**AERIAL GAMMA RAY AND MAGNETIC SURVEY
VAN HORN AND PECOS QUADRANGLES, TEXAS**

**FINAL REPORT
VOLUME I**

MASTER

Prepared by:

geoMetrics

Sunnyvale, California

October 1977

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

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

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ABSTRACT

Under the United States Department of Energy (DoE), National Uranium Resource Evaluation (NURE) Program, GeoMetrics, Inc. conducted a high sensitivity, airborne radiometric and magnetic survey of portions of the Big Bend, Texas area. The project area comprising the Van Horn and Pecos 1:250,000 NTMS sheets, consists of approximately 16,400 square miles (42,000 square kilometers). Approximately two thirds of this survey area lie within the Permian Basin of western Texas. A total of 6,666 line miles (10,725 line kilometers) of high sensitivity radiometric and magnetic data were collected. Traverse lines were flown at a spacing of 3.125 miles (5 kilometers) in an east/west direction with tie lines flown in a north/south direction at a 18.375 miles (30 kilometers) separation. All data were collected utilizing a fixed wing aircraft, Grumman G-89 (S2F Tracker, U.S. Registry No. N9AG) and over 3,500 cubic inches of NaI crystal detector (3,072 cubic inches in a downward looking configuration and 512 cubic inches in an upward looking configuration). Magnetometer data were collected utilizing a high sensitivity, 0.25 gamma, proton magnetometer. Data were digitally recorded at 0.5 second intervals aboard the aircraft with navigation performed using both visual and doppler techniques. All field data were returned to the GeoMetrics, Sunnyvale, California computer facilities for processing, statistical analysis, and interpretation. As an integral part of this final report, other data are presented which include corrected profiles of all radiometric variables (total count, potassium, uranium, thorium, uranium/thorium, uranium/potassium, and thorium/potassium ratios), magnetic data, radar altimeter data, barometric altimeter data, air temperature and airborne Bismuth contributions. Data presented have been summed to provide 1.0 second equivalent sample intervals, corrected for Compton Scatter, altitude dependence (data are all referenced to 400 foot mean terrain clearance) and atmospheric Bismuth. These data are presented in the form of strip charts (see Volume II of this report), microfiche (containing single record data), and digital magnetic tapes containing raw spectral data, single record data, magnetic data, and statistical analysis results. In addition, computer generated anomaly maps along with interpretation maps are presented relating mapped geology to the collected radiometric data.

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TABLE OF CONTENTS

	<u>Page Nos.</u>
Introduction and Summary	1
Introduction	
Summary	
Data Collection System	4
Aircraft	5
Electronics	6
Operations	9
Data Collection Procedures	9
Operating Parameters/Sampling Procedures	9
Navigation/Flight Path Recovery	9
Infield System Calibration	9
Production Summary	10
System Calibration	15
Aircraft and Cosmic Background	15
System Constants	15
Atmospheric Radon Correction	23
Data Processing	26
Data Preparation	26
Data Recording	26
Field Tape Editing	26
Flight Line Location	26
Radiometric Data Reduction	27
Magnetic Data Reduction	33
Statistical Analysis	34
Statistical Adequacy Test	34
Hypothesis Testing	35

	<u>Page Nos.</u>
Data Presentation	37
General	37
Radiometric Profiles	37
Flight Path Maps	39
Anomaly Maps	39
Histograms	39
Data Listings	40
Data Tapes	41
Data Interpretation	42
Methodology	42
Van Horn Quadrangle	43
Pecos Quadrangle	55
Bibliography	66
Appendices	
Appendix A - Geologic Legend - Van Horn Quadrangle	67
Appendix B - Statistical Tables - Van Horn Quadrangle	79
Appendix C - Geologic Legend - Pecos Sheet	95
Appendix D - Statistical Tables - Pecos Sheet	100
Appendix E - Tape Formats	108
Appendix F - Production Summary	119
Appendix G - Microfiche of Data with Index	

LIST OF TABLES

	Page Nos.
Table 1 Anomaly Summary - Van Horn	48
Table 2 Print Character Values - K, U, T	54
Table 3 Print Character Values - Magnetic	55
Table 4 Anomaly Summary - Pecos	59

