GJBX-17 '79

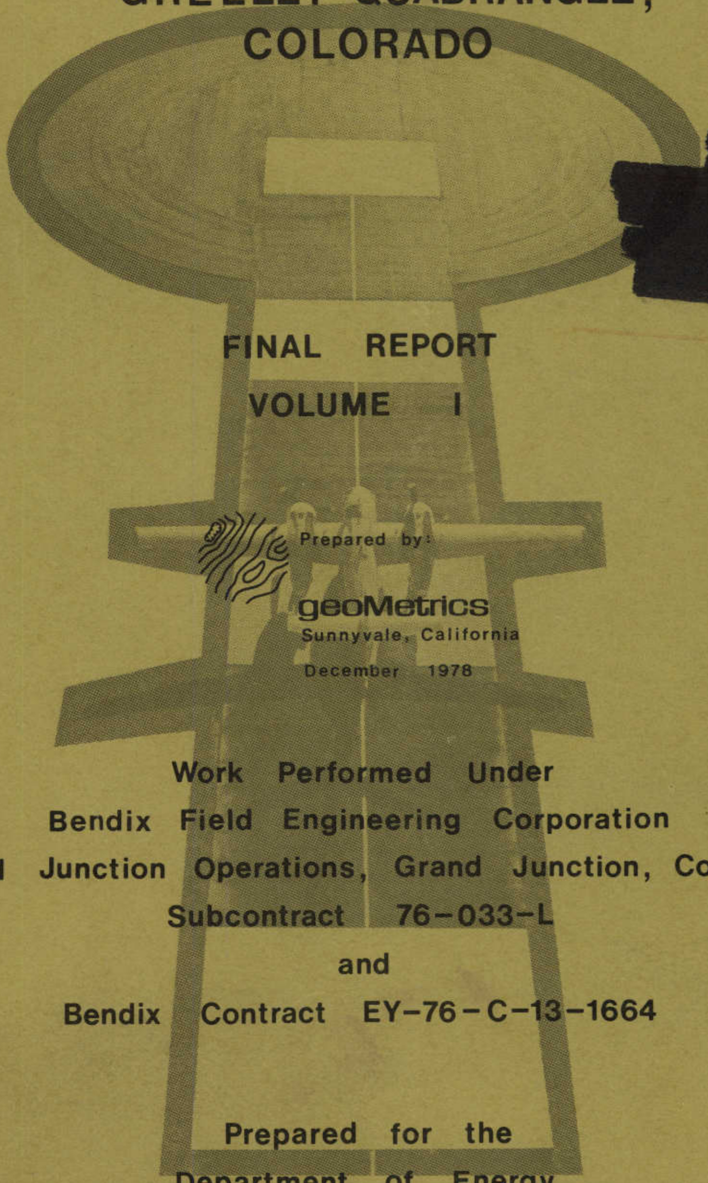
AERIAL GAMMA RAY AND MAGNETIC SURVEY

ROCK SPRINGS, RAWLINS, AND CHEYENNE QUADRANGLES, WYOMING

AND THE

GREELEY QUADRANGLE, COLORADO

aeromagnetic



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FINAL REPORT

VOLUME I

Prepared by:

geoMetrics
Sunnyvale, California

December 1978

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

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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 Rock Springs, Rawlins, and Cheyenne 1:250,000 Quadrangles in Wyoming, and the Greeley, 1:250,000 Quadrangle within the State of Colorado. A total of 14,104 lines miles of high sensitivity radiometric and magnetic data were collected within these quadrangles. Traverse lines were flown in an east/west direction at a spacing of 3.125 miles (5 kilometers) except in the Rotary wing portions of Greeley. In this quadrangle the rotary wing line spacing was 1 mile (1.6 kilometers). All data were collected utilizing a Grumman G-89, S2F Tracker, fixed wing aircraft equipped with 4,096 cubic inches of NaI crystal detector and a Aerospatiale, SA 315B Lama, helicopter carrying 2,304 cubic inches of crystal. Magnetometer data were collected utilizing a geoMetrics high sensitivity proton precession magnetometer. Data were recorded digitally at 1.0 second intervals aboard the aircraft. Navigation was performed using integrated visual and doppler techniques in the tracker and visual methods in the helicopter.

All field data were returned to the geoMetrics, Sunnyvale, California computer facilities for processing, statistical analysis, and interpretation. Data presented in this report are: corrected profiles of all radiometric variables, magnetic data, radar and barometric altimeter data, air temperatures, and airborne bismuth contributions. Radiometric data presented are corrected for Compton Scatter, altitude dependence, and atmospheric bismuth. These data are also presented on microfiche and digital magnetic tapes. Additionally, this report contains anomaly maps and interpretation maps relating mapped geology to the corrected radiometric and magnetic data.

The survey covered two, very different, geologic environments: (1) the intermontane Tertiary Basins of Wyoming - e.g. Green River, Wasatch, Laramie - and the western most basin of the Great Plains - Denver Basin and (2) fault bounded, major uplifts (Laramide age) - e.g. Medicine Bow, Laramie - with exposed Precambrian

Radiometric count rates in the Basins were generally lower than over the Precambrian crystalline rocks. Notable exceptions are the Red Desert and Poison Basins and Miller Hill area within the Rawlins quadrangle. Interpretation of the statistical results succeeded in delineating several anomalous uranium trends in: (1) known uranium districts such as Miller Hill and extensions thereof and (2) new areas near Chalk Bluff in the Cheyenne and Greeley quadrangles.

Magnetic pseudo-contour maps clearly outline the major structural features as well as provide more information about magnetic basement features that could generate new insight into the geologic structure of the area.

Principal component analysis for each formation was attempted in each quadrangle. Results were mixed. Several overall patterns were discernible, but individual instances were apparently contradictory. However, the approach holds much potential for further understanding of gamma-ray spectrometry.

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INTRODUCTION AND SUMMARY

INTRODUCTION

Under the U.S. Department of Energy's (DoE), National Uranium Resource Evaluation (NURE) Program, geoMetrics, Inc. conducted a high sensitivity airborne radiometric and magnetic survey of the Rock Springs, Rawlins, and Cheyenne, 1:250,000 Quadrangles, Wyoming and the Greeley, 1:250,000, Quadrangle, within the state of Colorado (see Figure 1). 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 distribution 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 cost-effective, semiquantitative reconnaissance radioelement distribution information to aid in the assessment of regional distribution of uraniferous materials within the United States.

All Airborne data collected during the course of this project were done so utilizing a Grumman G-89, S2F Tracker (U.S. Registry No. N9AG) fixed wing aircraft equipped with 4,096 cubic inches of NaI crystal detector and an Aerospatiale SA315B "Lama" helicopter (U.S.Registry No. N 47319) using 2304 cubic inches of NaI crystal. Both aircraft utilized high sensitivity proton magnetometers (0.25 gamma). 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

The four quadrangles covered in this report lie within three major physiographic provinces. These are, from west to east: the Wyoming Basin Province of Southern Wyoming; the southern tip of the Southern Rocky Mountains Province; and the western edge of the Great Plains Province. (Rocky Mountain Atlas of Geology, 1972).

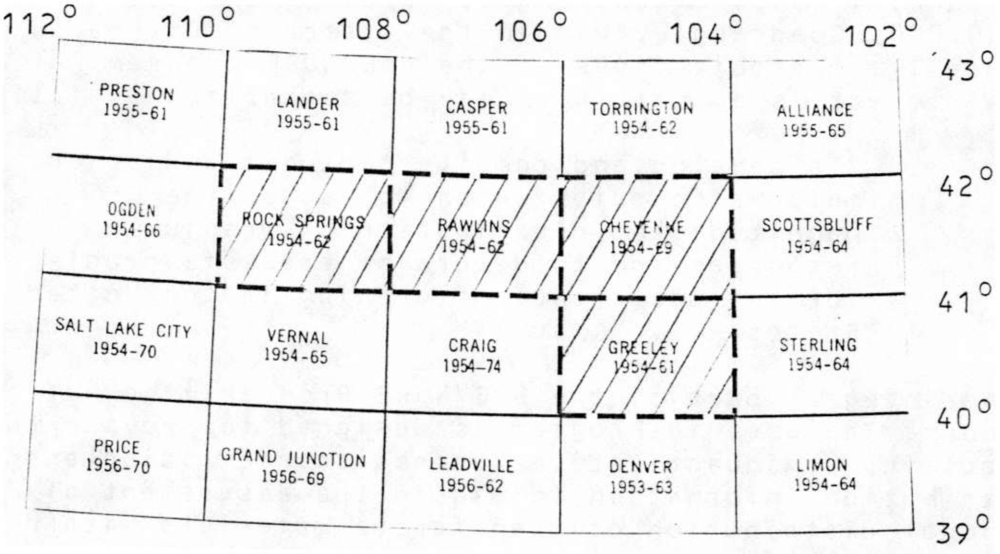


FIGURE 1. SURVEY AREA

Topography varies from the gently rolling high plains, 7000 ASL, of the Wyoming Basin Province to the rugged 12,000 ASL Front Range, Medicine Bow and Laramie Mountains to the 6,000 ASL Great Plains in the east.

Major geologic structures within the survey include: the deep Tertiary Basins of Wyoming (30,000 feet for the Washakie Basin) which occupy most of the Rock Springs and Rawlins Quadrangles; the major structural uplifts Front Range, Sierra Madre, Rock Springs, Medicine Bow and Laramie with their exposed Precambrian crystalline cores; and the asymmetric Denver Basin occupying the eastern half of the Cheyenne and Greeley Quadrangles. (See Figure 2). Major faults are dominantly high angle thrust faults forming the borders of the major uplifts - except for Rock Springs.

Economic deposits of oil and gas are present in the Cretaceous rocks of the Wyoming Basins and in the Denver Basin. Most of the oil shale reserves of the U.S.A. lie within the Green River Formation of the Green River Basin in Western Wyoming. Within the Colorado "Mineral Belt" of the Front Range are numerous gold, silver and lead deposits.

Uranium occurrences are present within the uraniferous coals of the Red Desert Basin; the Tertiary Brown's Park Formation in the Poison Basin and Miller Hill area of the Rawlins Quadrangle; scattered uraniferous Precambrian quartz conglomerates in the Sierra Madre and Medicine Bow Uplifts; an unmarked deposit near Sheep Mountain on the east edge of the Medicine Bow Mountains and the Jamestown District in the southern portion of the Greeley map (see Figure 3).

Geologic base maps for Rock Springs, Rawlins and Cheyenne Quadrangles were provided by Bendix Field Engineering Corporation. Formational descriptions were derived from several publications but primarily from the Geologic Atlas of the Rocky Mountains, 1972. The Greeley Quadrangle base map is from the U.S.G.S. Open File Report 78-532.

The total number of square miles covered by the four quadrangles is approximately 30,000 (76,000 square kilometers). To obtain regional reconnaissance coverage of this area, a total of 14,104 line miles (22,690 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. The exception is the Greeley Quadrangle, where the helicopter line spacing was 1 mile (1.6 kilometers)(See Figure 4).

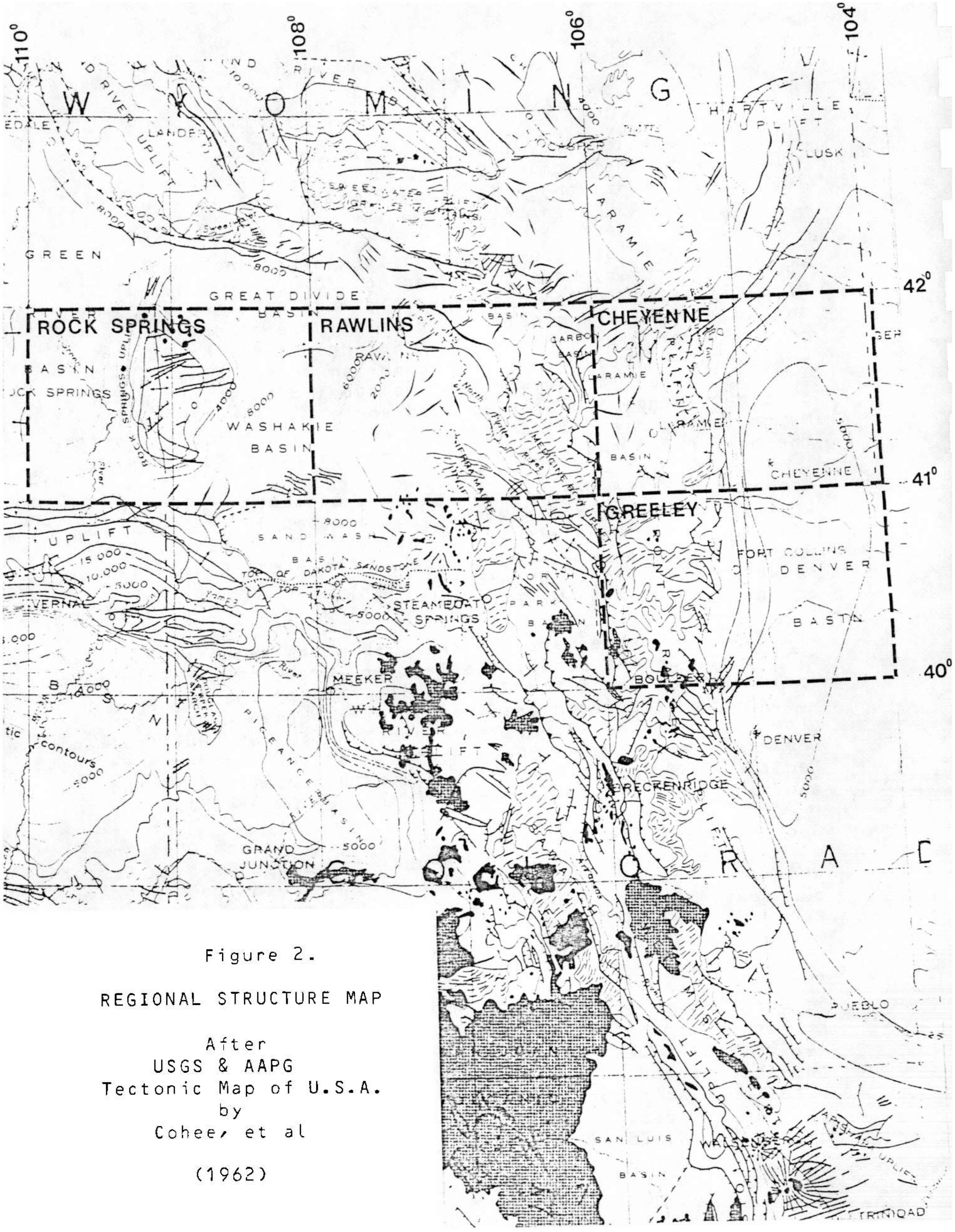


Figure 2.

REGIONAL STRUCTURE MAP

After
USGS & AAPG
Tectonic Map of U.S.A.
by
Cohee, et al

(1962)

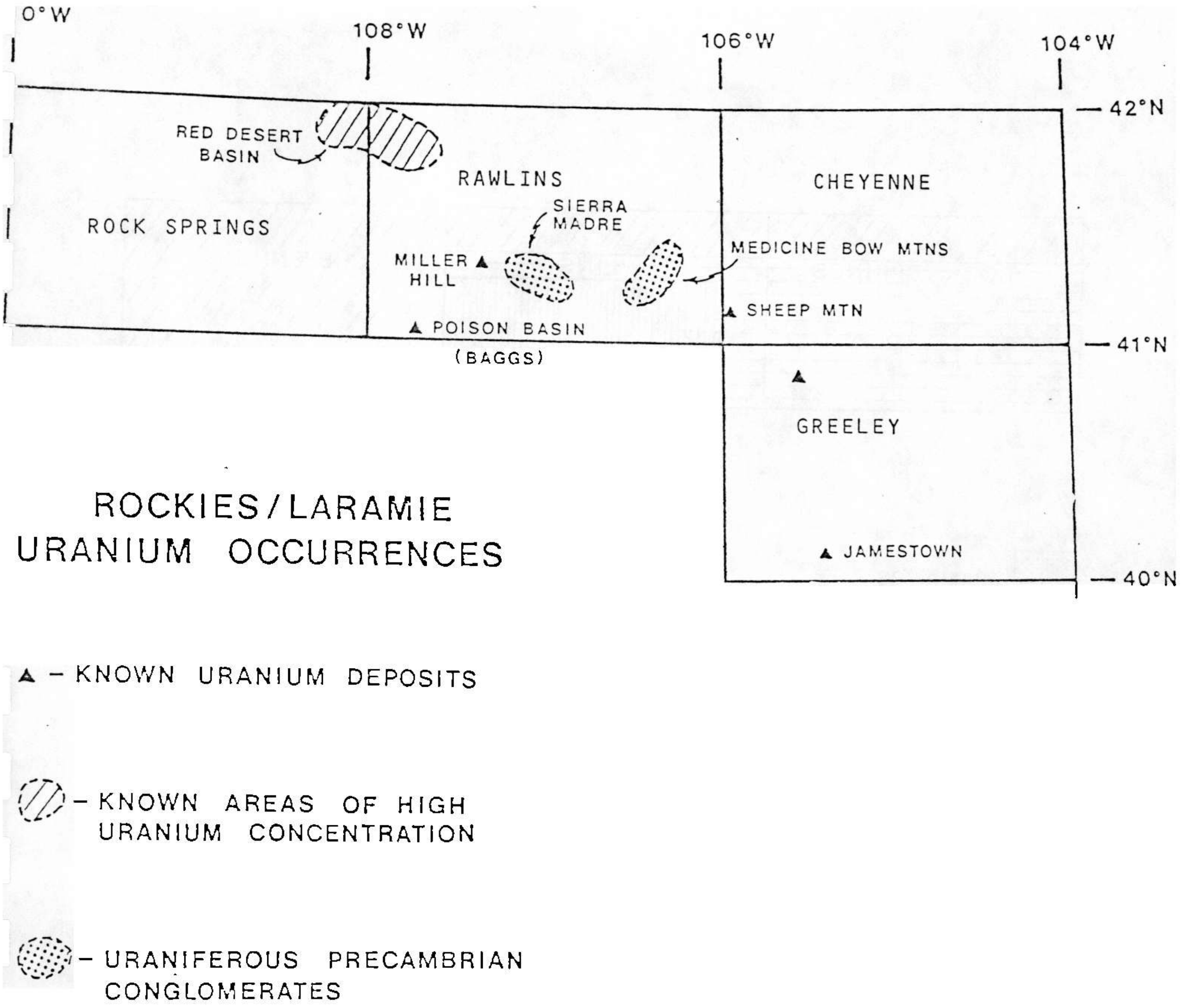


FIGURE 3

MAP OF KNOWN URANIUM OCCURRENCES

ROCKIES/LARAMIE RANGE PROJECT

1977 - 1978

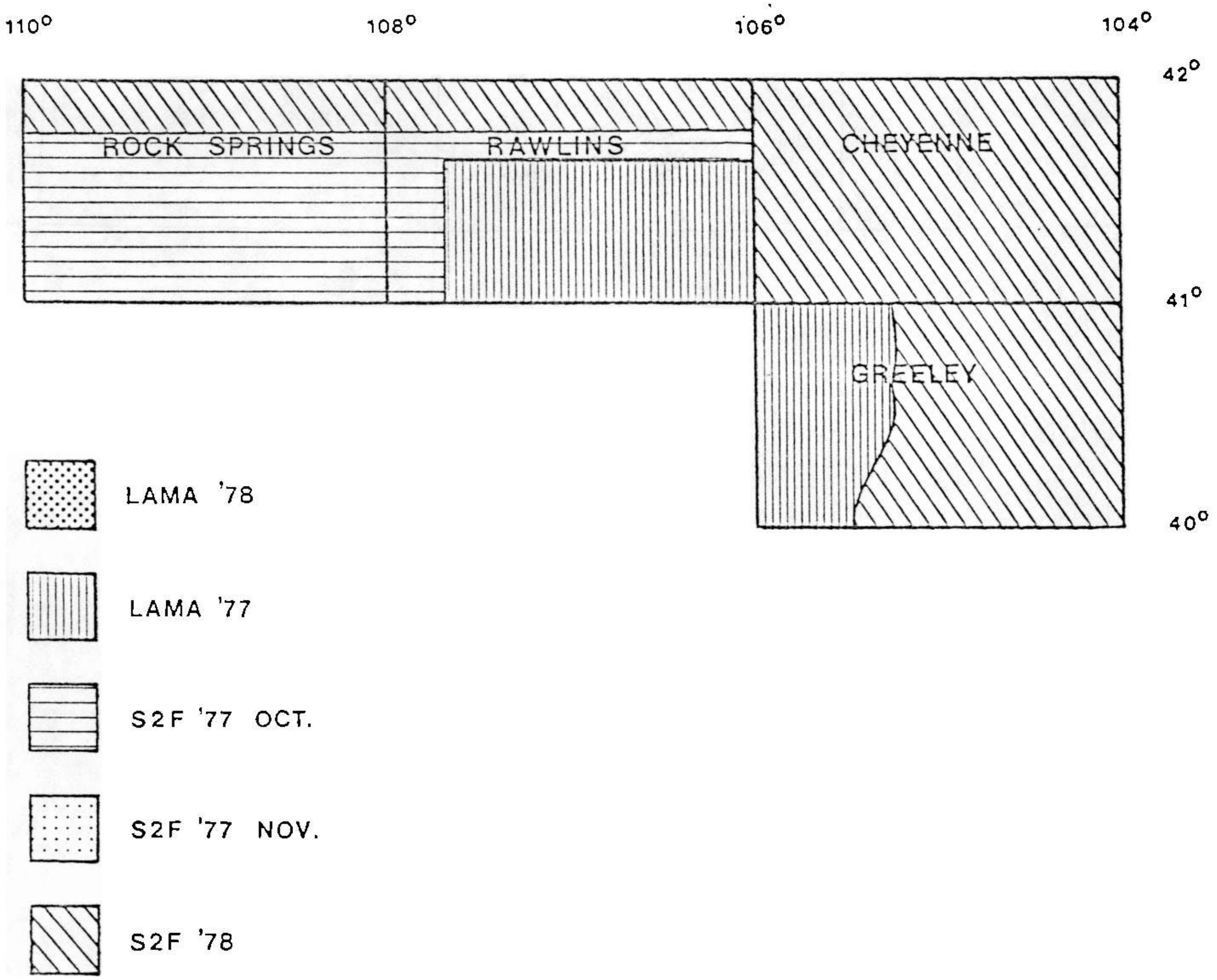


FIGURE 4

DIAGRAM OF FIXED AND ROTARY WINGED SURVEY AREAS

All data processing, statistical analysis, and interpretation were performed at the geoMetrics, Sunnyvale, California, computer facility. After processing, the data were correlated on a one-to-one basis with the geologic base maps. These data were then statistically evaluted to define those areas which were radiometrically anomalous relative to other areas within each similar geologic formation and displayed as anomaly maps. Anomaly maps and radiometric and magnetic profile data were first evaluated individually and then integrated into a final interpretation map for each NTMS quadrangle.

Other data integral to this final report 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 in Volume II of this report. Single record and averaged data are presented on microfiche at 1.0 second sample intervals, corrected for Compton Scatter, referenced to 400 foot mean terrain clearance, at Standard Temperature and Pressure (STP) and corrected for atmospheric bismuth (see Appendix I). Digital magnetic tapes are available containing raw spectral data, single record data, magnetic data, and statistical analysis results.

DATA COLLECTION SYSTEMS

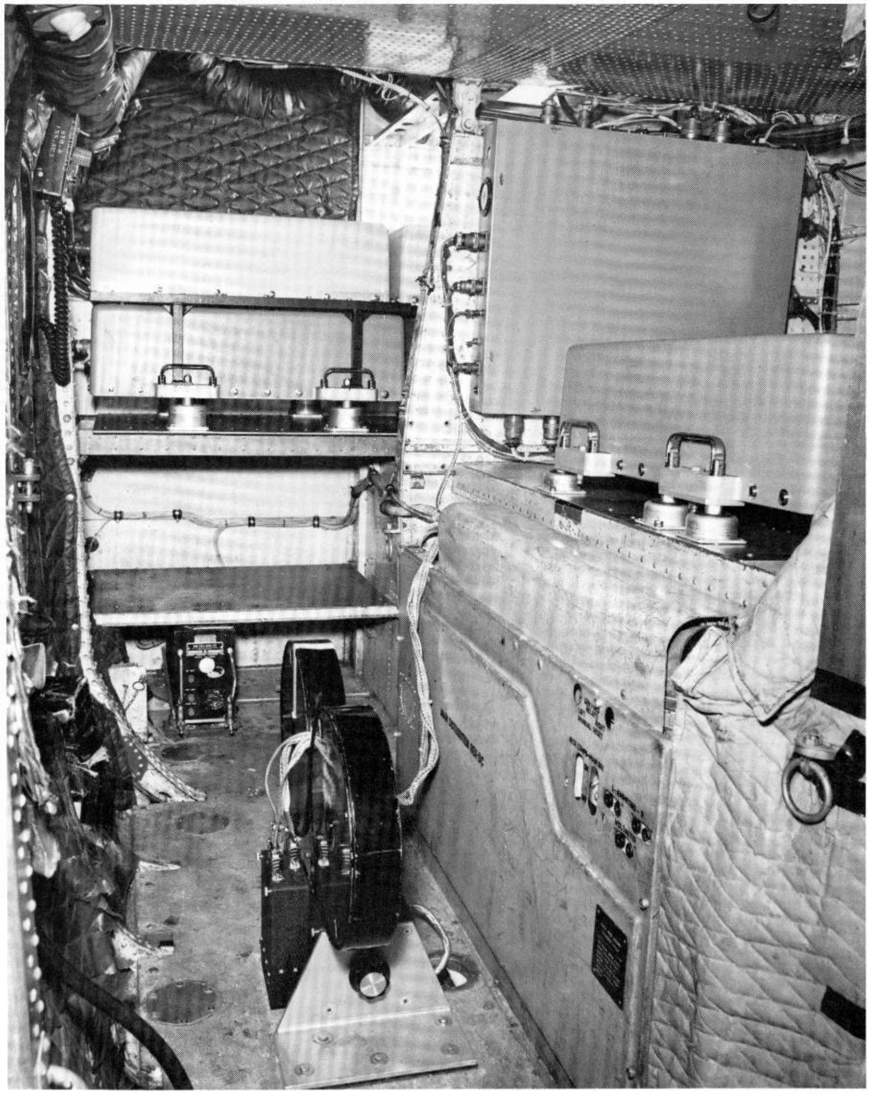
FIXED WINGED AIRCRAFT

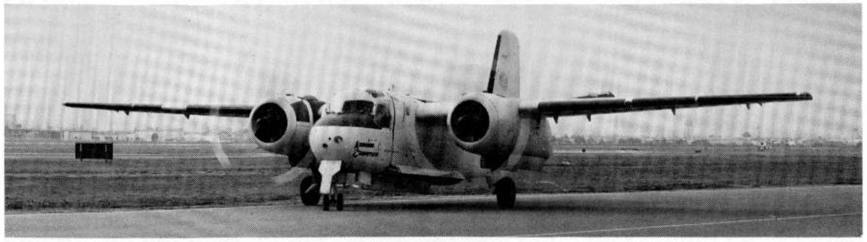
The fixed wing aircraft was a Grumman G-89, S2F Tracker, Serial Number 3, U.S. Registration N9AG (See Figure 5). This Aircraft was originally designed and built by Grumman Aircraft Corporation for the U.S. Navy as a highly stable platform for carrying electronic instrumentation in the search of submarines 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. Overall, the aircraft's performance and safety features make it ideal for low level, fixed-wing airborne geophysical survey work. There is virtually no other fixed-wing aircraft which can carry the adequate payload at the necessary constant low airspeeds and tight terrain clearances and still maintain a wide envelope of safety. Performance data for the S2F in its present geophysical survey configuration are given below:

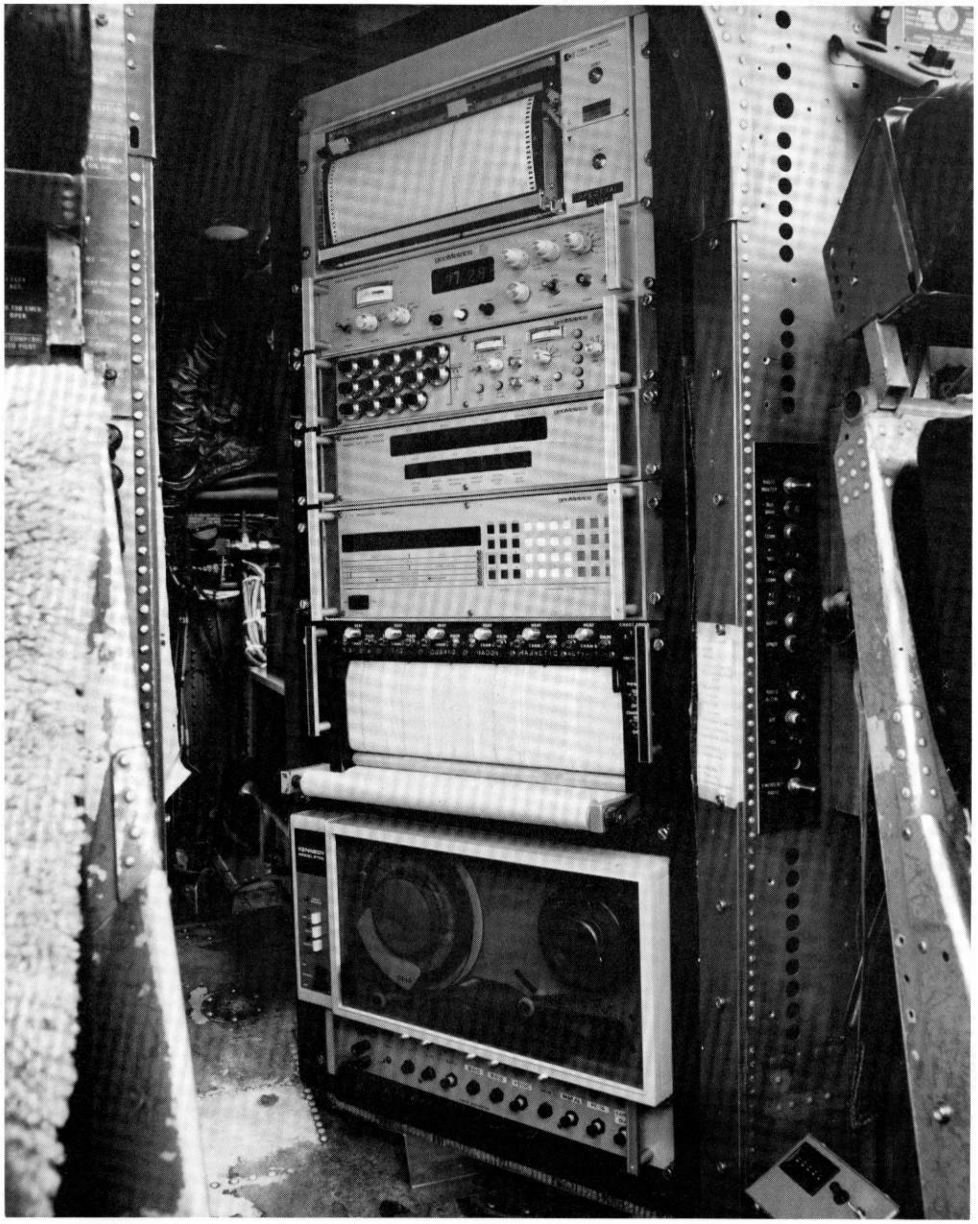
Aircraft Empty	15, 123 lbs
Electronic Equipment	1, 600 lbs
Main Fuel Usable	3, 108 lbs
Auxiliary Fuel Usable	900 lbs
Pilot	175 lbs
Electronic Operator	175 lbs
Maximum Gross Weight for Geophysical Survey Operation	21, 081 lbs
Maximum Allowable Aircraft Gross Weight	24, 500 lbs

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)	2, 000 FPM at	5, 000 ft
120 KIAS at 23, 000 lbs	1, 200 FPM at	10, 000 ft

(KIAS = Knots Indicated Air Speed)







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 5

Cruise Configuration Stalling Speed at Gross Weight 21, 000 lbs
0° Bank - 80 KIAS 45° 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.

Electronics

The major components of the airborne data collection system are summarized below (shown pictorially in Figure 5 and schematically in Figure 6):

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 3584 cubic inches in the downward looking configuration and 512 cubic inches appropriately shielded in an upward looking configuration.

3. A geoMetrics Digiatl 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

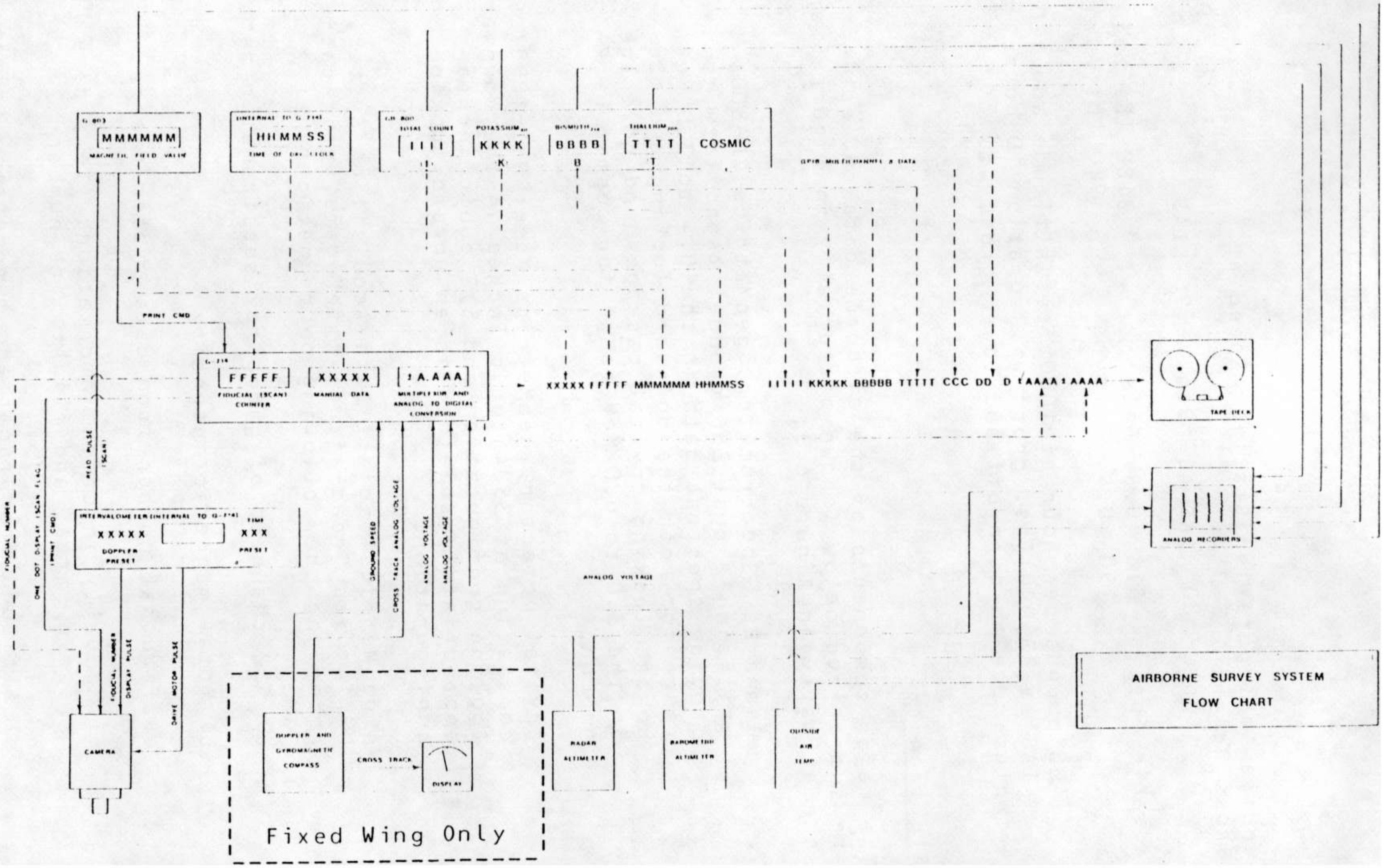
   d) Manually inserted information, i.e., date survey area, and flight line number

   e) Altitude from radar and barometric altimeters (by analog-to-digital conversion).

   f) Time in days, hours, minutes and seconds

   g) Outside air temperature

FIGURE 6



AIRBORNE SURVEY SYSTEM
FLOW CHART

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 upward looking system.

    c) Magnetometer

    d) Total Count for downward looking system (0.4 to 3.0 MeV)

    e) 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 system 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 availble at all times (Refer to Figure 7). This approach provides instant verification of system parameters.

FIGURE 7

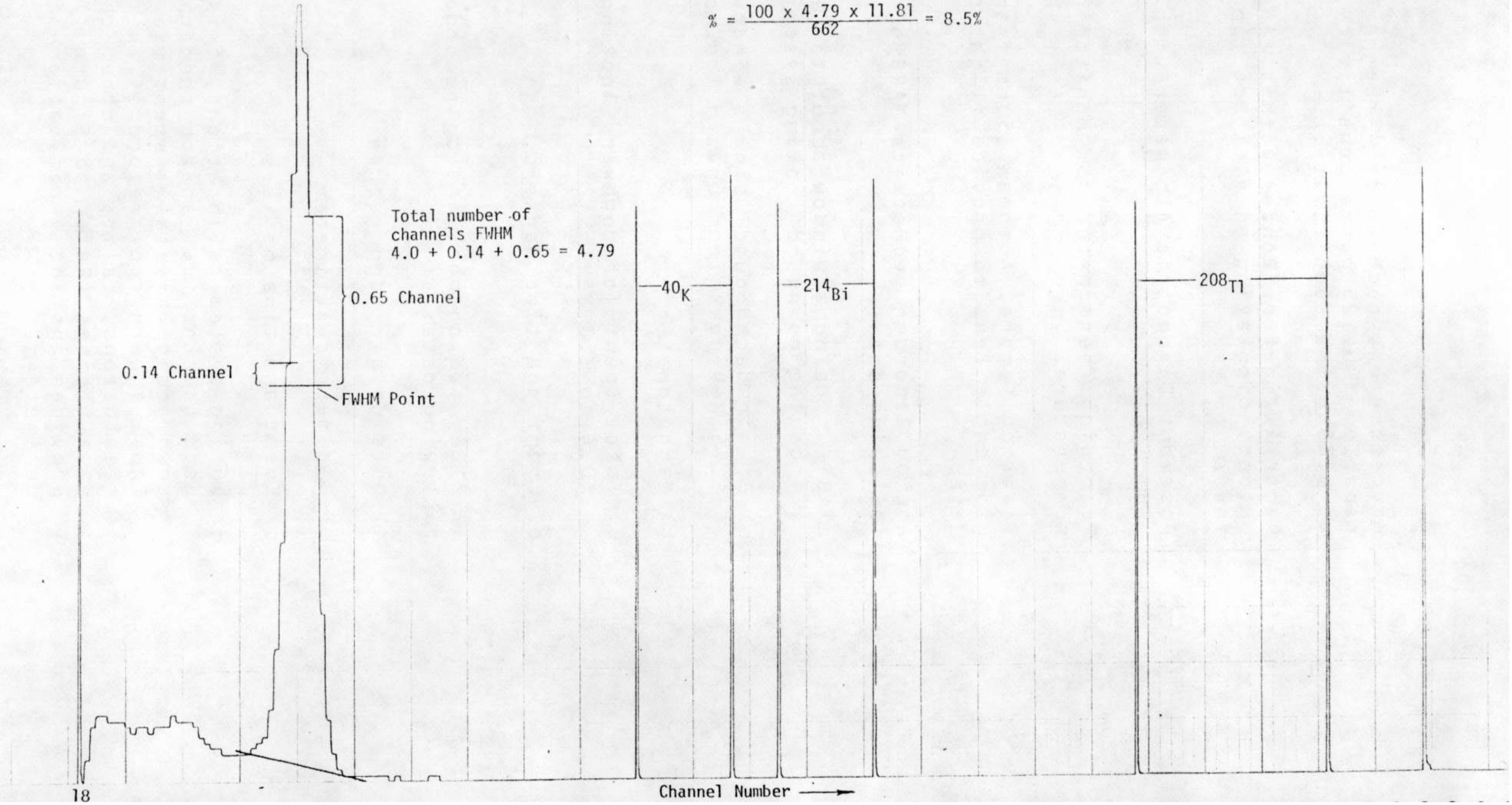
GR-800D ANALOG SPECTRUM PLOT
DET-1024 Crystal Detector (1,024 in^3)
^{137}Cs Source 11.81 Kev/Ch

20K c.p.s. Full Scale

<u>Resolution Calculation</u>

$$\% = \frac{100 \times \text{FWHM} \times \text{Kev/Ch}}{662 \text{ Kev}}$$

$$\% = \frac{100 \times 4.79 \times 11.81}{662} = 8.5\%$$



ROTARY WINGED AIRCRAFT

The helicopter used for the survey is an Aerospatiale SA315B LAMA, Registry No. N47319. The SA315B LAMA was designed and built by Societe Nationale Industrielle Aerospatial of France to meet the requirements of the Indian Armed Forces for a medium-sized helicopter capable of working in the Himalayas. In that the craft was initially designed to haul heavy pay loads in rugged mountainous terrain, its overall performance and safety features make it ideal for low level, rotary-wing airborne geophysical survey work. There is virtually no other medium-sized rotary-wing aircraft which can carry the adequate payload at the necessary constant low airspeeds and tight terrain clearances and still maintain a wide envelope of safety, all while operating economically. Performance data for the SA315B LAMA (both general and in its present geophysical survey configuration) are given below:

Type: Turbine-driven general purpose helicopter.

Rotor System: Three-blade main and antitorque rotors. All-metal main rotor blades, of constant chord, are on articulated hinges, with hydraulic drag-hinge dampers.

Rotor Drive: Main rotor driven through planetary gearbox, with free-wheel for autorotation. Take-off drive for tail rotor at lower end of main gearbox, from where a torque shaft runs to a small gearbox which supports the tail rotor and houses the pitch-change mechanism. Cyclic and collective pitch controls are powered.

Fuselage: Glazed cabin has light metal frame. Center and rear of fuselage have a triangulated steel-tube framework.

Landing Gear: Skid type, with removable wheels for ground maneuvering. Pneumatic floats for normal operation from water, and emergency flotation gear, inflatable in the air, are available.

Power Plant: One 870 shp Turbomeca Artouste IIIB turboshaft engine, derated to 550 shp. Fuel tank in fuselage center-section, with capacity of 151.3 U.S. gallons (useable) (573 litres).

Accommodation: Glazed cabin seats pilot and passenger side by side in front and three passengers behind. Provision for external sling for loads of up to 2,204 lbs. (1,000 kg). Can be equipped for rescue (hoist capacity 265 lb.; 120 kg), liaison, observaion, training, agricultural, photographic, ambulance and other duties. As an ambulance, can accommodate two stretchers and a medical attendant internally.

Dimensions, External:	Main rotor diameter	36 ft.,1-3/4 in.
	Tail rotor diameter	6 ft.,3-1/4 in.
	Main rotor blade chord (constant)	13.8 in.
	Length overall, both rotors turning	42 ft.,4-3/4 in.
	Length of fuselage	33 ft., 8 in.
	Height overall	10 ft.,1-3/4 in.
	Skid track	7 ft.,9-3/4 in.

Performance (Sea Level Standard Conditions)

		Internal		External	
		Average	Maximum	Average	Maximum
At Gross Weight	lb	3,310	4,300	4,200	5,070
Empty Weight	lb	2,216	2,216	2,216	2,216
Useful Load	lb	1,094	2,084	1,984	2,854
Sling Load (max)	lb				2,500
Cruise Speed	mph	118	118	55-75	55-75
Top Speed, Vne	mph	130	130	-	-
Useable Fuel US	gal	146	146	46	46
Service Ceiling	ft	(23,000)*	17,710	18,370	10,800
HIGE Ceiling	ft	(23,000)*	16,730	17,600	9,220
HOGE Ceiling	ft	(23,000)*	15,170	16,100	5,000
Rate of Climb SL	fpm	1,580	1,080	1,120	730
Max. Range, SL	mi	308	308	31**	31**

( ) Maximum certified altitude -23,000 ft.

** Mission radius -includes: 10 minutes fuel reserve
3 minutes SL Hover
Return with no load

Present Geophysical Configuration

Lama Weight Empty	2,193 lbs.
Maximum Fuel	900 lbs.
Geophysical Electronics	850 lbs.
Pilot	165 lbs.
Navigator	175 lbs.
TOTAL	4,458 lbs.

Electronics

The major components of the airborne data collection system are summarized below (shown pictorially in Figure 8 and schemtically in Figure 6):

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-100/CS consisting of 2048 cubic inches in the downward looking configuration and 256 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 follwing on magnetic tape:

   a) 512 channels of gamma ray spectrometer data

   b) Total magnetic intensity

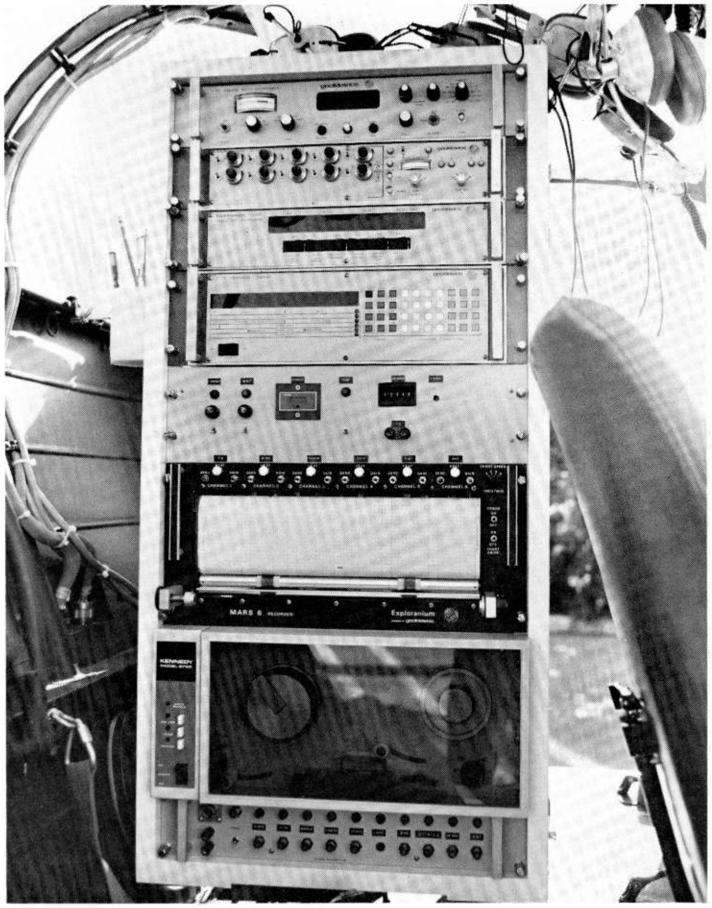
   c) Fiducial number from data system/camera

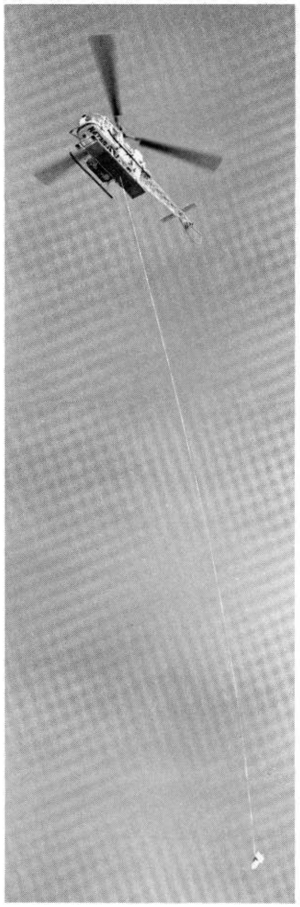
   d) Manually inserted information, i.e., date, survey area, and flight line number

   e) Altitude from radar altimeter and a barometric altimeter (by analog-to-digital conversion)

   f) Time in days, hours, minutes and seconds

   g) Outside air temperature





HELICOPTER GEOPHYSICAL SURVEY SYSTEM
(Aerospatiale SA315B Lama)

Ideally suited to contour flying, this exploration platform is employed on a Midwest E.R.D.A. survey along the front range of the Rocky Mountains in central Colorado. [Far left]: A single shock-mounted instrument rack includes GeoMetrics Model G-803 Proton Magnetometer (top of rack), Model GR-900-2 Detector Interface console, Model GR-800D Multichannel Gamma Ray Spectrometer and G-714 Digital Data Acquisition System. A specially designed Intervalometer console is located above the Exploranium MARS-6 six-channel Analog Recorder and the Kennedy Model 9700 Magnetic Tape Deck. A fused Power Distribution Panel is shown at the bottom of the rack. Operator's seat is folded up to the left of the instrument rack. [Left]: Magnetometer "bird" sensor is towed from a 100 ft. nylon sleeved signal cable. [Bottom left]: The Lama was outfitted at GeoMetrics manufacturing facilities in Sunnyvale, California. [Below]: A center platform, held secure by the cargo hook, contains both a Model DET-1024 and DET-1024/256R exSquare™ detector for a total volume of 2,048 cu. in. downward-looking and 256 cu. in. upward-looking. A Bonzer altimeter and Automax flight-path recovery camera are also included on the center platform. The entire instrumentation system, including detectors and hardware weighs approximately 700 lbs. (318 kg) installed.

FIGURE 8

4. Magnetometer, geoMetrics Airborne Model G-803, capable of 0.125 gamma sensitivity, but operated at 0.25 gamma sensitivity.

5. Radar Altimeter Sperry Model AA200 with recording output and display and minimum 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

   d) Radar Altitude

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

   f) Outside air temperature

   g) Event and time markers

10. HP 7155 single channel analog recorder during pre and post flight calibrations, this recorder is used to plot a 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 resolution, drift, etc., checks are available at all times. This approach provides instant verification of system parameters (refer to Figure 7).

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. All sensor data with analog output were digitally sampled at each scan based upon the clock timing rate of 1.0 seconds. The data so collected are the instantaneous values of the altimeter, temperature, pressure, and magnetometer parameters determined at the time of the data scan, but represent a count time of 1.0 seconds for the gamma ray spectrometer data.

2. The Tracker objective ground speed was 135 mph, and the helicopter objective ground speed was 70 mph. These were not exceeded unless dictated by safety.

3. The downward looking crystal volume was 3,584 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 27.5 (130 mph), and 25.6 (140 mph) for the S2F. Helicopter downward crystal volume was 2078 cubic inches providing an average V/v of 29.3 at 70 mph.

4. The volume of the upward looking crystal was 512 cubic inches for the S2F and 256 for the Lama.

Navigation/Flight Path Recovery

Navigation was accomplished using a combination of visual and doppler navigation techniques in the fixed wing and visual in the rotary wing aircraft. Flight lines were drawn on 1:250,000 scale NTMS quadrangle sheets for the S2F and on 1:24,000 quadrangles for the Lama. The pilot/navigator utilized these maps to provide visual navigation features. Flight lines were generally started and ended visually for both the Lama and the S2F. While doppler was used to fly a straight line between end points in the S2F, visual methods were continued for the Lama.

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 appropriate scale map sheets. At the boundaries of the fixed wing/rotary wing areas, flight lines were flown by both the S2F and the Lama with overlaps of 1 mile over the best available terrain.

Infield System Calibration

Due to the complex nature of both the systems and the required data interpretation, much emphasis was placed on infield calibration of each 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 in the following summary check list:

A. Pre Flight

1. Use cesium sources (same positioning on crystals every day), peak each Photomultiplier tube/crystal using the digital splitwindow 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 7). Run spectrum out past the K40 peak on down crystals for centering evaluation of K40 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 K40 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. Upon completion of production data collection, refly 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 K40 peak in the down crystals).

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

4. Determine shift, if any, in K40 peak position.

PRODUCTION SUMMARY-ROCKIES/LARAMIE PROJECT

This report covers 4 of 6 NTMS Quadrangles comprising the "Rockies/Larmie" Project. Included in this report are the Rock Springs, Rawlins, and Cheyenne, Wyoming, and Greeley, Colorado NTMS Quadrangles. Under separate cover, the balance of the "Rockies/Larmie" Project, is contained the Denver and Pueblo, Colorado NTMS quadrangles.

The four quadrangles reported herein consisted of a total of 14,104 line miles. Of this milage, 8643 line miles were flown with a fixed wing configured system. The production summary presented below and in Appendix H describes the total project, since in some cases, data collection overlapped in the Greeley, Denver and Pueblo quadrangles.

Rotary wing data collection within this project was initiated on August 9, 1977 at Saratoga, Wyoming. Data collection with the rotary wing ceased on November 18,1977 after encountering severe weather problems. All but 624 rotary wing line miles of the total project were completed. The balance of the data were collected during the 1978 flying season starting on July 31,1978 with completion on August

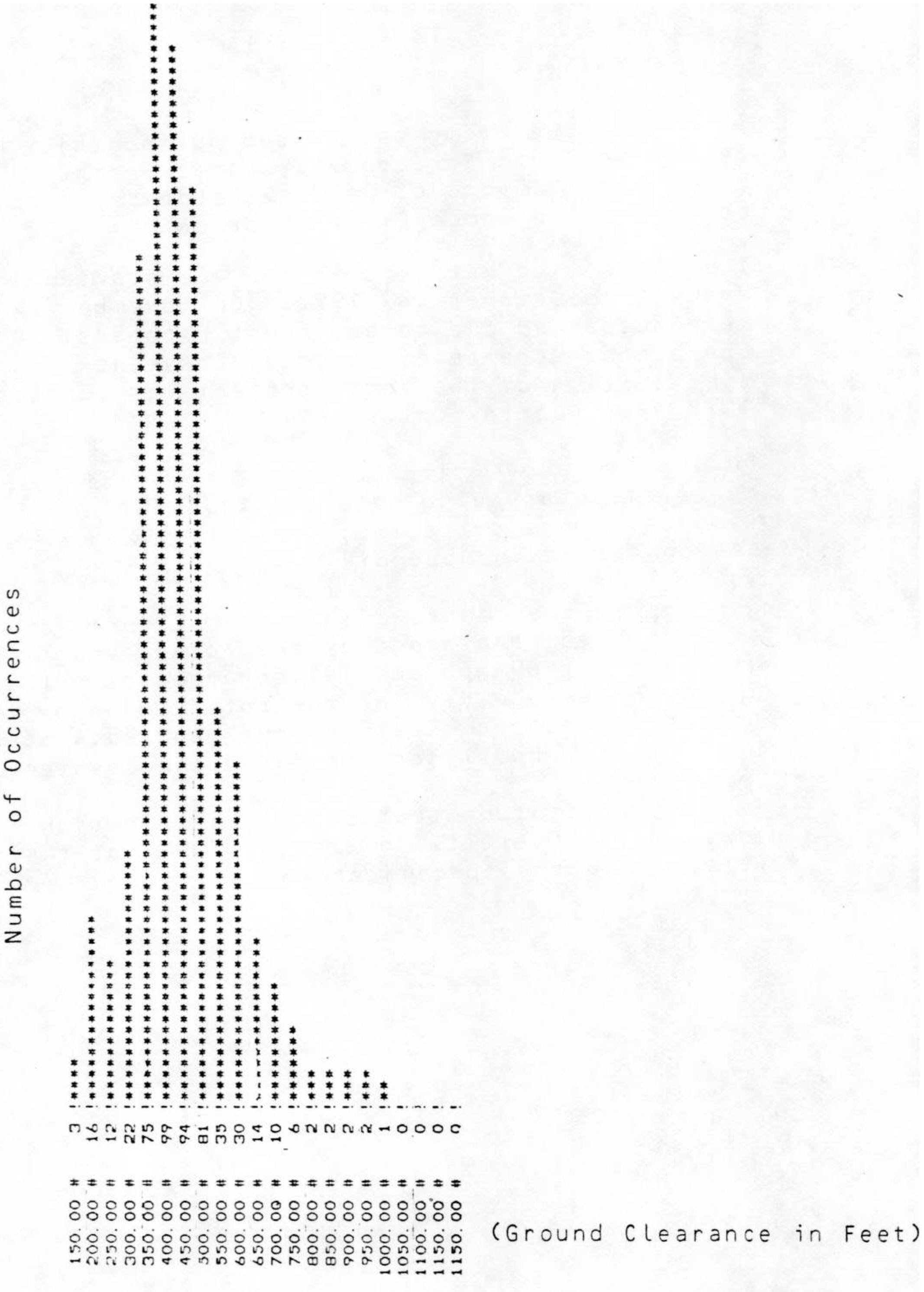
5, 1978. Operating bases used during this period include: Saratoga, Wyoming; Fort Collins, Colorado; Estes Park, Colorado; Golden, Colorado; Woodland Park, Colorado; and Canon City, Colorado.

The fixed wing data collection was started in Rock Springs, Wyoming on October 28, 1977. On November 7, 1977, operations were suspended due to equipment problems. On July 17, 1978 operations were reinitiated at Cheyenne, Wyoming. The fixed wing portion of the total project was completed on August 31, 1978 from Pueblo, Colorado.

During the above time period, a total of 13,855 line miles of rotary wing data and 11,495 line miles of fixed wing data were collected. Details of this daily production are contained in Appendix H.

Throughout the course of the overall project, the average ground speed maintained by the rotary wing and fixed wing aircraft was 69 mph and 141 mph respectively. This produced an average V/v for the rotary wing system of 29.7 (cubic inches per mile per hour) and 25.4 (cubic inches per mile per hour) for the fixed wing system.

(A sample altitude statistical distribution is shown in Figure 9). Overall, in excess of 97% of the data collected were within the specification limits.



