand gammas.

Anomaly truncations, dislocations and persistent straight magnetic gradients indicate that basement faulting is probably extensive. Two well developed patterns are recognizable; a northwest-southeast fault direction that veers to a more northly trend in the northwestern corner of the quadrangle, and a northeast-southwest fault direction. The mutual relationships of the two postulated fault patterns suggest that the northwest-southeast system antedates the northeast-southwest system. Both fault systems are recognized in the basement rocks; the degree of involvement of the sedimentary section, if any, is problematical.

The large positive anomalies are interpreted as having their sources in basement rock systems of variable, but relatively high, magnetic mineral content, of relatively mafic composition. The largest and most persistent of these is a long positive anomaly, oriented east-west in the west-central part of the quadrangle, and a discontinuous positive trend in the north-east, oriented northeast-southwest. These two features are separated by a broad magnetic low, but, are approximately on trend with each other and suggest the presence of a major basement rock system striking across the quadrangle in a general east-west direction.

In the east-central and southeastern part of the quadrangle, the anomalous orientation is northeast-southwest. A major rock mass delineated in the southeastern corner probably is the continuation of an extensive rock system inferred in the Manhattan quadrangle to the south (see Figure 23). In the south-central part of the quadrangle, an inferred elongated rock mass appears to be offset by faulting. This feature is oriented in a general east-west direction.

MANHATTAN QUADRANGLE

Two important geological structures are known to exist in the Manhattan quadrangle. First is the Nemaha Uplift, striking north-south along the eastern edge of the quadrangle. It is a long, narrow basement uplift, faulted on its eastern flank. The bulk of the movement, and the faulting, occurred during the pre-Pennsylvanian erosion interval, but arching of the upper Palezoic sediments indicates that uplift continued at least through mid-Permian time. Second is the Abilene arch, a salient of the Nemaha Uplift which strikes northeast-southwest across the central part of the quadrangle. Basement well control suggests that its relief and definition are less than that of the more persistent Nemaha Uplift.

Exposed rocks within the Manhattan quadrangle are sediments ranging in age from upper Pennsylvanian in the east to mid Cretaceous in the west. A large portion of the outcropping rocks is composed of the Dakota Sandstone, which is described by DoE (1976) as potentially uraniferous. The section dips gently westward in a monocline, forming the eastern side of the Salina Basin. A discontinuous veneer of Pleistocene and Recent alluvial material overlies the sedimentary sequence. The broadest areas of alluvial cover are a large area of Kansan and pre-Kansan drift in the northeast and an area of post-Kansan loess in the northwest.

Subsurface, the Precambrian basement is shallowest in the northeast at five hundred feet above sea level (700 to 800 feet subsurface). It realizes maximum depth in the southwestern corner of the quadrangle at about three thousand feet below sea level (roughly 4,300 to 4,600 feet subsurface). The basement is overlain by upper Cambrian limestone and dolomites. Above the Cambrian are lower and middle Ordovician rocks of the Arbuckle and Simpson groups, generally calcareous, and mid-Mississippian calcareous cherts. The lower and middle Paleozoic section is truncated by an unconformity above which lies a thick section of generally calcareous middle and upper Pennsylvanian and Permian rocks. Lower and middle Cretaceous sandstones and shales unconformably overlie the Permian in the west.

Six small Kimberlite plugs are present north and west of the Tuttle Creek Reservoir. They are associated with the Abilene Arch and emplacement is attributed to tension fractures developed transverse to the strike of the arch.

INTERPRETATION DISCUSSION AND RESULTS (MANHATTAN)

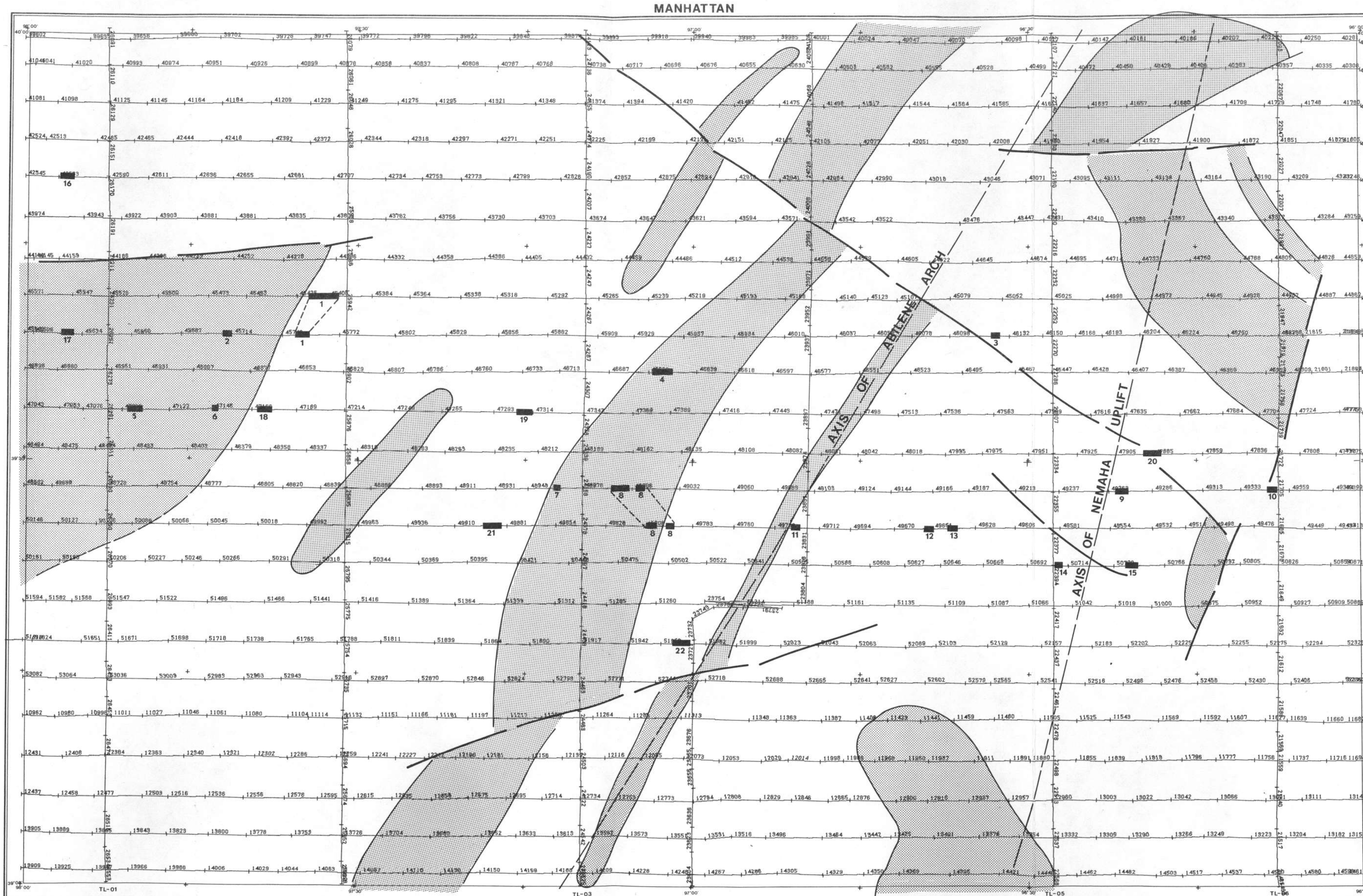
The resultant uranium anomaly magnetic interpretation map is shown in Figure 23. Uranium anomalies depicted are summarized in Table 5. Figures 24 through 27 present the pseudo contour maps prepared for regional overview. (Symbolism is the same as shown in Tables 2 and 3). All geologic symbol definitions are presented in Appendix E. Statistical tables defining the distribution type, measure of central tendency and standard deviation data for these rock types are shown in Appendix F.

Count rates as displayed by the pseudo contour maps over the Manhattan quadrangle are low. The average maximum count rates observed for the potassium 40 and bismuth 214 channels were 180 counts per second, and 90 counts per second for the thallium 208 channel.

The radiometric pattern observed across the Manhattan quadrangle correlates poorly with the surface geology. Several factors contribute to this. The exposed sedimentary section dips very gently westward so that outcropping geologic contacts tend to be extremely irregular; the soil overburden is extensive and is not necessarily related to the bedrock; and the lithologic differences between rock units are typically subtle. This is supported by the following list of mean equivalent geochemical concentrations as a function of the particular geologic units:

Geology	Mean % K	Mean ppm EU	Mean ppm ET
PCG	1.52	1.86	8.07
PPW	1.59	1.99	9.13
PS	1.66	1.97	9.43
KC	1.89	2.33	10.04
KD	1.41	2.00	8.89
KGG	1.52	2.27	8.92
KKC	1.31	1.77	8.32
NAL2	1.71	2.16	9.12
NAL3	1.74	2.10	8.80
NGD	1.44	1.82	8.78
NI	1.80	2.31	9.93
PA	1.63	2.06	8.64
PC	1.53	1.92	8.69

The most conspicuous correlation is an irregular zone of increased count rates over areas covered by the post-Kansan flood plain and stream terrace alluvium, particularly along the valleys of the Kansas, Republican and Solomon Rivers. The potassium 40 count rate over this alluvial unit generally ranges between 100 and 125 counts per second. Count rate changes often correlate to the alluvial contact. The bismuth 214 channel count rate is more irregular, although in places it ranges up to 160 counts per second. The alluvial unit is not discernible on the thallium 208 channel.



SCALE 1:500,000

— — INFERRED MAGNETIC FAULTS

INFERRED MAFIC BASEMENT ROCK

RADIOMETRIC ANOMALIES

APPROXIMATE AXIS OF BASEMENT

LOCATION INDEX

SURVEY AND COMPILATION BY: geoMetrics

INTERPRETATION MAP

EAST SALINA BASIN AREA

U.S. DEPARTMENT OF ENERGY

TABLE 5

MANHATTAN

URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Geology Type	Number of Data Samples (X5) with Defined σ																	
				-5σ	-4σ	-3σ	-2σ	-1σ	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ	9σ	10σ	11σ	12σ
*1	U	39,40	NAL3, KD							9	8	3									
2	U	39	NL							1	3										
3	U	39	PC							7	4										
4	U	38	KD							5	2	1									
5	U	37	NAL3							8	3										
6	U	37	NL							2	2										
7	U	35	NAL3							1	2										
*8	U	34, 35	PS							10	11	2	1								
9	U	35	PCG							2	5										
10	U	35	PCG								3										
11	U	34	NAL3							1	2										
12	U	34	PCG							1	4	1									
13	U	34	PCG							10	2										
14	U	33	NGD								3										
15	U	33	NGD							2	4										
16	TH	43	NL							2	2										
17	TH	39	KGG							2	2										
18	TH	37	NL								2										
19	TH	37	NL							2	5										
20	TH	36	NGD							1	2										
21	TH	34	KKC							7	2										
22	TH	31	NAL3							5	3										

*Discussed in report.

MANHATTAN

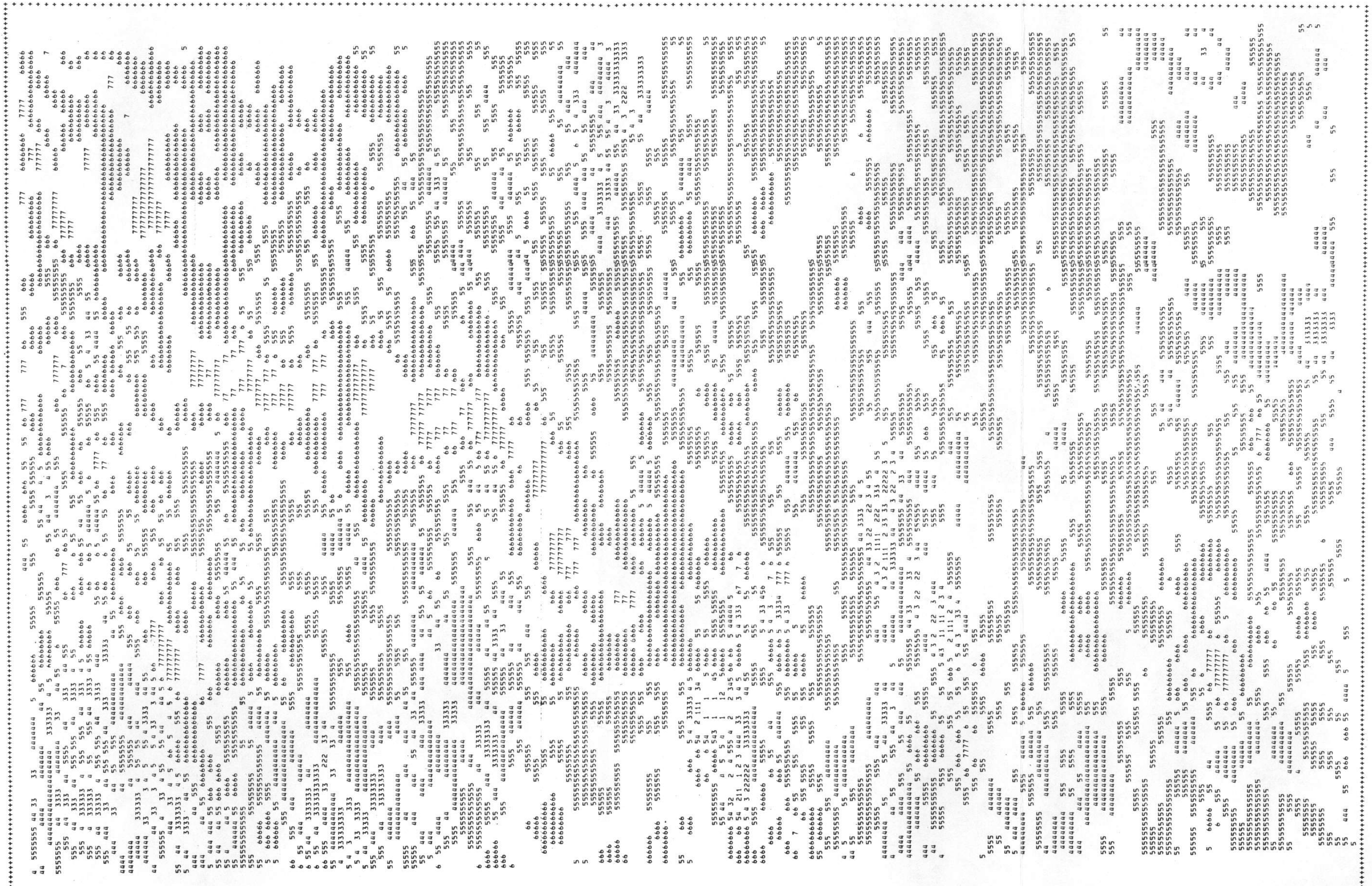


Figure 24 Manhattan Quadrangle, Potassium Pseudo-Contour Map*

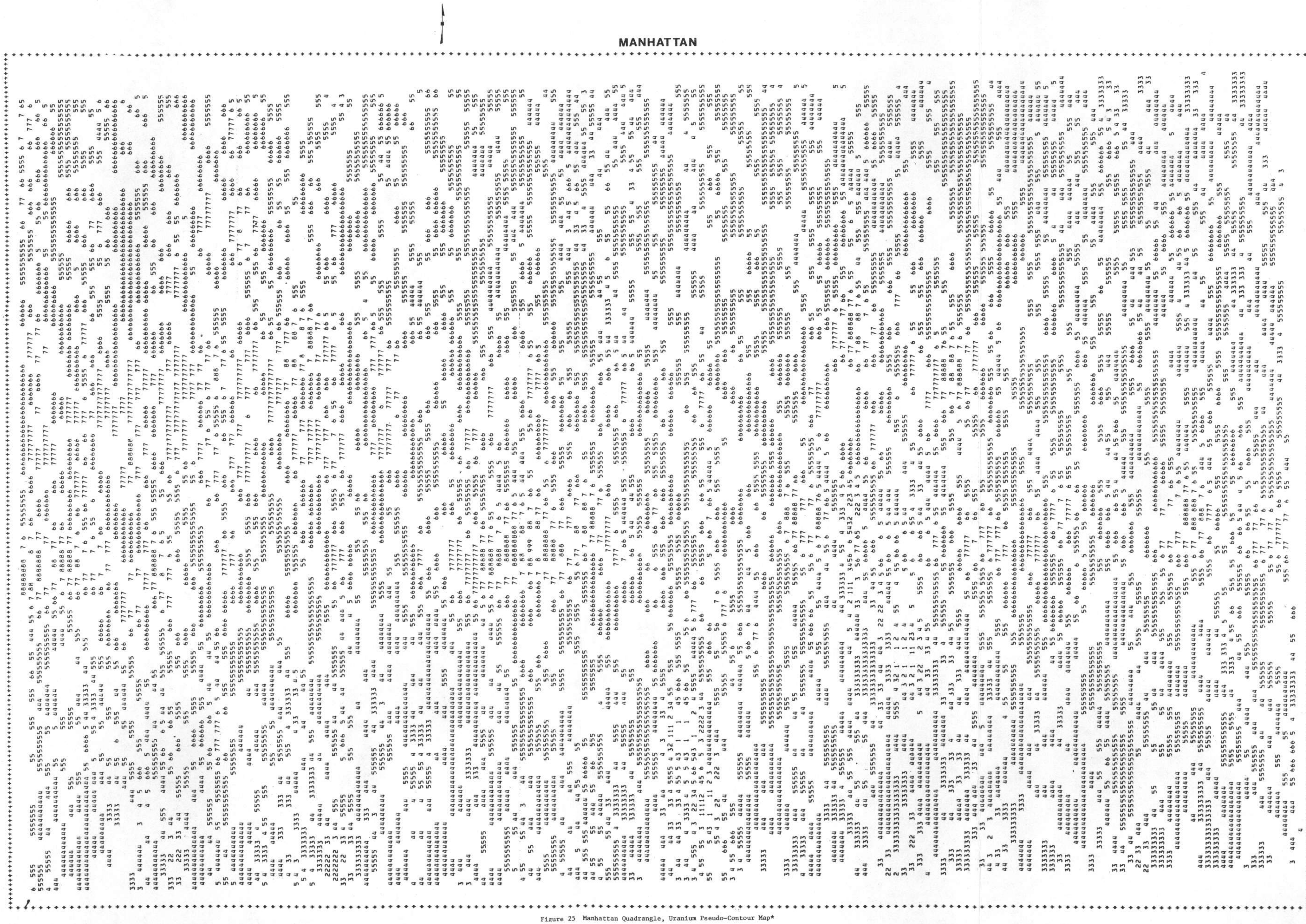


Figure 25 Manhattan Quadrangle, Uranium Pseudo-Contour Map*

MANHATTAN

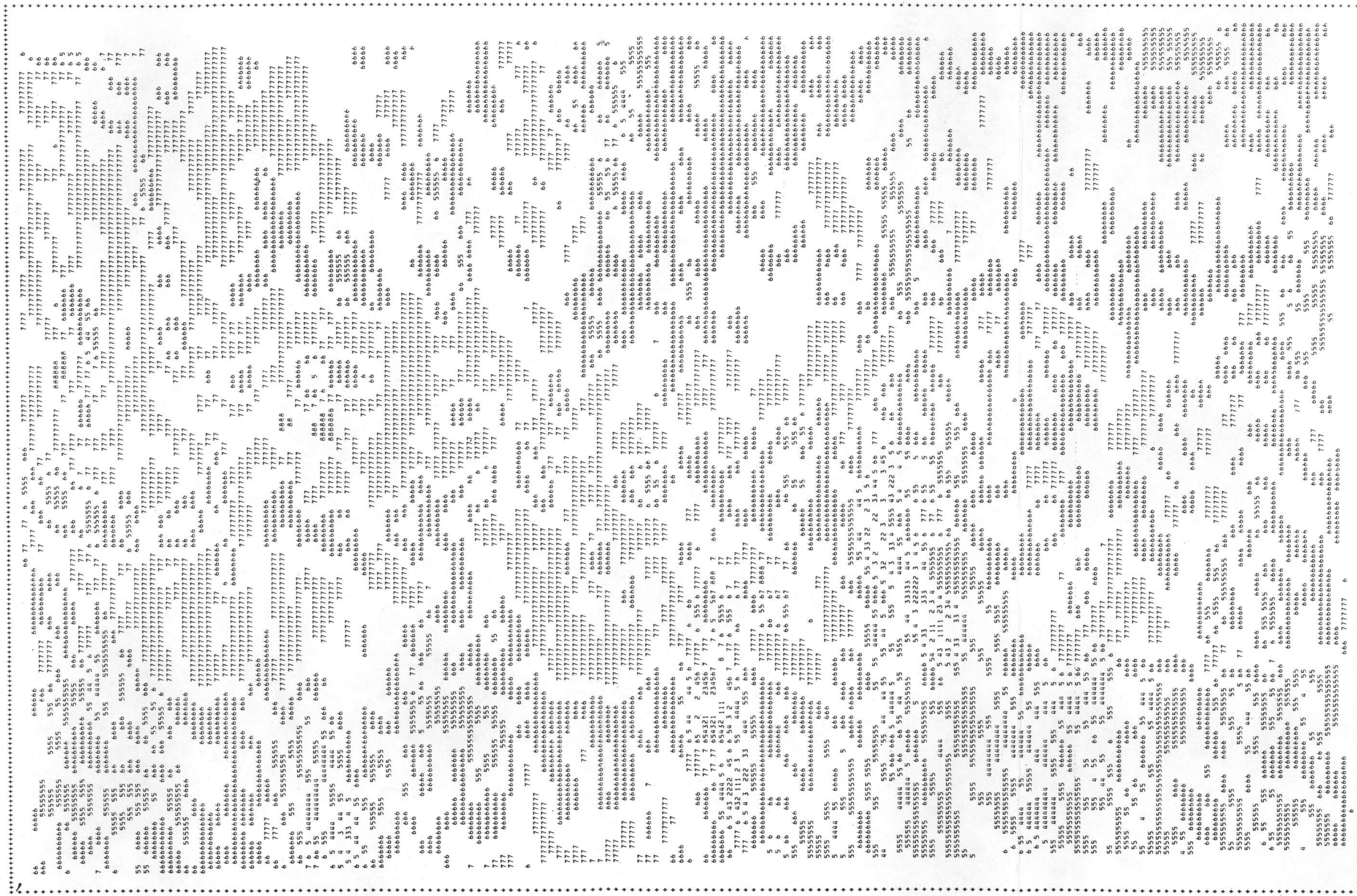


Figure 26 Manhattan Quadrangle, Thorium Pseudo-Contour Map*

MANHATTAN

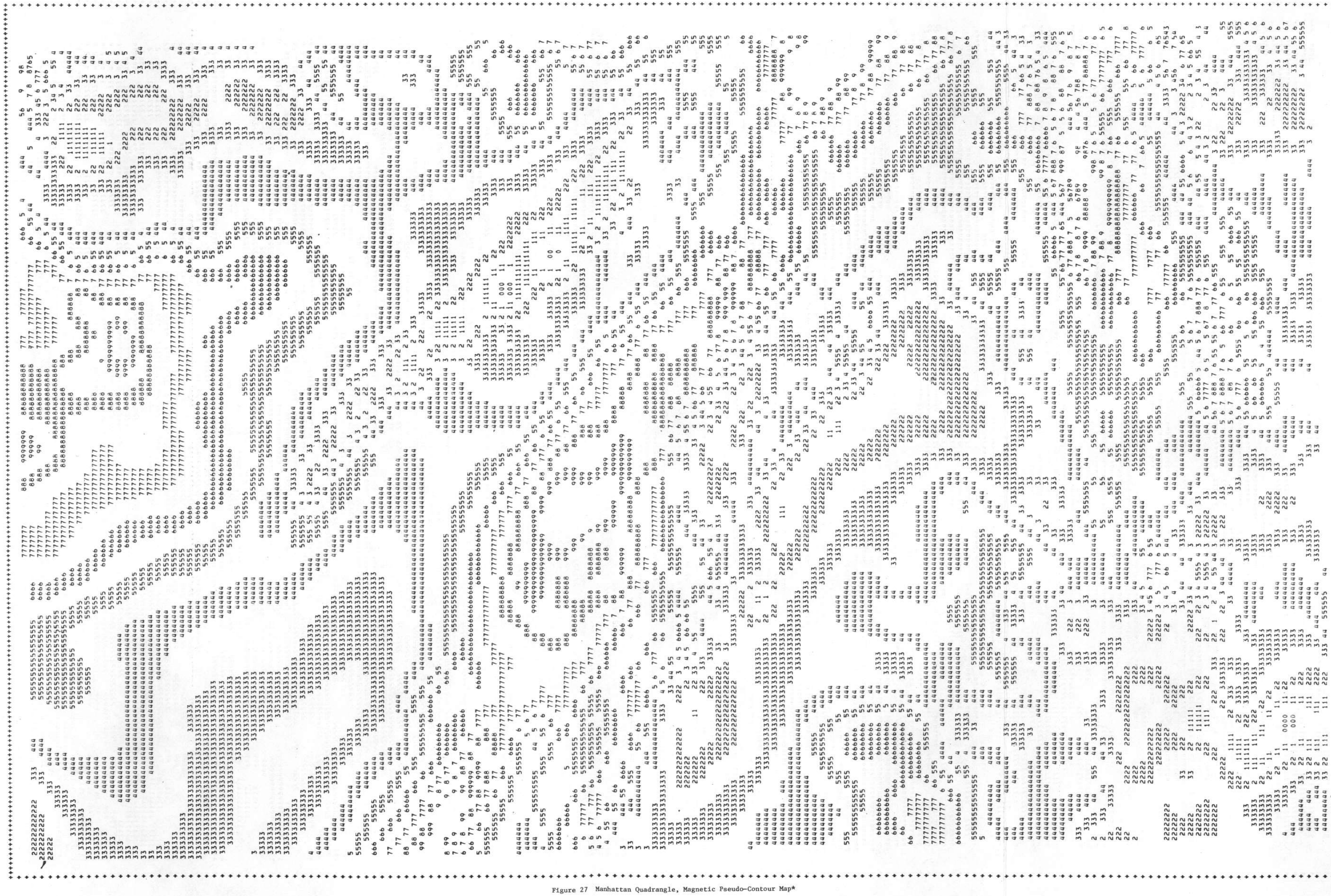


Figure 27 Manhattan Quadrangle, Magnetic Pseudo-Contour Map*

In the northeastern part of the Manhattan quadrangle, the glacial drift of Kansan age is distinguishable by a generally reduced count rate although with insufficient definition to clearly mark the boundaries. On the potassium 40 channel the count rates over the glacial drift range between 70 and 90 counts per second, on the thallium 208 channel 45 to 55 counts per second, and on the bismuth 214 channel 55 to 100 per second.

A total of twenty-two sites have been noted where the anomalous radiation exceeds the minimum criteria; ten consecutive samples exceeding the mean or median value by at least two standard deviation values, supported by comparable and consistent results on the pertinent ratio profiles. Fifteen of these are indicated to be anomalous uranium concentrations and seven are anomalous thorium concentrations. However, the count rates are so low for all of the twenty-two anomalous sites that it is likely that any of these are economic concentrations.

Anomaly #1 located in the northwestern part of the quadrangle on lines 39 and 40 is associated with post-Kansan alluvium and Dakota Sandstone. This association is interesting in view of the uraniferous potential of the Dakota described by DoE (1976). The maximum uranium anomaly expression is three standard deviations above the mean. The maximum Bi214 count rate was 160 counts per second, corresponding to approximately 3.4 ppm eU.

Anomaly #8 is in the central part of the quadrangle, a few miles northeast of Clay Center on lines 34 and 35. On each flight line a dual peak was recorded implying two or more discrete concentrations. The associated geological unit is the Permian Sumner group; presumably the Ninnescah shale member. The maximum uranium anomaly expression is four standard deviations above the mean. The maximum Bi214 count rate was 180 counts per second, corresponding to approximately 3.8 ppm eU. The remaining twenty sites of anomalous radiation were observed only on single flight lines, and in general, barely met the minimum criteria for recognition.

The magnetic pattern of the Manhattan quadrangle is dominated by a long, continuous positive anomaly (amplitude about 700 gammas) oriented northeast-southwest. This feature is flanked on the northwest and southwest by shorter narrower positive anomalies paralleling its trend. Along the eastern edge of quadrangle, the magnetic pattern is generally higher in frequency. Individual anomalies are smaller in areal extent and display an ill-defined northwest-southeast orientation. Local amplitudes are typically two hundred to five hundred gammas. This eastern area corresponds to the Nemaha Uplift. The irregular magnetic expression suggests that the basement structure of the Nemaha Uplift is considerably more complex than is indicated on regional Tectonic maps. In the extreme west there is a broad, regional positive anomaly which continues westward into the adjacent Beloit quadrangle.

The dominant positive trend traversing the central part of the quadrangle is interpreted as having its source in a rock system of relatively mafic bulk composition. Its location and extent coincide with the Abilene Arch, suggesting that the source rock system has relief above the general level of the basement surface. The narrow anomalies flanking the main positive trend on the northwest and southeast are also attributed to a relatively mafic rock source. Whether these features are accompanied by relief is problematical.