LIST OF FIGURES

Figure 1 Index Map Showing Survey Area	2
Figure 2 Survey Aircraft/Equipment	5
Figure 3 Airborne Survey System Flow Chart	7
Figure 4 GR-800 Analog Spectrum Plot	11
Figure 5 Typical Ground Speed Statistical Summary Histogram for Single Flight Line	13
Figure 6 Typical Radar Altimeter Statistical Summary Histogram for Single Flight Line	14
Figure 7 Multiple Altitude Spectra Schematic	16
Figure 8 Aircraft Background Downward Looking Crystal	17
Figure 9 Cosmic Spectrum Downward Looking Crystal	18
Figure 10 Data Processing Flow Diagram	28
Figure 11 Sample Histogram. Geologic Type	38
Figure 12 Plotter Step Value Labeling	40
Figure 13 Uranium Anomaly/Interpretation Map - Van Horn Quadrangle	45
Figure 14 Van Horn Quadrangle Potassium Pseudo-Contour Map	50
Figure 15 Van Horn Quadrangle Uranium Pseudo-Contour Map	51
Figure 16 Van Horn Quadrangle Thorium Pseudo-Contour Map	52
Figure 17 Van Horn Quadrangle Magnetic Pseudo-Contour Map	53
Figure 18 Uranium Anomaly/Interpretation Map - Pecos Quadrangle	56
Figure 19 Pecos Quadrangle Potassium Pseudo-Contour Map	61
Figure 20 Pecos Quadrangle Uranium Pseudo-Contour Map	62
Figure 21 Pecos Quadrangle Thorium Pseudo-Contour Map	63
Figure 22 Pecos Quadrangle Magnetic Pseudo-Contour Map	64
Figure 23 Bimodal Distribution for K ₄₀	66

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INTRODUCTION AND SUMMARY

INTRODUCTION

Under the U. S. Department of Energy (DoE), National Uranium Resource Evaluation (NURE) Program, GeoMetrics, Inc. conducted a high sensitivity airborne radiometric and magnetic survey of portions of the Big Bend, Texas area. This project represents a small portion of the DoE/NURE Program, the objectives of which may be summarized as follows (Ref. NURE Report, December 1976):

"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..."

A first step in the development of the information required to define the distribution of uranium sources is to undertake airborne radiometric reconnaissance programs oriented towards the goals of the DoE/NURE Program.

The project area encompasses the Van Horn and Pecos, Texas NTMS 1:250,000 map sheets (See Figure 1). All data were collected utilizing a fixed wing aircraft, Grumman G-89 (S2F Tracker U.S. Registry No. N9AG). These data were compiled and interpreted at the GeoMetrics computer facility and are presented as part of this final report.

SUMMARY

This portion of the Big Bend project area, the Van Horn and Pecos 1:250,000 NTMS sheets, consists of approximately 16,400 square miles (42,400 square kilometers). Large portions of this survey area lie within the Permian Basin of western Texas. A total of 6,666 line miles (10,725 line kilometers) of high sensitivity radiometric and magnetic data were collected. Traverse lines were flown at a spacing of 3.125 miles (5 kilometers) in an east/west direction with tie lines flown in a north/south direction at a 18.375 miles (30 kilometers) separation. In order to ensure high sensitivity radiometric data over 3,500 cubic inches of NaI crystal detector were utilized (3,072 cubic inches in a downward looking configuration and 512 cubic inches in an upward looking configuration). Magnetometer data were collected utilizing a high sensitivity, 0.25 gamma, proton precision magnetometer. All data were digitally recorded at 0.5 second intervals aboard the aircraft with navigation performed using both visual and doppler techniques.

This project area encompasses two separate and distinct geological structural provinces. The first occupies the eastern two-thirds of the area and corresponds to the Permian Delaware and Midland Basins with sediment thicknesses of up to 20,000+ feet. These basins are terminated on the west by the north-northwest trending Delaware anticline (forming the Delaware Mountains). West of this anticlinal structure lies the second major province, the Diablo Platform.