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THE MINIMUM RADAR ALTMTR IS      147.500 FEET
THE MAXIMUM RADAR ALTMTR IS      975.000 FEET

THE AVERAGE RADAR ALTMTR IS      424.336 FEET
THE  STANDARD DEVIATION  IS     123.4900 FEET
```

Figure 9. Typical Radar Altimeter Statistical Summary Histogram for Single Flight Line.

SYSTEM CALIBRATION

AIRCRAFT AND COSMIC BACKGROUND

Full spectral data are collected at five (5) altitudes over water (Tracker: 15,000 feet; Lama: 14,000 feet; 12,000 feet; 10,000 feet; 8,000 feet and 6,000 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 10. We define S(12,000) to be the spectra at 12,000 feet from 0.4 MeV to 3.0 MeV with S(8,000) the same spectra at a lower altitude (8,000) and ΣC (h) the total count between 3.0 and 6.0 MeV at respective altitudes. Since the aircraft background is constant, the difference between any two altitudes separated sufficiently - typically, 2,000 feet-yields the cosmic spectral curve shape as shown schematically in Figure 10. Thus

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

and

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

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 five altitudes, this procedure was repeated for each combination of altitudes and results averaged. Typical aircraft and cosmic spectra are shown in Figure 11 and 12 respectively.

SYSTEM CONSTANTS

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

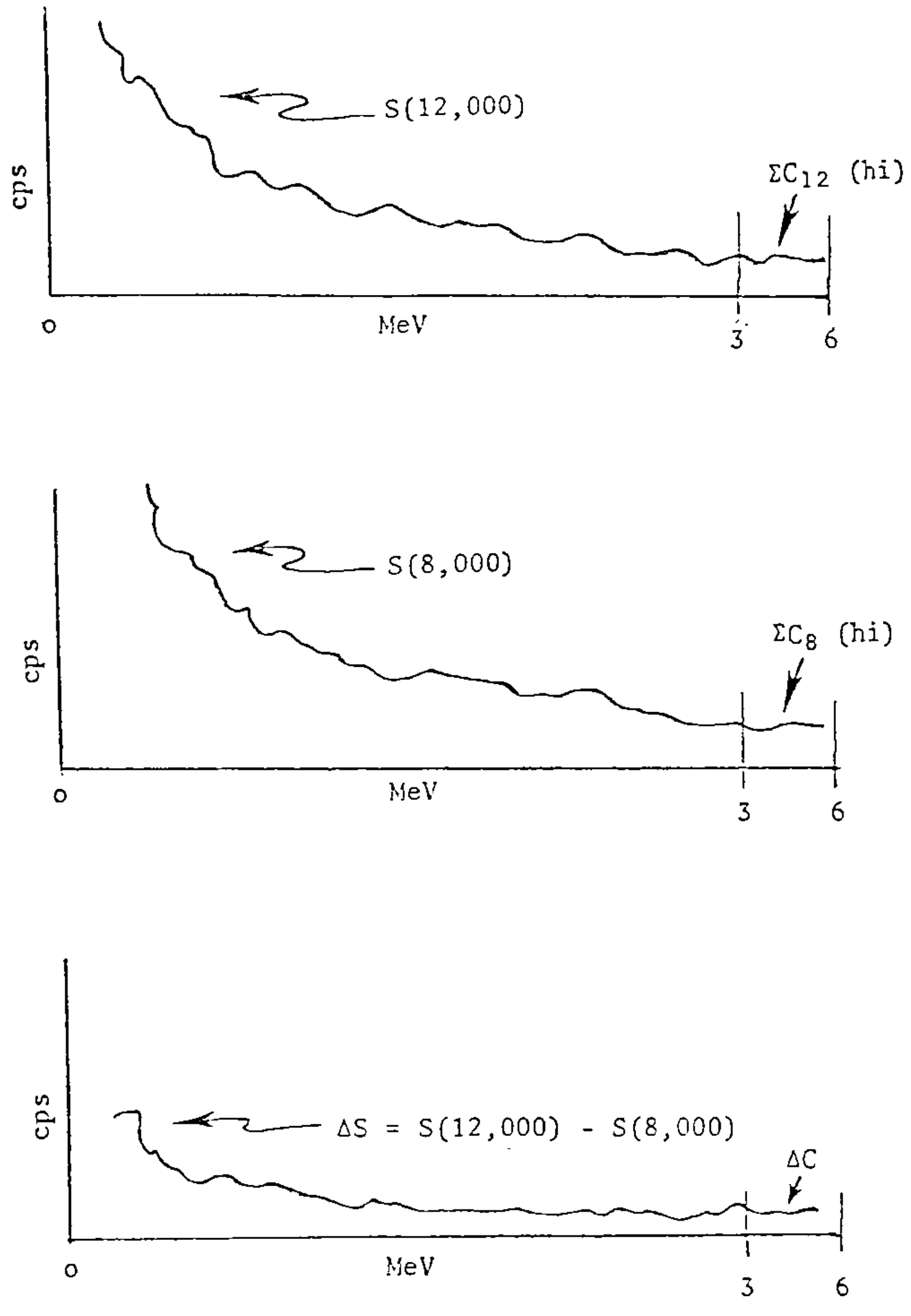

Figure 10 - Multiple altitude spectra schematic

AIRCRAFT BACKGROUND
ROTARY WING AIRCRAFT
DOWNWARD LOOKING CRYSTAL
2048 CUBIC INCHES
DATE: 25 JULY 1977

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DERIVED AIRCRAFT BACKGROUND SPECTRUM FROM PACIFIC OCEAN DATA

DOWNWARD-LOOKING CRYSTAL SPECTRUM FOR LINE AC BGD, DATED 072577

TC (0-6 MEV)  184.07 TC (0.4-3.0 MEV)  141.17 COSMIC (3-6 MEV)    0.00
U (1.12 MEV)     9.91 K (1.46 MEV)   14.54 U (1.76 MEV)    4.36 T (2.62 MEV)    4.29

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)  -0.025 CPS *
CH  19 (0.225 MEV)  -0.020 CPS *
CH  20 (0.236 MEV)   0.080 CPS *
CH  21 (0.248 MEV)   1.401 CPS *****
CH  22 (0.260 MEV)   3.792 CPS ************
CH  23 (0.272 MEV)   4.280 CPS **************
CH  24 (0.284 MEV)   4.334 CPS **************
CH  25 (0.295 MEV)   3.748 CPS ************
CH  26 (0.307 MEV)   3.897 CPS *************
CH  27 (0.319 MEV)   3.818 CPS ************
CH  28 (0.331 MEV)   4.236 CPS **************
CH  29 (0.343 MEV)   3.433 CPS ***********
CH  30 (0.355 MEV)   2.996 CPS **********
CH  31 (0.366 MEV)   2.559 CPS *********
CH  32 (0.378 MEV)   2.269 CPS ********
CH  33 (0.390 MEV)   2.102 CPS *******
CH  34 (0.402 MEV)   2.081 CPS ******* TOTAL COUNT
CH  35 (0.414 MEV)   2.121 CPS *******
CH  36 (0.426 MEV)   2.114 CPS *******
CH  37 (0.437 MEV)   1.976 CPS *******
CH  38 (0.449 MEV)   2.290 CPS ********
CH  39 (0.461 MEV)   2.188 CPS ********
CH  40 (0.473 MEV)   2.226 CPS ********
CH  41 (0.485 MEV)   1.983 CPS *******
CH  42 (0.496 MEV)   2.165 CPS *******
CH  43 (0.508 MEV)   2.158 CPS *******
CH  44 (0.520 MEV)   2.267 CPS ********
CH  45 (0.532 MEV)   2.217 CPS ********
CH  46 (0.544 MEV)   1.997 CPS *******
CH  47 (0.556 MEV)   2.447 CPS ********
CH  48 (0.567 MEV)   2.540 CPS *********
CH  49 (0.579 MEV)   2.586 CPS *********
CH  50 (0.591 MEV)   2.708 CPS *********
CH  51 (0.603 MEV)   2.481 CPS ********
CH  52 (0.615 MEV)   2.372 CPS ********
CH  53 (0.626 MEV)   1.866 CPS *******
CH  54 (0.638 MEV)   1.682 CPS ******
CH  55 (0.650 MEV)   1.661 CPS ******
CH  56 (0.662 MEV)   1.480 CPS *****
CH  57 (0.674 MEV)   1.474 CPS *****
CH  58 (0.686 MEV)   1.447 CPS *****
CH  59 (0.697 MEV)   1.431 CPS *****
CH  60 (0.709 MEV)   1.476 CPS *****
CH  61 (0.721 MEV)   1.453 CPS *****
CH  62 (0.733 MEV)   1.467 CPS *****
CH  63 (0.745 MEV)   1.579 CPS ******
CH  64 (0.756 MEV)   1.497 CPS *****
CH  65 (0.768 MEV)   1.548 CPS ******
CH  66 (0.780 MEV)   1.421 CPS *****
CH  67 (0.792 MEV)   1.282 CPS *****
CH  68 (0.804 MEV)   1.155 CPS ****
CH  69 (0.816 MEV)   1.246 CPS *****
CH  70 (0.827 MEV)   1.245 CPS *****
CH  71 (0.839 MEV)   1.161 CPS ****
CH  72 (0.851 MEV)   1.253 CPS *****
CH  73 (0.863 MEV)   1.231 CPS *****
CH  74 (0.875 MEV)   1.425 CPS *****
CH  75 (0.887 MEV)   1.452 CPS *****
CH  76 (0.898 MEV)   1.543 CPS ******
CH  77 (0.910 MEV)   1.444 CPS *****
CH  78 (0.922 MEV)   1.364 CPS *****
CH  79 (0.934 MEV)   1.289 CPS *****
CH  80 (0.946 MEV)   1.150 CPS ****
CH  81 (0.957 MEV)   1.144 CPS ****
CH  82 (0.969 MEV)   1.085 CPS ****
CH  83 (0.981 MEV)   1.061 CPS ****
CH  84 (0.993 MEV)   0.941 CPS ****
CH  85 (1.005 MEV)   0.919 CPS ****
CH  86 (1.017 MEV)   0.822 CPS ***
CH  87 (1.028 MEV)   0.816 CPS ***
CH  88 (1.040 MEV)   0.853 CPS ****
CH  89 (1.052 MEV)   0.901 CPS **** BISMUTH 214
CH  90 (1.064 MEV)   0.822 CPS ***
CH  91 (1.076 MEV)   0.867 CPS ****
CH  92 (1.087 MEV)   0.968 CPS ****
CH  93 (1.099 MEV)   0.851 CPS ****
CH  94 (1.111 MEV)   0.905 CPS ****
CH  95 (1.123 MEV)   0.847 CPS ****
CH  96 (1.135 MEV)   0.861 CPS ****
CH  97 (1.147 MEV)   0.800 CPS ***
CH  98 (1.158 MEV)   0.727 CPS ***
CH  99 (1.170 MEV)   0.751 CPS ***
CH 100 (1.182 MEV)   0.607 CPS *** BISMUTH 214
CH 101 (1.194 MEV)   0.663 CPS ***
CH 102 (1.206 MEV)   0.657 CPS ***
CH 103 (1.217 MEV)   0.633 CPS ***
CH 104 (1.229 MEV)   0.719 CPS ***
CH 105 (1.241 MEV)   0.671 CPS ***
CH 106 (1.253 MEV)   0.475 CPS **
CH 107 (1.265 MEV)   0.601 CPS ***
CH 108 (1.277 MEV)   0.661 CPS ***
CH 109 (1.288 MEV)   0.669 CPS ***
CH 110 (1.300 MEV)   0.606 CPS ***
CH 111 (1.312 MEV)   0.630 CPS ***
CH 112 (1.324 MEV)   0.652 CPS ***
CH 113 (1.336 MEV)   0.644 CPS ***
CH 114 (1.347 MEV)   0.652 CPS ***
CH 115 (1.359 MEV)   0.791 CPS ***
CH 116 (1.371 MEV)   0.787 CPS *** POTASSIUM 40
CH 117 (1.383 MEV)   0.834 CPS ****
CH 118 (1.395 MEV)   0.984 CPS ****
CH 119 (1.407 MEV)   1.072 CPS ****
CH 120 (1.418 MEV)   1.124 CPS ****
CH 121 (1.430 MEV)   1.088 CPS ****
CH 122 (1.442 MEV)   1.210 CPS *****
CH 123 (1.454 MEV)   1.231 CPS *****
CH 124 (1.466 MEV)   1.207 CPS *****
CH 125 (1.477 MEV)   0.995 CPS ****
CH 126 (1.489 MEV)   0.967 CPS ****
CH 127 (1.501 MEV)   0.624 CPS ***
CH 128 (1.513 MEV)   0.635 CPS ***
CH 129 (1.525 MEV)   0.512 CPS ***
CH 130 (1.537 MEV)   0.488 CPS **
CH 131 (1.548 MEV)   0.409 CPS **
CH 132 (1.560 MEV)   0.369 CPS ** POTASSIUM 40
CH 133 (1.572 MEV)   0.339 CPS **
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CH 136 (1.608 MEV)   0.259 CPS **
CH 137 (1.619 MEV)   0.250 CPS **
CH 138 (1.631 MEV)   0.353 CPS **
CH 139 (1.643 MEV)   0.323 CPS **
CH 140 (1.655 MEV)   0.332 CPS **
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CH 142 (1.678 MEV)   0.267 CPS **
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CH 145 (1.714 MEV)   0.347 CPS **
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CH 147 (1.738 MEV)   0.293 CPS **
CH 148 (1.749 MEV)   0.359 CPS **
CH 149 (1.761 MEV)   0.270 CPS **
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CH 151 (1.785 MEV)   0.245 CPS **
CH 152 (1.797 MEV)   0.255 CPS **
CH 153 (1.808 MEV)   0.174 CPS **
CH 154 (1.820 MEV)   0.228 CPS **
CH 155 (1.832 MEV)   0.188 CPS **
CH 156 (1.844 MEV)   0.115 CPS *
CH 157 (1.856 MEV)   0.084 CPS * BISMUTH 214
CH 158 (1.868 MEV)   0.147 CPS *
CH 159 (1.879 MEV)   0.147 CPS *
CH 160 (1.891 MEV)   0.139 CPS *
CH 161 (1.903 MEV)   0.109 CPS *
CH 162 (1.915 MEV)   0.091 CPS *
CH 163 (1.927 MEV)   0.151 CPS *
CH 164 (1.938 MEV)   0.088 CPS *
CH 165 (1.950 MEV)   0.136 CPS *
CH 166 (1.962 MEV)   0.157 CPS *
CH 167 (1.974 MEV)   0.119 CPS *
CH 168 (1.986 MEV)   0.109 CPS *
CH 169 (1.998 MEV)   0.113 CPS *
CH 170 (2.009 MEV)   0.106 CPS *
CH 171 (2.021 MEV)   0.147 CPS *
CH 172 (2.033 MEV)   0.137 CPS *
CH 173 (2.045 MEV)   0.171 CPS **
CH 174 (2.057 MEV)   0.154 CPS *
CH 175 (2.068 MEV)   0.108 CPS *
CH 176 (2.080 MEV)   0.162 CPS *
CH 177 (2.092 MEV)   0.104 CPS *
CH 178 (2.104 MEV)   0.138 CPS *
CH 179 (2.116 MEV)   0.137 CPS *
CH 180 (2.128 MEV)   0.119 CPS *
CH 181 (2.139 MEV)   0.169 CPS **
CH 182 (2.151 MEV)   0.148 CPS *
CH 183 (2.163 MEV)   0.101 CPS *
CH 184 (2.175 MEV)   0.114 CPS *
CH 185 (2.187 MEV)   0.088 CPS *
CH 186 (2.199 MEV)   0.101 CPS *
CH 187 (2.210 MEV)   0.085 CPS *
CH 188 (2.222 MEV)   0.130 CPS *
CH 189 (2.234 MEV)   0.117 CPS *
CH 190 (2.246 MEV)   0.113 CPS *
CH 191 (2.258 MEV)   0.116 CPS *
CH 192 (2.269 MEV)   0.088 CPS *
CH 193 (2.281 MEV)   0.097 CPS *
CH 194 (2.293 MEV)   0.095 CPS *
CH 195 (2.305 MEV)   0.087 CPS *
CH 196 (2.317 MEV)   0.059 CPS *
CH 197 (2.329 MEV)   0.015 CPS *
CH 198 (2.340 MEV)   0.041 CPS *
CH 199 (2.352 MEV)   0.070 CPS *
CH 200 (2.364 MEV)   0.087 CPS *
CH 201 (2.376 MEV)   0.085 CPS *
CH 202 (2.388 MEV)   0.084 CPS *
CH 203 (2.399 MEV)   0.064 CPS *
CH 204 (2.411 MEV)   0.123 CPS * THALLIUM 208
CH 205 (2.423 MEV)   0.076 CPS *
CH 206 (2.435 MEV)   0.116 CPS *
CH 207 (2.447 MEV)   0.147 CPS *
CH 208 (2.459 MEV)   0.108 CPS *
CH 209 (2.470 MEV)   0.120 CPS *
CH 210 (2.482 MEV)   0.092 CPS *
CH 211 (2.494 MEV)   0.127 CPS *
CH 212 (2.506 MEV)   0.169 CPS **
CH 213 (2.518 MEV)   0.206 CPS **
CH 214 (2.529 MEV)   0.262 CPS **
CH 215 (2.541 MEV)   0.184 CPS **
CH 216 (2.553 MEV)   0.206 CPS **
CH 217 (2.565 MEV)   0.195 CPS **
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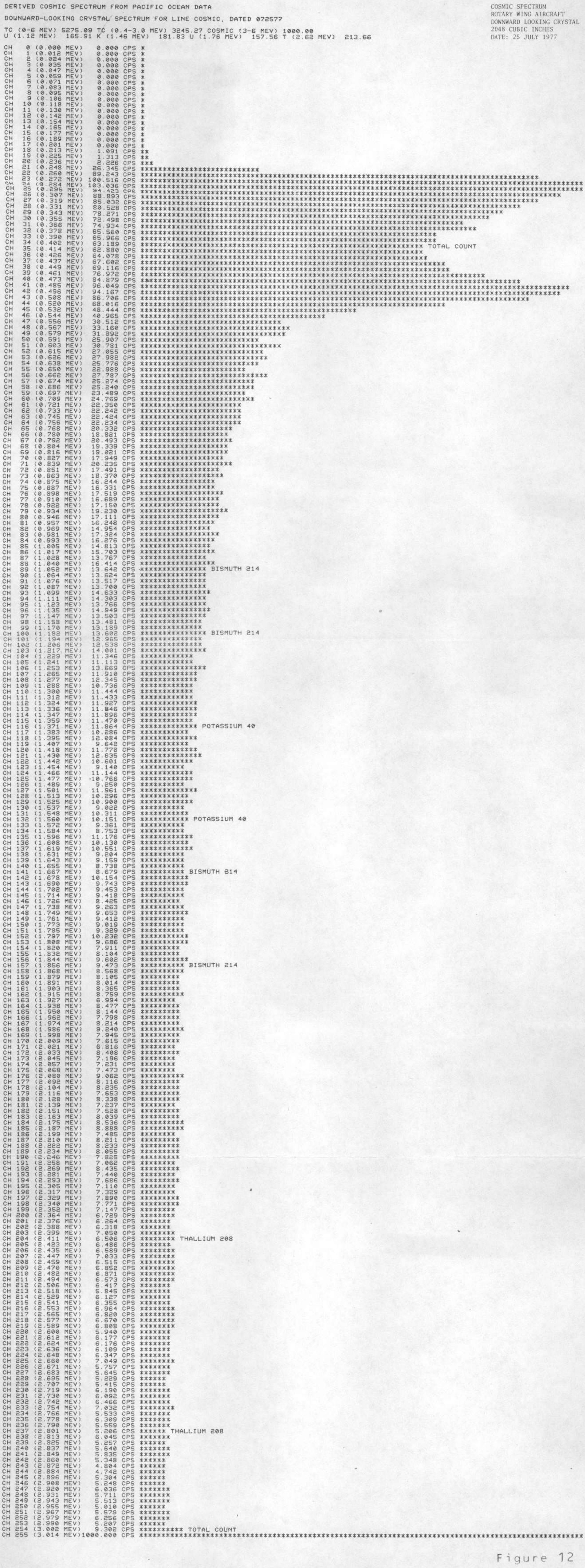
CH 220 (2.600 MEV)   0.329 CPS **
CH 221 (2.612 MEV)   0.232 CPS **
CH 222 (2.624 MEV)   0.187 CPS **
CH 223 (2.636 MEV)   0.171 CPS **
CH 224 (2.648 MEV)   0.177 CPS **
CH 225 (2.660 MEV)   0.089 CPS *
CH 226 (2.671 MEV)   0.122 CPS *
CH 227 (2.683 MEV)   0.124 CPS *
CH 228 (2.695 MEV)   0.131 CPS *
CH 229 (2.707 MEV)   0.090 CPS *
CH 230 (2.719 MEV)   0.027 CPS *
CH 231 (2.730 MEV)   0.012 CPS *
CH 232 (2.742 MEV)  -0.026 CPS *
CH 233 (2.754 MEV)  -0.024 CPS *
CH 234 (2.766 MEV)   0.038 CPS *
CH 235 (2.778 MEV)   0.003 CPS *
CH 236 (2.790 MEV)   0.060 CPS *
CH 237 (2.801 MEV)   0.038 CPS * THALLIUM 208
CH 238 (2.813 MEV)   0.023 CPS *
CH 239 (2.825 MEV)   0.008 CPS *
CH 240 (2.837 MEV)   0.078 CPS *
CH 241 (2.849 MEV)   0.027 CPS *
CH 242 (2.860 MEV)   0.047 CPS *
CH 243 (2.872 MEV)   0.039 CPS *
CH 244 (2.884 MEV)   0.084 CPS *
CH 245 (2.896 MEV)   0.025 CPS *
CH 246 (2.908 MEV)   0.025 CPS *
CH 247 (2.920 MEV)  -0.015 CPS *
CH 248 (2.931 MEV)   0.037 CPS *
CH 249 (2.943 MEV)  -0.005 CPS *
CH 250 (2.955 MEV)   0.042 CPS *
CH 251 (2.967 MEV)   0.002 CPS *
CH 252 (2.979 MEV)  -0.018 CPS *
CH 253 (2.990 MEV)   0.031 CPS *
CH 254 (3.002 MEV)  -0.106 CPS * TOTAL COUNT
CH 255 (3.014 MEV)   0.000 CPS *
```

Figure 11



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DERIVED COSMIC SPECTRUM FROM PACIFIC OCEAN DATA

DOWNWARD-LOOKING CRYSTAL SPECTRUM FOR LINE COSMIC, DATED 072577

TC (0-6 MEV) 5275.09 TC (0.4-3.0 MEV) 3245.27 COSMIC (3-6 MEV) 1000.00
U (1.12 MEV)  165.91 K (1.46 MEV)  181.83 U (1.76 MEV)  157.56 T (2.62 MEV)  213.66