Several magnetic faults are interpreted on the basis of anomaly dislocation, unusually straight and persistent gradients and abrupt truncation of anomaly pattern. All of these features are basement faults and the degree to which they involve the sedimentary section is unknown.

Two inferred faults offset the long positive anomaly in the central part of the quadrangle. The first strikes northwest-southeast with the northeastern block apparently displaced a few miles to the northwest relative to the southwestern block. The second fault in the south-central part of the quadrangle strikes northeast-southwest and has apparently displaced the northwestern block a few miles to the northeast relative to the southeastern block.

Along the eastern edge of the map sheet a discontinuous line of truncated anomalies bounding the zone of high frequency anomalies is interpreted as a fault or fault system, oriented about north 20 degrees east. It approximately coincides with the fault bounding the Nemaha Uplift.

The two distinct magnetic trends (northeast-southwest in the center and northwest-southeast in the east of the quadrangle) indicate that at least two orogenic intervals may have affected the basement complex. The northeast-southwest trend appears to be superimposed across the northwest-southeast trend, and is therefore likely to be younger.

The six kimberlite plugs are not reflected in the magnetic pattern. They are very small and none were crossed by a flight line. However, the theory that they were emplaced through fracture zones transverse to the Abilene Arch is supported by the interpreted fault in the north-central part of the quadrangle. The relatively mafic body postulated along the core of the Abilene Arch, or the smaller body east of it, may be the source magma for the kimberlites.

HUTCHINSON QUADRANGLE

This 1:250,000 quadrangle covers part of the NNE-SSW trending Nemaha Uplift, which separates the Cherokee Basin to the east from the Sedgwick and Salina Basins to the west. The Nemaha Uplift is a long basement high whose eastern flank is bounded by NNE-SSW faulting which in turn is complicated by transverse northwest-southeast faulting. The bulk of uplifting and faulting occurred during the pre-Pennsylvanian erosion interval. However, arching of the upper Paleozoic sediments indicates that uplift continued at least through mid-Permian time. The general depth to the top of the uplift within the center of the quadrangle (based on well data) is 3,000-3,500+ feet below surface; this being the shallowest depth to basement within the area. A salient of the Nemaha Uplift, the Abilene Arch, extends southwesterly from the Manhattan Quadrangle into the west central portion of the Hutchinson quadrangle. Basement well control suggests that its relief is less than the Nemaha Uplift and that it plunges southwestward, terminating in the west central part of the quadrangle. Depths to basement south of the axis' termination are around 5,500± feet below the surface.

Outcropping rocks of the Hutchinson quadrangle are predominantly marine sediments ranging in age from upper Pennsylvanian along the eastern margin to lower Cretaceous in the west. Generally, the section dips gently westward in a monocline, forming the eastern side of the Sedgwick Basin. Among the outcropping rock units is the Dakota sandstone which is cited by DoE (1976) as being potentially uraniferous. It occurs in the northwest corner of this quadrangle as outcrops on the more dissected slopes. A discontinuous veneer of Pleistocene and Recent alluvial material overlies the sedimentary sequence. The most extensive area of alluvial cover is a large area of post-Kansan loess (Nl) in the southwest.

Subsurface, the regional basement consists of Precambrian and lower to middle Cambrian granites, rhyolites, gabbros, and localized basalts. Within the area encompassed by the Hutchinson quadrangle, the basement is overlain by upper Cambrian limestones and dolomites. Above the Cambrian section are lower and middle Ordovician rocks of the Arbuckle and Simpson groups, generally calcareous, and mid-Mississippian calcareous cherts. The lower and middle Paleozoic section is truncated by an unconformity above which lies a thick section of middle and upper Pennsylvanian and Permian calcareous rocks. On the western side of the quadrangle, Cretaceous sandstones and shales lie unconformably over the Permian section.

INTERPRETATION DISCUSSION AND RESULTS (HUTCHINSON)

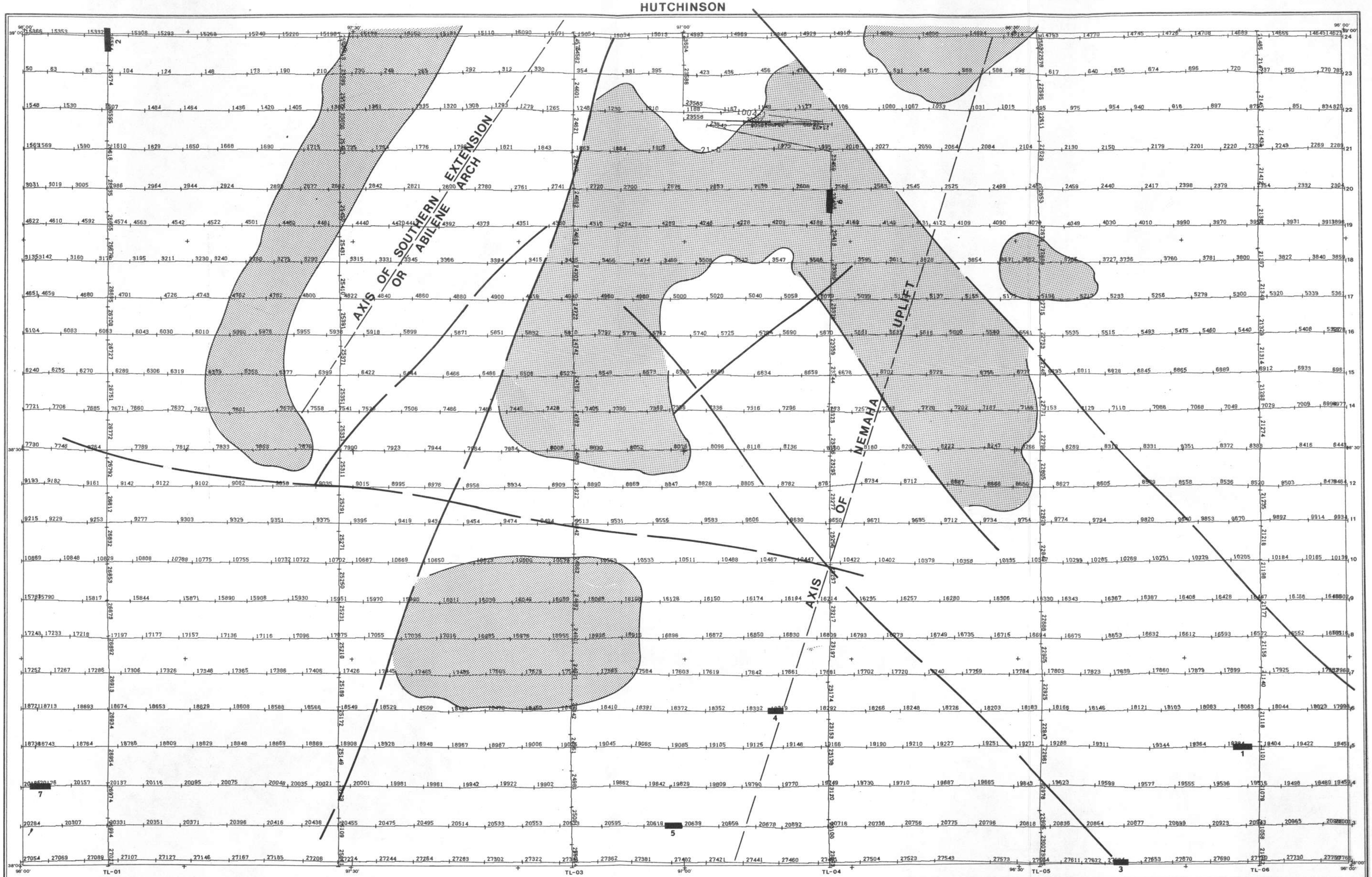
Abrupt truncation and disruptions of magnetic anomaly patterns are interpreted as manifestations of faulting and have been noted on the interpretation map. The resultant uranium anomaly magnetic interpretation map is shown in Figure 28. Uranium anomalies depicted are summarized in Table 6. Figures 29 through 32 present the pseudo contour maps prepared for regional overview. (Symbolism is the same as presented in Tables 2 and 3). All geologic symbol definitions are presented in Appendix E. Statistical tables defining the distribution type, measure of central tendency and standard deviation data for these rock types are shown in Appendix G.

Overall, the Hutchinson sheet is typified by relatively low counting rates in all channels. Again, this can be seen below on the list of equivalent geochemical concentrations as a function of geology. Scattered instances of relatively high counting rates are likely to be related to dissection of the alluvial cover and exposure of underlying shale or siltstone units within the predominately carbonate section. Specifically, the majority of uranium anomalies delineated on the interpretation map are questionable indicators of mineralization because of the surficial geology and low overall counting rates. They are displayed because they fit minimum anomaly recognition criteria.

Geology	Mean % K	Mean PPM EU	Mean PPM ET
KD	1.09	1.48	7.38
KGG	1.25	1.60	8.38
NAL2	1.49	1.82	8.09
KKC	1.12	1.59	7.49
NAL3	1.41	1.66	7.58
NDS	2.06	1.52	3.49
NGD	1.26	1.21	7.15
NI	1.59	1.91	8.33
NO	1.24	1.20	7.04
PA	1.12	1.42	7.72
PC	1.19	1.59	7.50
PCG	1.17	1.38	7.07
PPW	1.10	1.77	7.89
PS	1.44	1.71	7.92
PWN	1.51	1.73	8.07
PPS	.99	1.88	7.31
NAL1	.90	1.65	7.47

The most coherent radiometric pattern visible on the pseudo-contour maps occurs in the southwestern corner. This feature corresponds to a large exposure of Pleistocene loess next to Neogene dune sands separated by the Little Arkansas River. The pattern is most clearly seen in the K_{40} and

HUTCHINSON



SCALE 1:500,000

MILES

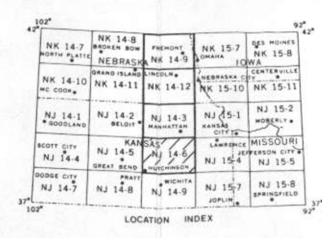
KILOMETRES

— — INFERRED MAGNETIC FAULTS

INFERRED MAFIC BASEMENT ROCK

RADIOMETRIC ANOMALIES

APPROXIMATE AXIS OF BASEMENT



LOCATION INDEX

SURVEY AND COMPILATION BY:

geoMetrics

INTERPRETATION MAP

EAST SALINA BASIN AREA

U.S. DEPARTMENT OF ENERGY

TABLE 6

HUTCHINSON

URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Geology Type	Number of Data Samples (XS) With Defined σ														
				-5σ	-4σ	-3σ	-2σ	-1σ	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ	8σ
1	U	5	PPW,NAL3								1	0	0	0	1	0	0	1(19)*
2	U	TL1	KKC							1	5	3						
3	U	2	PCG							1	1	1						
4	U	6	PC							5	1	0	1					
5	U	3	PC,NAL3							2	0	4	1					
6	U	TL4	PC						1	2	3							
7	U	4	NAL3							5	2	1						

*(19) denotes # of σ's

HUTCHINSON

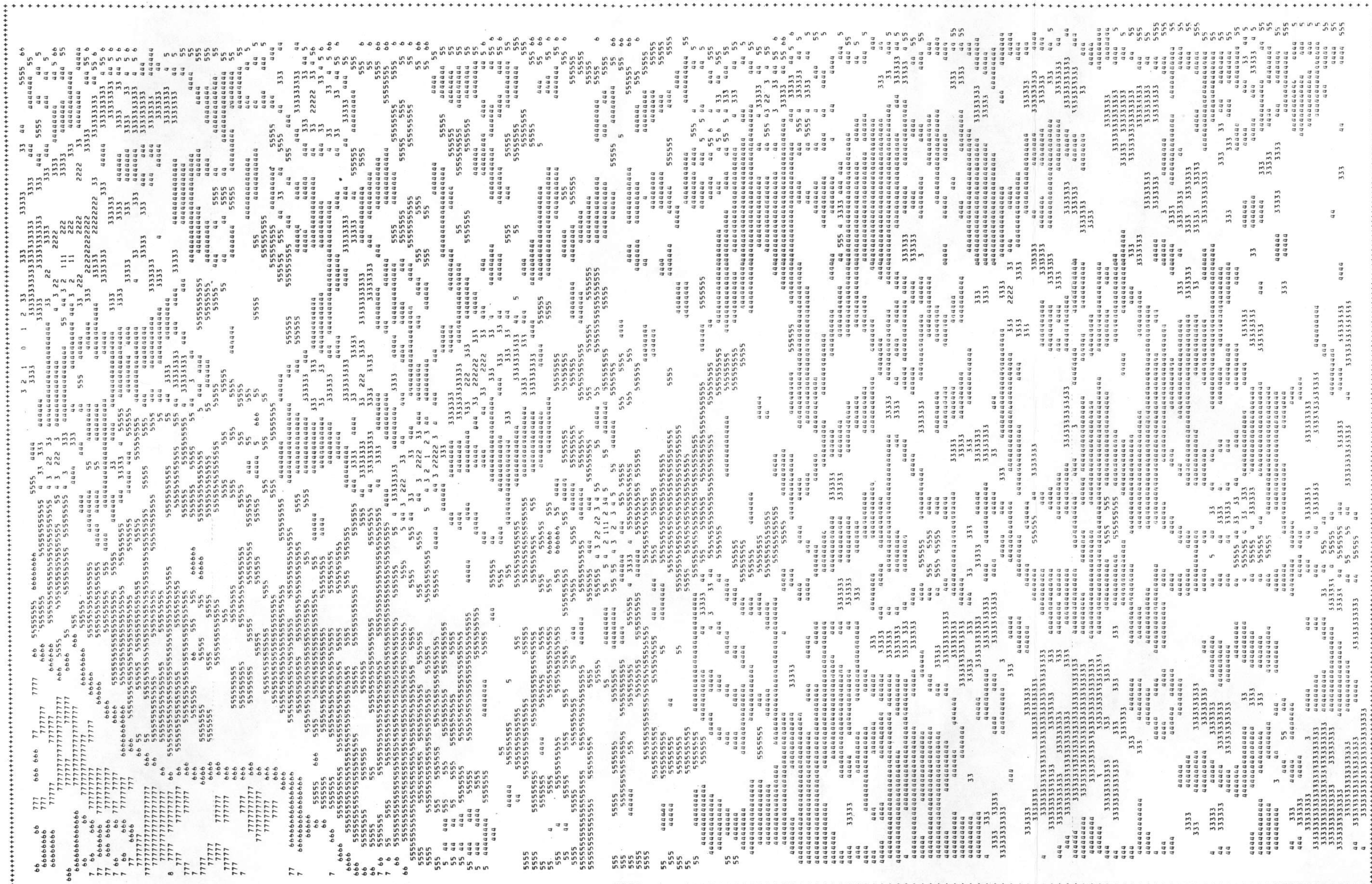


Figure 29 Hutchinson Quadrangle, Potassium Pseudo-Contour Map*

HUTCHINSON

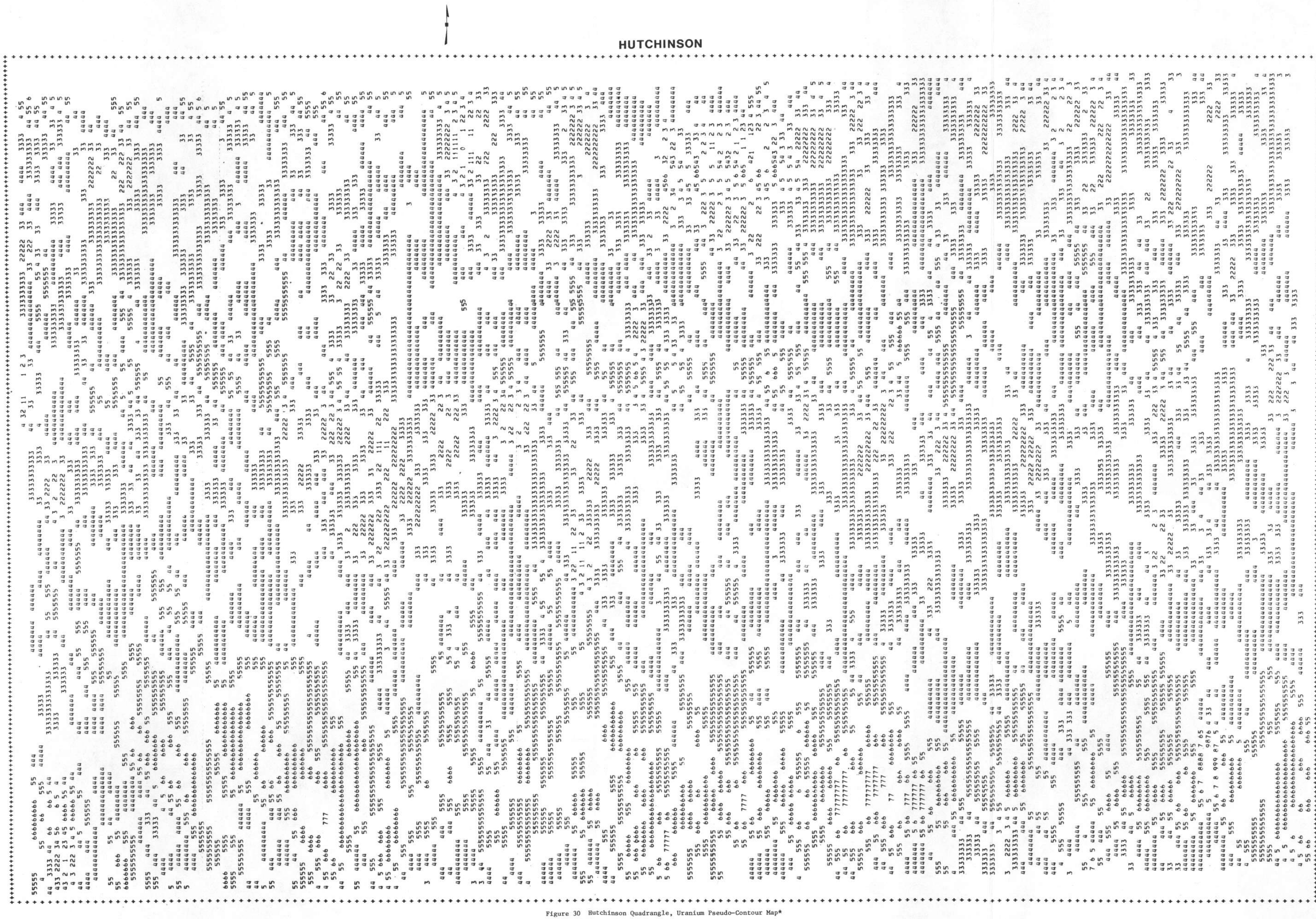


Figure 30 Hutchinson Quadrangle, Uranium Pseudo-Contour Map*

HUTCHINSON

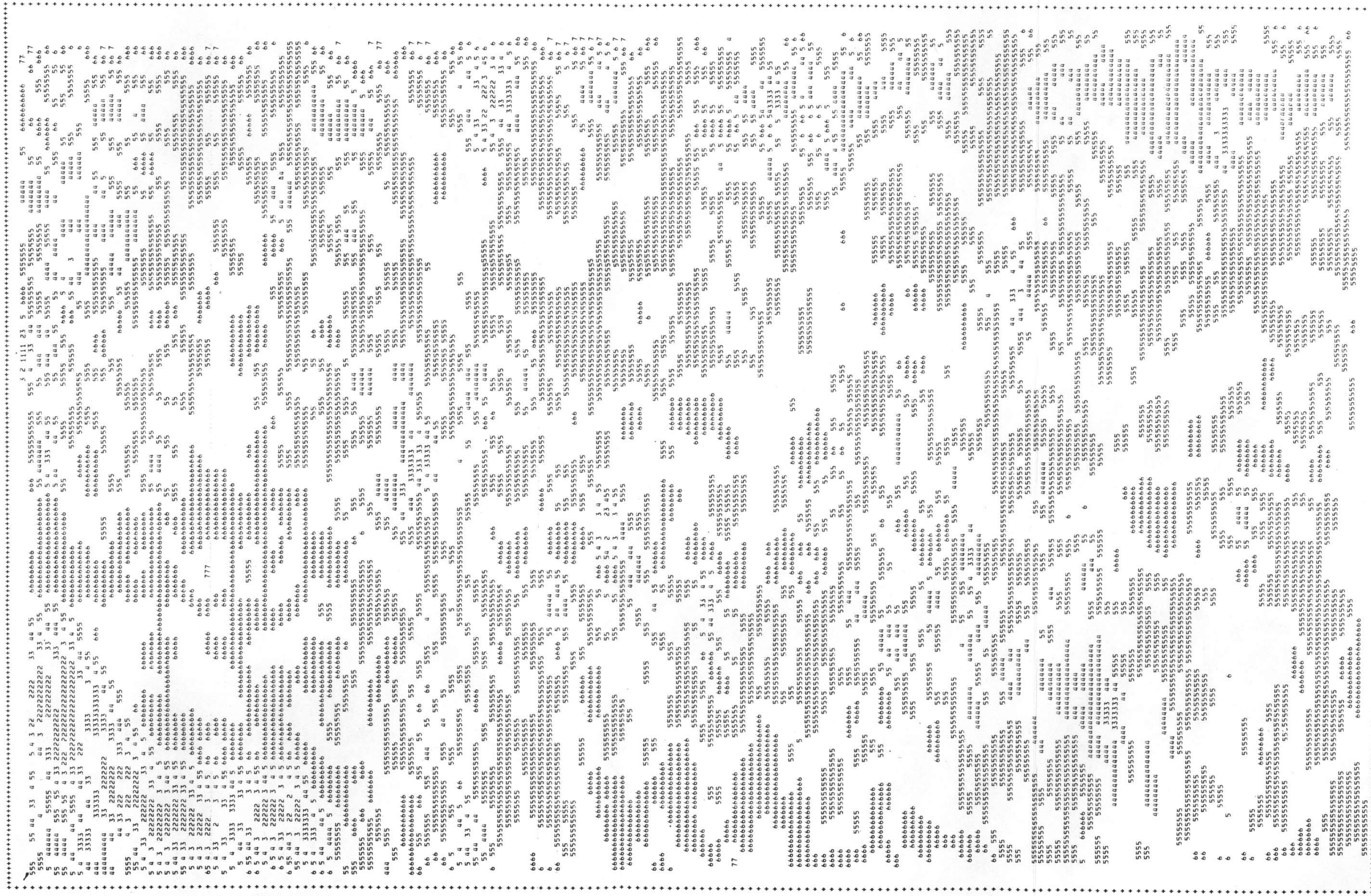


Figure 31 Hutchinson Quadrangle, Thorium Pseudo-Contour Map*

HUTCHINSON

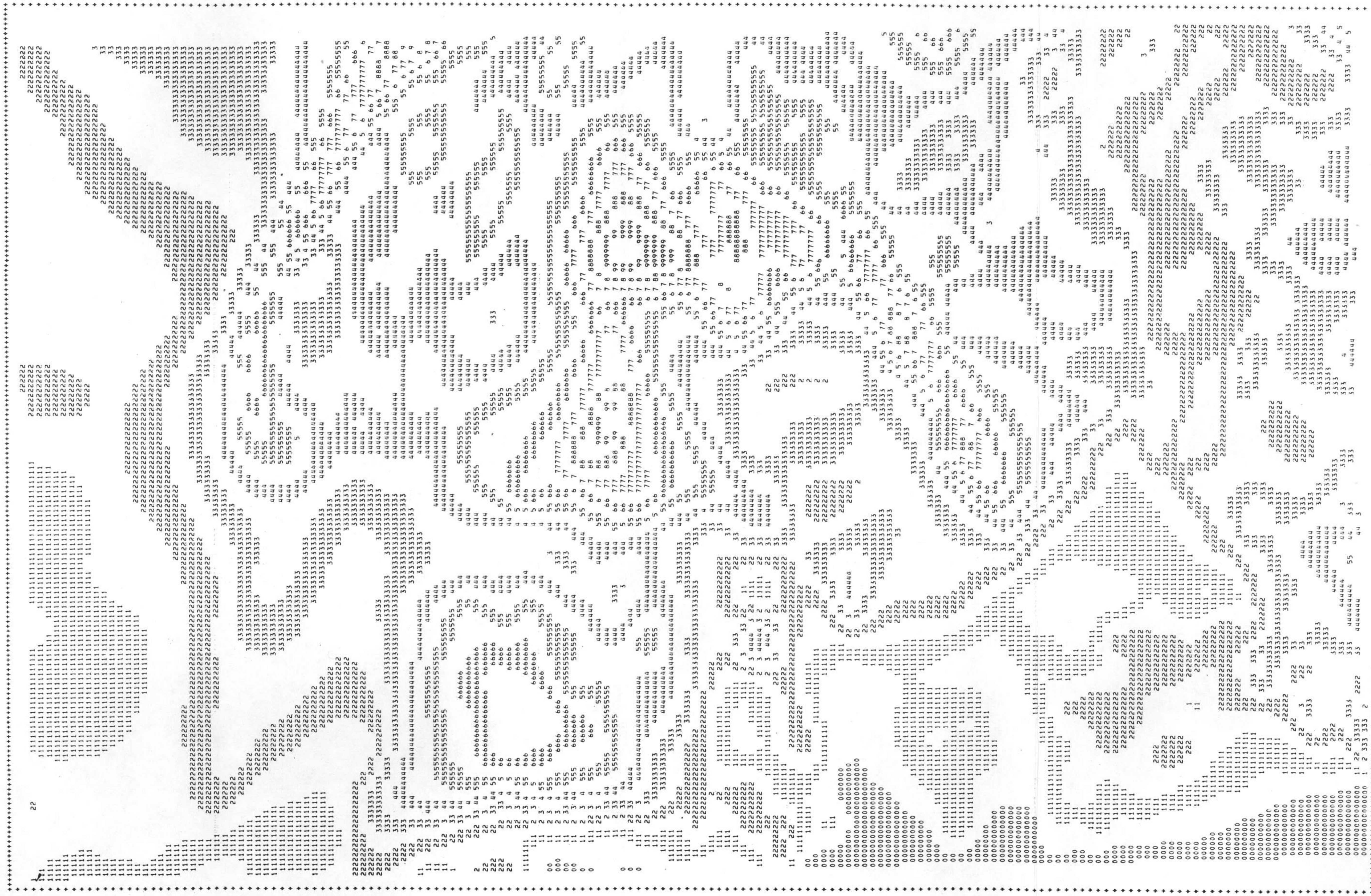


Figure 32 Hutchinson Quadrangle, Magnetic Pseudo-Contour Map*

Tl_{208} maps and not so well on the Bi 214 map. The loess generally has higher counting rates on the Tl_{208} channel, 55-60 cps, than the rest of the map. However, the dune sands have higher count rates in the K_{40} channel, 130-140 cps, than the loess, 90-100 cps.

Based upon the stated criteria for statistically significant enrichment of eU over eTh, a total of seven anomalies have been selected and displayed on the interpretation map. The largest, Anomaly 1, exhibits maximum count rates of 760 cps in Bi 214 and 120 cps in Tl_{208} implying eU and eTh values of 16 ppm and 18 ppm respectively. The high count rates and spatial restriction of this anomaly combined with its proximity to culture and the occurrence of a coincident high frequency, near surface magnetic anomaly implies that this anomaly is related to some cultural feature rather than to geology. Examination of the 35 mm film of line 5 shows a group of "tanks" and buildings coincident with the anomaly. This tends to confirm the relation to culture rather than geology.

Inspection of residual magnetic profiles in conjunction with the magnetic contour map (Figure 32) and base geologic map of the Hutchinson quadrangle indicates a predominance of broad wavelengths reflecting lithologic variations within, and relative relief of, the Precambrian basement. General magnetic trends show no widespread correlation with surficial geology. However, there is reasonable agreement between the magnetics and the basement structure as described in the geological summary.

An interesting correlation between the magnetic map and surficial topography is the coincidence of the northwest-southeast trending Neosho River in the northeastern portion of the quadrangle with a magnetic discontinuity striking in the same direction. This apparent correlation between geomorphology and magnetics may indicate that the Neosho River channel could in fact be a surficial expression of a basement fault along which there may have been later movement involving the overlaying sedimentary section.

The magnetic expression of the Nemaha Uplift and Abilene Arch is one of a broad high. Superimposed on this broad positive feature is a relatively complex (in a regional sense) series of discrete high amplitude anomalies which are interpreted to result primarily from the presence of more basic lithologies within the predominantly granitic basement; e.g., note the magnetic highs within the area of the Nemaha Uplift in the center of the quadrangle and the western flank of the Abilene Arch. In general, faulting interpreted from the magnetics supports the observation that the Nemaha Uplift is irregular in nature and complicated by transverse faulting within the Hutchinson quadrangle.

SECTION VIII

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________, undated, Geological Map of Hutchinson Quadrangle, Kansas, Scale 1:250,000 (blue line copy of hand drawn preliminary map used to compile State Map Sheet 1) courtesy of Kansas Geological Survey.