Figure 1, Index Map Showing Survey Area

A graben-like feature, the Salt Basin, separates the Diablo Platform on the west and the Delaware anticline on the east. Superimposed on the Diablo Platform are the Hueco Mountain uplift in the northwest and the Van Horn uplift in the south. Geological structure within the Diablo Platform trends generally northwest to west-northwest with some north-south faulting in the Hueco Mountains (Tectonic map of North America).

All field data were returned to the GeoMetrics, Sunnyvale, California computer facilities for processing, statistical analysis, and interpretation. As an integral part of this final report, other data are presented which include corrected profiles of all radiometric variables (total count, potassium, uranium, thorium, uranium/thorium, uranium/potassium, and thorium/potassium ratios), magnetic data, radar altimeter data, barometric altimeter data, air temperature, and airborne Bismuth contributions. Data presented have been summed to provide 1.0 second equivalent sample intervals, corrected for Compton Scatter, altitude dependence (data are all referenced to 400 foot mean terrain clearance) and atmospheric Bismuth. These data are presented in the form of strip charts (see Volume II of this report), microfiche (containing single record, averaged record and statistical analysis data, and digital magnetic tapes containing raw spectral data, single record data, magnetic data, and statistical analysis results. In addition, computer generated anomaly maps along with interpretation maps are presented relating mapped geology to the collected radiometric data.

The balance of this report contains a detailed description of the data collection system, data processing procedures, statistical analyses (relating the geology of the area to airborne radiometric data), and an interpretation summarizing the results for each of the NTMS sheets.

DATA COLLECTION SYSTEM

AIRCRAFT

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

Aircraft Empty		15,123 lbs.
Electronic Equipment		1,600 lbs.
Main Fuel Usable		3,108 lbs.
Auxilliary Fuel Usable		900 lbs.
Pilot		175 lbs.
Electronic Operator		175 lbs.
		<hr/>
Maximum Gross Weight for Airborne Geo. Survey Operation		21,081 lbs.
Maximum Allowable Aircraft Gross Weight		24,500 lbs.
Minimum Control Speed	85 KIAS at	24,500 lbs.
Safe Single Engine Speed	100 KIAS at	24,500 lbs.
Single Engine Rate of Climb at 120 KIAS	550 FPM at	23,000 lbs.
Single Engine Rate of Climb at 100 KIAS	390 FPM at	23,000 lbs.
Rate of Climb (2 Engines)	2000 FPM thru	5,000 ft.
120 KIAS at 23,000 lbs.	1200 FPM at	10,000 ft.
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 (Knots Indicated Air Speed) at 23,000 lbs. gross wt. duration		
10 hours plus, due to burn off and lower gross wt.		

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

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

Figure 2

ELECTRONICS

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

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

FIGURE 3

- d) Radar Altitude
 - e) Total count for downward looking system (0.4 to 3.0 MeV)
 - f) Event and time markers
10. HP 7128, two channel analog recorder to record the following data:
- a) Outside air temperature
 - b) Barometric altimeter
 - c) Event and time markers
 - d) During pre and post flight calibrations, this recorder is used to plot full analog spectra for both the down and up crystal systems via the GR-800. Thus, a hard copy record of the data used for resolutions, drift, and other checks is available at all times. (See Figure 4) This approach provides instant verification of system parameters.
11. Navigation System composed of the following units:
- a) Singer SSK-1000 Doppler System.
 - b) Singer Track Navigation Computer SKQ-601.
 - c) Singer Roll Stabilized Antenna configured for geophysical surveys.
 - d) Sperry C-12 Gyro Stabilized Compass.

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 0.5 second sample intervals.
2. The aircraft objective ground speed was 120 mph, but did not exceed 140 mph unless dictated by safety.
3. The downward looking crystal volume was 3,072 cubic inches, providing a range in V/v (i.e. crystal volume in cubic inches divided by ground speed in mph) of between 25.6 (120 mph), and 22 (140 mph).
4. The volume of the upward looking crystal was 512 cubic inches.
5. All sensor data with analog output were digitally sampled at each data scan based upon the clock timing rate of 0.5 seconds. The data so collected are the instantaneous values of these parameters determined at the time of the data scan.