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)    1.091 CPS
CH  19 (0.225 MEV)    1.313 CPS
CH  20 (0.236 MEV)    2.226 CPS
CH  21 (0.248 MEV)   26.345 CPS
CH  22 (0.260 MEV)   89.243 CPS
CH  23 (0.272 MEV)  100.516 CPS
CH  24 (0.284 MEV)  103.036 CPS
CH  25 (0.295 MEV)   94.423 CPS
CH  26 (0.307 MEV)   88.893 CPS
CH  27 (0.319 MEV)   85.032 CPS
CH  28 (0.331 MEV)   80.528 CPS
CH  29 (0.343 MEV)   78.271 CPS
CH  30 (0.355 MEV)   72.498 CPS
CH  31 (0.366 MEV)   74.934 CPS
CH  32 (0.378 MEV)   65.560 CPS
CH  33 (0.390 MEV)   65.966 CPS
CH  34 (0.402 MEV)   63.189 CPS
CH  35 (0.414 MEV)   62.880 CPS  TOTAL COUNT
CH  36 (0.426 MEV)   64.078 CPS
CH  37 (0.437 MEV)   67.602 CPS
CH  38 (0.449 MEV)   69.116 CPS
CH  39 (0.461 MEV)   76.972 CPS
CH  40 (0.473 MEV)   84.879 CPS
CH  41 (0.485 MEV)   96.049 CPS
CH  42 (0.496 MEV)   94.167 CPS
CH  43 (0.508 MEV)   86.706 CPS
CH  44 (0.520 MEV)   68.016 CPS
CH  45 (0.532 MEV)   48.444 CPS
CH  46 (0.544 MEV)   40.965 CPS
CH  47 (0.556 MEV)   30.512 CPS
CH  48 (0.567 MEV)   33.160 CPS
CH  49 (0.579 MEV)   31.892 CPS
CH  50 (0.591 MEV)   25.907 CPS
CH  51 (0.603 MEV)   30.781 CPS
CH  52 (0.615 MEV)   27.055 CPS
CH  53 (0.626 MEV)   27.982 CPS
CH  54 (0.638 MEV)   25.776 CPS
CH  55 (0.650 MEV)   22.988 CPS
CH  56 (0.662 MEV)   27.787 CPS
CH  57 (0.674 MEV)   25.274 CPS
CH  58 (0.686 MEV)   25.240 CPS
CH  59 (0.697 MEV)   23.489 CPS
CH  60 (0.709 MEV)   24.769 CPS
CH  61 (0.721 MEV)   22.350 CPS
CH  62 (0.733 MEV)   22.242 CPS
CH  63 (0.745 MEV)   22.424 CPS
CH  64 (0.756 MEV)   22.234 CPS
CH  65 (0.768 MEV)   20.332 CPS
CH  66 (0.780 MEV)   18.821 CPS
CH  67 (0.792 MEV)   20.493 CPS
CH  68 (0.804 MEV)   19.339 CPS
CH  69 (0.816 MEV)   19.021 CPS
CH  70 (0.827 MEV)   17.949 CPS
CH  71 (0.839 MEV)   20.235 CPS
CH  72 (0.851 MEV)   17.491 CPS
CH  73 (0.863 MEV)   18.370 CPS
CH  74 (0.875 MEV)   16.244 CPS
CH  75 (0.887 MEV)   16.331 CPS
CH  76 (0.898 MEV)   17.519 CPS
CH  77 (0.910 MEV)   16.689 CPS
CH  78 (0.922 MEV)   17.150 CPS
CH  79 (0.934 MEV)   19.230 CPS
CH  80 (0.946 MEV)   17.111 CPS
CH  81 (0.957 MEV)   16.248 CPS
CH  82 (0.969 MEV)   14.954 CPS
CH  83 (0.981 MEV)   17.324 CPS
CH  84 (0.993 MEV)   16.276 CPS
CH  85 (1.005 MEV)   14.813 CPS
CH  86 (1.017 MEV)   15.703 CPS
CH  87 (1.028 MEV)   13.767 CPS
CH  88 (1.040 MEV)   16.414 CPS
CH  89 (1.052 MEV)   13.642 CPS  BISMUTH 214
CH  90 (1.064 MEV)   13.624 CPS
CH  91 (1.076 MEV)   13.517 CPS
CH  92 (1.087 MEV)   13.700 CPS
CH  93 (1.099 MEV)   14.633 CPS
CH  94 (1.111 MEV)   14.303 CPS
CH  95 (1.123 MEV)   13.766 CPS
CH  96 (1.135 MEV)   14.949 CPS
CH  97 (1.147 MEV)   13.503 CPS
CH  98 (1.158 MEV)   13.481 CPS
CH  99 (1.170 MEV)   13.189 CPS
CH 100 (1.182 MEV)   13.602 CPS  BISMUTH 214
CH 101 (1.194 MEV)   12.965 CPS
CH 102 (1.206 MEV)   12.538 CPS
CH 103 (1.217 MEV)   14.001 CPS
CH 104 (1.229 MEV)   11.346 CPS
CH 105 (1.241 MEV)   11.113 CPS
CH 106 (1.253 MEV)   13.669 CPS
CH 107 (1.265 MEV)   11.910 CPS
CH 108 (1.277 MEV)   12.345 CPS
CH 109 (1.288 MEV)   10.736 CPS
CH 110 (1.300 MEV)   11.444 CPS
CH 111 (1.312 MEV)   11.433 CPS
CH 112 (1.324 MEV)   11.927 CPS
CH 113 (1.336 MEV)   11.846 CPS
CH 114 (1.347 MEV)   11.896 CPS
CH 115 (1.359 MEV)   11.470 CPS
CH 116 (1.371 MEV)   11.864 CPS  POTASSIUM 40
CH 117 (1.383 MEV)   10.286 CPS
CH 118 (1.395 MEV)   12.084 CPS
CH 119 (1.407 MEV)    9.642 CPS
CH 120 (1.418 MEV)   11.778 CPS
CH 121 (1.430 MEV)   12.635 CPS
CH 122 (1.442 MEV)   10.601 CPS
CH 123 (1.454 MEV)    9.140 CPS
CH 124 (1.466 MEV)   11.144 CPS
CH 125 (1.477 MEV)   10.766 CPS
CH 126 (1.489 MEV)    9.250 CPS
CH 127 (1.501 MEV)   11.961 CPS
CH 128 (1.513 MEV)   10.296 CPS
CH 129 (1.525 MEV)   10.900 CPS
CH 130 (1.537 MEV)    9.022 CPS
CH 131 (1.548 MEV)   10.311 CPS
CH 132 (1.560 MEV)   10.151 CPS  POTASSIUM 40
CH 133 (1.572 MEV)    9.361 CPS
CH 134 (1.584 MEV)    8.753 CPS
CH 135 (1.596 MEV)   11.176 CPS
CH 136 (1.608 MEV)   10.130 CPS
CH 137 (1.619 MEV)   10.551 CPS
CH 138 (1.631 MEV)    9.204 CPS
CH 139 (1.643 MEV)    9.159 CPS
CH 140 (1.655 MEV)    8.738 CPS
CH 141 (1.667 MEV)    8.679 CPS  BISMUTH 214
CH 142 (1.678 MEV)   10.154 CPS
CH 143 (1.690 MEV)    9.743 CPS
CH 144 (1.702 MEV)    9.453 CPS
CH 145 (1.714 MEV)    9.418 CPS
CH 146 (1.726 MEV)    8.425 CPS
CH 147 (1.738 MEV)    9.263 CPS
CH 148 (1.749 MEV)    9.653 CPS
CH 149 (1.761 MEV)    9.412 CPS
CH 150 (1.773 MEV)    9.019 CPS
CH 151 (1.785 MEV)    9.329 CPS
CH 152 (1.797 MEV)   10.232 CPS
CH 153 (1.808 MEV)    9.686 CPS
CH 154 (1.820 MEV)    7.911 CPS
CH 155 (1.832 MEV)    8.104 CPS
CH 156 (1.844 MEV)    9.602 CPS
CH 157 (1.856 MEV)    9.473 CPS  BISMUTH 214
CH 158 (1.868 MEV)    8.568 CPS
CH 159 (1.879 MEV)    8.105 CPS
CH 160 (1.891 MEV)    8.014 CPS
CH 161 (1.903 MEV)    8.365 CPS
CH 162 (1.915 MEV)    8.759 CPS
CH 163 (1.927 MEV)    6.994 CPS
CH 164 (1.938 MEV)    8.477 CPS
CH 165 (1.950 MEV)    8.144 CPS
CH 166 (1.962 MEV)    7.798 CPS
CH 167 (1.974 MEV)    8.214 CPS
CH 168 (1.986 MEV)    9.240 CPS
CH 169 (1.998 MEV)    7.945 CPS
CH 170 (2.009 MEV)    7.615 CPS
CH 171 (2.021 MEV)    6.816 CPS
CH 172 (2.033 MEV)    8.408 CPS
CH 173 (2.045 MEV)    7.196 CPS
CH 174 (2.057 MEV)    7.231 CPS
CH 175 (2.068 MEV)    7.473 CPS
CH 176 (2.080 MEV)    9.062 CPS
CH 177 (2.092 MEV)    8.116 CPS
CH 178 (2.104 MEV)    8.235 CPS
CH 179 (2.116 MEV)    7.653 CPS
CH 180 (2.128 MEV)    8.338 CPS
CH 181 (2.139 MEV)    7.237 CPS
CH 182 (2.151 MEV)    7.528 CPS
CH 183 (2.163 MEV)    8.039 CPS
CH 184 (2.175 MEV)    8.536 CPS
CH 185 (2.187 MEV)    8.888 CPS
CH 186 (2.199 MEV)    7.485 CPS
CH 187 (2.210 MEV)    8.211 CPS
CH 188 (2.222 MEV)    8.233 CPS
CH 189 (2.234 MEV)    8.055 CPS
CH 190 (2.246 MEV)    7.825 CPS
CH 191 (2.258 MEV)    7.062 CPS
CH 192 (2.269 MEV)    8.435 CPS
CH 193 (2.281 MEV)    7.440 CPS
CH 194 (2.293 MEV)    7.686 CPS
CH 195 (2.305 MEV)    7.110 CPS
CH 196 (2.317 MEV)    7.329 CPS
CH 197 (2.329 MEV)    7.890 CPS
CH 198 (2.340 MEV)    7.771 CPS
CH 199 (2.352 MEV)    7.147 CPS
CH 200 (2.364 MEV)    6.729 CPS
CH 201 (2.376 MEV)    6.264 CPS
CH 202 (2.388 MEV)    6.318 CPS
CH 203 (2.399 MEV)    7.050 CPS
CH 204 (2.411 MEV)    6.506 CPS  THALLIUM 208
CH 205 (2.423 MEV)    6.486 CPS
CH 206 (2.435 MEV)    6.589 CPS
CH 207 (2.447 MEV)    7.033 CPS
CH 208 (2.459 MEV)    6.515 CPS
CH 209 (2.470 MEV)    6.852 CPS
CH 210 (2.482 MEV)    6.871 CPS
CH 211 (2.494 MEV)    6.573 CPS
CH 212 (2.506 MEV)    6.417 CPS
CH 213 (2.518 MEV)    5.845 CPS
CH 214 (2.529 MEV)    6.127 CPS
CH 215 (2.541 MEV)    6.355 CPS
CH 216 (2.553 MEV)    6.964 CPS
CH 217 (2.565 MEV)    6.820 CPS
CH 218 (2.577 MEV)    6.670 CPS
CH 219 (2.589 MEV)    6.808 CPS
CH 220 (2.600 MEV)    5.940 CPS
CH 221 (2.612 MEV)    6.177 CPS
CH 222 (2.624 MEV)    6.176 CPS
CH 223 (2.636 MEV)    6.109 CPS
CH 224 (2.648 MEV)    6.347 CPS
CH 225 (2.660 MEV)    7.049 CPS
CH 226 (2.671 MEV)    5.757 CPS
CH 227 (2.683 MEV)    5.645 CPS
CH 228 (2.695 MEV)    5.229 CPS
CH 229 (2.707 MEV)    5.415 CPS
CH 230 (2.719 MEV)    6.190 CPS
CH 231 (2.730 MEV)    6.092 CPS
CH 232 (2.742 MEV)    6.466 CPS
CH 233 (2.754 MEV)    7.032 CPS
CH 234 (2.766 MEV)    5.533 CPS
CH 235 (2.778 MEV)    6.309 CPS
CH 236 (2.790 MEV)    5.559 CPS
CH 237 (2.801 MEV)    5.206 CPS  THALLIUM 208
CH 238 (2.813 MEV)    6.045 CPS
CH 239 (2.825 MEV)    5.257 CPS
CH 240 (2.837 MEV)    5.640 CPS
CH 241 (2.849 MEV)    5.835 CPS
CH 242 (2.860 MEV)    5.348 CPS
CH 243 (2.872 MEV)    4.804 CPS
CH 244 (2.884 MEV)    4.742 CPS
CH 245 (2.896 MEV)    5.304 CPS
CH 246 (2.908 MEV)    5.248 CPS
CH 247 (2.920 MEV)    6.036 CPS
CH 248 (2.931 MEV)    5.711 CPS
CH 249 (2.943 MEV)    5.513 CPS
CH 250 (2.955 MEV)    5.010 CPS
CH 251 (2.967 MEV)    5.579 CPS
CH 252 (2.979 MEV)    6.256 CPS
CH 253 (2.990 MEV)    5.207 CPS
CH 254 (3.002 MEV)    9.302 CPS  TOTAL COUNT
CH 255 (3.014 MEV)1000.000 CPS
```

COSMIC SPECTRUM
ROTARY WING AIRCRAFT
DOWNWARD LOOKING CRYSTAL
2048 CUBIC INCHES
DATE: 25 JULY 1977

Figure 12

PAD	K	U	T
Matrix	1.45%	2.19 ppm	6.26 ppm
K	5.14%	5.09 ppm	8.48 ppm
U	2.03%	30.29 ppm	9.19 ppm
T	2.01%	5.14 ppm	45.33 ppm
Mixed	4.11%	20.39 ppm	17.52 ppm

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 background (e.g., BiAir, etc.) effects. Thus, by subtracting the matrix pad count rates from the count rates in the four 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	3.7%	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 to T

We must now solve for the above nine variables to define the systems'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 (i.e. the energies are smeared to some extent). Thus, energy peaks within a spectrum of a given element are Gaussian shaped rather than a pure line spectrum. Additionally, we are dealing with finite spectral windows, multiple peaked spectra, and pulse pileup; 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 pad $\quad KC = \zeta_{kk}K + \zeta_{ku}U + \zeta_{kt}T$

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

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

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

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

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

Separating these equation into consistent groups we get

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

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

(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

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

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

$$\bar{A} = \bar{B}.\bar{\zeta} \qquad \text{or} \qquad \bar{\zeta} = \bar{B}^{-1}.\ \bar{A}$$

where $\bar{A}$ is the count rate matrix, $\bar{B}$ is the matrix of the known concentrations matrix, and ζ 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 $\bar{B} = \bar{A}\ .\ \bar{\zeta}^{-1}$ and define $\bar{\zeta}^{-1} = \bar{\Delta}$. Expanding this we have:

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

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

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

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

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

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

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 and which are sometimes defined slightly differently.) The results are defined as follows:

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

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

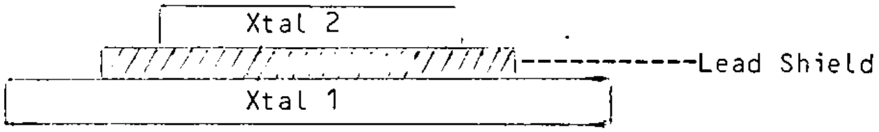
$$S_{ut} = \frac{\Delta_{ut}}{\Delta_{uu}} \quad \text{(effect of thorium on uranium)}$$

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

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

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 $I_1 = I_g + I_a + A_1 + C_1$

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

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

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 $I_1 = I_g$

$I_2 = \ell I_g$

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

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

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

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

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.

FIXED WING/ROTARY WING DATA NORMALIZATION

As required in the Rockies/Laramie Project, the rotary wing data were normalized to the fixed wing data to provide continuity within NTMS data sets. Normalization was accomplished by multiplying the rotary wing reduced averaged record K,U,T, and total count values by an appropriate constant derived from data obtained on the Walker Field Calibration Pads, Lake Mead Dynamic Test Range, and flight line overlaps/intersections within the project area.

To obtain the normalization constant the followong technique was implemented:

1) The fixed wing/rotary wing ratio of K, U, T and, total count cps for the Walker Field Calibration Pads were calculated and tabulated.

2) The fixed wing/rotary wing ratio of K, U, T and Total Count cps for quasi-coincident fixed wing/ rotary wing samples (spatially within 50 ± feet) were calculated for all four flights at each of the eight altitudes flown over the land portion of the Lake Mead Dynamic Test Range. Tabulation of these results included the plotting of histograms, scatter plots and associated statistical parameters.

and

3) Flight line overlaps/intersections occurring within each of the NTMS sheets were subjected to the same procedure as in 2) above.

From results of the above, the proper normalization constant was selected and input to the processing scheme. In the case of all six (6) quadrangles involved in the Rockies/Laramie PROJECT a multiplicative factor of 1.4 was applied to the rotary wing average record data (K, U, T and Total Count) to normalize it to the fixed wing 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 window's peak channel. The data are also checked for correct scan lengths and 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 rewritten 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 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 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 13 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 was performed using the window energies given below:

Total count - 0.4 to 3.0 MeV

K - 1.37 to 1.57 MeV

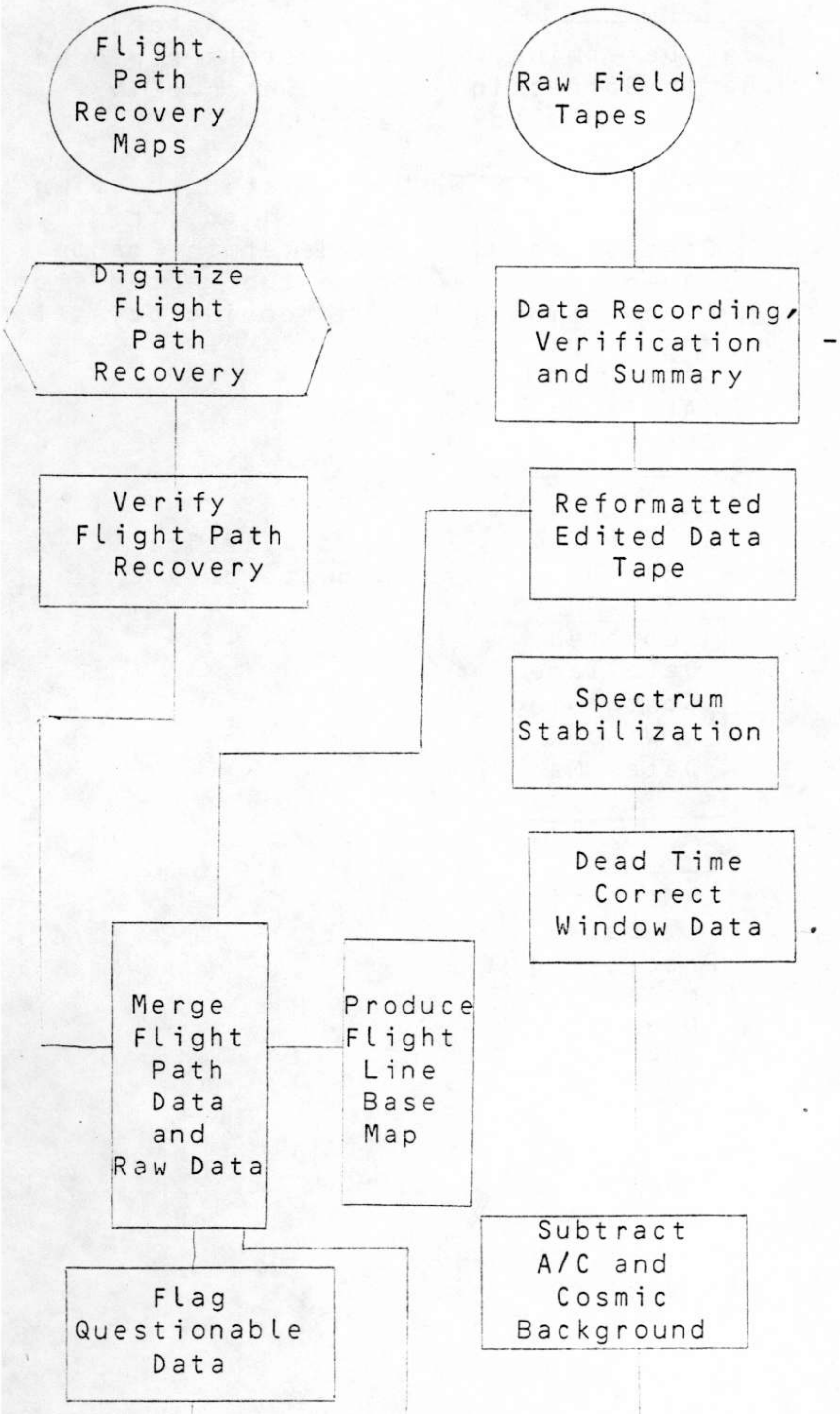
U - 1.66 to 1.87 MeV (downward and upward looking system)

T - 2.41 to 2.81 MeV

Cosmic - 3 to 6 MeV (downward and upward looking system)

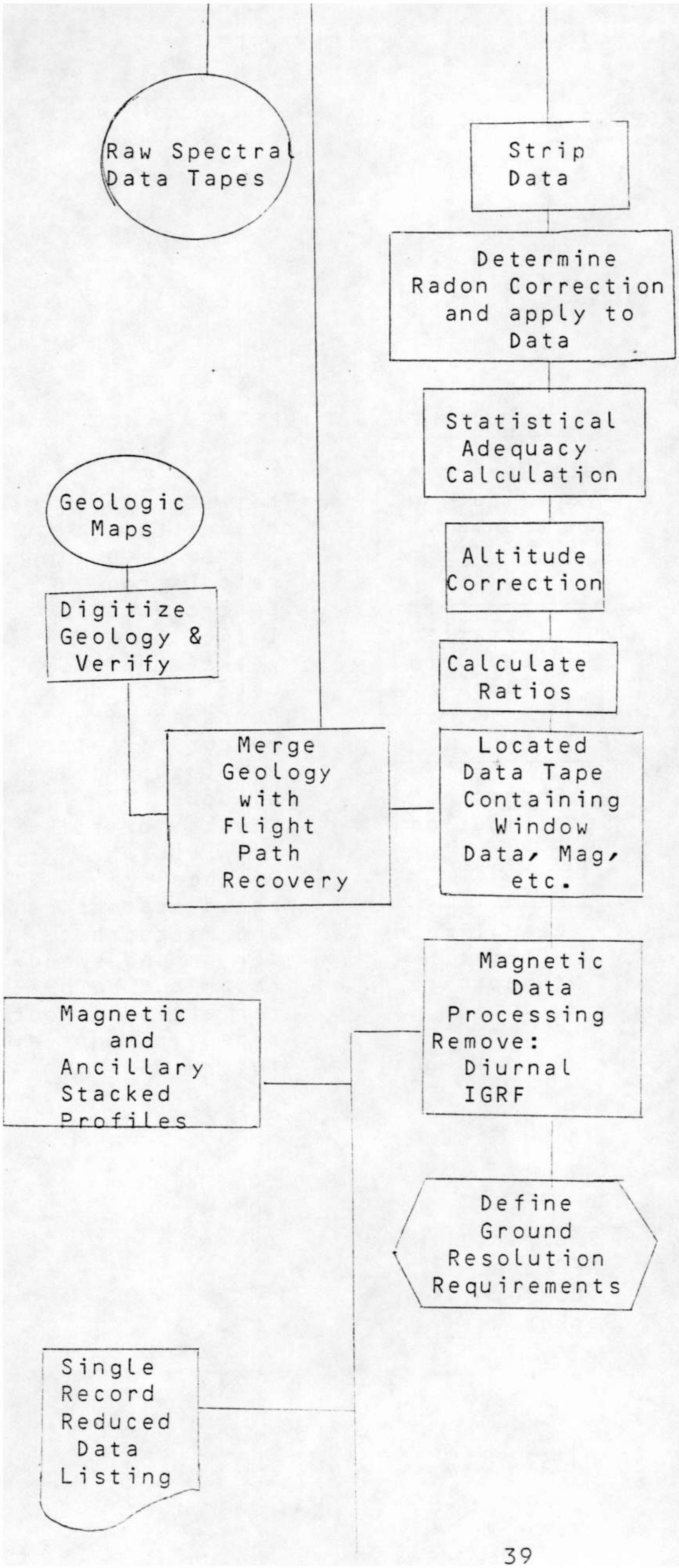
DATA PROCESSING FLOW DIAGRAM

Figure 13



----This step performs the following:

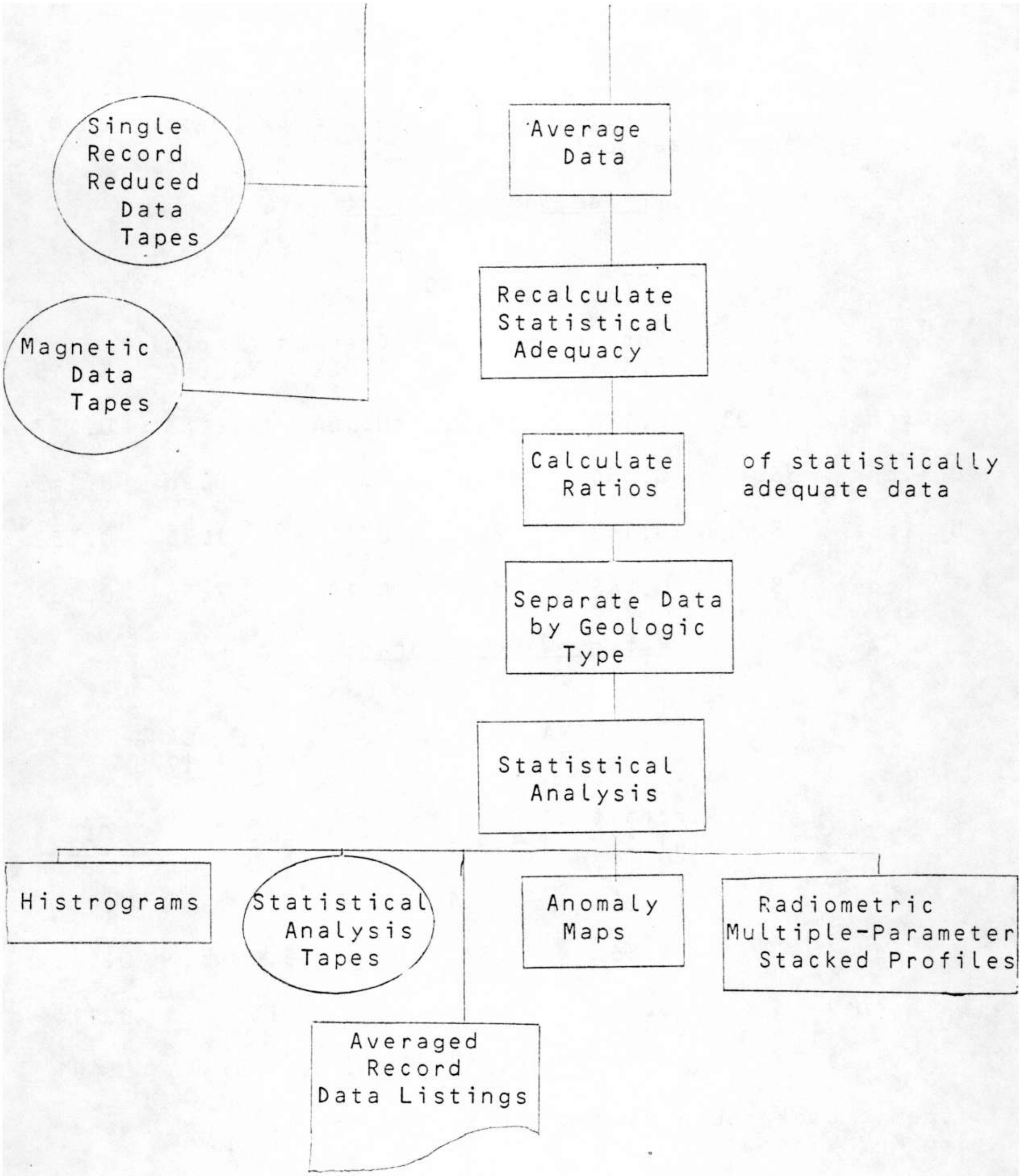
- .System Live time calculation
- .Centroid calculation of K,U,T peaks stability determination
- .Compares window output with spectral sums over windows
- .Checks for spiking, etc.
- .Produces Line based statistics and histograms for ground speed, radar and barometer altitude, outside air temperature, 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.

For 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
Histrograms
Statistical Analysis Tapes
Anomaly Maps
Radiometric Multiple-Parameter Stacked Profiles
Averaged Record Data Listings

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

Fixed Wing Aircraft

	S2F OCT 77		S2F NOV 77		S2F 1978	
	Aircraft	Cosmic*	Aircraft	Cosmic*	Aircraft	Cosmic*
TC (cps)	638.35	3.358	383.62	2.882	212.04	3.115
K (cps)	32.03	0.188	31.39	0.164	22.83	0.177
U_{dn} (cps)	33.76	0.154	17.91	0.134	8.90	0.145
U_{up} (cps)	3.22	0.148	3.30	0.150	1.75	0.152
T (cps)	8.16	0.148	8.50	0.184	7.76	0.189

Rotary Wing Aircraft

	LAMA 1977		LAMA 1978	
	Aircraft	Cosmic*	Aircraft	Cosmic*
TC (cps)	141.17	3.245	150.83	3.023
K (cps)	14.54	0.181	19.10	0.165
U_{dn} (cps)	4.36	0.57	5.06	0.142
U_{up} (cps)	0.60	0.119	0.36	0.114
T (cps)	4.29	0.213	4.25	0.191

*Cosmic background values are in cps per 1.0 cps in the 3-6 MeV window

Compton corrections to the down data were made using the following constants:

	S2F OCT 77	S2F NOV 77	S2F 1978	LAMA 1977	LAMA 1978
S_{k_u}	0.833	0.833	0.8613	0.826	0.8195
S_{kt}	0.1390	0.390	0.1588	0.174	0.1815

S_{ut}	0.2935	0.29350	0.2986	0.2716	0.2838
S_{uk}	0.0	0.0	0.0	0.0	0.0
S_{tn}	0.0753	0.0753	0.05312	0.0613	0.06926
S_{tk}	0.0	0.0	0.0	0.0	0.0

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:

ALTITUDE ATTENUATION COEFFICIENTS

	S2F OCT 77	S2F NOV 77	S2F 1978	LAMA 1977	LAMA 1978
μ_{TC} (per foot)	.001756	.002021	.0022065	.002065	.002129
μ_{K} (per foot)	.002754	.002771	.003001	.002859	.002897
μ_{U} (per foot)	.002510	0.02560	.002710	.002600	.002640
μ_{T} (per foot)	.002089	.002157	.002274	.002163	.002198

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

$$\exp u_i \left[\frac{273.15}{760} \times \frac{P}{T}\right]\left[h - 400\right]$$

where h is the height in feet, μi is the appropriate altitude attenuation coefficient, P is mm of Hg and T is in degrees Kelvin. 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 coefficients 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}, and C'_{uu} are given below:

	S2F OCT 1977	S2F NOV 1977	S2F 1978	LAMA 1977	LAMA 1978
ℓ	0.057	0.057	.0488	0.07	0.686
m	0.174	0.174	.189	0.19	0.168
C'_{uk}	0.0	0.0	0.0	0.0	0.0
C'_{uu}	.003615	0.03615	0.03586	0.06552	0.06078
C'_{ut}	0.01868	0.01868	0.01687	0.02046	0.02081
μ_ℓ	-.000039	-.000039	-.0000233	-.000039	-.000041
μ_m	-.0000305	-.0000305	-.000034	-.0000305	-.000014

μ_ℓ & μ_m are used as follows: $\ell = \ell - \mu_\ell \times h$, where h is in feet

$m = m - \mu_m \times h$, where h is in feet

These Bi Air data are filtered and the filtered results are then removed, on a point basis, from the corrected uranium window data.

MAGNETIC DATA REDUCTION

The magnetic data reduction processes are correction for diurnal variation, tieing to a common magnetic datum, and subtraction of the regional magnetic field as defined by the International Geomagnetic Reference Field (IGRF). During data acquistion, the magnetic field is monitored by a diurnal 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 manmade magnetic events. After edition, these data are displayed in profile form to ensure that all corrections necessary have been made. Next, the data are synchronized in time with the airborne data, interpolated, and subtracted from the airborne magnetic data.

The diurnally corrected magnetic data are then processed by a tieing program that compares the magnetic differences at intersections of flight lines and tie lines. This program calculates individual magnetic field biases for each flight tie line based on tie line intersections. This allows miss-ties to be minimized throughout the survey. These biases usually represent, after diurnal correction, systematic magnetic changes caused by such things 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 subtracted from the diurnally corrected, tied magnetic data yielding the reported residual magnetic field.

STATISTICAL ANALYSIS

The results of the data processing phase are single recorded samples (1.0 second interval). These data are then evaluated for statistical adequacy prior to altitude correction to ensure they are significant within the context of the anticipated errors in count statistics. The statistical adequacy test is made to determine whether the corrected sample is sufficiently greater than the "noise" to represent the "signal" of interest.

Statistical Adequacy Test

We can define three separate criteria for detection thresholds (ref. Currie, Analytical Chemistry, Volume 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 this critical level as that level at which the data are statistically adequate.

Setting the actual levels in counts per second, "a priori", for each elemental window is difficult at best since the full effect of all parameters affecting the counts is not known to a sufficient degree of certainty. If the corrections to the data are a significant portion of the count rate, most of the error (exclusive of systematic errors due to electronics, etc.) in the corrected data can be ascribed to random errors within the applied corrections. The corrections are basically the results of counting radioactive decay products (gamma rays) and are therefore assumed to follow the classical Poisson distribtuion. The following assumptions concerning these corrections are:

1. In the best case, the error in each correction is additive.

2. The sum of these corrections also follows 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 corrected single record data sample exceeds 1.5 times the square root of the summed correction applied to that data sample, then that data sample is statistically adequate."

Since any calculation using statistically inadequate data (such as ratios) is also inadequate, the adequacy of each element of the single sample record data is tested prior to its determination. This is done during the course of the processing by retaining all corrections applied to each data sample and determining its adequacy as explained above.

Not only are the results of this statistical adequacy test used to insure that calculated ratios will be meaningful (in terms of statistical adequacy), but they are also utilized to determine the 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. In the case of this project, the resulting averaging sample interval was 7 seconds. This resulted in 98% or better of the uranium data to be statistically adequate, exclusive of those data which were outside of altitude specifications (the overall altitude specification was maintained at the 98% level) and excluding the known water saturated formations and water bodies.

Hypothesis Testing

For this processing it is assumed that correlations between radiometric parameters (count rates of total count, K, U, T, and their ratios and corresponding geology) can be described by normal (Gaussian) and/or log normal distributions. The data are treated in a standardized manner, described below.

All data (K, U, T, and three ratios) are sorted in accordance with geographic location and related geologic unit. They are then grouped such that each of the formations 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 formation can be best represented by a normal distribution.

or

2. The count rate distribution for a specified formation 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 formation 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 14.

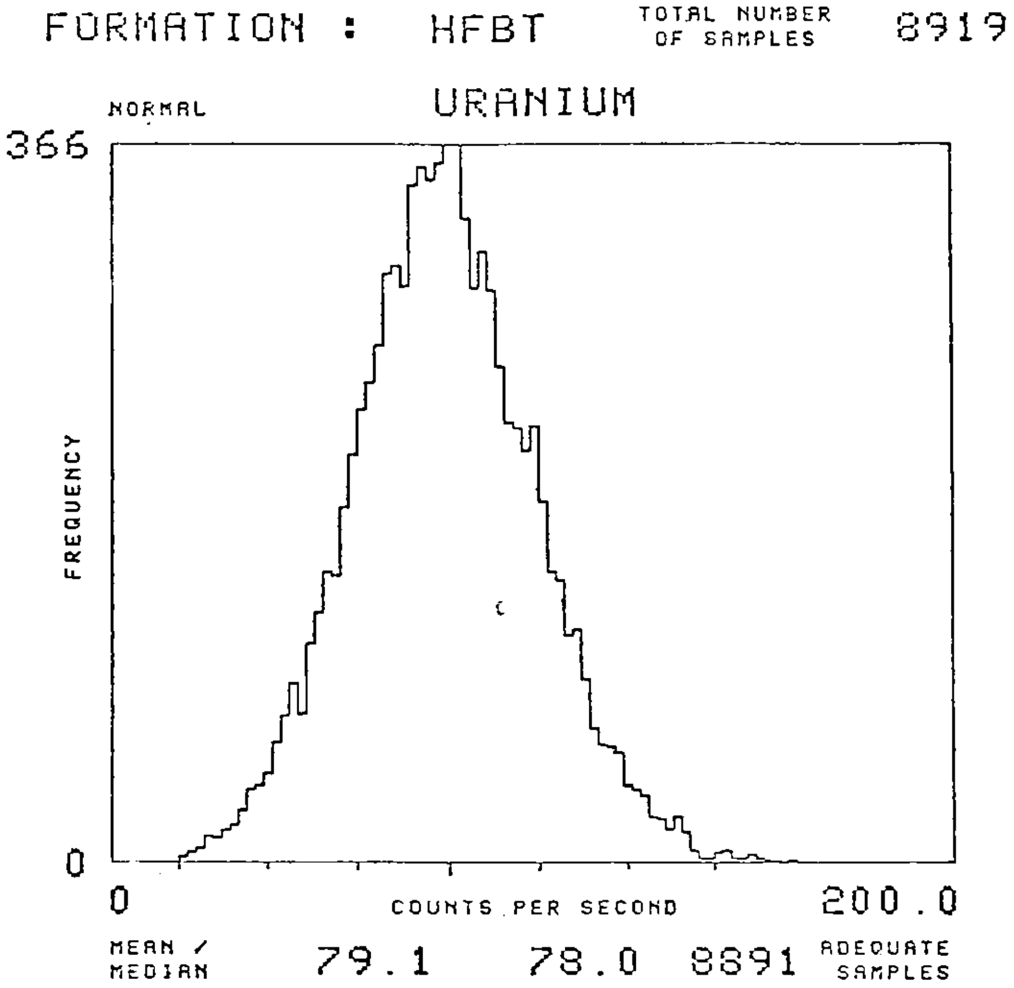


Figure 14. Sample Geologic/Soil Formation Histogram

GEOCHEMICAL ANALYSIS

The required "geochemical analysis" under this project had as its objective - "to establish geochemical units for comparison with mapped surface geologic units for gamma ray statistical analysis and interpretation purposes". Since any effective method of interpretation of radiometric data involves consideration of multiple populations of data, the following described process was applied to data from all of the quadrangles involved in the project.

This geochemical analysis comprised two separate processes. The first involved examination of each geologic formation's histograms for clearly polymodal distributions in the K, U, and T populations. If found to be polymodal, and if samples comprising each mode were spatially coherent, then the unit was broken into subunits and incorporated into the Uranium Anomaly/Interpretation Map. If however, the samples were randomly dispersed throughout the quadrangle, the formation in which they occurred was not subdivided and was treated in the normal fashion.

The second process in the geochemical analysis involved the generation of principal components for each formation within the quadrangle. The variables used were K, U, and T which resulted in three (3) components per unit. Principal components were examined for similarities and/or differences amongst the rock units. A discussion of similarities and/or discrepancies observed, as well as possible causes, has been incorporated into the interpretation of individual quadrnagles. Additionally, tabulated principal component results have been enclosed in each quadrangle's statistical appendix at the end of this report.

Principal component analysis has been used extensively in the sciences for many years. Good references are; J.C. Davis, 1973; the extensive and comprehensive series of statistical programs written at the University of Kansas edited by F. Merriam; and Multivariate Data Analysis by Cooley and Lohnes, 1971.

Principal component analysis is not a statistical procedure per se, that is, no assumptions about a variable's distribution or sampling are necessary to ensure useful results other than a sufficient number of samples (Reference Trochimczyk & Chayes, 1977, 1978) as is required for factor analysis. In principal component analysis the primary interest is in determining whether some small number of components account for most of the variance while the remaining components account for only small amounts of variance (which can often be due to idiosyncratic variations in individual variables).

In the principal component matrix, the eignevalues associated with each component represent the amount of total variance accounted for by the factor. Therefore, the importance of a component may be evaluated by examining the proportion of the total variance accounted for:

Proportion of total variance accounted for by component

$$i = \frac{\lambda_i}{n}$$

where λ_i represents the eigenvalue of the $i^{\underline{th}}$ component and n represents the number of variables in the set.

In order to compute the principal components for each formation, all individual samples of three variables, K, U, and T were normalized - that is, the individual variable's count rate minus its arithmetic mean was divided by its standard deviation prior to the generation of the correction matrix. This standardization has the advantage of allowing the use of measurements that are orders of magnitude different in absolute value by making them numerically equivalent. The normalized data were then input to a program to generate the correlation matrices, one per formation. Each correlation matrix is then input to the principal component program which computes: the three principal components; the percentage of total variance accounted for by each component and the correlation between each variable and that particular principal component. These data are included in the statistical appendices for each quadrangle.

In correlating ground data (geochemical, mineralogical, etc.) with results obtained from the above described process it must be remembered what an individual airborne gamma ray sample physically measures. First, the terrestrial component of the gamma ray radiation measured by the airborne detector emanated primarily from the upper 18 inches of material on the earth's surface (Gregory & Horwood, 1961). The airborne measurement cannot "see" any deeper into the underlying rock material, and is essentially a measurement of the soil or exposed rock (weathered) radioactivity. Secondly, since each airborne sample is an accumulation of occurrences measured on a moving platform over a fixed period of time, the individual sample represents a large areal extent of surficially exposed material. For this survey with specifications of 400 feet mean terrain clearance and an average ground speed of 141 miles per hour, a single sample roughly corresponds to an oval approximately 800 feet long by 600 feet wide (assuming an infinite, uniformly distributed source). Therefore, correlations of ppm measured on the ground and airborne measurements must be carefully considered in view of the large volume of material actually being measured. Accordingly, the principal components of a given formation represent tremendous volumes of surficial materials and must be considered as being such in the interpretation.

DATA PRESENTATION

GENERAL

Several 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 data presented in the form of radiometric profiles, flight path recovery maps, anomaly maps, and histograms. Microfiche data are contained in Appendix I of this volume. Data tapes are available separately.

RADIOMETRIC PROFILES

Stacked profiles were prepared from 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 15. 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.

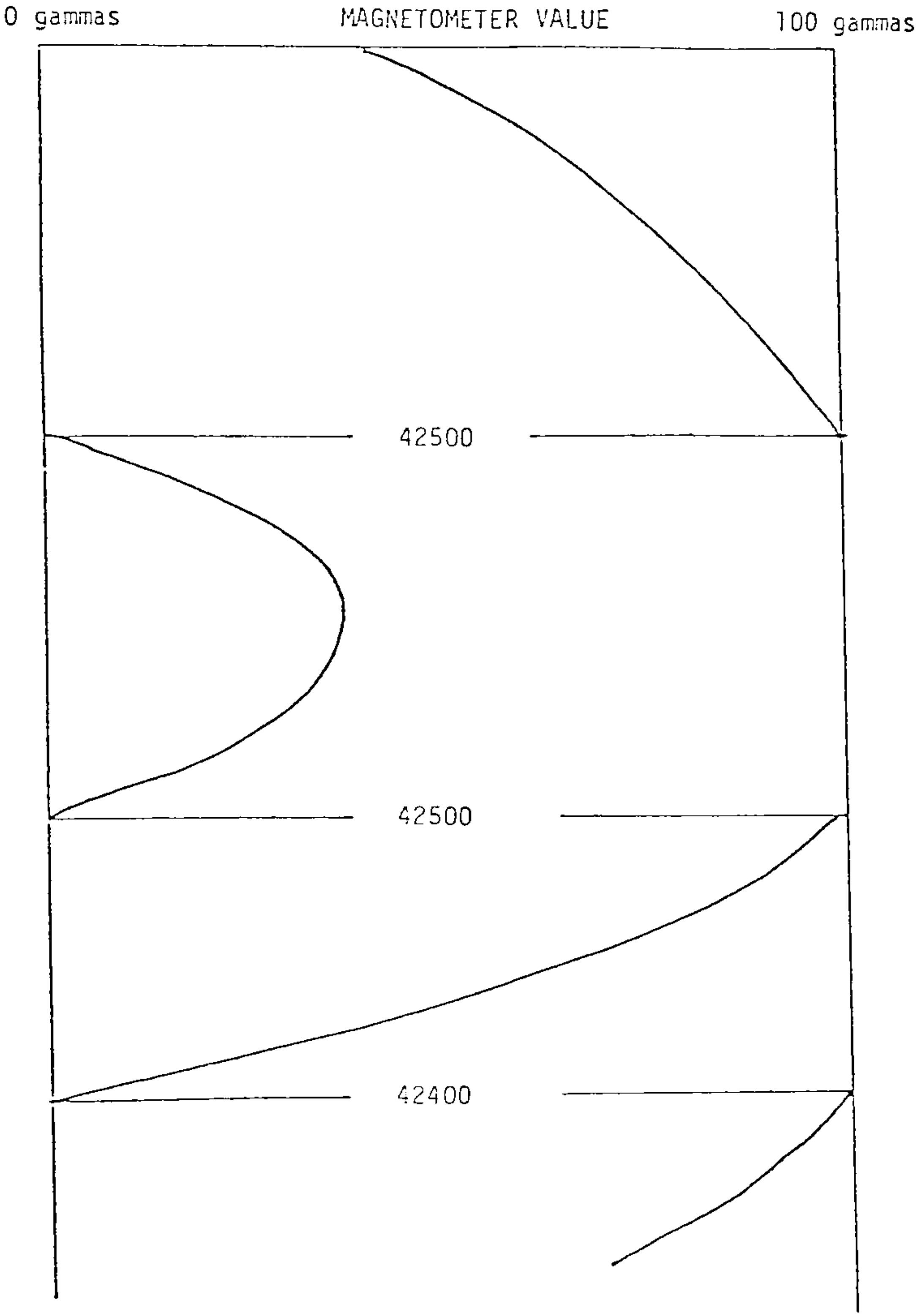


Figure 15. Plotter Step Value Labeling

MAGNETIC PROFILES

A set of profiles containing the magnetic data (corrected, with IGRF removed), barometric altimeter data, radar altimeter data, 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 flow. Reduced scale, 1:500,000 copies of these are presented in Volume II of this report.

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 seventh data point since the data had been averaged over a 7 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 line with negative standard deviation 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.

In addition, these anomaly maps are presented in Volume II of this report as 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 fuction of geologic formation, are presented in Volume II of this report. Information contained on these histograms includes the 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 on microfiche. The microfiche are contained in Volume I of this report as Appendix I. 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 indicated that the data are statistically adequate. A value of 1 indicates that the data are statistically inadequate. Data collected in excess of 700 feet 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 varies 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 formations.

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

7. U/TH, U/K, Th/K - calculated ratios of the various parameters, and the 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 G.

DATA INTERPRETATION

METHODOLOGY

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

Within this context, data interpretation has been oriented toward gross regional detection and description of anomalously high concentrations of uranium. To accomplish this, the profile data were located by geologic units (as described previously), histograms were produced and, "geochemical" and statistical analysis performed. The histogram/distribution of each variable for each geologic type was examined to determine its central tendency or most frequently observed count rate for that variable over that particular geologic unit. No Chi Square tests were performed on units having less than 20 statistically adequate samples. For some units the best estimate of central tendency for a particular variable was the median and not the arithmetic mean. The lower mode was used as the measure of central tendency for polymodal distributions. Each seventh sample from the averaged data was plotted with its corresponding standard deviation on the anomaly map for each variable.

Minimum requirements in the subsequent interpretation for a valid uranium anomaly are defined as follows:

1. Two (2) consecutive averaged U samples lying two or more standard deviations above the mean; or, three consecutive averaged Bi_{214} samples, two of which are one (1) or more standard deviations and the third of which is two (2) or more standard deviations above the mean.

2. Two (2) consecutive averaged U/T ratios which are one (1) or more standard deviations above the mean.

3. The U/T 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/T ratio is considered questionable.

Statistical anomalies which meet the above criteria can result from several factors or circumstances including: (1) True concentration of radioactive minerals, (2) differential surface cover (soils and/or vegetation) within a lithologic unit, (3) Processes concentrating uranium or thorium within soils (i.e.; aeolian sands, caliche, etc.), (4) Extreme facies variation within a mapped unit, (5) effects of variable weathering of different rocks within a mapped unit, and (6) discrepancies between actual outcrops and what has been mapped.

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 counting rates could thus be easily and quickly determined and compared with the associated geological, magnetic, and statistical trends. Only the long variations within each variable would show any continuity from line to line (on a wide line spacing); thus, only regional trends will appear on these maps. By overlaying each map on the altimeter map, areas of questionable altitude were immediately discarded from further interpretation (e.g., refer to Figures 17, 18, 19 and 20).

Each quadrangle's stacked profiles were overlaid on the corresponding geologic 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 surficial trends as reflected in the gamma ray profiles were only examined in a cursory manner. Even during such a cursory examination of the profiles it was clearly indicated that the spectrometer system was highly sensitive to changes in gross surface composition (even in areas of low counting rates). Thus radiometrics have a real potential for performing general surficial mapping/"geochemical analysis" on a geologic formation (or soils) basis in addition to merely radioactive mineral "anomaly hunting".

Mean values of percent potassium (%K), equivalent uranium (eU), and equivalent thorium (eT) incorporated into the text are based on the radiometric systems sensitivity as defined by calibrations on the DoE's Lake Mead Dynamic Test Range. Normalized equivalent sensitivities at 400 feet altitude are:

Radioelement	Equivalent Percent / PPm	Counts/Second
K	1% K	90.0
U	1 ppm eU	9.6
T	1 ppm eT	6.4

The anomaly tables included with each quadrangle's interpretation discussion list only the urainum anomaly map samples comprising the anomaly. On these tables, an anomaly is described as being either a U or U/T anomaly. The "U/T" designation implies at least one supporting U/T ratio is two (2) or more standard deviations above the mean. "U" only implies the U/T supporting ratios only meet minimum requirements.

ROCK SPRINGS QUADRANGLE

The geologic map on which the statistical analysis and interpretation were based was provided by DoE/BFEC. Formation descriptions included in Appendix A were derived primarily from the Geologic Atlas of the Rocky Mountains (1972).

Dominant regional structural features within the quadrangle are the north-south trending Rock Springs Uplift, an anticlinal feature with a central core of Cretaceous sediments, occupying the central third of the quadrangle and three major Tertiary basins; the Green River to the west, and the Red Desert and Washakie to the east. A small anticlinal feature, the Wamsutter Arch, trending westwardly towards the Uplift, separates the Red Desert Basin from the Washakie Basin. A series of east-northeasterly trending faults occur within the northern third of the uplift within the Cretaceous sediments.

Quaternary sediments comprise 20% of the total surface area within the quadrangle. Minor undifferentiated Tertiary Volcanics (Tvu), generally consisting of alkalic extrusive and intrusive rock, occur in the northern most extent of the Rock Springs Uplift. Tertiary sediments of Eocene age dominate the quadrangle (about 60% of exposed material). The Paleocene Fort Union Formation and Cretaceous sediments comprise the bulk of the remaining 20%.

The Wasatch, Green River, Bridger and Washakie Formations are dominantly continental and lacustrine sediments. Each of these formations exhibit great interformation variability. The Green River Formation was deposited in ancient Lake Gosiute and contain the majority of the known oil shale reserves in the U.S.A. The Cretaceous units (e.g. Lance, Fox Hills/Lewis, Almond, Ericson, Rock Springs, Blair, and Baxter Formations) are representative of complicated, short period/high energy, oscillating marine to continental, paludal, and lacustrine environments. In general, the intermontane basin sedimentation within the area becomes more pronounced and shifts away from marine influence after Cretaceous times. Much of the intra-formational facies descriptions available have been derived from extensive subsurface studies (logging, drillhole, seismic surveys, etc.) conducted for oil and gas exploration within the Tertiary basins. The outcrop map is deceptively simple in comparison to results of such work.

Both Cretaceous and Tertiary sequences present within the quadrangle contain complex lithologic relations resulting from shifting depositional conditions brought about by complex structural uplift and subsidence during the Laramide Orogeny. As a result of these conditions, formational characteristics may differ from basin to basin. This implies a potential for significant statistical variability of radiometric data within the formations.

Although no Precambrian rocks occur within the quadrangle, large exposures lie to the north and south in the Wind River and Uinta Mountains.

In general, Love (1960) and Denson (1964) provide a thorough treatment of Wyoming Miocene and Pliocene sediments, with special treatment of the uraniferous Browns Park formation by Buffler (1967). The Eocene has been extensively studied by such investigators as Cashion (1967), Bradley (1964), Roehler (1969), and Oriel (1962). Love (1961) has synthesized Cenozoic sediments and structural mobility. A number of investigators such as Waage (1967), Weimer (1960), and McCubbin and Brady (1969) have worked on Cretaceous environments in attempts to unravel the interrelation between units and paleo-environments.

Known uranium occurrences are restricted to the northeast corner of the quadrangle (refer to Figure 3) in the uraniferous coal deposits of the Red Desert Basin (Masursky and Pipiringos, 1959) and in some Eocene phosphatic sediments (Love, 1961).

Interpretation, Discussion, and Results

The resulting uranium anomaly/interpretation map is displayed in Figure 16 . Anomalies depicted on this map are summarized in Table 1 . Figures 17 through 20 present pseudo-contour maps of K, U, T and magnetics utilized for regional evaluation. General lithologic unit descriptions are presented in Appendix A . Statistical tables for these units, citing type of distribution, measure of central tendency, standard deviation, and principal component results are given in Appendix C .

In general, the Cretaceous units have lower counting rates than Tertiary units. This relationship can be seen on the potassium pseudo-contour map, especially over Cretaceous units flanking the eastern edge of the Rock Springs Uplift.

URANIUM ANOMALY/ INTERPRETATION MAP

ROCK SPRINGS QUADRANGLE

U.S. DEPARTMENT OF ENERGY

APPROXIMATE SCALE 1 : 500,000

- ▬ - URANIUM ANOMALIES
- ▭ - THORIUM ANOMALIES
- ┼ ┼ - SEDIMENTARY STRUCTURE

MAGNETIC STRUCTURE

- ┼ ┼ - MAGNETIC BASEMENT HIGHS
- — — - INFERRED FAULTS IN MAGNETIC BASEMENT
- ▨ - INFERRED MAGNETIC BODY

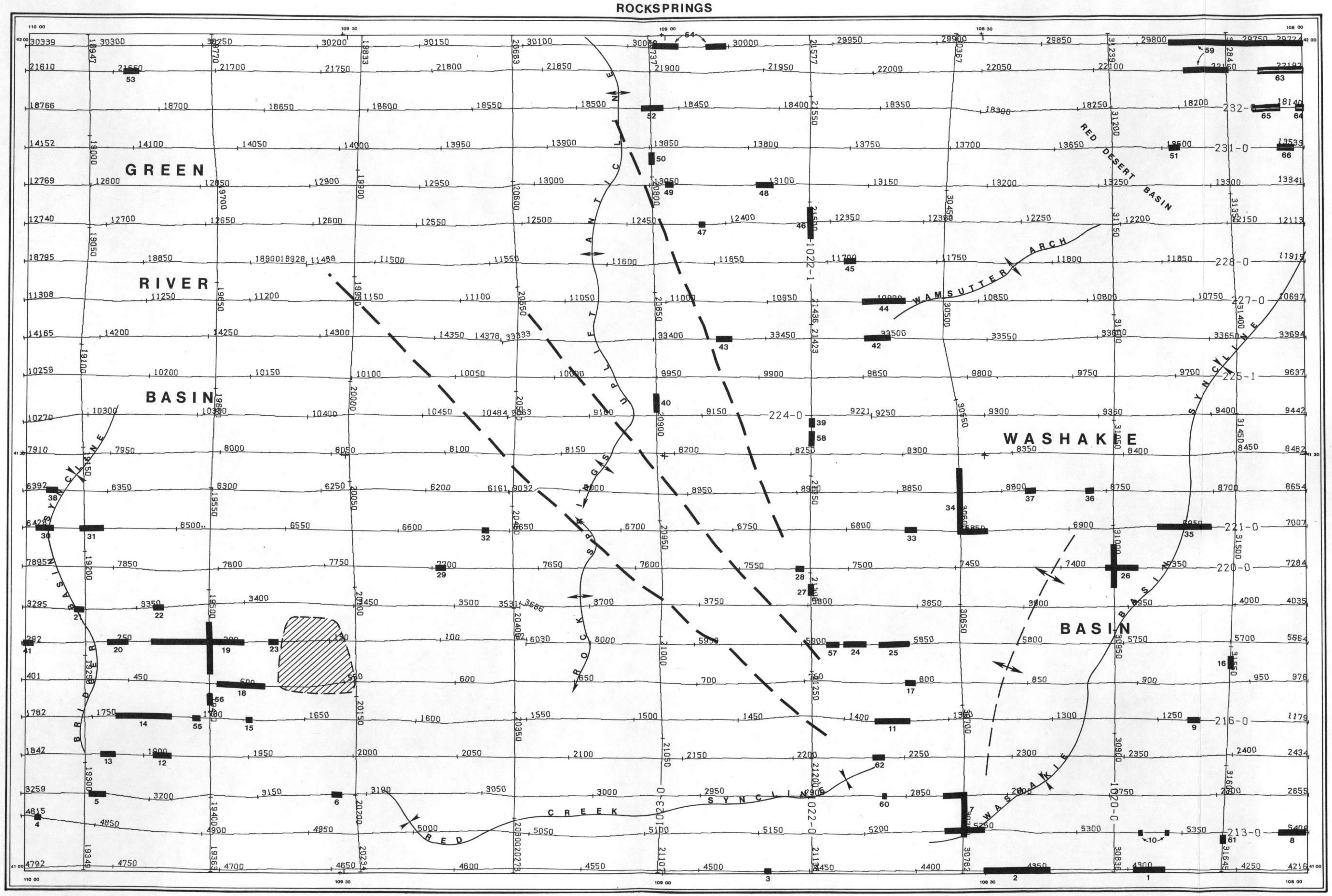


Figure 16 Rock Springs Quadrangle-Uranium Anomaly/Interpretation Map*

SURVEY AND COMPILATION BY:

geoMetrics

TABLE 1

ANOMALY SUMMARY

ROCK SPRINGS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
1	U/T	212	Tbp		6	3						
2	U	212	Tw, Tbp		4	11	3					
3	U/T	212	Trg		11	0	0	1				
4	U/T	213	Tb			2						
5	U	214	Tb		1	4						
6	U/T	214	Tgr		2	1						
7	U	213,214,TL21	Tw, Tgr		15	13						
8	U	213	Tgr		2	13						
9	U/T	216	Twk		2	4	2					
10	U/T	213	Twk		1	0	2					
11	U	216	Tgr		4	7	1					
12	U/T	215	Tb		1	3	1					
13	U/T	215	Tb		2	1	1					
14	U/T	216	Tb		5	4	6	1				

TABLE 1

ANOMALY SUMMARY

ROCK SPRINGS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
15	U	216	Tb		1	2						
16	U/T	T19	Twk		2		1					
17	U	217	Tgr		2		1					
18	U/T	217	Tb, Tgr		5	5	2	1				
19	U/T	218, T126	Tb		19	12	2	1				
20	U/T	218	Tb		2	2	1					
21	U/T	219	Tb		2	0	1					
22	U/T	219	Tb		2	1						
23	U/T	218	Tgr		2	1						
24	U	218	Tw, Tgr		2	4						
25	U	218	Tgr		3	2						
26	U/T	220, T120	Twk		2	6	3	7	1	3		
27	U/T	Tl22	Tw		2	1						
28	U/T	220	Tw		1	0	0	2				

TABLE 1

ANOMALY SUMMARY

ROCK SPRINGS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
29	U	220	Tw			2	1					
30	U/T	221	Tb		3	2						
31	U/T	221	Tb		3	3						
32	U/T	221	Tfu			1	1					
33	U	221	Tw		1	2						
34	U/T	221, T121	Tw, Tgr		11	10	2					
35	U/T	221	Twk		1	7	2	3				
36	U/T	222	Tgr		2	1						
37	U/T	222	Tw		2	1						
38	U/T	222	Tb		2	1						
39	U/T	Tl22	Ke				1	0	0	0	1	
40	U/T	Tl23	Kba		3	2						
41	U	218	Tb		2	1						
42	U	226	Kl	1	4	2	2					

TABLE 1

ANOMALY SUMMARY

ROCK SPRINGS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
43	U/T	226	Kbl			3	0	1				
44	U/T	227	Kl	3	1	6	2					
45	U	228	Kl		2	1						
46	U/T	Tl22	Kl	2	5	3	1					
47	U/T	229	Ke		1	0	0	1				
48	U	230	Kl		2	3						
49	U/T	230	Ke			2						
50	U/T	Tl23	Ke		2	1						
51	U/T	231	Tw/Q		2	3	0	1				
52	U	232	Tfu/TVU		2	3	0	1				
53	U	233	Tb		1	2	1	1				
54	U	234	Tw/Tgr	7	3	6	3	1	0	0	0	1
55	U/T	216	Tb		1		1					

TABLE 1

ANOMALY SUMMARY

ROCK SPRINGS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ* 0	1	2	3	4	5	6	7	8
56	U	Tl26	Tb		1	2						
57	U	218	Tgr		2	1						
58	U	Tl22	Kal		3	0	1					
59	U	234, 233	Q, Tw		2	6	14	5	7	3	1	3
60	U	214	Tw				1					
61	U/T	Tl19	Tgr, Tbp			2						
62	U	215	Tgr		2	1						
63	T	233	Tw, Tbs, Q			3	3	1	2	1		
64	T	232	Tw		1							
65	T	232	Tw		2	2	4					
66	T	231	Tw		1	2	1	1				

*Reflect only U channel except 63-66.

ROCK SPRINGS

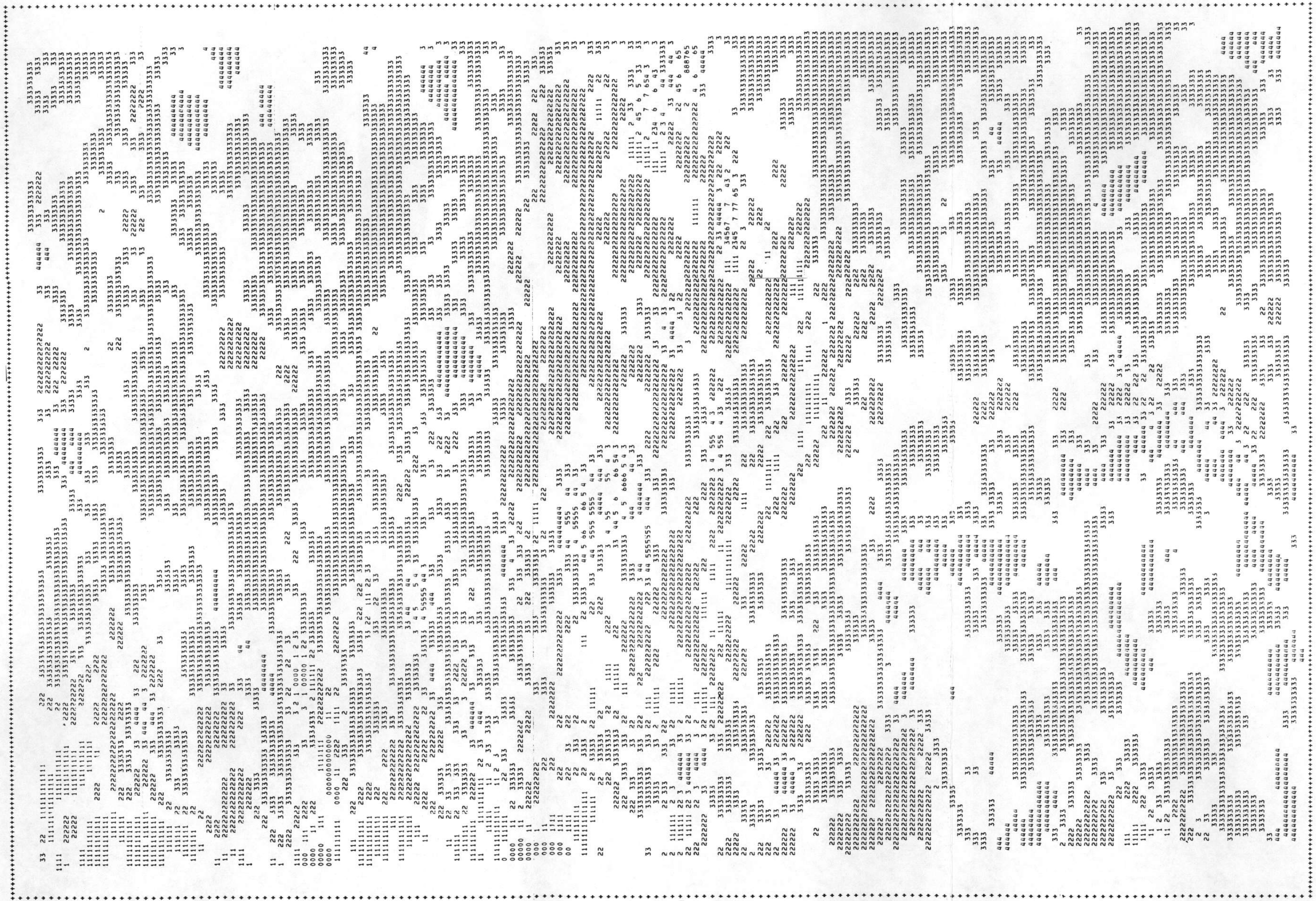


Figure 17 Rock Springs Quadrangle-Potassium Pseudo - Contour Map*

ROCK SPRINGS

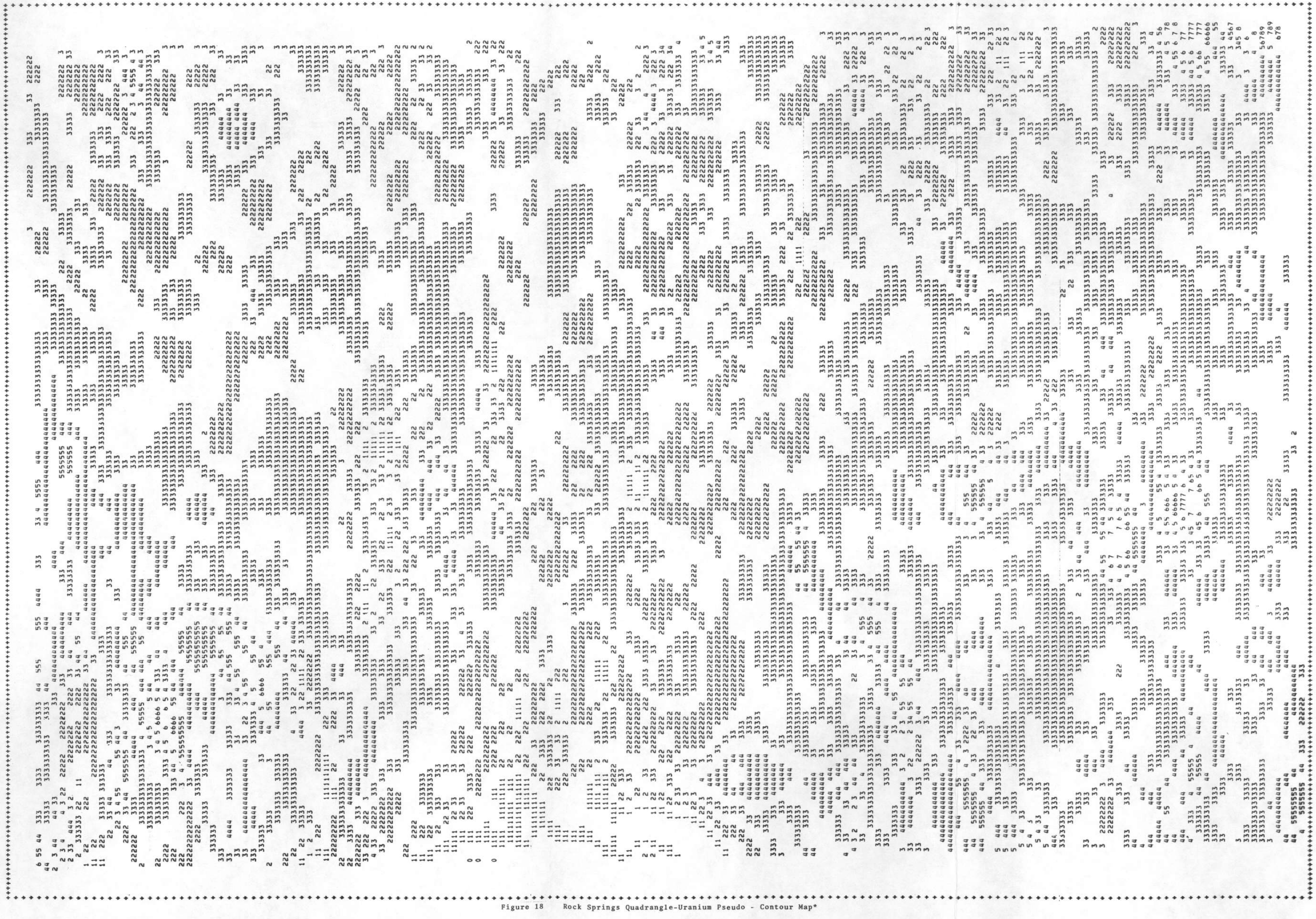


Figure 18 Rock Springs Quadrangle-Uranium Pseudo - Contour Map*

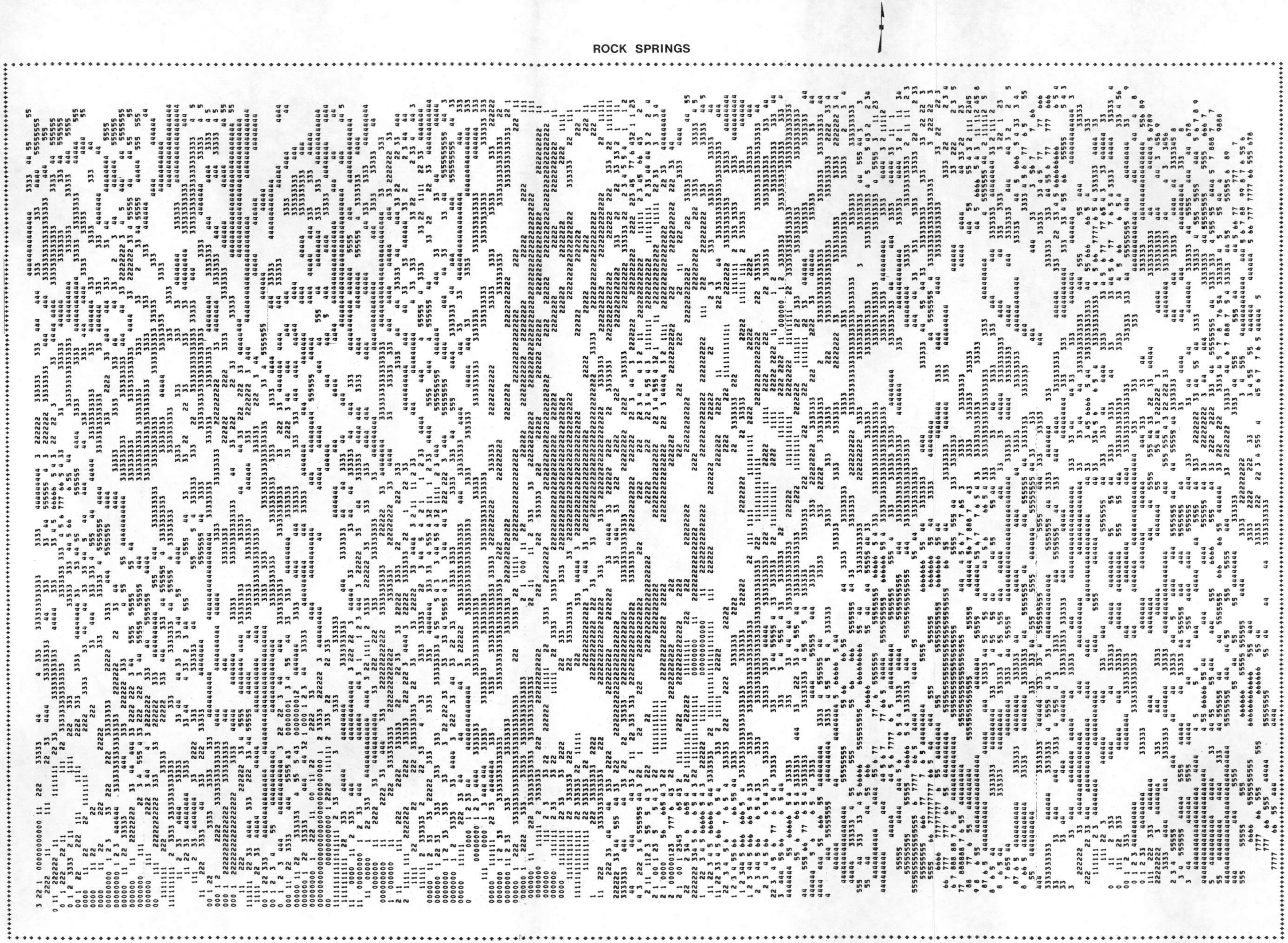


Figure 19 Rock Springs Quadrangle-Thorium Pseudo - Contour Map*

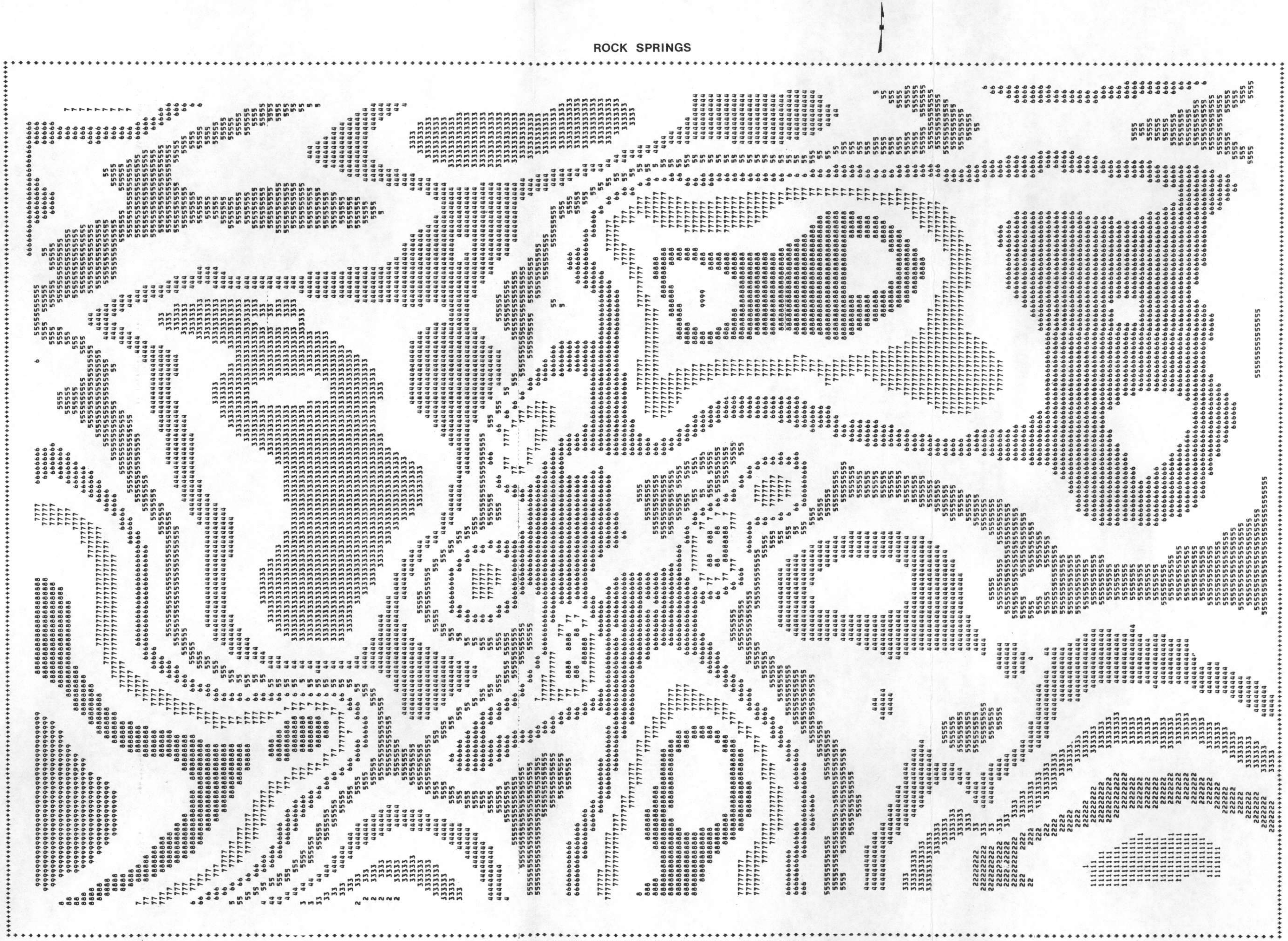


Figure 20 Rock Springs Quadrangle-Magnetic Pseudo - Contour Map*

The uranium pseudo-contour map displays broad areas of relative highs in the southeastern and southwestern portions of the quadrangle. These correspond approximately to the southern portions of the Washakie Basin, Red Creek Syncline and Green River Basin. In the Washakie, the radiometric pattern consists of a series of highs which, in general, correspond to the basin margins as defined by exposed Wasatch and Washakie formations. A similar pattern of statistical anomalies is clearly present on the statistical anomaly map. Both thorium and uranium pseudo-contour maps exhibit broad lows which trend through the axis of the Rock Springs Uplift.

In the western one-third of the quadrangle, the uranium pseudo-contour map highlights the Green River Basin/Rock Springs Uplift boundary. Within the Green River Basin, high count rates and statistical anomalies cluster within the southern portion of the Bridger Formation. This concentration of high count rates and anomalies may be related to exposed Precambrian rocks of the Uinta Uplift which occur to the south of the quadrangle. With the exception of Table Mountain, the minor volcanic extrusives and intrusives are not in evidence on the pseudo-contour maps.

The Uranium Anomaly/Interpretation map exhibits 62 Uranium and 4 Thorium anomalies which remain after screening for relative thorium depletion, U/T ratio values, water/marsh relationships, and proximity to cultural features. In certain cases the statistical anomalies do not meet all the specified criteria (particularly the U/T ratio) but were included due to high count rates and/or high standard deviations on the uranium channel (e.g., anomaly 59).

Anomaly 59 is the largest and most extensive uranium and thorium anomaly at 120 cps (12 ppm eU). Its occurrence over Quaternary material probably indicates extensive incorporation of the underlying Tertiary Wasatch and Battle Springs formations. The Red Desert basin, where this anomaly occurs, is noted for the presence of uraniferous coals (Masursky and Pipiringos, 1957).

Anomalies 1, 2, 7-11, 16, 17, 24 - 28, and 33 - 37 occur in an oval pattern within the Washakie basin in the Eocene Wasatch, Green River, and Washakie Formations. These anomalies generally occur in mild to moderate badland topography wherein outcrop exposures may be related to observed anomalies. Anomaly 26 is one of the strongest (106 to 109 cps or minimum 10 ppm eU) within the quadrangle and has a very strong associated U/T anomaly. Similarly, anomaly 35 at 91 cps (9 ppm eU) has one of the highest U/T ratios.

A cluster of anomalies (4, 5, 11 - 15, 18 - 21, 23, 55, and 56) occur within the Bridger Formation in the Green River Basin at the southwestern corner of the quadrangle. Most of these anomalies appear related to local high topographic features within the badland topography. In general, these anomalies have a lesser amplitude, but, are as broad as those occurring in the Washakie Basin. The highest count rate exhibited by this group occurs at anomaly 19 (70.9 cps or 7 ppm eU). Many of the anomalies (5, 13, 14, 19, and 18) may be structurally controlled.

Anomaly 54, at Steamboat Mountain, has a maximum value of 95 cps (or 9.5 ppm eU). It occurs in Green River and Wasatch Formations but is adjacent to volcanics (Tvu). This anomaly may be the result of the volcanics providing surficial detritus to the surrounding area.

Anomalies (39, 42 - 50, 52, and 54) form a group which are coincident with the northeast flank of the Rock Springs Uplift. These anomalies occur mostly within Cretaceous sediments (Lance and Erickson Formations). Within this group, the highest count rate is exhibited by anomaly 39 (103 cps or 10 ppm eU). This anomaly occurs within the Erickson and Almond Formations. Examination of the 35mm flight recovery film indicates the anomaly corresponds to a group of buildings and cultivated fields. The association with agricultural activity makes the anomaly suspect, but, no potassium anomaly is present as might be expected if a large quantity of fertilizer had been freshly applied. It is possible that farming activity has exposed underlying soil which is more indicative of the underlying sediments.

The magnetic pseudo-contour map generally reflects the mapped geology. Within the central portion of the quadrangle, an area of high amplitude, short wavelength anomalies (Rock Springs Uplift) separate two zones of low amplitude, very long wavelength response (Green River Basin to the west and the Washakie and Red Desert Basins on the east).

Three inferred faults within the magnetic basement strike northwesterly across the Rock Springs Uplift and are coincident with a mapped change in the strike of the axis of the uplift. The northern-most inferred fault appears spatially related to the cluster of uranium anomalies occurring on the northeast flank of the Rock Springs Uplift. The mapped Wamsutter Arch coincides approximately with a linear offset in the magnetic gradient as it approaches the Rock Springs Uplift from the east.

The weak, shorter wavelength anomalies to the south within the Washakie Basin, occur approximately centered in the oval cluster of uranium anomalies. This suggest that the magnetic basement may be relatively shallow. What influence, if any, this has with the overlying sediments is completely unknown.

The triangular shaped cluster of uranium anomalies in the southwest corner of the quadrangle terminates on an inferred magnetic basement feature. This feature occurs at the southwest end of a series of high applitude magnetic anomalies which trend to the northeast across the north-south striking Rock Springs Anticline. The western edge of these northeast trending magnetic highs may mark a fault, dipping down towards the deeper portion of the Green River Basin to the west. The area of South Table Mountain (location of anomaly 52) is also the location of a relatively steep magnetic gradient interpreted to be a relative magnetic basement high (refer to magnetic pseudo-contour map).

Geochemical Analysis Results

None of the K, U, and T histograms for the quadrangle's geologic units are sufficiently polymodal to warrant subdividing existing units (Refer to Histograms in Vol.2). Two of the Tertiary units, the Bridger and Wasatch formations, however, contain subunits which are separable on the profiles and pseudo-contour maps. The northern half of the Bridger has lower overall uranium count rates than does the southern portion. This is perhaps due to mantling by soil. Exposures of the Wasatch in The Red Desert differ greatly in the uranium and thorium channels from occurrences elsewhere in the quadrangle. This is due to uraniferous subituminous coal in the area (Masursky, Pipiringos, 1959).