APPENDIX A

SOIL ASSOCIATION LEGEND

BEDROCK GEOLOGY LEGEND

FREMONT QUADRANGLE

SOIL ASSOCIATIONS - FREMONT QUADRANGLE

M	ANTELOPE COUNTY	Marshall Association: Moderate depth, poor surface drainage (ample internal drainage), shallow depression, gentle slopes, low rounded hills and ridges, dark brown, loamy sand (variable grain size) surface layer high organic content; grading downward into light colored friable silt; developed on uplands from loess.
W		Waukesha Association: Shallow to moderately deep, good drainage level to nearly level, dark gray brown, sandy loam (variable grain size) surface layer, variable organic content; grading to light sandy clay at depth; developed on terraces from alluvial material.
C_sLW_b		Cass-Lamoure-Wabash Association: Moderate depth, moderate to well drained, level, gray brown to black, silty to sandy loam surface layer, typically rich in organic material, some lime concentrations; grading to either clayey or granular subsoil, developed on bottom lands from alluvial material.
H_b	BOONE COUNTY	Hobbs Association: Well drained, nearly level, silty soils on bottom lands subject to occasional flooding.
H_1H_d		Hall-Hord Association: Deep, well-drained, nearly level to gently sloping, dark silt loam with thick surface layer; grades to silty clay loam; developed on stream terraces.
W_b	BURT COUNTY	Wabash Association: Moderately deep, good drainage, level, dark brown to black, friable silt loam (some sand) surface layer high organic content, grading downward into heavy silt loam or silty clay loam (having high organic content), developed on bottom land from alluvial materials.

SOIL ASSOCIATIONS - FREMONT QUADRANGLE

L_1LW_b	BURT COUNTY (Also in Iowa)	Laurel-Lamoure-Wabash Association: Moderate to deep, moderate to well drained, level, dark brown to black, silty to fine sandy loam surface layer, abundant organic material; grading downward into variable subsoil (clayey to sandy) with relatively high organic content; developed on bottom lands from alluvial material.
M		Marshall Association: Moderate to deep, excellent drainage, nearly level to undulating, dark gray brown, silt loam (some sand) surface layer, high organic content; grades into light colored silt loam or silt at depth (some phases have clay component); developed on uplands from loess.
K		Knox Association: Shallow to moderate depth, well drained, steep slopes and ridge crests, light brown, silt loam with little organic matter; grades into a silt; developed on uplands from loess.
W		Waukesha Association: Moderate to deep, good drainage, level to nearly level, dark brown friable silt loam (some fine sand component), surface layer; grades into a higher silt loam or floury silt; developed on terraces from alluvial material from adjacent uplands.
C		Carrington Association: Moderate to deep, good drainage, gently rolling to hilly areas, dark brown, silt loam surface layer, moderately high organic matter; underlain by moderately compact silt or clay grading downward to granular silt/clay; developed on uplands of Kanson glacial drift.
SM		Sharpsburg-Marshall Association: Silty to clayey soils of the nearly level to rolling loess uplands east of Bell Creek.

SOIL ASSOCIATIONS - FREMONT QUADRANGLE

C_sL	BUTLER COUNTY	Cass - Lamoure Association: Level to nearly level bottom land soils having a loamy or clayey silt to sandy silt surface layer rich in organic matter; a more granular subsoil layer grading from abundant organic matter to gravelly sand; developed from alluvium washed in from adjacent uplands.
C		Carrington Association: Gently rolling to hilly soils having silt loam surface layer with moderate organic content; underlain by a moderately compact silty clay which grades downward into a silty clay having variable amounts of granular material; developed on uplands of Kansan glacial drift.
M		Marshall Association: Gently rolling to sloping soils characterized by friable silt loam surface layer with high organic content; a silt loam subsoil grading into a lime rich silt at depth; developed on uplands underlain by loess.
HC_rB_t		Hastings-Crete-Butler Association: Level to nearly level soils including basinal deposits with surface layer characterized by silt loam well supplied with organic matter; a moderately compact subsoil layer varying from claypan to clayey silt; developed on loess.
WOJ		Waukesha-O'Neil-Judson Association: Level to nearly level soils with surface layer characterized by a friable sandy to silty loam with varying degrees of organic content; a subsoil which varies from a heavy silt loam through silt to sand and gravel; developed on terraces comprised of alluvium.
B_t		Butler Association: Basinal soils poorly drained, surface layer characterized by a friable silt loam with variable dry and organic content; a subsoil of friable silt; developed in depressions.

SOIL ASSOCIATIONS - FREMONT QUADRANGLE

V	BUTLER COUNTY	Valentine Association: Strongly rolling soil having a surface layer characterized by porous loamy sand with poor organic content; a loose incoherent sand subsoil; developed from dune sand.
W_b		Wabash Association: Level to nearly level bottom land soils having a loamy silt surface layer with considerable organic matter; developed from alluvium washed in from adjacent uplands.
K		Knox Association: Level to nearly level soils having a thin silt loam surface layer poor in organic content; underlain by a floury silt to sandy loam rich in lime; developed in narrow zones along bluffs and steep slopes.
HG_c		Hastings-Geary Association: Moderately sloping to steep soils that are silty throughout; on uplands mantled with loess.
$W_bC_sS_a$	CASS COUNTY	Wabash - Cass - Sarpy Association: Moderately deep, good drainage, level to nearly level, dark brown, friable sandy silt loam surface layer, relatively high organic content; grades downward to silty sand and soil; developed on bottom land from alluvium.
M		Marshall Association: Nearly level to steeply sloping soils, typically well to excessively drained, having a friable silty clay loam surface layer with an abundance of organic matter; overlying a silt loam subsoil; on uplands underlain by the Peorian loess.
WK		Waukesha-Knox Association: Moderate to shallow depth, nearly level to gentle slopes, well drained, silty loam to silty loam clay surface layer, grades to silt loam or silt at depth; developed on stream terraces or adjacent upland area on either alluvium or residual loess.

SOIL ASSOCIATIONS - FREMONT QUADRANGLE

W_bL	CASS COUNTY	Wabash - Lamoure Association: Level to nearly level bottom-land soils having a loamy silt to clayey silt surface layer high in organic matter; developed from alluvium washed in from adjacent uplands.
C_sLW_b	COLFAX COUNTY	Cass-Lamoure-Wabash Association: Moderate depth, moderate to well drained, level, gray brown to black, silty to sandy loam surface layer, typically rich in organic material, with some lime concentrations; grading to either clayey or granular subsoil; developed on bottom lands from alluvial material.
M_d		Moody Association: Moderate depth, excellent drainage, gradual slopes and gently to steeply rolling areas, dark brown, silt loam surface layer, high organic content; grading into a lighter color silt loam subsoil; developed on uplands from loess.
M		Marshall Association: Deep, excellent drainage, nearly level to undulating, dark gray brown, silt loam surface layer, high organic content; grading into lighter silt loam at depth (some phases have clay loam subsoil); developed on uplands from loess.
WOH_l		Waukesha-O'Neill-Hall Association: Shallow to moderately deep, well to excessively drained, level to nearly level, gray brown silty loam to sandy loan surface layer, variable organic content; grading to silt and sand at depth; developed on terraces from alluvial material.
ZL_sW_n	CUMING COUNTY	Zook-Leshara-Wann Association: Deep, somewhat poorly drained, nearly level clayey, silty and loamy soils on bottom land.
$C_oC_lK_n$		Colo-Calco-Kennebec Association: Deep, somewhat poorly drained and moderately well drained, nearly level, silty soils on bottom lands.

SOIL ASSOCIATIONS - FREMONT QUADRANGLE

N_rM_dJ	CUMING COUNTY	Nora-Moody-Judson Association: Deep, well drained, gently sloping to moderately steep silty soils on uplands and foot slopes.
$M_dN_rB_f$		Moody-Nora-Belfore Association: Deep, well drained, nearly level to moderately steep, silty soils on uplands.
$T_hM_dL_y$		Thurman-Leisy-Moody Association: Deep, excessively drained to well drained, nearly level to moderately sloping, sandy, loamy and silty soils on uplands.
C_sL_bW	DODGE COUNTY	Cass-Lamoure-Wabash Association: Level to nearly level bottom land soils having a loamy or clayey silt to sand silt surface layer rich in organic matter; a subsoil varying from deep silt to more granular material, with high organic content; developed from alluvium washed in from adjacent uplands.
WOH_1		Waukesha-O'Neill-Hall Association: Moderate depth, well to excessively drained, level to nearly level soils, silty loam to sandy soils, moderate organic content; subsoil covering from silty loam to sand; developed on terraces.
M		Marshall Association: Moderate depth, well drained, nearly level to rolling dark gray brown, loamy sand surface layer abundant organic matter; grading to gray silt at depth; developed on uplands from loess.
S		Sharpsburg Association: Gently sloping to moderately sloping thick friable silty surface layer having an abundance of organic matter; subsoil is also thick and well oxidized; overall soil has high water holding capacity; developed in the uplands from floury Peorian loess.

SOIL ASSOCIATION - FREMONT QUADRANGLE

$C_sI_nW_n$	DOUGLAS AND SARPY COUNTIES	Cass-Invale-Wann Association: Deep, excessively drained to poorly drained, nearly level loamy and sandy soils on bottom land along the Platte and Elkhorn Rivers.
G_bEW_b		Gibbon - Eudora - Wabash Association: Deep, poorly drained to well drained, nearly level silty and clayey soils on bottom land along the Platte and Elkhorn Rivers.
P_oI		Ponca - Ida Association: Deep, well drained, strongly sloping to steep silty soils on loess uplands.
$M P_o$		Marshall - Ponca Association: Deep, well drained, nearly level to moderately steep silty soils on loess uplands.
M_nI		Monona - Ida Association: Deep, well drained, nearly level to very steep silty soils on bluffs adjacent to Missouri River Valley.
HFB_t	HAMILTON COUNTY	Hastings - Fillmore - Butler Association: Nearly level to gently rolling soils having a relatively thick silt loam surface layer, high organic matter content; subsoil of higher clay content; principally well drained but with shallow basins of poor drainage; some steep slope phases occur but principally developed on old loess mantled plain.
WO		Waukesha - O'Neill Association: Moderate to shallow depth, nearly level to level, well drained, silty loam to sandy silt loam; grades to silt or sandy-silt at depth; developed on stream terraces or slopes of adjacent upland areas from alluvium.

SOIL ASSOCIATION - FREMONT QUADRANGLE

C_yC_z	**HAMILTON COUNTY**	Coly - Cozad Association: Gently sloping to steep, deep, silty soils on upland breaks to the Platte River Valley.
V		Valentine Association: Strongly rolling soil having a surface layer characterized by porous loamy sand with poor organic content; a loose incoherent sand subsoil; developed from dune sand.
C_rB_t		Crete-Butler Association: Moderately sloping to steeply sloping soils characterized by friable granular highly organic silty clay surfacelayer; underlain by a dense clay subsoil with calcareous bottom layer; developed on uplands mantled with Peorian loess.
C_sL		Cass - Lamoure Association: Level to nearly level bottom land soils having a loamy or clayey silt to sandy silt surface layer rich in organic matter; a more granular subsoil layer grading from abundant organic matter to gravelly sand; developed from alluvium washed in from adjacent uplands.
$A_bH_yO_n$	**HARRISON/MONONA COUNTIES (Iowa)**	Albaton-Haynie-Onawa Association: Deep, poorly drained, nearly level, moderately dark, clayey to sandy soils of low bottom lands.
S_aC_a		Sarpy Association: Moderately drained, nearly level to gently sloping (0-5%) light, silty to sandy soil (alluvial) of higher bottom lands.
IH_mM_n		Ida-Hamburg-Monona Association: Deep, well drained, steep to very steep, dark, silty soils developed from deep calcareous coarse loess on uplands.

SOIL ASSOCIATION - FREMONT QUADRANGLE

$L_uK_gL_rS_1$	HARRISON/MONONA COUNTIES (Iowa)	Luton-Keg-Lakeport-Salix Association: Deep, poorly drained, dark, silty soils developed on bottom lands.
L_1LW_b		Laurel-Lamoure-Wabash Association: First and second bottom lands; deep, level to moderately sloping, poorly drained to well drained, moderately dark, silty to sandy soil, developed on bottom land and on some adjacent upland slopes.
S	LANCASTER COUNTY	Sharpsburg Association: Gently sloping to moderately sloping thick friable silty surface layer having an abundance of organic matter; subsoil is also thick and well oxidized; overall soil has high water holding capacity; developed in the uplands from floury Peorian loess.
W_bL		Wabash-Lamoure Association: Level to nearly level bottom land soils having a loamy silt to clayey silt surface layer high in organic matter; developed from alluvium washed in from adjacent uplands.
CB		Carrington-Buchard Association: Moderately sloping or rolling to steeply sloping soils characterized by a moderately deep friable silty surface layer; grades to a heavier clayey subsoil, organic matter and calcareous component; developed on uplands of Kansan glacial drift.
W		Waukesha Association: Deep, good drainage, level, dark friable granular silty loam; rich organic content; grades to silt; developed on stream terraces from alluvium worked in from adjacent slopes.

SOIL ASSOCIATION - FREMONT QUADRANGLE

C_sLW_b	MADISON COUNTY	Cass-Lamoure-Wabash Association: Shallow to deep, moderate to poor drainage, level, dark brown to black, silt loam to sandy loam with variable clay content, high organic content in surface layer; grades to silt and sands; developed on bottom land from alluvial material.
M		Marshall Association: Moderate depth, well drained, nearly level to rolling dark gray brown loamy sand surface layer abundant organic content; grading to silt at depth; developed on uplands from loess.
WOH_1		Waukesha-O'Neill-Hall Association: Shallow to moderately deep, well to excessively drained, level to nearly level, gray brown silty loam to sandy loam surface layer, variable organic content; grading to silt and sand at depth; developed on terraces from alluvial material.
K		Knox Association: Shallow to moderate depth, well drained, steep slopes and hillcrests, light brown, silt loam, with little organic matter; grading into a silt; developed on uplands from loess (on eroded phase of the Marshall).
V		Valentine Association: Shallow to moderate depth, totally drained, level to rolling, gray brown sand, little organic matter (thin surface layer); grading to sand at depth; developed on uplands from alluvial sand.
C_sL	MERRICK COUNTY	Cass-Lamoure Association: Moderate depth, moderate to well drained, level, gray brown to black, silty to sandy loam surface layers, typically rich in organic matter, with some lime concretions; grades to either clayey or granular subsoil; developed on bottom lands from alluvial material.

SOIL ASSOCIATION - FREMONT QUADRANGLE

WO	MERRICK COUNTY	Waukesha-O'Neill Association: Shallow to moderate depth, well to excessively drained, level to nearly level, dark gray brown, silty loam to sandy loam, moderate organic content; grades to a granular subsoil, developed on terraces from alluvial material and slopewash.
V		Valentine Association: Shallow to moderate depth, totally drained, almost flat to rolling, gray to gray brown sand, little organic matter; grades into loose sand at depth; developed on uplands from alluvial sand (essentially lime sand deposits).
N_wO_r	NANCE COUNTY	Newman-Ortello Association: Level to nearly level soils characterized by a silt loam surface layer contains abundant organic matter; a sandy loam to loamy sand subsoil; developed on terraces from alluvium transported from adjacent uplands.
VT_h		Valentine-Thurman Association: Gently rolling to hummocky soils having a sandy loam to loamy sand surface layer; underlain by sands; developed on dunelike portions of the upland areas.
W_n		Wann Association: Level to nearly level soils having a sandy loam surface layer; moderately sandy subsoil; some alkalai developed on flood plains.
H_1J		Hall-Judson Association: Deep, level to gently sloping soils having a silty surface layer; a moderately clayey to silty subsoil; abundant organic matter; developed on terraces at the base of long slopes from material transported in from adjacent uplands.

SOIL ASSOCIATION - FREMONT QUADRANGLE

LL_s	NANCE COUNTY	Lamoure-Leshara Association: Deep to moderate,characteristically imperfect drainage; level to nearly level soils having silt to clayey silt loam surface layer; high organic content; a silty clay loam to clayey loam subsoil; developed on bottom lands from moderately fine to medium textured calcareous clayey alluvium.
B_fM_d		Belfore-Moody Association: Deep, nearly level to gently sloping or rolling soils having a silt loamy surface layer with high organic content; a silty clay loam subsoil; developed on uplands underlain by Peorian loess.
$M_dN_fC_r$		Moody-Nora-Crofton Association: Rolling to very steep soils characterized by thick mixed fine sandy loam to silt loam surface layer with variable organic content; a subsoil which varies from a sandy loam to silt loam; developed in uplands underlain by calcareous Peorian loess.
L_pS_a		Loup-Sarpy Association: Moderate depth, good to imperfect drainage, level, dark black to gray sandy loam to loamy fine sand; grades downward in a loam sand; developed on low wet flood plains.
C_sLW_b	PLATTE COUNTY	Cass-Lamoure-Wabash Association: Moderate depth, moderate to well drained, level, gray brown to black, silty to sandy loam surface layer, typically rich in organic material; grading to either clayey or granular subsoil; developed on bottom lands from alluvial material.
M		Marshall Association: Moderate deep, adequate to excessive drainage (although very retentive), nearly flat to hilly or steeply rolling, dark gray brown, silt loam surface layer (variable fine sand content), high organic content, grading into loose and lighter silt loam at depth, developed on uplands from loess.

SOIL ASSOCIATION - FREMONT QUADRANGLE

H	PLATTE COUNTY	Hastings Association: Moderate depth, ample drainage, level, gray brown to black, heavy silt loam (considerable clay content), rich organic content, grades to a light colored silty clay at depth, calcareous, developed in uplands remnants of old loess plain.
WOH_1		Waukesha-O'Neill-Hall Association: Shallow to moderately deep, well to excessively drained, level to nearly level, gray brown silty loam to sandy loam surface layer, variable organic content; grading to silt and sand at depth; developed on terraces from alluvial material.
HH_d	POLK	Hastings-Hord Association: Deep, nearly level to moderately sloping, silty soils on loess - mantled uplands and stream terraces.
H_o		Holder Association: Deep, nearly level and very gently sloping silt soils in loess mantled uplands.
C_yC_z		Coly-Colzad Association: Deep, gently sloping to steep silty soils on upland breaks to the Platte River Valley.
T_hM_e		Thurman-Meadin Association: Deep, nearly level to gently rolling, sandy soils, and shallow, sandy soils over mixed soil and gravel on stream terraces.
$P_1L_eA_1$		Platt-Leshara-Alda Association: Shallow to deep, nearly level and very gently sloping, loamy soils over mixed sand and gravel on bottom banks of the Platte River Valley.

SOIL ASSOCIATION - FREMONT QUADRANGLE

LC_1R_v	SAUNDERS	Lamoure-Colo-Rauville Association: Imperfectly drained, and moderately to poorly drained, moderately clayey soils in alluvium on nearly level bottom lands.
SF		Sharpsburg - Fillmore Association: Deep, dark, moderately clayey, nearly level soils.
SM_n		Sharpsburg - Monona Association: Deep, dark well drained, moderately clayey soils on uplands.
SB		Sharpsburg - Burchard Association: Deep, dark, well drained moderately clayey and clayey soils on uplands.
BS_b		Burchard - Shelby Association: Deep, dark, well drained, moderately clayey soils on uplands.
M_uH_b		Muir-Hobbs Association: Deep, silty to clayey soils on low terraces and occasionally flooded bottom lands.
$S_aB_yL_eW_n$		Sarpy - Barney - Leshara - Wann Association: Well drained to imperfectly drained, silty and sandy soils in alluvium on bottom lands.
H_bH_l	SEWARD	Hobbs-Hall Association: Nearly level soils that are silty throughout; on bottom lands and stream terraces.
HFB_t		Hastings-Fillmore-Butler Association: Nearly level to gently sloping soils that have a silty surface layer and a loamy to clayey subsoil; on uplands mantled with loess and in depressions.

HG_e	<u>SEWARD</u>	Hastings-Geary Association: Moderately sloping to steep soils that are silty throughout; on uplands mantled with loess.
BS_t		Burchard-Steinaur Association: Moderately sloping to steep, loamy soils; on uplands of glacial till.
HW_y		Hastings-Wymore Association: Nearly level to moderately sloping soils that have a silty surface layer and silty or clayey subsoil; on uplands mantled with loess.
PS		Pawnee-Sharpsburg Association: Gently sloping to moderately sloping soils that have a loamy or silty surface layer and clayey to silty subsoil; on uplands mantled with loess and glacial till.
C_sLW_b	STANTON <u>COUNTY</u>	Cass-Lamoure-Wabash Association: Variable depth, moderate to well drained, level, silty to sandy loam surface layer typically rich in organic content; silt to sand subsoil; developed on bottom lands.
M_dK		Moody-Knox Association: Shallow to moderately deep, well to excessively drained, gently to steeply rolling, gray-brown silt loam surface layer, typically abundant organic matter (scattered impoverishment); grading into a lighter silt - silt loam subsoil; developed on uplands and some terraces from underlying loess.
WOH_1		Waukesha-O'Neill-Hall Association: Shallow to moderately deep, well to excessively drained, level to nearly level, gray brown silty loam to sand loam surface layer, variable organic content; grading to silt and sand at depth; developed on terraces from alluvium material.

SOIL ASSOCIATION - FREMONT QUADRANGLE

V	STANTON COUNTY	Valentine Association: Shallow to moderate depths, totally drained, level to rolling, gray - gray brown sand, little organic matter (thin surface layer); grading to sand at depth; developed on uplands from sand.
M		Marshall Association: Moderate depth, well drained, nearly level to rolling dark gray brown, loamy sand surface layer abundant organic matter; grading to gray silt at depth; developed on uplands from loess.
C_sL_s	WASHINGTON COUNTY	Cass-Leshara Association: Sandy to silty soils of the bottom lands of the Elkhorn River.
SM		Sharpsburg-Marshall Association: Silty to clayey soils of the nearly level to rolling loess uplands east of Bell Creek.
M_nC_f		Monona-Crofton Association: Silty soils of the rolling hills and bluffs west of the Missouri River bottom lands.
L_uV_o		Luton-Volin Association: Clayey to silty soils of the high bottom lands of the Missouri River.
A_bH_y		Albaton-Haynie Association: Clayey to sandy soils of the low bottom lands of the Missouri River.
M_dB_f		Moody-Belfore Association: Clayey to silty soils of the rolling loess uplands west of Bell Creek.

SOIL ASSOCIATION - FREMONT QUADRANGLE

HFB_t	<u>YORK COUNTY</u>	Hastings-Fillmore-Butler Association: Nearly level to gently sloping soils that have a silty surface layer and a loamy to clayey subsoil; on uplands mantled with loess and in depressions.
WW_bH_1		Waukesha-Wabash-Hall Association: Nearly level soils having a silt loam surface layer with variable amounts of fine sand, and considerable organic matter; overlying either a heavy silty loam or sandy alluvial material; on bottom lands and adjacent narrow terraces derives from alluvium.
S_c		Scott Association: Level to moderately sloping basinal soil characterized by a heavy silt loam surface layer; an impervious thick clay subsoil; extremely poor drainage; developed in deepest depressions of the uplands.

BEDROCK GEOLOGY - FREMONT QUADRANGLE

Symbol		Description
To	Ogallala Formation	Silt and sand. Unit is light gray, light olive gray, brownish gray, yellowish brown, contains silty clay lenses and, locally, thin basal gravel. Silt is slightly to moderately clayey and sandy. Sand is predominantly very fine to fine grained; silty; arkosic. Lenses and tabular zones of carbonate-cemented silt and sand are common. Unit is continental, predominantly fluvial, and lithologic variations are very common. Equivalent to Ogallala Group of the Nebraska Geological Survey which includes in this area (descending order): Ash Hollow Formation and Valentine Formation.
Kn	Niobrara Formation	Chalk and limestone, argillaceous. Chalk is medium gray to white; weathers dark yellowish orange, very pale orange, or white; contains interbedded chalky shale, many fossil clams, oysters, and Foraminifera, and shell fragments. Limestone is light gray to medium gray and yellowish gray; argillaceous; contains interbedded medium-gray chalky shale, and Foraminifera, Inoceramus, and shell fragments.
Kc	Carlile Shale	Shale, limestone, and sandstone. At top is a gray to pale-yellowish-brown siltstone or very fine grained sandstone, locally as much as 5 feet (1.5m) thick. Upper 150 feet (45.7m) of shale is dark gray to medium gray, fissile; locally contains ironstone concretions and very thin bedded siltstone. Lower 100 feet (30.5m) of shale is medium gray, calcareous, and contains many very thin bedded and thin bedded, fossiliferous, shaly limestone layers.
Kgg	Greenhorn Limestone and Graneros Shale	Greenhorn Limestone is medium gray to light gray; contains interbedded argillaceous limestone, marl, and calcareous shale; contains Inoceramus. Upper and lower boundaries are gradational with adjacent units.

Symbol	Description
(Cont'd.) Kgg Greenhorn Limestone and Graneros Shale	Graneros Shale is medium gray to dark gray, contains thin layers of silt; upper part, about 30 feet (9.1m) thick, is calcareous and contains thin limestone layers; lower part, about 35 feet (10.7m) thick, contains thin layers of carbonaceous material.
Kd Dakota Sandstone	Sandstone and shale. White, light gray, brownish gray, yellow, reddish brown, and red; lenticular; in part continental. Sandstone is very fine grained to coarse grained; friable; micaceous; crossbedded; locally contains gravel near base; iron oxide or iron carbonate content varies from slight to moderate; siltstone concretions; ironstone zones. Shale is light gray, yellow, red, brown, mottled, dark gray, sandy, carbonaceous; contains lenticular clay beds; siderite spherulites. Equivalent to Dakota Group of the Nebraska Geological Survey, which includes in this area (descending order): Omadi Sandstone, Skull Creek Shale, Fall River Sandstone, Fuson Shale, and Dakota Sandstone.
Ps Shawnee Group	Limestone, shale, and siltstone. Limestone is dark gray to light gray, yellowish gray, very thin bedded to massive, fossiliferous; locally the thin beds are argillaceous, other beds are oolitic, and a few beds contain chert. Shale is medium gray, greenish gray, pale red, dark reddish brown, black, sandy, fossiliferous and calcareous; black shale, in part, is fissile. Siltstone is light gray to grayish yellow, massive, calcareous; locally sandy. Shawnee Group of the Nebraska Geological Survey includes in descending order: Topeka Limestone, Calhoun Shale, Deer Creek Limestone, Tecumseh Shale, Lecompton Limestone, Kanwaka Shale, and Oread Limestone.
Pd Douglas Group	Shale and Limestone. Shale is dark gray to medium gray, red, black, fossiliferous, calcareous, and locally sandy. Limestone is dark gray to light gray, thin bedded to thick bedded, fossiliferous, and locally sandy. Douglas Group of the Nebraska Geological Survey

Symbol		Description
(Cont'd.) Pd	Douglas Group	includes in descending order: Lawrence Shale, Cass Limestone, and Plattford Shale.
Pl	Lansing Group	Limestone and shale. Limestone is dark gray to light gray, very thin bedded to massive, sandy, fossiliferous, and cherty. Shale is dark gray to light gray, maroon, black, fossiliferous, and calcareous. Lansing Group of the Nebraska Geological Survey includes in descending order: Stanton Limestone, Vilas Shale, and Plattsburg Limestone.
Pk	Kansas City and Pleasanton Groups	Kansas City Group. Limestone and shale. Limestone is dark gray to light gray, brownish gray, very thin bedded to massive, argillaceous, fossiliferous; contains very thin layers of chert, pyrite crystals, and scattered small flakes of mica near base. Shale is dark gray to light gray, greenish gray, red, and black; locally slightly sandy, calcareous, carbonaceous, fissile, and fossiliferous. Kansas City Group of the Nebraska Geological Survey includes in descending order: Bonner Springs Formation, Wyandotte Limestone, Lane Shale, Iola Limestone, Chanute Shale, Drum Limestone, Quivira Formation, Sarpy Formation, Fontana Formation, Dennis Limestone, Galesburg Shale, Swope Limestone, Ladore Shale, and Hertha Limestone. Thickness 0-200 feet (0-61m). Pleasanton Group. Shale. Shale is dark gray to medium gray, red, silty, and sandy; contains many small calcareous concretions in upper part, and scattered small flakes of mica near base. Undivided in Nebraska. Thickness 0-20 feet (6.1m).
Pm	Marmaton Group	Shale and limestone. Shale is dark gray to light gray, greenish gray, black, red, silty, sandy, carbonaceous, fissile, calcareous; contains scattered limestone nodules. Limestone is medium gray to light gray, red, mottled, thin bedded to thick bedded, sandy, shaly, vuggy, fossiliferous. Marmaton Group of the Nebraska Geological Survey includes in descending order: Altamont Limestone, Bandera Shale, Pawnee Limestone, Labette Shale, and Fort Scott Limestone.