Navigation/Flight Path Recovery

Navigation was accomplished using a combination of visual and doppler navigation techniques. Flight lines were drawn on 1:250,000 scale topographic maps. The pilot/navigator utilized these maps to provide visual navigation features. The flight line was generally started and ended visually, while the doppler was used to fly a straight line between end points.

Simultaneously, a 35 mm tracking camera was used to record actual flight position. The camera's fiducial numbering system was directly synchronized to the digital recording system such that a one-to-one correlation in position and data could be made. Upon completion of a data collection flight, the 35 mm film was processed and actual flight path positions located on the 1:250,000 scale map sheets.

Infield System Calibration

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

A. Pre Flight

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

2. Run full cesium spectrum on analog recorder for both down and up looking crystals. Calculate the cesium resolution (see sample in Figure 4). Run spectrum out past the K_{40} peak on down crystals for centering evaluation of K_{40} peak.
3. Use thorium sources (same position every day) to check upper end of spectrum in both up and down crystals (slope of ADC curve) - using the digital split window of the GR-800.
4. Run full thorium spectrum of down crystals on analog recorder. Check for centering of K_{40} and Th peaks in spectrum.

B. During Flight

1. Run test line at survey altitude (400 ft.), for approximately five miles, prior to production data collection (record both analog and digital).
2. Prior to production data collection, the above data are evaluated to ensure $\pm 20\%$ limits on total count - compared to first test flight from that base of operations.
3. During production data collection, monitor radon analog data for unusual increases. Visually correlate these with temperature and barometric pressure.
4. During production data collection, annotate operator logs with unusual features such as recently fertilized fields, lakes, snow/rain showers, man-made features, etc., along with their fiducial numbers.
5. Upon completion of production data collection, re-fly test line at survey altitude (400 ft.). Record both analog and digital.

C. Post Flight

1. Verify test line total count within $\pm 20\%$ of first test line at that base of operations.
2. Using cesium sources (same position as pre-flight), run full cesium spectrum for both down and up crystals (allow it to record through the K_{40} peak in the down crystals).
3. Calculate the resolution of down and up crystal pack for both before and after data collection flight.
4. Determine shift, if any, in K_{40} peak position.

PRODUCTION SUMMARY

Data for this project were collected during the month of January, 1977. The base of operations of this survey was Midland, Texas. The full 6,666 line miles required a total of 15 days to complete. Throughout the survey, an average ground speed of 132 miles per hour was maintained. The objective altitude was 400 feet within the envelope of 200 to 700 feet. The average altitude was maintained at 446 feet mean terrain clearance.

Fig:

GR-8000 ANALOG SPECTRUM PLOT
DET-1024 Crystal Detector (1,024 in³)
¹³⁷Cs Source 11.81 Kev/Ch

20K c.p.s. Full Scale

Resolution Calculation

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

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

Total number of
channels FWHM
 $4.0 + 0.14 + 0.65 = 4.79$

0.65 Channel

0.14 Channel

FWHM Point

40K

214Bi

208Tl

18

Channel Number →

(Samples of the typical flight line distribution of ground speed and radar altimeter data are presented in Figures 5 and 6). Overall, in excess of 95% of the data collected were within the specification limits. See Appendix F for a daily production summary.