Principal component analysis revealed that: the first two components generally account for 80-90% of the total variance of the data; the first component generally correlates with potassium and thorium; the second component generally correlates with uranium. Three formations, Q (undifferentiated Quaternary), Tw (Tertiary Wasatch), and Kr (Cretaceous Rock Springs) differ from this in that their first components correlated with uranium and thorium and the second with potassium. (Refer to Appendix C). An attempt was made to discover the underlying cause(s) of the principal component results by comparing them with, (1) mean count rates per channel per formation, (2) available formation descriptions, (3) number of valid statistical anomalies, and (4) geographic location.

Two of the units whose first components correlated with uranium and thorium and whose second correlated with potassium, the Rock Springs and Wasatch Formations, are nowhere in contact with each other and differ in age by 30 million years. Their respective mean count rates per channel are different; the Tertiary (Wasatch) being greater than the Cretaceous (Rock Springs). The Rock Springs formation contains no uranium anomalies, whereas the Wasatch contains 14. The Wasatch is described as a red bed of mixed fluvial, alluvial, peidmont, and paludal sediments while the Rock Springs is a coarse, arkosic sandstone.

Comparison of the Wasatch with the Eocene Bridger Formation, TB, (which has components in agreement with the previously described general results) shows, (1) almost identical mean counting rates for the three radiometric channels, (2) Wasatch has 18 uranium anomalies versus 14 within the Bridger, and (3) the Bridger is a varicolored siltstone with interbedded volcanic ash layers while the Wasatch is a coarse, clastic redbed sequence.

The Cretaceous Blair Formation, KBL, which is in contact with the Rock Springs, has almost identical mean count rates as does the Rock Springs; and has one uranium anomaly compared to none for Rock Springs Formation. Each was an equivalent number of samples. The Blair is described as being predominantly a shale compared to the arkosic sandstone of the Rock Springs Formation.

The undifferentiated Quaternary unit (Q) presents a different problem. It is scattered throughout the map, overlying (and containing material from) formations that follow the general rule as well as the other two formations (Tw, Kr) which differ. The Quaternary has count rates in all channels which are very similar to both the Bridger and Wasatch Formations.

The comparisons noted above have no obvious common denominator that could link the principal component results to the formations involved. Hopefully, more detailed studies would suggest an answer to the apparent contradictions.

RAWLINS QUADRANGLE

The geologic map upon which the interpretation and statistical analysis were based was provided by Doe/BFEC. It should be noted that units labeled Ql and Tg which occur in the northwest corner of the Rawlins Quadrangle are not defined in the map's explanation. For purposes of this report, they have been defined as Lake deposits and Green River Formation, respectively. Formation descriptions in Appendix A were derived primarily from the Rocky Mountain Atlas of Geology (1972).

Topography within the quadrangle varies from gently rolling plains (at approximately 7,000 feet above sea level) to rugged mountains with elevations upward of 11,000 feet (Medicine Bow, etc.) comprising the Continental Divide. The area is in general semi-arid with few major bodies of water (except for the Seminoe Reservoir northeast of the City of Rawlins). The North Platte River flows approximately through the center of the quadrangle, separating the Sierra Madre Mountains on the west from the Medicine Bow Mountains to the east.

Major geological structures within the area include: (1) the large Tertiary Washakie and Great Divide Basins in the west, (2) the northwesterly trending Rawlins, Sierra Madre and Medicine Bow Uplifts, (3) the lesser intermontane Tertiary Hanna and Carbon Basins in the northeast and, (4) the western edge of the Laramie Basin.

Approximately 40% of the quadrangle is mapped as Tertiary sediments contained primarily within the major basins. Precambrian rocks exposed in the major uplifts account for about 15% of the total area within the quadrangle. Mixed Quaternary sediments account for roughly 20%. The balance of exposed rocks are mapped as Cretaceous sediments with a few scattered outcroppings of Paleozoic rocks.

Faulting in the quadrangle includes major northwest trending thrust faults, forming the northern and eastern boundaries of the Precambrian uplifts, and complex normal faults which occur within the Tertiary and Cretaceous sediments. A large, northeasterly trending feature, the Mullen Creek - Nash Fork Shear Zone, cuts across the southeast corner of the quadrangle.

There are several known uranium occurrences and economic deposits within the Rawlins Quadrangle (refer to Figure 3). Commercial uranium deposits lie within the Poison Basin, in the southwest corner of the quadrangle (Ormond, 1957) -

also known as the Baggs area - and within the Miller Hill area northeast of the Town of Baggs. These deposits are within the Miocene Brown's Park Formation. A large district of non-economic uranium lies in the northwest portion of the quadrangle, in the uraniferous coals of the Red Desert Basin (Masursky and Pipiringos, 1959, Breger, et al., 1955). Within the Red Desert area, the thickest uraniferous coal beds occur along the transition between the Wasatch and Green River Formations.

Scattered uranium occurrences also lie within the Precambrian rocks of the Sierra Madre and Medicine Bow Mountains. (Houston, et al 1977). The location of these have been noted on the interpretation map. These uranium occurrences are within quartz pebble conglomerates, such as found within the Deep Lake Formation in the Medicine Bow Mountains and have been tentatively correlated with occurrences of uraniferous conglomerates within the Sierra Madre Uplift to the west. None of these occurrences are of economic grade, but their similarity to the Blind River deposits of southern Canada makes them of interest for further investigation.

Interpretation, Discussion and Results

The resulting uranium anomaly interpretation map is displayed in Figure 21. Anomalies depicted on this map are summarized in Table 2. Figures 22 through 25 represent pseudo-contour maps of K, U, T and magnetics used for regional evaluation. General lithologic unit descriptions for the quadrangle are given in Appendix A. Statistical tables, including principal component results, for each formation (citing type of distribution, measure of central tendency, and standard deviation) are given in Appendix D.

Within the Rawlins Quadrangle, the areas exhibiting the highest overall uranium count rates are the Red Desert Basin in the northwest; the Miller Peak Area in the central third of the quadrangle, immediately north and west of the Sierra Madre Uplift and the Poison Basin in the southwest corner of the quadrangle. Lesser uranium highs are present both in the north (Hanna Basin) and southeastern basin margins, near Sheep Mountain. Formations typically having the highest uranium count rates are not the crystalline Precambrian rocks. Rather, they are the Tertiary sediments such as the Battle Springs, Wasatch, and Browns Park Formations. Lowest uranium count rates generally occur in the eastern portion of the quadrangle, to the north of the Mullen Creek - Nash Fork Shear Zone; perhaps due to the overlying glacial deposits. (Refer to Figure 23, Uranium Pseudo-contour Map.)

URANIUM ANOMALY/ INTERPRETATION MAP

RAWLINS QUADRANGLE

U.S. DEPARTMENT OF ENERGY

APPROXIMATE SCALE 1 : 500,000

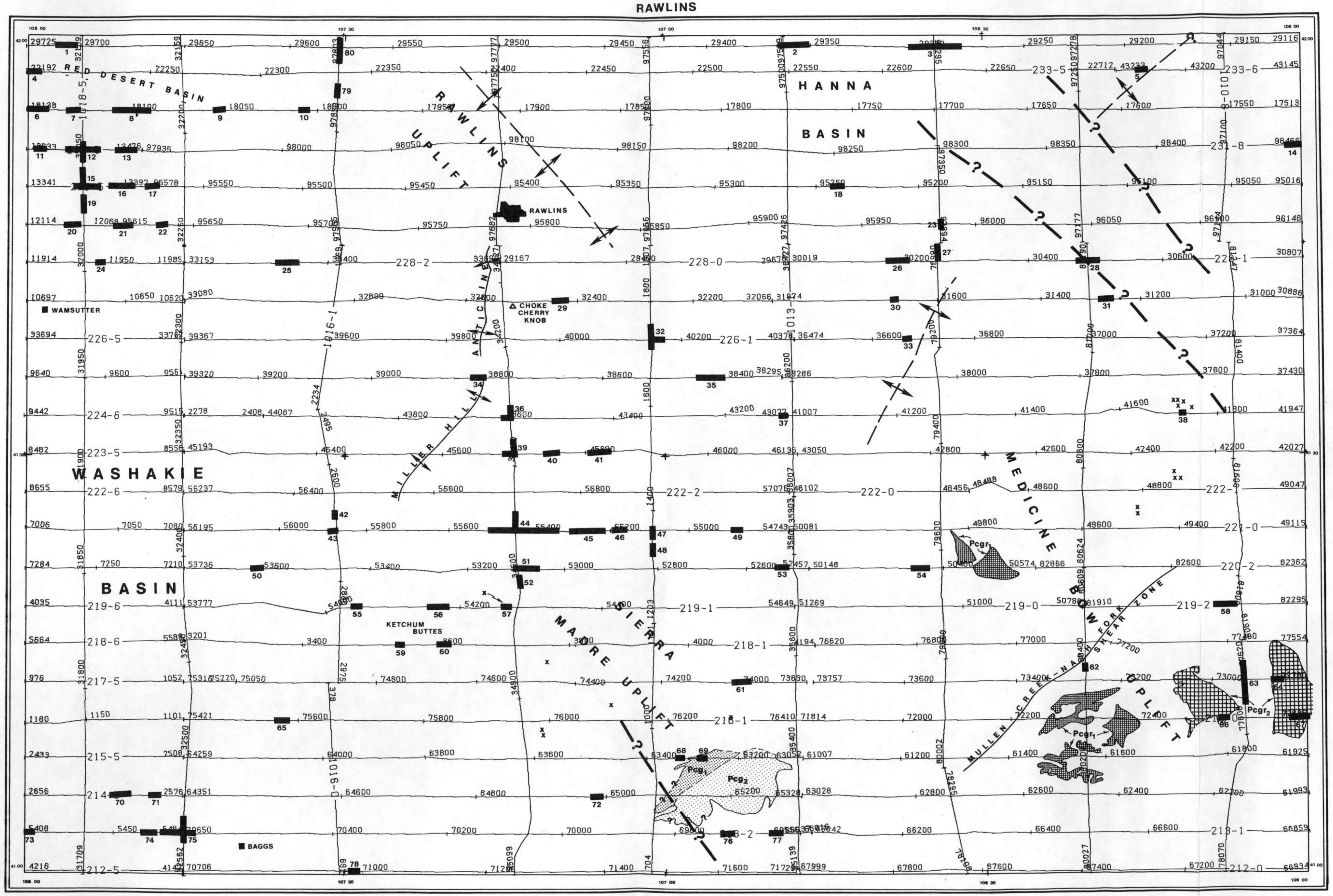


Figure 21 Rawlins Quadrangle-Uranium Anomaly/Interpretation Map*

▬ 00 - URANIUM ANOMALIES

-┼-┼- - SEDIMENTARY STRUCTURE

■ PERCY - TOWNS / CITIES

MAGNETIC STRUCTURE

-┼-┼- - MAGNETIC BASEMENT HIGHS

— — — - INFERRED FAULTS IN MAGNETIC BASEMENT

GEOCHEMICAL UNITS

Precambrian Granite

▦	Pcgr$_1$	T < 60 cps K < 230 cps
▦	Pcgr$_2$	T > 60 cps K > 230 cps
▨	Pcg$_1$	K < 160 cps
░	Pcg$_2$	K > 160 cps

x - Precambrian Uraniferous Conglomerates (Graff and Houston, 1977)

SURVEY AND COMPILATION BY:

geoMetrics

TABLE 2

ANOMALY SUMMARY

RAWLINS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ* 0 . 1	2	3	4	5	6	7	8
1	U	234	Ql	1	2	2	1				
2	U/T	234	TKF	4	3	2					
3	U/T	234	TH	7	7						
4	U	233	Q/TW	2		1	1				
5	U	233	KF	1	2						
6	U	232	Q/TBS	4	1	1					
7	U	232	TBS		3						
8	U	232	Q	8	2	1					
9	U/T	232	Q/Tbs	1	3						
10	U/T	232	Ql	1	2						
11	U	231	Tw	2		1					
12	U	231, TL 18	Tbs/Tw	9	3	2					
13	U	231	Ql, Q	4	1		1				

TABLE 2

ANOMALY SUMMARY

RAWLINS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
14	U	231	Tu/Ksn		1	2						
15	U	230/Tl18	Q/Tw		3	8						
16	U	230	Q/Tw		1	4	3	1				
17	U	230	TBS		1	3						
18	U/T	230	Kmb		2	1						
19	U	TL 18	Tw		1	4						
20	U/T	229	Tw		4	2						
21	U	229	Tbs/Tw		2	3	1					
22	U	229	Tbs/Tg		1	1						
23	U	229	Tu			1	1					
24	U	228	Tw		2	1						
25	U	228	Tfu/Q		4	1						
26	U/T	228	Tu/KLe		3	1	1					

TABLE 2

ANOMALY SUMMARY

RAWLINS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ* 0	1	2	3	4	5	6	7	8
27	U	TL 12	Tu/Kle		2	4						
28	U/T	228	Td/Kle		3	2						
29	U	227	Kmv		3	1						
30	U/T	227	Ksn/Kfmf			1	1					
31	U	227	Td		2	1						
32	U/T	226TL14	Kmv		6	2	1	1				
33	U/T	226	Pcu			1	1					
34	U	225	Kmv		2	2						
35	U	225	Kmv		4	2	1					
36	U	224/TL15	Q/Ksn		3	2	1					
37	U/T	224	Thp		1	1						
38	U/T,U	224	PCi/Pcsch			1	1					
39	U/T	223/TL15	Ksn/Q		5							

TABLE 2

ANOMALY SUMMARY

RAWLINS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ* 0	1	2	3	4	5	6	7	8
40	U	223	Q/Ksn		2	1						
41	U/T	223	Q/Ksn		1	3	1					
42	U	TL 16	Kmv/Tbp		2	1						
43	U/T	221	Tbp					1				
44	U/T	221/TL15	Tbp		6	18	2					
45	U/T	221	Tbp		6	4	3					
46	U/T	221	Tbp		2	2						
47	U/T	TL 14	Q/Tbp		1	1						
48	U	TL 14	Tbp		1		1					
50	U/T	220	Kle		2							
51	U	220	Tbp		6							
52	U/T	TL 15	Tbp		1	1						
53	U/T	220	Tnp		2	2	1					

TABLE 2

ANOMALY SUMMARY

RAWLINS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ* 0	1	2	3	4	5	6	7	8
54	U	220	Pcgn		2	2						
55	U	219	Kmv		2	1						
56	U/T	219	Tbp		4							
57	U/T	219	PCu		2	3						
58	U	219	Pcgn/Qal		2							
59	U/T	218	Tbp		2							
60	U/T	218	Tbp		2	1						
61	U	217	Pcu		2	1	1					
62	U	TL11	Pcgn		1		1					
63	U	TL10	Qal		3	8						
64	U	217	Pcgr		2	1						
65	U/T	216	Kle/Tbp		1	2						
66	U	216	Pcgr		1							

TABLE 2

ANOMALY SUMMARY

RAWLINS QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
67	U	216	Pcgr		3	1						
68	U	215	Pcu/Pcg		1	1						
69	U	215	Pcqm/Pcq		2	1						
70	U	214	Twc/Tgl		4	1						
71	U	214	Twc		2	1						
72	U	214	Pcqm		2	1						
73	U	213	Tgl		2		1					
74	U/T	213	Tbp		2	1	1					
75	U/T	213/TL17	Tbp/Twc		4	3	1		1			
76	U	213	Pcgn		2	1	1					
77	U	213	Pcu		2	1						
78	U/T	212	Kl/Tbp		1		1					
79	U	TL 16	Ql		3	1						
80	U	TL 16	Q/QL		1	4						

*Reflect only U channel

RAWLINS

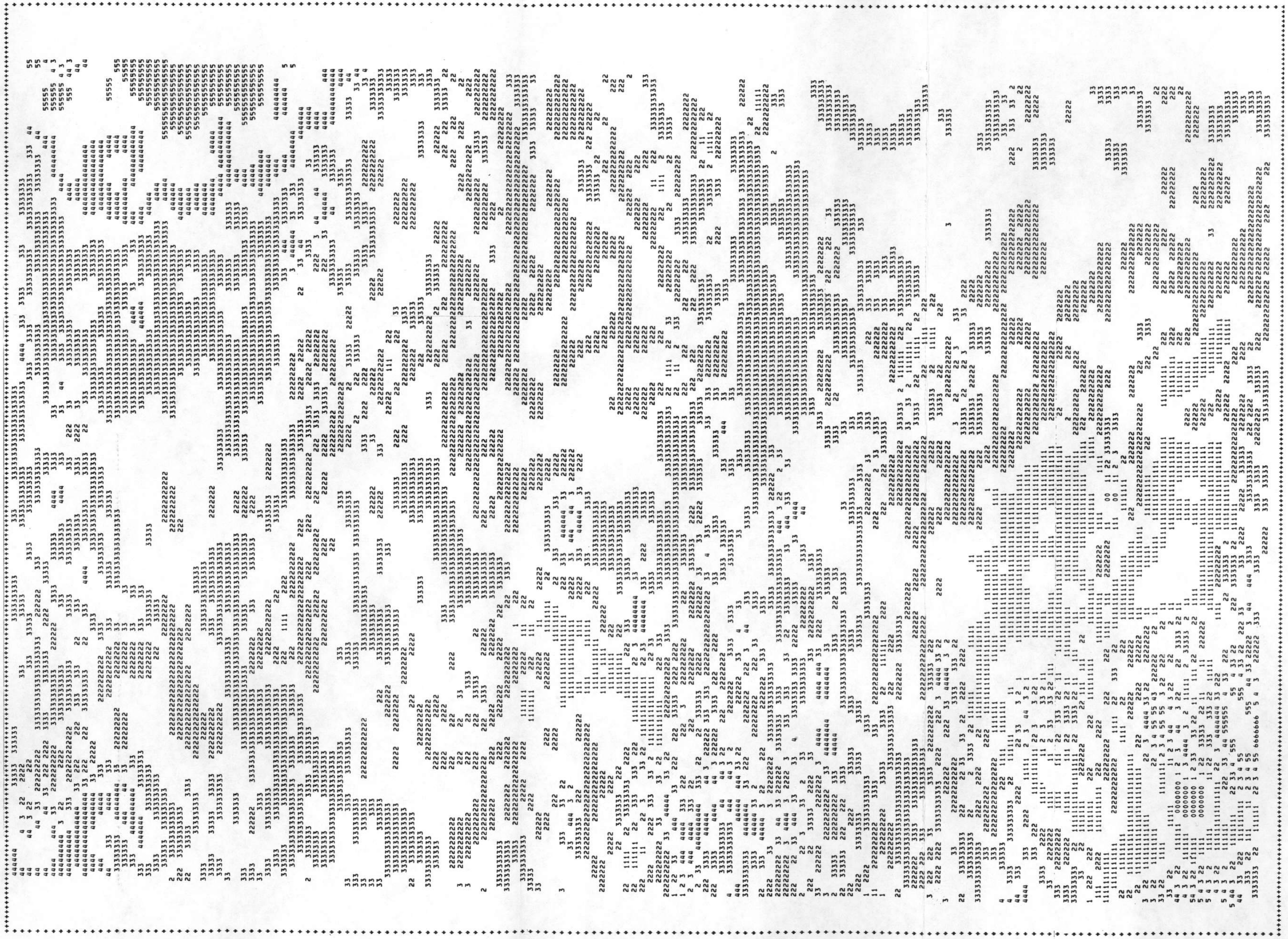


Figure 22 Rawlins Quadrangle-Potassium Pseudo - Contour Map*

RAWLINS

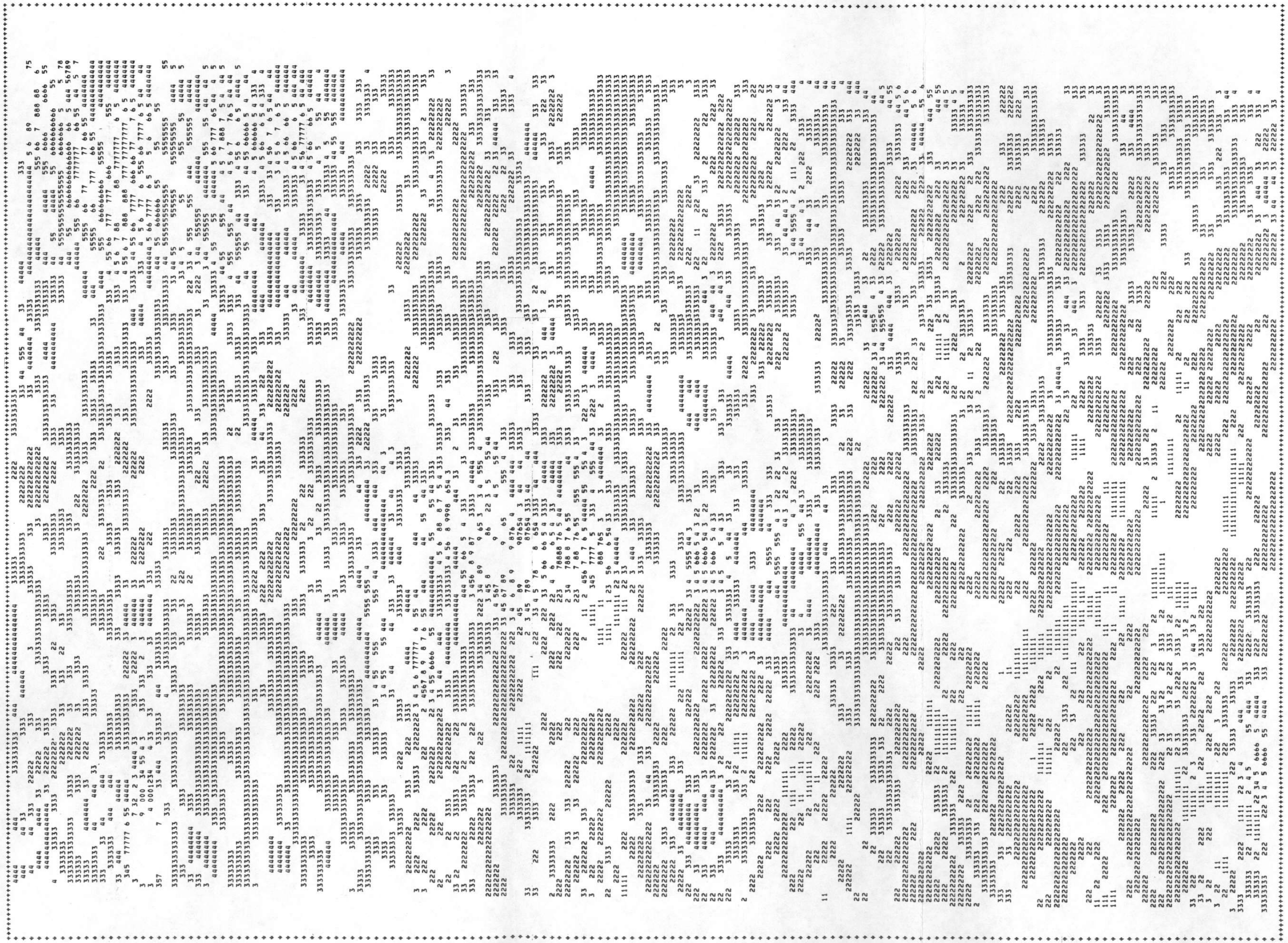


Figure 23   Rawlins Quadrangle-Uranium Pseudo - Contour Map*

RAWLINS

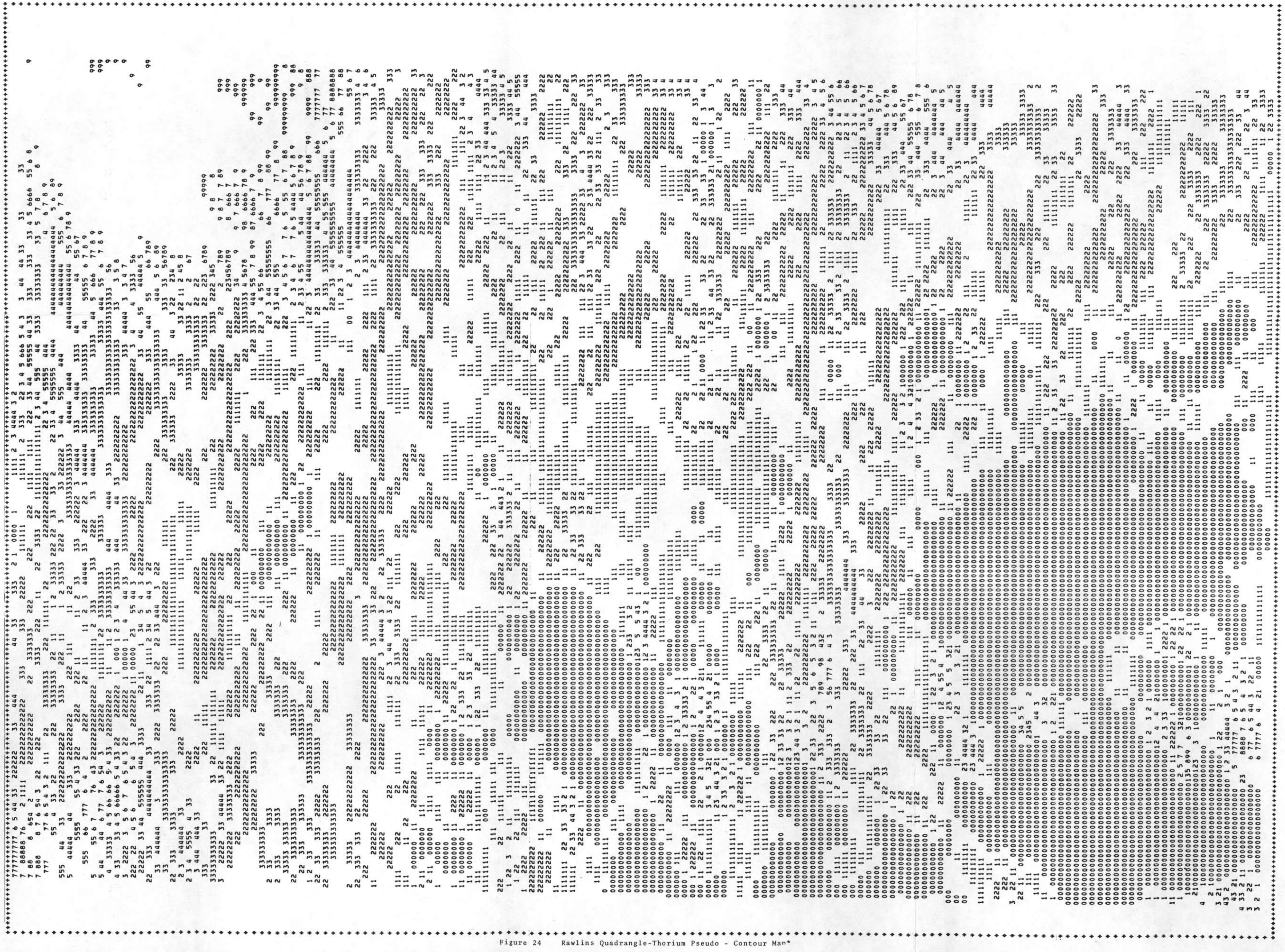


Figure 24 Rawlins Quadrangle-Thorium Pseudo - Contour Map*

RAWLINS

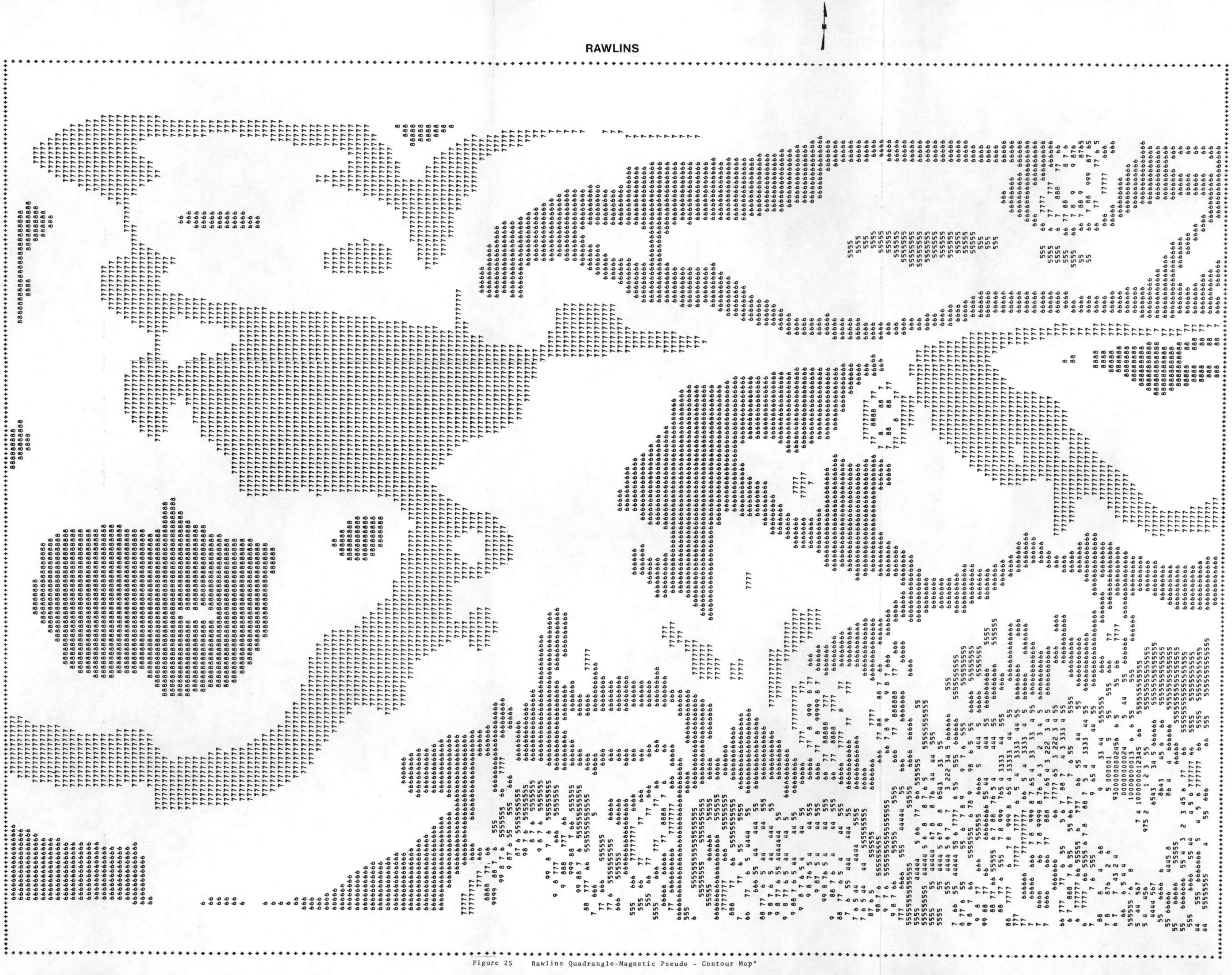


Figure 25 Rawlins Quadrangle-Magnetic Pseudo - Contour Map*

Of the 80 statistically significant uranium anomalies listed in Table 2, the majority occur within areas of general high counting rates. There are no obvious associations with mapped coal mines or oil fields (at least at the 1:250,000 scale). Several statistical anomalies were rejected as being too near cultural features such as roads, cities, etc.

Most of the seventeen (17) anomalies occurring within the Red Desert Basin are in the Tertiary Battle Springs Formation and overlying Quaternary units. Of this group, the largest uranium count rates occur at anomalies 4 and 6 (both 130 cps, or 13 ppm eU).

The anomaly with the highest count rate and highest statistical significance within the quadrangle is Number 75 which occurs in the Poison Basin near Baggs. This anomaly has a peak count rate in the uranium channel of over 850 counts per second (approximately 90 ppm eU) and occurs at the contact between the Brown's Park and Wasatch Formations. Examination of the 35 mm flight recovery film reveals what appears to be extensive ground exploration activities (possibly grid drilling) within the area.

Northeast of the Poison Basin, beginning near the Ketchum Buttes and continuing somewhat northeast of the Miller Hill Anticline, is a series of anomalies which occur within the Brown's Peak Formation, Cretaceous Steel Shale and the Niobrara Formation. Of the anomalies within the Brown's Park Formation, the highest count rates are associated with anomalies 44 and 45 (both of which are greater than 250 cps, approximately 26 ppm eU). The Miller Hill area is known for uranium deposits discovered in 1951. These deposits are a sandstone-impregnation type and are not confined to specific stratigraphic horizons (Ormond, 1957). The Brown's Park and Cretaceous Formation anomalies occur in an area of complex folding and faulting (refer to the geologic base map). If a single, uniform mechanism is assumed both for the Cretaceous and Tertiary anomalies, the spatial relationship suggests a post Brown's Park age for the uranium mineralization. It should be noted here that the geologic map indicates Eocene, whereas the Rocky Mountain Atlas indicates Miocene and Pliocene ages for the Brown's Park.

Anomaly 57, northwest of Divide Peak, at the northern edge of the Sierra Madre Uplift occurs over a uraniferous Precambrian conglomerate (Graff and Houston, 1977).

Northeast of the anomalies within the Brown's Park Formation is another group consisting of four anomalies (29, 32, 35 and 37). These anomalies form a linear band which begins at Lake Creek Flats in the southeast and ends near Choke Cherry Knob in the northwest. Except for Anomaly 37, which lies within the Brown's Park Formation, all anomalies occur within the Cretaceous Mesa Verde Group. An interesting aspect of these anomalies is their association with a series of north-south striking en echelon faults which comprise a zone trending in a northwest-southeasterly direction.

East of these four anomalies is another group of five (5) anomalies which occur at the confluence of the Ridge Anticline, Wallcott Syncline and the Bloody Lake Anticline. With the exception of one (Anomaly 33), these anomalies (23, 26, 27 and 30) lie within undifferentiated Tertiary sediments and the Cretaceous Lewis Shale. Anomaly 33, which has the highest count rate at 67 counts per second (approximately 7 ppm eU), occurs within undifferentiated Precambrian rocks. Here, again, this group of anomalies occurs in an area of intersecting structure.

Anomaly 38, on the eastern edge of the quadrangle, occurs in an area of Precambrian basic intrusives and schists. It is associated with uraniferous Precambrian conglomerates occuring in the Rock Mountain area of the Medicine Bow Mountains (Graff and Houston, 1977).

Another cluster of anomalies lies to the south in the vicinity of Sheep Mountain, near two northwest trending thrust faults. These anomalies occur within Precambrian granites, with the exception of anomaly 63, which is in Quaternary sediments, probably derived from the uplifted Precambrian material comprising the surrounding mountains.

Of special note in the quadrangle is the large BiAir (Radon) signal observed over the Poison Basin along flight lines 212 and 213. High radon was also observed over the Red Desert Basin along flight lines 232 and 234. This high BiAir signal is not seen over the areas of high uranium count rates on lines 220 and 221 occurring in the Brown's Park Formation nor directly over the Poison Basin anomaly (75). This could be a result of local atmospheric conditions as well as excess radon emanating from the ground.

The magnetic pseudo-contour map generally correlates with major geological structures present in the quadrangle. The Deep (30,000 feet) Washakie Basin in the western portion of the quadrangle corresponds to a long wavelength, low amplitude magnetic anomaly. The Hanna and Carbon Basins also correspond to areas of low amplitude, long wavelength anomalies.

Both the Sierra Madre and Medicine Bow Uplifts are indicated in the magnetics (Figure 25) by groups of high amplitude, short wavelength anomalies. Mapped major faults and shear zones are not obviously reflected in the pseudo-contour map due to the 1:250,000 scale. The Continental Divide can be seen as a series of ill defined, high amplitude anomalies trending to the northwest.

Both the Rawlins Uplift and Flat Top Anticline are clearly defined magnetically. The Flat Top Anticline is apparently underlain by a more magnetized basement material than that comprising the Rawlins Uplift. The relief of the magnetics in the area of the Anticline has similar amplitudes and wavelength characteristics as those in the Elk Mountain area to the southwest. The Elk Mountain area is marked as a magnetic basement high on the interpretation map. Inferred magnetic basement faulting trends northwest, generally paralleling mapped thrust faults.

Geochemical Analysis Results

Two of the Precambrian granites, Pcg and Pcgr, have sufficiently bimodal potassium histograms to warrant a subdivision of the units. The older Precambrian granite (Pcg) occurs only at Green Mountain in the Sierra Madre Uplift (refer to the interpretation map, Figure 21. The younger Precambrian unit (Pcgr) is more wide spread, but occurs mostly in the Medicine Bow Mountains. The higher potassium mode (greater than 230 cps) and thorium mode (greater than 60 cps) are coincident with outcrops at Sheep Mountain and an outcroping to the west which is separated from the Sheep Mountain outcrop by a small basin and a thrust fault. Additionally, the areal boundary of data represented by this mode (of the polymodal distribution) roughly coincides with the boundary of a thermal event dated at 1450 m.y. (Hedge, et al 1967).

Principal component results are generally similar to those of the Rock Springs Quadrangle: the first two components generally account for 80-90% of the total variance; the first component is highly correlated with potassium and thorium while the second appears highly correlated with uranium.

A major difference occurs within the Tertiary units. More than 50% of the total Tertiary samples (Units Tbs, Tw, Twc, Tkf, Ths and Td) exhibit a high degree of correlation with thorium and uranium for the first component and potassium for the second. Note, however, that a majority of the statistical uranium anomalies, a total of 17, are within the Brown's Park Formation (Tbp) which clearly follows the more general trend.

Formations common to both the Rock Springs and Rawlins Quadrangles (Tw, Wasatch; Tbp, Browns Park and Tfu, Fort Union) have differing numbers of samples and in the case of Brown's Park, different means for the K, U and T proportions. However, the first two principal component results in both quadrangles have similar correlations.

A most unusual concentration of thorium is present in surface materials of the Red Desert Basin area. Typically, Tl208 count rates range from 200 to 300 cps, which is as great or greater than throium count rates from exposed Precambrian granites (e.g., Sheep Mountain). Available literature, Masursky and Pipiringos, 1952, and Breger, 1955, does not discuss the thorium content of the sediments or uraniferous coals. However, Breger does list several rare earths, such as Lanthanum, in his tables of chemical analyses. Considering this, it is possible that the thorium may be associated with the rare earth compounds.

CHEYENNE QUADRANGLE

Statistical analysis and interpretations of this quadrangle were based on a geologic map provided by DoE/BFEC. Formation descriptions given in Appendix A were obtained primarily from the Geologic Atlas of the Rocky Mountains (1972). Topographic and cultural information were derived from the 1:250,000 scale NTMS Cheyenne Quadrangle (1969 revision) and the 35 mm flight path recovery film.

Topography within the quadrangle varies from the gently rolling Great Plains occupying the eastern half of the quadrangle (approximately 5,000 to 6,000 feet above sea level), to the rugged Larmie Mountains with several thousand feet of relief. The land form within the Larmie Basin, west of the Larmie Mountains, resembles that of the Great Plains. However,it is some 1,000 feet higher in elevation.

There are three principal structural features present in this quadrangle: (1) The Larmie Basin (2) The Laramie uplift and (3) The Denver Basin. The Laramie Basin occupies the western quarter of the quadrangle Structurally, it is asymmetrical being deeper to the west near the Medicine Bow Mountains and shoaling in the direction of the Larmie Mountains. Anticlinal and synclinal warps, high angle normal faults and thrusts are present, but their relation to deeper structure is unknown.

Exposed units within the quadrangle are Tertiary, Mesozoic and Palezoic sediments, overlain by abundant Quarternary cover. Thorough treatments of Miocene and Pliocene sediments are given by Love (1960) and Denson (1964). More specific efforts, such as Love (1961), focus on individual formations; e.g., the Arikaree (Split Rock). The Eocene and Paleocene rocks have been described in detail by a number of workers such as Cashion (1967), Bradley (1964), Roehler (1967), and Oriel (1962). A large number of general Upper and Lower Cretaceous studies exist: e.g., Weimer (1960), Cardinal (1970), Haun et al (1960), Asquith (1970). More specifically, Berg, et al (1964), has treated the Pre-Niobrara stratigraphy (including Paleozoic materials) of the Larmie Basin. Hoyt (1963) has reported the Permian-Pennsylvanina relationship in the northern Denver Basin. Many specific formational studies exist; e.g., Steitman's work (1974) on the Casper, Formation.

Similarly, there have been many studies which deal with Precambrian crystalline rocks as potential sources for the stratiform uranium deposits with the area. One uranium occurrence is reported at Sheep Mountain (refer to Figure 3), but its exact nature was not found in the published literature. A number of units occurring in the quadrangle, such as the Wind River and Ogallala Formations, are either uranium producers or have occurrences within them elsewhere (Ruckley, 1972).

The youngest materials in the quadrangle are composed of a sequence of Quaternary units ranging from alluvium to terrace deposits. These constitute approximately 17% of the mapped units. Sediments of Miocene, Pliocene, and Oligocene age dominate the surface of the Denver Basin and are exposed like patchwork within the Laramie Basin and Uplift; e.g., the Ogallala, Arikaree, Brule, White River, North Park, and Chadron Formations. These account for some 51% of the exposed rocks in the quadrangle. These are dominantly continental to littoral in nature, often have an arkosic nature, and exhibit channel cut and fill effects at their contacts.

Cretaceous units constituting some 6% of the surface materials are dominantly marine and reflect fluctuations in a "seaway" margin. Resulting sediments have extensive lateral and vertical variations within individual lithologies. The Laramie Basin contains exposures of both Upper and Lower Cretaceous units such as: The Lance, Niobrara, and Frontier Formations: The Lewis, Mowry, Pierre, Steele, and Thermopolis shales; and the Cloverly group. Other mesozoic units account for only 2% of mapped exposures.

Palezoic units occur principally on the east flank of the Laramie Uplift and represent some 4% of mapped exposures. Of the Paleozoics, the Casper, a calcareous aeolian arkosic sandstone/quartzite with limestone interbeds, is the most prominent.

Precambrian Rocks comprise some 20% of the mapped exposures and are restricted entirely to the Laramie Uplift. Granite, quartz monzonite, granitic schists, and gneisses are the dominant rock types. In some cases, aplites and granites are found to intrude older crystalline rocks. Lesser occurrences of norites, metanorites, anorthosite, and quartz diorite are noted.

Interpretation, Discussion, and Results

The resulting uranium anomaly/interpretation map is displayed in Figure 26. Anomalies depicted on this map are summarized in Table 3. Figures 27 through 30 present pseudo contour maps of K, U, T and the magnetics utilized for regional evaluation. General lithologic unit descriptions are presented in Appendix A. Statistical tables, including principal component results, for each formation (citing type of distribution, measure of central tendency, and standard deviation)are given in Appendix E.

In general, older sedimentary units (exclusive of the Precambrian) have lower count rates than do the younger sediments. The diversity of lithologies mapped are, in general, reflected in the variable radiometric pattern exhibited by the psuedocontour maps. This is especially true in the case of the potassium and thorium data. In many specific cases, however, formational contacts are indistinguishable; e.g., the contacts between the Precambrian anorthosites and gneisses with younger sediments in the vicinity of Laramie. While statistical anomalies are distributed throughout most of the mapped geologic units, the larger single anomalies and well defined clusters of anomalies tend to be associated with Tertiary or Precambrian units. Anomalies occuring within Cretaceous units are generally isolated and exhibit lower count rates. The Tertiary Ogallala, which has the broadest areal extent of any of the units contains more anomalies (a total of 14) than any other formation in the quadrangle. However, due to its broad distribution, it perhaps has the greatest potential for intraformational variability.

Depicted on the uranium anomaly/interpretation map and summarized in Table 3 are a total of 66 anomalies which remain after screening for relative thorium depletion, U/T ratios, water/marsh relationships and proximity to cultural features. Most instances of high count rates correlate with valid anomalies. Exceptions exist where high counts correspond to railroad beds and road cuts.

Anomaly 5, near Chalk Bluff possesses the highest uranium count rate in the quadrangle at 94 cps (10 ppm eU). It, together with anomalies 1, 8, 12, 13, 15, 16, 18, and 19, form a northeast trending zone in the southeast corner of the quadrangle. This group of anomalies occur coincident with the contact between the Ogallala Formation and the Brule, Arikaree, and Quaternary terrace deposits. A similar cluster of anomalies (numbers 6, 7 and 11) occur further to the east at the edge of the quadrangle. The area circumscribed by both these groups of anomalies appears to be an anticlinal warping associated with petroleum production. Presence

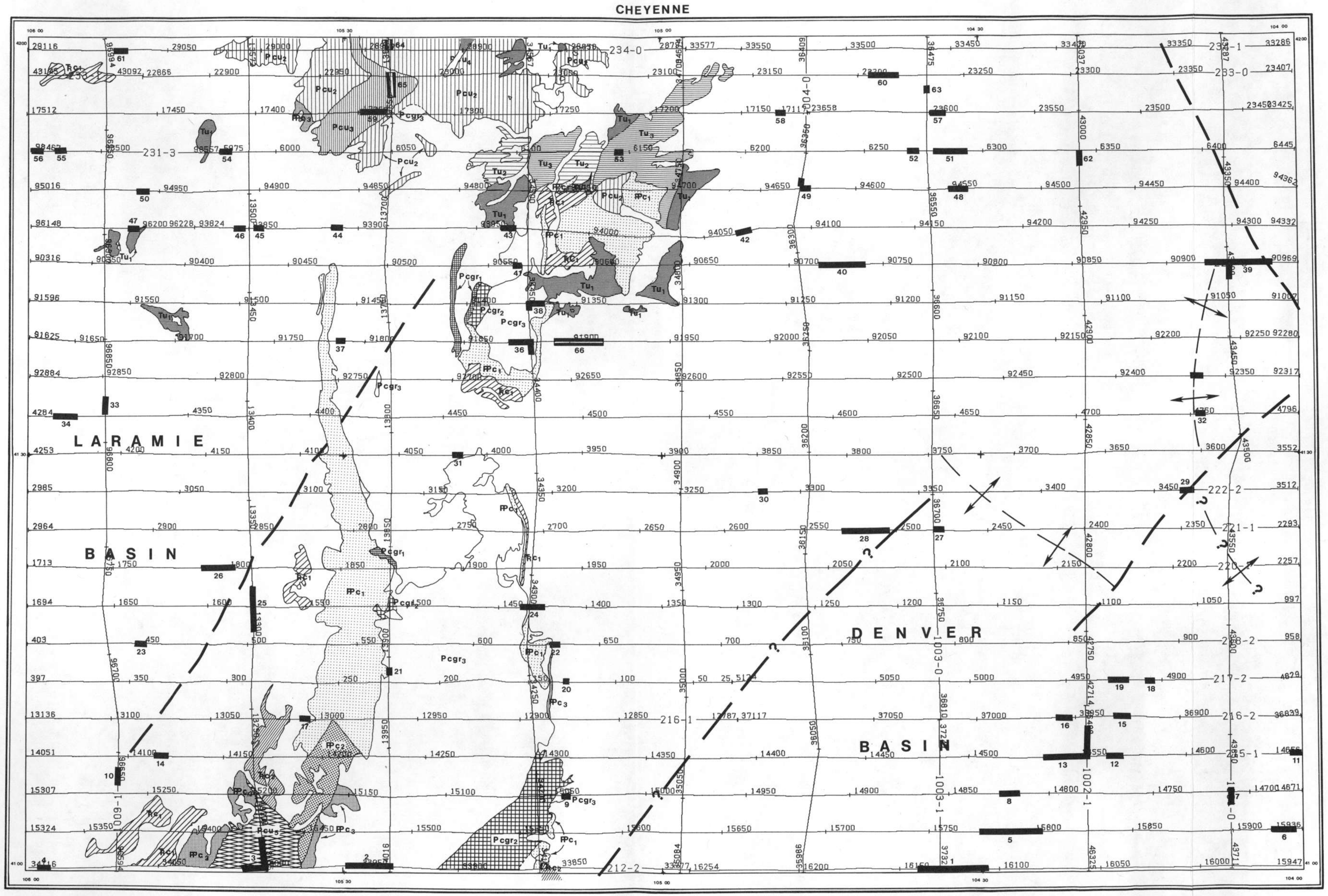


Figure 26 Cheyenne Quadrangle-Uranium Anomaly/Interpretation Map*

URANIUM ANOMALY/ INTERPRETATION MAP

CHEYENNE QUADRANGLE

U.S. DEPARTMENT OF ENERGY

APPROXIMATE SCALE 1 : 500,000

▬ - URANIUM ANOMALIES

▭ - THORIUM ANOMALIES

-+-+- - SEDIMENTARY STRUCTURE

MAGNETIC STRUCTURE

-+-+- - MAGNETIC BASEMENT HIGHS

— — — - INFERRED FAULTS IN MAGNETIC BASEMENT

GEOCHEMICAL UNITS

Tu - Tertiary Undifferentiated

▦	Tu_1	T <65 cps K <250 cps
▤	Tu_2	T >65 cps K <250 cps
▤	Tu_3	T >65 cps K >250 cps

PPc - Casper Formation

░	PPc_1	T <60 cps K <220 cps
▒	PPc_2	T <60 cps K >220 cps
▓	PPc_3	T >60 cps K >220 cps

₨c - Chugwater Formation

▨	$₨c_1$	T <50 cps K <200 cps
▨	$₨c_2$	T >50 cps K >200 cps

Pcgr - Precambrian Granite

▦	$Pcgr_1$	T <50 cps K <255 cps
▦	$Pcgr_2$	T >50 cps K <255 cps
□	$Pcgr_3$	T >50 cps K >255 cps

Pcu - Precambrian Undifferentiated

▥	Pcu_1	T <40 cps K <100 cps
▥	Pcu_2	T <125 cps K <290 cps
▥	Pcu_3	T >125 cps K <290 cps
▥	Pcu_4	T >125 cps K >290 cps
▩	Pcu_5	T <125 cps K >290 cps

N

SURVEY AND COMPILATION BY:

geoMetrics

TABLE 3

ANOMALY SUMMARY

CHEYENNE QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
1	U/T	212, TL3	To/Tb		4	4	6	1	1	3		
2	U	212	PCgr		5	5						
3	U	212, TL8	PCgr		5	7	1					
4	U	212	Ku, KCV	1		1	1					
5	U/T	213	To, Tb		4		2	4	1	3		
6	U	213	To		5	2						
7	U	TL1	Tb, Qt		1	3						
8	U/T	214	To		2	1	3					
9	U	214	To		1		3					
10	U	TL9	KmT, Q		3	2	1					
11	U	215	To		2	2						
12	U/T	215	To, Ta		1	3	1					
13	U/T	213, TL2	To	1	8	7	5	1				

TABLE 3

ANOMALY SUMMARY

CHEYENNE QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
14	U	215	Qal, Kn		2	2						
15	U	216	To, Q$_t$, Qal		4	2						
16	U	216	To, Qt		1	3	1					
17	U	216	PCS		2		1					
18	U	217	Ta		2	1						
19	U	217	To		4	2						
20	U/T	217	Tb, Tc			2						
21	U	TL7	Pcgr			2						
22	U	218	PPC, Q		2	1						
23	U	218	Ks		2	1						
24	U	219	Tb, Q		3	2	1					
25	U	TL8	Qal, Km$_t$, Qmc		7	4	2					
26	U/T	220	Kn, Qal		3	4		1				
27	U/T	221	To		1	2						

TABLE 3

ANOMALY SUMMARY

CHEYENNE QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ* 0	1	2	3	4	5	6	7	8
28	U/T	221	To, Ta		6	9	1					
29	U/T	222	Ta		2	1						
30	U/T	222	To, Ta		1	2						
31	U	223	PCs		2	1						
32	U	224	Qal		2	1						
33	U	TL9	Twdr, Qt		2	2	1					
34	U	224	Qal,Qt		4	2						
35	U	225	Tb		2	1						
36	U	226, TL6	PCgr		4	5	2					
37	U	226	PCgr		2	1						
38	U	227	PCgr		4	2	1					
39	U	228	Tb,Ta		8	9	2					
40	U/T	228	Ta		4	3	1	2	3			
41	U	228	Qal, PgL		1	2						

TABLE 3

ANOMALY SUMMARY

CHEYENNE QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
42	U	229	Qal,TA		3	1	1					
43	U	229	Pcan,Pcs		2	1						
44	U	229	Th,PPc		2	1						
45	U	229	Th		2	1						
46	U	229	Qmc			2	1					
47	U	229	Ksn,Tv			2	1					
48	U	230	Kl,Tb		4	2	1					
49	U/T	230,TL6	Tb,Ta		4	4						
50	U/T	230	Ju,Trc			3						
51	U	231	Kl		2	6						
52	U	231	Tb		3	2						
53	U	231	Tu		2	1						
54	U	231	Tnp		2	1						
55	U	231	Tu			2		1				

TABLE 3

ANOMALY SUMMARY

CHEYENNE QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Samples with Defined σ*								
				0	1	2	3	4	5	6	7	8
56	U	231	Tu			2	1					
57	U	232	Tc		3		1					
58	U	232	Tb		2	1						
59	U	232	PCu		3	3	2					
60	U	233	Tc	1	4	2						
61	U	234	PPta	1	2	1						
62	U	TL2	Tc		3		1					
63	U	TL3	Tc			1	1					
64	T	TL7	PCU			1	1					
65	T	TL7	PCU			4	1	2				
66	T	226	Tb		7	6	2					

*Reflect only U channel

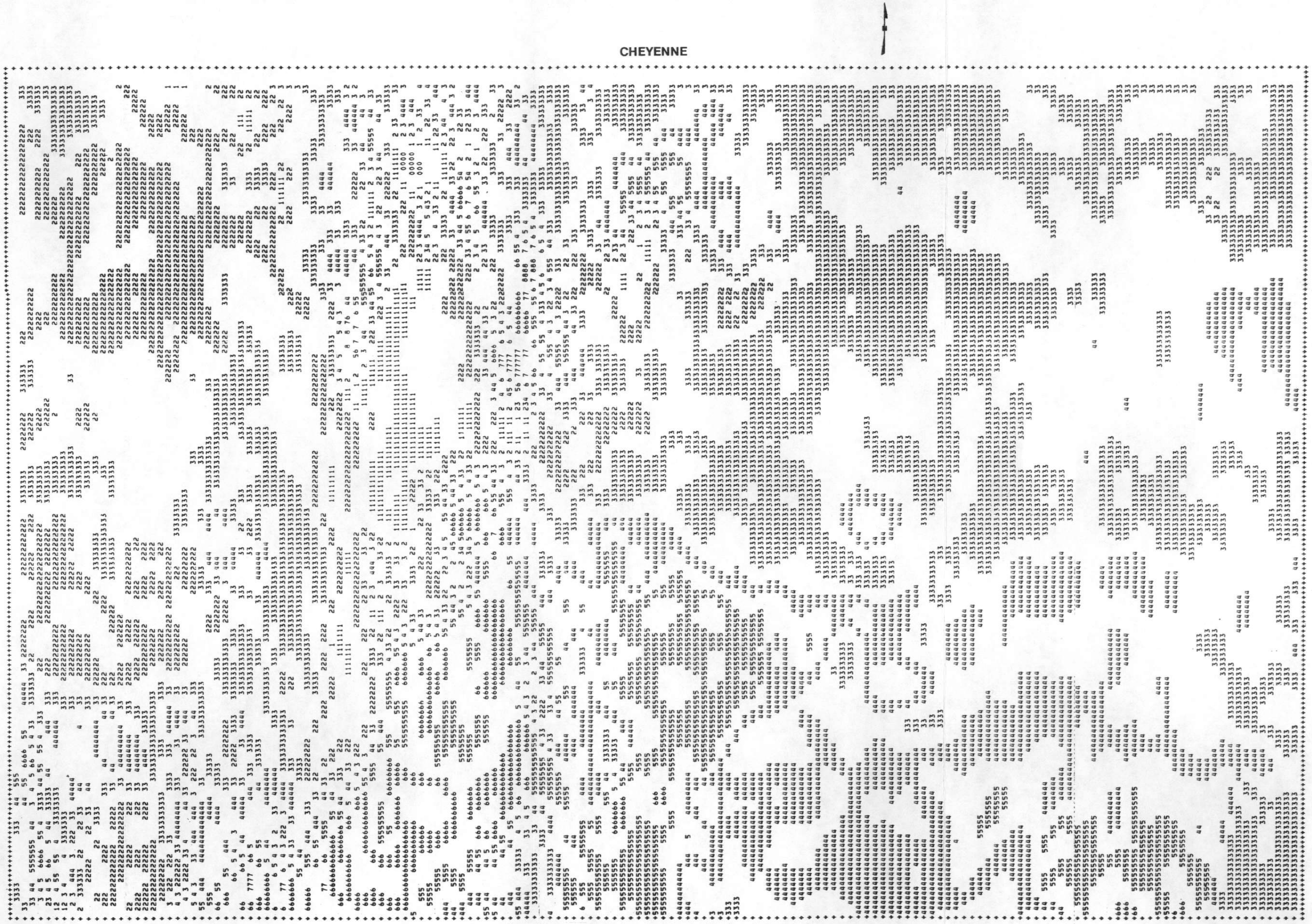


Figure 27 Cheyenne Quadrangle-Potassium Pseudo - Contour Map*

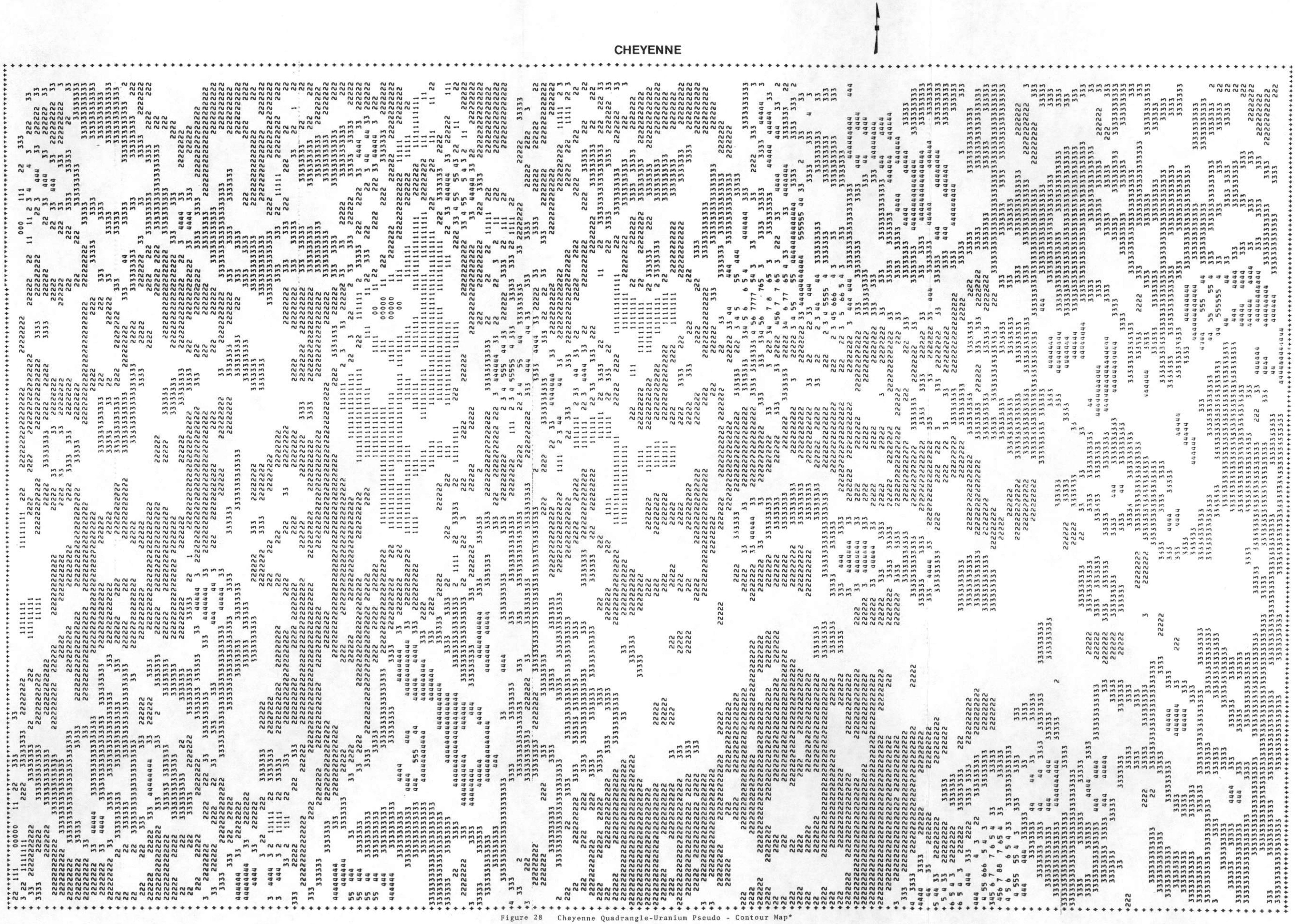


Figure 28 Cheyenne Quadrangle-Uranium Pseudo - Contour Map*

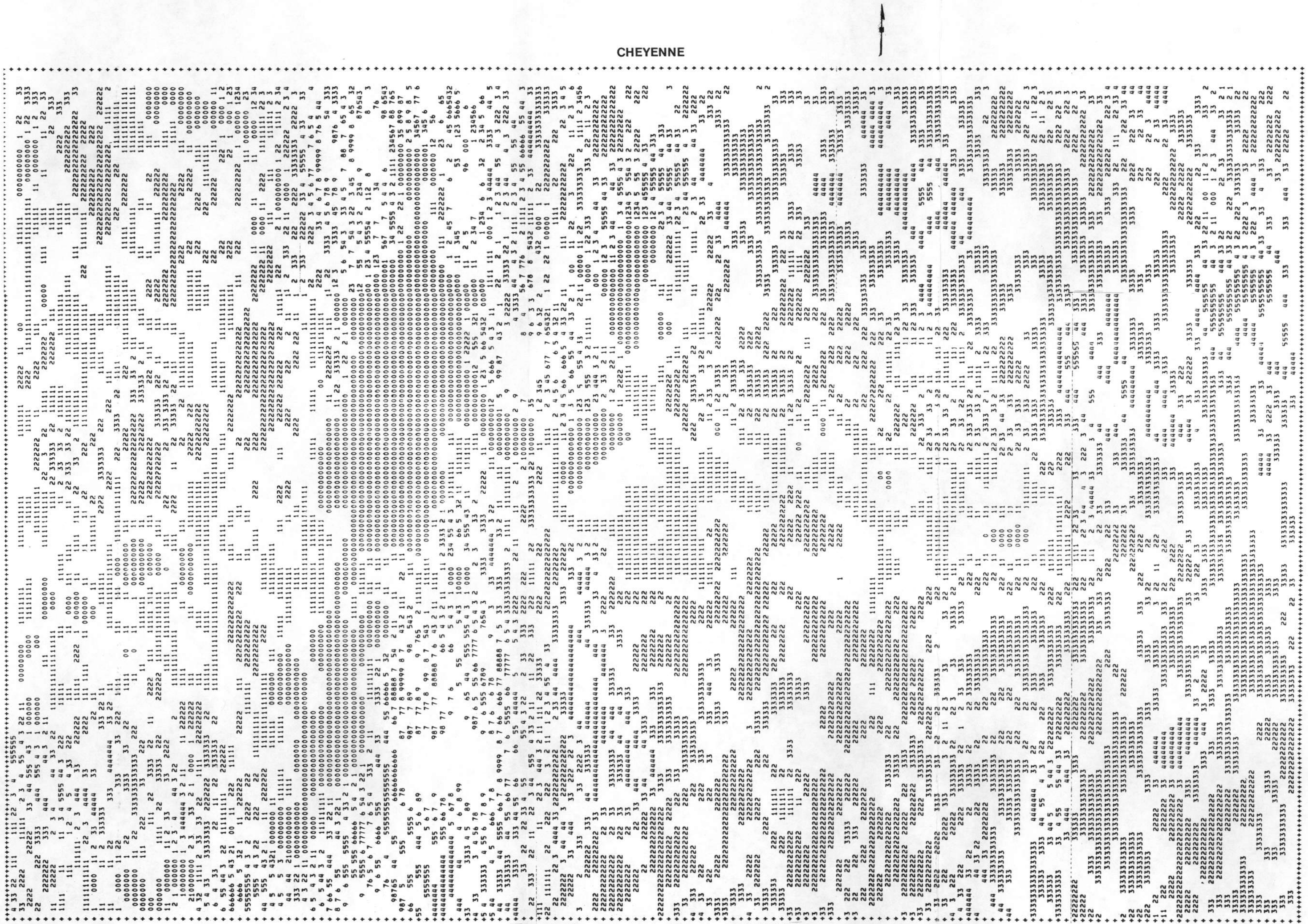


Figure 29 Cheyenne Quadrangle-Thorium Pseudo -Contour Map*

Figure 30 Cheyenne Quadrangle-Magnetic Pseudo - Contour Map*

of cultural features near many anomalies in this area is not believed to invalidate them.

Anomalies 2, 7, and 28 - 30 occur along the northern contact of the Ogallala Formation with the Brule and Arikaree Formations. Anomaly 30 has the highest uranium count rate at 44 cps (4.7 ppm eU). While uranium count rates associated with these anomalies are lower than those exhibited by the Chalk Bluff features, they appear to be of similar character.

Anomalies 40, 42, and 49 occur in and adjacent to Chugwater and Slater Flats which are underlain by the Brule and Arikaree formations. None of the anomalies correspond to lithologic contacts or topography. All of the uranium anomalies are above 50 cps, anomaly 40 having the highest count rate at 76.8 cps (8.2 ppm eU). Culture in the area is restricted to scattered farms. These anomalies may arise from in-situ minerals or transported material from the nearby Richeau Hills (Casper formation).

Goshen hole, in the northeast corner of the quadrangle, is an area of present exploration activity. Anomalies 48, 51, 52, 57, and 60 - 63 occur in this region. Anomaly 63 has the highest uranium count rate at 54 cps (5.7 ppm eU). All of these features occur within what is mapped as Brule and Lance Formations, forming a zone roughly coincident with the contact between the two formations. Examination or the flight path film indicates some correlation of cultivated areas and anomalous features.

Anomalies 10 and 14 (maximum count rates of 50 cps or 5.3 ppm eU) are located in the gently rolling topography of the Laramie Basin. This area is underlain by the Cretaceous Niobrara and Frontier Formations. These anomalies are typical of the small, dispersed, moderate count rate anomalies observed elsewhere in the Laramie Basin.

Anomalies 9, 20, 22 and 24 occur at the south end of the Laramie Mountains just east of mapped outcrops of Precambrian granites and quartz monzonites in contact with the Brule and Casper formation. Count rates exhibited by those anomalies are moderately high; most of these being above 40 cps, with maximum of 51 cps (5.4 ppm eU). Associated thorium highs, such as 180 cps (28 ppm) near anomaly 24, may indicate primary mineralization. Anomaly 9, is adjacent to a highway, railroad, and quarry and may result from artificial exposure.

Anomaly 2 lies well within Precambrian granites. It has a maximum of 55 cps (5.5 ppm eU) and a thorium count of 213 cps (33 ppm eT). There are mapped Tertiary dikes nearby which may be related to the anomaly. These dikes could be thorium rich intrusives as in the Wet Mountains of Colorado. Anomaly 3, within an area of undifferentiated Precambrian (54 cps or 5 ppm eU), has similar dikes mapped in the area.

The exposed Precambrian rocks of the Laramie Uplift are clearly delineated in the pseudo-contour magnetic map. The abrupt north-south trending demarcation between the long wave-length, low amplitude anomalies of the deep Denver Basin on the east and the high frequency, higher amplitude magnetic expression of the Uplift corresponds to the major thrust fault running south along the Front Ranges. In the west-central portion of the quadrangle, the Laramie Basin corresponds to a broad magnetic low.

The Magnetic basement within the Denver Basin is more complex than suggested by available literature. Several inferred magnetic basement uplifts and faults are displayed in the interpretation map in the eastern third of the quadrangle. Some corroborating evidence is suggested by the Bouger anomaly map with the Rock Mountain atlas of Geology (1972).

Within the Laramie Uplift, a mapped Precambrian Anorthosite (PCan) corresponds to a magnetic low surrounded by a magnetic high. This probably results from the very low susceptibility PCan in contact with more magnetic rocks. Another low, immediately to the southwest, may also correspond to more low susceptibility anorthosites.

Geochemical Analysis Results

Five geologic formations had sufficiently distinct ploymodal histograms to suggest discrete radiometric (geochemical) subsets of the parent unit. These formations include Precambrian granite, Precambrian undifferentiated, Permo-Pennsylvanian Casper, Triassic Chugwater, and Tertiary undifferentiated formations. The procedure utilized to attempt this subdivision consisted of: (1) examination of each histogram (6) per formation for polymodal tendencies; (2) thresholding the stacked profiles based on boundaries of polymodal samples; and (3) plotting the boundaries within the parent unit. No subdivision was attempted if too few samples were available.

Those subunits which fell above or below the threshold and were spatially consistent across multiple flight lines are summarized in Table 4. The anomaly interpretation map (Figure 26), illustrates the resulting distribution of these subunits. Even though each parent unit contained some uranium anomalies, the uranium channel data was not sufficiently diagnostic relative to unit separation. For example, the Ogallala, with the most uranium anomalies and samples, was not readily separable into subunits.

Radiometric definition of rock subunits is dominantly restricted to formations within, or adjacent to, the Laramie Uplift. Subunits are differentiated from north to south along the axis of the Uplift, on an inlier/outlier basis (portions of a unit adjacent to the uplift versus portions out in the Basins), and finally on an east flank/west flank of the Uplift basis. The Precambrian crystalline rocks and the Casper Formation exhibit the most prominent axial variation.

Results of principal component analysis demonstrate that 80-90% of the total sample variance is accounted for in the first two components for all the formations. The Precambrian crystalline rocks (granite, gneiss, schists, etc.) generally have first principal components (eigenvalues) a third again as large as most of the Mesozoic and Tertiary sedimentary units. In general, the Tertiary units have first components equal to those of the Mesozoic units.

The sedimentary rocks separate into two major classifications: (1) first component correlating with uranium and thorium and the second correlating with potassium (Brule, Ogallala, Wind River, Arikaree, Chardron Formations, and the Cloverly Group etc.) and (2) first component correlating to potassium and thorium and the second component correlating with uranium (Undifferentiated Tertiary, White River, Hanna, Casper, Amsden Formations, terrace deposits, alluvium etc.). The Precambrian crystalline rocks have relatively equal first components, but, considerable variability in the second component, e.g., the undifferentiated Precambrian (PCu) correlated with thorium, while the Precambrian granite (PCgr) correlated with potassium and Precambrian anorthosite (PCan) correlated with uranium.

The Precambrian rocks split into two groupings with respect to mean counts in the K, U, and T channels: (1) gneiss, anorthosite, norite, and the quartz diorite had relatively low mean counts in all channels (except quartz diorite which exhibited the third highest mean thorium count rate; (2) granite, undifferentiated Precambrian and granite/quartz

TABLE 4

MAIN UNIT	SUBUNIT	THORIUM Level in CPS	POTASSIUM Level in CPS
PCgr	PCgr1	< 50	< 255
	PCgr2	> 50	< 255
	PCgr3	> 50	> 255
PCu	PCu1	< 40	< 100
	PCu2	< 125	< 290
	PCu3	> 125	< 290
	PCu4	> 125	> 290
	PCu5	< 125	> 290
PPc	PPc1	< 60	< 220
	PPc2	< 60	> 220
	PPc3	> 60	> 220
Trc	Trc1	< 50	< 200
	Trc2	> 50	> 200
Tu	Tu1	< 65	< 250
	Tu2	> 65	< 250
	Tu3	> 65	> 250

monzonite exhibited the greatest mean count rates in the thorium and potassium channels (granite/quartz monzonites also have very high uranium means). These groupings are consistent with the radiometric mineral composition for the various rocks (GSA Memoir 97).

In general, the Mesozoic and Paleozoic units have variable mean count rates in all channels. The higher uranium mean count rate was dominated by the Cretaceous units (Frontier Formation, Undifferentiated Cretaceous, Niobrara Formation, and the Mowry/Thermopolis Shales). Tertiary units generally had high to moderate count rates in each of the channels. The Arikaree, Brule, and Ogallala had overall similar mean count rates in each channel.

GREELEY QUADRANGLE

The geologic map used for statistical analysis and interpretation was the U.S. Geological Survey (U.S.G.S.) preliminary map of the Greeley Quadrangle (Braddock and Cole, 1978). Formation descriptions given in Appendix B are derived from the explanation of the U.S.G.S. map and the Geologic Atlas of the Rocky Mountains (1972). Cultural and topographic information was obtained from the 1:250,000 NTMS Greeley Quadrangle map (revision 1976) and 35 mm flight path recovery film.

Topography varies from high relief and high elevation (13,000 feet) in the Front Range to low relief and moderate elevations (on the order of 5,000 feet) in the Piedmont and Great Plains. Over two thirds of the quadrangle is in the latter category.

The Front Range Uplift in the western portion of the quadrangle and the Denver Basin in the eastern portion are the two principal structural features within the quadrangle. The Medicine Bow and Laramie Uplifts are secondary features which trend obliquely into the Front Range Uplift within the northwestern corner of the quadrangle. A narrow portion of the North Park Basin lies along the quadrangles' western boundary.

Essentially anticlinal, the Front Range has a Precambrian core flanked by steeply dipping, upturned Paleozoic and Mesozoic rocks. The Precambrian core is a complex mass of metamorphic and igneous rock, locally cut by Tertiary intrusives. Faults which border the Uplift dominate the regional fracture pattern. The east flank of the Front Range is demarcated by a northeast trending en echelon belt of faults and associated anticlinal warpings. Within the Uplift, major shears have been postulated as controlling the mineralization within the northeast trending Colorado Mineral Belt.

The Denver Basin is relatively broad (100 miles) and deep (13,000 feet near Denver). A thin veneer of Tertiary material covers older, slightly warped marine and continental sediments. Upturned materials along the Front Range exhibit the most severe folding. Oil fields exist in both the Denver and North Park Basins.

The North Park Basin is essentially a small, deep, down-faulted segment of a broader uplifted region within the Front Range. It contains 14,000 feet of marine and fresh water sediments ranging in age from Paleozoic to Cenozoic. Folding and thrusting complicate its western margin.

Nearly 32% of the quadrangle is mantled by Quaternary materials ranging in composition from aeolian sands to landslide debris. Tertiary sediments account for 12% of the mapped exposures. These materials are dominantly continental and include fluvial deposits, tuffaceous beds, arkosic units and lacustrine and paludal deposits. Beds of coal and carbonaceous shales occur in the Coalmont, Middle Park and North Park Formations. Cretaceous units account for approximately 24% of the surface area, with another 2% being mapped as combined Tertiary and Cretaceous. Cretaceous rocks are generally marine, but represent many different environments (e.g., the non-marine Laramie Formation). Mesozoic units account for only 5% of the surface area. Paleozoic units which include marine limestones and aeolian sands comprise only 3% of the materials exposed at the surface. Precambrian rocks account for about 22% of the outcrops.

Uranium occurrences have been reported in the Jamestown mining district within the Colorado Mineral Belt. (Refer to Figure 3). Mineralization within the Jamestown District is within breccias located on the periphery of an alkaline granitic mass. Localized areas of high counting rates have been reported within Precambrian rocks, particularly in the vicinity of younger intrusives. Small outcrops of Ogallala, Morrison, and Dakota sandstones are mapped within the quadrangle. While there are no reported uranium occurrences in these units within the quadrangle, they are uraniferous at locations outside the quadrangle.

Interpretation, Discussion, and Results

The resulting Uranium Anomaly/Interpretation Map is displayed in Figure 31. Anomalies depicted on this map are summarized in Table 5. Figures 32 through 35 present pseudo-contour maps of K, U, T and magnetics utilized for regional evaluation. General lithologic unit descriptions are presented in Appendix B. Statistical tables for these units, citing type of distribution, measure of central tendency, standard deviation, and principal component results are given in Appendix F.

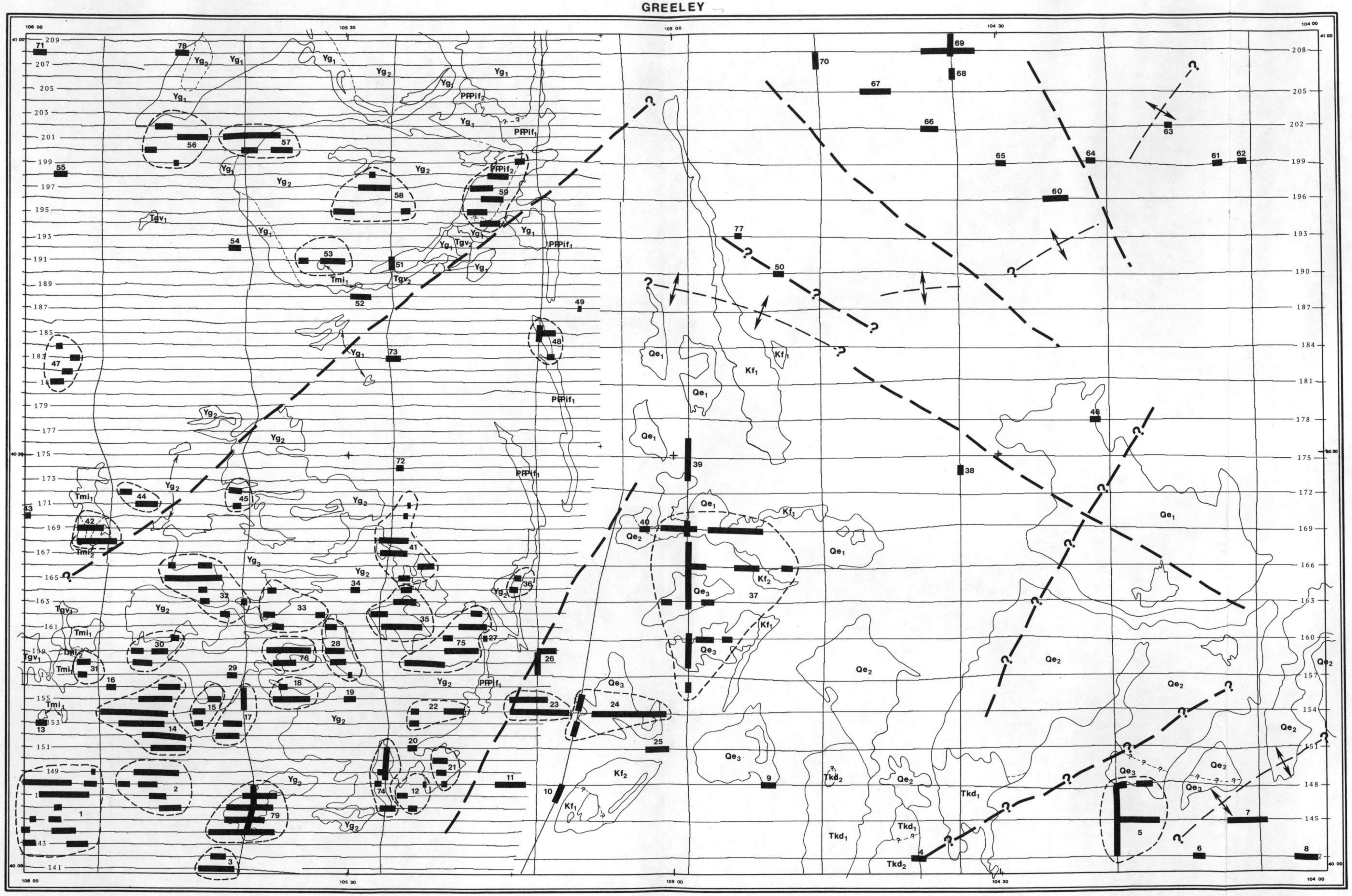


Figure 31 Greeley Quadrangle-Uranium Anomaly/Interpretation Map*

URANIUM ANOMALY/ INTERPRETATION MAP

GREELEY QUADRANGLE

U.S. DEPARTMENT OF ENERGY

APPROXIMATE SCALE 1 : 500,000

00 – URANIUM ANOMALIES

– SEDIMENTARY STRUCTURE

MAGNETIC STRUCTURE

– MAGNETIC BASEMENT HIGHS

– INFERRED FAULTS IN MAGNETIC BASEMENT

GEOCHEMICAL UNITS

Tkd - Denver Formation

Tkd_1 { T < 95 cps, K > 240 cps, T/K <.40

Tkd_2 { T > 95 cps, K < 240 cps, T/K >.40

PPif - Ingleside and Fountain Formations, Undivided

$PPif_1$ { T < 52 cps, K < 120 cps

$PPif_2$ { T > 52 cps, K > 120 cps

Qe - Quaternary Eolian Deposits

Qe_1 { T < 65 cps, K < 240 cps

Qe_2 { T < 65 cps, K > 240 cps

Qe_3 { T > 65 cps, K > 240 cps

Tgv - Tertiary Volcanics

Tgv_1 { T/K > .43, K < 215 cps

Tgv_2 { T/K < .43, K > 215 cps

Kf - Fox Hills Sandstone

Kf_1 { T < 85 cps

Kf_2 { T > 85 cps

Tmi - Tertiary Intrusives

Tmi_1 { T < 150 cps

Tmi_2 { T > 150 cps

Yg - Precambrian (Y) Granite

Yg_1 { T/K > .34, K < 115 cps

Yg_2 { T/K < .34, K > 115 cps

N

SURVEY AND COMPILATION BY:

geoMetrics

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ 0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
1	U/T	143	Xb,Kc		6	3						
	U/T	144	Kmw,T, KTR dc, Kc		3		3	2				
	U/T	145	T		2	1		1				
	U/T	146	Qg		1		1					
	U	147	Qal,T, Qgo		4	4	4	1				
	U/T	148	Tm,Tbb,T, Qgo,KTR dc,	1	4	6	2	1	1			
	U	149	Xg				1					
2	U	146	Xg		2	4						
	U	147	Xg		3	2						
	U	148	Xg	2	4	3	1					
	U	149	Xg,Qd		7	3	1					
3	U	141	Xg,Xb		3	4	3		1			
	U	142	Xb		2	1						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ								
				0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
4	U/T	142	TKd,Qgu		2		1	1				
5	U	142	K		2	1						
	U	145	K		5	3	4					
	U	148	Qe		4	2						
	U	TL 2	Kl		4	13	4					
6	U	142	Kl		2	2						
7	U	145	Kl,Kf,Qa		4	6						
8	U	142	Qa		2	3	1					
9	U	148	Qe		3	2						
10	U	Tl 56	Qb,Qgb		1	4		1				
11	U	148	Kpm	1	4	3						
12	U/T	146	TKi, Xb, Xg		1	1	1					

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ								
				0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
	U/T	147	TKi,Xb		1	1	1					
	U/T	148	TKi,Yg						1			
13	U/T	153	Tmi	1	2							
14	U	151	Xfh, Xg		5	3	1					
	U	152	Xfh, Tg	1	4	7						
	U	153	Xfh	1	5	5	1	1				
	U	154	Qd,Xfh		9	7	1					
	U	155	Xfh		4	1	4	1	1			
	U	156	Xfh	1	2	3	1					
15	U	153	Xg		2		1					
	U	154	Xg,xb		3	2						
	U	155	Xg		2	2						
16	U	156	T		2	1						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ 0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
17	U/T	152	Xb		2	1	2		1	2		
	U/T	153	Xb		4	2						
	U/T	155	Xb		2	2	1					
	U/T	Tl3	Xb		2	2		1				
18	U	155	Qd, Yg		6	3						
	U	156	Yg		1		1					
19	U/T	155	Yg		1	2	1					
20	U	151	Yg		2	1						
21	U/T	149	Yg		1	2						
	U/T	148	Yg			1			1			
	U/T	150	Yg		3	1	1					
22	U	153	Yg		1	1						
	U	154	Yg		3	4	3					
23	U	154	Kpu, Kpl, Kpm, Qa, Kl		2	10	1	1				
	U	155	KJds, Kc		3	5	1					

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
				Number of Data Samples (X7) with defined σ								
24	U	154	Kpu,Qe	2	8	7						
	U	Tl 56	Qa,Qe,Kpu		5	3	2					
25	U	151	Qa,Kpu		4	2	1					
26	U/T	159	Kc,Kpl		2	2		1				
	U/T	Tl 6	Kjds		2	1	2	1				
27	U/T	160	PPif				1					
28	U	157	Xb					1				
	U	158	Xb		2	2						
	U	159	Xb	1	3		1	1				
	U	161	Xb		2	1						
29	U/T	157	Yg		2	1						
30	U/T	159	Xb, Qd		5	2	1					
	U/T	158	Xg, Qd		4	2						
	U/T	160	Yg		1	2						
31	U	157	Xg				1	1	1			

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ 0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
	U	158	Xg,Qd		1	3						
32	U	162	Yg		1	2						
	U	163	Yg		1	2						
	U/T	164	Yg		1	2						
	U	165	Yg		10	6		1				
	U	166	Yg		3	1	2	1				
	U	Tl 8	Yg		2	1						
33	U	161	Yg		2	1						
	U	162	Yg, Qd		4	2						
	U	164	Qd			2						
34	U	164	Yg		2	1						
35	U	161	Xb,Yg		7	5						
	U	162	Xb,Yg		2	3						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ 0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
	U	163	Xb,Yg		1	3	1	1				
	U	164	Xb,Yg		2	1						
	U	Tl 7	Xb		2	1						
36	U	165	p₱if		1	2						
	U	166	P₱if			1	1					
37	U	160	Qe	2	5	3						
	U	163	Kpu,Qe,Qa		10	4						
	U	166	Kpu,Qa,Kc		8	6	1					
	U	169	Kc, Qe		13	11	1					
	U	Tl 5	Kpu,Qe		16	16	6	1				
38	U/T	Tl 3	Kl		2	1						
39	U/T	Tl 5	Qa,Qpu		7	7						
40	U	169	Qe		1	2						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
				Number of Data Samples (X7) with defined σ								
41	U	165	Xg,Yg		2	1						
	U	166	Xg,Yb	1		2	1					
	U	167	Xg,Yg	1	4	1	3					
	U	168	Xb,Xg,Yg	2	4	1	1	1				
	U/T	170	Xg		1		1					
	U/T	171	Xg				1					
	U/T	Tl 7	Xg, Xb		2	1						
42	U	168	Tmi,Qd	1	6	5	1					
	U	169	Tmi	1	2	4	1					
43	U	170	Tc,Xb		2							
44	U	171	Tv,Taf		4	4						
	U	172	Tv		2					1		
45	U	171	Yg,Xb		2	1						
	U/T	172	Yg		2	2						