APPENDIX B

Statistical Analysis - Fremont

Quadrangle

ROCK UNIT ABHY

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	26.3446	44.8297	63.3149	81.8000	100.2851	118.7703	137.2554
BI214	DIST	NORMAL	-1.8802	19.8799	41.6399	63.4000	85.1601	106.9201	128.6802
TL208	DIST	NORMAL	7.5238	17.6825	27.8413	38.0000	48.1587	58.3175	68.4762
U/K	DIST	NORMAL	.0027	.2573	.5120	.7667	1.0213	1.2760	1.5306
U/TH	DIST	NORMAL	.1869	.6643	1.1418	1.6192	2.0967	2.5742	3.0516
TH/K	DIST	NORMAL	.2022	.2907	.3791	.4675	.5560	.6444	.7328

ROCK UNIT ABHYON

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	57.3875	71.2583	85.1292	99.0000	112.8708	126.7417	140.6125
BI214	DIST	NORMAL	8.5573	29.6049	50.6524	71.7000	92.7476	113.7951	134.8427
TL208	DIST	NORMAL	29.9965	35.2310	40.4655	45.7000	50.9345	56.1690	61.4035
U/K	DIST	LOG	.2319	.3349	.4836	.6982	1.0082	1.4557	2.1019
U/TH	DIST	NORMAL	.0592	.5698	1.0803	1.5908	2.1014	2.6119	3.1224
TH/K	DIST	LOG	.2997	.3467	.4009	.4637	.5363	.6203	.7174

ROCK UNIT BF

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	75.9047	88.7031	101.5016	114.3000	127.0984	139.8969	152.6953
BI214	DIST	NORMAL	3.2605	26.5070	49.7535	73.0000	96.2465	119.4930	142.7395
TL208	DIST	NORMAL	42.5000	47.5000	52.5000	57.5000	62.5000	67.5000	72.5000
U/K	DIST	NORMAL	-.0726	.1709	.4144	.6579	.9014	1.1449	1.3884
U/TH	DIST	NORMAL	.0141	.4342	.8544	1.27454	1.6947	2.1148	2.5350
TH/K	DIST	LOG	.3208	.3730	.4338	.5044	.5865	.6819	.7929

ROCK UNIT C

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	49.0156	61.9770	74.9385	87.9000	100.8615	113.8230	126.7844
BI214	DIST	NORMAL	6.1072	27.0715	48.0357	69.0000	89.9643	110.9285	131.8928
TL208	DIST	LOG	34.4175	38.6162	43.3272	48.6130	54.5435	61.1976	68.6634
U/K	DIST	LOG	.2339	.3454	.5100	.7529	1.1117	1.6414	2.4234
U/TH	DIST	LOG	.4761	.6731	.9517	1.3456	1.9026	2.6900	3.8034
TH/K	DIST	LOG	.3346	.3971	.4713	.5593	.6638	.7877	.9349

ROCK UNIT CB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	42.9926	55.1951	67.3975	79.6000	91.8025	104.0049	116.2074
BI214	DIST	NORMAL	20.3828	38.6885	56.9943	75.3000	93.6057	111.9115	130.2172
TL208	DIST	LOG	35.7067	39.7246	44.1945	49.1674	54.6998	60.8548	67.7023
U/K	DIST	NORMAL	.0683	.3708	.6733	.9757	1.2782	1.5806	1.8831
U/TH	DIST	LOG	.6369	.8439	1.1181	1.4815	1.9629	2.6007	3.4458
TH/K	DIST	LOG	.3929	.4587	.5355	.6251	.7297	.8519	.9945

ROCK UNIT COCLKN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	65.5219	77.2479	88.9740	100.7000	112.4260	124.1521	135.8781
BI214	DIST	NORMAL	16.8052	36.1702	55.5351	74.9000	94.2649	113.6298	132.9947
TL208	DIST	NORMAL	38.5581	42.7054	46.8527	51.0000	55.1473	59.2946	63.4419
U/K	DIST	NORMAL	.0204	.2686	.5167	.7649	1.0130	1.2612	1.5093
U/TH	DIST	NORMAL	.2408	.6557	1.0706	1.4854	1.9003	2.3151	2.7300
TH/K	DIST	LOG	.3583	.4025	.4520	.5077	.5702	.6404	.7193

ROCK UNIT CSIWN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	10.3578	34.0052	57.6526	81.3000	104.9474	128.5948	152.2422
BI214	DIST	LOG	15.8249	23.9308	36.1887	54.7255	82.7573	125.1476	189.2513
TL208	DIST	NORMAL	2.0088	11.2392	20.4696	29.7000	38.9304	48.1608	57.3912
U/K	DIST	LOG	.1927	.2963	.4557	.7007	1.0775	1.6568	2.5478
U/TH	DIST	LOG	.6920	.9739	1.3706	1.9289	2.7148	3.8207	5.3772
TH/K	DIST	LOG	.1980	.2431	.2985	.3665	.4500	.5525	.6784

ROCK UNIT BFMD

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	74.6422	86.0614	97.4807	108.9000	120.3193	131.7386	143.1578
BI214	DIST LOG	41.5781	51.7209	64.3380	80.0331	99.5568	123.8434	154.0545
TL208	DIST NORMAL	39.1237	44.6824	50.2412	55.8000	61.3588	66.9176	72.4763
U/K	DIST NORMAL	.1192	.3357	.5522	.7687	.9851	1.2016	1.4181
U/TH	DIST LOG	.6499	.8474	1.1049	1.4407	1.8785	2.4494	3.1938
TH/K	DIST NORMAL	.3381	.3975	.4569	.5163	.5757	.6351	.6946

ROCK UNIT BSB

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	49.0553	60.4702	71.8851	83.3000	94.7149	106.1298	117.5447
BI214	DIST NORMAL	11.1502	31.1001	51.0501	71.0000	90.9499	110.8999	130.8498
TL208	DIST LOG	34.7489	38.7983	43.3195	48.3676	54.0039	60.2971	67.3236
U/K	DIST LOG	.2508	.3727	.5539	.8231	1.2233	1.8180	2.7017
U/TH	DIST NORMAL	.0800	.5474	1.0148	1.4821	1.9495	2.4169	2.8842
TH/K	DIST LOG	.3588	.4226	.4977	.5862	.6904	.8131	.9576

ROCK UNIT BST

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	47.4239	56.2159	65.0080	73.8000	82.5920	91.3841	100.1761
BI214	DIST NORMAL	8.6001	23.6334	38.6667	53.7000	68.7333	83.7666	98.7999
TL208	DIST NORMAL	32.7384	36.1589	39.5795	43.0000	46.4205	49.8411	53.2616
U/K	DIST NORMAL	.0590	.2860	.5130	.7401	.9671	1.1941	1.4211
U/TH	DIST LOG	.4734	.6463	.8824	1.2048	1.6450	2.2460	3.0666
TH/K	DIST LOG	.3957	.4507	.5134	.5848	.6662	.7588	.8644

ROCK UNIT BT

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	59.1690	70.2460	81.3230	92.4000	103.4770	114.5540	125.6310
BI214	DIST LOG	44.9972	54.9116	67.0103	81.7749	99.7925	121.7800	148.6120
TL208	DIST LOG	36.5228	40.0021	43.8128	47.9865	52.5579	57.5647	63.0485
U/K	DIST LOG	.3731	.4989	.6671	.8920	1.1928	1.5951	2.1330
U/TH	DIST LOG	.8223	1.0484	1.3366	1.7041	2.1727	2.7700	3.5316
TH/K	DIST LOG	.3396	.3923	.4532	.5235	.6046	.6984	.8067

ROCK UNIT CSL

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	50.1214	67.6143	85.1071	102.6000	120.0929	137.5857	155.0786
BI214	DIST	NORMAL	.1744	20.6829	41.1915	61.7000	82.2085	102.7171	123.2256
TL208	DIST	NORMAL	8.9667	17.9445	26.9222	35.9000	44.8778	53.8555	62.8333
U/K	DIST	LOG	.1645	.2493	.3779	.5727	.8681	1.3156	1.9940
U/TH	DIST	LOG	.5684	.8129	1.1626	1.6627	2.3780	3.4010	4.8640
TH/K	DIST	LOG	.1576	.2043	.2649	.3435	.4453	.5774	.7486

ROCK UNIT CSLS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56.0754	69.2169	82.3585	95.5000	108.6415	121.7831	134.9246
BI214	DIST	NORMAL	.4144	21.3763	42.3381	63.3000	84.2619	105.2237	126.1856
TL208	DIST	LOG	23.1171	28.4172	34.9325	42.9416	52.7868	64.8894	79.7667
U/K	DIST	LOG	.1964	.2901	.4287	.6334	.9358	1.3827	2.0429
U/TH	DIST	LOG	.4766	.6817	.9750	1.3946	1.9947	2.8530	4.0807
TH/K	DIST	LOG	.2399	.2967	.3671	.4542	.5619	.6951	.8600

ROCK UNIT CSLWB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	47.9646	65.1431	82.3215	99.5000	116.6785	133.8569	151.0354
BI214	DIST	NORMAL	4.3660	25.2107	46.0553	66.9000	87.7447	108.5893	129.4340
TL208	DIST	NORMAL	14.5700	24.5800	34.5900	44.6000	54.6100	64.6200	74.6300
U/K	DIST	NORMAL	-.0454	.1980	.4414	.6848	.9281	1.1715	1.4149
U/TH	DIST	NORMAL	.0675	.5518	1.0362	1.5205	2.0048	2.4892	2.9735
TH/K	DIST	NORMAL	.1599	.2575	.3551	.4528	.5504	.6480	.7456

ROCK UNIT CSMPWN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	40.0365	59.6910	79.3455	99.0000	118.6545	138.3090	157.9635
BI214	DIST	NORMAL	3.2547	23.0032	42.7516	62.5000	82.2484	101.9968	121.7453
TL208	DIST	NORMAL	3.6525	17.0017	30.3508	43.7000	57.0492	70.3983	83.7475
U/K	DIST	NORMAL	.0248	.2293	.4337	.6382	.8427	1.0472	1.2516
U/TH	DIST	LOG	.5355	.7370	1.0143	1.3959	1.9212	2.6441	3.6390
TH/K	DIST	NORMAL	.1558	.2505	.3451	.4398	.5345	.6291	.7238

ROCK UNIT CYCZ

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	58.0069	69.7713	81.5356	93.3000	105.0644	116.8287	128.5931
BI214	DIST	NORMAL	33.9414	50.9943	68.0471	85.1000	102.1529	119.2057	136.2586
TL208	DIST	NORMAL	28.5675	35.4450	42.3225	49.2000	56.0775	62.9550	69.8325
U/K	DIST	NORMAL	.2262	.4610	.6959	.9307	1.1655	1.4004	1.6352
U/TH	DIST	LOG	.7373	.9765	1.2933	1.7129	2.2686	3.0045	3.9791
TH/K	DIST	LOG	.2994	.3612	.4358	.5257	.6342	.7651	.9231

ROCK UNIT GBEWB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	51.0254	65.2169	79.4085	93.6000	107.7915	121.9831	136.1746
BI214	DIST	NORMAL	5.7775	26.4850	47.1925	67.9000	88.6075	109.3150	130.0225
TL208	DIST	NORMAL	17.1505	24.6003	32.0502	39.5000	46.9498	54.3997	61.8495
U/K	DIST	NORMAL	-.0518	.2130	.4777	.7425	1.0073	1.2721	1.5369
U/TH	DIST	NORMAL	.0001	.5864	1.1727	1.7590	2.3453	2.9316	3.5179
TH/K	DIST	NORMAL	.1809	.2627	.3445	.4262	.5080	.5898	.6716

ROCK UNIT H

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	62.7571	76.0047	89.2524	102.5000	115.7476	128.9953	142.2429
BI214	DIST	NORMAL	21.8200	40.6800	59.5400	78.4000	97.2600	116.1200	134.9800
TL208	DIST	NORMAL	36.0903	41.0602	46.0301	51.0000	55.9699	60.9398	65.9097
U/K	DIST	LOG	.2612	.3703	.5249	.7442	1.0551	1.4959	2.1208
U/TH	DIST	NORMAL	.1203	.6008	1.0813	1.5617	2.0422	2.5226	3.0031
TH/K	DIST	LOG	.3408	.3874	.4404	.5005	.5689	.6467	.7351

ROCK UNIT HB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	71.6503	82.7002	93.7501	104.8000	115.8499	126.8998	137.9497
BI214	DIST	NORMAL	9.1075	32.6383	56.1692	79.7000	103.2308	126.7617	150.2925
TL208	DIST	NORMAL	41.0617	45.3745	49.6872	54.0000	58.3128	62.6255	66.9383
U/K	DIST	LOG	.2580	.3650	.5164	.7306	1.0336	1.4623	2.0689
U/TH	DIST	NORMAL	.1506	.5950	1.0395	1.4839	1.9283	2.3728	2.8172
TH/K	DIST	LOG	.3613	.4071	.4587	.5168	.5822	.6560	.7391

ROCK UNIT HBHL

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	30.4352	50.0235	69.6117	89.2000	108.7883	128.3765	147.9648
BI214	DIST	NORMAL	11.9334	35.3556	58.7778	82.2000	105.6222	129.0444	152.4666
TL208	DIST	LOG	34.2219	38.0278	42.2569	46.9564	52.1785	57.9814	64.4297
U/K	DIST	LOG	.3241	.4560	.6415	.9026	1.2699	1.7867	2.5137
U/TH	DIST	NORMAL	.1259	.6681	1.2104	1.7526	2.2948	2.8371	3.3793
TH/K	DIST	NORMAL	.2757	.3657	.4557	.5457	.6357	.7257	.8157

ROCK UNIT HCRBT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	62.2235	71.5485	82.2709	94.6002	108.7773	125.0789	143.8236
BI214	DIST	NORMAL	23.1423	42.6616	62.1808	81.7000	101.2192	120.7384	140.2577
TL208	DIST	NORMAL	35.1288	39.8192	44.5096	49.2000	53.8904	58.5808	63.2712
U/K	DIST	LOG	.2997	.4219	.5941	.8364	1.1776	1.6580	2.3343
U/TH	DIST	NORMAL	.2731	.7429	1.2127	1.6825	2.1523	2.6221	3.0919
TH/K	DIST	LOG	.3305	.3838	.4458	.5177	.6013	.6984	.8111

ROCK UNIT HFBT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	53.8779	67.1519	80.4260	93.7000	106.9740	120.2481	133.5221
BI214	DIST	NORMAL	12.6170	33.2447	53.8723	74.5000	95.1277	115.7553	136.3830
TL208	DIST	LOG	35.2249	39.6376	44.6032	50.1907	56.4782	63.5534	71.5149
U/K	DIST	LOG	.2547	.3680	.5319	.7686	1.1108	1.6053	2.3199
U/TH	DIST	NORMAL	.0461	.5313	1.0165	1.5017	1.9869	2.4720	2.9572
TH/K	DIST	LOG	.3492	.4039	.4672	.5405	.6253	.7233	.8368

ROCK UNIT HGE

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	47.9377	64.6918	81.4459	98.2000	114.9541	131.7082	148.4623
BI214	DIST	LOG	45.9572	55.7524	67.6353	82.0509	99.5390	120.7545	146.4918
TL208	DIST	LOG	38.5672	43.1429	48.2615	53.9874	60.3926	67.5577	75.5729
U/K	DIST	NORMAL	.1229	.3768	.6307	.8846	1.1385	1.3924	1.6463
U/TH	DIST	LOG	.7022	.9083	1.1749	1.5198	1.9659	2.5430	3.2894
TH/K	DIST	LOG	.3911	.4402	.4954	.5576	.6277	.7065	.7952

ROCK UNIT HHD

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	59.9590	71.1393	82.3197	93.5000	104.6803	115.8607	127.0410
BI214	DIST	NORMAL	18.2623	38.0082	57.7541	77.5000	97.2459	116.9918	136.7377
TL208	DIST	NORMAL	35.5929	40.2619	44.9310	49.6000	54.2690	58.9381	63.6071
U/K	DIST	NORMAL	.0329	.3054	.5778	.8503	1.1227	1.3952	1.6676
U/TH	DIST	NORMAL	.2279	.6793	1.1307	1.5821	2.0336	2.4850	2.9364
TH/K	DIST	LOG	.3435	.3974	.4599	.5322	.6158	.7125	.8245

ROCK UNIT HLHD

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	75.7243	84.3276	93.9084	104.5777	116.4591	129.6905	144.4251
BI214	DIST	NORMAL	12.3219	32.4813	52.6406	72.8000	92.9594	113.1187	133.2781
TL208	DIST	NORMAL	29.0154	35.9436	42.8718	49.8000	56.7282	63.6564	70.5846
U/K	DIST	NORMAL	.0397	.2612	.4826	.7041	.9255	1.1470	1.3684
U/TH	DIST	NORMAL	.2891	.6885	1.0878	1.4871	1.8865	2.2858	2.6851
TH/K	DIST	NORMAL	.2931	.3538	.4146	.4753	.5360	.5968	.6575

ROCK UNIT HLJ

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	70.9155	79.6103	88.3052	97.0000	105.6948	114.3897	123.0845
BI214	DIST	NORMAL	6.3508	19.9338	33.5169	47.1000	60.6831	74.2662	87.8492
TL208	DIST	NORMAL	23.7700	28.7800	33.7900	38.8000	43.8100	48.8200	53.8300
U/K	DIST	LOG	.1696	.2375	.3326	.4658	.6524	.9137	1.2796
U/TH	DIST	LOG	.4244	.5951	.8344	1.1700	1.6405	2.3002	3.2252
TH/K	DIST	NORMAL	.2684	.3124	.3565	.4005	.4446	.4886	.5326

ROCK UNIT HO

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	55.8305	69.4870	83.1435	96.8000	110.4565	124.1130	137.7695
BI214	DIST	NORMAL	17.2516	38.4011	59.5505	80.7000	101.8495	122.9989	144.1484
TL208	DIST	NORMAL	26.6764	32.7509	38.8255	44.9000	50.9745	57.0491	63.1236
U/K	DIST	LOG	.2818	.4010	.5706	.8120	1.1554	1.6442	2.3397
U/TH	DIST	LOG	.7367	.9827	1.3108	1.7484	2.3322	3.1108	4.1494
TH/K	DIST	LOG	.2539	.3105	.3797	.4644	.5680	.6946	.8496

ROCK UNIT HWY

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	54.3094	63.9063	73.5031	83.1000	92.6969	102.2937	111.8906
BI214 DIST LOG	31.4271	39.2774	49.0888	61.3509	76.6761	95.8294	119.7671
TL208 DIST NORMAL	39.2327	42.4885	45.7442	49.0000	52.2558	55.5115	58.7673
U/K DIST LOG	.3114	.4161	.5560	.7431	.9929	1.3269	1.7731
U/TH DIST NORMAL	.3194	.6453	.9712	1.2970	1.6229	1.9488	2.2747
TH/K DIST LOG	.3994	.4554	.5193	.5921	.6751	.7697	.8776

ROCK UNIT K

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	60.9516	73.6677	86.3839	99.1000	111.8161	124.5323	137.2484
BI214 DIST LOG	39.9537	50.1374	62.9168	78.9536	99.0779	124.3316	156.0223
TL208 DIST NORMAL	32.0307	38.7538	45.4769	52.2000	58.9231	65.6462	72.3693
U/K DIST LOG	.3495	.4613	.6088	.8034	1.0603	1.3993	1.8468
U/TH DIST LOG	.6963	.9041	1.1741	1.5246	1.9797	2.5708	3.3383
TH/K DIST NORMAL	.2985	.3766	.4546	.5327	.6107	.6887	.7668

ROCK UNIT LCLRV

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	50.4231	63.4154	76.4077	89.4000	102.3923	115.3846	128.3769
BI214 DIST NORMAL	17.5707	34.9805	52.3902	69.8000	87.2098	104.6195	122.0293
TL208 DIST NORMAL	25.5846	31.9564	38.3282	44.7000	51.0718	57.4436	63.8154
U/K DIST LOG	.3063	.4155	.5636	.7645	1.0370	1.4067	1.9082
U/TH DIST LOG	.6592	.8723	1.1544	1.5278	2.0219	2.6757	3.5410
TH/K DIST LOG	.3019	.3572	.4228	.5004	.5922	.7009	.8296

ROCK UNIT LCLWN

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	71.6892	84.9595	98.2297	111.5000	124.7703	138.0405	151.3108
BI214 DIST NORMAL	9.9277	28.5851	47.2426	65.9000	84.5574	103.2149	121.8723
TL208 DIST NORMAL	35.5410	41.0273	46.5137	52.0000	57.4863	62.9727	68.4590
U/K DIST NORMAL	-.0034	.2010	.4054	.6098	.8142	1.0186	1.2230
U/TH DIST NORMAL	-.0362	.4087	.8536	1.2985	1.7434	2.1883	2.6332
TH/K DIST NORMAL	.2505	.3245	.3984	.4724	.5464	.6203	.6943

ROCK UNIT LLLWB

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	33.6203	53.6802	73.7401	93.8000	113.8599	133.9198	153.9797
BI214 DIST NORMAL	7.5590	27.9060	48.2530	68.6000	88.9470	109.2940	129.6410
TL208 DIST NORMAL	15.0802	25.1202	35.1601	45.2000	55.2399	65.2798	75.3198
U/K DIST LOG	.2232	.3255	.4748	.6925	1.0100	1.4731	2.1486
U/TH DIST NORMAL	.0882	.5647	1.0411	1.5175	1.9939	2.4703	2.9467
TH/K DIST LOG	.2660	.3240	.3947	.4809	.5859	.7137	.8695

ROCK UNIT LLS

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	58.0378	69.9918	81.9459	93.9000	105.8541	117.8082	129.7622
BI214 DIST LOG	20.3680	27.5552	37.2784	50.4327	68.2287	92.3042	124.8752
TL208 DIST LOG	19.7919	23.6722	28.3131	33.8639	40.5030	48.4436	57.9410
U/K DIST LOG	.1810	.2609	.3759	.5417	.7807	1.1250	1.6212
U/TH DIST LOG	.5560	.7721	1.0722	1.4888	2.0674	2.8708	3.9863
TH/K DIST LOG	.1989	.2432	.2973	.3636	.4445	.5435	.6646

ROCK UNIT LPSA

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	39.0171	52.5781	66.1390	79.7000	93.2610	106.8219	120.3829
BI214 DIST NORMAL	7.1914	16.8609	26.5305	36.2000	45.8695	55.5391	65.2086
TL208 DIST NORMAL	9.3371	16.2580	23.1790	30.1000	37.0210	43.9420	50.8629
U/K DIST LOG	.1706	.2319	.3153	.4287	.5828	.7923	1.0772
U/TH DIST LOG	.4520	.6147	.8361	1.1371	1.5465	2.1032	2.8605
TH/K DIST LOG	.1996	.2456	.3021	.3717	.4573	.5626	.6922

ROCK UNIT LUKGLT

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	60.1551	74.0367	87.9184	101.8000	115.6816	129.5633	143.4449
BI214 DIST NORMAL	11.4575	31.9050	52.3525	72.8000	93.2475	113.6950	134.1425
TL208 DIST NORMAL	30.6043	36.7362	42.8681	49.0000	55.1319	61.2638	67.3957
U/K DIST LOG	.2369	.3383	.4831	.6898	.9850	1.4066	2.0085
U/TH DIST LOG	.5187	.7272	1.0196	1.4295	2.0042	2.8099	3.9396
TH/K DIST LOG	.3055	.3558	.4144	.4827	.5622	.6548	.7627

ROCK UNIT LUVO

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	63.9865	73.5652	84.5777	97.2388	111.7953	128.5308	147.7715
BI214 DIST NORMAL	14.9895	34.8263	54.6632	74.5000	94.3368	114.1737	134.0105
TL208 DIST NORMAL	32.5000	37.5000	42.5000	47.5000	52.5000	57.5000	62.5000
U/K DIST LOG	.2445	.3532	.5102	.7369	1.0645	1.5375	2.2209
U/TH DIST NORMAL	.1932	.6584	1.1237	1.5889	2.0541	2.5194	2.9846
TH/K DIST LOG	.2935	.3472	.4106	.4857	.5744	.6794	.8036

ROCK UNIT M

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	59.7416	73.5944	87.4472	101.3000	115.1528	129.0056	142.8584
BI214 DIST NORMAL	19.8969	39.4980	59.0990	78.7000	98.3010	117.9020	137.5031
TL208 DIST NORMAL	35.6683	41.1455	46.6228	52.1000	57.5772	63.0545	68.5317
U/K DIST NORMAL	.0213	.2807	.5400	.7994	1.0587	1.3181	1.5774
U/TH DIST NORMAL	.2270	.6622	1.0975	1.5327	1.9680	2.4033	2.8385
TH/K DIST NORMAL	.2829	.3626	.4422	.5218	.6014	.6810	.7607

ROCK UNIT MD

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	69.8534	78.6771	88.6154	99.8092	112.4168	126.6171	142.6111
BI214 DIST NORMAL	17.8297	35.0198	52.2099	69.4000	86.5901	103.7802	120.9703
TL208 DIST LOG	40.5620	44.1463	48.0472	52.2929	56.9137	61.9428	67.4163
U/K DIST NORMAL	.0516	.2703	.4890	.7077	.9264	1.1451	1.3638
U/TH DIST NORMAL	.2586	.6176	.9767	1.3357	1.6948	2.0538	2.4129
TH/K DIST LOG	.3527	.4024	.4592	.5239	.5978	.6821	.7783

ROCK UNIT MDBF

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	68.6194	81.0129	93.4065	105.8000	118.1935	130.5871	142.9806
BI214 DIST NORMAL	29.0416	46.4944	63.9472	81.4000	98.8528	116.3056	133.7584
TL208 DIST NORMAL	40.2288	44.9192	49.6096	54.3000	58.9904	63.6808	68.3712
U/K DIST NORMAL	.1345	.3517	.5689	.7861	1.0033	1.2205	1.4377
U/TH DIST NORMAL	.4123	.7798	1.1472	1.5147	1.8822	2.2496	2.6171
TH/K DIST LOG	.3520	.3996	.4537	.5150	.5846	.6637	.7534

ROCK UNIT MDK

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	76.2783	84.7251	94.1074	104.5285	116.1037	128.9607	143.2414
BI214 DIST NORMAL	23.5757	42.4171	61.2586	80.1000	98.9414	117.7829	136.6243
TL208 DIST NORMAL	37.4827	42.6885	47.8942	53.1000	58.3058	63.5115	68.7173
U/K DIST NORMAL	.1065	.3299	.5532	.7765	.9998	1.2231	1.4464
U/TH DIST LOG	.6550	.8578	1.1234	1.4711	1.9265	2.5229	3.3040
TH/K DIST LOG	.3333	.3829	.4400	.5055	.5808	.6674	.7668

ROCK UNIT MDNRBF

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	71.6217	82.0811	92.5406	103.0000	113.4594	123.9189	134.3783
BI214 DIST NORMAL	21.9528	40.1352	58.3176	76.5000	94.6824	112.8648	131.0472
TL208 DIST NORMAL	38.5115	43.4410	48.3705	53.3000	58.2295	63.1590	68.0885
U/K DIST NORMAL	.0855	.3096	.5337	.7578	.9820	1.2061	1.4302
U/TH DIST NORMAL	.2988	.6826	1.0664	1.4502	1.8341	2.2179	2.6017
TH/K DIST LOG	.3428	.3933	.4513	.5179	.5943	.6820	.7826

ROCK UNIT MDNRCF

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	76.6139	88.5092	100.4046	112.3000	124.1954	136.0908	147.9861
BI214 DIST NORMAL	25.8907	43.5938	61.2969	79.0000	96.7031	114.4062	132.1093
TL208 DIST NORMAL	43.6288	48.3192	53.0096	57.7000	62.3904	67.0808	71.7712
U/K DIST NORMAL	.0985	.3052	.5118	.7185	.9252	1.1318	1.3385
U/TH DIST NORMAL	.3389	.6863	1.0338	1.3813	1.7288	2.0763	2.4238
TH/K DIST LOG	.3513	.3991	.4534	.5152	.5853	.6650	.7555

ROCK UNIT MNCF

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	51.5843	64.9896	78.3948	91.8000	105.2052	118.6104	132.0157
BI214 DIST NORMAL	28.2130	46.6087	65.0043	83.4000	101.7957	120.1913	138.5870
TL208 DIST NORMAL	35.3694	40.5463	45.7231	50.9000	56.0769	61.2537	66.4306
U/K DIST LOG	.3382	.4676	.6466	.8940	1.2362	1.7093	2.3635
U/TH DIST NORMAL	.3691	.8000	1.2309	1.6619	2.0928	2.5237	2.9547
TH/K DIST LOG	.3399	.4010	.4730	.5581	.6584	.7768	.9164

ROCK UNIT MNI

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	39.7259	54.4839	69.2420	84.0000	98.7580	113.5161	128.2741
BI214	DIST NORMAL	10.0772	30.6515	51.2257	71.8000	92.3743	112.9485	133.5228
TL208	DIST NORMAL	24.1903	31.7268	39.2634	46.8000	54.3366	61.8732	69.4097
U/K	DIST LOG	.2758	.3977	.5734	.8268	1.1922	1.7191	2.4789
U/TH	DIST NORMAL	.1124	.5915	1.0707	1.5498	2.0290	2.5081	2.9873
TH/K	DIST LOG	.3111	.3782	.4599	.5592	.6799	.8267	1.0052