-- BIG BEND AREA, TEXAS -- FLIGHT TWO

LINE NUMBER 17-0

RANGE	VALUE	0
RANGE-99999.9	VALUE	0
RANGE 75.0	VALUE	24
RANGE 77.0	VALUE	0
RANGE 79.0	VALUE	0
RANGE 81.0	VALUE	0
RANGE 83.0	VALUE	0
RANGE 85.0	VALUE	0
RANGE 87.0	VALUE	0
RANGE 89.0	VALUE	0
RANGE 91.0	VALUE	0
RANGE 93.0	VALUE	0
RANGE 95.0	VALUE	0
RANGE 97.0	VALUE	0
RANGE 99.0	VALUE	0
RANGE 101.0	VALUE	0
RANGE 103.0	VALUE	0
RANGE 105.0	VALUE	0
RANGE 107.0	VALUE	0
RANGE 109.0	VALUE	3
RANGE 111.0	VALUE	1
RANGE 113.0	VALUE	0
RANGE 115.0	VALUE	19
RANGE 117.0	VALUE	40
RANGE 119.0	VALUE	64
RANGE 121.0	VALUE	107
RANGE 123.0	VALUE	356
RANGE 125.0	VALUE	543
RANGE 127.0	VALUE	793
RANGE 129.0	VALUE	1100
RANGE 131.0	VALUE	1621
RANGE 133.0	VALUE	1723
RANGE 135.0	VALUE	1665
RANGE 137.0	VALUE	1412
RANGE 139.0	VALUE	1016
RANGE 141.0	VALUE	651
RANGE 143.0	VALUE	409
RANGE 145.0	VALUE	371
RANGE 147.0	VALUE	272
RANGE 149.0	VALUE	141
RANGE 151.0	VALUE	82
RANGE 153.0	VALUE	49
RANGE 155.0	VALUE	26
RANGE 157.0	VALUE	25
RANGE 159.0	VALUE	36
RANGE 161.0	VALUE	24
RANGE 163.0	VALUE	10
RANGE 165.0	VALUE	2
RANGE 167.0	VALUE	0
RANGE 169.0	VALUE	0
RANGE 171.0	VALUE	0
RANGE 173.0	VALUE	0
RANGE 175.0	VALUE	0
RANGE 99999.9	VALUE	0

THE MINIMUM GROUND SPEED IS 43.49 MPH
 THE MAXIMUM GROUND SPEED IS 165.65 MPH
 THE MEAN GROUND SPEED IS 133.67 MPH
 THE STANDARD DEVIATION IS 11.01

Figure 5

E -- BIG BEND AREA, TEXAS -- FLIGHT ONE

LINE NUMBER 14-0

RANGE	VALUE	VALUE
RANGE-99999.9	VALUE	6 !
RANGE 100.0	VALUE	6 !
RANGE 112.0	VALUE	7 !
RANGE 124.0	VALUE	6 !
RANGE 136.0	VALUE	6 !
RANGE 148.0	VALUE	0 !
RANGE 160.0	VALUE	0 !
RANGE 172.0	VALUE	0 !
RANGE 184.0	VALUE	0 !
RANGE 196.0	VALUE	0 !
RANGE 208.0	VALUE	0 !
RANGE 220.0	VALUE	3 !#
RANGE 232.0	VALUE	5 !#
RANGE 244.0	VALUE	4 !#
RANGE 256.0	VALUE	2 !#
RANGE 268.0	VALUE	16 !#
RANGE 280.0	VALUE	4 !#
RANGE 292.0	VALUE	13 !#
RANGE 304.0	VALUE	22 !#
RANGE 316.0	VALUE	22 !#
RANGE 328.0	VALUE	16 !#
RANGE 340.0	VALUE	50 !#
RANGE 352.0	VALUE	186 !#
RANGE 364.0	VALUE	183 !#
RANGE 376.0	VALUE	463 !#
RANGE 388.0	VALUE	624 !#
RANGE 400.0	VALUE	836 !#
RANGE 412.0	VALUE	1247 !#
RANGE 424.0	VALUE	210 !#
RANGE 436.0	VALUE	1206 !#
RANGE 448.0	VALUE	559 !#
RANGE 460.0	VALUE	459 !#
RANGE 472.0	VALUE	279 !#
RANGE 484.0	VALUE	196 !#
RANGE 496.0	VALUE	52 !#
RANGE 508.0	VALUE	37 !#
RANGE 520.0	VALUE	23 !#
RANGE 532.0	VALUE	33 !#
RANGE 544.0	VALUE	0 !#
RANGE 556.0	VALUE	5 !#
RANGE 568.0	VALUE	12 !#
RANGE 580.0	VALUE	4 !#
RANGE 592.0	VALUE	15 !#
RANGE 604.0	VALUE	4 !#
RANGE 616.0	VALUE	7 !#
RANGE 628.0	VALUE	13 !#
RANGE 640.0	VALUE	29 !#
RANGE 652.0	VALUE	15 !#
RANGE 664.0	VALUE	21 !#
RANGE 676.0	VALUE	8 !#
RANGE 688.0	VALUE	3 !#
RANGE 700.0	VALUE	1 !#
RANGE 99999.9	VALUE	1 !#