46	U	178	Qe,Kl		2	1						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ 0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
47	U	181	Xg		1	3						
	U	182	Xg		2	1						
	U	183	Xg		1	2						
	U	184	Xg			1	1					
48	U/T	183	Pℙif		2	1						
	U/T	185	Pℙif TRPjs		2	3						
	U/T	Tl 6	Pℙif		1	2	1					
49	U/T	187	Kc				1					
50	U	190	Kl,Qgo		2	1						
51	U	Tl 7	Xfh		2	2						
52	U	188	Xb		5	2						
53	U	191	Yg		7	4						
54	U	192	Xfh		2					1		

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	Number of Data Samples (X7) with defined σ 0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
55	U	198	Xg, Tnp		3	2						
56	U	199	Xg					1				
	U	200	Xfh, Xg		2	1						
	U	201	Xfh		2	6						
	U	202	Xfh		2		2					
57	U	200	Xfh, Yg		4	3	1					
	U	201	Xfh, Yg		10	2	1		1			
58	U	195	Yg		3	4	2					
	U	197	Yg		4	5			1			
	U	198	Yg				1					
59	U	194	P₱if		4	3						
	U	195	P₱if		3	2						
	U	196	P₱if		2	3						
	U	197	P₱if		3	2	1					
	U	198	P₱if		3	2						
	U	199	P₱if		2	1						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly		Line	Rock	Number of Data Samples (X7) with defined σ								
Number	Type	Number	Type	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
		198	PIPif TRPjs		5	5						
		199	PIPif		2	2						
60	U/T	196	Kl		4	2	1					
61	U/T	199	Twr		2	1						
62	U	199	Twr		2	1						
63	U/T	202	Twr			2						
64	U/T	199	Twr		2	1						
65	U	199	Twr		2	1						
66	U	202	Twr		3	2						
67	U/T	205	Twr/To		5	3	1					
68	U	Tl 3	Twr		2	1						
69	U/T	208	Twr/To		5	5	2					
	U/T	Tl 3	Twr/To		3	2	1					

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly		Line	Rock	Number of Data Samples (X7) with defined σ								
Number	Type	Number	Type	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
70	U/T	Tl 4	Twr,To		1	1	2					
71	U	208	KJds,Tnp		2	1						
72	U/T	174	tb		2	1						
73	U/T	183	Xg,tb		2	2						
74	U	146	Xg,tb		2	2						
	U	147	Xb				1					
	U	148	Xg			2						
	U	149	Xg		1	3						
	U	Tl 7	Xg		4	3						
75	U	158	Yg		8	4						
	U	159	Yg		5	5						
	U	160	Yg		2	1						
	U	161	Yg		3	5						

TABLE 5

ANOMALY SUMMARY

GREELEY QUADRANGLE

Anomaly Number	Type	Line Number	Rock Type	0	1σ	2σ	3σ	4σ	5σ	6σ	7σ	8σ
				Number of Data Samples (X7) with defined σ								
		162	Yg		1	2						
76	U	158	Yg,Xb		3	2	1					
	U	159	Yg	2	5	4	1	1				
77	U	193	Kl			2						
78	U	208	PPcf, Xg		2	1						
79	T	144	Xb,Yg, TKi		7	19						
	T	145	Xb,Yg		4	5	2					
	T	146	Yg,TKi		7	5						
	T	147	Xb,Yg,TKi		2	5		1	2			
	T	Tl 8				4						

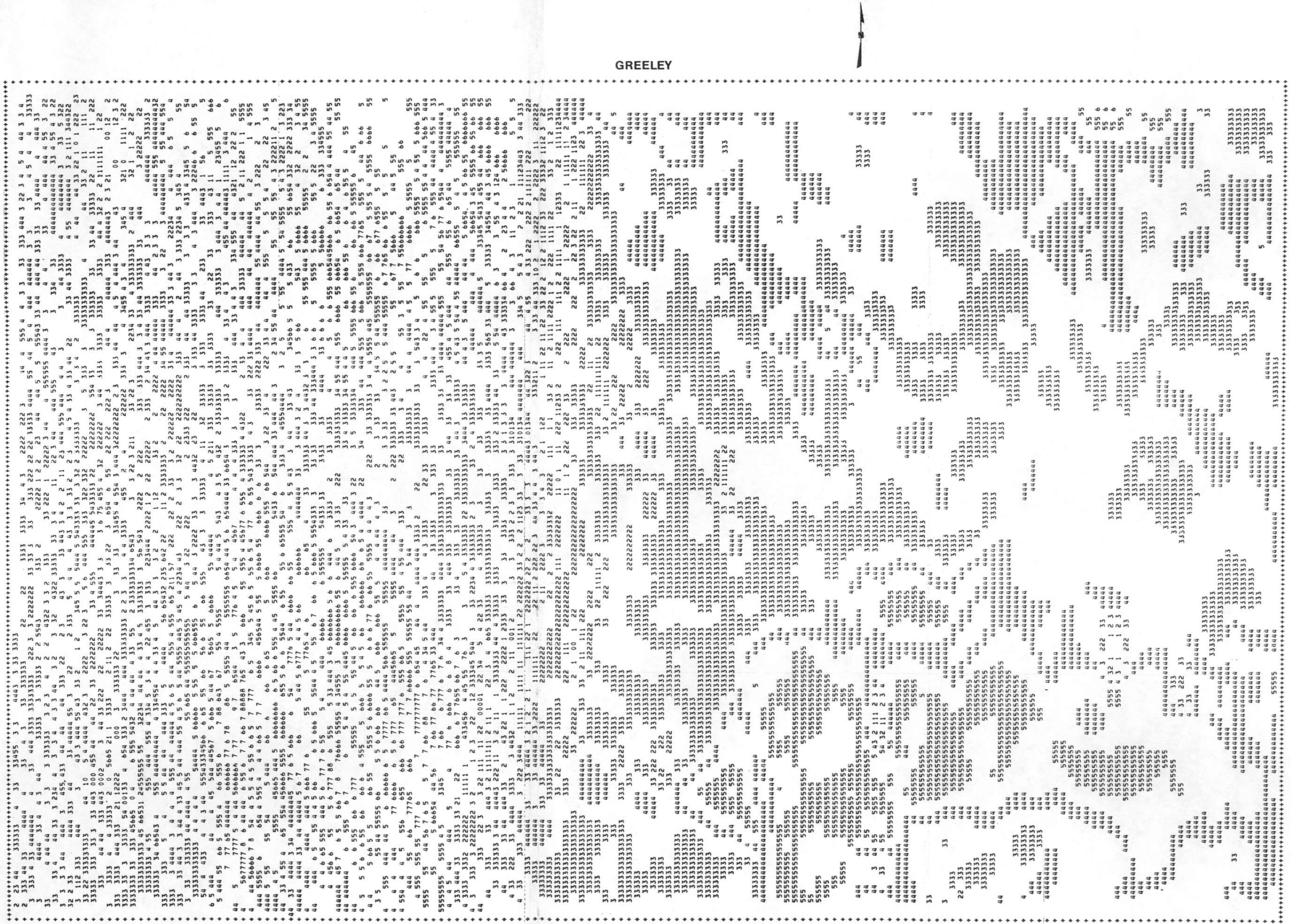


Figure 32 /Greeley/Quadrangle-Potassium Pseudo - Contour Map*

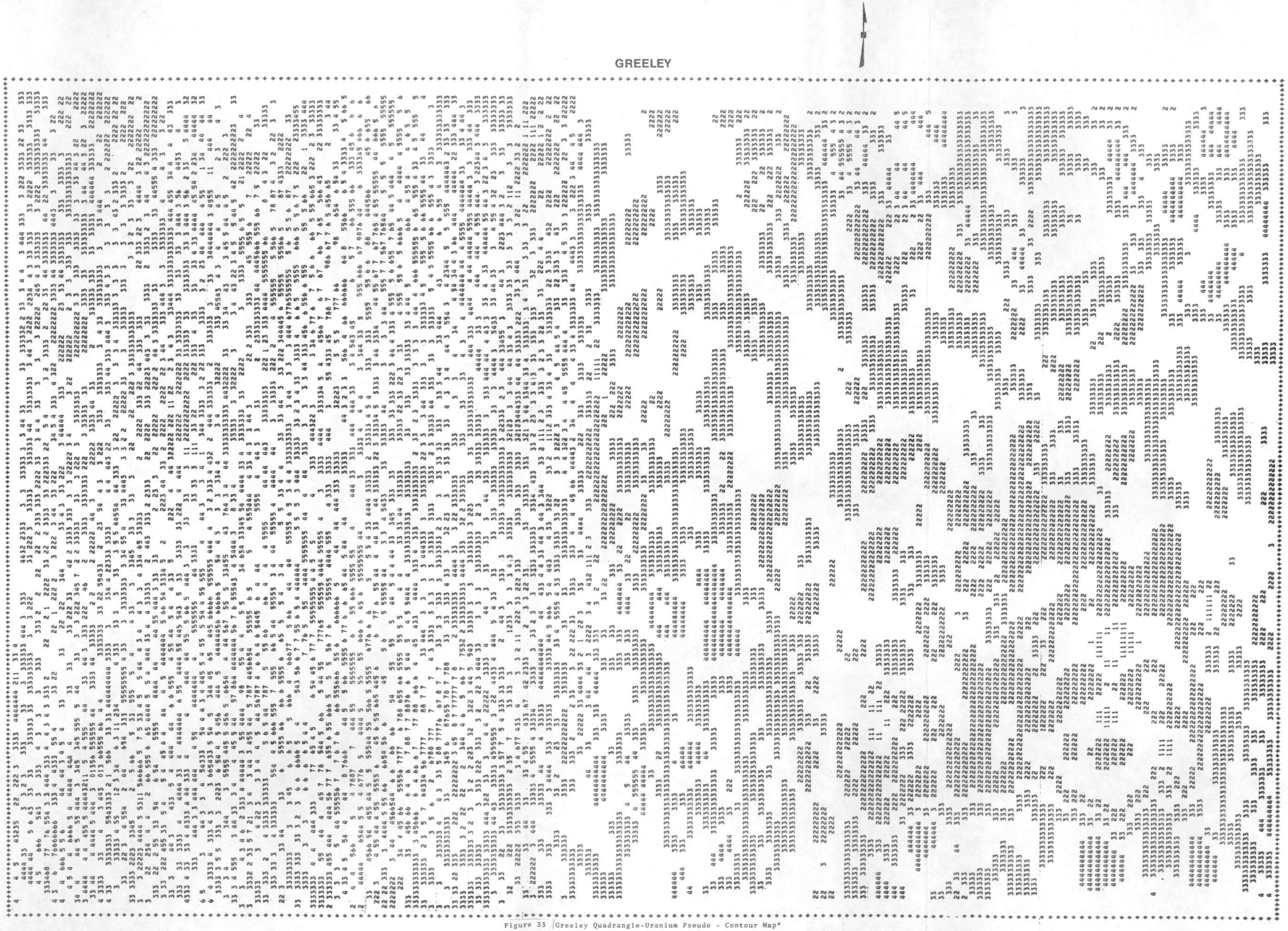


Figure 33 Greeley Quadrangle-Uranium Pseudo - Contour Map*

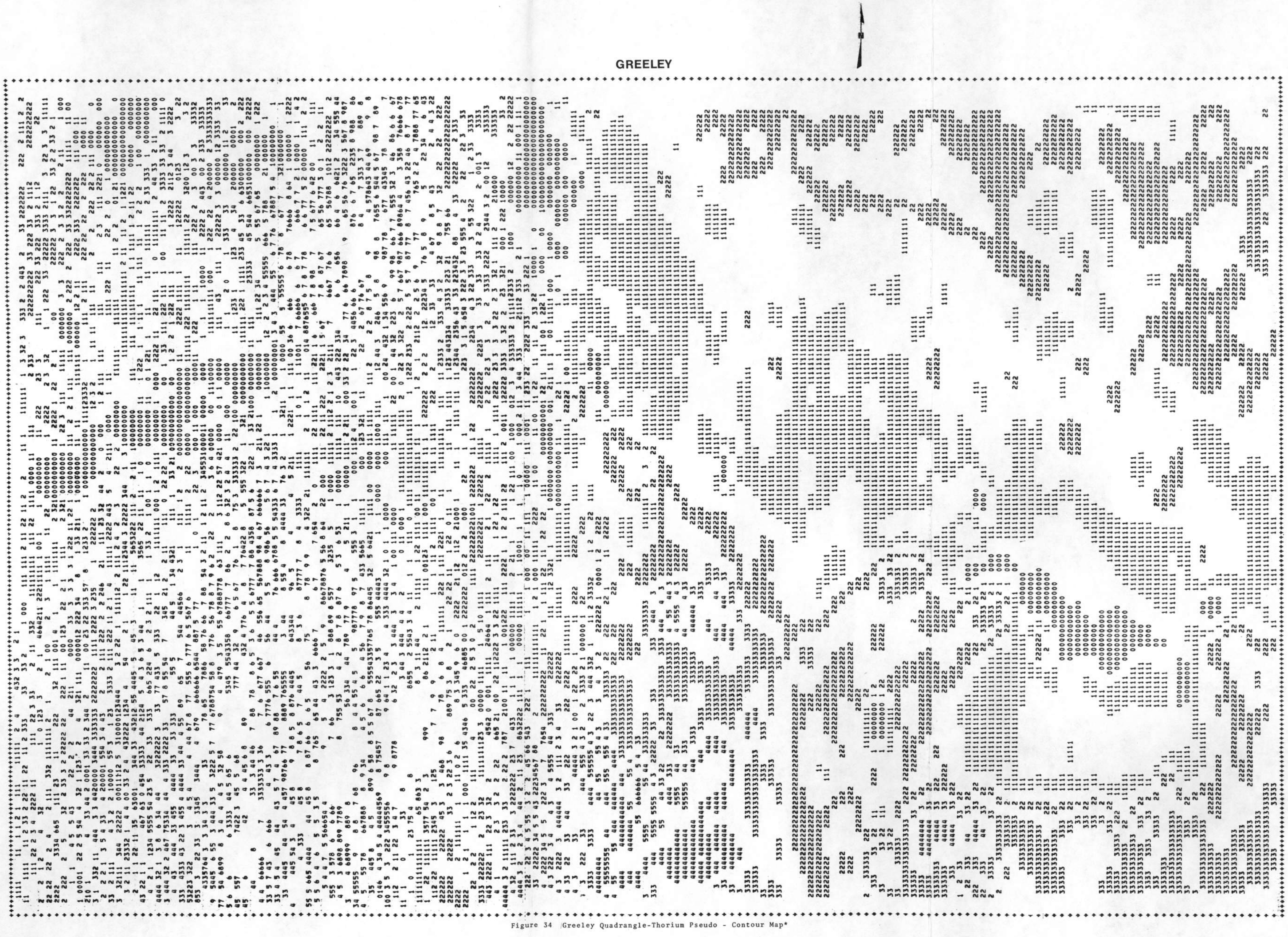


Figure 34 Greeley Quadrangle-Thorium Pseudo - Contour Map*

GREELEY

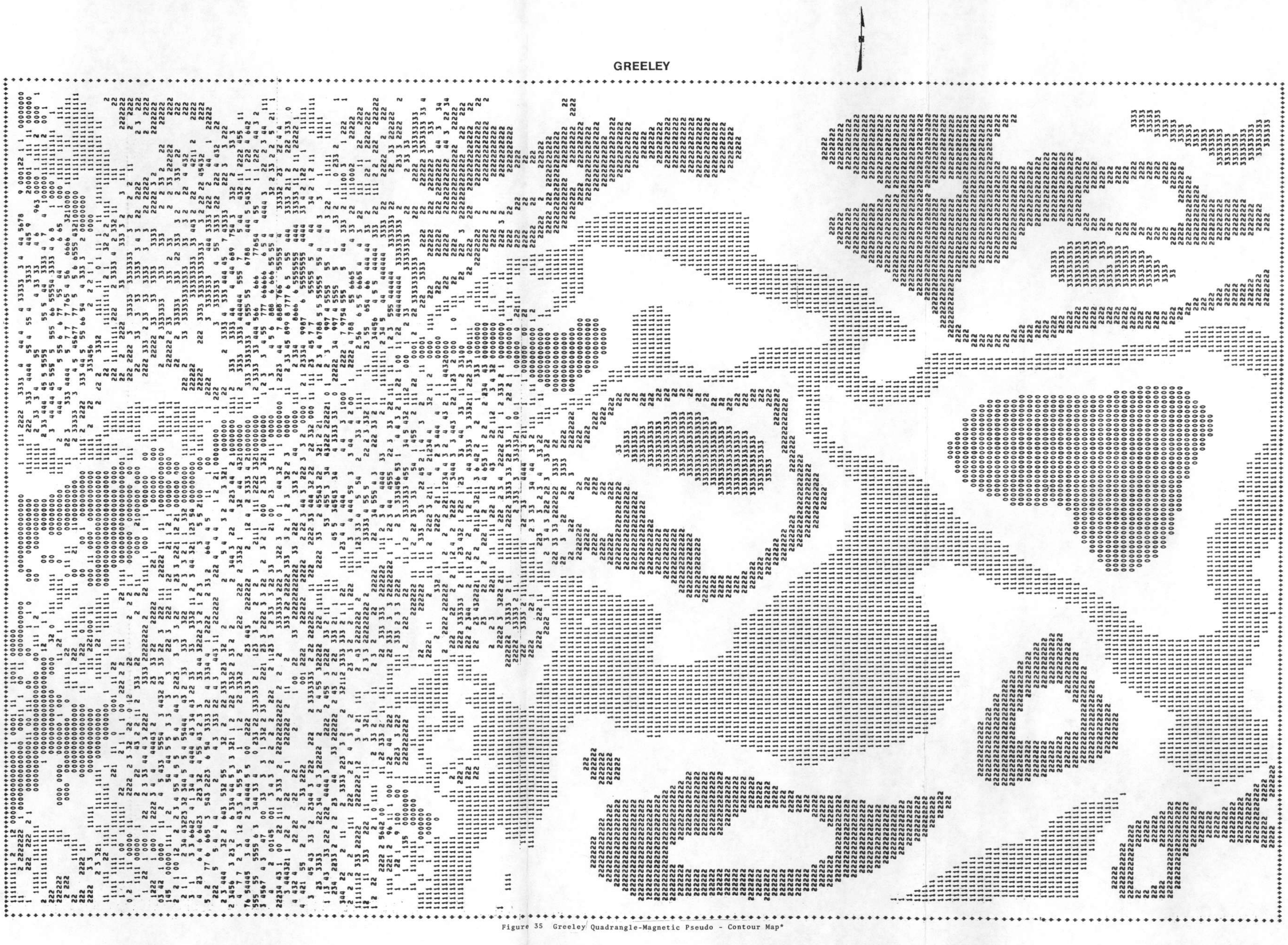


Figure 35 Greeley Quadrangle-Magnetic Pseudo - Contour Map*

In general, Precambrian rocks in the Uplift have the highest counting rates and Cenozoic sedimentary units of the plains have the lowest. Most of the mapped geology does not correlate well with radiometric patterns displayed by the pseudo-contour maps, with a few exceptions. Two of these are the Chalk Bluffs area (anomalies 68 through 70) and most of the Precambrian Yg unit, all of which are well defined by the radiometrics. A broad low zone, in evidence on the thorium and uranium pseudo-contour maps, extends east-west from the Denver Basin to the North Park Basin, across the Front Range Uplift. This feature is coincident with a major magnetic discontinuity.

The Front Range Uplift has the greatest number of anomalies. These are both larger and more tightly grouped than the scattered, often culture related anomalies occurring in the Denver Basin. This profusion of anomalies is partly coupled to the threefold increase in number of flight lines over the Uplift. Greater surface cover variability, resulting from the highly irregular terrain and the "timberline" effect (barren rock), serves to accentuate the disparity. Further, the variety of Precambrian lithologies lumped under simple labels (Xg, Yg, etc.) increases the possibility for statistical anomalies. (The Yg unit contains proportionately more anomalies than any other unit.) Overall, the youngest units, (Quaternary) exhibit the lowest counting rates. In some cases higher rates may locally reflect contributions of "fresh" Precambrian debris. Cretaceous arkosic and tuffaceous units have the highest overall count of the mapped sedimentary rocks.

Table 5 and the uranium anomaly interpretation map cite 79 anomalies which meet the criteria for statistically valid features. In the Yg unit some high count features do not satisfy the criteria because of the high unit mean. It is suspected that debris from upslope Precambrian units may shed across adjacent units creating anomalies. Some of the anomalous features in the Precambrian Yg are probably due to mining operations. Many anomalies matched discrete cultural features in the more densely populated Denver Basin.

Anomaly 37 contains 13 discrete elements along five separate flight lines. It encompasses a large developed (principally farmland) region wherein Highway 87 provides the largest count rate at 64 cps (6.4 ppm eU). The area is underlain by Quaternary aeolian and alluvial deposits as well as the Laramie Formation. Specific elements of the anomaly seem to occur over such diverse features as gravel pits and reservoir banks. It is interesting that the larger communities, Fort Collins and Greely, do not exhibit statistical anomalies comparable to this region of crisscrossing rural roads.

Anomalies 39, 10, 24, 25, 40 and 9 are presumed to also represent culture. Anomaly 25 corresponds to a gravel pit; anomaly 10 to a sequence of highways and roads. Anomaly 23 is partially adjacent to gravel pits but is quite extensive, covering 4 to 5 miles along one flight line. Exhumed or imported materials may be responsible for these features.

Anomaly 48, maximum 59 cps (6 ppm eU) and 70 cps (11 ppm eT), occurs further north near Rist Canyon downslope from Xg. Anomaly 59 is the most extensive anomaly in the PPif and occupies much of the Lower Lone Pine and Rabbit Creek Valleys. The peak amplitudes of the anomaly are 75 cps uranium (7 ppm eU) and 240 cps thorium (37 ppm eT). The two creeks themselves drain an extensive area of Precambrian Yg. The valleys form an irregular graben-like feature within a crystalline core. The PPif is primarily a fine to coarse arkose containing silty interbeds and is bordered by faults on all sides. The nearby Precambrian crystalline rocks may be the source from which the uranium and thorium were derived.

Pitchblende and Uranothorite have been noted (Nash and Cunningham, 1975) in shear zone breccia of the Jamestown area, otherwise well known for gold, lead and molybdenum production. Anomaly 12 is a multiline feature whose elements occur at or near the contact between Tertiary-Cretaceous intrusives (Tki) and Precambrian Xy, Xb and Xy units in the Jamestown area. This specific Tki intrusive body consists of Jamestown sodic granite and a granodiorite. Phair and Gottfried (1964) describe the surrounding Precambrian (termed the Silver Plume) as being strongly radioactive. The alkalinity of the Jamestown sodic granite invites consideration as an analog to the Bokan Mountain occurrence (Murphy, Wollenberg et al, 1978). The mineralized, sheared, and brecciated contact between the Tertiary intrusives and country rock served as a conduit and depositional site.

It is analogous to thorium enriched brecciated features in the Wet Mountains. (Christman et al, 1953). The maximum count of the anomaly is 86 cps (8.6 ppm eU) and 322 cps (50 ppm eT). A thorium high of 580 cps (91 ppm eT) occurs adjacent to the intrusion. Potassium counts are also extremely large. Individual uranium anomalies are strong, but only a few samples are broad, and are restricted to the mapped contact. Their extreme narrowness (sometimes a single sample), multiple occurrences over the contacts and coincidence with known, narrowly zoned uranium occurrences indicates that these anomalies are real and not culturally related.

Anomaly 42 at Baker Mountain with a maximum count rate of 91 cps (9.7 ppm eU) and 250 cps (39 ppm eT) occurs principally in Miocene to Eocene intrusive rocks (Tmi). It differs from anomaly 12 by encompassing the intrusive body and extending into glacial drift (Qd). Anomaly 79 a thorium feature, has a maximum count of 501 cps (78 ppm eT). It is restricted to the Yg and its contact with a Tki body and differs from anomaly 12 by not being restricted to the contact zone. Its statistical significance and high thorium count make it worthy of follow-up study.

The Chalk Bluff area at the northern quadrangle boundary contains a group of anomalies which are continuations of an anomalous trend in the Cheyenne quadrangle. The Cheyenne anomalies are at the Ogallala contact with Brule, Arikaree and Quaternary terrace deposits and circumscribe an oil producing anticline. Anomalies 67, 68, and 69 have a maximum count rate of 66 cps (7 ppm eU). This is substantially less than their counterparts in Cheyenne with 90 cps (9 ppm eU). These anomalies may be due to exposure of buried uraniferous distributary channels along contacts. Alternatively, seepage from adjacent petroleum reservoirs may create pockets of uranium enriched asphalt through formation of organo-uranium compounds and subsequent distillation. The two mechanisms discussed are only a few of many which might be suggested. These anomalies warrant further investigation.

Many of the discrete anomalies and elements of the composite anomalies are associated spatially with formational contacts. Although examining contacts (structural and formational) is an old prospecting technique, radiometric data may provide semi-quantitative criteria to separate the more probable ones for further investigation. Isolated statistical anomalies, those not exhibiting correspondence with mapped contacts or lineations might be related to unrecognized contacts. A possible example is an anomalously high potassium feature occurring in an expanse of Precambrian Yg north of the Jamestown intrusive complex. This could be the northernmost intrusive body in a series of four existing alkalic granitic bodies.

17 out of the 79 statistical anomalies in the Greeley Quadrangle show direct correspondence with linear features such as faults and dikes. Another 6 directly adjoin inferred magnetic discontinuities. Others have an indirect relation to linear trends (geology, magnetics, etc.). Previous studies indicate brecciated zones or dikes in the Precambrian rocks often localize uraniferous fluids.

A northwest-southeast trending shear zone, consisting of discontinuous faults and dikes, crosses the southwest quarter of the quadrangle from the Denver Basin to the North Park Basin (Geologic base maps). This extends over 60 miles through high relief terrain across the Front Range and along the west side of the Medicine Bow Mountains. Although principally in Precambrian rocks, the Front Range shear also offsets Tertiary volcanics. Anomalies 12, 74, 76, 32, 44, 47, 19 and 33 appear to coincide with the shear zone, although magnetics do not indicate a structural break. Anomalies 32, 76, and 19 occur primarily in the Yg. Anomalies 47 and 74 are in the Xg and 32 is in the Xb. There does not appear to be any direct lithologic relation between these anomalies.

The Colorado "Mineral Belt" is a several hundred miles long, loosely associated trend of mining districts and reported mineral occurrences. The Jamestown district is at its northern terminus. Anomalies 3, 79, 74, 12, 20, 21, 22, 23, 26, 75, 27, and 36 could be considered within the Belt. Anomaly 22 at 116 cps (12 ppm eU), occurring in Yg on Coffintop Mountain within the Belt has the highest uranium count rate in the quadrangle. A thorium high zone by anomaly 79 also coincides with the Belt. Thorium counts as high as 580 cps (90.6 ppm eT) are noted in this zone. Anomalies tend to be adjacent or aligned with an irregular string of TKi bodies which intrude the Yg, Xb and Xg units.

A northeast-southwest trending magnetic discontinuity obliquely cuts across the northcentral Front Range in the vicinity of Mummy Pass. (See Figures 31 and 35). This feature, along with parallel discontinuous, mapped faults, and some topographic features appear to spatially correlate with a broad uranium and thorium pseudo-contour low zone which crosses the front Range Uplift from the Denver Basin to the North Park Basin. This zone coincides with Xfh and Xb unitts, effectively separating the Precambrian Yg into northern and southern components.

Statistical anomalies are similarly split. Anomalies 42 and 44 occur at theintersection of this magnetic discontinuity and the Front Range Shear near the North Park Basin Uplift boundary. Anomaly 59 adjoins the discontinuity at the Denver Basin/Uplift boundary. Anomaly 44 is on a short northwest-southeast mapped fault segment separating Tertiary volcanics from Precambrian Xb. It has a maximum count rate of 100 cps (10.6 ppm eU) and 200 cps (31 ppm eT). A one sample wide, six standard deviation anomaly apparently lies directly on the fault. The second element of the cluster is broader (four or five samples). The confluence of large features like the Mummy Pass discontinuity and the Front Range shear, coupled with the presence of both acidic volcanics, intrusives and Precambrian country rock and radiometric anomalies would indicate further study of this region is warranted.

The Permo-Pennsylvanian Ingleside and Fountain Formations, combined, (PPif) is typically exposed in narrow upturned beds adjancent to the Precambrian core of the Front Range. Anomalies 36, 48, and 59 are associated with it. These are narrow, restricted, often multiline features which tend not to overlap into adjacent Precambrian or Triassic units. Anomaly 36 has a maximum of 75 cps (7.5 ppm eU) and 50 cps (7.8 ppm eT) and occurs across a fault contact with the Precambrian Xg. The anomaly extends from the eastern flanks of Blue Mountain into the downslop drainage course and may result from surface debris shed by the adjacent Xg. A power plant complex is situated one half mile to the north with an associated pumped storage reservoir one quarter of a mile east. If this is a coal burning plant, the anomaly might result from fly ash deposition or contaminated water.

Anomaly 48, maximum 59 cps (6 ppm eU) and 70 cps (11 ppm eT) occurs further north near Rist Canyon downslope from Precambrian Xg. Anomaly 59 is the most extensive feature in the PPif and occupies much of the Lower Lone Pine and Rabbit Creek Valleys. Maximum count rates are 75 cps (7 ppm eU) and 240 cps (37 ppm eT). The two Creeks drain extensive areas of Precambrian Yg and the valley is essentially an irregular graben-like feature inset in the crystalline core. The continental origin, overall fine to coarse arkosic nature, silty interbeds and proximity to Precambrian crystalline rocks indicate this formation is a possible host rock.

The magnetic pseudo-contour map, Figure 35, clearly shows the sediment filled Denver Basin abruptly terminating against the uplifted Front Range on the west. The boundary between these two structures is not the relatively simple north-south magnetic trend which exists further north in the Cheyenne Quadrangle.

First, there is a magnetic basement ridge striking east-northeast which apparently divides the Denver Basin into two sub-basins to the north and south. The ridge is broken into at least three segments by northwest trending faults within the magnetic basement. Also, there is another smaller magnetic basement high in the southeast corner of the quadrangle.

Second, there is a major magnetic lineation, striking north-east, just north of the basement high and is inferred to be a major magnetic basement fault. It is coincident with a series of mapped faults which trend northeast across the boundary between the Front Range Uplift and into the Denver Basin. Topography within the Uplift also coincides with the inferred fault, e.g., at Mummy Pass. Since this magnetic lineation cuts the Uplift/Basin boundary, it could indicate post Laramide activation of an old Precambrian feature. Both the inferred magnetic basement ridge and the major inferred fault correspond to features on the Bouger anomaly map in the Rocky Mountain Atlas of Geology (1972).

Geochemical Analysis Results

Seven mapped formations, Precambrian granitic rocks - Yg, high level gravel deposits - Tgr, Middle Tertiary intrusive rocks, - Tmi, the Denver Formation - Tkd, Fox Hills Sandstone - KF, Ingleside and Fountain Formations, combined - PPif, and aeolian deposits - Qe, have sufficiently polymodal distributions and the requisite spatial coherency to allow them to be subdivided. This subdivision is accomplished by picking the count rate which best separates the modes and using it as a threshold to compare the stacked profiles with the appropriate parent unit on the geologic map. Table 6 summarizes the geochemical sub units and the radiometric criteria. The interpretation map displays the spatial relationship of the subunits.

TABLE 6

MAIN UNIT	SUBUNIT	THORIUM	POTASSIUM	THORIUM/POTASSIUM
Tgr	Tgr1		<215	>.43
	Tgr2		>215	<.43
Kf	Kf1	< 85		
	Kf2	> 85		
Tmi	Tmi1	< 150		
	Tmi2	> 150		
Yg	Yg1	< 115		>.34
	Yg2	> 115		<.34
Tkd	Tkd1			<.40
	Tkd2			>.40
PPif	PPif1			
	PPif2			
Qe	Qe1	< 65	<240	
	Qe2	< 65	>240	
	Qe3	> 65	>240	

Pseudo-contour trends do not clearly distinguish boundaries between the geochemical subunits. The statistical anomaly distribution does not unequivocally make distinctions either, although 30 anomalies are associated with the Yg2 subunit and none occur in the Ygl subunit. Subunits of the Ingleside and Fountain Formation (composite) and the Qe sub units each contain selected anomalies, indicating no obvious preference for geochemical sub units.

The geochemical subunits are primarily within: (1) mapped Precambrian Yg and flanking sediment units in the western one-third of the map; or broad areas in the eastern two-thirds of the map overlain by Quaternary material. A third "class" consists of small clusters of Tertiary intrusive rocks.

Principle components analysis indicates that nearly 90% of the total sample variance is accounted for by the first and second principle components. There is no apparent relationship between the age of the formations and the eigenvalues - eigenvalues are proportional to the percent of variance accounted for by each component.

Glacial drift (Qd, and Qdo) has 75-80% of the variance accounted for in the first component. This may be due to homogeneous mixing of the constituents within the sediments. Tertiary units generally have 80-90% of the total variance accounted for in the first and second components, with 45-60% accounted for by the first. The Coalmont (TC), Denver (Tkd), and gravels (Tgv) have first and second components accounting for 80-90% of the total variance. Lithologically, these are fluvial/alluvial conglomerates (Tc), non-marine sandstone (Tkd), and partially cemented gravels (Tgv). Tkd has local conglomeratic lenses. A common denominator may be the coarse clastic nature of these units.

Permo-Pennsylvanian and Triassic units show 90-95% of variance accounted for by the first two principal components with 60-65% represented by the first alone. The Lykins Formation and Lyons Sandstone combined (Trplf) and Ingleside and Fountain Formation, combined (PPif) have 85% of variance accounted for by the first component indicating remarkable cohesiveness for combined units. The Precambrian rocks had 90% of the variance associated with the first two components with 70-80% in the first component alone. Tertiary volcancis and intrusives appear similar. Both differ from the sedimentary units in having larger eigenvalues for the first component.

Most of the formations separate into three classes in the principle component analysis: (1) first component correlates with potassium and thorium, and the second component correlates to uranium; (2) first component correlates with potassium; and (3) equal correlation in the first component with all channels and second component correlates with uranium. Each class contained equal numbers of Mesozoic units, indicating no preference for lithology. Tertiary units tended to occur in classification 1 and Quaternary units in classification 1 and 3. Tertiary volcanics were found in classes 2 and 3. The significance of the classification is indeterminate at this time. However, the number of samples in Xb and Xg units in class 1 (18684 and 8846) and the Yg unit in class 3 (20322) indicate neither class is a trivial result. The anomaly maps and pseudo-contour maps illustrate a similar tendency for these Precambrian units to separate.

SECTION VIII

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APPENDIX A

GEOLOGIC DESCRIPTION

ROCK SPRINGS, RAWLINS, AND CHEYENNE QUADRANGLES

WYOMING

GEOLOGIC DESCRIPTION

ROCK SPRINGS, RAWLINS, AND CHEYENNE QUADRANGLES

PRECAMBRIAN

PCGN- Gneiss (Proterozic - Precambrian X). Augen, quartzo-feldspathic, biotite, and hornblende gneiss of Jelms Mountain.

PCG
PCSCH- Schist (Proterozoic - Precambrian Y). Intermixed black to gray phyallite and slate with chlorite and amphibole, white massive quartzite, sericitic schists, and marble.

PCG- Older Precambrian granite and quartz monzonite. (Proterozoic - Precambrian X).

PCNOR- Norite and Metanorite (Proterozoic - Precambrian Y).

PCQM- Precambrian quartzite (Proterozoic - Precambrian Y).

PCAN- Anorthosite (Proterozoic - Precambrian Y). Gray to light-brown quartz diorite and minor quartz monzonite.

PCQ- Precambrian Quartz Monzonite (Proterozoic - Precambrian Y).

PCGR- Granite (Proterozoic - Precambrian X). Pink to pinkish-gray granite and minor quartz monzonite.

PCU- Undivided Precambrian igneous and metamorphic rock. (Proterozoic).

PCI- Undivided Precambrian Intrusive rocks (Proterozoic).

PALEOZOIC

CU - Cambrian Rocks (Undivided).

MCU- Cambrian and Mississippian Rocks (Undivided).

PTA- Pennyslvanian Undivided (Morrowan to Virgilian) Darwin Sandstone member and red Horsehoe Shale member of Amsden Formation, with intertongues of shaley carbonate rock of laterally equivalent lower Casper Formation, and white to calcareous sandstones of Tensleep Formation.

PMU- Mississippian and Pennsylvanian Rocks (Undivided).

PPC- Casper Formation (Pennsylvanian to lower Permian) White Cross-bedded calcareous sandstone with limestone in upper sections.

PPFSC- Pennsylvanian and Permian Rocks (Undivided).

PG- Goose Egg Formation (Permian - Leonardian to Guadalupian) Predominantly red shales and siltstones with interbedded limestone and thin gypsum beds, laterally equivalent to Satanka Shale and Forelle Limestone.

PFS- Satanka Shale and Forelle Limestone Undivided (Permian-Leonardian to Guadalupian) Thin beds of red shales and siltstones with interbedded evaporites, grading into clastic, bluish-gray, crenulated limestone. Represents shallow water deposition in lower portions grading upward into deepening marine shelf depositional evrinorment. Uncomforambly overlies Casper Formation.

PU- Permian Rocks (Undivided).

PALEOZOIC - MESOZOIC

TRPU- Undivided Permian and Triassic Rocks Inclusdes Satanka Shale, Forelle Limestone and Chugwater Formation.

MESOZOIC

TRJC-	Chugwater Group (Early Triassic). Red shale and siltstones with interbedded Limestone and Red shale and evaporates in basal sections, and clay pebble conglomerate at base of upper Jelm Formation. Represents deepening marine sequence from a more restricted marine embayment. See Greeley unit descriptions for Jelm Formation description
TRU TRJC	Triassic Rocks (Undivided).
JS-	Sundance Formation (Jurassic). Gray and green non-marine shales, and sandstone beds. Represents continental flood plain and/or drier climate sheetwash (Stokes, 1950).
JM-	Morrison Formation (Latest Jurassic). Varicolored shales with chert and light colored aeolian and non-marine sandstone beds. Represents continental flood plain and/or drier climate sheetwash (Stokes, 1950).
JU JMS-	Undivided Jurassic Rocks. Includes rocks of the Morrison Formation, the Sundance Formation, and the uppermost Jelm Formation. See Greeley unit descriptions for Jelm Formation descriptions.
KJCS-	Lower Cretaceous - Upper Jurassic Rocks (Undivided). May include Sundance Formation, Morrison Formation and Cloverly Group.
KCV-	Cloverly Group (Cretaceous - Aptian). Base of Pryor Conglomerate (conglomeratic sandstone) grading into pink shale. Grey Bull "Rusty Beds" sandstone lies disconformably above the lower member. Probably represents fluvial and lacustrine deposits prior to the transgression of the Skull Creek marine invasion associated with early Albian down warping.
KJCM-	Morrison Formation and Cloverly Group (Undivided).

KMT-	Mowry Shale and Thermopolis Shale (Cretaceous - Albian). Basal dark shale with interbedded thin brown sandstone beds, grading into siliceous, bentonitic, porcelaneous shale. Represents westward-transgressing marine environment of the Skull Creek Seaway and the later, more restricted, Mowry Sea.
KF-	Frontier Formation (Cretaceous - Albian through Turonian). Dark marine shale with siderite concretions and bentonitic beds. Several disconformaties could indicate local periods of non deposition. Wall Creek glauconitic sandstone lies discomformably above shale member.
KFMF-	Mowry Shale, Termopolis Shale, and Frontier Formation (Undivided).
KN-	Niobrara Formation (Cretaceous - Coniacian through lower Campanian). Gray marine shales and silty limestone of the lower sections of the formation. Represents approximate statigraphic position of maximum transgression of the Niobrara Seaway to the east. The seaway attained depths of only 600 ft., but northflowing surface currents operated with little restriction. Thickness in southern Wyoming varies from 1000 to 2500 ft.
KS-	Steel Shale (Cretaceous - Campanian). Gray marine shales deposited during regressive stage of the early Clagget Cycle. Depositional conditions similar to those of the Niobrara Formation, though shallower seas are indicated - nearly 2500 ft. of shale deposition in the area. Upper sections marked by thick beds of fine grained near shore marine sandstones, which are transitional to Mesa Verde group.
KSN-	Steele Shale and Niobrara Formation (Undivided).
KMV-	Mesa Verde Group (Cretaceous - Campanian). Interbedded marine and non-marine shales, coal, and crossbedded sandstones. The near shore marine, and non-marine fluvial flood plain and paludal depositional environment represented here are related to still-stand conditions near maximum regression of the Claggett Cycle.

KLE- Lewis Shale (Cretaceous - Maestrichtian).
Gray marine shale with minor interbedded siltstone, sandstone, and coal. Related to transgressive portions of the Bearpaw Cycle. Lateral equivalent of the Pierre Shale to the east, and the non-marine Lance Formation to the west. The shales are 1000 to 1200 feet thick in southern Wyoming.

KBA- Baxter Shale.
Marine shale lateral Tununk and Lower Mancos shale equivalent; Cenomanian age (upper Cretaceous); a transgressive unit of Greenhorn cycle; a glauconitic shale interbedded with sandstone; some calcareous interbeds.

KP- Steel Shale Mesa Verde Group, and Lewis Shale Undivided.

KPN- Niobrara Formation, Steel Shale, Mesa Verde Group and Lewis Shale Undivided.

KBL- Blair Formation.
Dominantly shale - Lateral equivalent of Cody and Steele Shale; transgressive; Cenomanian - Turonian age.

KMB- Medicine Bow Formation (Cretaceous - Maestrichtian).
Interbedded non-marine shales and sandstone, with coal beds some black shales near base. Fluvial to paludal environment. Equivalent to Lance Formation, but confined to the Hanna and Laramie basins.

KR- Rock Springs Formation.
Coarse arkosic sandstone; mid-Maestrichtian Age; representative of the regressive phase of the Clagget Cycle; derived from flood of coarse clastics and cycles of oscillating uplift/deposition.

KE- Ericson Formation.
Fluvial sandstone; mid-Maestrichtian age; representing relatively slow transgression of Bearpaw Cycle; reflects irregular inundation patterns.

KAL- Almond Formation.
Fluvial sandstones with local marine stillstands preserving barrier bars; mid-Maestrichtian age; essentially representing high energy environment (well sorted) pinchouts etc., shows shifting from barrier island to swamp and lagoon environments.

KFL- Fox Hills Sandstone and Lewis Shale, (Undifferentiated). Yellow-brown, white, and gray calcareous sandstone, and gray sandy shale interfingered with gray-brown shale representing marine-to-continental transitional oscillating environments; mid-Maestrichtian age; Fox Hills Sandstone shallow water and littoral unit resulting from the Bearpaw regression; Lewis Shale is considered uppermost marine shale of Clagget Cycle units.

KI
KL- Lance Formation (Cretaceous - Maestrichtian). Interbedded non-marine shales, and sandstone with coal beds and black shale at base. Fluvial to paludal environment. Deposition during final regression at the Pierre Seaway. Lower sections laterally equivalent to Lewis Shale. KL - Exposed in Rock Springs Uplift in central part of quadrangle. KI refers to the Cheyenne quadrangle outcrops.

KU- Cretaceous Rocks (Undivided).

KJU- Cretaceous - Upper Jurassic Rocks (Undivided).

KJCS- Lower Cretaceous - Upper Jurassic Rocks (Undivided). May include Sundance Formation, Morrison Formation and Cloverly Group.

MESOZOIC-CENOZOIC

TKF- Ferris Formation (Cretaceous to Tertiary). Light to dark gray, carbonaceous shale. Fossiliferous, cross bedded sandstone and numerous coal beds also are present. Represents continental fluvial and paludal environments, and is laterally equivalent to the Lance Formation.

CENOZOIC

TFU- Fort Union Formation. Lithologic generalization difficult because of extensive variability (a) Red Desert Basin: mixture of low to high energy fluvial, paludal and piedmont type sandstone, shales siltstone, and lignitic coals; (b) Washakie Basin: mixed low to moderate energy fluvial, drab paludal sandstone, shale, siltstone and lignitic coals (some interbedded red beds); (c) Green River Basin: mixed depositional environment, including floodplain, alluvial, paludal materials, some local massive coals; Paleocene age; in places, seems to grade upward to Wasatch, unconformable at basin margins; contacts sometimes indistinct; thickens to eastward on east flank of Rock Springs uplift and thickens westward and northward on west flank; 2000-2500 feet thick in Green River Basin, 4000 feet thick in Red Desert Basin, and 4500 feet thick in the Washakie Basin.

TH- Hanna Formation (Tertiary - Paleocene). Restricted unit of arkosic sandstones, local conglomerate, minor lignite coal, and dark shale beds. Laterally equivalent to more extensive Fort Union Formation of similar lithology in the Red Desert, Washakie, and Green River Basins. Mixed low-to-high-energy fluvial, paludal, and piedmont plains depositional environment.

TBS- Battle Springs Formation. High energy fluvial arkosic sandstone; Eocene age; extensive interfingering with low to moderate energy fluvial and paludal Wasatch Formation and with overlying Luman and Wilkens peak members of Green River Formation.

TW- Wasatch Formation. Mid-Eocene redbed unit of mixed fluvial, alluvial, piedmont and locally paludal environments deposited in subsiding basin; variable lithologies (a) Washakie Basin: mixture of fluvial and paludal environments; reduction with some local areas of sandy gray mudstones and channel sandstones, and coal and carbonaceous materials. (b) Green River Basin: mixed fluvial environment of high to low energy with vertical and lateral gradations. (c) Red Desert Basin: low to moderate energy fluvial and paludal environment; overall, a thick unit of sandy shale and siltstone having variqated (pink, red, etc.) appearance, and variable amounts of channel sandstone depending on local paleo-drainage system configuration. Extensive intertonguing with Green River and Battle Springs formations; shifting depositional centers produced variable thickness - estimated to be approximately 5000 feet in central Washakie Basin.

TWK- Washakie Formation.
Eocene continental fluvial sediments; lateral equivalent of Bridger Formation and Uinta of Bradley, 1964.

TWDR- Wind River Formation (Tertiary - Eocene).
Poorly sorted arkosic gravelly sandstones with interbedded non-marine shales. Restricted to Hanna and Laramie Basins. Low to moderate energy fluvial and lacustrine environment indicated. Probably equivalent to more extensive Washakie, Battle Springs and Green River Formation in more westerly basins.

TGR- Green River Formation.
Eocene, lacustrine-derived fine grained sediment. Widespread anaerobic bottom water conditions coupled with high organic activity produced kerogenous, thinly to very thinly bedded marlstones ("oil shales") in most formation members. The members have somewhat different characteristics from basin to basin. (a) Green River Basin: Tipton shale member - thick fine-grained calcareous shale, marls, etc., 400 feet of Luman tongue mudstone and siltstone; Wilkens Peak member - complex bedded evaporite; Laney Shale Member - interbedded marlstone, limestone, Tuff, and sandstone. (b) Washakie Basin: Laney shale member marlstone, and oil shale. Tipton shale member soft, brown fissile, shale and flaky marlstone. (c) Red Desert: Luman and Wilkins Peak complex represent lacustrine interface with Battle Springs Formation. Unconformably overlies Washakie Formation.

TG- Assumed to be Green River Formation;
Rawlins quadrangle only.

TB- Bridger Formation (Rock Springs Quadrangle only).
Middle to late Eocene mudstone from mixed fluvial environment; varicolored white and light gray to dark green and deep brown, with some pink and red banding in upper part; nearly pure interbedded volcanic ash beds are common, associated with limesstones representing ponding and lignitic coal; covers much of the central parts of the Green River and Washakie Basin. Unconformably overlies Green River Formation.

TC-	Chadron Formation (Tertiary - Oligocene). Thin, but extensive varicolored, loosely to moderately cementedbentonitic clay and silt. Part of the White River Group and stratigraphic equivalent of the White River Formation to the north and east.
TB-	Brule Formation (Tertiary - Oligocene - Cheyenne Quadrangle only). Brittle argillaceous siltstone with minor limestone, clay, and ash. Part of the White River Group and stratigraphically equivalent to the White River Formation to the north and east. Overlies Chadron Formation.
TWR-	White River Formation (Tertiary - Oligocene). White to gray non-marine siltstones and shales, with layers of varicolored tuff. Environment of deposition probably lacustrine and low-energy fluvial. Laterally equivalent to Castle Rock Conglomerate to the south.
TD-	Dutton Creek Formation (Tertiary). Highly restricted unit of yellow to gray, generally coarse, sandstone with some local conglomerates. Probably represents medium to high-energy fluvial environment associated with northerly divided drainage into the Hanna Basin.
TBC-	Bishop Conglomerate. (Mid-Miocene). Continental conglomerate representative of high energy fluvial environment; lateral equivalent of Split Rock Formation.
TBP-	Browns Park Formation (Tertiary - Mid Miocene). Fine grained aeolian and fluvial sandstones, rough gravelly conglomerates and local nonmarine limestones. Individual beds show cut-fill characteristics. Deposited in structural basins. Generally restricted to south central Wyoming.
TA-	Arikaree Formation (Tertiary - Miocene to Pliocene). Relatively thin unit of light gray, very fine-to-fine grained, loose to well-cemented sandstone. Previously known as Split Rock Formation (Keefer, 1970).

TO- Ogallala Formation (Tertiary - Miocene to Pliocene).
Heterogeneous thin unit of intermixed, poorly-to-well-cemented silt, sand, and gravel.

TNP- North Park Formation (Tertiary - Miocene to Pliocene).
White fine grained sandstone, siltstone, and shale with layers of white tuff.

TVU- Tertiary VolcanicRocks (Undivided).
Upper Tertiary intrusive and extrusive rocks in Leucite Hills of north center Rock Springs Uplift.

TI- Tertiary Intrusive Rocks (Undivided).
Probable Miocene intrusives of basaltic composition in the Battle Mountain area in the south central Rawlins Quadrangle.

TU- Tertiary Rocks (Undivided).

QTU- Plio - Pleistocene sandstones and conglomerates.

QT- Terrace Deposits (Quaternary - Pleistocene).
Intermixed sand, gravel, cobbles, and boulders.

QG- Glacial Deposits (Pleistocene).
Glacial dust, outwash deposits, loess and various shales.

QAL- Alluvium (Quaternary - Recent).

QF- Fan Deposits (Recent).

QSW- Slope Wash (Recent).
Intermixed clay, silt, sand, and gravel.

QMC- Mantle Cover (Recent).

QLS- Land Debris.
Unsorted rock debris emplaced by mass movement.

QS- Eolian Sand (Recent).

Q-	Surficial Deposits. Combined alluvial deposits, terrace gravels, and windblown sand.
QU QD-	Undivided Surface Deposits (Quaternary). Includes alluvium, colluvium and pediment surface deposits.
QLE QL-	Quaternary Deposits (Unspecified). Assumed to be lake deposits in Rawlins Quadrangle.

APPENDIX B

GEOLOGIC DESCRIPTION
GREELEY QUADRANGLE,
COLORADO

GEOLOGIC DESCRIPTION

GREELEY QUADRANGLE*

PRECAMBRIAN

XB- Biotite Gneiss, Schist, and Migmatite (Precambrian X).
Principally derived from sedimentary rocks; locally contain interbedded hornblende gneiss, calc-silicate rock, quartz-rich rock, and metaconglomerate.

XFH- Felsic and Hornblendic Gneisses (Precambrian X).
May have been principally derived from volcanic rocks; locally contain interbedded biotite gneiss, amphibolite, and calc-silicate rock.

XG- Grandiorite and Granite (Precambrian X).
Includes Boulder Creek Granodiorite and tonalite in the Front Range, and granite in southern Medicine Bow Range; approximately 1,750 m.y. old.

YG- Granitic Rocks (Precambrian Y)
Includes Silver Plume Granite and Sherman Granite; 1,350-1,450 m.y. old.

PALEOZOIC

PPIF- Ingleside and Fourtain Formations (Undivided).
Ingleside Formation (Lower Permian): Gray-white sandstone and crinoidal limestone; eastern foothills area; 30-40 meters thick.

PPCF- Casper and Fountain Formations (Undivided).
Casper Formation (Lower Permian, and Upper and Middle Pennsylvanian. Continental, well-sorted crossbedded arkosic sandstone, interbedded with thin beds of marine limestone; Laramie River valley; 30-120 meters thick.

PPF- Fountain Formation (Lower Permian and Upper and Middle Pennsylvanian).
Red, continental, fine to coarse grained arkosic sandstone and conglomerate, and thin beds of variegated siltstone; eastern foothills and Laramie River valley; 300 meters thick.

PALEOZOIC - MESOZOIC

TRPLF- Lykins Formation, Lyons Sandstone, and Forntain Formation, (Undivided Lower Triassic/Upper Permian to Lower Permian/Upper Pennslyvanian).
Reddish mudstone having dolomitic and gypsiferous interbeds (Lykins Formation); aeollian sandstone exhibiting large scale crossbedding, some local fluvial coarse grained arkose and conglomerate (Lyons); sandstone, red continental, fine to coarse grained arkosic sandstone and conglomerate (Fountain Formation); combined thickness 465-495 meters.

TRPLL- Lykins Formation and Lyons Sandstone, (Undivided Lower Triasic/Upper Permian to Permian).
Reddish aeolian sandstone exhibiting a large-scale crossbedding (Lyons). Local fluvial coarse-grained arkose and conglomerate (Lyons Formation), combined thickness 165-195 meters.

TRPJS- Jelm Formation, Lykins Formation, Chugwater Formation, Forelle Limestone, and Lyons Sandstone and Satanka Formation (Undivided - Lower Triassic to Lower Permian). Buff-red continental arkosic sandstone, exhibiting cross beds (Jelm Formation); reddish mudstones (Lykins); red sandstone interbedded with siltstone and shales (Chugwater Formation); reddish marine dolomitic limestone (Forelle Limestone); aeolian sandstone with local fluvial arkoses and conglomerates siltstone interbedded with sandstone and some limestone, locally gypsiferous (Satanka Formation). Combined thickness of 361-651 meters.

TRPR- Jelm Formation, Forelle Limestone, and Satanka Formation, (Undivided Upper Triassic to Lower Permian).
Buff-red continential arkosic sandstone (Jelm); reddish impure dolomitic limestone (Forelle Limestone); and red brown marine mudstone and siltstone interbedded with sandstone and limestone (Satanka Formation); 96-156 meters combined thickness.

MESOZOIC

MZ- Undivided Mesozoic Rocks
Symbol used only in areas of complex structure; western flank of Front Range.

KJDS-	Dakota Group (Sandstone), Morrison Formation and Sundance Formation, Undivided - Lower Cretaceous to Middle Jurassic. Buff, aeolian crossbedded sandstones whose base is a regional unconformity; eastern and northwestern flanks of Frong Range (Sundance Formation); variegated shale and siltstone (Morrison Formation); gray fine- to medium-grained sandstone and shale - South Platte Formation, and underlying fine - to coarse-grained sandstone with variegated siltstone - Lytle Formation (Dakota Group) combined thickness of 255-285 meters.
KTRDC-	Dakota Group or Sandstone, Morrison Formation and Upper Part of Chugwater Formation, (Undivided). (Lower Cretaceous to Triassic): fine-to medium-grained gray sandstone and shale - South Platte Formation; and underlying, fine to coarse grained sandstone with variegated siltstone- Formation, occurs in Denver Basin and western flank of Front Range (Dakota Group); Variegated shale and siltstone with minor limestone and sandstone occurring on eastern and western flanks of Front Range (Morrison); Red sandstone, siltstone, and shale locally gypsiferous; occurring on eastern and western flanks of Front Range (Chugwater); combined thickness 180-435 meters.
KC-	Colorado Group (Cretaceous). Includes Niobrara Formation (Upper Cretaceous), dark-grey calcareous shale and limestone, 100 meters thick; and underlying Benton Group or Shale (Upper and Lower Cretaceous), consisting of upper marine black shale unit, middle limestone unit know by various local names, and lower marine black unit, 90-120 meters thick in total; Denver Basin and western flank of Front Range.
KP-	Pierre Shale (Undivided - Upper Cretaceous).
KPL-	Pierre Shale Lower unit (Upper Cretaceous). Black marine shale, including the Sharon Springs Member composed of carbonaceous shale and bentonite beds; 450 meters thick.

KPM- Pierre Shale, Middle unit (Upper Cretaceous) Also known as Hygiene Interval, dominantly muddy marine sandstone and sandy mudstone including the Hygiene Sandstone Member at the base, and the Roberts Sand of informal usage at the top; includes zone of Baculites scotti at the base; 700 meters thick.

KPU- Pierre Shale, Upper unit (Upper Cretaceous). Dark-grey silty marine shale with minor carbonceous shale; above zone of Baculites reesidei; 1,200 meters thick.

KLF- Laramie Formation and Fox Hills Sandstone (Undivided- Upper Cretaceous). Yellow-brown calcarous marine sandstone interbedded with carbonaceous sandy shale in Denver Basin (Fox Hills Sandstone) combined thickness of 115-300 meters. Yellow to gray-brown non-marine carbonaceous shale and thick beds of claystone, some thin beds of coal and crossbedded sandstone in Denver Basins (Laramie Formation).

KF- Fox Hills Sandstone (Upper Cretaceous). Yellow-brown calcareous marine sandstone interbedded with carbanceous sandy shale Denver Basin; 15-120 meters thick.

KL- Laramie Formation (Upper Cretaceous). Yellow gray-brown nonmarine carbonacous shale and thick beds of kaolinitic claystone; minor crossbedded sandstone and thin beds of coal; Denver Basin; 100-180 meters thick.

KMW- Windy Gap Volcanic Member (Upper Cretaceous). Andesitic breccia and well-bedded volcanic siltstone; Colorado River valley; less than 90 meters thick.

MESOZOIC - CENOZOIC

TKI- Intrusive Rocks (Lower Tertiary and Cretaceous). Dominantly intermediate to felsic in composition some syenite and monzonite; 40-70 m.y. old.

TKD-	Denver Formation (Tertiary-Paleocene and Upper Cretaceous). Yellowish-brown nonmarine sandstone with abundent volcanic debris; local conglomerate and claystone southeastern Great Plains area; 250-300 meters thick.
TKDA-	Denver and Arapahoe Formations, Combined (Tertiary-Paleocene and Upper Cretaceous). Nonmarine channel deposits consisting of conglomerate, crossbedded sandstone, and minor claystone; southeastern Great Plains area (Arapahoe Formation) Yellow-brown nonmarine sandstone with abundant volcanic debris, local conglomerate and claystone, southeastern Great Plains (Denver Formation) combined thickness of 240-420 meters.

CENOZOIC

TM-	Middle Park Formation (Tertiary - Paleocene). Variegated arkosic sandstone and conglomerate with abundant volcanic debris; mudstone and claystone in upper part, locally carbonaceous and contians beds of impure coal; arbitrary line to the north from Middle Park Formation to the south in the Colorado River valley; as great as 1,800 meters thick.
TC-	Coalmont Formation (Tertiary - Eocene and Paleocene). Fluvial and alluvial conglomerate with abundant volcanic debris, and sandstone; some carbonaceous shale and coal in lower part; unconformably overlain by White River and North Park Formations; and unconformably overlies pre-Tertiary rocks; North Park area; greater than 300 meters thick.
TMI-	Intrusvie Rocks (Tertiary - Miocene to Eocene). Dominantly intermediate to felsic in composition 20-40 m.y. old.
TAF-	Ash-Flow Tuff (Tertiary - Oligocene). Near Cameron Pass; about 28 m.y. old.

TWR-	White River Formation or Group (Tertiary - Oligocene). Variegated fluvial tuffaceous silstone and friable to moderately well cemented sandstone; local channel sandstone and conglomerate in drainage channels of early Tertiary age; northern Great Plains areas and upper Laramie River valley; less than 180 meters thick.
TV -	Volcanic Rocks (Tertiary - Miocene and Oligocene). Primarily flows, breccias, and tuffs, dominantly of intermediate composition, and volcanicastic sediments.
TNP-	North Park Formation (Tertiary - Miocene). Continental tuffaceous sandstone, conglomerate and shale, with minor bentonitic on White River Formation in North Park; less than 250 meters thick.
TT-	Volcanic Rocks (Miocene and Oligocene). Tertiary Primarily flows, breccias, and tuffs, dominantly of intermediate composition, and volcanicastic sediments.
TBR-	Rhyolite Plugs and Flows of Bimodal Suite (Tertiary - Miocene). Near Granby; about 25 m.y. old.
TBB-	Basalt Flows of Bimodal Suite (Tertiary - Miocene). Near Granby; abouth 25 m.y. old.
TO-	Ogallala Formation (Tertiary-Pliocene and Miocene). Uncemented to well-cemented stream-deposited gravel, sand, silt, and minor clay; contians caliche horizons; northern Great Plains area; less than 60 meters thick.
TGV-	High-Level Gravel Deposits (Tertiary - Pliocene and Miocene). Probably equivalent to Ogallala and Arikaree Formations.
QDO-	Older Glacial Drift (Quaternary - Pleistocene). Deposits of pre-Bull Lake ages.
QD-	Glacial Drift (Quaternary - Pleistocene). Deposits of Pinedale and Bull Lake ages.

QGO- Older Gravel and Alluvium (Quaternary - Pleistocene).
Includes slocum, Verdos, and Rocky Flats alluviums of pre-Bull Lake age.

QG- Gravel and Alluvium (Quaternary - Pleistocene).
Includes Broadway and Louviers Alluviums of Pinedale and Bull Lake ages.

QE- Eolian Deposits (Quaternary - Holocene and Pleistocene).
Holocene silt-sand dunes and Pleistocene leosses

QL- Landslide Deposits (Quaternary - Holocene and Pleistocene).
Locally includes talus and rock glacier deposits.

QA- Alluvium (Quaternary - Holocene).
Piney Creek Alluvium and younger deposits.

* From Geological Survey Open file Report 78-532

APPENDIX C

STATISTICAL TABLES AND PRINCIPAL COMPONENT RESULTS

ROCK SPRINGS QUADRANGLE