ROCK UNIT MPO

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	48.6885	61.6923	74.6962	87.7000	100.7038	113.7077	126.7115
BI214	DIST NORMAL	11.2703	31.9802	52.6901	73.4000	94.1099	114.8198	135.5297
TL208	DIST NORMAL	30.1790	36.0527	41.9263	47.8000	53.6737	59.5473	65.4210
U/K	DIST LOG	.2529	.3727	.5494	.8098	1.1936	1.7594	2.5933
U/TH	DIST NORMAL	.0218	.5341	1.0524	1.56765	2.083	2.5182	3.1134
TH/K	DIST LOG	.3246	.3863	.4598	.5473	.6514	.7753	.9227

ROCK UNIT MUH

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	49.3171	61.9781	74.6390	87.3000	99.9610	112.6219	125.2829
BI214	DIST NORMAL	1.5949	22.7633	43.9316	65.1000	86.2684	107.4367	128.6051
TL208	DIST NORMAL	27.8136	34.4091	41.0045	47.6000	54.1955	60.7909	67.3864
U/K	DIST LOG	.1907	.2957	.4586	.7112	1.1029	1.7104	2.6525
U/TH	DIST LOG	.3935	.5866	.8746	1.3040	1.9442	2.8988	4.3219
TH/K	DIST LOG	.2998	.3661	.4471	.5459	.6666	.8139	.9939

ROCK UNIT NRCFMD

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	73.0787	84.7191	96.3596	108.0000	119.6404	131.2809	142.9213
BI214	DIST NORMAL	21.4236	42.2491	63.0745	83.9000	104.7255	125.5509	146.3764
TL208	DIST LOG	42.6259	46.3485	50.3961	54.7972	59.5827	64.7861	70.4439
U/K	DIST LOG	.2904	.3994	.5494	.7557	1.0395	1.4299	1.9669
U/TH	DIST LOG	.6279	.8358	1.1125	1.4808	1.9710	2.6235	3.4920
TH/K	DIST LOG	.3458	.3937	.4483	.5103	.5810	.6615	.7530

ROCK UNIT NRMDJ

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	71.8234	80.4906	90.2037	101.0889	113.2876	126.9584	142.2789
BI214	DIST NORMAL	33.1232	49.5488	65.9744	82.4000	98.8256	115.2512	131.6768
TL208	DIST NORMAL	36.9972	42.2981	47.5991	52.9000	58.2009	63.5019	68.8028
U/K	DIST LOG	.3584	.4681	.6113	.7985	1.0429	1.3621	1.7790
U/TH	DIST LOG	.7229	.9287	1.1932	1.5329	1.9694	2.5302	3.2507
TH/K	DIST LOG	.3221	.3781	.4438	.5209	.6114	.7176	.8423

ROCK UNIT NWOR

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	60.6025	73.1683	85.7342	98.3000	110.8658	123.4317	135.9975
BI214	DIST NORMAL	-1.7139	19.3574	40.4287	61.5000	82.5713	103.6426	124.7139
TL208	DIST LOG	21.0942	25.5289	30.8960	37.3914	45.2523	54.7659	66.2796
U/K	DIST NORMAL	-.1339	.1253	.3844	.6435	.9026	1.1617	1.4208
U/TH	DIST NORMAL	-.2475	.3893	1.0261	1.6630	2.2998	2.9366	3.5735
TH/K	DIST LOG	.2243	.2682	.3207	.3835	.4586	.5483	.6557

ROCK UNIT PLLEAL

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	52.8297	69.0531	85.2766	101.5000	117.7234	133.9469	150.1703
BI214	DIST NORMAL	18.6338	35.9226	53.2113	70.5000	87.7887	105.0774	122.3662
TL208	DIST NORMAL	20.0845	25.8897	31.6948	37.5000	43.3052	49.1103	54.9155
U/K	DIST NORMAL	.0086	.2461	.4836	.7212	.9587	1.1962	1.4338
U/TH	DIST NORMAL	.3382	.8651	1.3920	1.9189	2.4458	2.9727	3.4996
TH/K	DIST LOG	.1982	.2439	.3003	.3697	.4551	.5603	.6897

ROCK UNIT POI

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	48.6041	62.5360	76.4680	90.4000	104.3320	118.2640	132.1959
BI214	DIST NORMAL	16.4085	37.2723	58.1362	79.0000	99.8638	120.7277	141.5915
TL208	DIST NORMAL	35.8570	40.7046	45.5523	50.4000	55.2477	60.0954	64.9430
U/K	DIST NORMAL	-.0782	.2531	.5845	.9158	1.2472	1.5785	1.9099
U/TH	DIST NORMAL	.1863	.6552	1.1241	1.5930	2.0618	2.5307	2.9996
TH/K	DIST LOG	.3476	.4079	.4786	.5616	.6590	.7733	.9074

ROCK UNIT PS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	40.2724	51.4483	62.6241	73.8000	84.9759	96.1517	107.3276
BI214	DIST	LOG	24.0699	34.3694	49.0759	70.0753	100.0602	142.8756	204.0115
TL208	DIST	NORMAL	30.8261	35.6840	40.5420	45.4000	50.2580	55.1160	59.9739
U/K	DIST	LOG	.2806	.4229	.6374	.9608	1.4482	2.1828	3.2900
U/TH	DIST	NORMAL	-.0344	.5272	1.0888	1.6504	2.2120	2.7736	3.3352
TH/K	DIST	LOG	.4074	.4681	.5380	.6182	.7104	.8164	.9382

ROCK UNIT SACA

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	27.7180	48.0454	68.3727	88.7000	109.0273	129.3546	149.6820
BI214	DIST	NORMAL	5.1475	25.3317	45.5158	65.7000	85.8842	106.0683	126.2525
TL208	DIST	NORMAL	12.4045	21.5697	30.7348	39.9000	49.0652	58.2303	67.3955
U/K	DIST	LOG	.2730	.3763	.5187	.7148	.9852	1.3579	1.8715
U/TH	DIST	LOG	.6127	.8415	1.1557	1.5873	2.1801	2.9943	4.1126
TH/K	DIST	LOG	.2578	.3103	.3737	.4499	.5416	.6521	.7851

ROCK UNIT SB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	48.0000	62.0000	76.0000	90.0000	104.0000	118.0000	132.0000
BI214	DIST	NORMAL	8.5794	29.1196	49.6598	70.2000	90.7402	111.2804	131.8206
TL208	DIST	LOG	35.5859	39.8485	44.6218	49.9669	55.9522	62.6544	70.1595
U/K	DIST	NORMAL	-.1137	.1959	.5055	.8151	1.1247	1.4342	1.7438
U/TH	DIST	NORMAL	-.0459	.4459	.9377	1.4296	1.9214	2.4132	2.9050
TH/K	DIST	LOG	.3373	.3999	.4740	.5619	.6662	.7897	.9361

ROCK UNIT SBLWN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	33.5453	50.4302	67.3151	84.2000	101.0849	117.9698	134.8547
BI214	DIST	NORMAL	7.6036	26.2690	44.9345	63.6000	82.2655	100.9310	119.5964
TL208	DIST	NORMAL	8.6735	18.0490	27.4245	36.8000	46.1755	55.5510	64.9265
U/K	DIST	NORMAL	-.4274	-.0164	.3946	.8056	1.2166	1.6277	2.0387
U/TH	DIST	NORMAL	-.4589	.3009	1.0606	1.8204	2.5801	3.3399	4.0996
TH/K	DIST	LOG	.2120	.2693	.3419	.4343	.5515	.7003	.8894

ROCK UNIT SC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	58.5703	68.7114	80.6084	94.5652	110.9386	130.1470	152.6811
BI214	DIST	LOG	39.8911	48.6596	59.3555	72.4024	88.3173	107.7304	131.4107
TL208	DIST	NORMAL	39.4671	43.5781	47.6890	51.8000	55.9110	60.0219	64.1329
U/K	DIST	LOG	.3214	.4292	.5733	.7656	1.0226	1.3657	1.8240
U/TH	DIST	LOG	.7215	.9006	1.1241	1.4031	1.7513	2.1859	2.7283
TH/K	DIST	NORMAL	.3133	.3927	.4721	.5514	.6308	.7102	.7896

ROCK UNIT SF

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	55.7618	69.3412	82.9206	96.5000	110.0794	123.6588	137.2382
BI214	DIST	NORMAL	7.1263	30.9842	54.8421	78.7000	102.5579	126.4158	150.2737
TL208	DIST	NORMAL	30.5141	36.9094	43.3047	49.7000	56.0953	62.4906	68.8859
U/K	DIST	LOG	.2554	.3712	.5393	.7836	1.1385	1.6542	2.4035
U/TH	DIST	NORMAL	.1485	.6308	1.1131	1.5954	2.0776	2.5599	3.0422
TH/K	DIST	LOG	.3168	.3729	.4389	.5165	.6079	.7154	.8419

ROCK UNIT SM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	60.3539	73.3692	86.3846	99.4000	112.4154	125.4307	138.4461
BI214	DIST	NORMAL	30.9423	49.8949	68.8474	87.8000	106.7526	125.7051	144.6577
TL208	DIST	NORMAL	39.7382	44.4921	49.2461	54.0000	58.7539	63.5079	68.2618
U/K	DIST	NORMAL	.1152	.3797	.6442	.9087	1.1732	1.4377	1.7021
U/TH	DIST	NORMAL	.3979	.8144	1.2308	1.6473	2.0638	2.4803	2.8967
TH/K	DIST	LOG	.3463	.4031	.4691	.5460	.6355	.7397	.8610

ROCK UNIT SMN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56.4982	69.6321	82.7661	95.9000	109.0339	122.1679	135.3018
BI214	DIST	NORMAL	17.4140	37.7094	58.0047	78.3000	98.5953	118.8906	139.1860
TL208	DIST	LOG	35.8973	40.2871	45.2137	50.7428	56.9480	63.9120	71.7277
U/K	DIST	LOG	.2840	.4002	.5641	.7950	1.1205	1.5793	2.2259
U/TH	DIST	NORMAL	.1794	.6389	1.0984	1.5580	2.0175	2.4771	2.9366
TH/K	DIST	LOG	.3437	.3982	.4613	.5345	.6192	.7174	.8312

ROCK UNIT THMDLY

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	63.8139	75.7092	87.6046	99.5000	111.3954	123.2908	135.1861
BI214	DIST NORMAL	-11.8714	11.4524	34.7762	58.1000	81.4238	104.7476	128.0714
TL208	DIST NORMAL	4.4475	16.1650	27.8825	39.6000	51.3175	63.0350	74.7525
U/K	DIST NORMAL	-.1086	.1238	.3561	.5885	.8208	1.0532	1.2855
U/TH	DIST NORMAL	.0705	.5311	.9918	1.4524	1.9131	2.3737	2.8344
TH/K	DIST NORMAL	.0936	.1945	.2954	.3963	.4972	.5981	.6990

ROCK UNIT THME

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	74.0604	82.3861	91.6479	101.9508	113.4119	126.1615	140.3444
BI214	DIST NORMAL	11.5066	25.3378	39.1689	53.0000	66.8311	80.6622	94.4934
TL208	DIST LOG	22.2537	25.5353	29.3007	33.6213	38.5791	44.2679	50.7956
U/K	DIST NORMAL	.0712	.2227	.3741	.5256	.6770	.8285	.9800
U/TH	DIST NORMAL	.1764	.6496	1.1228	1.5960	2.0691	2.5423	3.0155
TH/K	DIST LOG	.1930	.2307	.2759	.3298	.3942	.4713	.5634

ROCK UNIT V

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	63.1230	71.9552	82.0232	93.4999	106.5824	121.4953	138.4950
BI214	DIST LOG	13.0212	19.2665	28.5073	42.1802	62.4109	92.3450	136.6362
TL208	DIST LOG	13.9859	17.8176	22.6991	28.9179	36.8404	46.9335	59.7918
U/K	DIST LOG	.1218	.1891	.2935	.4555	.7071	1.0975	1.7035
U/TH	DIST LOG	.4324	.6490	.9739	1.4616	2.1935	3.2920	4.9404
TH/K	DIST LOG	.1448	.1865	.2402	.3093	.3983	.5129	.6605

ROCK UNIT VTH

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	59.2859	70.9906	82.6953	94.4000	106.1047	117.8094	129.5141
BI214	DIST NORMAL	-.8052	16.3965	33.5983	50.8000	68.0017	85.2035	102.4052
TL208	DIST NORMAL	8.8761	16.5507	24.2254	31.9000	39.5746	47.2493	54.9239
U/K	DIST LOG	.1455	.2214	.3369	.5125	.7797	1.1863	1.8048
U/TH	DIST NORMAL	-.1899	.4219	1.0337	1.6456	2.2574	2.8692	3.4811
TH/K	DIST LOG	.1665	.2120	.2699	.3436	.4375	.5571	.7093

ROCK UNIT W

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	60.3396	74.3931	88.4465	102.5000	116.5535	130.6069	144.6604
BI214 DIST NORMAL	22.2046	41.6031	61.0015	80.4000	99.7985	119.1969	138.5954
TL208 DIST NORMAL	38.4288	43.1192	47.8096	52.5000	57.1904	61.8808	66.5712
U/K DIST NORMAL	.0602	.3095	.5588	.8081	1.0574	1.3068	1.5561
U/TH DIST NORMAL	.2698	.6975	1.1253	1.5530	1.9807	2.4084	2.8362
TH/K DIST LOG	.3313	.3839	.4447	.5153	.5970	.6917	.8014

ROCK UNIT WB

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	56.6614	70.1076	83.5538	97.0000	110.4462	123.8924	137.3386
BI214 DIST NORMAL	18.6607	39.2738	59.8869	80.5000	101.1131	121.7262	142.3393
TL208 DIST NORMAL	35.6570	40.5046	45.3523	50.2000	55.0477	59.8954	64.7430
U/K DIST LOG	.2790	.3979	.5674	.8093	1.1543	1.6463	2.3479
U/TH DIST LOG	.6314	.8526	1.1511	1.5543	2.0986	2.8336	3.8260
TH/K DIST LOG	.3231	.3788	.4441	.5207	.6105	.7158	.8392

ROCK UNIT WBCSSA

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	26.7373	40.8582	54.9791	69.1000	83.2209	97.3418	111.4627
BI214 DIST NORMAL	-17.4005	9.8996	37.1998	64.5000	91.8002	119.1004	146.4005
TL208 DIST NORMAL	-13.0912	2.2059	17.5029	32.8000	48.0971	63.3941	78.6912
U/K DIST NORMAL	-.4133	.0397	.4927	.9458	1.3988	1.8518	2.3048
U/TH DIST LOG	.5615	.8358	1.2439	1.8514	2.7555	4.1011	6.1039
TH/K DIST NORMAL	-.1624	.0508	.2640	.4772	.6905	.9037	1.1169

ROCK UNIT WBL

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	51.6793	60.1741	70.0652	81.5821	94.9921	110.6064	128.7873
BI214 DIST NORMAL	10.1832	31.5888	52.9944	74.4000	95.8056	117.2112	138.6168
TL208 DIST NORMAL	32.6211	37.6807	42.7404	47.8000	52.8596	57.9193	62.9789
U/K DIST LOG	.2781	.4072	.5962	.8729	1.2781	1.8713	2.7398
U/TH DIST NORMAL	-.0119	.5195	1.0509	1.5823	2.1138	2.6452	3.1766
TH/K DIST LOG	.3669	.4281	.4995	.5828	.6800	.7934	.9258

ROCK UNIT WK

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	20.2988	40.1659	60.0329	79.9000	99.7671	119.6341	139.5012
BI214	DIST NORMAL	30.7987	45.3658	59.9329	74.5000	89.0671	103.6342	118.2013
TL208	DIST NORMAL	20.3536	29.7024	39.0512	48.4000	57.7488	67.0976	76.4464
U/K	DIST LOG	.3232	.4635	.6646	.9530	1.3666	1.9596	2.8099
U/TH	DIST NORMAL	.3152	.7426	1.1700	1.5975	2.0249	2.4523	2.8797
TH/K	DIST NORMAL	.3042	.4119	.5196	.6273	.7350	.8427	.9504

ROCK UNIT WN

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	58.3607	66.4475	75.6548	86.1379	98.0737	111.6633	127.1360
BI214	DIST LOG	14.0771	20.2575	29.1514	41.9501	60.3679	86.8720	125.0125
TL208	DIST LOG	16.6682	19.5829	23.0072	27.0303	31.7570	37.3101	43.8343
U/K	DIST NORMAL	-.0824	.1226	.3277	.5327	.7378	.9429	1.1479
U/TH	DIST NORMAL	-.4214	.2960	1.0134	1.7308	2.4481	3.1655	3.8829
TH/K	DIST NORMAL	.1489	.2055	.2621	.3186	.3752	.4318	.4883

ROCK UNIT WO

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	57.9538	71.2692	84.5846	97.9000	111.2154	124.5308	137.8462
BI214	DIST NORMAL	.7927	20.5285	40.2642	60.0000	79.7358	99.4715	119.2073
TL208	DIST LOG	17.8789	21.8001	26.5813	32.4111	39.5194	48.1868	58.7551
U/K	DIST NORMAL	-.0779	.1572	.3923	.6274	.8624	1.0975	1.3326
U/TH	DIST NORMAL	-.1991	.4916	1.1822	1.8729	2.5635	3.2541	3.9448
TH/K	DIST NORMAL	.1526	.2151	.2775	.3400	.4024	.4649	.5273

ROCK UNIT WOHL

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	61.9225	76.4483	90.9742	105.5000	120.0258	134.5517	149.0775
BI214	DIST NORMAL	10.8754	30.9503	51.0251	71.1000	91.1749	111.2497	131.3246
TL208	DIST NORMAL	21.5209	30.6806	39.8403	49.0000	58.1597	67.3194	76.4791
U/K	DIST NORMAL	.0136	.2384	.4632	.6880	.9128	1.1376	1.3624
U/TH	DIST NORMAL	.1962	.6216	1.0469	1.4723	1.8977	2.3230	2.7484
TH/K	DIST NORMAL	.2063	.2937	.3811	.4685	.5559	.6433	.7307

ROCK UNIT WOJ

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	53.7402	68.6935	83.6467	98.6000	113.5533	128.5065	143.4598
BI214	DIST	NORMAL	19.9433	39.3289	58.7144	78.1000	97.4856	116.8711	136.2567
TL208	DIST	NORMAL	28.9846	35.3564	41.7282	48.1000	54.4718	60.8436	67.2154
U/K	DIST	LOG	.2905	.4030	.5590	.7755	1.0758	1.4923	2.0701
U/TH	DIST	LOG	.6724	.8950	1.1914	1.5860	2.1112	2.8104	3.7411
TH/K	DIST	LOG	.2783	.3358	.4052	.4890	.5900	.7120	.8592

ROCK UNIT WWBHL

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	78.5092	84.1394	89.7697	95.4000	101.0303	106.6606	112.2908
BI214	DIST	LOG	49.1496	57.3389	66.8927	78.0383	91.0410	106.2103	123.9070
TL208	DIST	LOG	37.3962	41.5076	46.0710	51.1361	56.7580	62.9981	69.9242
U/K	DIST	LOG	.4488	.5485	.6703	.8192	1.0012	1.2236	1.4953
U/TH	DIST	LOG	.8862	1.0622	1.2732	1.5261	1.8292	2.1926	2.6282
TH/K	DIST	LOG	.3682	.4175	.4734	.5368	.6086	.6901	.7825

ROCK UNIT ZLSWN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	48.6323	64.4215	80.2108	96.0000	111.7892	127.5785	143.3677
BI214	DIST	NORMAL	1.5254	21.8503	42.1751	62.5000	82.8249	103.1497	123.4746
TL208	DIST	NORMAL	13.8231	24.2154	34.6077	45.0000	55.3923	65.7846	76.1769
U/K	DIST	NORMAL	-.0116	.2165	.4447	.6728	.9009	1.1291	1.3572
U/TH	DIST	LOG	.5363	.7425	1.0278	1.4228	1.9696	2.7266	3.7744
TH/K	DIST	NORMAL	.1747	.2669	.3591	.4513	.5435	.6357	.7279

ROCK UNIT S

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	47.2877	59.3251	71.3626	83.4000	95.4374	107.4749	119.5123
BI214	DIST	NORMAL	24.6363	41.3575	58.0788	74.8000	91.5212	108.2425	124.9637
TL208	DIST	LOG	22.6129	29.2459	37.8244	48.9192	63.2684	81.8265	105.8283
U/K	DIST	LOG	.3141	.4429	.6244	.8803	1.2411	1.7497	2.4668
U/TH	DIST	NORMAL	.3980	.7773	1.1567	1.5360	1.9154	2.2947	2.6741
TH/K	DIST	LOG	.3640	.4282	.5038	.5927	.6972	.8203	.9650

APPENDIX C

SOIL ASSOCIATION LEGEND

BEDROCK GEOLOGY LEGEND

LINCOLN QUADRANGLE

M	CASS COUNTY	Marshall Association: Nearly level to steeply sloping soils, typically well to excessively drained, having a friable silty clay loam surface layer with an abundance of organic matter; overlying a silt loam subsoil; on uplands underlain by the Peorian loess.
WK		Waukesha-Knox Association: Moderate to shallow depth, nearly level to gentle slopes, well drained, silty loam to silty loam clay surface layer; grades to silt loam or silt at depth; developed on stream terraces or adjacent upland areas on either alluvium or residual loess.
CB		Carrington-Buchard Association: Moderately sloping or rolling to steeply sloping soils characterized by a moderately deep friable silty surface layer; grades to a heavier clayey subsoil, organic matter and calcareous component; developed on uplands of Kansan glacial drift.
W_bL		Wabash-Lamoure Association: Level to nearly level bottom-land soils having a loamy silt to clayey silt surface layer high in organic matter; developed from alluvium washed in from adjacent uplands.
HFB_t	CLAY COUNTY	Hastings-Fillmore-Butler Association: Nearly level to gently rolling soils having a relatively thick silt loam surface layer high organic matter content; subsoil of higher clay content; principally well drained but with shallow basins of poor drainage; some steep slope phases occur but principally developed on old loess mantled plain.

S_c	FILLMORE COUNTY	Scott Association: Level to moderately sloping basinal soils characterized by a heavy silt loam surface layer; with an impervious thick clay subsoil; extremely poor drainage; developed in deepest depression of the uplands.
G		Grundy Association: Gently sloping to moderately sloping soils having a loamy to silty clay surface layer, rich in organic matter; grades to a silty clay subsoil; on uplands mantled with glacial drift.
WW_bS_a		Waukesha-Wabash-Sarpy Association: Nearly level soils having a silt loam surface layer rich in organic material and having variable amounts of fine to medium sand intermixed; overlying with heavy silty loam or sandy alluvial material; on bottom lands and adjacent narrow terraces; derived from alluvium.
C_rB_t		Crete-Butler Association: Moderately sloping to basinal soils characterized by a surface layer of porous silt loam with moderate to rich organic content; a relatively higher clay content subsoil layer; developed in depressions on loessial uplands.
C		Carrington Association: Moderate depth, nearly level to gently rolling, variably drained, silty loam (variable clay content) surface layer; grades into subsoil with higher clay content; developed on uplands underlain by glacial drift.
W_yPA	GAGE COUNTY	Wymore-Pawnee-Adair Association: Soils of gently sloping rounded ridge crests and sloping valley sides.

LINCOLN QUADRANGLE

S_bBM_r	GAGE COUNTY	Shelby-Burchard Morill Association: Sloping or moderately steep soils of glacial till uplands.
H_bJ		Hobbs-Judson Association: Level or nearly level soils of flood plains and foot slopes.
C_rPA		Crete-Pawnee-Adair Association: Soils of nearly level tablelands and sloping valley sides.
L_cS_g		Lancaster-Sogn Association: Moderately deep, gently sloping or sloping soils, and shallow, strongly sloping to steep soils.
HFB_t	HAMILTON COUNTY	Hastings-Fillmore-Butler Association: Nearly level to gently rolling soils having a relatively thick silt loam surface layer high organic matter content; subsoil of higher clay content; principally well drained but with shallow basins of poor drainage; some steep slope phases occur but principally developed on old loess mantled plain.
C_rB_t		Crete-Butler Association: Moderately sloping to basinal soils characterized by a surface layer of porous silt loam with moderate to rich organic content; a relatively higher clay content subsoil layer; developed in depressions on loessial uplands.
WW_bH_l		Waukesha-Wabash-Hall Association: Nearly level soils having a silt loam surface layer with variable amounts of fine sand, and considerable organic matter; overlying either a heavy silty loam or sandy alluvial material; on bottom lands and adjacent narrow terraces derives from alluvium.

LINCOLN QUADRANGLE

L_cH_v	JEFFERSON COUNTY	Lancaster-Hedville Association: Moderately sloping to steep, moderately deep and shallow loamy soils; on sandstone and sandy shale uplands.
M_rB		Morrill-Burchard Association: Moderately sloping to steep, deep loamy soils; on glaciated uplands.
$H_bH_dC_s$		Hobbs-Hord-Cass Association: Nearly level and gently sloping, deep silty and loamy soils on alluvial benches and bottom land.
C_rM_y		Crete-Mayberry Association: Nearly level to strongly sloping, deep soils that have silty surface layer and a clayey subsoil; on loess and glaciated uplands.
G_eJ_n		Geary-Jansen Association: Moderately sloping to steep, deep silty and loamy soils that formed in loess on uplands.
G_eH		Geary-Hastings Association: Gently sloping to steep, deep silty soils on loess uplands.
B_kK_p		Benfield-Kipson Association: Moderately sloping to steep, moderately deep to shallow silty soils that have a clayey to silty subsoil; on limestone uplands.
P	JOHNSON COUNTY	Pawnee Association: Gently sloping to moderately sloping soils that have a loamy to silty clay surface layer abundant organic matter, with a heavy clay subsoil; on uplands mantled with glacial drift.
G		Grundy Association: Gently sloping to moderately sloping soils having a loamy to silty clay surface layer, rich in organic matter; grades to a silty clay subsoil; on uplands mantled with glacial drift.

LINCOLN QUADRANGLE

CS	JOHNSON COUNTY	Carrington-Sharpsburg Association: Gently sloping to moderately sloping soils having a clayey to silty surface layer, with varying amounts of intermixed granular material; with subsoil varying from clayey silt to a gritty clay; developed on uplands underlain by Peorian loess and Kansan glacial drift.
W_b		Wabash Association: Level to nearly level bottom-land soils having a loamy silt surface layer with abundant organic matter; developed from alluvium washed in from adjacent uplands.
CB	LANCASTER COUNTY	Carrington-Buchard Association: Moderately sloping or rolling to steeply sloping soils characterized by a moderately deep friable silty surface layer; grades to a heavier clayey subsoil, organic matter and calcareous component; developed on uplands of Kansan glacial drift.
C_rB_t		Crete-Butler Association: Moderately sloping to steeply sloping soils characterized by friable granular highly organic silty clay surface layer underlain by a dense clay subsoil with calcareous bottom layer; developed on uplands mantled with Peorian loess.
W_bL		Wabash-Lamoure Association: Level to nearly level bottom-land soils having a loamy silt to clayey silt surface layer high in organic matter; developed from alluvium washed in from adjacent uplands.
S		Sharpsburg Association: Gently sloping to moderately sloping thick friable silty surface layer having an abundance of organic matter; subsoil is also thick and well oxidized; overall soil has high water holding capacity; developed in the uplands from floury Peorian loess.

LINCOLN QUADRANGLE

L_c	LANCASTER COUNTY	Lancaster Association: Relatively shallow, excessive drainage, rolling to steeply sloping, sandy loam surface layer, considerable organic material; grades into friable sandy loam; developed on upland areas underlain chiefly by weathered sandstone of the Dakota formation.
W		Waukesha Association: Deep, good drainage, level, dark fine granular silty loam, rich organic content; grades into silt; developed on stream terraces from alluvium worked in from superjacent slopes.
CS	NEMAHA	Carrington-Sharpsburg Association: Gently sloping to moderately sloping soils having a clayey to silty surface layer with varying amounts of intermixed granular material with abundant organic matter; subsoil varying from clayey silt to sandy clay; developed on uplands underlain by Peorian loess and Kansan glacial drift.
G		Grundy Association: Gently sloping to moderately sloping soils having a loamy to silty clay surface layer, rich in organic matter; grades to a silty clay subsoil; on uplands mantled with glacial drift.
WW_b		Waukesha-Wabash Association: Nearly level soils having a silt loam surface layer with variable admixed fine sand and extensive organic matter; on bottom lands and adjacent narrow terraces derived from alluvium.
C_rB_t	NUCKOLLS COUNTY	Crete-Butler Association: Moderately sloping to basinal soils characterized by a surface layer of porous silt loam with moderate to rich organic content; a relatively higher clay content subsoil layer; developed in depressions on loessial uplands.