THE MINIMUM RADAR ALTMTR IS 224.00 FEET
 THE MAXIMUM RADAR ALTMTR IS 703.00 FEET
 THE MEAN RADAR ALTMTR IS 421.67 FEET
 THE STANDARD DEVIATION IS 45.36

Figure 6

SYSTEM CALIBRATION

AIRCRAFT AND COSMIC BACKGROUND

Full spectral data are collected at multiple altitudes over water (e.g. 12,000 feet and 8000 feet) in an area where the existence of no airborne Bi_{214} can be assured (offshore over the Pacific Ocean). This results in separate spectra as shown schematically in Figure 7. We define $S(12,000)$ to be the spectra at 12,000 feet from 0.4 to 3 MeV, with $S(8000)$ the same spectra at a lower altitude (8000 feet) and $\Sigma C(h_i)$ the total count between 3.0 and 6.0 MeV at the respective altitudes. Since the aircraft background is constant, the difference between $S(12,000)$ and $S(8000)$ yields the cosmic spectral curve shape as shown schematically in Figure 7. Thus

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

and

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

where h_i is each channel, .012 MeV wide

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

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

The aircraft background is derived as follows:

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

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

SYSTEM CONSTANTS

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

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

Figure 7 - Multiple altitude spectra schematic

DERIVED AIRCRAFT BACKGROUND SPECTRUM FROM PACIFIC OCEAN DATA
DOWNWARD-LOOKING CRYSTAL SPECTRUM FOR LINE AC BGD, DATED 111376
TC (0-6 MEV) 2134.49 TC (0.4-3.0 MEV) 1304.53 COSMIC (3-6 MEV) 0.00
U (1.12 MEV) 105.48 K (1.46 MEV) 107.38 U (1.78 MEV) 80.31 T (2.62 MEV) 11.83