```
@ADD,P RCKSPR,DISTFILE
                                     ROCK UNIT  KAL

                         -3          -2          -1          0          +1          +2          +3

  K40   DIST NORMAL    2,3584     45,2723     88,1861   131,1000   174,0139   216,9277   259,8416
 BI214  DIST NORMAL   -2,4457      5,4029     13,2514    21,1000    28,9486    36,7971    44,6457
 TL208  DIST NORMAL   16,5237     26,0158     35,5079    45,0000    54,4921    63,9842    73,4763
 U/K    DIST  LOG       ,0428       ,0663       ,1026      ,1590      ,2462      ,3813      ,5906
 U/TH   DIST NORMAL    -,1289       ,0738       ,2766      ,4793      ,6820      ,8848     1,0875
 TH/K   DIST NORMAL     ,0722       ,1692       ,2661      ,3631      ,4601      ,5570      ,6540
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                                     ROCK UNIT  KBA

                         -3          -2          -1          0          +1          +2          +3

  K40   DIST  LOG     79,9477     95,2033    113,3701   135,0034   160,7648   191,4420   227,9731
 BI214  DIST NORMAL    7,9068     14,0712     20,2356    26,4000    32,5644    38,7288    44,8932
 TL208  DIST NORMAL   27,1597     34,4398     41,7199    49,0000    56,2801    63,5602    70,8403
 U/K    DIST NORMAL     ,0305       ,0774       ,1243      ,1712      ,2181      ,2650      ,3119
 U/TH   DIST NORMAL     ,1788       ,2996       ,4205      ,5413      ,6621      ,7830      ,9038
 TH/K   DIST NORMAL     ,1785       ,2243       ,2702      ,3160      ,3618      ,4077      ,4535
-----------------------------------------------------------------------------------------------------

                                     ROCK UNIT  KBL

                         -3          -2          -1          0          +1          +2          +3

  K40   DIST NORMAL   56,4888     87,5259    118,5629   149,6000   180,6371   211,6741   242,7112
 BI214  DIST NORMAL    5,6407     10,9605     16,2802    21,6000    26,9198    32,2395    37,5593
 TL208  DIST NORMAL   30,6683     36,1455     41,6228    47,1000    52,5772    58,0545    63,5317
 U/K    DIST NORMAL     ,0278       ,0678       ,1078      ,1478      ,1878      ,2278      ,2678
 U/TH   DIST NORMAL     ,0959       ,2184       ,3408      ,4633      ,5858      ,7082      ,8307
 TH/K   DIST NORMAL     ,1780       ,2260       ,2739      ,3219      ,3699      ,4178      ,4658
-----------------------------------------------------------------------------------------------------

                                     ROCK UNIT   KE

                         -3          -2          -1          0          +1          +2          +3

  K40   DIST NORMAL   12,2264     44,0510     75,8755   107,7000   139,5245   171,3490   203,1736
 BI214  DIST NORMAL   -5,5441      2,9706     11,4853    20,0000    28,5147    37,0294    45,5441
 TL208  DIST NORMAL   13,0781     22,6854     32,2927    41,9000    51,5073    61,1146    70,7219
 U/K    DIST  LOG       ,0441       ,0678       ,1041      ,1600      ,2458      ,3777      ,5802
 U/TH   DIST NORMAL    -,1462       ,0525       ,2513      ,4500      ,6487      ,8475     1,0462
 TH/K   DIST NORMAL     ,1711       ,2486       ,3260      ,4035      ,4810      ,5584      ,6359
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                                          ROCK UNIT  KFL

                                 -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL      -12.9369    44.3754   101.6877   159.0000   216.3123   273.6246   330.9369
 BI214  DIST NORMAL        -.3682     7.6879    15.7439    23.8000    31.8561    39.9121    47.9682
 TL208  DIST NORMAL       11.8429    25.8286    39.8143    53.8000    67.7857    81.7714    95.7571
 U/K    DIST NORMAL         .0172      .0608      .1044      .1480      .1916      .2352      .2788
 U/TH   DIST NORMAL        -.0257      .0878      .2014      .3150      .4286      .5422      .6557
 TH/K   DIST NORMAL         .1636      .2202      .2767      .3333      .3899      .4464      .5030
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                                          ROCK UNIT   KL
                                 -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL       60.6195    85.0797   109.5398   134.0000   158.4602   182.9203   207.3805
 BI214  DIST NORMAL        2.8337     7.7225    12.6112    17.5000    22.3888    27.2775    32.1663
 TL208  DIST NORMAL       30.3022    37.2014    44.1007    51.0000    57.8993    64.7986    71.6978
 U/K    DIST NORMAL         .0238      .0625      .1013      .1400      .1787      .2175      .2562
 U/TH   DIST NORMAL         .1630      .2557      .3485      .4412      .5339      .6267      .7194
 TH/K   DIST NORMAL         .1784      .2323      .2861      .3400      .3939      .4477      .5016
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                                          ROCK UNIT   KR

                                 -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL       37.0589    71.1059   105.1530   139.2000   173.2470   207.2941   241.3411
 BI214  DIST NORMAL        4.0103     9.8069    15.6034    21.4000    27.1966    32.9931    38.7897
 TL208  DIST NORMAL       22.7464    30.8642    38.9821    47.1000    55.2179    63.3358    71.4536
 U/K    DIST NORMAL        -.0065      .0491      .1048      .1605      .2162      .2719      .3275
 U/TH   DIST NORMAL         .0969      .2177      .3386      .4594      .5802      .7011      .8219
 TH/K   DIST NORMAL         .1345      .2066      .2787      .3508      .4229      .4950      .5671
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                                     ROCK UNIT   KU

                            -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL      18.9431    33.4621    47.9810    62.5000    77.0190    91.5379   106.0569
 BI214  DIST NORMAL       4.6771    10.5848    16.4924    22.4000    28.3076    34.2152    40.1229
 TL208  DIST NORMAL      16.1220    20.2813    24.4407    28.6000    32.7593    36.9187    41.0780
 U/K    DIST NORMAL        .0336      .1454      .2572      .3690      .4808      .5926      .7044
 U/TH   DIST NORMAL       -.0065      .2652      .5368      .8085     1.0802     1.3518     1.6235
 TH/K   DIST NORMAL        .2161      .3015      .3870      .4724      .5578      .6433      .7287
-----------------------------------------------------------------------------------------------

                                     ROCK UNIT   Q

                            -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL      76.0354   110.7903   145.5451   180.3000   215.0549   249.8097   284.5646
 BI214  DIST NORMAL      -6.1468     4.5021    15.1511    25.8000    36.4489    47.0979    57.7468
 TL208  DIST NORMAL     -16.9721     8.6853    34.3426    60.0000    85.6574   111.3147   136.9721
 U/K    DIST NORMAL       -.0297      .0269      .0834      .1400      .1966      .2531      .3097
 U/TH   DIST NORMAL       -.0113      .1258      .2629      .4000      .5371      .6742      .8113
 TH/K   DIST NORMAL        .0244      .1335      .2426      .3517      .4608      .5699      .6790
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                                     ROCK UNIT  QLS

                            -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL     163.7544   179.8696   195.9848   212.1000   228.2152   244.3304   260.4456
 BI214  DIST NORMAL      11.2125    16.5417    21.8708    27.2000    32.5292    37.8583    43.1875
 TL208  DIST NORMAL      52.0394    60.4596    68.8798    77.3000    85.7202    94.1404   102.5606
 U/K    DIST NORMAL        .0669      .0869      .1069      .1269      .1469      .1669      .1869
 U/TH   DIST NORMAL        .1826      .2382      .2939      .3496      .4053      .4610      .5166
 TH/K   DIST NORMAL        .2972      .3196      .3419      .3643      .3867      .4090      .4314
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                                        ROCK UNIT   TB

                              -3         -2         -1          0         +1         +2         +3

  K40  DIST NORMAL       66.7580   104.2387   141.7193   179.2000   216.6807   254.1613   291.6420
 BI214 DIST NORMAL        -.0143     9.3238    18.6619    28.0000    37.3381    46.6762    56.0143
 TL208 DIST NORMAL       24.4940    36.9960    49.4980    62.0000    74.5020    87.0040    99.5060
 U/K   DIST NORMAL        -.0321      .0319      .0960      .1600      .2240      .2881      .3521
 U/TH  DIST NORMAL        -.0750      .1033      .2817      .4600      .6383      .8167      .9950
 TH/K  DIST NORMAL         .1971      .2481      .2991      .3501      .4011      .4521      .5031
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                                        ROCK UNIT   TBC

                              -3         -2         -1          0         +1         +2         +3

  K40  DIST NORMAL     -104.9339   -28.2893    48.3554   125.0000   201.6446   278.2893   354.9339
 BI214 DIST NORMAL       -1.1862     6.1759    13.5379    20.9000    28.2621    35.6241    42.9862
 TL208 DIST NORMAL       18.8077    29.3718    39.9359    50.5000    61.0641    71.6282    82.1923
 U/K   DIST NORMAL         .0109      .0509      .0909      .1309      .1709      .2109      .2509
 U/TH  DIST NORMAL         .0615      .1782      .2948      .4114      .5280      .6446      .7613
 TH/K  DIST NORMAL        -.0050      .0750      .1550      .2350      .3150      .3950      .4750
--------------------------------------------------------------------------------------------------

                                        ROCK UNIT   TBP

                              -3         -2         -1          0         +1         +2         +3

  K40  DIST NORMAL     -103.9083   -47.6055     8.6972    65.0000   121.3028   177.6055   233.9083
 BI214 DIST  LOG         12.7230    15.9572    20.0135    25.1008    31.4813    39.4838    49.5204
 TL208 DIST NORMAL      -27.5609    -8.6506    10.2597    29.1700    48.0803    66.9906    85.9009
 U/K   DIST  LOG           .0274      .0504      .0925      .1700      .3123      .5737     1.0540
 U/TH  DIST  LOG           .0801      .1369      .2340      .4000      .6838     1.1689     1.9982
 TH/K  DIST NORMAL         .2346      .2866      .3385      .3905      .4425      .4944      .5464
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                              ROCK UNIT  TFU

                        -3        -2        -1         0        +1        +2        +3

   K40   DIST NORMAL  67.8517  102.9345  138.0172  173.1000  208.1828  243.2655  278.3483
  BI214  DIST NORMAL   7.4025   13.5016   19.6008   25.7000   31.7992   37.8984   43.9975
  TL208  DIST NORMAL  32.3504   41.3003   50.2501   59.2000   68.1499   77.0997   86.0496
  U/K    DIST NORMAL    .0389     .0763     .1137     .1511     .1885     .2259     .2633
  U/TH   DIST NORMAL    .1550     .2488     .3426     .4364     .5302     .6240     .7178
  TH/K   DIST NORMAL    .2226     .2638     .3051     .3463     .3875     .4288     .4700
------------------------------------------------------------------------------------------

                              ROCK UNIT  TGR

                        -3        -2        -1         0        +1        +2        +3

   K40   DIST NORMAL  71.3541  108.8027  146.2514  183.7000  221.1486  258.5973  296.0459
  BI214  DIST NORMAL   4.0161   11.8774   19.7387   27.6000   35.4613   43.3226   51.1839
  TL208  DIST NORMAL  22.4271   36.8181   51.2090   65.6000   79.9910   94.3819  108.7729
  U/K    DIST  LOG      .0583     .0798     .1094     .1500     .2056     .2818     .3863
  U/TH   DIST NORMAL    .0164     .1509     .2855     .4200     .5545     .6891     .8236
  TH/K   DIST NORMAL    .1465     .2144     .2822     .3500     .4178     .4856     .5535
------------------------------------------------------------------------------------------

                              ROCK UNIT   TW

                        -3        -2        -1         0        +1        +2        +3

   K40   DIST NORMAL  80.6325  113.7550  146.8775  180.0000  213.1225  246.2450  279.3675
  BI214  DIST NORMAL    .9155    9.6103   18.3052   27.0000   35.6948   44.3897   53.0845
  TL208  DIST NORMAL   7.3583   25.9055   44.4528   63.0000   81.5472  100.0945  118.6417
  U/K    DIST NORMAL    .0000     .0500     .1000     .1500     .2000     .2500     .3000
  U/TH   DIST NORMAL   -.0116     .1323     .2761     .4200     .5639     .7077     .8516
  TH/K   DIST NORMAL    .0937     .1791     .2646     .3500     .4354     .5209     .6063
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                                  ROCK UNIT  TWK

                        -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  123,4755  150,7170  177,9585  205,2000  232,4415  259,6830  286,9245
 BI214 DIST NORMAL   -4,5550    6,6967   17,9483   29,2000   40,4517   51,7033   62,9550
 TL208 DIST NORMAL   35,6819   47,2879   58,8940   70,5000   82,1060   93,7121  105,3181
 U/K   DIST NORMAL    -,0373     ,0251     ,0876     ,1500     ,2124     ,2749     ,3373
 U/TH  DIST NORMAL    -,0770     ,0953     ,2677     ,4400     ,6123     ,7847     ,9570
 TH/K  DIST NORMAL     ,1757     ,2305     ,2852     ,3400     ,3948     ,4495     ,5043
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ROCK SPRINGS

UNIT	NO. SAMPLES	EIGENVALUES		% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
KAL	1508	1)	1.441	48.0	K	.716	-.542	.439
		2)	1.013	33.8	U	.444	.848	.289
		3)	.546	18.2	T	.855	.014	-.518
KBA	1113	1)	1.806	60.2	K	.803	-.475	-.359
		2)	.835	28.4	U	.596	.786	-.164
		3)	.341	11.4	T	.897	-.097	.430
KBL	1602	1)	1.538	51.3	K	.815	-.182	.551
		2)	.891	29.7	U	.524	.845	-.109
		3)	.571	19.0	T	.774	-.381	-.505
KE	1143	1)	1.978	65.9	K	.875	-.372	-.310
		2)	.804	26.8	U	.596	.799	-.074
		3)	.218	7.3	T	.926	-.163	.341
KF1	521	1)	2.380	79.3	K	.891	.403	.210
		2)	.488	16.3	U	.823	-.560	.098
		3)	.132	4.4	T	.954	.107	-.280
KL	518	1)	1.732	57.7	K	.856	-.220	-.468
		2)	.847	28.2	U	.552	.832	.051
		3)	.421	14.1	T	.833	-.325	.447
KR	1463	1)	1.608	53.6	K	.658	-.694	-.292
		2)	.833	27.8	U	.707	.591	-.388
		3)	.559	18.6	T	.822	.047	.568

ROCK SPRINGS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
KU	51	1) 1.517	50.6	K	.908	-.258	.331
		2) 1.211	40.4	U	.815	.485	-.317
		3) .273	9.1	T	.169	-.953	-.251
Q	13428	1) 2.089	69.6	K	.700	.706	.107
		2) .701	23.4	U	.857	-.429	.285
		3) .210	7.0	T	.929	-.136	-.343
QLS	27	1) 2.595	86.5	K	.964	-.082	.254
		2) .301	10.0	U	.927	-.331	-.178
		3) .104	3.5	T	.899	.429	-.089
TB	10636	1) 1.928	64.3	K	.901	-.286	-.327
		2) .851	28.3	U	.521	.853	-.029
		3) .221	7.4	T	.919	-.203	.337
TBC	853	1) 2.393	79.8	K	.908	-.091	.410
		2) .341	11.4	U	.880	.454	-.138
		3) .266	8.8	T	.891	-.356	-.281
TBP	308	1) 2.235	74.5	K	.955	.256	.152
		2) .719	24.0	U	-.644	.765	.001
		3) .046	1.5	T	.954	.260	-.151
TFU	3031	1) 2.011	67.0	K	.839	-.423	.843
		2) .687	22.9	U	.708	.696	.117
		3) .302	10.1	T	.898	-.154	-.413

ROCK SPRINGS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	PRINCIPAL COMPONENT 2	PRINCIPAL COMPONENT 3
TGR	13600	1) 1.906	63.5	K	.824	-.444	-.352
		2) .776	25.9	U	.649	.749	-.134
		3) .318	10.6	T	.898	-.134	.420
TW	10184	1) 1.932	64.4	K	.687	.709	-.159
		2) .740	24.7	U	.812	-.474	-.341
		3) .327	10.9	T	.895	-.114	.431
TWK	5560	1) 1.477	49.2	K	.821	.328	-.467
		2) 1.026	34.2	U	.221	-.956	-.195
		3) .498	16.6	T	.868	-.068	.491

APPENDIX D

STATISTICAL TABLES AND PRINCIPAL COMPONENT RESULTS

RAWLINS QUADRANGLE

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@ADD,P RAWLIN,DISTFILE
                                    ROCK UNIT   JS

                          -3        -2        -1         0        +1        +2        +3

   K40   DIST  LOG    120.8844  133.3961  147.2028  162.4386  179.2513  197.8041  218.2772
  BI214  DIST  LOG      8.0969   11.6665   16.8098   24.2205   34.8984   50.2836   72.4516
  TL208  DIST  LOG     33.5305   38.8654   45.0490   52.2166   60.5245   70.1543   81.3161
  U/K    DIST  LOG       .0526     .0744     .1053     .1491     .2111     .2988     .4229
  U/TH   DIST  LOG       .2011     .2657     .3511     .4638     .6129     .8097    1.0698
  TH/K   DIST NORMAL     .2281     .2598     .2914     .3230     .3546     .3862     .4179
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                                    ROCK UNIT  KCV

                          -3        -2        -1         0        +1        +2        +3

   K40   DIST NORMAL   -51.1823  -14.1215   22.9392   60.0000   97.0608  134.1215  171.1823
  BI214  DIST NORMAL     2.5726   10.7150   18.8575   27.0000   35.1425   43.2850   51.4274
  TL208  DIST  LOG      58.4156   77.0141  101.5341  133.8607  176.4796  232.6676  306.7449
  U/K    DIST NORMAL     -.0124     .0670     .1463     .2257     .3051     .3844     .4638
  U/TH   DIST NORMAL      .1070     .2452     .3834     .5216     .6598     .7980     .9362
  TH/K   DIST NORMAL      .0950     .2068     .3186     .4304     .5422     .6540     .7658
-------------------------------------------------------------------------------------------

                                    ROCK UNIT   KF

                          -3        -2        -1         0        +1        +2        +3

   K40   DIST NORMAL    51.9294   83.0196  114.1098  145.2000  176.2902  207.3804  238.4706
  BI214  DIST NORMAL     4.0882   12.0255   19.9627   27.9000   35.8373   43.7745   51.7118
  TL208  DIST NORMAL    20.8673   35.3449   49.8224   64.3000   78.7776   93.2551  107.7327
  U/K    DIST NORMAL      .0589     .1037     .1484     .1931     .2378     .2825     .3273
  U/TH   DIST NORMAL      .1561     .2494     .3426     .4359     .5292     .6224     .7157
  TH/K   DIST NORMAL      .1913     .2774     .3634     .4494     .5354     .6214     .7075
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                                     ROCK UNIT  KLE

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL    91.7621  116.8081  141.8540  166.9000  191.9460  216.9919  242.0379
 BI214  DIST NORMAL     6.0346   12.5231   19.0115   25.5000   31.9885   38.4769   44.9654
 TL208  DIST NORMAL    32.2540   40.6027   48.9513   57.3000   65.6487   73.9973   82.3460
 U/K    DIST NORMAL      .0312     .0724     .1137     .1549     .1961     .2374     .2786
 U/TH   DIST NORMAL      .1046     .2195     .3344     .4493     .5642     .6791     .7940
 TH/K   DIST NORMAL      .1687     .2287     .2887     .3487     .4087     .4687     .5287
------------------------------------------------------------------------------------------------

                                     ROCK UNIT  KMV

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL    62.6136   88.8757  115.1379  141.4000  167.6621  193.9243  220.1864
 BI214  DIST NORMAL     7.1346   13.6231   20.1115   26.6000   33.0885   39.5769   46.0654
 TL208  DIST NORMAL    26.2185   35.1124   44.0062   52.9000   61.7938   70.6876   79.5815
 U/K    DIST NORMAL      .0220     .0794     .1369     .1943     .2517     .3092     .3666
 U/TH   DIST NORMAL      .0960     .2350     .3739     .5128     .6517     .7906     .9296
 TH/K   DIST NORMAL      .1680     .2394     .3108     .3822     .4536     .5250     .5964
------------------------------------------------------------------------------------------------

                                     ROCK UNIT  PCG
                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL   -68.3513   -5.5675   57.2162  120.0000  182.7838  245.5675  308.3513
 BI214  DIST NORMAL    -5.8536    5.0642   15.9821   26.9000   37.8179   48.7358   59.6536
 TL208  DIST   LOG     13.9658   19.4641   27.1272   37.8072   52.6920   73.4370  102.3493
 U/K    DIST NORMAL      .0269     .0669     .1069     .1469     .1869     .2269     .2669
 U/TH   DIST NORMAL     -.1045     .1227     .3498     .5770     .8042    1.0313    1.2585
 TH/K   DIST   LOG       .1274     .1632     .2090     .2677     .3429     .4393     .5627
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                              ROCK UNIT   PCGN

                 -3        -2        -1         0        +1        +2        +3

 K40   DIST NORMAL     7.3217   55.0145  102.7072  150.4000  198.0928  245.7855  293.4783
BI214  DIST NORMAL    -1.3262    4.9826   11.2913   17.6000   23.9087   30.2174   36.5262
TL208  DIST NORMAL   -55.7569  -35.9604  -16.1640    3.6325   23.4290   43.2254   63.0219
U/K    DIST  LOG        .0345     .0516     .0770     .1151     .1720     .2569     .3839
U/TH   DIST  LOG        .1009     .1639     .2662     .4323     .7021    1.1403    1.8519
TH/K   DIST NORMAL      .0235     .1084     .1932     .2781     .3630     .4478     .5327
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                              ROCK UNIT   PCGR

                 -3        -2        -1         0        +1        +2        +3

 K40   DIST NORMAL  -126.4601  -42.6401   41.1800  125.0000  208.8200  292.6401  376.4601
BI214  DIST  LOG       5.1031    8.3774   13.7525   22.5763   37.0616   60.8409   99.8775
TL208  DIST  LOG       7.7788   14.3163   26.3482   48.4921   89.2463  164.2517  302.2940
U/K    DIST  LOG        .0463     .0634     .0869     .1189     .1629     .2230     .3054
U/TH   DIST  LOG        .1573     .2255     .3233     .4633     .6641     .9519    1.3644
TH/K   DIST  LOG        .1035     .1401     .1895     .2565     .3470     .4695     .6352
-----------------------------------------------------------------------------------------

                              ROCK UNIT   PCI

                 -3        -2        -1         0        +1        +2        +3

 K40   DIST  LOG      25.2714   39.5849   62.0056   97.1251  152.1362  238.3052  373.2798
BI214  DIST  LOG       4.0624    6.0951    9.1448   13.7206   20.5860   30.8865   46.3410
TL208  DIST  LOG       6.6064   10.3631   16.2563   25.5005   40.0017   62.7491   98.4321
U/K    DIST  LOG        .0358     .0564     .0888     .1398     .2201     .3466     .5458
U/TH   DIST  LOG        .1493     .2276     .3470     .5290     .8065    1.2295    1.8744
TH/K   DIST  LOG        .1117     .1485     .1975     .2626     .3491     .4642     .6173
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                                      ROCK UNIT  PCQ

                          -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL     9.5594    38.3396    67.1198    95.9000   124.6802   153.4604   182.2406
 BI214  DIST NORMAL    -1.5665     3.8556     9.2778    14.7000    20.1222    25.5444    30.9665
 TL208  DIST NORMAL     4.1458    13.5639    22.9819    32.4000    41.8181    51.2361    60.6542
 U/K    DIST NORMAL     -.0132      .0424      .0981      .1538      .2095      .2652      .3208
 U/TH   DIST NORMAL     -.0643      .1118      .2878      .4639      .6400      .8160      .9921
 TH/K   DIST NORMAL      .0739      .1666      .2594      .3521      .4448      .5376      .6303
-------------------------------------------------------------------------------------------------

                                      ROCK UNIT  PCQD

                          -3         -2         -1          0         +1         +2         +3

  K40   DIST  LOG      46.7056    66.1931    93.8116   132.9536   188.4272   267.0468   378.4696
 BI214  DIST NORMAL     3.7622     9.5415    15.3207    21.1000    26.8793    32.6585    38.4378
 TL208  DIST NORMAL   -16.8280    -4.5520     7.7240    20.0000    32.2760    44.5520    56.8280
 U/K    DIST NORMAL     -.0400      .0200      .0800      .1400      .2000      .2600      .3200
 U/TH   DIST NORMAL     -.2494      .0470      .3435      .6400      .9365     1.2330     1.5294
 TH/K   DIST NORMAL      .1088      .1475      .1863      .2250      .2637      .3025      .3412
-------------------------------------------------------------------------------------------------

                                      ROCK UNIT  PCQM

                          -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL    -6.6854    43.5430    93.7715   144.0000   194.2285   244.4570   294.6854
 BI214  DIST NORMAL    -5.5631     3.2912    12.1456    21.0000    29.8544    38.7088    47.5631
 TL208  DIST  LOG      15.6139    21.5960    29.8700    41.3139    57.1423    79.0350   109.3153
 U/K    DIST NORMAL      .0023      .0423      .0823      .1223      .1623      .2023      .2423
 U/TH   DIST NORMAL      .0308      .1841      .3374      .4907      .6440      .7973      .9506
 TH/K   DIST NORMAL      .0783      .1375      .1966      .2558      .3150      .3741      .4333
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                                ROCK UNIT PCSCH

                        -3        -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  -29.8052   10.7966    51.3983    92.0000   132.6017   173.2034   213.8052
 BI214  DIST NORMAL   -4.1494    2.3004     8.7502    15.2000    21.6498    28.0996    34.5494
 TL208  DIST NORMAL   -4.1615    7.1257    18.4128    29.7000    40.9872    52.2743    63.5615
 U/K    DIST  LOG       .0419     .0629      .0944      .1418      .2130      .3199      .4805
 U/TH   DIST NORMAL    -.0467     .1436      .3338      .5241      .7144      .9046     1.0949
 TH/K   DIST NORMAL     .0488     .1342      .2197      .3051      .3905      .4760      .5614
------------------------------------------------------------------------------------------------

                                ROCK UNIT   Q

                        -3        -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   58.5578   97.6052   136.6526   175.7000   214.7474   253.7948   292.8422
 BI214  DIST NORMAL  -33.3366  -13.2244     6.8878    27.0000    47.1122    67.2244    87.3366
 TL208  DIST NORMAL  -56.1735  -18.7824    18.6088    56.0000    93.3912   130.7824   168.1735
 U/K    DIST NORMAL    -.0959    -.0088      .0784      .1656      .2528      .3400      .4271
 U/TH   DIST NORMAL    -.3655    -.0970      .1715      .4400      .7085      .9770     1.2455
 TH/K   DIST NORMAL    -.0569     .0787      .2144      .3500      .4856      .6213      .7569
------------------------------------------------------------------------------------------------

                                ROCK UNIT  QAL

                        -3        -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  -22.9368   29.8088    82.5544   135.3000   188.0456   240.7912   293.5368
 BI214  DIST NORMAL  -11.2490    -.8327     9.5837    20.0000    30.4163    40.8327    51.2490
 TL208  DIST NORMAL     .0989   13.3992    26.6996    40.0000    53.3004    66.6008    79.9011
 U/K    DIST  LOG       .0466     .0710      .1083      .1650      .2514      .3832      .5839
 U/TH   DIST NORMAL    -.1407     .0795      .2998      .5200      .7402      .9605     1.1807
 TH/K   DIST  LOG       .1553     .1981      .2526      .3222      .4109      .5241      .6685
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                                  ROCK UNIT   QG

                           -3          -2          -1           0          +1          +2          +3

  K40   DIST   LOG      43.7777     56.4685     72.8383     93.9535    121.1899    156.3218    201.6383
 BI214  DIST   LOG       4.6910      6.7396      9.6828     13.9113     19.9864     28.7146     41.2545
 TL208  DIST   LOG      11.3476     15.3381     20.7318     28.0223     37.8765     51.1960     69.1993
 U/K    DIST NORMAL       .0057       .0557       .1057       .1557       .2057       .2557       .3057
 U/TH   DIST   LOG        .1575       .2309       .3385       .4962       .7275      1.0664      1.5633
 TH/K   DIST NORMAL       .0941       .1648       .2355       .3062       .3769       .4476       .5183
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                                  ROCK UNIT  QLS

                           -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL     18.7265     44.2510     69.7755     95.3000    120.8245    146.3490    171.8735
 BI214  DIST   LOG       5.6233      7.9638     11.2786     15.9730     22.6214     32.0369     45.3714
 TL208  DIST NORMAL      9.5203     17.2468     24.9734     32.7000     40.4266     48.1532     55.8797
 U/K    DIST   LOG        .0678       .0926       .1266       .1729       .2362       .3228       .4410
 U/TH   DIST   LOG        .1961       .2683       .3671       .5022       .6872       .9402      1.2864
 TH/K   DIST NORMAL       .1588       .2258       .2929       .3600       .4271       .4942       .5612
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                                  ROCK UNIT  QMC

                           -3          -2          -1           0          +1          +2          +3

  K40   DIST   LOG      50.1284     67.3830     90.5766    121.7537    163.6621    219.9957    295.7197
 BI214  DIST NORMAL       .3300      5.3200     10.3100     15.3000     20.2900     25.2800     30.2700
 TL208  DIST NORMAL     16.4292     23.6195     30.8097     38.0000     45.1903     52.3805     59.5708
 U/K    DIST NORMAL       .0109       .0483       .0857       .1231       .1605       .1979       .2353
 U/TH   DIST   LOG        .1434       .2003       .2800       .3913       .5468       .7641      1.0678
 TH/K   DIST NORMAL       .1303       .1935       .2568       .3200       .3832       .4465       .5097
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                              ROCK UNIT   QT

                     -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL -29.2118    12.5255    54.2627    96.0000   137.7373   179.4745   221.2118
BI214  DIST NORMAL   4.2593     7.9062    11.5531    15.2000    18.8469    22.4938    26.1407
TL208  DIST NORMAL  18.1404    23.3270    28.5135    33.7000    38.8865    44.0730    49.2596
U/K    DIST NORMAL   -.0003      .0507      .1017      .1527      .2037      .2547      .3057
U/TH   DIST NORMAL    .0370      .1647      .2923      .4200      .5477      .6753      .8030
TH/K   DIST NORMAL    .1157      .1938      .2719      .3500      .4281      .5062      .5843
-----------------------------------------------------------------------------------------------

                              ROCK UNIT  QTU

                     -3         -2         -1          0         +1         +2         +3

 K40   DIST   LOG   36.7404    51.1511    71.2142    99.1466   138.0351   192.1768   267.5546
BI214  DIST   LOG    4.6415     6.8325    10.0578    14.8055    21.7944    32.0823    47.2266
TL208  DIST   LOG   10.0538    14.1644    19.9557    28.1149    39.6100    55.8051    78.6217
U/K    DIST   LOG     .0548      .0765      .1068      .1492      .2085      .2912      .4068
U/TH   DIST   LOG     .1703      .2480      .3613      .5262      .7664     1.1162     1.6258
TH/K   DIST   LOG     .1266      .1657      .2168      .2836      .3710      .4853      .6350
-----------------------------------------------------------------------------------------------

                              ROCK UNIT  TBP

                     -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  90.3279   117.2853   144.2426   171.2000   198.1574   225.1147   252.0721
BI214  DIST  LOG     5.8279     9.9989    17.1549    29.4325    50.4970    86.6372   148.6425
TL208  DIST NORMAL  20.7237    31.3491    41.9746    52.6000    63.2254    73.8509    84.4763
U/K    DIST  LOG      .0363      .0612      .1032      .1741      .2938      .4956      .8361
U/TH   DIST  LOG      .1227      .2048      .3419      .5707      .9527     1.5904     2.6550
TH/K   DIST NORMAL    .1431      .1987      .2544      .3101      .3658      .4215      .4771
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                              ROCK UNIT   TBS

                  -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  152.3250   185.5500   218.7750   252.0000   285.2250   318.4500   351.6750
 BI214  DIST  LOG     16.7769    22.6653    30.6204    41.3677    55.8870    75.5024   102.0024
 TL208  DIST NORMAL   13.0415    54.2277    95.4138   136.6000   177.7862   218.9723   260.1585
 U/K    DIST  LOG       .0673      .0913      .1239      .1680      .2279      .3092      .4194
 U/TH   DIST  LOG       .1694      .2085      .2567      .3160      .3890      .4789      .5896
 TH/K   DIST  LOG       .2408      .3135      .4083      .5316      .6923      .9014     1.1738
-------------------------------------------------------------------------------------------------

                              ROCK UNIT   TD

                  -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  121.2985   133.7324   146.1662   158.6000   171.0338   183.4676   195.9015
 BI214  DIST  LOG      8.2748    10.9972    14.6153    19.4238    25.8143    34.3073    45.5945
 TL208  DIST NORMAL   26.5621    34.8747    43.1874    51.5000    59.8126    68.1253    76.4379
 U/K    DIST  LOG       .0469      .0646      .0891      .1228      .1693      .2334      .3217
 U/TH   DIST NORMAL     .0757      .1825      .2892      .3960      .5028      .6095      .7163
 TH/K   DIST NORMAL     .1398      .2022      .2647      .3271      .3895      .4520      .5144
-------------------------------------------------------------------------------------------------

                              ROCK UNIT   TFU

                  -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   94.3102   117.9068   141.5034   165.1000   188.6966   212.2932   235.8898
 BI214  DIST NORMAL    5.1530    11.9353    18.7177    25.5000    32.2823    39.0647    45.8470
 TL208  DIST NORMAL   12.7126    27.1417    41.5709    56.0000    70.4291    84.8583    99.2874
 U/K    DIST NORMAL     .0158      .0606      .1053      .1500      .1947      .2394      .2842
 U/TH   DIST NORMAL     .0939      .2126      .3314      .4501      .5688      .6876      .8063
 TH/K   DIST NORMAL     .1388      .2058      .2729      .3400      .4071      .4742      .5412
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                             ROCK UNIT   TGL

                    -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL   47.8501    83.9001   119.9500   156.0000   192.0500   228.0999   264.1499
BI214 DIST  LOG      11.5774    14.9803    19.3834    25.0807    32.4526    41.9914    54.3338
TL208 DIST NORMAL     2.6624    20.4416    38.2208    56.0000    73.7792    91.5584   109.3376
U/K    DIST  LOG       .0774      .0989      .1264      .1616      .2064      .2638      .3371
U/TH   DIST  LOG       .1928      .2512      .3272      .4262      .5552      .7232      .9421
TH/K   DIST NORMAL     .1657      .2438      .3219      .4000      .4781      .5562      .6343
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                             ROCK UNIT   TGM

                    -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL   83.7533   117.1689   150.5844   184.0000   217.4156   250.8311   284.2467
BI214 DIST NORMAL     6.2731    13.6487    21.0244    28.4000    35.7756    43.1513    50.5269
TL208 DIST NORMAL    33.8606    43.3737    52.8869    62.4000    71.9131    81.4263    90.9394
U/K    DIST NORMAL     .0588      .0920      .1251      .1583      .1915      .2246      .2578
U/TH   DIST NORMAL     .1630      .2605      .3579      .4554      .5529      .6503      .7478
TH/K   DIST NORMAL     .2272      .2684      .3097      .3509      .3921      .4334      .4746
-------------------------------------------------------------------------------------------------

                             ROCK UNIT   TGT

                    -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  101.3277   126.6851   152.0426   177.4000   202.7574   228.1149   253.4723
BI214 DIST NORMAL     8.9539    14.2359    19.5180    24.8000    30.0820    35.3641    40.6461
TL208 DIST NORMAL    23.3060    36.8707    50.4353    64.0000    77.5647    91.1293   104.6940
U/K    DIST NORMAL     .0312      .0686      .1060      .1434      .1808      .2182      .2556
U/TH   DIST NORMAL     .1147      .2090      .3034      .3977      .4920      .5864      .6807
TH/K   DIST NORMAL     .1321      .2096      .2870      .3645      .4420      .5194      .5969
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                              ROCK UNIT    TH

                   -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  103.5172  126.3448  149.1724  172.0000  194.8276  217.6552  240.4828
 BI214 DIST  LOG      8.6486   12.7097   18.6777   27.4482   40.3369   59.2778   87.1127
 TL208 DIST NORMAL   13.6089   34.0393   54.4696   74.9000   95.3304  115.7607  136.1911
 U/K   DIST NORMAL   -.0132     .0468     .1068     .1668     .2268     .2868     .3468
 U/TH  DIST NORMAL    .1224     .2118     .3013     .3907     .4801     .5696     .6590
 TH/K  DIST NORMAL    .1429     .2362     .3294     .4227     .5160     .6092     .7025
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                              ROCK UNIT    TI

                   -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  145.6424  158.6616  171.6808  184.7000  197.7192  210.7384  223.7577
 BI214 DIST NORMAL    3.6005    6.6337    9.6668   12.7000   15.7332   18.7663   21.7995
 TL208 DIST NORMAL   26.8430   31.0620   35.2810   39.5000   43.7190   47.9380   52.1570
 U/K   DIST NORMAL    .0170     .0344     .0517     .0690     .0863     .1036     .1210
 U/TH  DIST NORMAL    .0583     .1471     .2360     .3249     .4138     .5027     .5915
 TH/K  DIST NORMAL    .1472     .1696     .1919     .2143     .2367     .2590     .2814
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                              ROCK UNIT    TKF

                   -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  118.1019  134.3346  150.5673  166.8000  183.0327  199.2654  215.4980
 BI214 DIST NORMAL    2.0103    9.4735   16.9368   24.4000   31.8632   39.3265   46.7897
 TL208 DIST NORMAL   32.0908   41.8939   51.6969   61.5000   71.3031   81.1061   90.9092
 U/K   DIST NORMAL    .0098     .0556     .1015     .1473     .1931     .2390     .2848
 U/TH  DIST NORMAL    .1179     .2101     .3023     .3945     .4867     .5789     .6711
 TH/K  DIST NORMAL    .1930     .2522     .3113     .3705     .4297     .4888     .5480
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                                    ROCK UNIT  TKHF

                        -3          -2          -1           0          +1          +2          +3

  K40   DIST  LOG    51,9616     65,8208     83.3766    105,6150    133,7847    169.4679    214.6686
 BI214  DIST  LOG     4.9922      7,2166     10.4321     15,0805     21,8000     31.5137     45.5555
 TL208  DIST  LOG    13.6899     17,9066     23.4222     30,6367     40,0735     52,4169     68.5623
 U/K    DIST  LOG      ,0455       ,0666       ,0976       ,1428       ,2090       ,3060       ,4479
 U/TH   DIST  LOG      ,1475       ,2205       ,3296       ,4927       ,7365      1.1010      1,6457
 TH/K   DIST NORMAL    ,1138       ,1746       ,2355       ,2963       ,3571       ,4180       ,4788
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                                    ROCK UNIT  TNP

                        -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  72,0461    107,9641    143,8820    179,8000    215,7180    251,6359    287,5539
 BI214  DIST NORMAL  -,4558       8,0294     16,5147     25,0000     33,4853     41,9706     50,4558
 TL208  DIST NORMAL  13.2047     26,0031     38,8016     51,6000     64,3984     77.1969     89,9953
 U/K    DIST  LOG      ,0502       ,0697       ,0967       .1342       ,1863       ,2587       .3591
 U/TH   DIST  LOG      ,1393       ,1955       ,2744       ,3850       ,5403       ,7582      1,0639
 TH/K   DIST NORMAL    ,1125       .1717       ,2308       ,2900       ,3492       ,4083       ,4675
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                                    ROCK UNIT  TRC

                        -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL 118,6320    135,0880    151.5440    168,0000    184,4560    200,9120    217.3680
 BI214  DIST NORMAL  11,8889     16,2593     20,6296     25,0000     29,3704     33.7407     38,1111
 TL208  DIST NORMAL  29,6043     35,7362     41,8681     48,0000     54,1319     60,2638     66,3957
 U/K    DIST NORMAL    ,0717       ,0962       ,1207       ,1452       ,1697       ,1942       ,2187
 U/TH   DIST NORMAL    ,2662       ,3437       ,4211       ,4986       ,5761       ,6535       ,7310
 TH/K   DIST NORMAL    .1731       ,2131       ,2531       ,2931       ,3331       ,3731       ,4131
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                                ROCK UNIT  TWC

                      -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  75,1824   112,7883   150,3941   188,0000   225,6059   263,2117   300,8176
BI214  DIST NORMAL   7,3352    15,1901    23,0451    30,9000    38,7549    46,6099    54,4648
TL208  DIST NORMAL   7,2598    28,8398    50,4199    72,0000    93,5801   115,1602   136,7402
U/K    DIST NORMAL    ,0453      ,0840      ,1228      ,1615      .2002      ,2390      .2777
U/TH   DIST  LOG      ,2126      ,2650      ,3302      ,4114      .5126      ,6388      .7960
TH/K   DIST NORMAL    ,1670      ,2405      ,3140      .3875      ,4610      ,5345      .6080
------------------------------------------------------------------------------------------------

                                ROCK UNIT  TWDR

                      -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL 133,9456   154,3637   174,7819   195,2000   215,6181   236,0363   256,4544
BI214  DIST NORMAL  10,9509    15,0006    19,0503    23,1000    27,1497    31,1994    35,2491
TL208  DIST NORMAL  26,9237    32,6158    38,3079    44,0000    49,6921    55,3842    61,0763
U/K    DIST NORMAL    ,0524      ,0748      ,0971      ,1195      ,1419      ,1642      ,1866
U/TH   DIST  LOG      ,2475      ,3174      ,4071      ,5221      ,6696      ,8587     1,1013
TH/K   DIST NORMAL    ,1124      ,1511      ,1899      ,2286      ,2673      ,3061      ,3448
------------------------------------------------------------------------------------------------

                                ROCK UNIT  TWK

                      -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL 182,8579   195,5386   208,2193   220,9000   233,5807   246,2614   258,9421
BI214  DIST NORMAL  27,8935    30,1957    32,4978    34,8000    37,1022    39,4043    41,7065
TL208  DIST NORMAL  60,8029    65,9020    71.0010    76.1000    81,1990    86,2980    91,3971
U/K    DIST NORMAL    ,1062      ,1236      .1409      .1582      ,1755      ,1928      ,2102
U/TH   DIST NORMAL    ,3842      ,4087      ,4332      ,4577      ,4822      ,5067      ,5312
TH/K   DIST NORMAL    ,2420      ,2766      .3113      ,3459      .3805      ,4152      ,4498
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                        ROCK UNIT   TWR

                 -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL    90,7528    124,5019    158,2509    192,0000    225,7491    259,4981    293,2472
 BI214  DIST NORMAL    10,4800     12,1534     13,8267     15,5000     17,1733     18,8466     20,5200
 TL208  DIST NORMAL    10,3088     19,5392     28,7696     38,0000     47,2304     56,4608     65,6912
 U/K    DIST NORMAL    -,0049       ,0234       ,0517       ,0800       ,1083       ,1366       ,1649
 U/TH   DIST NORMAL     ,1267       ,2178       ,3089       ,4000       ,4911       ,5822       ,6733
 TH/K   DIST NORMAL     ,0300       ,0900       ,1500       ,2100       ,2700       ,3300       ,3900
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                        ROCK UNIT   TW

                 -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL   110,0571    134,1714    158,2857    182,4000    206,5143    230,6286    254,7429
 BI214  DIST NORMAL    -4,5469      6,3021     17,1510     28,0000     38,8490     49,6979     60,5469
 TL208  DIST NORMAL   -20,6725      9,5517     39,7758     70,0000    100,2242    130,4483    160,6725
 U/K    DIST NORMAL     ,0253       ,0722       ,1191       ,1660       ,2129       ,2598       ,3067
 U/TH   DIST NORMAL     ,1363       ,2263       ,3163       ,4063       ,4963       ,5863       ,6763
 TH/K   DIST NORMAL     ,0338       ,1525       ,2713       ,3900       ,5087       ,6275       ,7462
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                        ROCK UNIT   KL

                 -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL   106,0316    124,4544    142,8772    161,3000    179,7228    198,1456    216,5684
 BI214  DIST NORMAL     8,8972     14,1981     19,4991     24,8000     30,1009     35,4019     40,7028
 TL208  DIST NORMAL    33,9304     41,3869     48,8435     56,3000     63,7565     71,2131     78,6696
 U/K    DIST NORMAL     ,0434       ,0808       ,1182       ,1556       ,1930       ,2304       ,2678
 U/TH   DIST NORMAL     ,1208       ,2294       ,3381       ,4467       ,5553       ,6640       ,7726
 TH/K   DIST NORMAL     ,1992       ,2502       ,3012       ,3522       ,4032       ,4542       ,5052
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                                   ROCK UNIT  KSN

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL  105,4180  123,5453  141,6727  159,8000  177,9273  196,0547  214,1820
 BI214  DIST NORMAL    4,8902   12,3601   19,8301   27,3000   34,7699   42,2399   49,7098
 TL208  DIST NORMAL   28,4795   36,9530   45,4265   53,9000   62,3735   70,8470   79,3205
 U/K    DIST NORMAL    -,0175     ,0417     .1008     ,1600     ,2192     ,2783     ,3375
 U/TH   DIST NORMAL    -,0642     ,1172     ,2986     ,4800     ,6614     ,8428    1,0242
 TH/K   DIST NORMAL     ,1916     ,2406     ,2896     ,3386     ,3876     ,4366     ,4856
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                                   ROCK UNIT  PCU

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL  -23,0393   28,6404   80,3202  132,0000  183,6798  235,3596  287,0393
 BI214  DIST NORMAL    -,8590    5,3940   11,6470   17,9000   24,1530   30,4060   36,6590
 TL208  DIST NORMAL  -15,8832    2,0779   20,0389   38,0000   55,9611   73,9221   91,8832
 U/K    DIST NORMAL    -,0093     ,0387     ,0866     ,1346     ,1826     ,2305     ,2785
 U/TH   DIST NORMAL    -,0651     ,1119     ,2888     ,4657     ,6426     ,8195     ,9965
 TH/K   DIST NORMAL     ,0713     ,1475     ,2236     ,2998     .3760     ,4521     ,5283
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                                   ROCK UNIT PPFSC

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL   80,9816  129,9878  178,9939  228,0000  277,0061  326,0122  375,0184
 BI214  DIST NORMAL   -8,2697    5,9536   20,1768   34,4000   48,6232   62,8464   77,0697
 TL208  DIST NORMAL    2,5926   26,0617   49,5309   73,0000   96,4691  119,9383  143,4074
 U/K    DIST NORMAL     ,0100     ,0500     ,0900     ,1300     .1700     ,2100     ,2500
 U/TH   DIST NORMAL     ,1415     ,2410     ,3405     ,4400     ,5395     ,6390     .7385
 TH/K   DIST NORMAL     .1470     ,1960     ,2450     ,2940     ,3430     ,3920     ,4410
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                                 ROCK UNIT   TRJC

                        -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL   -8.6458    44.2361    97.1181   150.0000   202.8819   255.7639   308.6458
BI214  DIST NORMAL    2.1639     8.9093    15.6546    22.4000    29.1454    35.8907    42.6361
TL208  DIST NORMAL  -10.1597     4.8935    19.9468    35.0000    50.0532    65.1065    80.1597
U/K    DIST  LOG      .0499      .0664      .0883      .1173      .1560      .2074      .2757
U/TH   DIST NORMAL    -.0095      .1602      .3299      .4996      .6693      .8390     1.0087
TH/K   DIST NORMAL     .1355      .1742      .2130      .2517      .2904      .3292      .3679
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                                 ROCK UNIT    KU

                        -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL   43.1431    83.7621   124.3810   165.0000   205.6190   246.2379   286.8569
BI214  DIST NORMAL    2.2214     9.2143    16.2071    23.2000    30.1929    37.1857    44.1786
TL208  DIST NORMAL   19.5870    29.0580    38.5290    48.0000    57.4710    66.9420    76.4130
U/K    DIST NORMAL    -.0846      .0003      .0851      .1700      .2549      .3397      .4246
U/TH   DIST NORMAL     .1267      .2454      .3642      .4829      .6016      .7204      .8391
TH/K   DIST NORMAL    -.1796     -.0064      .1668      .3400      .5132      .6864      .8596
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                                 ROCK UNIT    JU