LINCOLN QUADRANGLE

H_gW_bN	NUCKOLLS COUNTY	Holdrege-Wabash-Nuckolls Association: Level to rolling soils characterized by a loose friable silt loam topsoil typically rich in organic matter; a variable subsoil (calcareous friable light silt loam to highly organic silt loam with some sand); developed on bottom level, and narrow lower terraces.
WW_bC_s		Waukesha-Wabash-Cass Association: Level to nearly level soils characterized by a loamy silt to clayey silt surface layer with some sand and a rich organic component; a more granular subsoil layer also high in organic content) grading from sandy silt to gravely sand; developed on bottom lands and terraces from alluvium washed in from adjacent uplands.
CB	OTOE COUNTY	Carrington-Burchard Association: Moderately sloping or rolling to steeply sloping soils characterized by a moderately deep friable silty surface layer; a friable to moderately heavy subsoil, moderate organic content; developed on uplands of Kansan glacial drift.
NC		Nuckolls-Carrington Association: Steeply sloping friable clay loam soils developed in narrow basal strips on slopes; characterized by moderate organic content; developed principally on Loveland loess.
S		Sharpsburg Association: Gently sloping to moderately sloping friable silty surface layer having an abundance of organic matter; subsoil is relatively thick and well oxidized; good water holding capacity; developed on uplands from Peorian loess.
W_bLC_s		Wabash-Lamoure-Cass Assoication: Level to nearly level bottom land soils having a loamy silt to clayey silt surface layer with some sand and an abundance of organic matter; a granular subsoil layer grading from sandy silt to gravelly sand; developed from alluvium washed in from adjacent uplands.

C_rS	OTOE COUNTY	Crete-Sharpsburg Association: Moderate to steeply sloping well drained soils (susceptible to gullying) consisting principally of silty clay loams; developed on uplands from Peorian loess.
W_y	PAWNEE AND RICHARDSON COUNTIES	Wymore Association: Deep, nearly level to gently sloping, silty to clayey soils; on loess capped uplands.
PM_yB		Pawnee-Mayberry-Burchard Association: Deep, nearly level to moderately steep, loamy and clayey soils; on glacial uplands.
K_nJW_b		Kennebec-Judson-Wabash Association: Deep nearly level to gently sloping, silty and clayey soils; on bottom lands.
$B_nK_pS_g$		Benfield-Kipson-Sogn Association: Moderately deep and shallow gently sloping to very steep, silty and clayey soils; on shale and limestone uplands.
HC	SALINE COUNTY	Hastings-Carrington Association: Nearly level to rolling slopes (particularly along valleys and small drainage divides) soils consisting of silt loam rich in organic matter; oxidized silt subsoil; developed uplands atop the Loveland loess and Kansan glacial drift.
C_rFB_t		Crete-Fillmore-Butler Association: Nearly level or depressed area soils consisting principally of a well drained silt loam of varying thicknesses underlain by a dense nearly unpenetrable subsoil; developed in the uplands from Peorian loess.

LINCOLN QUADRANGLE

WW_bC_s	SALINE COUNTY	Waukesha-Wabash-Cass Association: Nearly level soils having a silt loam surface layer with variable amounts of fine sand, considerable organic matter; overlying either a heavy silty loam to clay loam or sandy alluvium material; derived from alluvium, on bottom lands and adjacent slopes.
HFB_t	SEWARD COUNTY	Hastings-Fillmore-Butler Association: Nearly level to gently sloping soils that have a silty surface layer and a loamy to clayey subsoil; on uplands mantled with loess and in depressions.
HG_e		Hastings-Geary Association: Moderately sloping to steep soils that are silty throughout; on uplands mantled with loess.
H_bH_l		Hobbs-Hall Association: Nearly level soils that are silty throughout; on bottom lands and stream terraces.
HW_y		Hastings-Wymore Association: Nearly level to moderately sloping soils that have a silty layer and silty or clayey subsoil; on uplands mantled with loess.
PS		Pawnee-Sharpsburg Association: Gently sloping to moderately sloping soils that have a loamy or silty surface layer and clayey to silty subsoil; on uplands mantled with loess and glacial till.
BS		Burchard-Steinaur Association: Moderately sloping to steep, loamy soils; on uplands of glacial till.
HG_e	THAYER COUNTY	Hastings-Geary Association: Deep, strongly sloping silty soils on uplands.

LINCOLN QUADRANGLE

$H_bM_uC_s$	THAYER COUNTY	Hobbs-Muir-Cass Association: Deep, nearly level silty soils on benches and bottom lands.
C_rHB_t		Crete-Hastings-Butler Association: Deep, nearly level, soils that have a silty surface layer and a clayey subsoil; on uplands.
J_nM_e		Jansen-Meadin Association: Moderately sloping to strongly sloping soils that are moderately deep or shallow to gravel; on uplands.
G_eH		Geary-Hastings Association: Deep, moderately sloping to strongly sloping silty soils on uplands.
K_pW_k		Kipson-Wakeen Association: Shallow and moderately deep soils overlying limestones; on uplands.
HFB_t	YORK COUNTY	Hastings-Fillmore-Butler Association: Nearly level to gently rolling soils having a relatively thick silt loam surface layer; high organic matter content; subsoil of higher clay content; principally well drained but with shallow basins of poor drainage; some steep slope phases occur but principally developed on old loess mantled plain.
C_rB_t		Crete-Butler Association: Moderately sloping to basinal soils characterized by a surface layer of porous silt loam with moderate to rich organic content; a relatively higher clay content subsoil layer; developed in depressions on loessial uplands.
S_c		Scott Association: Level to moderately sloping basinal soil characterized by a heavy silt loam surface layer; an impervious thick clay subsoil; extremely poor drainage; developed in deepest depressions of the uplands.

WW_bH_1	YORK COUNTY	Waukesha-Wabash-Hall Association: Nearly level soils having a silt loam surface layer with variable amounts of fine sand, and considerable organic matter; overlying either a heavy silty loam or sandy alluvial material; on bottom lands and adjacent narrow terraces derived from alluvium.

Symbol		Description
Kn	Niobrara Formation	Chalk and limestone, argillaceous. Chalk is medium gray to yellowish gray; contains interbedded thin or very thin layers of chalky shale; weathers dark yellowish orange, very pale orange, or light gray; contains many fossil clams, oysters, and Foraminifera, and shell fragments. Light to yellowish-gray and medium-gray argillaceous limestone; contains interbedded thin layers of medium-gray chalky shale; the limestone contains shells of Foraminifera and Inoceramus and shell fragments.
Kc	Carlile Shale	Shale, limestone, and sandstone. At top, locally about 5 feet thick, gray to pale-yellowish-brown siltstone or very fine grained sandstone. Shale, upper 200 feet, is dark gray to medium gray; locally contains ironstone concretions, and interbedded very thin siltstone layers. Shale, lower 80 feet, is medium gray, calcareous, and contains many very thin and thin bedded, fossiliferous, shaly limestone and calcareous shale layers.
Kgg	Greenhorn Limestone and Graneros Shale	Greenhorn Limestone is medium gray to light gray; contains interbedded argillaceous limestone, marl, and calcareous shale; fossiliferous. Upper and lower boundaries are both gradational and conformable. Thickness 0-30 feet. Graneros Shale is medium gray to dark gray, interbedded with thin layers of silt; upper part, about 40 feet thick, interbedded with thin limestone layers; lower part, about 25 feet thick, contains thin layers of carbonaceous material.
Kd	Dakota Sandstone	Sandstone and interbedded sandy carbonaceous shale, lenses of sand cemented by iron oxide, and siltstone concretions; light gray, yellowish gray, brownish gray, and reddish brown; beds are lenticular, locally crossbedded; sandstone is fine to coarse grained, micaceous, and contains scattered chert pebbles. Equivalent to Dakota Group of the Nebraska Geological Survey, which includes (descending order): the Omadi Sandstone, Skull Creek Shale, Fall River Sandstone, Fuson Shale, and Dakota Sandstone.

BEDROCK GEOLOGY - LINCOLN QUADRANGLE

Symbol		Description
Pc	Chase Group	Limestone and shale. Limestone is light gray to dark gray, yellowish gray to pale yellowish brown. Two limestones in the upper part are thin bedded to medium bedded, argillaceous, cherty and fossiliferous; two limestones in the lower part are medium bedded to massive bedded, very cherty, and fossiliferous. Shale is gray, green, red, reddish brown, calcareous, arenaceous, fossiliferous; locally fissile. Chase Group equivalent to upper part of Big Blue Series of the Nebraska Geological Survey, which includes (descending order): Nolans Limestone, Odell Shale, Winfield Limestone, Gage Shale, Towanda Limestone, Holmesville Shale, Barneston Limestone, Blue Springs Shale, Kinney Limestone, Wymore Shale, and Wreford Limestone.
Pcg	Council Grove Group	Shale and interbedded limestone. Shale is gray, green, red, reddish brown, or maroon, sandy, calcareous, fossiliferous; locally fissile; several fissile black shale beds are in lower 75 feet. Interbedded dark to light-gray, medium to thick-bedded, argillaceous, cherty limestone beds are very fossiliferous and locally contain shale partings. Council Grove Group equivalent to middle part of the Big Blue Series of Nebraska Geological Survey, which includes (descending order): Speiser Shale, Funston Limestone, Blue Rapids Shale, Crouse Limestone, Easly Creek Shale, Bader Limestone, Stearns Shale, Beattie Limestone, Eskridge Shale, Grenola Limestone, Roca Shale, Red Eagle Limestone, Johnson Shale and Foraker Limestone.
Pa	Admire Group	Shale and interbedded limestone. Shale is dark gray to light gray, brown, red, or green, sandy, calcareous, and fossiliferous. Interbedded dark to light-gray, very thin to medium bedded, argillaceous, very fossiliferous limestone beds. Near top of unit a fine-grained, micaceous sandstone bed underlies a stromatolite limestone bed which has distinctive lobate bedding. Admire Group equivalent to lower part of Big Blue Series of the Nebraska Geological Survey, which includes (descending order): Hamlin Shale, Five Point Limestone, West Branch Shale, Falls City Limestone, and Onaga Shale.

BEDROCK GEOLOGY - LINCOLN QUADRANGLE

Symbol		Description
Pw	Wabaunsee Group	Shale, sandstone, and interbedded limestone. Shale is light gray to dark gray, greenish gray, red, or black; contains very thin layers of siltstone; locally very fossiliferous, carbonaceous. Sandstone is brownish gray to yellowish gray, or gray, argillaceous, and micaceous. Limestone is dark gray to medium gray, yellowish gray, thin bedded to thick bedded; very fossiliferous; weathered surface is brownish gray. Contains coal beds less than 1 foot thick. Wabaunsee Group of the Nebraska Geological Survey includes (descending order): Wood Siding Formation, Root Shale, Stotler Limestone, Pillsbury Shale, Zeandale Limestone, Willard Shale, Emporia Limestone, Auburn Shale, Wakarusa Limestone, Soldier Creek Shale, Burlingame Limestone, Scranton Shale, Howard Limestone, and Severy Shale.
Ps	Shawnee Group	Limestone and shale. Limestone is dark gray to very light gray, yellowish gray, very thin bedded to massive bedded, and fossiliferous; locally the thin beds are argillaceous. Shawnee Group of the Nebraska Geological Survey includes (descending order): Topeka Limestone, Calhoun Shale, Deer Creek Limestone, Tecumseh Shale, Lecompton Limestone, Kanwaka Shale, and Oread Limestone.
Pd	Douglas Group	Shale and limestone. Shale is dark gray to medium gray, red, or black, fossiliferous, and calcareous. Limestone is dark gray to light gray, thin bedded to thick bedded, fossiliferous, and locally sandy. Douglas Group of the Nebraska Geological Survey includes (descending order): Lawrence Shale, Cass Limestone and Plattford Shale.
Pl	Lansing Group	Limestone and shale. Limestone is dark gray to light gray, very thin bedded to massive bedded, sandy, fossiliferous; cherty. Shale is dark gray to light gray, maroon, fossiliferous, and calcareous. Lansing Group of the Nebraska Geological Survey includes (descending order): Stanton Limestone, Vilas Shale, and Plattsburg Limestone.

BEDROCK GEOLOGY - LINCOLN QUADRANGLE

Symbol		Description
Pk	Kansas City Group	Limestone and shale. Limestone is dark gray to light gray, brownish gray, very thin bedded to massive bedded, fossiliferous, argillaceous, cherty; contains thin layers of chert, pyrite, and scattered small flakes of mica near base. Shale is dark gray to light gray, greenish gray, black; locally fissile or carbonaceous, calcareous; fossiliferous; locally contains some sand. Kansas City Group of the Nebraska Geological Survey includes (descending order): Bonner Springs Formation, Wyandotte Limestone, Lane Shale, Iola Limestone, Chanute Shale, Drum Limestone, Quivira Formation, Sarpy Formation, Fontana Formation, Dennis Limestone, Galesburg Shale, Swope Limestone, Ladore Shale, and Hertha Limestone.

APPENDIX D

Statistical Analysis - Lincoln Quadrangle

ROCK UNIT CRS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	51.4362	61.6400	73.8681	88.5219	106.0828	127.1273	152.3467
BI214	DIST	NORMAL	14.8840	34.5893	54.2947	74.0000	93.7053	113.4107	133.1160
TL208	DIST	NORMAL	32.1138	39.4759	46.8379	54.2000	61.5621	68.9241	76.2862
U/K	DIST	LOG	.2833	.3954	.5518	.7701	1.0748	1.4999	2.0933
U/TH	DIST	NORMAL	.1764	.5609	.9455	1.3300	1.7145	2.0991	2.4836
TH/K	DIST	LOG	.3862	.4489	.5218	.6065	.7050	.8195	.9525

ROCK UNIT WB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	63.3322	73.4459	85.1747	98.7765	114.5504	132.8433	154.0575
BI214	DIST	NORMAL	21.6371	43.3581	65.0790	86.8000	108.5210	130.2419	151.9629
TL208	DIST	NORMAL	38.1694	43.3463	48.5231	53.7000	58.8769	64.0537	69.2306
U/K	DIST	NORMAL	.0269	.3169	.6069	.8969	1.1870	1.4770	1.7670
U/TH	DIST	NORMAL	.2312	.7010	1.1709	1.6407	2.1106	2.5804	3.0503
TH/K	DIST	LOG	.3256	.3856	.4567	.5409	.6407	.7588	.8987

ROCK UNIT CS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	50.6780	64.9853	79.2927	93.6000	107.9073	122.2147	136.5220
BI214	DIST	NORMAL	16.5879	38.8253	61.0626	83.3000	105.5374	127.7747	150.0121
TL208	DIST	NORMAL	38.8882	44.6588	50.4294	56.2000	61.9706	67.7412	73.5118
U/K	DIST	LOG	.2938	.4214	.6043	.8668	1.2433	1.7832	2.5577
U/TH	DIST	NORMAL	.1589	.6066	1.0543	1.5020	1.9497	2.3974	2.8451
TH/K	DIST	LOG	.3670	.4334	.5118	.6044	.7138	.8430	.9955

ROCK UNIT P

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	51.3514	65.5676	79.7838	94.0000	108.2162	122.4324	136.6486
BI214	DIST	NORMAL	25.4232	46.5822	67.7411	88.9000	110.0589	131.2178	152.3768
TL208	DIST	NORMAL	40.3844	45.7229	51.0615	56.4000	61.7385	67.0771	72.4156
U/K	DIST	LOG	.3419	.4813	.6777	.9540	1.3431	1.8909	2.6621
U/TH	DIST	NORMAL	.2967	.7298	1.1629	1.5960	2.0291	2.4622	2.8953
TH/K	DIST	LOG	.3761	.4445	.5255	.6212	.7343	.8681	1.0262

ROCK UNIT WYPA

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	66.7789	76.3528	87.2993	99.8152	114.1254	130.4872	149.1948
BI214	DIST	NORMAL	23.7022	46.7348	69.7674	92.8000	115.8326	138.8652	161.8978
TL208	DIST	NORMAL	42.1777	47.7185	53.2592	58.8000	64.3408	69.8815	75.4223
U/K	DIST	LOG	.3436	.4737	.6531	.9005	1.2417	1.7120	2.3606
U/TH	DIST	LOG	.6455	.8616	1.1501	1.5351	2.0490	2.7350	3.6506
TH/K	DIST	LOG	.3774	.4372	.5064	.5866	.6795	.7872	.9118

ROCK UNIT WY

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56.5153	68.0435	79.5718	91.1000	102.6282	114.1565	125.6847
BI214	DIST	NORMAL	20.5269	41.2512	61.9756	82.7000	103.4244	124.1488	144.8731
TL208	DIST	NORMAL	42.5401	47.5601	52.5800	57.6000	62.6200	67.6399	72.6599
U/K	DIST	NORMAL	.0886	.3684	.6482	.9280	1.2078	1.4876	1.7674
U/TH	DIST	NORMAL	.2539	.6526	1.0513	1.4500	1.8487	2.2474	2.6461
TH/K	DIST	LOG	.4009	.4675	.5450	.6355	.7409	.8639	1.0072

ROCK UNIT WWBSA

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	62.1868	78.7579	95.3289	111.9000	128.4711	145.0421	161.6132
BI214	DIST	NORMAL	30.1168	48.0779	66.0389	84.0000	101.9611	119.9221	137.8832
TL208	DIST	NORMAL	34.4364	41.7576	49.0788	56.4000	63.7212	71.0424	78.3636
U/K	DIST	LOG	.3411	.4419	.5725	.7416	.9606	1.2444	1.6120
U/TH	DIST	LOG	.7072	.9021	1.1507	1.4678	1.8722	2.3882	3.0463
TH/K	DIST	NORMAL	.3110	.3773	.4437	.5100	.5763	.6427	.7090

ROCK UNIT WWBS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56.4858	70.4572	84.4286	98.4000	112.3714	126.3428	140.3142
BI214	DIST	NORMAL	43.6969	57.7646	71.8323	85.9000	99.9677	114.0354	128.1031
TL208	DIST	LOG	41.7570	45.9003	50.4547	55.4610	60.9641	67.0132	73.6625
U/K	DIST	NORMAL	.1885	.4266	.6648	.9030	1.1412	1.3794	1.6175
U/TH	DIST	LOG	.7909	.9851	1.2270	1.5283	1.9036	2.3711	2.9534
TH/K	DIST	LOG	.3557	.4161	.4868	.5695	.6662	.7794	.9117

ROCK UNIT WWBHL

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	60.1934	71.3392	84.5487	100.2042	118.7585	140.7485	166.8102
BI214	DIST	NORMAL	21.9162	40.5441	59.1721	77.8000	96.4279	115.0559	133.6838
TL208	DIST	LOG	31.7354	37.4450	44.1817	52.1305	61.5093	72.5755	85.6326
U/K	DIST	LOG	.2972	.4051	.5523	.7530	1.0265	1.3995	1.9080
U/TH	DIST	LOG	.6206	.8230	1.0915	1.4474	1.9195	2.5455	3.3758
TH/K	DIST	LOG	.3380	.3903	.4506	.5202	.6006	.6935	.8006

ROCK UNIT WWBCS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	62.5988	78.0325	93.4663	108.9000	124.3337	139.7675	155.2012
BI214	DIST	NORMAL	20.5432	41.9955	63.4477	84.9000	106.3523	127.8045	149.2568
TL208	DIST	NORMAL	33.8391	41.1261	48.4130	55.7000	62.9870	70.2739	77.5609
U/K	DIST	LOG	.3022	.4113	.5597	.7618	1.0368	1.4111	1.9205
U/TH	DIST	NORMAL	.2040	.6533	1.1027	1.5520	2.0013	2.4507	2.9000
TH/K	DIST	LOG	.3283	.3809	.4418	.5126	.5946	.6898	.8002

ROCK UNIT WK

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	64.3913	75.3258	88.1171	103.0805	120.5849	141.0618	165.0159
BI214	DIST	NORMAL	30.2746	48.5831	66.8915	85.2000	103.5085	121.8169	140.1254
TL208	DIST	LOG	40.2952	45.6741	51.7710	58.6818	66.5151	75.3941	85.4583
U/K	DIST	LOG	.3338	.4481	.6016	.8076	1.0841	1.4554	1.9538
U/TH	DIST	NORMAL	.4544	.7883	1.1221	1.4560	1.7899	2.1237	2.4576
TH/K	DIST	LOG	.3263	.3928	.4729	.5693	.6853	.8250	.9931

ROCK UNIT WBLCS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	52.3122	62.1257	73.7802	87.6209	104.0582	123.5790	146.7618
BI214	DIST	NORMAL	15.6842	34.6895	53.6947	72.7000	91.7053	110.7105	129.7158
TL208	DIST	NORMAL	32.8142	38.5761	44.3381	50.1000	55.8619	61.6239	67.3858
U/K	DIST	NORMAL	.0277	.3011	.5746	.8480	1.1214	1.3949	1.6683
U/TH	DIST	NORMAL	.2776	.6743	1.0711	1.4678	1.8645	2.2613	2.6580
TH/K	DIST	LOG	.3447	.4071	.4807	.5676	.6702	.7914	.9344

ROCK UNIT WBL

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	35.4649	47.4044	63.3635	84.6953	113.2086	151.3212	202.2647
BI214 DIST NORMAL	2.5931	24.2288	45.8644	67.5000	89.1356	110.7712	132.4069
TL208 DIST LOG	20.2335	26.7193	35.2841	46.5944	61.5301	81.2535	107.2991
U/K DIST LOG	.2358	.3457	.5067	.7426	1.0885	1.5955	2.3386
U/TH DIST LOG	.4717	.6665	.9416	1.3304	1.8797	2.6558	3.7523
TH/K DIST LOG	.3190	.3846	.4638	.5593	.6744	.8132	.9806

ROCK UNIT W

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	18.1266	42.9177	67.7089	92.5000	117.2911	142.0823	166.8734
BI214 DIST NORMAL	6.5898	28.4599	50.3299	72.2000	94.0701	115.9401	137.8102
TL208 DIST NORMAL	25.4910	33.0606	40.6303	48.2000	55.7697	63.3394	70.9090
U/K DIST LOG	.2575	.3717	.5365	.7746	1.1182	1.6142	2.3303
U/TH DIST LOG	.5709	.7776	1.0590	1.4423	1.9644	2.6755	3.6439
TH/K DIST LOG	.2551	.3268	.4187	.5365	.6874	.8807	1.1283

ROCK UNIT SC

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	64.5026	75.4921	88.3538	103.4067	121.0243	141.6434	165.7754
BI214 DIST NORMAL	20.2517	40.1011	59.9506	79.8000	99.6494	119.4989	139.3483
TL208 DIST NORMAL	33.4804	40.3870	47.2935	54.2000	61.1065	68.0130	74.9196
U/K DIST LOG	.3108	.4165	.5580	.7477	1.0019	1.3425	1.7988
U/TH DIST LOG	.5977	.8009	1.0731	1.4379	1.9267	2.5816	3.4592
TH/K DIST NORMAL	.2804	.3624	.4443	.5263	.6083	.6903	.7722

ROCK UNIT SBBMR

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	58.4654	71.4769	84.4885	97.5000	110.5115	123.5231	136.5346
BI214 DIST NORMAL	15.0299	39.8532	64.6766	89.5000	114.3234	139.1468	163.9701
TL208 DIST NORMAL	39.1790	45.0527	50.9263	56.8000	62.6737	68.5473	74.4210
U/K DIST LOG	.3229	.4528	.6349	.8903	1.2484	1.7506	2.4548
U/TH DIST LOG	.6082	.8258	1.1212	1.5222	2.0668	2.8061	3.8099
TH/K DIST LOG	.3701	.4311	.5021	.5849	.6812	.7935	.9243

ROCK UNIT S

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	46.7306	57.2246	70.0750	85.8112	105.0812	128.6784	157.5747
BI214	DIST	NORMAL	9.4815	29.6210	49.7605	69.9000	90.0395	110.1790	130.3185
TL208	DIST	NORMAL	29.8330	36.6887	43.5443	50.4000	57.2557	64.1113	70.9670
U/K	DIST	LOG	.2542	.3690	.5355	.7771	1.1278	1.6367	2.3752
U/TH	DIST	LOG	.4960	.6893	.9579	1.3311	1.8497	2.5704	3.5719
TH/K	DIST	LOG	.3446	.4106	.4892	.5829	.6945	.8275	.9859

ROCK UNIT PS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	35.6687	52.2458	68.8229	85.4000	101.9771	118.5542	135.1313
BI214	DIST	NORMAL	9.8989	27.1326	44.3663	61.6000	78.8337	96.0674	113.3011
TL208	DIST	LOG	31.5899	36.3887	41.9165	48.2840	55.6188	64.0679	73.8004
U/K	DIST	NORMAL	-.0984	.1871	.4726	.7582	1.0437	1.3292	1.6147
U/TH	DIST	NORMAL	.2152	.5670	.9189	1.2708	1.6226	1.9745	2.3264
TH/K	DIST	LOG	.3296	.3973	.4789	.5773	.6958	.8387	1.0110

ROCK UNIT PMYB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	44.3503	57.4002	70.4501	83.5000	96.5499	109.5998	122.6497
BI214	DIST	NORMAL	8.7700	31.2800	53.7900	76.3000	98.8100	121.3200	143.8300
TL208	DIST	NORMAL	36.9071	42.7381	48.5690	54.4000	60.2310	66.0619	71.8929
U/K	DIST	NORMAL	-.1036	.2453	.5941	.9430	1.2919	1.6408	1.9897
U/TH	DIST	NORMAL	.1002	.5378	.9754	1.4130	1.8506	2.2882	2.7258
TH/K	DIST	NORMAL	.3016	.4231	.5447	.6663	.7879	.9094	1.0310

ROCK UNIT NC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	38.6606	53.1071	67.5535	82.0000	96.4465	110.8929	125.3394
BI214	DIST	NORMAL	24.7702	39.8135	54.8567	69.9000	84.9433	99.9865	115.0298
TL208	DIST	NORMAL	37.6172	42.0781	46.5391	51.0000	55.4609	59.9219	64.3828
U/K	DIST	LOG	.3328	.4540	.6193	.8448	1.1524	1.5720	2.1444
U/TH	DIST	LOG	.5872	.7734	1.0187	1.3417	1.7672	2.3276	3.0657
TH/K	DIST	LOG	.3727	.4440	.5290	.6303	.7509	.8946	1.0659

ROCK UNIT MRB

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	51.7196	67.8130	83.9065	100.0000	116.0935	132.1870	148.2804
BI214	DIST LOG	42.7811	54.8428	70.3052	90.1270	115.5374	148.1121	189.8708
TL208	DIST NORMAL	42.0103	47.8069	53.6034	59.4000	65.1966	70.9931	76.7897
U/K	DIST LOG	.3190	.4571	.6551	.9387	1.3452	1.9277	2.7625
U/TH	DIST LOG	.6773	.8877	1.1636	1.5252	1.9992	2.6205	3.4349
TH/K	DIST NORMAL	.1233	.2922	.4611	.6300	.7989	.9678	1.1367

ROCK UNIT M

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	35.3502	52.9001	70.4501	88.0000	105.5499	123.0999	140.6498
BI214	DIST NORMAL	16.4875	35.6917	54.8958	74.1000	93.3042	112.5083	131.7125
TL208	DIST LOG	32.8196	37.6960	43.2969	49.7301	57.1191	65.6059	75.3538
U/K	DIST NORMAL	.0101	.2909	.5717	.8525	1.1333	1.4142	1.6950
U/TH	DIST NORMAL	.2426	.6609	1.0792	1.4975	1.9158	2.3340	2.7523
TH/K	DIST LOG	.3535	.4125	.4814	.5618	.6556	.7650	.8928

ROCK UNIT LCSG

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	37.1001	52.0667	67.0334	82.0000	96.9666	111.9333	126.8999
BI214	DIST LOG	52.3059	61.1843	71.5696	83.7177	97.9278	114.5499	133.9934
TL208	DIST NORMAL	40.0501	46.0334	52.0167	58.0000	63.9833	69.9666	75.9499
U/K	DIST NORMAL	.2471	.5030	.7590	1.0150	1.2709	1.5269	1.7829
U/TH	DIST LOG	.7273	.9140	1.1485	1.4433	1.8136	2.2791	2.8639
TH/K	DIST NORMAL	.3156	.4407	.5658	.6909	.8160	.9411	1.0662

ROCK UNIT LCHV

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-.0616	21.4256	42.9128	64.4000	85.8872	107.3744	128.8616
BI214	DIST NORMAL	21.6485	42.0324	62.4162	82.8000	103.1838	123.5676	143.9515
TL208	DIST NORMAL	33.6202	40.3134	47.0067	53.7000	60.3933	67.0866	73.7798
U/K	DIST LOG	.3355	.5297	.8362	1.3202	2.0843	3.2906	5.1949
U/TH	DIST LOG	.6930	.8964	1.1593	1.4994	1.9392	2.5081	3.2438
TH/K	DIST LOG	.3308	.4584	.6352	.8802	1.2198	1.6903	2.3423

ROCK UNIT LC

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	49.6727	58.4818	67.2909	76.1000	84.9091	93.7182	102.5273
BI214	DIST NORMAL	14.5535	31.9690	49.3845	66.8000	84.2155	101.6310	119.0465
TL208	DIST LOG	31.7668	34.6783	37.8567	41.3263	45.1140	49.2488	53.7626
U/K	DIST LOG	.2879	.4133	.5934	.8519	1.2231	1.7560	2.5210
U/TH	DIST LOG	.6286	.8508	1.1513	1.5581	2.1086	2.8536	3.8619
TH/K	DIST NORMAL	.3128	.3927	.4727	.5526	.6325	.7125	.7924