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

CH	0	(0.000 MEV)	0.000	CPS	*
CH	1	(0.012 MEV)	0.000	CPS	*
CH	2	(0.024 MEV)	0.000	CPS	*
CH	3	(0.036 MEV)	0.000	CPS	*
CH	4	(0.047 MEV)	0.000	CPS	*
CH	5	(0.059 MEV)	0.000	CPS	*
CH	6	(0.071 MEV)	0.000	CPS	*
CH	7	(0.083 MEV)	0.000	CPS	*
CH	8	(0.095 MEV)	0.000	CPS	*
CH	9	(0.106 MEV)	0.000	CPS	*
CH	10	(0.118 MEV)	0.000	CPS	*
CH	11	(0.130 MEV)	0.000	CPS	*
CH	12	(0.142 MEV)	0.000	CPS	*
CH	13	(0.154 MEV)	0.000	CPS	*
CH	14	(0.165 MEV)	0.000	CPS	*
CH	15	(0.177 MEV)	0.000	CPS	*
CH	16	(0.189 MEV)	0.000	CPS	*
CH	17	(0.201 MEV)	0.000	CPS	*
CH	18	(0.213 MEV)	41.587	CPS	*****
CH	19	(0.225 MEV)	65.548	CPS	*****
CH	20	(0.236 MEV)	68.564	CPS	*****
CH	21	(0.248 MEV)	63.207	CPS	*****
CH	22	(0.260 MEV)	62.849	CPS	*****
CH	23	(0.272 MEV)	61.598	CPS	*****
CH	24	(0.284 MEV)	57.919	CPS	*****
CH	25	(0.295 MEV)	53.586	CPS	*****
CH	26	(0.307 MEV)	51.300	CPS	*****
CH	27	(0.319 MEV)	51.807	CPS	*****
CH	28	(0.331 MEV)	55.518	CPS	*****
CH	29	(0.343 MEV)	55.710	CPS	*****
CH	30	(0.355 MEV)	46.971	CPS	*****
CH	31	(0.367 MEV)	35.410	CPS	*****
CH	32	(0.379 MEV)	31.720	CPS	*****
CH	33	(0.390 MEV)	27.477	CPS	*****
CH	34	(0.402 MEV)	25.400	CPS	*****
CH	35	(0.414 MEV)	24.120	CPS	*****
CH	36	(0.426 MEV)	23.627	CPS	*****
CH	37	(0.437 MEV)	26.365	CPS	*****
CH	38	(0.449 MEV)	21.963	CPS	*****
CH	39	(0.461 MEV)	20.882	CPS	*****
CH	40	(0.473 MEV)	21.473	CPS	*****
CH	41	(0.485 MEV)	20.737	CPS	*****
CH	42	(0.496 MEV)	21.513	CPS	*****
CH	43	(0.508 MEV)	20.193	CPS	*****
CH	44	(0.520 MEV)	19.160	CPS	*****
CH	45	(0.532 MEV)	18.979	CPS	*****
CH	46	(0.544 MEV)	19.391	CPS	*****
CH	47	(0.556 MEV)	20.251	CPS	*****
CH	48	(0.567 MEV)	22.881	CPS	*****
CH	49	(0.579 MEV)	22.925	CPS	*****
CH	50	(0.591 MEV)	31.780	CPS	*****
CH	51	(0.603 MEV)	31.605	CPS	*****
CH	52	(0.615 MEV)	31.768	CPS	*****
CH	53	(0.626 MEV)	29.078	CPS	*****
CH	54	(0.638 MEV)	29.230	CPS	*****
CH	55	(0.650 MEV)	18.437	CPS	*****
CH	56	(0.662 MEV)	15.442	CPS	*****
CH	57	(0.674 MEV)	12.595	CPS	*****
CH	58	(0.686 MEV)	12.595	CPS	*****
CH	59	(0.697 MEV)	11.549	CPS	*****
CH	60	(0.709 MEV)	11.326	CPS	*****
CH	61	(0.721 MEV)	11.325	CPS	*****
CH	62	(0.733 MEV)	11.673	CPS	*****
CH	63	(0.745 MEV)	11.000	CPS	*****
CH	64	(0.756 MEV)	12.680	CPS	*****
CH	65	(0.768 MEV)	12.397	CPS	*****
CH	66	(0.780 MEV)	11.307	CPS	*****
CH	67	(0.792 MEV)	10.963	CPS	*****
CH	68	(0.804 MEV)	11.206	CPS	*****
CH	69	(0.816 MEV)	9.517	CPS	*****
CH	70	(0.827 MEV)	9.365	CPS	*****
CH	71	(0.839 MEV)	8.322	CPS	*****
CH	72	(0.851 MEV)	8.193	CPS	*****
CH	73	(0.863 MEV)	8.003	CPS	*****
CH	74	(0.875 MEV)	8.008	CPS	*****
CH	75	(0.887 MEV)	7.966	CPS	*****
CH	76	(0.899 MEV)	8.271	CPS	*****
CH	77	(0.910 MEV)	8.304	CPS	*****
CH	78	(0.922 MEV)	8.425	CPS	*****
CH	79	(0.934 MEV)	8.047	CPS	*****
CH	80	(0.946 MEV)	8.554	CPS	*****
CH	81	(0.957 MEV)	8.317	CPS	*****
CH	82	(0.969 MEV)	7.979	CPS	*****