                        -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  103.4272   120.9515   138.4757   156.0000   173.5243   191.0485   208.5728
BI214  DIST NORMAL   11.3719    14.5813    17.7906    21.0000    24.2094    27.4187    30.6281
TL208  DIST NORMAL   11.0690    20.7127    30.3563    40.0000    49.6437    59.2873    68.9310
U/K    DIST NORMAL     .0178      .0552      .0926      .1300      .1674      .2048      .2422
U/TH   DIST NORMAL     .2965      .3644      .4322      .5000      .5678      .6356      .7035
TH/K   DIST NORMAL     .0119      .0980      .1840      .2700      .3560      .4420      .5281
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                         ROCK UNIT   TRU

                -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  124.2320   142.5213   160.8107   179.1000   197.3893   215.6787   233.9680
BI214  DIST NORMAL   13.8771    17.9514    22.0257    26.1000    30.1743    34.2486    38.3229
TL208  DIST NORMAL   34.2371    41.1580    48.0790    55.0000    61.9210    68.8420    75.7629
U/K    DIST NORMAL     .0736      .0981      .1226      .1471      .1716      .1961      .2206
U/TH   DIST NORMAL     .2544      .3292      .4041      .4789      .5537      .6286      .7034
TH/K   DIST NORMAL     .2177      .2477      .2777      .3077      .3377      .3677      .3977
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                         ROCK UNIT   QLE

                -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  160.9314   175.2876   189.6438   204.0000   218.3562   232.7124   247.0686
BI214  DIST NORMAL   11.7382    16.4921    21.2461    26.0000    30.7539    35.5079    40.2618
TL208  DIST NORMAL   52.1530    58.8687    65.5843    72.3000    79.0157    85.7313    92.4470
U/K    DIST NORMAL     .0780      .0954      .1127      .1300      .1473      .1646      .1820
U/TH   DIST NORMAL     .2056      .2639      .3222      .3805      .4388      .4971      .5554
TH/K   DIST NORMAL     .2878      .3078      .3278      .3478      .3678      .3878      .4078
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                         ROCK UNIT   JMS

                -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL   65.6454    97.0969   128.5485   160.0000   191.4515   222.9031   254.3546
BI214  DIST  LOG      9.7445    12.6573    16.4408    21.3553    27.7388    36.0306    46.8009
TL208  DIST NORMAL   17.5648    27.7432    37.9216    48.1000    58.2784    68.4568    78.6352
U/K    DIST NORMAL    -.0008      .0428      .0864      .1300      .1736      .2172      .2608
U/TH   DIST NORMAL     .0210      .1733      .3256      .4779      .6302      .7825      .9348
TH/K   DIST NORMAL     .1363      .1929      .2494      .3060      .3626      .4191      .4757
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                              ROCK UNIT   KJU

                      -3          -2          -1           0          +1          +2          +3

  K40   DIST   LOG    66,7892     85,5351    109,5426    140,2884    179,6636    230,0905    294,6709
 BI214  DIST   LOG    11,7277     16,2133     22,4147     30,9880     42,8404     59,2263     81,8794
 TL208  DIST NORMAL   23,2299     33,4866     43,7433     54,0000     64,2567     74,5134     84,7701
 U/K    DIST   LOG      ,0933       ,1244       ,1657       ,2209       ,2944       ,3923       ,5229
 U/TH   DIST   LOG      ,2447       ,3278       ,4392       ,5883       ,7881      1,0558      1,4144
 TH/K   DIST NORMAL     ,0519       ,1380       ,2240       ,3100       ,3960       ,4820       ,5681
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                              ROCK UNIT   KMB

                      -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  119,3112    135,5408    151,7704    168,0000    184,2296    200,4592    216,6888
 BI214  DIST NORMAL    2,2216      9,4810     16,7405     24,0000     31,2595     38,5190     45,7784
 TL208  DIST NORMAL   34,8154     43,3769     51,9385     60,5000     69,0615     77,6231     86,1846
 U/K    DIST NORMAL     ,0185       ,0609       ,1034       ,1458       ,1882       ,2307       ,2731
 U/TH   DIST NORMAL    -,0014       ,1324       ,2662       ,4000       ,5338       ,6676       ,8014
 TH/K   DIST NORMAL     ,1651       ,2267       ,2884       ,3500       ,4116       ,4733       ,5349
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                              ROCK UNIT   KMT

                      -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL   91,9271    110,7181    129,5090    148,3000    167,0910    185,8819    204,6729
 BI214  DIST NORMAL    8,0667     17,0445     26,0222     35,0000     43,9778     52,9555     61,9333
 TL208  DIST NORMAL   32,1128     45,0085     57,9043     70,8000     83,6957     96,5915    109,4872
 U/K    DIST NORMAL     ,0451       ,1067       ,1684       ,2300       ,2916       ,3533       ,4149
 U/TH   DIST NORMAL     ,0461       ,1987       ,3514       ,5040       ,6566       ,8093       ,9619
 TH/K   DIST NORMAL     ,2117       ,3011       ,3906       ,4800       ,5694       ,6589       ,7483
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                                   ROCK UNIT   TRPU

                          -3         -2         -1          0         +1         +2         +3

   K40   DIST NORMAL   32.5158    67.4772   102.4386   137.4000   172.3614   207.3228   242.2842
  BI214  DIST NORMAL   -.8279      6.1148    13.0574    20.0000    26.9426    33.8852    40.8279
  TL208  DIST NORMAL    6.2509    18.1672    30.0836    42.0000    53.9164    65.8328    77.7491
  U/K    DIST  LOG       .0524      .0740      .1044      .1473      .2079      .2933      .4139
  U/TH   DIST  LOG       .2228      .2945      .3893      .5145      .6800      .8988     1.1879
  TH/K   DIST  LOG       .1546      .1898      .2331      .2863      .3516      .4318      .5302
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                                   ROCK UNIT   PMU

                          -3         -2         -1          0         +1         +2         +3

   K40   DIST NORMAL   39.4263    68.9509    98.4754   128.0000   157.5246   187.0491   216.5737
  BI214  DIST NORMAL    2.4879     7.3253    12.1626    17.0000    21.8374    26.6747    31.5121
  TL208  DIST NORMAL     .2040    14.4693    28.7347    43.0000    57.2653    71.5307    85.7960
  U/K    DIST NORMAL   -.0035      .0455      .0945      .1435      .1925      .2415      .2905
  U/TH   DIST NORMAL   -.0637      .0975      .2588      .4200      .5812      .7425      .9037
  TH/K   DIST NORMAL   -.1157      .0229      .1614      .3000      .4386      .5771      .7157
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                                   ROCK UNIT   TG

                          -3         -2         -1          0         +1         +2         +3

   K40   DIST NORMAL  121.1717   142.1144   163.0572   184.0000   204.9428   225.8856   246.8283
  BI214  DIST  LOG     11.9677    15.8855    21.0859    27.9887    37.1512    49.3132    65.4567
  TL208  DIST  LOG     26.7274    38.0306    54.1142    76.9996   109.5634   155.8989   221.8300
  U/K    DIST  LOG       .0717      .0918      .1175      .1504      .1925      .2464      .3153
  U/TH   DIST  LOG       .1794      .2270      .2873      .3635      .4600      .5820      .7365
  TH/K   DIST  LOG       .1812      .2386      .3142      .4137      .5448      .7173      .9445
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                              ROCK UNIT  MCU

                         -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL    -5.4603    28.3598    62.1799    96.0000   129.8201   163.6402   197.4603
BI214  DIST NORMAL    -5.7275     -.8184     4.0908     9.0000    13.9092    18.8184    23.7275
TL208  DIST NORMAL   -25.7434   -11.4956     2.7522    17.0000    31.2478    45.4956    59.7434
U/K    DIST NORMAL      .0324      .0589      .0853      .1118      .1383      .1647      .1912
U/TH   DIST NORMAL     -.0139      .1508      .3154      .4800      .6446      .8092      .9739
TH/K   DIST NORMAL      .0557      .1105      .1652      .2200      .2748      .3295      .3843
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                              ROCK UNIT  KFMF

                         -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL    68.9673    90.3449   111.7224   133.1000   154.4776   175.8551   197.2327
BI214  DIST NORMAL     7.4643    17.9762    28.4881    39.0000    49.5119    60.0238    70.5357
TL208  DIST  LOG      32.5665    38.9348    46.5485    55.6510    66.5335    79.5441    95.0989
U/K    DIST  LOG        .1591      .1997      .2506      .3145      .3947      .4954      .6217
U/TH   DIST  LOG        .2947      .4005      .5444      .7399     1.0057     1.3670     1.8581
TH/K   DIST NORMAL      .1726      .2551      .3375      .4200      .5025      .5849      .6674
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                              ROCK UNIT  PTA

                         -3         -2         -1          0         +1         +2         +3

 K40   DIST  LOG      49.4524    63.8758    82.5059   106.5698   137.6521   177.8000   229.6575
BI214  DIST  LOG       2.5015     4.0841     6.6678    10.8862    17.7734    29.0178    47.3758
TL208  DIST  LOG       4.9182     8.9098    16.1412    29.2418    52.9751    95.9708   173.8628
U/K    DIST  LOG        .0325      .0475      .0695      .1016      .1486      .2174      .3179
U/TH   DIST  LOG        .1068      .1600      .2397      .3591      .5380      .8059     1.2074
TH/K   DIST  LOG        .0844      .1250      .1852      .2744      .4065      .6023      .8923
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                              ROCK UNIT   TU

                         -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL   96,2129  117,7419  139,2710  160,8000  182.3290  203,8581  225.3871
 BI214  DIST  LOG      7,9254   10,9483   15,1241   20,8927   28,8615   39,8698   55,0769
 TL208  DIST  LOG     30,1420   35,7379   42,3728   50.2394   59.5665   70,6252   83,7371
 U/K    DIST  LOG       ,0475     ,0666     ,0935     ,1311     ,1839     ,2580     ,3618
 U/TH   DIST  LOG       ,1419     ,2030     ,2906     ,4159     ,5952     ,8518    1,2190
 TH/K   DIST NORMAL     ,1532     ,2088     ,2645     ,3202     ,3759     ,4316     ,4872
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                              ROCK UNIT   QU

                         -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL   48,8685  105,9123  162,9562  220,0000  277,0438  334,0877  391,1315
 BI214  DIST NORMAL  -22,4722   -8,9815    4,5093   18,0000   31,4907   44,9815   58,4722
 TL208  DIST NORMAL   -8,4241   36,0506   80,5253  125,0000  169,4747  213,9494  258,4241
 U/K    DIST NORMAL     ,0120     ,0640     ,1159     ,1679     ,2199     ,2718     .3238
 U/TH   DIST NORMAL    -,1102     ,0265     ,1633     ,3000     ,4367     ,5735     ,7102
 TH/K   DIST NORMAL     ,1500     ,3000     ,4500     ,6000     ,7500     ,9000    1,0500
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                              ROCK UNIT   CU

                         -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL   19,5683   58,8456   98,1228  137,4000  176,6772  215,9544  255,2317
 BI214  DIST NORMAL    8,5771   12,6514   16,7257   20,8000   24,8743   28,9486   33,0229
 TL208  DIST NORMAL   22,2439   31,4959   40,7480   50,0000   59,2520   68,5041   77,7561
 U/K    DIST NORMAL     ,0209     ,0678     ,1147     ,1616     ,2085     ,2554     ,3023
 U/TH   DIST NORMAL     ,1122     ,2236     ,3349     ,4463     ,5577     ,6690     ,7804
 TH/K   DIST NORMAL     ,2086     ,2596     ,3106     ,3616     ,4126     ,4636     ,5146
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                               ROCK UNIT  KJCM

                    -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL  47.5581   78.3721  109.1860  140.0000  170.8140  201.6279  232.4419
 BI214  DIST NORMAL   8.0979   15.3986   22.6993   30.0000   37.3007   44.6014   51.9021
 TL208  DIST NORMAL  29.6057   43.0705   56.5352   70.0000   83.4648   96.9295  110.3943
 U/K    DIST NORMAL    .0151     .0767     .1384     .2000     .2616     .3233     .3849
 U/TH   DIST NORMAL    .1667     .2578     .3489     .4400     .5311     .6222     .7133
 TH/K   DIST NORMAL    .2038     .2825     .3613     .4400     .5187     .5975     .6762
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                               ROCK UNIT   QL

                    -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL 142.7582  186.8388  230.9194  275.0000  319.0806  363.1612  407.2418
 BI214  DIST NORMAL -17.1970    1.8686   20.9343   40.0000   59.0657   78.1314   97.1970
 TL208  DIST NORMAL -25.0436   29.9709   84.9855  140.0000  195.0145  250.0291  305.0436
 U/K    DIST NORMAL   -.2230    -.0953     .0323     .1600     .2877     .4153     .5430
 U/TH   DIST NORMAL    .1369     .1977     .2586     .3194     .3802     .4411     .5019
 TH/K   DIST NORMAL   -.6337    -.2558     .1221     .5000     .8779    1.2558    1.6337
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                               ROCK UNIT   PU

                    -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL  42.3467   66.5645   90.7822  115.0000  139.2178  163.4355  187.6533
 BI214  DIST NORMAL   6.0000   12.0000   18.0000   24.0000   30.0000   36.0000   42.0000
 TL208  DIST NORMAL  20.7112   27.5741   34.4371   41.3000   48.1629   55.0259   61.8888
 U/K    DIST NORMAL    .0728     .1089     .1449     .1810     .2171     .2531     .2892
 U/TH   DIST NORMAL    .2367     .3608     .4849     .6090     .7331     .8572     .9813
 TH/K   DIST NORMAL    .1998     .2330     .2661     .2993     .3325     .3656     .3988
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RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
JS	40	1) 2.158	71.9	K	.812	-.561	.161
		2) .747	24.9	U	.743	.657	.126
		3) .095	3.1	T	.972	-.034	-.231
KCV	90	1) 1.636	54.5	K	.148	-.971	-.189
		2) 1.136	37.9	U	.870	.388	-.304
		3) .228	7.6	T	.925	-.209	.316
KF	497	1) 2.260	75.3	K	.838	-.545	.013
		2) .432	14.4	U	.881	.272	.387
		3) .309	10.3	T	.884	.246	-.398
KLE	2545	1) 1.736	57.9	K	.778	.366	-.511
		2) .695	23.2	U	.714	-.698	-.054
		3) .569	18.9	T	.788	.271	.553
KMV	4888	1) 1.703	56.8	K	.820	-.357	.447
		2) .859	28.6	U	.545	.834	.082
		3) .437	14.6	T	.856	-.189	-.480
PCG	546	1) 2.380	79.3	K	.956	-.011	.293
		2) .481	16.0	U	.860	-.482	-.169
		3) .139	4.6	T	.853	.498	-.158

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
PCGN	4444	1) 2.029	67.6	K	.894	-.236	.381
		2) .695	23.2	U	.684	.729	-.039
		3) .276	9.2	T	.873	-.329	-.360
PCGR	936	1) 2.481	82.7	K	.921	-.022	.389
		2) .288	9.6	U	.905	-.368	-.215
		3) .231	7.7	T	.902	.391	-.181
PCI	1053	1) 2.190	72.9	K	.900	-.329	-.287
		2) .631	21.0	U	.724	.689	-.039
		3) .180	5.9	T	.925	-.219	.309
PCQ	524	1) 1.980	66.0	K	.845	.337	.416
		2) .647	21.6	U	.725	-.687	.043
		3) .373	12.4	T	.861	.249	-.445
PCQD	278	1) 2.378	79.3	K	.939	-.287	.189
		2) .548	18.3	U	.768	.641	.013
		3) .075	2.5	T	.952	-.233	-.197
PCQM	507	1) 2.391	79.7	K	.887	-.396	-.238
		2) .341	11.4	U	.883	.428	-.191
		3) .267	8.9	T	.908	-.030	.418

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
PCSCH	722	1) 2.113	70.4	K	.821	.505	.265
		2) .525	17.5	U	.818	-.519	.248
		3) .362	12.1	T	.877	.011	-.480
Q	10704	1) 1.973	65.8	K	.833	.430	-.348
		2) .716	23.9	U	.690	-.713	-.122
		3) .311	10.4	T	.896	.150	.418
QAL	766	1) 2.301	76.7	K	.923	-.204	-.326
		2) .505	16.8	U	.799	.599	.047
		3) .195	6.5	T	.900	-.323	.293
QG	1299	1) 2.129	70.9	K	.895	.236	.379
		2) .601	20.0	U	.747	-.663	-.038
		3) .270	8.9	T	.877	.325	-.354
QLS	366	1) 2.154	71.8	K	.864	.214	-.456
		2) .473	15.8	U	.823	-.565	.061
		3) .373	12.4	T	.855	.328	.402
QMC	329	1) 1.955	65.2	K	.870	.023	-.493
		2) .648	21.6	U	.780	.551	.295
		3) .397	13.2	T	.768	-.587	.258

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
QT	87	1) 1.461	48.7	K	.852	.028	-.522
		2) .996	33.2	U	.159	-.985	.067
		3) .543	18.1	T	.842	.157	.516
QTU	655	1) 2.247	74.9	K	.902	-.126	-.414
		2) .470	15.7	U	.827	.548	.127
		3) .283	9.4	T	.866	-.392	.310
TBP	5644	1) 1.568	52.2	K	.834	-.210	.510
		2) .921	30.7	U	.440	.897	-.030
		3) .512	17.1	T	.823	-.267	-.501
TBS	2364	1) 1.869	62.3	K	.412	.909	.069
		2) .932	31.1	U	.901	-.311	.303
		3) .199	6.6	T	.942	-.100	-.320
TD	875	1) 1.633	54.4	K	-.644	.706	.294
		2) .873	29.1	U	.851	.030	.524
		3) .494	16.5	T	.702	.611	-.365
TFU	1332	1) 1.949	64.9	K	.786	.534	.312
		2) .693	23.1	U	.739	-.636	.220
		3) .358	11.9	T	.886	.057	-.461

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
TGL	675	1) 2.241	74.7	K	.879	.330	.344
		2) .484	16.1	U	.813	-.579	.060
		3) .275	9.1	T	.898	.201	-.391
TGM	807	1) 2.365	78.8	K	.928	-.173	-.329
		2) .444	14.8	U	.831	.552	.064
		3) .191	6.3	T	.901	-.331	.280
TGT	609	1) 1.542	51.4	K	.468	-.840	-.275
		2) 1.046	34.9	U	.722	.583	.373
		3) .412	13.7	T	.895	-.031	.444
TKF	1150	1) 1.699	56.6	K	.348	.929	.130
		2) .985	32.8	U	.859	-.350	-.374
		3) .316	10.5	T	.916	-.024	-.400
TKHF	1171	1) 1.889	63.0	K	.877	-.224	.425
		2) .767	25.6	U	.630	.774	-.053
		3) .343	11.4	T	.850	-.343	-.399
TNP	3462	1) 1.906	63.5	K	.864	.244	-.440
		2) .726	24.2	U	.668	-.743	.045
		3) .368	12.3	T	.844	.338	.415

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
TWC	1532	1) 2.281	76.0	K	.854	-.471	-.219
		2) .541	18.0	U	.813	.562	-.150
		3) .177	5.9	T	.943	-.058	.327
TWDR	62	1) 1.280	42.7	K	-.576	-.727	.373
		2) .941	31.4	U	-.751	.029	-.659
		3) .779	26.0	T	.619	-.641	-.453
TWK	36	1) 1.948	64.9	K	-.662	-.742	-.105
		2) .745	24.8	U	.897	-.165	-.411
		3) .307	10.2	T	.840	-.409	.356
TW	2970	1) 2.325	77.5	K	.789	-.600	-.060
		2) .510	17.0	U	.901	.344	-.262
		3) .165	5.4	T	.936	.180	.304
KL	894	1) 1.423	47.4	K	.737	-.413	.534
		2) .915	30.5	U	.512	.847	.146
		3) .662	22.1	T	.786	-.164	-.596
KSN	2544	1) 1.540	51.3	K	.860	.098	.500
		2) .969	32.3	U	-.319	.944	.081
		3) .491	16.4	T	.836	.260	-.484

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
PCU	1912	1) 2.144	71.5	K	.876	.326	.356
		2) .580	19.3	U	.760	-.648	.041
		3) .276	9.2	T	.894	.232	-.384
TRJC	74	1) 2.253	75.1	K	.955	-.173	.240
		2) .642	21.4	U	.721	.691	-.052
		3) .105	3.5	T	.906	-.368	-.211
KU	102	1) 2.022	67.4	K	.747	.659	.089
		2) .618	20.6	U	.840	-.381	.387
		3) .360	11.9	T	.871	-.198	-.449
JU	34	1) 2.046	68.2	K	.561	.825	-.073
		2) .867	28.9	U	-.973	.090	-.214
		3) .087	2.9	T	-.886	.423	.188
TRU	83	1) 1.949	65.0	K	.814	-.499	.298
		2) .796	26.5	U	.660	.734	.159
		3) .256	8.5	T	.923	-.085	-.376
PLS	53	1) 2.234	74.5	K	.940	.052	-.337
		2) .576	20.0	U	.801	-.577	.160
		3) .190	6.3	T	.842	.490	.224

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					2	2	3
JMS	134	1) 1.606	53.5	K	.878	-.131	.460
		2) .972	32.4	U	.268	.963	-.015
		3) .422	14.1	T	.874	-.164	-.458
KJU	134	1) 1.845	61.5	K	.827	.218	-.518
		2) .674	22.5	U	.802	.393	.451
		3) .480	16.0	T	.720	-.688	.093
KMB	1193	1) 1.156	38.5	K	.327	-.841	-.432
		2) 1.051	35.0	U	-.632	-.576	.518
		3) .793	26.4	T	-.806	.111	-.582
KMT	276	1) 1.559	52.0	K	.681	.725	.103
		2) .765	25.5	U	.732	-.423	.534
		3) .676	22.5	T	.748	-.246	-.616
TRPU	95	1) 2.179	72.6	K	.874	.432	.222
		2) .690	23.0	U	.710	-.699	.089
		3) .130	4.3	T	.955	.124	-.270
TG	638	1) 2.448	81.6	K	.873	-.466	.147
		2) .445	14.8	U	.868	.478	.139
		3) .107	3.6	T	.966	-.008	-.257

RAWLINS

UNIT	NO.SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
MCU	41	1) 2.739	91.3	K	.984	.145	-.106
		2) .241	8.0	U	.914	-.405	.016
		3) .020	.7	T	.968	.235	.093
KFMF	49	1) 1.469	49.0	K	.920	-.041	-.389
		2) 1.173	39.1	U	.497	-.809	.313
		3) .358	11.9	T	.612	.718	.330
PTA	138	1) 2.406	80.2	K	.929	-.290	-.230
		2) .481	16.0	U	.807	.591	-.022
		3) .113	3.7	T	.945	-.219	.245
TN	1265	1) 1.368	45.6	K	.812	.067	-.580
		2) .977	32.6	U	.360	-.918	.170
		3) .655	21.8	T	.761	.362	.538
QU	183	1) 2.627	87.6	K	.905	.415	.087
		2) .289	9.6	U	.930	-.334	.154
		3) .084	2.8	T	.971	-.067	-.229
CU	50	1) 2.004	66.8	K	.944	.182	-.275
		2) .850	28.3	U	.520	-.854	.033
		3) .146	4.9	T	.918	.297	.264

RAWLINS

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
KJCM	54	1) 2.114	70.5	K	.768	.621	-.158
		2) .773	25.8	U	.767	-.623	-.158
		3) .113	3.7	T	.968	.001	.250
QL	472	1) 2.054	68.5	K	-.533	.846	-.021
		2) .834	27.8	U	.950	.198	-.240
		3) .112	3.7	T	.931	.282	.233
PU	113	1) 2.278	75.9	K	.902	-.229	-.366
		2) .471	15.7	U	.817	.575	.031
		3) .252	8.4	T	.892	-.296	.342
TH	2041	1) 2.172	72.4	K	.704	-.707	-.071
		2) .676	22.5	U	.887	.388	-.251
		3) .151	5.1	T	.943	.163	.289