ROCK UNIT KPWK

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	34.7449	45.3580	59.2128	77.2997	100.9113	131.7352	171.9745
BI214	DIST NORMAL	20.0661	46.1774	72.2887	98.4000	124.5113	150.6226	176.7339
TL208	DIST NORMAL	28.2260	36.5507	44.8753	53.2000	61.5247	69.8493	78.1740
U/K	DIST NORMAL	-.4660	.1452	.7563	1.3674	1.9786	2.5897	3.2009
U/TH	DIST NORMAL	-.0854	.5840	1.2535	1.9229	2.5924	3.2618	3.9313
TH/K	DIST LOG	.3504	.4368	.5445	.6787	.8460	1.0546	1.3146

ROCK UNIT KNJWB

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	51.4221	63.9481	76.4740	89.0000	101.5260	114.0519	126.5779
BI214	DIST NORMAL	15.5528	37.1352	58.7176	80.3000	101.8824	123.4648	145.0472
TL208	DIST NORMAL	37.9429	43.5286	49.1143	54.7000	60.2857	65.8714	71.4571
U/K	DIST NORMAL	-.0024	.3084	.6191	.9299	1.2406	1.5514	1.8622
U/TH	DIST NORMAL	.2142	.6367	1.0592	1.4816	1.9041	2.3266	2.7491
TH/K	DIST NORMAL	.3039	.4116	.5193	.6270	.7347	.8424	.9501

ROCK UNIT JME

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	67.8905	83.5270	99.1635	114.8000	130.4365	146.0730	161.7095
BI214	DIST NORMAL	21.4303	43.2202	65.0101	86.8000	108.5899	130.3798	152.1697
TL208	DIST NORMAL	34.4501	41.9334	49.4167	56.9000	64.3833	71.8666	79.3499
U/K	DIST NORMAL	.1296	.3421	.5547	.7673	.9798	1.1924	1.4049
U/TH	DIST NORMAL	.2418	.6767	1.1115	1.5464	1.9812	2.4161	2.8510
TH/K	DIST NORMAL	.2496	.3341	.4186	.5030	.5875	.6720	.7565

ROCK UNIT HWY

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	46.2098	63.1065	80.0033	96.9000	113.7967	130.6935	147.5902
BI214	DIST NORMAL	22.0597	38.6398	55.2199	71.8000	88.3801	104.9602	121.5403
TL208	DIST LOG	33.7063	38.6201	44.2503	50.7012	58.0926	66.5615	76.2650
U/K	DIST LOG	.2600	.3669	.5177	.7306	1.0309	1.4548	2.0529
U/TH	DIST NORMAL	.2339	.6341	1.0343	1.4345	1.8347	2.2349	2.6351
TH/K	DIST LOG	.3334	.3895	.4550	.5316	.6210	.7254	.8475

ROCK UNIT HGWBN

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	77.9965	90.2643	102.5322	114.8000	127.0678	139.3357	151.6035
BI214	DIST NORMAL	35.5622	56.9748	78.3874	99.8000	121.2126	142.6252	164.0378
TL208	DIST LOG	49.2694	53.6860	58.4985	63.7424	69.4564	75.6825	82.4668
U/K	DIST LOG	.3716	.4902	.6467	.8530	1.1251	1.4841	1.9577
U/TH	DIST LOG	.6979	.9062	1.1767	1.5278	1.9837	2.5757	3.3444
TH/K	DIST LOG	.3790	.4312	.4907	.5583	.6353	.7228	.8225

ROCK UNIT HGE

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	61.6728	77.9485	94.2243	110.5000	126.7757	143.0515	159.3272
BI214	DIST NORMAL	17.8241	42.1161	66.4080	90.7000	114.9920	139.2839	163.5759
TL208	DIST NORMAL	33.6279	41.7519	49.8760	58.0000	66.1240	74.2481	82.3721
U/K	DIST NORMAL	.0983	.3443	.5903	.8363	1.0823	1.3283	1.5743
U/TH	DIST NORMAL	.3088	.7323	1.1558	1.5792	2.0027	2.4262	2.8496
TH/K	DIST NORMAL	.3122	.3849	.4576	.5302	.6029	.6755	.7482

ROCK UNIT HFBT

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	61.1975	72.2381	85.2705	100.6541	118.8131	140.2481	165.5501
BI214	DIST NORMAL	16.2001	37.1667	58.1334	79.1000	100.0666	121.0333	141.9999
TL208	DIST LOG	35.0247	40.1938	46.1257	52.9332	60.7453	69.7103	79.9984
U/K	DIST NORMAL	.0411	.2931	.5452	.7973	1.0493	1.3014	1.5535
U/TH	DIST NORMAL	.2432	.6620	1.0809	1.4998	1.9186	2.3375	2.7563
TH/K	DIST LOG	.3421	.3948	.4557	.5259	.6069	.7005	.8085

ROCK UNIT HC

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	60.6936	76.0624	91.4312	106.8000	122.1688	137.5376	152.9064
BI214	DIST NORMAL	28.2316	47.2211	66.2105	85.2000	104.1895	123.1789	142.1684
TL208	DIST NORMAL	38.1875	44.8583	51.5292	58.2000	64.8708	71.5417	78.2125
U/K	DIST NORMAL	.1137	.3490	.5842	.8195	1.0547	1.2900	1.5252
U/TH	DIST NORMAL	.3337	.7181	1.1025	1.4870	1.8714	2.2558	2.6403
TH/K	DIST LOG	.3609	.4145	.4762	.5470	.6284	.7218	.8291

ROCK UNIT HBMUCS

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	60.3332	76.9555	93.5777	110.2000	126.8223	143.4445	160.0668
BI214	DIST NORMAL	31.5857	51.4905	71.3952	91.3000	111.2048	131.1095	151.0143
TL208	DIST NORMAL	32.8541	41.0028	49.1514	57.3000	65.4486	73.5972	81.7459
U/K	DIST LOG	.3408	.4560	.6101	.8163	1.0921	1.4611	1.9549
U/TH	DIST NORMAL	.4582	.8454	1.2325	1.6197	2.0069	2.3940	2.7812
TH/K	DIST LOG	.2853	.3486	.4259	.5203	.6357	.7767	.9489

ROCK UNIT HBJ

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	55.3180	69.2787	83.2393	97.2000	111.1607	125.1213	139.0820
BI214	DIST LOG	33.8185	46.0539	62.7160	85.4063	116.3059	158.3849	215.6879
TL208	DIST NORMAL	36.0890	42.3260	48.5630	54.8000	61.0370	67.2740	73.5110
U/K	DIST LOG	.3025	.4332	.6203	.8881	1.2716	1.8208	2.6071
U/TH	DIST LOG	.5841	.8118	1.1282	1.5679	2.1790	3.0283	4.2086
TH/K	DIST LOG	.3438	.4061	.4796	.5664	.6690	.7901	.9331

ROCK UNIT HBHL

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	42.4001	60.4334	78.4667	96.5000	114.5333	132.5666	150.5999
BI214	DIST NORMAL	6.9283	31.8522	56.7761	81.7000	106.6239	131.5478	156.4717
TL208	DIST NORMAL	26.5682	35.0121	43.4561	51.9000	60.3439	68.7879	77.2318
U/K	DIST NORMAL	-.0263	.2722	.5707	.8692	1.1676	1.4661	1.7646
U/TH	DIST NORMAL	.1009	.5979	1.0949	1.5919	2.0889	2.5859	3.0829
TH/K	DIST LOG	.2964	.3619	.4419	.5396	.6588	.8044	.9822

ROCK UNIT GEH

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	62.0274	77.7849	93.5425	109.3000	125.0575	140.8151	156.5726
BI214	DIST	NORMAL	31.4308	51.1538	70.8769	90.6000	110.3231	130.0462	149.7692
TL208	DIST	NORMAL	42.8424	49.3616	55.8808	62.4000	68.9192	75.4384	81.9576
U/K	DIST	LOG	.3685	.4806	.6267	.8172	1.0657	1.3897	1.8123
U/TH	DIST	LOG	.6822	.8719	1.1144	1.4244	1.8205	2.3269	2.9741
TH/K	DIST	LOG	.3593	.4200	.4909	.5737	.6706	.7838	.9162

ROCK UNIT GEJN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56.6693	74.8462	93.0231	111.2000	129.3769	147.5538	165.7307
BI214	DIST	NORMAL	23.1079	49.3719	75.6360	101.9000	128.1640	154.4281	180.6921
TL208	DIST	NORMAL	34.7647	41.5765	48.3882	55.2000	62.0118	68.8235	75.6353
U/K	DIST	NORMAL	.0593	.3547	.6501	.9454	1.2408	1.5362	1.8315
U/TH	DIST	NORMAL	.2150	.7690	1.3231	1.8772	2.4313	2.9853	3.5394
TH/K	DIST	NORMAL	.2009	.3039	.4068	.5098	.6127	.7157	.8186

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ROCK UNIT G

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	59.4161	75.3441	91.2720	107.2000	123.1280	139.0559	154.9839
BI214	DIST	NORMAL	29.5615	48.6744	67.7872	86.9000	106.0128	125.1256	144.2385
TL208	DIST	NORMAL	38.1346	44.6231	51.1115	57.6000	64.0885	70.5769	77.0654
U/K	DIST	LOG	.3289	.4420	.5941	.7986	1.0734	1.4427	1.9391
U/TH	DIST	NORMAL	.3773	.7611	1.1449	1.5288	1.9126	2.2964	2.6803
TH/K	DIST	LOG	.3548	.4082	.4695	.5400	.6211	.7145	.8218

ROCK UNIT CRPA

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56.7088	71.1725	85.6363	100.1000	114.5637	129.0275	143.4912
BI214	DIST	NORMAL	22.5375	43.8917	65.2458	86.6000	107.9542	129.3083	150.6625
TL208	DIST	NORMAL	42.9445	48.3297	53.7148	59.1000	64.4852	69.8703	75.2555
U/K	DIST	LOG	.3294	.4515	.6187	.8478	1.1618	1.5921	2.1817
U/TH	DIST	LOG	.6132	.8125	1.0766	1.4265	1.8901	2.5044	3.3184
TH/K	DIST	LOG	.3654	.4297	.5053	.5942	.6988	.8218	.9664

ROCK UNIT CRMY

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	63,0230	77,4487	91,8743	106,3000	120,7257	135,1513	149,5770
BI214	DIST	NORMAL	33,4033	53,7355	74,0678	94,4000	114,7322	135,0645	155,3967
TL208	DIST	NORMAL	44,2136	49,7091	55,2045	60,7000	66,1955	71,6909	77,1864
U/K	DIST	LOG	,3597	,4836	,6502	,8742	1,1754	1,5804	2,1249
U/TH	DIST	NORMAL	,4095	,7972	1,1849	1,5726	1,9603	2,3480	2,7357
TH/K	DIST	LOG	,3611	,4214	,4918	,5740	,6699	,7818	,9124

ROCK UNIT CRHBT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	67,8433	82,6622	97,4811	112,3000	127,1189	141,9378	156,7567
BI214	DIST	NORMAL	34,7864	55,6909	76,5955	97,5000	118,4045	139,3091	160,2136
TL208	DIST	NORMAL	42,4317	48,7878	55,1439	61,5000	67,8561	74,2122	80,5683
U/K	DIST	LOG	,3747	,4932	,6491	,8544	1,1245	1,4800	1,9479
U/TH	DIST	NORMAL	,5126	,8735	1,2345	1,5954	1,9563	2,3172	2,6781
TH/K	DIST	LOG	,3625	,4166	,4787	,5501	,6321	,7263	,8346

ROCK UNIT CRFBT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	72,7735	85,7156	98,6578	111,6000	124,5422	137,4844	150,4265
BI214	DIST	NORMAL	30,7500	49,9333	69,1167	88,3000	107,4833	126,6667	145,8500
TL208	DIST	NORMAL	42,1533	48,2689	54,3844	60,5000	66,6156	72,7311	78,8467
U/K	DIST	NORMAL	,1386	,3621	,5856	,8092	1,0327	1,2562	1,4798
U/TH	DIST	NORMAL	,3536	,7288	1,1039	1,4791	1,8542	2,2294	2,6045
TH/K	DIST	LOG	,3674	,4187	,4771	,5436	,6194	,7058	,8043

ROCK UNIT CRBT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	56,2612	74,0742	91,8871	109,7000	127,5129	145,3258	163,1388
BI214	DIST	NORMAL	25,7273	47,7182	69,7091	91,7000	113,6909	135,6818	157,6727
TL208	DIST	NORMAL	40.191	46.794	53.396	60.0	66.603	73.206	79.809
U/K	DIST	NORMAL	,1369	,3763	,6158	,8553	1,0948	1,3342	1,5737
U/TH	DIST	NORMAL	,3965	,7769	1,1573	1,5377	1,9181	2,2985	2,6789
TH/K	DIST	NORMAL	,3050	,3894	,4738	,5583	,6427	,7272	,8116

ROCK UNIT CB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	47.3892	57.3475	69.3985	83.9818	101.6297	122.9860	148.8302
BI214	DIST	NORMAL	9.6898	29.0598	48.4299	67.8000	87.1701	106.5402	125.9102
TL208	DIST	NORMAL	29.0803	36.3535	43.6268	50.9000	58.1732	65.4465	72.7197
U/K	DIST	NORMAL	-.0253	.2557	.5366	.8176	1.0986	1.3795	1.6605
U/TH	DIST	NORMAL	.1149	.5254	.9359	1.3465	1.7570	2.1675	2.5781
TH/K	DIST	LOG	.3628	.4290	.5074	.6001	.7098	.8395	.9929

ROCK UNIT C

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	80.0069	91.7713	103.5356	115.3000	127.0644	138.8287	150.5931
BI214	DIST	NORMAL	35.7294	54.1196	72.5098	90.9000	109.2902	127.6804	146.0706
TL208	DIST	LOG	44.7068	49.1790	54.0986	59.5103	65.4634	72.0120	79.2157
U/K	DIST	LOG	.3539	.4596	.5967	.7748	1.0059	1.3061	1.6959
U/TH	DIST	LOG	.6814	.8852	1.1499	1.4937	1.9404	2.5206	3.2743
TH/K	DIST	LOG	.3568	.4042	.4579	.5187	.5875	.6655	.7539

ROCK UNIT BST

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	41.6061	50.9505	62.3936	76.4067	93.5670	114.5815	140.3156
BI214	DIST	NORMAL	9.1935	23.4623	37.7312	52.0000	66.2688	80.5377	94.8065
TL208	DIST	LOG	29.3012	33.8879	39.1927	45.3278	52.4233	60.6294	70.1202
U/K	DIST	NORMAL	-.0735	.1766	.4267	.6767	.9268	1.1769	1.4270
U/TH	DIST	NORMAL	.0357	.3955	.7553	1.1152	1.4750	1.8348	2.1946
TH/K	DIST	LOG	.3367	.4067	.4912	.5932	.7165	.8654	1.0453

ROCK UNIT BNKPSG

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	57.8476	66.3826	76.1768	87.4161	100.3137	115.1143	132.0985
BI214	DIST	NORMAL	22.7348	42.1898	61.6449	81.1000	100.5551	120.0102	139.4652
TL208	DIST	NORMAL	37.8103	43.6069	49.4034	55.2000	60.9966	66.7931	72.5897
U/K	DIST	NORMAL	.0175	.3273	.6371	.9470	1.2568	1.5666	1.8764
U/TH	DIST	NORMAL	.2280	.6491	1.0702	1.4914	1.9125	2.3337	2.7548
TH/K	DIST	LOG	.3842	.4526	.5332	.6281	.7399	.8716	1.0267

ROCK UNIT BNKP

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	10.0614	32.0409	54.0205	76.0000	97.9795	119.9591	141.9386
BI214	DIST NORMAL	26.6871	47.8247	68.9624	90.1000	111.2376	132.3753	153.5129
TL208	DIST NORMAL	32.5364	39.8576	47.1788	54.5000	61.8212	69.1424	76.4636
U/K	DIST LOG	.3384	.5102	.7694	1.1601	1.7493	2.6378	3.9776
U/TH	DIST NORMAL	.1679	.6770	1.1861	1.6952	2.2043	2.7134	3.2225
TH/K	DIST LOG	.3419	.4374	.5596	.7159	.9159	1.1717	1.4991

APPENDIX E

Geologic Legend - Manhattan and Hutchinson

Quadrangle

SEDIMENTARY ROCKS

Cenozoic

(Formal names of stratigraphic units not included, except in Pliocene Series)

NEOGENE SYSTEM

PLEISTOCENE SERIES

POST-KANSAN DEPOSITS

Nal_3

Alluvium

Below floodplains and in stream terraces

Nds

Dune sand

Nl

Loess

Thin except locally in northeastern Kansas and along some stream valleys elsewhere

KANSAN AND OLDER DEPOSITS

Nal_2

Alluvium

Non-glacial in stream terraces and in fillings of old valleys

Ngd

Drift

Till; lacustrine and fluvial deposits

Southern limit of glaciation (approximate)

PLEISTOCENE AND PLIOCENE SERIES

Nal_1

Alluvium

Largely chert gravel

PLIOCENE SERIES

No

Ogallala Formation

Locally includes Rexroad, Laverne, and Delmore Formations

Mesozoic

CRETACEOUS SYSTEM

Kp

Pierre Shale

Kn

Niobrara Chalk

Kc

Carlile Shale

Kgg

Greenhorn Limestone and Graneros Shale

Kd

Dakota Formation

Kkc

Kiowa Shale and Cheyenne Sandstone

Cheyenne Sandstone not identified in outcrops north of T. 29 S. and west of R. 21 W.

TRIASSIC SYSTEM

TRd

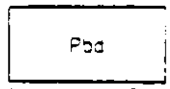
Dockum Group

Identified in outcrops in one small area in Morton County

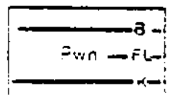
Paleozoic

PERMIAN SYSTEM

CIMARRONIAN STAGE

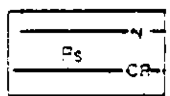


Big Basin Formation and Day Creek Dolomite



Whitehorse Sandstone and Nippewalla Group

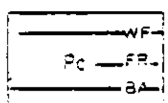
Nippewalla Group (below) with Dog Creek Formation, Blaine Gypsum (base B), Flowerpot Shale (base FL), Cedar Hills Sandstone, Salt Plains Siltstone, Harper Siltstone with Kingman Siltstone Member (base K)



Sumner Group

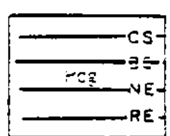
Stone Corral Formation, Ninnescah Shale (base N), and Wellington Formation with Carlton Limestone Member (base CR)

GEARYAN STAGE



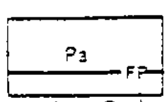
Chase Group

Nolans Limestone, Odell Shale, Winfield Limestone (base WF), Doyle Shale, Barneston Limestone (base BA) with Fort Riley Limestone Member (base FR), Matfield Shale, and Wreford Limestone



Council Grove Group

Speiser Shale, Funston Limestone, Blue Rapids Shale, Crouse Limestone (base CS), Easly Creek Shale, Bader Limestone, Stearns Shale, Beattie Limestone (base BE), Eskridge Shale, Grenola Limestone with Neva Limestone Member (base NE), Roca Shale, Red Eagle Limestone (base RE), Johnson Shale, and Foraker Limestone

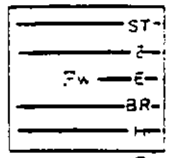


Admire Group

Janesville Shale with Five Point Limestone Member (base FP), Falls City Limestone, and Onaga Shale

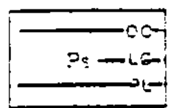
PENNSYLVANIAN SYSTEM

VIRGILIAN STAGE



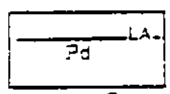
Wabaunsee Group

Woods Siding Formation, Root Shale, Stotler Limestone (base ST), Pillsbury Shale, Zeandale Limestone (base Z), Willard Shale, Emporia Limestone (base E), Auburn Shale, Bern Limestone (base BR).Scranton Shale, Howard Limestone (base H), and Severy Shale



Shawnee Group

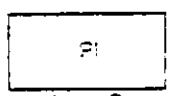
Topeka Limestone, Calhoun Shale, Deer Creek Limestone (base DC), Tecumseh Shale, Lecompton Limestone (base LC), Kanwaka Shale, Oread Limestone with Plattsmouth Limestone Member (base PL)



Douglas Group

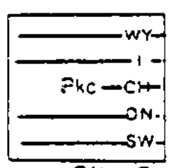
Lawrence Formation (base LA), and Stranger Formation

MISSOURIAN STAGE



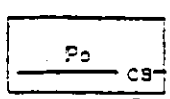
Lansing Group

Stanton Limestone, Vilas Shale, and Plattsburg Limestone



Kansas City Group

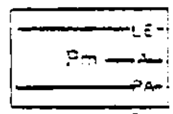
Bonner Springs Shale, Wyandotte Limestone (base WY), Lane Shale, Iola Limestone (base I), Chanute Shale (base CH), Drum Limestone, Cherryvale Shale, Dennis Limestone (base DN), Galesburg Shale, Swope Limestone (base SW), Ladore Shale, and Hertha Limestone



Pleasanton Group

Tacket Formation, Checkerboard Limestone (base CB), and Seminole Formation

DESMOINESIAN STAGE



Marmaton Group

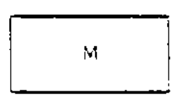
Holdenville Shale, Lenapah Limestone (base LE), Nowata Shale, Altamont Limestone (base A), Bandera Shale, Pawnee Limestone (base PA), Labette Shale, and Fort Scott Limestone

Cherokee Group

Cabaniss Formation (base CA) with Verdigris Limestone Member (base V) and Mineral coal (base MC), Krebs Formation with Blue Jacket Sandstone Member (base BJ) and WarnerSandstone Member (base WR)

MISSISSIPPIAN SYSTEM

MERAMECIAN AND OSAGIAN STAGES



Warsaw and Keokuk Limestones

APPENDIX F

Statistical Tables - Manhattan

Quadrangle

ROCK UNIT KC

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	61.9229	79.6486	97.3743	115.1000	132.8257	150.5514	168.2771
BI214 DIST NORMAL	23.6553	52.7035	81.7518	110.8000	139.8482	168.8965	197.9447
TL208 DIST NORMAL	40.1823	48.5549	56.9274	65.3000	73.6726	82.0451	90.4177
U/K DIST LOG	.3631	.4989	.6855	.9420	1.2943	1.7785	2.4437
U/TH DIST LOG	.6586	.8951	1.2163	1.6529	2.2463	3.0525	4.1482
TH/K DIST LOG	.3826	.4370	.4990	.5699	.6508	.7432	.8487

ROCK UNIT KGG

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	26.1007	48.2005	70.3002	92.4000	114.4998	136.5995	158.6993
BI214 DIST NORMAL	30.9739	56.5492	82.1246	107.7000	133.2754	158.8508	184.4261
TL208 DIST NORMAL	27.5977	37.7318	47.8659	58.0000	68.1341	78.2682	88.4023
U/K DIST LOG	.3916	.5639	.8120	1.1693	1.6837	2.4246	3.4915
U/TH DIST LOG	.7481	1.0085	1.3594	1.8326	2.4704	3.3301	4.4891
TH/K DIST LOG	.1154	.2040	.3608	.6380	1.1283	1.9953	3.5286

ROCK UNIT KD

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	20.3405	42.0937	63.8468	85.6000	107.3532	129.1063	150.8595
BI214 DIST NORMAL	17.7954	43.5636	69.3318	95.1000	120.8682	146.6364	172.4046
TL208 DIST NORMAL	32.3618	40.8412	49.3206	57.8000	66.2794	74.7588	83.2382
U/K DIST LOG	.3313	.4955	.7411	1.1084	1.6579	2.4797	3.7090
U/TH DIST NORMAL	.1546	.6610	1.1675	1.6740	2.1805	2.6870	3.1934
TH/K DIST LOG	.3547	.4437	.5550	.6942	.8684	1.0863	1.3588

ROCK UNIT KKC

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	5.4780	30.2187	54.9593	79.7000	104.4407	129.1813	153.9220
BI214 DIST NORMAL	3.7208	30.4472	57.1736	83.9000	110.6264	137.3528	164.0792
TL208 DIST NORMAL	17.8012	29.9008	42.0004	54.1000	66.1996	78.2992	90.3988
U/K DIST LOG	.3179	.4749	.7094	1.0598	1.5833	2.3653	3.5336
U/TH DIST LOG	.5556	.7765	1.0853	1.5168	2.1199	2.9627	4.1408
TH/K DIST LOG	.3567	.4469	.5600	.7017	.8793	1.1018	1.3805

ROCK UNIT NAL3

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	40.6062	62.3041	84.0021	105.7000	127.3979	149.0959	170.7938
BI214 DIST NORMAL	8.3256	38.8837	69.4419	100.0000	130.5581	161.1163	191.6744
TL208 DIST NORMAL	27.6687	37.5124	47.3562	57.2000	67.0438	76.8876	86.7313
U/K DIST LOG	.3014	.4372	.6343	.9202	1.3350	1.9368	2.8099
U/TH DIST LOG	.6273	.8729	1.2146	1.6901	2.3518	3.2725	4.5536
TH/K DIST NORMAL	.1884	.3115	.4345	.5575	.6806	.8036	.9267

ROCK UNIT NI

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	61.4438	77.4625	93.4813	109.5000	125.5187	141.5375	157.5562
BI214 DIST NORMAL	34.1715	59.4144	84.6572	109.9000	135.1428	160.3856	185.6285
TL208 DIST NORMAL	44.0112	50.8741	57.7371	64.6000	71.4629	78.3259	85.1888
U/K DIST LOG	.4074	.5471	.7348	.9868	1.3252	1.7797	2.3900
U/TH DIST LOG	.7457	.9742	1.2728	1.6629	2.1726	2.8385	3.7084
TH/K DIST LOG	.3881	.4471	.5151	.5934	.6836	.7876	.9074

ROCK UNIT NAL2

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	52.4905	69.7936	87.0968	104.4000	121.7032	139.0064	156.3095
BI214 DIST NORMAL	35.1300	57.6200	80.1100	102.6000	125.0900	147.5800	170.0700
TL208 DIST NORMAL	37.2955	44.6303	51.9652	59.3000	66.6348	73.9697	81.3045
U/K DIST LOG	.4282	.5629	.7400	.9727	1.2787	1.6809	2.2096
U/TH DIST LOG	.8353	1.0583	1.3408	1.6987	2.1521	2.7266	3.4544
TH/K DIST LOG	.3497	.4122	.4858	.5726	.6749	.7955	.9376

ROCK UNIT NGD

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	43.5548	58.3365	73.1183	87.9000	102.6817	117.4635	132.2452
BI214 DIST NORMAL	16.9509	40.1673	63.3836	86.6000	109.8164	133.0327	156.2491
TL208 DIST NORMAL	32.5073	40.7049	48.9024	57.1000	65.2976	73.4951	81.6927
U/K DIST LOG	.3350	.4760	.6764	.9610	1.3654	1.9401	2.7566
U/TH DIST NORMAL	.2468	.6774	1.1080	1.5387	1.9693	2.3999	2.8305
TH/K DIST NORMAL	.2939	.4170	.5400	.6631	.7861	.9091	1.0322

ROCK UNIT PC

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	44.7020	60.9346	77.1673	93.4000	109.6327	125.8654	142.0980
BI214	DIST NORMAL	16.7006	41.6004	66.5002	91.4000	116.2998	141.1996	166.0994
TL208	DIST NORMAL	28.5018	37.8345	47.1673	56.5000	65.8327	75.1655	84.4982
U/K	DIST NORMAL	.0008	.3392	.6777	1.0161	1.3546	1.6931	2.0315
U/TH	DIST NORMAL	.1546	.6550	1.1555	1.6559	2.1563	2.6568	3.1572
TH/K	DIST NORMAL	.2944	.4014	.5084	.6155	.7225	.8295	.9365

ROCK UNIT PCG

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	46.2131	61.5754	76.9377	92.3000	107.6623	123.0246	138.3869
BI214	DIST NORMAL	5.9011	33.4674	61.0337	88.6000	116.1663	143.7326	171.2989
TL208	DIST NORMAL	22.9687	32.8124	42.6562	52.5000	62.3438	72.1876	82.0313
U/K	DIST NORMAL	-.0803	.2766	.6334	.9903	1.3472	1.7041	2.0609
U/TH	DIST NORMAL	.0663	.6161	1.1659	1.7157	2.2655	2.8153	3.3651
TH/K	DIST NORMAL	.2102	.3334	.4566	.5798	.7030	.8262	.9494

ROCK UNIT PA

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	48.8572	65.6381	82.4191	99.2000	115.9809	132.7619	149.5428
BI214	DIST NORMAL	13.9000	41.9000	69.9000	97.9000	125.9000	153.9000	181.9000
TL208	DIST NORMAL	25.6059	35.8039	46.0020	56.2000	66.3980	76.5961	86.7941
U/K	DIST LOG	.2938	.4354	.6452	.9562	1.4172	2.1002	3.1126
U/TH	DIST NORMAL	.1339	.6842	1.2344	1.7846	2.3349	2.8851	3.4353
TH/K	DIST LOG	.2875	.3600	.4509	.5648	.7073	.8859	1.1095

ROCK UNIT PPW

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	51.0336	66.2224	81.4112	96.6000	111.7888	126.9776	142.1664
BI214	DIST NORMAL	17.6504	43.2336	68.8168	94.4000	119.9832	145.5664	171.1496
TL208	DIST NORMAL	36.7505	44.3003	51.8502	59.4000	66.9498	74.4997	82.0495
U/K	DIST NORMAL	.0669	.3788	.6907	1.0025	1.3144	1.6263	1.9381
U/TH	DIST NORMAL	.3194	.7460	1.1726	1.5993	2.0259	2.4525	2.8791
TH/K	DIST LOG	.3770	.4446	.5242	.6180	.7287	.8592	1.0131

ROCK UNIT PS

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	56.4737	71.2824	86.0912	100.9000	115.7088	130.5176	145.3263
BI214 DIST NORMAL	27.0989	49.2326	71.3663	93.5000	115.6337	137.7674	159.9011
TL208 DIST NORMAL	41.7424	48.2616	54.7808	61.3000	67.8192	74.3384	80.8576
U/K DIST LOG	.3539	.4850	.6646	.9108	1.2481	1.7105	2.3441
U/TH DIST NORMAL	.3048	.7189	1.1330	1.5470	1.9611	2.3752	2.7892
TH/K DIST LOG	.3817	.4465	.5222	.6108	.7144	.8356	.9773

@FIN

APPENDIX G

Statistical Analysis - Hutchinson Quadrangle

ROCK UNIT KD

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-.7960	21.6027	44.0013	66.4000	88.7987	111.1973	133.5960
BI214	DIST	NORMAL	-5.4895	19.8404	45.1702	70.5000	95.8298	121.1596	146.4895
TL208	DIST	NORMAL	18.0901	28.0601	38.0300	48.0000	57.9700	67.9399	77.9099
U/K	DIST	LOG	.2728	.4274	.6696	1.0490	1.6434	2.5747	4.0336
U/TH	DIST	NORMAL	-.0191	.4801	.9793	1.4785	1.9777	2.4769	2.9761
TH/K	DIST	LOG	.3460	.4487	.5820	.7549	.9791	1.2699	1.6471

ROCK UNIT KGG

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	14.4680	35.0786	55.6893	76.3000	96.9107	117.5214	138.1320
BI214	DIST	NORMAL	23.4136	41.0091	58.6045	76.2000	93.7955	111.3909	128.9864
TL208	DIST	NORMAL	28.8329	37.3886	45.9443	54.5000	63.0557	71.6114	80.1671
U/K	DIST	NORMAL	.4061	.6153	.8245	1.0337	1.2430	1.4522	1.6614
U/TH	DIST	NORMAL	.7044	.9339	1.1634	1.3929	1.6223	1.8518	2.0813
TH/K	DIST	LOG	.4119	.5004	.6080	.7387	.8974	1.0903	1.3246

ROCK UNIT NAL2

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	26.6909	47.9606	69.2303	90.5000	111.7697	133.0394	154.3091
BI214	DIST	NORMAL	5.5894	32.4929	59.3965	86.3000	113.2035	140.1071	167.0106
TL208	DIST	NORMAL	33.0424	39.5616	46.0808	52.6000	59.1192	65.6384	72.1576
U/K	DIST	LOG	.3111	.4478	.6445	.9277	1.3352	1.9218	2.7661
U/TH	DIST	NORMAL	.0815	.6055	1.1296	1.6537	2.1777	2.7018	3.2258
TH/K	DIST	LOG	.2818	.3614	.4634	.5942	.7618	.9769	1.2525

ROCK UNIT KKC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	14.1584	32.1389	50.1195	68.1000	86.0805	104.0611	122.0416
BI214	DIST	NORMAL	-8.2660	19.6894	47.6447	75.6000	103.5553	131.5106	159.4660
TL208	DIST	NORMAL	24.7939	32.7626	40.7313	48.7000	56.6687	64.6374	72.6061
U/K	DIST	LOG	.2724	.4295	.6770	1.0673	1.6825	2.6524	4.1814
U/TH	DIST	NORMAL	-.0746	.4678	1.0102	1.5526	2.0950	2.6374	3.1798
TH/K	DIST	LOG	.3545	.4520	.5764	.7350	.9373	1.1953	1.5242

ROCK UNIT NAL3

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	38.9954	50.6965	65.9086	85.6852	111.3960	144.8218	188.2773
BI214 DIST NORMAL	4.3368	29.2245	54.1123	79.0000	103.8877	128.7755	153.6632
TL208 DIST NORMAL	24.3260	32.6507	40.9753	49.3000	57.6247	65.9493	74.2740
U/K DIST LOG	.2679	.3969	.5879	.8710	1.2903	1.9115	2.8317
U/TH DIST LOG	.5117	.7385	1.0657	1.5380	2.2196	3.2032	4.6226
TH/K DIST NORMAL	.0998	.2632	.4266	.5900	.7534	.9168	1.0802

ROCK UNIT NDS

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	67.0433	86.4289	105.8144	125.2000	144.5856	163.9711	183.3567
BI214 DIST NORMAL	13.9962	33.4974	52.9987	72.5000	92.0013	111.5026	131.0038
TL208 DIST LOG	10.3741	13.4666	17.4811	22.6922	29.4567	38.2378	49.6365
U/K DIST LOG	.2151	.2953	.4054	.5565	.7640	1.0488	1.4398
U/TH DIST LOG	.8502	1.3018	1.9933	3.0523	4.6737	7.1564	10.9580
TH/K DIST LOG	.0667	.0935	.1312	.1840	.2581	.3620	.5077

ROCK UNIT NGD

	-3	-2	-1	0	+1	+2	+3
K40 DIST LOG	49.8469	57.5742	66.4993	76.8081	88.7149	102.4675	118.3521
BI214 DIST LOG	31.1248	38.2376	46.9759	57.7111	70.8996	87.1021	107.0072
TL208 DIST LOG	31.1991	35.6426	40.7190	46.5185	53.1439	60.7130	69.3601
U/K DIST NORMAL	.2406	.4179	.5953	.7726	.9500	1.1273	1.3046
U/TH DIST NORMAL	.4290	.7100	.9910	1.2720	1.5530	1.8340	2.1150
TH/K DIST NORMAL	.4120	.4777	.5434	.6091	.6749	.7406	.8063

ROCK UNIT NI

	-3	-2	-1	0	+1	+2	+3
K40 DIST NORMAL	56.8638	70.2092	83.5546	96.9000	110.2454	123.5908	136.9362
BI214 DIST NORMAL	17.9839	42.1893	66.3946	90.6000	114.8054	139.0107	163.2161
TL208 DIST NORMAL	32.7547	39.9031	47.0516	54.2000	61.3484	68.4969	75.6453
U/K DIST LOG	.3383	.4700	.6531	.9074	1.2608	1.7518	2.4340
U/TH DIST LOG	.6266	.8600	1.1802	1.6198	2.2231	3.0511	4.1874
TH/K DIST NORMAL	.2769	.3741	.4712	.5684	.6656	.7627	.8599

ROCK UNIT NO

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	21.8931	39.7621	57.6310	75.5000	93.3690	111.2379	129.1069
BI214	DIST	LOG	15.5008	23.9167	36.9017	56.9367	87.8492	135.5450	209.1362
TL208	DIST	NORMAL	22.0450	29.9633	37.8817	45.8000	53.7183	61.6367	69.5550
U/K	DIST	LOG	.1811	.2933	.4750	.7694	1.2462	2.0186	3.2695
U/TH	DIST	LOG	.3419	.5257	.8083	1.2427	1.9107	2.9378	4.5169
TH/K	DIST	LOG	.2957	.3777	.4825	.6162	.7871	1.0053	1.2840

ROCK UNIT PA

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	42.2872	49.5950	58.1656	68.2174	80.0063	93.8324	110.0479
BI214	DIST	LOG	25.8344	35.5751	48.9884	67.4590	92.8939	127.9187	176.1494
TL208	DIST	NORMAL	-502.3215	-318.1477	-133.9738	50.2000	234.3738	418.5477	602.7215
U/K	DIST	LOG	.3050	.4516	.6686	.9900	1.4657	2.1701	3.2130
U/TH	DIST	LOG	.4614	.6607	.9461	1.3547	1.9398	2.7777	3.9774
TH/K	DIST	LOG	.4081	.4954	.6014	.7301	.8864	1.0761	1.3064

ROCK UNIT PC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	27.7816	42.6544	57.5272	72.4000	87.2728	102.1456	117.0184
BI214	DIST	NORMAL	.2202	25.4135	50.6067	75.8000	100.9933	126.1865	151.3798
TL208	DIST	NORMAL	24.9882	32.9255	40.8627	48.8000	56.7373	64.6745	72.6118
U/K	DIST	LOG	.2896	.4388	.6649	1.0076	1.5268	2.3135	3.5056
U/TH	DIST	LOG	.5036	.7216	1.0339	1.4814	2.1226	3.0414	4.3578
TH/K	DIST	LOG	.3709	.4539	.5554	.6797	.8317	1.0178	1.2455

ROCK UNIT PCG

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	39.2628	47.8558	58.3294	71.0952	86.6549	105.6200	128.7358
BI214	DIST	LOG	23.9371	33.5247	46.9525	65.7586	92.0971	128.9850	180.6478
TL208	DIST	NORMAL	23.9342	31.2895	38.6447	46.0000	53.3553	60.7105	68.0658
U/K	DIST	LOG	.2652	.4022	.6101	.9253	1.4034	2.1286	3.2284
U/TH	DIST	LOG	.4914	.7049	1.0112	1.4506	2.0808	2.9849	4.2818
TH/K	DIST	LOG	.3277	.4092	.5108	.6377	.7961	.9939	1.2408

ROCK UNIT PPW

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	30.7418	42.9279	55.1139	67.3000	79.4861	91.6721	103.8582
BI214	DIST	NORMAL	-11.5431	20.3379	52.2190	84.1000	115.9810	147.8621	179.7431
TL208	DIST	NORMAL	33.4003	39.3669	45.3334	51.3000	57.2666	63.2331	69.1997
U/K	DIST	LOG	.3525	.5308	.7991	1.2031	1.8113	2.7270	4.1056
U/TH	DIST	LOG	.5496	.7783	1.1022	1.5610	2.2106	3.1307	4.4337
TH/K	DIST	LOG	.4119	.5076	.6255	.7708	.9498	1.1704	1.4422

ROCK UNIT PS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	43.4378	58.1585	72.8793	87.6000	102.3207	117.0415	131.7622
BI214	DIST	NORMAL	7.9502	32.4001	56.8501	81.3000	105.7499	130.1999	154.6498
TL208	DIST	NORMAL	30.5429	37.5286	44.5143	51.5000	58.4857	65.4714	72.4571
U/K	DIST	LOG	.2896	.4217	.6140	.8941	1.3020	1.8959	2.7608
U/TH	DIST	LOG	.5324	.7542	1.0684	1.5136	2.1441	3.0374	4.3028
TH/K	DIST	LOG	.3333	.4034	.4881	.5906	.7147	.8648	1.0465

ROCK UNIT PWN

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	37.4263	55.5509	73.6754	91.8000	109.9246	128.0491	146.1737
BI214	DIST	NORMAL	8.6440	33.1960	57.7480	82.3000	106.8520	131.4040	155.9560
TL208	DIST	NORMAL	27.4361	35.7907	44.1454	52.5000	60.8546	69.2093	77.5639
U/K	DIST	LOG	.3067	.4350	.6168	.8746	1.2401	1.7585	2.4935
U/TH	DIST	LOG	.5603	.7807	1.0879	1.5159	2.1122	2.9432	4.1011
TH/K	DIST	NORMAL	.1634	.3072	.4511	.5949	.7388	.8826	1.0264

ROCK UNIT PPS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	22.0281	34.8188	47.6094	60.4000	73.1906	85.9812	98.7719
BI214	DIST	NORMAL	9.5711	36.1474	62.7237	89.3000	115.8763	142.4526	169.0289
TL208	DIST	LOG	33.9187	37.9598	42.4824	47.5437	53.2081	59.5474	66.6419
U/K	DIST	LOG	.3560	.5673	.9042	1.4411	2.2968	3.6607	5.8344
U/TH	DIST	LOG	.5827	.8465	1.2298	1.7866	2.5954	3.7705	5.4776
TH/K	DIST	LOG	.4393	.5379	.6587	.8066	.9878	1.2096	1.4812

ROCK UNIT NAL1

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	40.1509	44.5416	49.4124	54.8159	60.8103	67.4602	74.8373
BI214	DIST	LOG	44.6307	53.8612	65.0009	78.4444	94.6683	114.2477	137.8765
TL208	DIST	NORMAL	40.6627	43.3085	45.9542	48.6000	51.2458	53.8915	56.5373
U/K	DIST	LOG	.7616	.9398	1.1597	1.4311	1.7659	2.1790	2.6889
U/TH	DIST	NORMAL	.6862	1.0073	1.3283	1.6493	1.9703	2.2914	2.6124
TH/K	DIST	NORMAL	.6391	.7224	.8058	.8892	.9725	1.0559	1.1393

APPENDIX H

Tape Formats

RAW SPECTRAL DATA TAPE

REFERENCE: PARAGRAPHS 4.7.1 AND 6.1.5, PMD 1200-B

The RAW SPECTRAL DATA TAPE is unlabeled nine track, 800 BPI, NRZI. All data are recorded as EBCDIC characters. Each tape contains but one file of header, data, and trailer records for no more than one NTMS quadrangle. The maximum record length is 5472 characters.

The tape is organized such that each flight line of data is preceded by a header record and followed by trailer record. If a flight line is not complete on a given physical tape, no trailer record follows its last data record on the first tape, nor does a header record precede its first data record on the second tape.

Header Record

The header record is 144 characters long with seven defined data fileds. These fields are:

1. Type of tape. A 32-character field with the text "RAW SPECTRAL DATA" left justified.

2. Project identification. A 32-character field with, for example, the text "NTMS NJ 14-6 HUTCHINSON, KANSAS" left justified. With the exception of special projects, such as the Walker Field Test Pads and Lake Mead Dynamic Test Range, all project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.

3. Subcontractor name. A 10-character field with the text "GEOMETRICS".

4. System Identification. A 6-character field with the aircraft registration number right justified.

5. Flight line number. A 6-character field with the flight line number right justified.

6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the Julian date.

7. Sample period. A 6-character field describing the spectrometer accumulation time. Examples are: 1.0 SEC, 0.5 SEC, etc.

The remaining 46 characters of the header record are blank filled. A length of 144 characters was chosen to allow for future expansion and because 144 is divisible by the number of characters per word of many popular computers.

Data Record

Each data record may contain up to four data scans (logical records), with each scan 1368 characters long. Therefore, the minimum physical length of a data record is 1368 characters and the maximum physical length is 5472 characters.

The data scan has fifteen defined data fileds.

	Field	Fortran Format	Characters
1.	Record identification number	F10.2	1-10
2.	Latitude in degrees	F10.4	11-20
3.	Longitude in degrees	F10.4	21-30
4.	Time of day (HHMMSS)	3I2	31-36
5.	Total magnetic field in gammas	F 9.2	37-45
6.	Terrain clearance in feet	F 5.0	46-50
7.	Barometric pressure in inches mercury	F 5.2	51-55
8.	Outside temperature in degrees C	F 5.1	56-60
9.	Quality flag code (altitude)	I4	60-64
10.	Raw count data - 4π detector	255I3	65-829
11.	Live time - 4π detector - in seconds	F10.5	830-839
12.	Raw count data - 2π detector	255I2	840-1349
13.	Live time - 2π detector - in seconds	F10.5	1350-1359
14.	Cosmic - 4π detector	I5	1360-1364
15.	Cosmic - 2π detector	I4	1365-1368

If a scan is not within the recovered flight path locations, the latitude and longitude, data fields 2 and 3, are set to 0.0000.

The quality flag code, data field 9, is made equal to 0000 if the radar altimeter is within specifications and equal to 1000 if the radar altimeter is not within specifications.

The raw count data, fields 10 and 12, are presented for channels 0 through 254, corresponding to energies from 0 to 3 MeV for both the downward looking (4π) and upward looking (2π) detector arrays. The accumulation periods for the 4π and 2π detectors are identical, so each scan has data for both detectors. The counts in each channel are as observed, with no corrections for ADC dead time nor conversion to counts per second. Energy per channel is 11.82 KeV. Since the spectrometer does not respond to energies below 200 KeV, the counts in channels 0 through 17 will always be zero.

The live times, data field 11 and 13, are calculated by subtracting the product of the gross counts (0 to 6 MeV) and ADC dead time (8μ sec) from the actual accumulation period for the data scan. This procedure is valid because the successive approximation ADC used has a fixed conversion time of 8μ sec regardless of pulse amplitude.

The cosmic counts, data fields 14 and 15, are as observed, with no corrections for ADC dead time nor conversion to counts per second.

The data scan logical record length of 1368 characters was chosen to allow recording of all spectrometer channels for both 4π and 2π detectors with little chance of individual channel overflow given accumulation times of approximately one second. If overflow does occur, the overflow value is represented modulo 1000 (4π detector) or modulo 100 (2π detector) with leading zeroes not suppressed. The specific value of 1368 characters was chosen because it is divisible by the number of characters per word of many popular computers.

Trailer Record

Trailer record follows the last data record for each flight line. This record is always 5472 characters long, all of which are the digit nine.

SINGLE RECORD REDUCED DATA TAPE

REFERENCE: PARAGRAPHS 4.7.2 AND 6.1.5, PMD 1200-B

The SINGLE RECORD REDUCED DATA TAPE is unlabeled nine track, 800 BPI, NRZI. All data are recorded as EBCDIC characters. Each tape contains but one file of header, data, and trailer records for no more than one NTMS quadrangle. The maximum record length is 5472 characters.

The tape is organized such that each flight line of data is preceded by a header record and followed by a trailer record. If a flight line is not complete on a given physical tape, no trailer record follows its last data record on the first tape, nor does a header record precede its first data record on the second tape.

Header Record

The header record is 144 characters long with six defined data fields. These fields are:

1. Type of tape. A 32-character field with the text "SINGLE RECORD REDUCED DATA" left justified.

2. Project identification. A 32-character field with, for example, the text "NTMS NJ 14-6 HUTCHINSON, KANSAS" left justified. With the exception of special projects, such as the Lake Mead Dynamic Test Range, all project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.

3. Subcontractor name. A 10-character field with the text "GEOMETRICS".

4. System Identification. A 6-character field with the aircraft registration number right justified.

5. Flight line number. A 6-character field with the flight line number right justified.

6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the Julian date. When reflights require the insertion of data from multiple days' flying, the date used is that of the original flight.

The remaining 52 characters of the header record are blank filled. A length of 144 characters was chosen to allow for future expansion and because 144 is divisible by the number of characters per word of many popular computers.

SINGLE RECORD REDUCED DATA TAPE

Data Record

Each data record may contain up to 38 data scans (logical records), with each scan 144 characters long. Therefore, the minimum physical length of a data record is 144 characters and the maximum physical length is 5472 characters.

The data scan has eighteen defined data fields.

	Field	Fortran Format	Characters
1.	Record identification number	F10.2	1-10
2.	Latitude in degrees	F10.4	11-20
3.	Longitude in degrees	F10.4	21-30
4.	Residual magnetic field in gammas	F15.2	31-45
5.	Terrain clearance in feet	F 5.0	46-50
6.	Surface geologic map unit	A10	51-60
7.	Quality flag code (AKUT)	A 4	61-64
8.	Cosmic count rate, in cps	F 8.1	65-72
9.	Atmospheric Bi-214 count rate, in cps	F 8.1	73-80
10.	Gross count rate (0.4-3.0 MeV), in cps	F 9.1	81-89
11.	Thorium (Tl-208) count rate, in cps	F 9.1	90-98
12.	Uranium (Bi-214) count rate, in cps	F 9.1	99-107
13.	Potassium (K-40) count rate, in cps	F 9.1	108-116
14.	Uranium/Thorium count rate ratio	F 6.3	117-122
15.	Uranium/Potassium count rate ratio	F 6.3	123-128
16.	Thorium/Potassium count rate ratio	F 6.3	129-134
17.	Outside air temperature, in degrees C	F 5.1	135-139
18.	Barometric pressure, in inches of mercury	F 5.2	140-144

Trailer Record

A trailer record follows the last data record for each flight line. This record is always 5472 characters long, all of which are the digit nine.

STATISTICAL ANALYSIS TAPE

REFERENCE: PARAGRAPHS 4.7.3 AND 6.1.5, PMD 1200-B

The STATISTICAL ANALYSIS TAPE is unlabeled nine track, 800 BPI, NRZI. All data are recorded as EBCDIC characters. The maximum record length is 5472 characters. Each tape contains but one file of data for no more than one NTMS Quadrangle.

For each NTMS Quadrangle, the first record(s) on the tape contain summary information for all the geologic map units within the quadrangle. This summary information is followed by averaged record data for each survey flight line.

The tape is organized such that the summary geologic information and each flight line of data are preceded by a header record and followed by a trailer record. If a flight line is not complete on a given physical tape, no trailer record follows its last data record on the first tape, nor does a header record precede its first data record on the second tape.

Header Record

The header record is 144 characters long with four defined fields for the summary geologic information and six defined fields for the averaged record data. The fields in common are:

1. Type of tape. A 32-character field with the text "STATISTICAL ANALYSIS" left justified.

2. Project Identification. A 32-character field with, for example, the text "NTMS NJ 14-16 HUTCHINSON, KANSAS" left justified. All project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.

3. Subcontractor name. A 10-character field with the text "GEOMETRICS".

4. System Identification. A 6-character field with the aircraft registration number right justified.

The additional fields for the averaged record data are:

5. Flight line number. A 6-character field with the flight line number right justified.

6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the

Julian date. When reflights require the insertion of data from multiple days' flying, the date used is that of the original flight.

Undefined fields of the header record are blank filled. A length of 144 characters was chosen to allow for future expansion and because 144 is divisible by the number of characters per word of many popular computers.

Trailer Record

A trailer record follows the last data record for the summary geologic information and the averaged record data for each flight line. This record is always 5472 characters long, all of which are the digit nine.

Summary Geologic Information Record

Each summary geologic Information Record may contain up to 38 geologic map units (logical records), with each logical record 144 characters long. Therefore, the minimum physical length of the summary geologic information record is 144 characters and the maximum physical length is 5472 characters.

The summary geologic information logical record has nineteen defined data fields.

	Field	Fortran Format	Characters
1.	Geologic map unit	A10,2X	1-12
2.	Potassium Distribution Type	A2	13-14
3.	Potassium measure of central tendency	F10.4	15-24
4.	Potassium standard deviation	F10.4	25-34
5.	Uranium distribution type	A2	35-36
6.	Uranium measure of central tendency	F10.4	37-46
7.	Uranium standard deviation	F10.4	47-56
8.	Thorium distribution type	A2	57-58
9.	Thorium measure of central tendency	F10.4	59-68
10.	Thorium standard deviation	F10.4	69-78
11.	Uranium/Thorium distribution type	A2	79-80
12.	Uranium/Thorium measure of central tendency	F10.4	81-90
13.	Uranium/Thorium standard deviation	F10.4	91-100
14.	Uranium/Potassium distribution type	A2	101-102
15.	Uranium/Potassium measure of central tendency	F10.4	103-112
16.	Uranium/Potassium standard deviation	F10.4	113-122
17.	Thorium/Potassium distribution type	A2	123-124
18.	Thorium/Potassium measure of central tendency	F10.4	125-134
19.	Thorium/Potassium standard deviation	F10.4	135-144

The distribution type field is coded NM for normal distributions and LN for log normal distributions. The measure of central tendency (mean/median) and standard deviation are in units appropriate to the distribution.

Data Record

Each record of averaged record data may contain up to 38 data scans (logical records), with each scan 144 characters long. Therefore, the minimum physical length of a data record is 144 characters and the maximum physical length is 5472 characters.

The data scan has twenty defined data fields.

	Field	Fortran Format	Characters
1.	Record identification number	F10.2	1-10
2.	Latitude in degrees	F10.4	11-20
3.	Longitude in degrees	F10.4	21-30
4.	Residual magnetic field in gammas	F15.2	31-45
5.	Surface geologic map unit	5X,A10	46-60
6.	Quality flag code (AKUT)	A4	61-64
7.	Gross count rate (0.4-3.0 MeV), in CPS	F7.1	65-71
8.	Atmospheric Bi-214 count rate, in CPS	F7.1	72-78
9.	Thorium (Tl-208) count rate, in CPS	F7.1	79-85
10.	Uranium (Bi-214) count rate, in CPS	F7.1	86-92
11.	Potassium (K-40) count rate, in CPS	F7.1	93-99
12.	Thorium standard deviations from the mean	F4.1	100-103
13.	Uranium standard deviations from the mean	F4.1	104-107
14.	Potassium standard deviations from the mean	F4.1	108-111
15.			
a.	Uranium/Thorium count rate ratio	F7.3	112-118
b.	Uranium/Thorium standard deviations from the mean	F4.1	119-122
16.			
a.	Uranium/Potassium count rate ratio	F7.3	123-129
b.	Uranium/Potassium standard deviations from the mean	F4.1	130-133
17.			
a.	Thorium/Potassium count rate ratio	F7.3	134-140
b.	Thorium/Potassium standard deviations from the mean	F4.1	141-144

MAGNETIC DATA TAPE

REFERENCE: PARAGRAPHS 4.7.4 and 6.1.5, PMD 1200-B

The MAGNETIC DATA TAPE is unlabeled nine track, 800 BPI, NRZI. All data are recorded as EBCDIC characters. Each tape contains but one file of header, data, and trailer records for no more than one NTMS quadrangle. The maximum record length is 4800 characters.

The tape is organized such that each flight line of data is preceded by a header record and followed by a trailer record. If a flight line is not complete on a given physical tape, no trailer record follows its last data record on the first tape, nor does a header record precede its first data record on the second tape.

Header Record

The header record is 120 characters long with six defined data fields. These fields are:

1. Type of tape. A 32-character field with the text "MAGNETIC DATA" left justified.

2. Project identification. A 32-character field with, for example, the text "NTMS NJ 14-6 HUTCHINSON, KANSAS" left justified. All project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.

3. Subcontractor name. A 10-character field with the text "GEOMETRICS".

4. System identification. A 6-character field with the aircraft registration number right justified.

5. Flight line number. A 6-character field with the flight line number right justified.

6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the Julian date. When reflights require the insertion of data from multiple days' flying, the date used is that of the original flight.

The remaining 28 characters of the header record are blank filled. A length of 120 characters was chosen to allow for future expansion and because 120 is divisible by the number of characters per word of many popular computers.

MAGNETIC DATA TAPE

Data Record

Each data record may contain up to 40 data scans (logical records), with each scan 120 characters long. Therefore, the minimum physical length of a data record is 120 characters and the maximum physical length is 4800 characters.

The data scan has eleven defined data fields.

	Field	Fortran Format	Characters
1.	Record identification number	F10.2	1-10
2.	Latitude in degrees	F10.4	11-20
3.	Longitude in degrees	F10.4	21-30
4.	Time of day (hour, minutes, seconds)	3I2	31-36
5.	Terrain clearance in feet	F9.0	37-45
6.	Barometric pressure in inches of mercury	F5.2	46-50
7.	Surface geologic map unit	A10	51-60
8.	Total magnetic field in gammas	F10.2	61-70
9.	Residual magnetic field in gammas	F10.2	71-80
10.	Optional data	30X	81-110
11.	Base station magnetic field in gammas	F10.2	111-120

Trailer Record

A trailer record follows the last data record for each flight line. This record is always 4800 characters long, all of which are the digit nine.

APPENDIX I

Daily Production Summary

DAILY PRODUCTION SUMMARY

DATE	REMARKS
11-28-76	Ferry from Jamestown
11-29-76	217 line miles (project initiation)
11-30-76	Weather day
12-1-76	655 line miles
12-2-76	Weather day
12-3-76	657 line miles
12-4-76	652 line miles
12-5-76	Aircraft U/S
12-9-76	732 line miles
12-10-76	815 line miles
12-11-76	Aircraft U/S
12-12-76	Aircraft U/S
12-13-76	718 line miles
12-14-76	720 line miles
12-15-76	883 line miles
12-16-76	675 line miles
12-17-76	674 line miles
12-18-76	680 line miles
12-19-76	Weather
12-23-76	Crew stand down - holidays
1-2-77 - 2-13-77	Kansas/Nebraska weather prohibited project completion

DAILY PRODUCTION SUMMARY (continued)

DATE	REMARKS
2-14-77	Ferry to Salina, Kansas
2-15-77	432 line miles
2-16-77	432 line miles
2-17-77	Electronics man sick
2-18-77	Electronics man sick
2-19-77	654 line miles
2-20-77	Aircraft U/S
2-21-77	648 line miles
2-22-77 - 2-23-77	Weather
2-24-77 - 2-28-77	Pilot absent buying spares
3-1-77	Aircraft Maintenance
3-5-77	720 line miles
3-6-77	681 line miles
3-7-77	398 line miles (project completed)
3-8-77	Ferry Salina-Tulsa