APPENDIX E

STATISTICAL TABLES AND PRINCIPAL COMPONENT RESULTS

CHEYENNE QUADRANGLE

```
@ADD,P CHYNNE.DISTFILE
                                    ROCK UNIT    JM

                              -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL      -22.2097    30.1935    82.5968   135.0000   187.4032   239.8065   292.2097
BI214  DIST NORMAL        8.4016    12.6677    16.9339    21.2000    25.4661    29.7323    33.9984
TL208  DIST NORMAL       21.7780    29.6520    37.5260    45.4000    53.2740    61.1480    69.0220
U/K    DIST NORMAL        -.0323      .0251      .0826      .1400      .1974      .2549      .3123
U/TH   DIST NORMAL         .1653      .2683      .3712      .4742      .5772      .6801      .7831
TH/K   DIST NORMAL        -.0839      .0140      .1120      .2100      .3080      .4060      .5039
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                                    ROCK UNIT    JU

                              -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL       51.8928    82.7618   113.6309   144.5000   175.3691   206.2382   237.1072
BI214  DIST NORMAL        5.6771    11.5848    17.4924    23.4000    29.3076    35.2152    41.1229
TL208  DIST NORMAL       12.2935    22.7290    33.1645    43.6000    54.0355    64.4710    74.9065
U/K    DIST NORMAL         .0029      .0585      .1142      .1699      .2256      .2813      .3369
U/TH   DIST NORMAL        -.1371      .0952      .3276      .5600      .7924     1.0248     1.2571
TH/K   DIST NORMAL         .1430      .1920      .2410      .2900      .3390      .3880      .4370
-----------------------------------------------------------------------------------------------------

                                    ROCK UNIT   KCV

                              -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL      -14.5299    31.2467    77.0234   122.8000   168.5766   214.3533   260.1299
BI214  DIST NORMAL        6.4103    11.4402    16.4701    21.5000    26.5299    31.5598    36.5897
TL208  DIST NORMAL       22.2069    30.4712    38.7356    47.0000    55.2644    63.5288    71.7931
U/K    DIST NORMAL        -.0281      .0467      .1216      .1964      .2712      .3461      .4209
U/TH   DIST NORMAL         .1465      .2523      .3582      .4640      .5698      .6757      .7815
TH/K   DIST NORMAL         .0535      .1763      .2992      .4221      .5450      .6679      .7907
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                              ROCK UNIT   KF

                             -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL    108.5843    126.6895    144.7948    162.9000    181.0052    199.1105    217.2157
 BI214  DIST NORMAL      3.0500     12.0667     21.0833     30.1000     39.1167     48.1333     57.1500
 TL208  DIST NORMAL     31.7190     41.2793     50.8397     60.4000     69.9603     79.5207     89.0810
 U/K    DIST NORMAL       .0139       .0713       .1288       .1862       .2436       .3011       .3585
 U/TH   DIST NORMAL      -.0524       .1250       .3025       .4800       .6575       .8350      1.0124
 TH/K   DIST NORMAL       .2005       .2579       .3154       .3728       .4302       .4877       .5451
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                              ROCK UNIT   KJCS

                             -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL      1.8306     51.0871    100.3435    149.6000    198.8565    248.1129    297.3694
 BI214  DIST NORMAL    -10.6958      1.6695     14.0347     26.4000     38.7653     51.1305     63.4958
 TL208  DIST NORMAL     11.7022     23.8348     35.9674     48.1000     60.2326     72.3652     84.4978
 U/K    DIST  LOG         .0659       .0896       .1219       .1658       .2255       .3068       .4172
 U/TH   DIST  LOG         .1494       .2241       .3360       .5039       .7556      1.1332      1.6994
 TH/K   DIST  LOG         .1502       .1951       .2534       .3291       .4275       .5553       .7212
-----------------------------------------------------------------------------------------------------

                              ROCK UNIT   KJU
                             -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL    159.1974    164.8982    170.5991    176.3000    182.0009    187.7018    193.4026
 BI214  DIST NORMAL      9.3370     13.1580     16.9790     20.8000     24.6210     28.4420     32.2630
 TL208  DIST NORMAL     39.4169     43.9446     48.4723     53.0000     57.5277     62.0554     66.5831
 U/K    DIST NORMAL       .0577       .0777       .0977       .1177       .1377       .1577       .1777
 U/TH   DIST NORMAL       .2091       .2699       .3308       .3916       .4524       .5133       .5741
 TH/K   DIST NORMAL       .2481       .2655       .2828       .3001       .3174       .3347       .3521
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                                    ROCK UNIT   KI

                        -3         -2         -1          0          +1         +2         +3

  K40   DIST NORMAL  148.1428   164.2952   180.4476   196.6000   212.7524   228.9048   245.0572
 BI214  DIST NORMAL   10.0864    15.5909    21.0955    26.6000    32.1045    37.6091    43.1136
 TL208  DIST NORMAL   43.9325    51.3216    58.7108    66.1000    73.4892    80.8784    88.2675
 U/K    DIST NORMAL     .0562      .0827      .1091      .1356      .1621      .1885      .2150
 U/TH   DIST NORMAL     .1592      .2411      .3229      .4048      .4867      .5685      .6504
 TH/K   DIST NORMAL     .2291      .2652      .3012      .3373      .3734      .4094      .4455
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                                    ROCK UNIT   KLE

                        -3         -2         -1          0          +1         +2         +3

  K40   DIST NORMAL  101.6616   117.5077   133.3539   149.2000   165.0461   180.8923   196.7384
 BI214  DIST  LOG     11.0271    13.8756    17.4601    21.9705    27.6460    34.7877    43.7743
 TL208  DIST NORMAL   40.3823    45.6549    50.9274    56.2000    61.4726    66.7451    72.0177
 U/K    DIST NORMAL     .0564      .0881      .1197      .1513      .1829      .2145      .2462
 U/TH   DIST  LOG       .1964      .2473      .3115      .3923      .4940      .6222      .7836
 TH/K   DIST NORMAL     .2492      .2928      .3364      .3800      .4236      .4672      .5108
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                                    ROCK UNIT   KMB

                        -3         -2         -1          0          +1         +2         +3

  K40   DIST NORMAL  104.8036   120.5357   136.2679   152.0000   167.7321   183.4643   199.1964
 BI214  DIST NORMAL    5.8880     9.9253    13.9627    18.0000    22.0373    26.0747    30.1120
 TL208  DIST NORMAL   25.8307    32.5538    39.2769    46.0000    52.7231    59.4462    66.1693
 U/K    DIST NORMAL     .0300      .0583      .0866      .1149      .1432      .1715      .1998
 U/TH   DIST NORMAL     .0580      .1570      .2560      .3550      .4540      .5530      .6520
 TH/K   DIST NORMAL     .2282      .2614      .2945      .3277      .3609      .3940      .4272
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                                 ROCK UNIT  KMT

                         -3         -2         -1          0         +1         +2         +3

  K40  DIST NORMAL    40.0192    77.3461   114.6731   152.0000   189.3269   226.6539   263.9808
BI214  DIST NORMAL    14.0752    20.0501    26.0251    32.0000    37.9749    43.9499    49.9248
TL208  DIST NORMAL    28.2528    40.1019    51.9509    63.8000    75.6491    87.4981    99.3472
U/K    DIST NORMAL      .0334      .0908      .1483      .2057      .2631      .3206      .3780
U/TH   DIST NORMAL      .2215      .3210      .4205      .5200      .6195      .7190      .8185
TH/K   DIST NORMAL      .1891      .2591      .3291      .3991      .4691      .5391      .6091
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                                 ROCK UNIT  KMV

                         -3         -2         -1          0         +1         +2         +3

  K40  DIST NORMAL    87.8384   109.3256   130.8128   152.3000   173.7872   195.2744   216.7616
BI214  DIST NORMAL     4.8786     9.0857    13.2929    17.5000    21.7071    25.9143    30.1214
TL208  DIST NORMAL    31.8845    37.6897    43.4948    49.3000    55.1052    60.9103    66.7155
U/K    DIST NORMAL      .0175      .0507      .0838      .1170      .1502      .1833      .2165
U/TH   DIST NORMAL      .1088      .1913      .2737      .3562      .4387      .5211      .6036
TH/K   DIST NORMAL      .1703      .2232      .2761      .3290      .3819      .4348      .4877
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                                 ROCK UNIT  KN

                         -3         -2         -1          0         +1         +2         +3

  K40  DIST NORMAL   104.3035   126.1690   148.0345   169.9000   191.7655   213.6310   235.4965
BI214  DIST NORMAL    12.8250    18.8167    24.8083    30.8000    36.7917    42.7833    48.7750
TL208  DIST NORMAL    30.6292    37.8195    45.0097    52.2000    59.3903    66.5805    73.7708
U/K    DIST NORMAL      .0388      .0878      .1368      .1858      .2348      .2838      .3328
U/TH   DIST NORMAL      .1152      .2702      .4251      .5800      .7349      .8898     1.0448
TH/K   DIST NORMAL      .1932      .2319      .2707      .3094      .3481      .3869      .4256
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                              ROCK UNIT   KP

                       -3          -2          -1           0          +1          +2          +3

 K40   DIST NORMAL  131.7390    158.7927    185.8463    212.9000    239.9536    267.0073    294.0609
BI214  DIST NORMAL    5.4195     12.1796     18.9398     25.7000     32.4602     39.2204     45.9805
TL208  DIST NORMAL   23.0956     36.6971     50.2985     63.9000     77.5015     91.1029    104.7044
U/K    DIST NORMAL     .0153       .0514       .0874       .1235       .1596       .1956       .2317
U/TH   DIST NORMAL     .1010       .2029       .3049       .4069       .5089       .6109       .7128
TH/K   DIST NORMAL     .0306       .1239       .2171       .3104       .4037       .4969       .5902
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                              ROCK UNIT  KPN

                       -3          -2          -1           0          +1          +2          +3

 K40   DIST NORMAL  101.0844    143.4896    185.8948    228.3000    270.7052    313.1104    355.5156
BI214  DIST NORMAL    3.0501      9.0334     15.0167     21.0000     26.9833     32.9666     38.9499
TL208  DIST NORMAL   40.8698     46.4465     52.0233     57.6000     63.1767     68.7535     74.3302
U/K    DIST  LOG       .0385       .0529       .0726       .0997       .1368       .1878       .2578
U/TH   DIST  LOG       .1724       .2262       .2967       .3892       .5106       .6699       .8788
TH/K   DIST NORMAL     .1061       .1541       .2020       .2500       .2980       .3459       .3939
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                              ROCK UNIT   KS

                       -3          -2          -1           0          +1          +2          +3

 K40   DIST NORMAL   97.1389    117.7592    138.3796    159.0000    179.6204    200.2408    220.8611
BI214  DIST NORMAL    5.3382     10.0921     14.8461     19.6000     24.3539     29.1079     33.8618
TL208  DIST NORMAL   31.0372     37.2581     43.4791     49.7000     55.9209     62.1419     68.3628
U/K    DIST NORMAL     .0294       .0611       .0927       .1243       .1559       .1875       .2192
U/TH   DIST NORMAL     .1013       .1998       .2983       .3968       .4953       .5938       .6923
TH/K   DIST NORMAL     .1920       .2332       .2745       .3157       .3569       .3982       .4394
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                          ROCK UNIT  KSN

                  -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL   97.3591    117.5061    137.6530    157.8000    177.9470    198.0939    218.2409
 BI214  DIST NORMAL    5.1429     12.1286     19.1143     26.1000     33.0857     40.0714     47.0571
 TL208  DIST NORMAL   34.5972     41.0314     47.4657     53.9000     60.3343     66.7686     73.2028
 U/K    DIST NORMAL     .0018       .0574       .1131       .1688       .2245       .2802       .3358
 U/TH   DIST  LOG       .1877       .2551       .3466       .4710       .6399       .8695      1.1815
 TH/K   DIST NORMAL     .2239       .2639       .3039       .3439       .3839       .4239       .4639
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                          ROCK UNIT   KU

                  -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  112.6773    132.8515    153.0258    173.2000    193.3742    213.5485    233.7227
 BI214  DIST NORMAL   17.1524     21.5682     25.9841     30.4000     34.8159     39.2318     43.6476
 TL208  DIST NORMAL   38.3860     46.8240     55.2620     63.7000     72.1380     80.5760     89.0140
 U/K    DIST NORMAL     .0824       .1141       .1457       .1773       .2089       .2405       .2722
 U/TH   DIST  LOG       .2750       .3303       .3967       .4765       .5724       .6876       .8259
 TH/K   DIST NORMAL     .2259       .2739       .3218       .3698       .4178       .4657       .5137
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                          ROCK UNIT  PCAN

                  -3          -2          -1           0          +1          +2          +3

  K40   DIST  LOG     41.9151     59.4378     84.2859    119.5219    169.4885    240.3437    340.8201
 BI214  DIST  LOG      2.5451      4.1041      6.6180     10.6717     17.2086     27.7494     44.7469
 TL208  DIST  LOG      9.5454     13.9764     20.4644     29.9641     43.8736     64.2401     94.0607
 U/K    DIST NORMAL    -.0064       .0268       .0599       .0931       .1263       .1594       .1926
 U/TH   DIST NORMAL    -.0437       .0775       .1988       .3200       .4412       .5625       .6837
 TH/K   DIST NORMAL     .1117       .1673       .2230       .2787       .3344       .3901       .4457
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                                ROCK UNIT  PCG

                        -3          -2          -1          0           +1          +2          +3

  K40   DIST NORMAL  205,9530    239,7687    273,5843    307,4000    341,2157    375,0314    408,8470
 BI214  DIST NORMAL   14,5250     16,7834     19,0417     21,3000     23,5583     25,8166     28,0750
 TL208  DIST NORMAL   40,5601     45,5401     50,5200     55,5000     60,4800     65,4599     70,4399
 U/K    DIST NORMAL     ,0396       ,0496       ,0596       ,0696       ,0796       ,0896       ,0996
 U/TH   DIST NORMAL     ,2223       ,2771       ,3318       ,3866       ,4414       ,4961       ,5509
 TH/K   DIST NORMAL     ,0981       ,1264       ,1547       ,1830       ,2113       ,2396       ,2679
------------------------------------------------------------------------------------------------

                                ROCK UNIT  PCGN

                        -3          -2          -1          0           +1          +2          +3

  K40   DIST NORMAL   19,9485     51,9656     83,9828    116,0000    148,0172    180,0344    212,0515
 BI214  DIST NORMAL    -,2616      3,1589      6,5795     10,0000     13,4205     16,8411     20,2616
 TL208  DIST NORMAL   -6,9500      8,0334     23,0167     38,0000     52,9833     67,9666     82,9500
 U/K    DIST NORMAL    -,0131       ,0186       ,0502       ,0818       ,1134       ,1450       ,1767
 U/TH   DIST NORMAL    -,1100       ,0000       ,1100       ,2200       ,3300       ,4400       ,5500
 TH/K   DIST NORMAL     ,1310       ,1973       ,2637       ,3300       ,3963       ,4627       ,5290
------------------------------------------------------------------------------------------------

                                ROCK UNIT  PCGR

                        -3          -2          -1          0           +1          +2          +3

  K40   DIST NORMAL  126,8037    191,2025    255,6012    320,0000    384,3988    448,7975    513,1963
 BI214  DIST NORMAL    5,2540     13,6027     21,9513     30,3000     38,6487     46,9973     55,3460
 TL208  DIST NORMAL  -22,8215     14,7856     52,3928     90,0000    127,6072    165,2144    202,8215
 U/K    DIST NORMAL     ,0286       ,0531       ,0776       ,1021       ,1266       ,1511       ,1756
 U/TH   DIST NORMAL     ,1025       ,1787       ,2548       ,3310       ,4072       ,4833       ,5595
 TH/K   DIST NORMAL     ,0030       ,1020       ,2010       ,3000       ,3990       ,4980       ,5970
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                                    ROCK UNIT PCNOR

                           -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   -29.2770    32.8486    94.9743   157.1000   219.2257   281.3514   343.4770
 BI214  DIST NORMAL     -.6456     3.9696     8.5848    13.2000    17.8152    22.4304    27.0456
 TL208  DIST NORMAL     7.0938    16.6958    26.2979    35.9000    45.5021    55.1042    64.7062
 U/K    DIST NORMAL      .0087      .0352      .0616      .0881      .1146      .1410      .1675
 U/TH   DIST NORMAL      .0883      .1789      .2694      .3600      .4506      .5411      .6317
 TH/K   DIST NORMAL     -.0012      .0658      .1329      .2000      .2671      .3342      .4012
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                                    ROCK UNIT  PCQD

                           -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL    88.1485   107.9323   127.7162   147.5000   167.2838   187.0677   206.8515
 BI214  DIST NORMAL     5.6158     9.4105    13.2053    17.0000    20.7947    24.5895    28.3842
 TL208  DIST NORMAL    28.9075    45.7717    62.6358    79.5000    96.3642   113.2283   130.0925
 U/K    DIST NORMAL      .0481      .0705      .0928      .1152      .1376      .1599      .1823
 U/TH   DIST NORMAL      .0042      .0777      .1512      .2247      .2982      .3717      .4452
 TH/K   DIST NORMAL      .2461      .3446      .4431      .5416      .6401      .7386      .8371
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                                    ROCK UNIT  PCS

                           -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  -108.8417      .7389   110.3194   219.9000   329.4806   439.0611   548.6417
 BI214  DIST  LOG       3.8509     6.5072    10.9957    18.5803    31.3965    53.0529    89.6475
 TL208  DIST  LOG       8.0369    14.9244    27.7143    51.4649    95.5692   177.4700   329.5579
 U/K    DIST  LOG        .0179      .0315      .0556      .0981      .1732      .3055      .5389
 U/TH   DIST NORMAL     -.0071      .1182      .2435      .3688      .4941      .6194      .7447
 TH/K   DIST NORMAL     -.2181     -.0367      .1447      .3261      .5075      .6889      .8703
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                                  ROCK UNIT   PCU

                        -3         -2         -1          0         +1         +2         +3

   K40   DIST NORMAL  -31.0795    48.6137   128.3068   208.0000   287.6932   367.3863   447.0795
  BI214  DIST NORMAL   -4.4028     4.0648    12.5324    21.0000    29.4676    37.9352    46.4028
  TL208  DIST NORMAL  -27.0584     8.6277    44.3139    80.0000   115.6861   151.3723   187.0584
  U/K    DIST  LOG       .0313      .0466      .0694      .1034      .1539      .2293      .3414
  U/TH   DIST  LOG       .0738      .1125      .1714      .2613      .3983      .6071      .9255
  TH/K   DIST NORMAL    -.0133      .1306      .2744      .4183      .5622      .7060      .8499
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                                  ROCK UNIT   PFS

                        -3         -2         -1          0         +1         +2         +3

   K40   DIST NORMAL   75.6601   105.3401   135.0200   164.7000   194.3800   224.0599   253.7399
  BI214  DIST NORMAL   -1.5806     4.9463    11.4731    18.0000    24.5269    31.0537    37.5806
  TL208  DIST NORMAL    9.7907    19.8605    29.9302    40.0000    50.0698    60.1395    70.2093
  U/K    DIST NORMAL    -.0036      .0325      .0685      .1046      .1407      .1767      .2128
  U/TH   DIST NORMAL     .0041      .1567      .3094      .4620      .6146      .7673      .9199
  TH/K   DIST NORMAL     .0919      .1367      .1814      .2261      .2708      .3155      .3603
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                                  ROCK UNIT    PG

                        -3         -2         -1          0         +1         +2         +3

   K40   DIST NORMAL   67.6061    89.9040   112.2020   134.5000   156.7980   179.0960   201.3939
  BI214  DIST NORMAL     .0003     6.0335    12.0668    18.1000    24.1332    30.1665    36.1997
  TL208  DIST NORMAL   20.7979    28.0986    35.3993    42.7000    50.0007    57.3014    64.6021
  U/K    DIST NORMAL     .0335      .0667      .0998      .1330      .1662      .1993      .2325
  U/TH   DIST NORMAL     .0846      .1964      .3082      .4200      .5318      .6436      .7554
  TH/K   DIST NORMAL     .2196      .2528      .2859      .3191      .3523      .3854      .4186
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                                       ROCK UNIT   PPC
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                              -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL     -96,8609   -20,5739    55,7130   132,0000   208,2870   284,5739   360,8609
 BI214  DIST NORMAL       -,3499     5,6667    11,6834    17,7000    23,7166    29,7333    35,7499
 TL208  DIST NORMAL     -16,2328     1,8448    19,9224    38,0000    56,0776    74,1552    92,2328
 U/K    DIST NORMAL       -,0459      ,0061      ,0580      ,1100      ,1620      ,2139      ,2659
 U/TH   DIST NORMAL       -,0290      ,1207      ,2703      ,4200      ,5697      ,7193      ,8690
 TH/K   DIST NORMAL        ,0551      ,1299      ,2048      ,2796      ,3544      ,4293      ,5041
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                                       ROCK UNIT   PTA

                              -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL      46,7718    68,9146    91,0573   113,2000   135,3427   157,4854   179,6282
 BI214  DIST NORMAL       2,9547     7,3364    11,7182    16,1000    20,4818    24,8636    29,2453
 TL208  DIST NORMAL      16,1432    24,3955    32,6477    40,9000    49,1523    57,4045    65,6568
 U/K    DIST  LOG          ,0590      ,0786      ,1048      ,1397      ,1862      ,2483      ,3310
 U/TH   DIST  LOG          ,1706      ,2241      ,2944      ,3867      ,5080      ,6673      ,8766
 TH/K   DIST NORMAL        ,2399      ,2811      ,3224      ,3636      ,4048      ,4461      ,4873
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                                       ROCK UNIT    Q

                              -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL      30,3093    80,2062   130,1031   180,0000   229,8969   279,7938   329,6907
 BI214  DIST NORMAL       2,2339     8,4226    14,6113    20,8000    26,9887    33,1774    39,3661
 TL208  DIST NORMAL      15,4788    27,6525    39,8263    52,0000    64,1737    76,3475    88,5212
 U/K    DIST NORMAL       -,0034      ,0353      ,0741      ,1128      ,1515      ,1903      ,2290
 U/TH   DIST NORMAL        ,0735      ,1789      ,2842      ,3896      ,4950      ,6003      ,7057
 TH/K   DIST NORMAL        ,1287      ,1816      ,2345      ,2874      ,3403      ,3932      ,4461
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                           ROCK UNIT  QAL

                   -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   49.3471    94.2314   139.1157   184.0000   228.8843   273.7686   318.6529
 BI214  DIST NORMAL    2.0417     8.7944    15.5472    22.3000    29.0528    35.8056    42.5583
 TL208  DIST NORMAL   18.7420    31.2280    43.7140    56.2000    68.6860    81.1720    93.6580
 U/K    DIST NORMAL    -.0114      .0334      .0781      .1228      .1675      .2122      .2570
 U/TH   DIST NORMAL     .0136      .1444      .2751      .4059      .5367      .6674      .7982
 TH/K   DIST NORMAL     .1023      .1702      .2380      .3058      .3736      .4414      .5093
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                           ROCK UNIT   QF

                   -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  141.4365   163.6243   185.8122   208.0000   230.1878   252.3757   274.5635
 BI214  DIST NORMAL    8.9339    15.1226    21.3113    27.5000    33.6887    39.8774    46.0661
 TL208  DIST NORMAL   37.7708    46.6138    55.4569    64.3000    73.1431    81.9862    90.8292
 U/K    DIST NORMAL     .0608      .0853      .1098      .1343      .1588      .1833      .2078
 U/TH   DIST NORMAL     .2233      .2903      .3574      .4245      .4916      .5587      .6257
 TH/K   DIST NORMAL     .2215      .2532      .2848      .3164      .3480      .3796      .4113
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                           ROCK UNIT  QMC

                   -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   56.6438    93.7625   130.8813   168.0000   205.1187   242.2375   279.3562
 BI214  DIST NORMAL    3.3790     9.2527    15.1263    21.0000    26.8737    32.7473    38.6210
 TL208  DIST NORMAL   26.3900    34.7267    43.0633    51.4000    59.7367    68.0733    76.4100
 U/K    DIST NORMAL    -.0555      .0053      .0662      .1270      .1878      .2487      .3095
 U/TH   DIST NORMAL    -.1116      .0648      .2411      .4175      .5939      .7702      .9466
 TH/K   DIST NORMAL     .1272      .1864      .2455      .3047      .3639      .4230      .4822
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                              ROCK UNIT   QS

                       -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  169,5967   175,1645   180,7322   186,3000   191,8678   197,4355   203,0033
BI214  DIST NORMAL    6,4786     9,9857    13,4929    17,0000    20,5071    24,0143    27,5214
TL208  DIST NORMAL   40,7645    44,2430    47,7215    51,2000    54,6785    58,1570    61,6355
U/K    DIST NORMAL     ,0313      ,0513      ,0713      ,0913      ,1113      ,1313      ,1513
U/TH   DIST NORMAL     ,1288      ,1967      ,2645      ,3323      ,4001      ,4679      ,5358
TH/K   DIST NORMAL     ,2229      ,2403      ,2576      ,2749      ,2922      ,3095      ,3269
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                              ROCK UNIT   QSW

                       -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL    4,8545    64,5697   124,2848   184,0000   243,7152   303,4303   363,1455
BI214  DIST NORMAL    5,4984    10,6656    15,8328    21,0000    26,1672    31,3344    36,5016
TL208  DIST NORMAL   45,6803    52,9535    60,2268    67,5000    74,7732    82,0465    89,3197
U/K    DIST NORMAL     ,0299      ,0523      ,0746      ,0970      ,1194      ,1417      ,1641
U/TH   DIST NORMAL     ,1303      ,1935      ,2568      ,3200      ,3832      ,4465      ,5097
TH/K   DIST NORMAL     ,1870      ,2380      ,2890      ,3400      ,3910      ,4420      ,4930
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                              ROCK UNIT   QT

                       -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL   51,3424   108,2283   165,1142   222,0000   278,8858   335,7717   392,6576
BI214  DIST NORMAL    5,6501    11,6667    17,6834    23,7000    29,7166    35,7333    41,7499
TL208  DIST NORMAL   33,3818    42,9212    52,4606    62,0000    71,5394    81,0788    90,6182
U/K    DIST NORMAL     ,0082      ,0428      ,0775      ,1121      ,1467      ,1814      ,2160
U/TH   DIST NORMAL     ,1113      ,2067      ,3021      ,3975      ,4929      ,5883      ,6837
TH/K   DIST NORMAL     ,1100      ,1700      ,2300      ,2900      ,3500      ,4100      ,4700
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                              ROCK UNIT   QTU

                       -3          -2          -1           0          +1          +2          +3

  K40  DIST NORMAL  113.1989    126.4992    139.7996    153.1000    166.4004    179.7008    193.0011
 BI214 DIST NORMAL   12.4154     15.7769     19.1385     22.5000     25.8615     29.2231     32.5846
 TL208 DIST NORMAL   41.7320     47.2546     52.7773     58.3000     63.8227     69.3454     74.8680
 U/K   DIST NORMAL     .0742       .0987       .1232       .1477       .1722       .1967       .2212
 U/TH  DIST NORMAL     .2515       .2963       .3410       .3857       .4304       .4751       .5199
 TH/K  DIST NORMAL     .2228       .2767       .3305       .3844       .4383       .4921       .5460
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                              ROCK UNIT    TA

                       -3          -2          -1           0          +1          +2          +3

  K40  DIST NORMAL  139.5316    158.5211    177.5105    196.5000    215.4895    234.4789    253.4684
 BI214 DIST NORMAL    1.6100      9.1067     16.6033     24.1000     31.5967     39.0933     46.5900
 TL208 DIST NORMAL   24.0197     35.7798     47.5399     59.3000     71.0601     82.8202     94.5803
 U/K   DIST NORMAL     .0031       .0431       .0831       .1231       .1631       .2031       .2431
 U/TH  DIST NORMAL     .0808       .1899       .2990       .4081       .5172       .6263       .7354
 TH/K  DIST NORMAL     .1209       .1817       .2426       .3034       .3642       .4251       .4859
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                              ROCK UNIT    TB

                       -3          -2          -1           0          +1          +2          +3

  K40  DIST NORMAL   94.8271    133.8847    172.9424    212.0000    251.0576    290.1153    329.1729
 BI214 DIST NORMAL     .3857      9.7238     19.0619     28.4000     37.7381     47.0762     56.4143
 TL208 DIST NORMAL   30.7622     43.0748     55.3874     67.7000     80.0126     92.3252    104.6378
 U/K   DIST NORMAL    -.0040       .0429       .0898       .1367       .1836       .2305       .2774
 U/TH  DIST NORMAL     .0488       .1725       .2962       .4199       .5436       .6673       .7910
 TH/K  DIST NORMAL     .1360       .1992       .2625       .3257       .3889       .4522       .5154
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                           ROCK UNIT   TC

                  -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  107.1794  133.3863  159.5931  185.8000  212.0069  238.2137  264.4206
BI214  DIST NORMAL    9.0790   14.9527   20.8263   26.7000   32.5737   38.4473   44.3210
TL208  DIST NORMAL   37.2667   46.2778   55.2889   64.3000   73.3111   82.3222   91.3333
U/K    DIST NORMAL     .0379     .0740     .1100     .1461     .1822     .2182     .2543
U/TH   DIST NORMAL     .1553     .2430     .3308     .4185     .5062     .5940     .6817
TH/K   DIST NORMAL     .1860     .2408     .2955     .3503     .4051     .4598     .5146
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                           ROCK UNIT   TH

                  -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL   83.9332  110.6221  137.3111  164.0000  190.6889  217.3779  244.0668
BI214  DIST NORMAL    4.2738   10.5826   16.8913   23.2000   29.5087   35.8174   42.1262
TL208  DIST NORMAL   19.7128   32.6085   45.5043   58.4000   71.2957   84.1915   97.0872
U/K    DIST NORMAL     .0345     .0691     .1038     .1384     .1730     .2077     .2423
U/TH   DIST NORMAL     .1239     .2161     .3083     .4005     .4927     .5849     .6771
TH/K   DIST NORMAL     .1788     .2354     .2919     .3485     .4051     .4616     .5182
------------------------------------------------------------------------------------------------

                           ROCK UNIT   TNP

                  -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL   90.5869  111.0246  131.4623  151.9000  172.3377  192.7754  213.2131
BI214  DIST NORMAL    3.2501    9.2667   15.2834   21.3000   27.3166   33.3333   39.3499
TL208  DIST NORMAL   31.0501   38.5334   46.0167   53.5000   60.9833   68.4666   75.9499
U/K    DIST NORMAL     .0116     .0552     .0988     .1424     .1860     .2296     .2732
U/TH   DIST NORMAL     .0705     .1805     .2905     .4005     .5105     .6205     .7305
TH/K   DIST NORMAL     .1889     .2445     .3002     .3559     .4116     .4673     .5229
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                          ROCK UNIT   TO

                 -3        -2        -1         0        +1        +2        +3

 K40  DIST NORMAL  113.5234  151.6822  189.8411  228.0000  266.1589  304.3178  342.4766
BI214 DIST NORMAL    1.6325    8.2884   14.9442   21.6000   28.2558   34.9116   41.5675
TL208 DIST NORMAL   34.7511   43.8341   52.9170   62.0000   71.0830   80.1659   89.2489
U/K   DIST NORMAL    -.0129     .0232     .0592     .0953     .1314     .1674     .2035
U/TH  DIST NORMAL     .0523     .1538     .2553     .3568     .4583     .5598     .6613
TH/K  DIST NORMAL     .1127     .1637     .2147     .2657     .3167     .3677     .4187
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                          ROCK UNIT  TRC

                 -3        -2        -1         0        +1        +2        +3

 K40  DIST NORMAL   36.9411   85.0607  133.1804  181.3000  229.4196  277.5393  325.6589
BI214 DIST NORMAL    1.6043    7.7362   13.8681   20.0000   26.1319   32.2638   38.3957
TL208 DIST NORMAL   14.4794   25.8196   37.1598   48.5000   59.8402   71.1804   82.5206
U/K   DIST NORMAL    -.0026     .0386     .0799     .1211     .1623     .2036     .2448
U/TH  DIST NORMAL     .0220     .1631     .3041     .4452     .5863     .7273     .8684
TH/K  DIST NORMAL     .1130     .1669     .2207     .2746     .3285     .3823     .4362
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                          ROCK UNIT  TRJC

                 -3        -2        -1         0        +1        +2        +3

 K40  DIST NORMAL  104.5080  128.3387  152.1693  176.0000  199.8307  223.6613  247.4920
BI214 DIST NORMAL    5.9365    9.6244   13.3122   17.0000   20.6878   24.3756   28.0635
TL208 DIST NORMAL   28.4649   33.1766   37.8883   42.6000   47.3117   52.0234   56.7351
U/K   DIST NORMAL    -.0095     .0237     .0568     .0900     .1232     .1563     .1895
U/TH  DIST NORMAL     .1054     .1903     .2751     .3600     .4449     .5297     .6146
TH/K  DIST NORMAL     .1615     .1932     .2248     .2564     .2880     .3196     .3513
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                              ROCK UNIT  TRPU

                  -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  149,2443   164,8295   180,4148   196,0000   211,5852   227,1705   242,7557
 BI214  DIST NORMAL    5,3934     8,9289    12,4645    16,0000    19,5355    23,0711    26,6066
 TL208  DIST NORMAL   38,1196    40,7464    43,3732    46,0000    48,6268    51,2536    53,8804
 U/K    DIST NORMAL     ,0397      ,0538      ,0680      ,0821      ,0962      ,1104      ,1245
 U/TH   DIST NORMAL     ,1143      ,1829      ,2514      ,3200      ,3886      ,4571      ,5257
 TH/K   DIST NORMAL     ,1867      ,2041      ,2214      ,2387      ,2560      ,2733      ,2907
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                              ROCK UNIT  TU

                  -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   23,6166    80,4444   137,2722   194,1000   250,9278   307,7556   364,5834
 BI214  DIST NORMAL     ,4735     7,0157    13,5578    20,1000    26,6422    33,1843    39,7265
 TL208  DIST NORMAL    3,0859    20,7239    38,3620    56,0000    73,6380    91,2761   108,9141
 U/K    DIST   LOG      ,0306      ,0456      ,0680      ,1014      ,1512      ,2253      ,3358
 U/TH   DIST   LOG      ,1186      ,1666      ,2339      ,3285      ,4614      ,6479      ,9099
 TH/K   DIST   LOG      ,1720      ,2099      ,2562      ,3127      ,3816      ,4658      ,5685
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                              ROCK UNIT  TWDR

                  -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  136,0947   147,4965   158,8982   170,3000   181,7018   193,1035   204,5053
 BI214  DIST NORMAL    4,7824    10,9550    17,1275    23,3000    29,4725    35,6450    41,8176
 TL208  DIST NORMAL   35,4444    42,5296    49,6148    56,7000    63,7852    70,8704    77,9556
 U/K    DIST NORMAL     ,0248      ,0622      ,0996      ,1370      ,1744      ,2118      ,2492
 U/TH   DIST NORMAL     ,1575      ,2412      ,3248      ,4085      ,4922      ,5758      ,6595
 TH/K   DIST NORMAL     ,2031      ,2467      ,2903      ,3339      ,3775      ,4211      ,4647
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                                    ROCK UNIT  TWR

                         -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  122.2896   134.1597   146.0299   157.9000   169.7701   181.6403   193.5104
 BI214  DIST NORMAL     .2965     5.5310    10.7655    16.0000    21.2345    26.4690    31.7035
 TL208  DIST NORMAL   32.8978    41.1318    49.3659    57.6000    65.8341    74.0682    82.3022
 U/K    DIST NORMAL    -.0022      .0324      .0671      .1017      .1363      .1710      .2056
 U/TH   DIST NORMAL    -.0274      .0760      .1795      .2829      .3863      .4898      .5932
 TH/K   DIST NORMAL     .2602      .2948      .3295      .3641      .3987      .4334      .4680
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                                    ROCK UNIT   QG

                         -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  114.9722   128.4815   141.9907   155.5000   169.0093   182.5185   196.0278
 BI214  DIST NORMAL    8.3037    12.4024    16.5012    20.6000    24.6988    28.7976    32.8963
 TL208  DIST NORMAL   38.0523    42.6348    47.2174    51.8000    56.3826    60.9652    65.5477
 U/K    DIST NORMAL     .0652      .0876      .1099      .1323      .1547      .1770      .1994
 U/TH   DIST NORMAL     .1450      .2367      .3283      .4200      .5117      .6033      .6950
 TH/K   DIST NORMAL     .2138      .2525      .2913      .3300      .3687      .4075      .4462
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CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
JM	181	1) 1.501	50.0	K	.430	-.856	.288
		2) 1.071	35.7	U	.719	.580	.382
		3) .428	14.2	T	.893	-.055	-.446
JU	145	1) 1.852	61.7	K	.901	-.337	-.273
		2) .981	32.7	U	-.354	-.931	.090
		3) .168	5.6	T	.956	-.027	.291
KCV	328	1) 1.716	57.2	K	.680	.672	-.295
		2) .854	28.5	U	.703	-.634	-.322
		3) .431	14.4	T	.872	-.012	.490
KF	220	1) 1.491	49.7	K	.776	.337	.532
		2) .906	30.2	U	.495	-.866	.073
		3) .603	20.1	T	.802	.208	-.560
KI	1879	1) 1.757	58.6	K	.806	.262	-.530
		2) .717	23.9	U	.693	-.719	.055
		3) .526	17.5	T	.791	.363	.492
KLE	70	1) 1.642	54.7	K	.835	-.027	-.550
		2) .833	27.8	U	.703	-.613	.361
		3) .526	17.5	T	.671	.675	.306

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
KMB	101	1) 1.689	56.3	K	.912	.044	.407
		2) .983	32.8	U	.274	-.958	-.085
		3) .328	10.9	T	.884	.252	-.394
KMT	194	1) 1.669	55.6	K	.843	.453	-.291
		2) 1.114	37.1	U	.273	-.944	-.183
		3) .217	7.2	T	.940	-.131	.314
KMV	356	1) 1.383	46.1	K	.055	.998	-.035
		2) 1.000	33.3	U	.830	-.065	-.554
		3) .617	20.6	T	.832	-.001	.555
KN	212	1) 1.695	56.5	K	.894	-.057	-.444
		2) .929	31.0	U	-.524	-.830	-.191
		3) .375	12.5	T	.788	-.487	.377
KP	64	1) 2.088	69.6	K	.833	.482	.270
		2) .692	23.0	U	-.727	.671	-.145
		3) .221	7.4	T	-.930	-.093	.356
KPN	173	1) 1.460	48.6	K	.827	.252	.503
		2) 1.000	33.3	U	-.217	.968	-.130
		3) .541	18.0	T	.854	.002	-.520

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
KS	606	1) 1.630	54.3	K	.784	-.340	.520
		2) .807	26.9	U	.619	.785	.036
		3) .563	18.8	T	.795	-.276	-.540
KSN	500	1) 1.521	50.7	K	-.857	-.146	-.494
		2) .987	32.9	U	.201	-.979	.032
		3) .492	16.4	T	-.864	-.083	.497
KU	225	1) 1.419	47.3	K	.788	.338	.514
		2) .989	33.0	U	.313	-.935	.167
		3) .592	19.7	T	.836	.032	-.548
PCAN	2115	1) 2.523	84.0	K	.927	-.265	.265
		2) .318	10.6	U	.884	.465	.038
		3) .160	5.3	T	.938	-.177	-.297
PCGN	115	1) 1.876	62.5	K	.896	-.214	.389
		2) .831	27.7	U	.555	.831	-.038
		3) .293	9.8	T	.875	-.308	-.374
PCGR	4546	1) 2.259	75.3	K	.801	.598	.022
		2) .502	16.7	U	.904	-.241	-.354
		3) .239	7.9	T	.895	-.292	.337

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
PCNOR	101	1) 2.471	82.4	K	.913	-.242	.327
		2) .298	9.9	U	.916	-.196	-.350
		3) .230	7.7	T	.893	.449	.024
PCQD	47	1) 1.727	57.6	K	.970	.003	-.244
		2) 1.142	38.1	U	.620	.762	.188
		3) .131	4.4	T	.634	-.750	.190
PCS	628	1) 2.252	75.1	K	.730	.682	-.031
		2) .616	20.5	U	.939	-.219	.265
		3) .132	4.4	T	.914	-.321	-.247
PCU	2334	1) 2.017	67.2	K	.856	-.287	-.430
		2) .616	20.5	U	.855	-.295	.427
		3) .367	12.2	T	.744	.669	.004
PFS	229	1) 2.102	70.1	K	.879	-.275	-.389
		2) .599	20.0	U	.749	.663	.007
		3) .299	10.0	T	.876	-.290	.384
PG	120	1) 2.397	79.9	K	.941	-.072	.332
		2) .425	14.1	U	.854	.503	-.134
		3) .178	5.9	T	.885	-.409	-.223

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	 2	 3
PPC	1918	1) 2.301	76.7	K	.871	.423	.249
		2) .502	16.7	U	.818	-.560	.128
		3) .197	6.6	T	.934	.096	-.345
PTA	472	1) 2.069	69.0	K	.915	.300	-.270
		2) .779	26.0	U	.598	-.801	-.024
		3) .152	5.1	T	.935	.219	.280
Q	1129	1) 1.893	63.1	K	.784	.550	.290
		2) .842	28.2	U	.653	-.733	.190
		3) .265	8.8	T	.923	.052	-.381
QAL	4576	1) 1.738	57.9	K	.743	.560	.367
		2) .793	26.4	U	.679	-.690	.251
		3) .469	15.6	T	.852	.062	-.521
QF	182	1) 2.436	81.2	K	.880	-.453	-.142
		2) .348	11.6	U	.896	.372	-.243
		3) .216	7.2	T	.926	.071	.370
QMC	2228	1) 1.777	59.2	K	.721	.625	.299
		2) .760	25.3	U	.729	-.608	.316
		3) .463	15.4	T	.852	-.009	-.523

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
QS	34	1) 1.410	47.0	K	.551	-.759	.348
		2) .983	32.8	U	.645	.638	.420
		3) .607	20.2	T	.831	.007	-.556
QSW	48	1) 2.408	80.3	K	.948	.151	-.280
		2) .455	15.1	U	.828	-.557	.068
		3) .136	4.5	T	.908	.350	.230
QT	3621	1) 1.796	59.9	K	.758	.544	-.361
		2) .741	24.7	U	.708	-.664	-.242
		3) .463	15.4	T	.849	.068	.524
QTU	33	1) 1.609	53.6	K	.016	.982	.190
		2) 1.102	36.7	U	-.894	.273	-.354
		3) .288	9.6	T	-.900	-.254	.356
TA	8396	1) 1.624	54.1	K	.399	.916	.045
		2) .935	31.1	U	.847	-.261	.463
		3) .441	14.7	T	.864	-.167	-.474
TB	7753	1) 1.616	53.9	K	.508	-.844	.171
		2) .916	30.5	U	.784	.440	.437
		3) .468	15.6	T	.862	.097	-.498

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	PRINCIPAL COMPONENT 2	PRINCIPAL COMPONENT 3
TC	3183	1) 1.541	51.4	K	.480	-.861	-.169
		2) .931	31.0	U	.775	.423	-.470
		3) .529	17.6	T	.843	.101	.528
TH	505	1) 2.019	67.3	K	.834	-.311	-.455
		2) .549	18.3	U	.787	.616	-.022
		3) .432	14.4	T	.838	-.270	.474
TNP	1215	1) 1.516	50.5	K	.630	.690	-.357
		2) .986	32.9	U	.610	-.714	-.344
		3) .498	16.6	T	.864	.001	.503
TO	15372	1) 1.423	47.4	K	.251	.929	.273
		2) 1.064	35.5	U	.781	-.433	.450
		3) .513	17.0	T	.866	.121	-.485
TRC	741	1) 1.881	62.7	K	.860	-.339	.381
		2) .807	26.9	U	.589	.806	.056
		3) .312	10.4	T	.891	-.206	-.405
TU	13053	1) 2.008	66.9	K	.868	.395	-.299
		2) .781	26.0	U	.626	-.775	-.086
		3) .211	7.0	T	.929	.153	.338

CHEYENNE

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
TWDR	253	1) 1.687	56.2	K	.315	.949	-.031
		2) .959	32.0	U	.885	-.204	-.418
		3) .355	11.8	T	.896	-.132	.423
TWR	96	1) 1.791	59.7	K	.943	-.065	.327
		2) .994	33.1	U	.112	.994	.004
		3) .214	7.1	T	.943	-.053	-.327
QG	94	1) 1.615	53.8	K	-.870	.347	.349
		2) 1.095	36.5	U	-.915	-.179	-.362
		3) .290	9.7	T	.143	.971	-.192

APPENDIX F

STATISTICAL TABLES AND PRINCIPAL COMPONENT RESULTS

GREELEY QUADRANGLE

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@ADD,P GREELY.DISTFILE
                                 ROCK UNIT   KC

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST  LOG      35.3310   52.7996   78.9057  117.9192  176.2223  263.3522  393.5620
 BI214  DIST  LOG       9.1510   13.5435   20.0445   29.6660   43.9058   64.9808   96.1719
 TL208  DIST  LOG      16.6662   24.8350   37.0077   55.1469   82.1768  122.4554  182.4763
 U/K    DIST  LOG        .0687     .1059     .1632     .2516     .3878     .5978     .9216
 U/TH   DIST  LOG        .1278     .2014     .3174     .5001     .7879    1.2415    1.9561
 TH/K   DIST  LOG        .1800     .2378     .3140     .4148     .5478     .7236     .9556
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                                 ROCK UNIT   KF

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST NORMAL   157.1267  171.2511  185.3756  199.5000  213.6244  227.7489  241.8733
 BI214  DIST NORMAL    10.5619   15.6413   20.7206   25.8000   30.8794   35.9587   41.0381
 TL208  DIST NORMAL    38.6857   46.5838   54.4819   62.3800   70.2781   78.1762   86.0743
 U/K    DIST NORMAL    -.9545    -.5927    -.2309     .1309     .4927     .8545    1.2163
 U/TH   DIST NORMAL   -1.4472    -.8432    -.2392     .3648     .9688    1.5728    2.1768
 TH/K   DIST NORMAL   -1.3934    -.8189    -.2445     .3300     .9045    1.4789    2.0534
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                                 ROCK UNIT  KJDS

                          -3        -2        -1         0        +1        +2        +3

  K40   DIST  LOG      20.5472   32.0881   50.1111   78.2571  122.2121  190.8553  298.0536
 BI214  DIST  LOG       6.2221    9.1651   13.5002   19.8857   29.2915   43.1463   63.5543
 TL208  DIST  LOG      13.4497   19.4135   28.0219   40.4473   58.3824   84.2703  121.6375
 U/K    DIST NORMAL   -1.3036    -.7764    -.2493     .2779     .8051    1.3322    1.8594
 U/TH   DIST NORMAL   -1.6425    -.9219    -.2014     .5192    1.2398    1.9603    2.6809
 TH/K   DIST NORMAL   -1.6741    -.9330    -.1918     .5493    1.2904    2.0316    2.7727
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                                     ROCK UNIT   KL

                           -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   166.5259   181.0172   195.5086   210.0000   224.4914   238.9828   253.4741
 BI214  DIST NORMAL     9.6508    14.6005    19.5503    24.5000    29.4497    34.3995    39.3492
 TL208  DIST NORMAL    39.1882    47.1255    55.0627    63.0000    70.9373    78.8745    86.8118
 U/K    DIST NORMAL     -.9085     -.5667     -.2250      .1168      .4586      .8003     1.1421
 U/TH   DIST NORMAL    -1.4614     -.8494     -.2375      .3745      .9865     1.5984     2.2104
 TH/K   DIST NORMAL    -1.3432     -.7954     -.2477      .3000      .8477     1.3954     1.9432
-----------------------------------------------------------------------------------------------------

                                     ROCK UNIT  KLF

                           -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   160.7935   175.0623   189.3312   203.6000   217.8688   232.1377   246.4065
 BI214  DIST NORMAL    14.0048    19.5365    25.0683    30.6000    36.1317    41.6635    47.1952
 TL208  DIST NORMAL    87.1366    98.0911   109.0455   120.0000   130.9545   141.9089   152.8634
 U/K    DIST NORMAL    -1.0170     -.6274     -.2378      .1518      .5414      .9310     1.3206
 U/TH   DIST NORMAL    -1.2743     -.7621     -.2498      .2624      .7746     1.2869     1.7991
 TH/K   DIST NORMAL    -1.7075     -.9441     -.1806      .5829     1.3464     2.1099     2.8733
-----------------------------------------------------------------------------------------------------

                                     ROCK UNIT  KMW
                           -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   167.6018   182.1346   196.6673   211.2000   225.7327   240.2654   254.7982
 BI214  DIST NORMAL    12.8445    18.2297    23.6148    29.0000    34.3852    39.7703    45.1555
 TL208  DIST NORMAL    40.8132    48.8755    56.9377    65.0000    73.0623    81.1245    89.1868
 U/K    DIST NORMAL     -.9912     -.6131     -.2351      .1429      .5209      .8989     1.2770
 U/TH   DIST NORMAL    -1.5655     -.8929     -.2202      .4525     1.1252     1.7979     2.4705
 TH/K   DIST NORMAL    -1.3747     -.8103     -.2458      .3186      .8830     1.4475     2.0119
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                                ROCK UNIT   KP

                         -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  155.9649    170.0433    184.1216    198.2000    212.2784    226.3567    240.4351
 BI214  DIST NORMAL   12.0539     17.3359     22.6180     27.9000     33.1820     38.4641     43.7461
 TL208  DIST NORMAL   42.8525     51.0683     59.2842     67.5000     75.7158     83.9317     92.1475
 U/K    DIST NORMAL    -.9985      -.6172      -.2359       .1454       .5267       .9080      1.2893
 U/TH   DIST  LOG       .1587       .2178       .2991       .4107       .5638       .7742      1.0630
 TH/K   DIST NORMAL   -1.4093      -.8262      -.2431       .3400       .9231      1.5062      2.0893
---------------------------------------------------------------------------------------------------------

                                ROCK UNIT  KPL

                         -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  122.9343    135.6228    148.3114    161.0000    173.6886    186.3772    199.0657
 BI214  DIST NORMAL   15.7663     21.5109     27.2554     33.0000     38.7446     44.4891     50.2337
 TL208  DIST NORMAL   34.3505     41.9003     49.4502     57.0000     64.5498     72.0997     79.6495
 U/K    DIST  LOG       .0348       .0566       .0920       .1496       .2432       .3953       .6428
 U/TH   DIST  LOG       .1118       .1778       .2826       .4493       .7143      1.1356      1.8053
 TH/K   DIST  LOG       .1375       .1834       .2447       .3263       .4351       .5803       .7740
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                                ROCK UNIT  KPM

                         -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  126.0227    138.8485    151.6742    164.5000    177.3258    190.1515    202.9773
 BI214  DIST NORMAL   10.2805     15.3203     20.3602     25.4000     30.4398     35.4797     40.5195
 TL208  DIST NORMAL   41.4648     49.5766     57.6883     65.8000     73.9117     82.0234     90.1352
 U/K    DIST NORMAL   -1.0272      -.6330      -.2388       .1554       .5496       .9438      1.3380
 U/TH   DIST NORMAL   -1.4804      -.8577      -.2349       .3878      1.0105      1.6333      2.2560
 TH/K   DIST NORMAL   -1.4835      -.8590      -.2345       .3900      1.0145      1.6390      2.2635
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                              ROCK UNIT  KPU

                   -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  149.0043   162.8029   176.6014   190.4000   204.1985   217.9971   231.7957
 BI214 DIST NORMAL   10.3507    15.4005    20.4502    25.5000    30.5498    35.5995    40.6493
 TL208 DIST NORMAL   38.7019    46.6013    54.5006    62.4000    70.2994    78.1987    86.0981
 U/K   DIST NORMAL   -1.0003     -.6182     -.2361      .1460      .5281      .9102     1.2923
 U/TH  DIST NORMAL   -1.4409     -.8404     -.2399      .3606      .9611     1.5616     2.1621
 TH/K  DIST NORMAL   -1.5154     -.8725     -.2296      .4133     1.0562     1.6991     2.3420
-------------------------------------------------------------------------------------------------

                              ROCK UNIT   MZ

                   -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  108.4376   120.4584   132.4792   144.5000   156.5208   168.5416   180.5624
 BI214 DIST NORMAL    7.2523    11.8348    16.4174    21.0000    25.5826    30.1652    34.7477
 TL208 DIST NORMAL   13.5683    19.0455    24.5228    30.0000    35.4772    40.9545    46.4317
 U/K   DIST NORMAL    -.9517     -.5911     -.2306      .1300      .4906      .8511     1.2117
 U/TH  DIST NORMAL   -1.6433     -.9222     -.2011      .5200     1.2411     1.9622     2.6833
 TH/K  DIST NORMAL   -1.3255     -.7870     -.2485      .2900      .8285     1.3670     1.9055
-------------------------------------------------------------------------------------------------

                              ROCK UNIT  PPCF

                   -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  200.6655   216.4103   232.1552   247.9000   263.6448   279.3897   295.1345
 BI214 DIST NORMAL    6.2524    10.6682    15.0841    19.5000    23.9159    28.3318    32.7476
 TL208 DIST NORMAL   33.9501    41.4667    48.9834    56.5000    64.0166    71.5333    79.0499
 U/K   DIST NORMAL    -.8120     -.5112     -.2103      .0905      .3913      .6922      .9930
 U/TH  DIST NORMAL   -1.4979     -.8651     -.2324      .4004     1.0332     1.6659     2.2987
 TH/K  DIST NORMAL   -1.2087     -.7292     -.2496      .2300      .7096     1.1892     1.6687
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                                    ROCK UNIT  PPF

                         -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  213.2593   229.4395   245.6198   261.8000   277.9802   294.1605   310.3407
 BI214  DIST NORMAL   12.4844    17.8229    23.1615    28.5000    33.8385    39.1771    44.5156
 TL208  DIST NORMAL   70.2550    80.2700    90.2850   100.3000   110.3150   120.3300   130.3450
 U/K    DIST NORMAL    -.9088     -.5669     -.2250      .1169      .4588      .8007     1.1426
 U/TH   DIST NORMAL   -1.3432     -.7954     -.2477      .3000      .8477     1.3954     1.9432
 TH/K   DIST NORMAL   -1.4716     -.8539     -.2361      .3816      .9993     1.6171     2.2348
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                                    ROCK UNIT  PPIF

                         -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   36.7621    44.5081    52.2540    60.0000    67.7460    75.4919    83.2379
 BI214  DIST NORMAL    5.7596    10.0897    14.4199    18.7500    23.0801    27.4103    31.7404
 TL208  DIST NORMAL    9.1367    14.0112    18.8856    23.7600    28.6344    33.5088    38.3833
 U/K    DIST NORMAL   -1.0389     -.6394     -.2399      .1596      .5591      .9586     1.3581
 U/TH   DIST NORMAL   -1.5747     -.8965     -.2182      .4600     1.1382     1.8165     2.4947
 TH/K   DIST NORMAL   -1.4004     -.8221     -.2439      .3344      .9127     1.4909     2.0692
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                                    ROCK UNIT   QA

                         -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  182.7010   197.8007   212.9003   228.0000   243.0997   258.1993   273.2990
 BI214  DIST NORMAL   12.4844    17.8229    23.1615    28.5000    33.8385    39.1771    44.5156
 TL208  DIST NORMAL   59.5215    68.8810    78.2405    87.6000    96.9595   106.3190   115.6785
 U/K    DIST NORMAL    -.9731     -.6031     -.2331      .1369      .5069      .8769     1.2469
 U/TH   DIST NORMAL   -1.4093     -.8262     -.2431      .3400      .9231     1.5062     2.0893
 TH/K   DIST NORMAL   -1.4835     -.8590     -.2345      .3900     1.0145     1.6390     2.2635
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                                    ROCK UNIT   QD

                      -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  155.7863    169.8575    183.9288    198.0000    212.0712    226.1425    240.2137
 BI214  DIST NORMAL   14.8092     20.4394     26.0697     31.7000     37.3303     42.9606     48.5908
 TL208  DIST NORMAL   54.0000     63.0000     72.0000     81.0000     90.0000     99.0000    108.0000
 U/K    DIST NORMAL   -1.0383      -.6391      -.2398       .1594       .5586       .9579      1.3571
 U/TH   DIST NORMAL   -1.4919      -.8626      -.2333       .3960      1.0253      1.6546      2.2839
 TH/K   DIST NORMAL   -1.5500      -.8866      -.2233       .4400      1.1033      1.7666      2.4300
------------------------------------------------------------------------------------------------------

                                    ROCK UNIT   QDO

                      -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  150.4308    164.2872    178.1436    192.0000    205.8564    219.7128    233.5692
 BI214  DIST NORMAL   11.4115     16.6077     21.8038     27.0000     32.1962     37.3923     42.5885
 TL208  DIST NORMAL   39.1882     47.1255     55.0627     63.0000     70.9373     78.8745     86.8118
 U/K    DIST NORMAL   -1.0400      -.6400      -.2400       .1600       .5600       .9600      1.3600
 U/TH   DIST NORMAL   -1.5500      -.8866      -.2233       .4400      1.1033      1.7666      2.4300
 TH/K   DIST NORMAL   -1.3771      -.8114      -.2457       .3200       .8857      1.4514      2.0171
------------------------------------------------------------------------------------------------------

                                    ROCK UNIT    QE

                      -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL  169.2164    183.8110    198.4055    213.0000    227.5945    242.1890    256.7836
 BI214  DIST NORMAL    6.2524     10.6682     15.0841     19.5000     23.9159     28.3318     32.7476
 TL208  DIST NORMAL   36.7621     44.5081     52.2540     60.0000     67.7460     75.4919     83.2379
 U/K    DIST NORMAL    -.7685      -.4857      -.2028       .0800       .3628       .6457       .9285
 U/TH   DIST NORMAL   -1.3771      -.8114      -.2457       .3200       .8857      1.4514      2.0171
 TH/K   DIST NORMAL   -1.1871      -.7181      -.2490       .2200       .6890      1.1581      1.6271
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                                   ROCK UNIT    QG

                          -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  183,4216   198,5477   213,6739   228,8000   243,9261   259,0523   274,1784
 BI214  DIST NORMAL   11,5539    16,7693    21,9846    27,2000    32,4154    37,6307    42,8461
 TL208  DIST NORMAL   38,6209    46,5139    54,4070    62,3000    70,1930    78,0861    85,9791
 U/K    DIST NORMAL    -,9291     -,5784     -,2277      ,1230      ,4737      ,8244     1,1751
 U/TH   DIST NORMAL   -1,4093     -,8262     -,2431      ,3400      ,9231     1,5062     2,0893
 TH/K   DIST NORMAL   -1,4093     -,8262     -,2431      ,3400      ,9231     1,5062     2,0893
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                                   ROCK UNIT   QGO

                          -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  171,9990   186,6993   201,3997   216,1000   230,8003   245,5007   260,2010
 BI214  DIST NORMAL    9,2337    14,1225    19,0112    23,9000    28,7888    33,6775    38,5663
 TL208  DIST NORMAL   41,3019    49,4012    57,5006    65,6000    73,6994    81,7988    89,8981
 U/K    DIST NORMAL    -,8989     -,5613     -,2236      ,1140      ,4516      ,7893     1,1269
 U/TH   DIST NORMAL   -1,4564     -,8473     -,2381      ,3711      ,9803     1,5895     2,1986
 TH/K   DIST NORMAL   -1,3255     -,7870     -,2485      ,2900      ,8285     1,3670     1,9055
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                                   ROCK UNIT    QL

                          -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL   44,4900    52,8267    61,1633    69,5000    77,8367    86,1733    94,5100
 BI214  DIST NORMAL    8,8879    13,7253    18,5626    23,4000    28,2374    33,0747    37,9121
 TL208  DIST NORMAL   30,4459    37,6639    44,8820    52,1000    59,3180    66,5361    73,7541
 U/K    DIST NORMAL    -,9517     -,5911     -,2306      ,1300      ,4906      ,8511     1,2117
 U/TH   DIST NORMAL   -1,5853     -,9006     -,2159      ,4688     1,1535     1,8382     2,5229
 TH/K   DIST NORMAL   -1,3432     -,7954     -,2477      ,3000      ,8477     1,3954     1,9432
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                         ROCK UNIT   TAF

                   -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  236.4502   253.4002   270.3501   287.3000   304.2499   321.1998   338.1498
 BI214 DIST NORMAL   21.7906    28.1938    34.5969    41.0000    47.4031    53.8062    60.2094
 TL208 DIST NORMAL   74.1738    84.4159    94.6579   104.9000   115.1421   125.3841   135.6262
 U/K   DIST NORMAL    -.9873     -.6110     -.2347      .1416      .5179      .8942     1.2705
 U/TH  DIST NORMAL   -1.4906     -.8620     -.2335      .3951     1.0237     1.6522     2.2808
 TH/K  DIST NORMAL   -1.4460     -.8426     -.2393      .3640      .9673     1.5706     2.1740
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                         ROCK UNIT   TBB

                   -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  165.6295   180.0863   194.5432   209.0000   223.4568   237.9137   252.3705
 BI214 DIST NORMAL   12.4844    17.8229    23.1615    28.5000    33.8385    39.1771    44.5156
 TL208 DIST NORMAL   43.3432    51.5955    59.8477    68.1000    76.3523    84.6045    92.8568
 U/K   DIST NORMAL   -1.0281     -.6335     -.2389      .1557      .5503      .9449     1.3395
 U/TH  DIST NORMAL   -1.5753     -.8967     -.2181      .4605     1.1391     1.8177     2.4963
 TH/K  DIST NORMAL   -1.3966     -.8204     -.2442      .3320      .9082     1.4844     2.0606
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                         ROCK UNIT   TBR

                   -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  205.2821   221.1881   237.0940   253.0000   268.9060   284.8119   300.7179
 BI214 DIST NORMAL   17.6254    23.5836    29.5418    35.5000    41.4582    47.4164    53.3746
 TL208 DIST NORMAL   67.7926    77.6617    87.5309    97.4000   107.2691   117.1383   127.0074
 U/K   DIST NORMAL    -.9517     -.5911     -.2306      .1300      .4906      .8511     1.2117
 U/TH  DIST NORMAL   -1.4093     -.8262     -.2431      .3400      .9231     1.5062     2.0893
 TH/K  DIST NORMAL   -1.4548     -.8466     -.2383      .3700      .9783     1.5866     2.1948
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                                   ROCK UNIT   TC

                       -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  103,1942   114,9628   126,7314   138,5000   150,2686   162,0372   173,8058
 BI214  DIST NORMAL    8,2698    13,0132    17,7566    22,5000    27,2434    31,9868    36,7302
 TL208  DIST NORMAL   25,1084    31,8389    38,5695    45,3000    52,0305    58,7611    65,4916
 U/K    DIST NORMAL   -1,0574     -,6494     -,2415      ,1664      ,5743      ,9822     1,3902
 U/TH   DIST NORMAL   -1,6516     -,9252     -,1987      ,5277     1,2541     1,9806     2,7070
 TH/K   DIST NORMAL   -1,3955     -,8199     -,2443      ,3313      ,9069     1,4825     2,0581
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                                   ROCK UNIT   TGV

                       -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  137,9750   151,3167   164,6583   178,0000   191,3417   204,6833   218,0250
 BI214  DIST NORMAL   14,2237    19,7824    25,3412    30,9000    36,4588    42,0176    47,5763
 TL208  DIST NORMAL   65,0830    74,7887    84,4943    94,2000   103,9057   113,6113   123,3170
 U/K    DIST NORMAL    -,9768     -,6051     -,2335      ,1381      ,5097      ,8813     1,2530
 U/TH   DIST NORMAL   -1,4245     -,8331     -,2416      ,3498      ,9412     1,5327     2,1241
 TH/K   DIST NORMAL   -1,3603     -,8036     -,2468      ,3100      ,8668     1,4236     1,9803
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                                   ROCK UNIT   TKD

                       -3         -2         -1          0         +1         +2         +3

  K40   DIST NORMAL  163,8375   178,2250   192,6125   207,0000   221,3875   235,7750   250,1625
 BI214  DIST NORMAL   11,2694    16,4463    21,6231    26,8000    31,9769    37,1537    42,3306
 TL208  DIST NORMAL   56.5045    65,6697    74,8348    84,0000    93,1652   102,3303   111,4955
 U/K    DIST NORMAL    -,8487     -,5325     -,2162      ,1000      ,4162      ,7325     1,0487
 U/TH   DIST NORMAL   -1,3432     -,7954     -,2477      ,3000      ,8477     1,3954     1,9432
 TH/K   DIST NORMAL   -1,3075     -,7783     -,2492      ,2800      ,8092     1,3383     1,8675
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                                 ROCK UNIT   TKDA

                      -3          -2          -1           0          +1          +2          +3

 K40   DIST NORMAL  139.7508    153.1672    166.5836    180.0000    193.4164    206.8328    220.2492
BI214  DIST NORMAL   13.7864     19.2909     24.7955     30.3000     35.8045     41.3091     46.8136
TL208  DIST NORMAL   74.0031     84.2354     94.4677    104.7000    114.9323    125.1646    135.3969
U/K    DIST NORMAL   -1.0517      -.6464      -.2410       .1643       .5696       .9750      1.3803
U/TH   DIST NORMAL   -1.3250      -.7868      -.2435       .2897       .8279      1.3662      1.9044
TH/K   DIST NORMAL   -1.7047      -.9432      -.1816       .5800      1.3416      2.1032      2.8647
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                                 ROCK UNIT   TKI

                      -3          -2          -1           0          +1          +2          +3

 K40   DIST NORMAL  253.5214    271.0143    288.5071    306.0000    323.4929    340.9857    358.4786
BI214  DIST NORMAL   30.7629     38.0086     45.2543     52.5000     59.7457     66.9914     74.2371
TL208  DIST NORMAL   74.2591     84.5061     94.7530    105.0000    115.2470    125.4939    135.7409
U/K    DIST NORMAL    -.9395      -.5843      -.2290       .1262       .4814       .8367      1.1919
U/TH   DIST NORMAL   -1.3576      -.8024      -.2469       .3085       .8639      1.4194      1.9748
TH/K   DIST NORMAL   -1.5109      -.8706      -.2303       .4100      1.0503      1.6906      2.3309
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                                 ROCK UNIT   TM

                      -3          -2          -1           0          +1          +2          +3

 K40   DIST NORMAL  145.0855    158.7236    172.3618    186.0000    199.6382    213.2764    226.9145
BI214  DIST NORMAL   12.5563     17.9042     23.2521     28.6000     33.9479     39.2958     44.6437
TL208  DIST NORMAL   51.1727     59.9818     68.7909     77.6000     86.4091     95.2182    104.0273
U/K    DIST NORMAL   -1.0247      -.6316      -.2386       .1545       .5476       .9406      1.3337
U/TH   DIST NORMAL   -1.4757      -.8557      -.2356       .3845      1.0046      1.6247      2.2447
TH/K   DIST NORMAL   -1.5242      -.8761      -.2281       .4200      1.0681      1.7161      2.3642
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                                    ROCK UNIT   TMI

                          -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL    196.9577    212.5718    228.1859    243.8000    259.4141    275.0282    290.6423
 BI214  DIST NORMAL     13.5683     19.0455     24.5228     30.0000     35.4772     40.9545     46.4317
 TL208  DIST NORMAL     41.1389     49.2259     57.3130     65.4000     73.4870     81.5741     89.6611
 U/K    DIST NORMAL     -.9517      -.5911      -.2306       .1300       .4906       .8511      1.2117
 U/TH   DIST NORMAL    -1.4400      -.8400      -.2400       .3600       .9600      1.5600      2.1600
 TH/K   DIST NORMAL    -1.3432      -.7954      -.2477       .3000       .8477      1.3954      1.9432
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                                    ROCK UNIT   TNP

                          -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL    192.4405    207.8937    223.3468    238.8000    254.2532    269.7063    285.1595
 BI214  DIST NORMAL     11.8393     17.0929     22.3464     27.6000     32.8536     38.1071     43.3607
 TL208  DIST NORMAL     55.7522     64.8682     73.9841     83.1000     92.2159    101.3318    110.4478
 U/K    DIST NORMAL     -.9166      -.5713      -.2261       .1192       .4645       .8097      1.1550
 U/TH   DIST NORMAL    -1.4088      -.8260      -.2431       .3397       .9225      1.5054      2.0882
 TH/K   DIST NORMAL    -1.4277      -.8345      -.2413       .3519       .9451      1.5383      2.1315
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                                    ROCK UNIT    TO

                          -3          -2          -1           0          +1          +2          +3

  K40   DIST NORMAL    177.3010    192.2007    207.1003    222.0000    236.8997    251.7993    266.6990
 BI214  DIST  LOG        8.8383     12.2975     17.1106     23.8075     33.1255     46.0904     64.1298
 TL208  DIST NORMAL     47.2031     55.7354     64.2677     72.8000     81.3323     89.8646     98.3969
 U/K    DIST  LOG         .0374       .0545       .0793       .1153       .1678       .2442       .3553
 U/TH   DIST  LOG         .1319       .1796       .2445       .3329       .4532       .6170       .8400
 TH/K   DIST  LOG         .1959       .2369       .2865       .3465       .4190       .5066       .6126
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                              ROCK UNIT TRPLF

                 -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  220.8867  237.3245  253.7622  270.2000  286.6378  303.0755  319.5133
 BI214 DIST NORMAL    8.6125   13.4083   18.2042   23.0000   27.7958   32.5917   37.3875
 TL208 DIST NORMAL   48.6886   57.3257   65.9629   74.6000   83.2371   91.8743  100.5114
 U/K   DIST NORMAL    -.8076    -.5086    -.2096     .0894     .3884     .6874     .9864
 U/TH  DIST NORMAL   -1.3649    -.8057    -.2465     .3127     .8719    1.4311    1.9903
 TH/K  DIST NORMAL   -1.3071    -.7781    -.2492     .2798     .8088    1.3377    1.8667
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                              ROCK UNIT TRPIL

                 -3        -2        -1         0        +1        +2        +3

  K40  DIST  LOG     11.3295   19.0729   32.1090   54.0549   91.0005  153.1977  257.9057
 BI214 DIST  LOG      2.9106    5.0141    8.6376   14.8797   25.6329   44.1569   76.0678
 TL208 DIST  LOG      6.1313   10.4048   17.6570   29.9641   50.8493   86.2917  146.4377
 U/K   DIST NORMAL   -1.2187    -.7342    -.2498     .2347     .7192    1.2036    1.6881
 U/TH  DIST NORMAL   -1.5653    -.8928    -.2202     .4523    1.1248    1.7974    2.4699
 TH/K  DIST NORMAL   -1.6213    -.9142    -.2071     .5000    1.2071    1.9142    2.6213
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                              ROCK UNIT TRPJS

                 -3        -2        -1         0        +1        +2        +3

  K40  DIST NORMAL  108.0000  120.0000  132.0000  144.0000  156.0000  168.0000  180.0000
 BI214 DIST NORMAL    8.4752   13.2501   18.0251   22.8000   27.5749   32.3499   37.1248
 TL208 DIST NORMAL   23.4820   30.0547   36.6273   43.2000   49.7727   56.3453   62.9180
 U/K   DIST NORMAL   -1.0600    -.6509    -.2417     .1674     .5765     .9857    1.3948
 U/TH  DIST NORMAL   -1.6433    -.9222    -.2011     .5200    1.2411    1.9622    2.6833
 TH/K  DIST NORMAL   -1.3432    -.7954    -.2477     .3000     .8477    1.3954    1.9432
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                                    ROCK UNIT   TRPR

                        -3         -2         -1          0         +1         +2         +3

   K40  DIST NORMAL  114.6622   126.9748   139.2874   151.6000   163.9126   176.2252   188.5378
 BI214  DIST NORMAL    6.1205    10.5136    14.9068    19.3000    23.6932    28.0864    32.4795
 TL208  DIST NORMAL   22.2506    28.7004    35.1502    41.6000    48.0498    54.4996    60.9494
 U/K    DIST NORMAL    -.9639     -.5979     -.2320      .1339      .4998      .8657     1.2317
 U/TH   DIST NORMAL   -1.5747     -.8965     -.2182      .4600     1.1382     1.8165     2.4947
 TH/K   DIST NORMAL   -1.2697     -.7598     -.2499      .2600      .7699     1.2798     1.7897
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                                    ROCK UNIT    TT

                        -3         -2         -1          0         +1         +2         +3

   K40  DIST NORMAL  170.1138   184.7425   199.3713   214.0000   228.6287   243.2575   257.8862
 BI214  DIST NORMAL   20.2650    26.5100    32.7550    39.0000    45.2450    51.4900    57.7350
 TL208  DIST NORMAL   55.4181    64.5121    73.6060    82.7000    91.7940   100.8879   109.9819
 U/K    DIST NORMAL   -1.1341     -.6904     -.2468      .1968      .6404     1.0840     1.5277
 U/TH   DIST NORMAL   -1.5985     -.9056     -.2128      .4800     1.1728     1.8656     2.5585
 TH/K   DIST NORMAL   -1.4693     -.8529     -.2364      .3800      .9964     1.6129     2.2293
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                                    ROCK UNIT    TV

                        -3         -2         -1          0         +1         +2         +3

   K40  DIST NORMAL  139.7508   153.1672   166.5836   180.0000   193.4164   206.8328   220.2492
 BI214  DIST NORMAL   14.2967    19.8645    25.4322    31.0000    36.5678    42.1355    47.7033
 TL208  DIST NORMAL   49.0192    57.6795    66.3397    75.0000    83.6603    92.3205   100.9808
 U/K    DIST NORMAL    -.9965     -.6161     -.2357      .1447      .5251      .9055     1.2859
 U/TH   DIST NORMAL   -1.4693     -.8529     -.2364      .3800      .9964     1.6129     2.2293
 TH/K   DIST NORMAL   -1.4498     -.8444     -.2389      .3666      .9721     1.5776     2.1830
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                              ROCK UNIT  TWR

                      -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  171.9092   186.6061   201.3031   216.0000   230.6969   245.3939   260.0908
BI214  DIST NORMAL   12.7003    18.0669    23.4334    28.8000    34.1666    39.5331    44.8997
TL208  DIST NORMAL   48.3582    56.9721    65.5861    74.2000    82.8139    91.4279   100.0418
U/K    DIST NORMAL    -.9573     -.5943     -.2312      .1318      .4948      .8579     1.2209
U/TH   DIST NORMAL   -1.4693     -.8529     -.2364      .3800      .9964     1.6129     2.2293
TH/K   DIST NORMAL   -1.4248     -.8332     -.2416      .3500      .9416     1.5332     2.1248
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                              ROCK UNIT   XB

                      -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  166.5259   181.0172   195.5086   210.0000   224.4914   238.9828   253.4741
BI214  DIST NORMAL   13.5683    19.0455    24.5228    30.0000    35.4772    40.9545    46.4317
TL208  DIST  LOG     17.7333    28.1335    44.6333    70.8100   112.3388   178.2235   282.7485
U/K    DIST NORMAL   -1.0076     -.6222     -.2369      .1485      .5339      .9192     1.3046
U/TH   DIST NORMAL   -1.5572     -.8896     -.2219      .4458     1.1135     1.7812     2.4488
TH/K   DIST NORMAL   -1.4542     -.8463     -.2383      .3696      .9775     1.5855     2.1934
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                              ROCK UNIT  XFH

                      -3         -2         -1          0         +1         +2         +3

 K40   DIST NORMAL  151.0551   164.9367   178.8184   192.7000   206.5816   220.4633   234.3449
BI214  DIST NORMAL   11.6252    16.8501    22.0751    27.3000    32.5249    37.7499    42.9748
TL208  DIST NORMAL   34.1903    41.7268    49.2634    56.8000    64.3366    71.8732    79.4097
U/K    DIST NORMAL    -.9977     -.6167     -.2358      .1451      .5260      .9069     1.2879
U/TH   DIST NORMAL   -1.6521     -.9253     -.1986      .5282     1.2550     1.9817     2.7085
TH/K   DIST NORMAL   -1.3248     -.7867     -.2485      .2896      .8277     1.3659     1.9040
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                                        ROCK UNIT    XG

                              -3          -2          -1           0          +1          +2          +3

   K40   DIST NORMAL     180.0000    195.0000    210.0000    225.0000    240.0000    255.0000    270.0000
  BI214  DIST NORMAL      11.4115     16.6077     21.8038     27.0000     32.1962     37.3923     42.5885
  TL208  DIST NORMAL      41.6279     49.7519     57.8760     66.0000     74.1240     82.2481     90.3721
  U/K    DIST NORMAL      -.9551      -.5931      -.2310       .1311       .4932       .8553      1.2173
  U/TH   DIST NORMAL     -1.4974      -.8649      -.2325       .4000      1.0325      1.6649      2.2974
  TH/K   DIST NORMAL     -1.3075      -.7783      -.2492       .2800       .8092      1.3383      1.8675
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                                        ROCK UNIT    YG

                              -3          -2          -1           0          +1          +2          +3

   K40   DIST NORMAL     252.9729    270.4486    287.9243    305.4000    322.8757    340.3514    357.8271
  BI214  DIST NORMAL      26.7457     33.6305     40.5152     47.4000     54.2848     61.1695     68.0543
  TL208  DIST NORMAL      60.7822     70.2214     79.6607     89.1000     98.5393    107.9786    117.4178
  U/K    DIST NORMAL     -1.0306      -.6349      -.2391       .1566       .5523       .9481      1.3438
  U/TH   DIST NORMAL     -1.4001      -.8220      -.2439       .3342       .9123      1.4904      2.0685
  TH/K   DIST NORMAL     -1.6272      -.9164      -.2055       .5053      1.2161      1.9270      2.6378
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                                        ROCK UNIT KTRDC

                              -3          -2          -1           0          +1          +2          +3

   K40   DIST NORMAL     113.2577    125.5051    137.7526    150.0000    162.2474    174.4949    186.7423
  BI214  DIST NORMAL      17.2518     23.1678     29.0839     35.0000     40.9161     46.8322     52.7482
  TL208  DIST NORMAL      44.0801     52.3868     60.6934     69.0000     77.3066     85.6132     93.9199
  U/K    DIST NORMAL     -1.2241      -.7370      -.2498       .2373       .7244      1.2116      1.6987
  U/TH   DIST NORMAL     -1.5747      -.8965      -.2182       .4600      1.1382      1.8165      2.4947
  TH/K   DIST NORMAL     -1.7047      -.9432      -.1816       .5800      1.3416      2.1032      2.8647
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GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
KC	1368	1) 1.816	60.5	K	.864	-.286	.414
		2) .835	27.8	U	.553	.833	.019
		3) .349	11.6	T	.874	-.244	-.421
KF	1538	1) 1.611	53.7	K	.041	.991	.129
		2) 1.031	34.4	U	.894	-.179	.411
		3) .358	11.9	T	.901	.132	-.414
KJDS	2031	1) 1.993	66.4	K	.766	.597	-.238
		2) .653	21.8	U	.788	-.544	-.288
		3) .353	11.8	T	.886	-.032	.462
KL	11076	1) 1.475	49.2	K	.255	.932	-.258
		2) 1.074	35.8	U	-.822	-.124	-.455
		3) .451	15.0	T	-.795	.436	.422
KLF	643	1) 1.923	64.1	K	.904	-.218	-.368
		2) .815	27.2	U	.570	.821	.034
		3) .262	8.7	T	.884	-.307	.354
KMW	168	1) 1.534	51.1	K	.386	.919	.078
		2) .948	31.6	U	-.846	.139	.515
		3) .517	17.2	T	-.819	.289	-.495

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
KP	1046	1) 1.597	53.2	K	.820	-.273	-.503
		2) .892	29.7	U	.494	.869	-.012
		3) .511	17.0	T	.825	-.250	.508
KPL	1259	1) 1.477	49.2	K	.845	-.399	-.355
		2) 1.194	39.8	U	.050	.961	-.272
		3) .330	11.0	T	.872	.332	.360
KPM	906	1) 2.356	78.5	K	.874	-.426	.233
		2) .430	14.3	U	.854	.496	.160
		3) .214	7.1	T	.929	-.054	-.366
KPU	3342	1) 1.860	62.0	K	.494	.867	.065
		2) .881	29.4	U	.880	-.326	.346
		3) .258	8.6	T	.917	-.155	-.367
MZ	177	1) 2.333	77.8	K	.924	.114	-.365
		2) .447	14.9	U	.838	-.533	.118
		3) .220	7.3	T	.881	.387	.270
PPCF	299	1) 1.858	61.9	K	.611	-.770	-.185
		2) .906	30.2	U	.781	.559	-.278
		3) .236	7.8	T	.935	.036	.353

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
PPF	261	1) 2.226	74.1	K	.827	-.530	-.188
		2) .632	21.1	U	.791	.592	-.153
		3) .142	4.7	T	.957	-.032	.289
PPIF	2347	1) 2.570	85.7	K	.895	.435	.101
		2) .315	10.5	U	.920	-.348	.181
		3) .114	3.8	T	.961	-.072	-.267
QA	3943	1) 1.705	56.8	K	-.224	-.966	-.131
		2) 1.030	34.3	U	.931	.060	-.359
		3) .265	8.8	T	.888	-.306	.344
QD	4878	1) 2.431	81.0	K	.929	-.236	-.285
		2) .410	13.7	U	.843	.539	.006
		3) .159	5.3	T	.926	-.253	.280
QDO	209	1) 2.221	74.0	K	.735	.671	.096
		2) .673	22.4	U	.867	-.461	.192
		3) .106	3.5	T	.964	-.098	-.245
QE	7357	1) 1.805	60.2	K	-.431	.894	.125
		2) .963	32.1	U	.938	.041	.344
		3) .231	7.7	T	.860	.403	-.312

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
QG	3183	1) 1.664	55.5	K	.188	.976	.106
		2) 1.010	33.7	U	.890	-.235	.391
		3) .326	10.9	T	.915	.029	-.402
QGO	3192	1) 1.453	48.4	K	.301	.926	-.227
		2) 1.022	34.1	U	.788	-.403	-.466
		3) .525	17.5	T	.862	.045	.506
QL	140	1) 2.002	66.7	K	.915	-.284	-.287
		2) .828	27.6	U	.544	.839	-.023
		3) .170	5.7	T	.932	-.211	.295
TAF	196	1) 2.632	87.7	K	.916	-.398	.053
		2) .240	8.0	U	.941	.254	.225
		3) .128	4.3	T	.953	.132	-.275
TBB	121	1) 2.114	70.5	K	.643	.762	-.082
		2) .807	26.9	U	.866	-.469	-.171
		3) .079	2.6	T	.975	-.085	.206
TC	287	1) 1.931	64.4	K	.876	.248	-.413
		2) .740	24.7	U	.651	-.759	.033
		3) .329	11.1	T	.860	.321	.396

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT		
					1	2	3
TGV	508	1) 2.210	73.7	K	.840	-.480	.253
		2) .507	16.9	U	.826	.525	.205
		3) .283	9.4	T	.907	-.033	-.420
TKD	1187	1) 2.293	76.4	K	.881	-.207	.425
		2) .378	12.6	U	-.863	-.503	.044
		3) .330	11.0	T	-.878	.287	.383
TKDA	227	1) 1.641	54.7	K	.703	-.613	-.359
		2) .817	27.2	U	.680	.664	-.312
		3) .542	18.1	T	.827	-.024	.562
TKI	434	1) 2.224	74.1	K	.867	.299	.398
		2) .426	14.2	U	.872	.221	-.436
		3) .350	11.7	T	.843	-.536	.042
TM	315	1) 1.729	57.6	K	.584	.783	-.216
		2) .908	30.3	U	.764	-.541	-.351
		3) .363	12.1	T	.897	-.048	.439
TMI	597	1) 2.390	79.7	K	.818	-.569	-.085
		2) .491	16.4	U	.897	.391	-.205
		3) .119	4.0	T	.957	.120	.264

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
TNP	453	1) 1.657	55.2	K	.701	-.633	-.329
		2) .972	32.4	U	.596	.755	-.271
		3) .372	12.4	T	.900	-.008	.436
TO	1411	1) 1.383	46.1	K	-.124	-.937	-.327
		2) 1.179	39.3	U	.863	.291	-.413
		3) .438	14.6	T	.790	-.465	.400
TRPIL	388	1) 2.591	85.4	K	.921	.365	.137
		2) .236	7.9	U	.926	-.318	.204
		3) .172	5.7	T	.941	-.045	-.335
TRPJS	1685	1) 2.001	66.7	K	.745	-.656	.123
		2) .631	21.0	U	.828	.417	.375
		3) .368	12.3	T	.872	.164	-.461
TRPR	699	1) 1.945	64.8	K	.756	.599	.263
		2) .711	23.7	U	.759	-.594	.267
		3) .343	11.4	T	.893	-.003	-.450
TT	849	1) 1.922	64.0	K	.868	-.313	.385
		2) .770	25.7	U	.621	.783	.030
		3) .308	10.3	T	.884	-.243	-.399

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
TV	630	1) 2.524	84.1	K	.915	.365	-.171
		2) .385	12.8	U	.867	-.492	-.081
		3) .091	3.0	T	.967	.096	.235
TWR	5102	1) 1.702	56.7	K	.645	-.752	.135
		2) .786	26.2	U	-.777	-.434	-.456
		3) .512	17.1	T	-.826	-.179	.535
XB	18684	1) 2.151	71.7	K	.920	-.144	.363
		2) .619	20.6	U	.750	.653	-.107
		3) .231	7.7	T	.861	-.414	-.295
XFH	9420	1) 2.420	80.7	K	.886	-.409	-.217
		2) .377	12.6	U	.875	.456	-.163
		3) .203	6.8	T	.932	-.040	.359
XG	8846	1) 2.040	68.0	K	.816	.477	.327
		2) .576	19.2	U	.786	-.585	.199
		3) .384	12.8	T	.870	.081	-.487
YG	20322	1) 2.151	71.7	K	.853	-.389	.349
		2) .521	17.4	U	.801	.588	.113
		3) .328	10.9	T	.884	-.158	-.439

GREELEY

UNIT	NO. SAMPLES	EIGENVALUES	% TOTAL VARIANCE	VARIABLE	PRINCIPAL COMPONENT 1	2	3
KTRDC	245	1) 2.120	70.7	K	.873	.332	.358
		2) .600	20.0	U	.749	-.661	.045
		3) .280	9.3	T	.893	.230	-.388

APPENDIX G

TAPE FORMATS

SINGLE RECORD REDUCED DATA TAPE

REFERENCE: PARAGRAPHS 4.7.2 AND 6.1.5, BFEC 1200-B

The SINGLE RECORD REDUCED DATA TAPE is unlabeled nine track, 800 BPI, NRZI. All data 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 NL 16-1,2 RAWLINS" 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 the 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.

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.

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)	F 8.1	61-64
8.	Cosmic count rate, in cps	F 8.1	65-72
9.	Asmospheric 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	99-10
13.	Potasium (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	123-12
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	140-14

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, BFEC 1200-B

The STATISTICAL ANALYSIS TAPE is unlabeled nine track, 800 BPI, NRZI. All data 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 NL 16-1,2 RAWLINS" left justified. All project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbrevated.

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 Julain 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 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 maximum physical length is 5472 characters.

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

1.	Geologic map unit	A10,2X	1-12
2.	Potassium Distribution	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/Thorium distribution type	A2	101-102
15.	Uranium/Potassium measure of central tendenccy	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 the following defined data fields:

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.	Redisual 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 (T1-208) count rate, ic 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

MAGNETIC DATA TAPE

REFERENCE: PARAGRAPHS 4.7.4 AND 6.1.5, BFEC 1200-B

The MAGNETIC DATA TAPE is unlabeled nine track, 800 BPI, NRZI. All data re 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 doed a header record precede its first data record on the second tape.

Header Record

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

1. Type of type a 32-character field with the text "MAGNETIC DATA" left justified.
2. Project identification. A 32-character field with, for example, the text "NTMS NL 16-1,2 RAWLINS" 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.

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.

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 in 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	46-51
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	81-11
11.	Base station magnetic field in gammas	F10.2	111-12

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.

RAW SPECTRAL DATA TAPE

REFERENCE: PARAGRAPHS 4.7.1 AND 6.1.5, BFEC 1200-B

The RAW SPECTRAL DATA is unlabeled nine track, 800 BPI, NRZI. All data are recorded as EBECIC 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 fields. These fields are:

1. Type of type. 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 NL 16-1,2 RAWLINS" 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 ylear and JJJ is the Julian date.

7. Sample period. A 6-character field dexcribing 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 fields.

1.	Record identification	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)	312	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 - 4 detector	25513	65-829
11.	Live time - 4 detector - in seconds	F10.5	830-839
12.	Raw count data - 2 detector	25512	840-1349
13.	Live time - 2 detector - in seconds	F10.5	1350-1359
14.	Cosmic - 4 detector	I5	1360-1364
15	Cosmic - 2 detector	I4	1365-1368

If a scan is not within the recovered path locations, the latitude and longigute, data fields 2 and 3, 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 (4) and upward looking (2) detector arrays. The accumulation periods for the 4 and 2 detectors are indentical, so each scan has data for both detectors. The counts in each channel are 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 alive times, data field 11 and 13, are calculated by subtracting the product of the gross counts (0to 6 MeV) and ADC dead time (8 sec) from the actural acccumulation period for the data scan. This procedure is valid because the succesive approximation ADC used has a fixed conversion time of 8 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 4 and 2 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 (4 detector) or modulo 100 (2 detector) with leading zeros 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.

APPENDIX H

PRODUCTION SUMMARY

PRODUCTION SUMMARY

ROTARY WING

DATE	REMARKS
08-09-77	Ferry to Saratoga, Wyoming - set up base.
08-10-77	267 line miles.
08-11-77	399 line miles.
08-12-77	372 line miles.
08-13-77	279 line miles.
08-14-77	364 line miles.
08-15-77 to 08-17-77	Ferry to Fort Collins, Colorado.
08-18-77	Rain.
08-19-77	Rain.
08-20-77	457 line miles.
08-21-77	228 line miles.
08-22-77	240 line miles.
08-23-77	387 line miles.
08-24-77	187 line miles.
08-25-77 to 08-28-77	Weather - Rain and snow. Move to Estes Park, Colorado.
08-29-77	Equipment unserviceable.
08-30-77	249 line miles.
08-31-77	271 line miles.
09-01-77	93 line miles.
09-02-77	185 line miles.
09-03-77	62 line miles.

PRODUCTION SUMMARY

ROTARY WING

DATE	REMARKS
09-04-77	132 line miles.
09-05-77	135 line miles.
09-06-77	337 line miles.
09-07-77	239 line miles.
09-08-77	Reflights.
09-09-77	Moved Diurnal to Golden.
09-10-77	95 line miles, ferry to Golden.
09-11-77	Weather.
09-12-77 to 09-13-77	Weather, rain.
09-14-77	357 line miles.
09-15-77	68 line miles.
09-16-77	272 line miles.
09-17-77	305 line miles.
09-18-77	141 line miles.
09-19-77	Aborted, temperature inversion.
09-20-77	224 line miles.
09-21-77 to 09-23-77	Weather; high winds; temperature inversion.
09-24-77	208 line miles.
09-25-77	313 line miles.
09-26-77	55 line miles.
09-27-77	Abort - temperature inversion.

PRODUCTION SUMMARY

ROTARY WING

DATE	REMARKS
09-28-77	Ferry to Woodland Park.
09-29-77	328 line miles.
09-30-77	133 line miles.
10-01-77	106 line miles.
10-02-77	323 line miles.
10-03-77	107 line miles - high winds.
10-04-77	Weather, high winds.
10-05-77	Weather, radon high.
10-06-77	Tail rotor repairs.
10-07-77	Weather, high winds.
10-08-77	89 line miles, high winds.
10-09-77	312 line miles.
10-10-77	21 line miles, high winds.
10-11-77	Weather, snow.
10-12-77	405 line miles.
10-13-77	463 line miles.
10-14-77	312 line miles.
10-15-77	Weather.
10-16-77	120 line miles, high winds.
10-17-77	Test flight only, nil production.
10-18-77	Ferry to Dillon.

PRODUCTION SUMMARY

ROTARY WING

DATE	REMARKS
10-19-77	110 line miles.
10-20-77	212 line miles.
10-21-77	Weather, low clouds and fog.
10-22-77	57 line miles, high winds.
10-23-77	110 line miles.
10-24-77	Ferry to Canon City.
10-25-77	326 line miles.
10-26-77	238 line miles.
10-27-77	206 line miles.
10-28-77	307 line miles.
10-29-77	Weather, low clouds and fog.
10-30-77	245 line miles.
10-31-77	246 line miles.
11-01-77	235 line miles.
11-02-77	355 line miles.
11-03-77	211 line miles. High winds.
11-04-77	9 line miles. High winds, low clouds.
11-05-77	134 line miles. High winds, low clouds.
11-06-77 to 11-07-77	Weather.
11-08-77	Weather.

PRODUCTION SUMMARY

ROTARY WING

DATE	REMARKS
11-09-77	Weather.
11-10-77	Weather.
11-11-77	Weather.
11-12-77	Weather. High winds.
11-13-77	Weather. High winds.
11-14-77	48 line miles. High winds.
11-15-77	162 line miles.
11-16-77	Weather. High winds.
11-17-77	111 line miles. High winds.
11-18-77	8 line miles. High winds.
11-19-77 to 11-23-77	Weather. High winds.
11-24-77	Weather. High winds.
11-25-77	175 line miles.
11-26-77	Weather. High winds.
11-27-77	Weather. High winds.
11-28-77	Operations suspended due to weather problems.
11-29-77	Aircraft and crew left Canon City.

PRODUCTION SUMMARY

ROTARY WING

DATE	REMARKS
07-31-78	150 line miles.
08-01-78	36 miles. Weather, rain.
08-02-78	207 miles.
08-03-78	Nil production. Low clouds.
08-04-78	Nil production. Low clouds.
08-05-78	231 miles.

Completion of Helicopter portion of Rockies/Laramie Project Area.

PRODUCTION SUMMARY

FIXED WING

DATE	REMARKS
10-26-77	Ferry, Rock Springs.
10-27-77	Survey preparation.
10-28-77	552 line miles.
10-29-77	392 line miles.
10-30-77	Nil production, weather, high winds.
10-31-77	708 line miles.
11-01-77	708 line miles.
11-02-77 to 11-06-77	Aircraft equipment problems.
11-07-77	Temporary suspension of operations; aircraft and crew returned to Tulsa.
11-08-77 to 11-25-77	Equipment repairs, tests, calibrations, etc.
11-26-77	Aircraft ferry, Grand Junction - Test pad checks - aircraft ferry to Las Vegas.
11-27-77	Lake Mead Test Preparations.
11-29-77	Awaiting data approval.
11-30-77 to 12-02-77	Awaiting data approval.

PRODUCTION SUMMARY

FIXED WING

DATE	REMARKS
12-03-77	Ferry - Grand Junction to Pueblo.
12-04-77	474 line miles.
12-05-77 to 12-08-77	Weather. High winds.
12-09-77	Survey suspended for flying season due to weather.
07-12-78 to 07-16-78	Remobilize and ferry to Cheyenne for start of survey to finish Rockies/Laramie area.
07-17-78	832 line miles.
07-18-78	538 line miles.
07-19-78	593 line miles.
07-20-78	Weather. Rain.
07-21-78	Weather. Low clouds, high winds.
07-22-78	Equipment. Radar altimeter unserviceable.
07-23-78	679 line miles.
07-24-78	Equipment unserviceable.
07-25-78	1075 line miles.
07-26-78	726 line miles.
07-27-78	766 line miles.
07-28-78	524 line miles.
07-29-78	Weather. Low clouds, rain.
07-30-78	811 line miles.

PRODUCTION SUMMARY

FIXED WING

DATE	REMARKS
07-31-78	562 line miles.
08-01-78	Aircraft and crew move to Pueblo from Cheyenne.
08-02-78 to 08-04-78	Weather.
08-05-78	696 miles.
08-06-78	623 miles.
08-07-78	762 miles.
08-24-78	594 miles.
08-25-78	Weather.
08-26-78	652 miles.
08-27-78	Weather.
08-28-78	585 miles.
08-29-78	500 miles.
08-30-78	514 miles.
08-31-78	707 miles.

Completion of Fixed Wing portion of Rockies/Laramie Project.

APPENDIX I

MICROFICHE OF DATA