CH	83	(0.981 MEV)	7.930	CPS	*****
CH	84	(0.993 MEV)	7.907	CPS	*****
CH	85	(1.005 MEV)	6.625	CPS	*****
CH	86	(1.017 MEV)	6.625	CPS	*****
CH	87	(1.029 MEV)	6.030	CPS	*****
CH	88	(1.040 MEV)	6.262	CPS	*****
CH	89	(1.052 MEV)	6.410	CPS	*****
CH	90	(1.064 MEV)	7.101	CPS	*****
CH	91	(1.076 MEV)	7.395	CPS	*****
CH	92	(1.087 MEV)	8.000	CPS	*****
CH	93	(1.099 MEV)	9.201	CPS	*****
CH	94	(1.111 MEV)	10.045	CPS	*****
CH	95	(1.123 MEV)	9.500	CPS	*****
CH	96	(1.135 MEV)	11.003	CPS	*****
CH	97	(1.147 MEV)	9.916	CPS	*****
CH	98	(1.159 MEV)	9.780	CPS	*****
CH	99	(1.170 MEV)	8.459	CPS	*****
CH	100	(1.182 MEV)	7.986	CPS	*****
CH	101	(1.194 MEV)	7.950	CPS	*****
CH	102	(1.206 MEV)	6.988	CPS	*****
CH	103	(1.217 MEV)	6.315	CPS	*****
CH	104	(1.229 MEV)	6.555	CPS	*****
CH	105	(1.241 MEV)	6.150	CPS	*****
CH	106	(1.253 MEV)	6.702	CPS	*****
CH	107	(1.265 MEV)	6.200	CPS	*****
CH	108	(1.277 MEV)	5.983	CPS	*****
CH	109	(1.288 MEV)	5.746	CPS	*****
CH	110	(1.300 MEV)	5.430	CPS	*****
CH	111	(1.312 MEV)	4.886	CPS	*****
CH	112	(1.324 MEV)	5.186	CPS	*****
CH	113	(1.336 MEV)	5.957	CPS	*****
CH	114	(1.347 MEV)	5.163	CPS	*****
CH	115	(1.359 MEV)	5.280	CPS	*****
CH	116	(1.371 MEV)	5.920	CPS	*****
CH	117	(1.383 MEV)	5.993	CPS	*****
CH	118	(1.395 MEV)	6.748	CPS	*****
CH	119	(1.407 MEV)	6.400	CPS	*****
CH	120	(1.418 MEV)	7.341	CPS	*****
CH	121	(1.430 MEV)	7.090	CPS	*****
CH	122	(1.442 MEV)	7.950	CPS	*****
CH	123	(1.454 MEV)	7.644	CPS	*****
CH	124	(1.466 MEV)	7.587	CPS	*****
CH	125	(1.477 MEV)	7.378	CPS	*****
CH	126	(1.489 MEV)	6.975	CPS	*****
CH	127	(1.501 MEV)	5.870	CPS	*****
CH	128	(1.513 MEV)	6.375	CPS	*****
CH	129	(1.525 MEV)	5.380	CPS	*****
CH	130	(1.537 MEV)	4.772	CPS	*****
CH	131	(1.549 MEV)	3.911	CPS	*****
CH	132	(1.560 MEV)	3.971	CPS	*****
CH	133	(1.572 MEV)	4.460	CPS	*****
CH	134	(1.584 MEV)	3.435	CPS	*****
CH	135	(1.596 MEV)	3.057	CPS	*****
CH	136	(1.608 MEV)	3.119	CPS	*****
CH	137	(1.619 MEV)	2.882	CPS	*****
CH	138	(1.631 MEV)	3.036	CPS	*****
CH	139	(1.643 MEV)	2.700	CPS	*****
CH	140	(1.655 MEV)	2.772	CPS	*****
CH	141	(1.667 MEV)	2.903	CPS	*****
CH	142	(1.678 MEV)	3.275	CPS	*****
CH	143	(1.690 MEV)	3.247	CPS	*****
CH	144	(1.702 MEV)	4.118	CPS	*****
CH	145	(1.714 MEV)	4.152	CPS	*****
CH	146	(1.726 MEV)	4.917	CPS	*****
CH	147	(1.738 MEV)	5.101	CPS	*****
CH	148	(1.749 MEV)	6.169	CPS	*****
CH	149	(1.761 MEV)	6.099	CPS	*****
CH	150	(1.773 MEV)	6.473	CPS	*****
CH	151	(1.785 MEV)	6.018	CPS	*****
CH	152	(1.797 MEV)	5.984	CPS	*****
CH	153	(1.808 MEV)	5.355	CPS	*****
CH	154	(1.820 MEV)	5.159	CPS	*****
CH	155	(1.832 MEV)	4.225	CPS	*****
CH	156	(1.844 MEV)	3.843	CPS	*****
CH	157	(1.856 MEV)	3.270	CPS	*****
CH	158	(1.868 MEV)	2.754	CPS	*****
CH	159	(1.879 MEV)	2.213	CPS	*****
CH	160	(1.891 MEV)	2.231	CPS	*****
CH	161	(1.903 MEV)	1.797	CPS	*****
CH	162	(1.915 MEV)	1.692	CPS	*****
CH	163	(1.927 MEV)	1.260	CPS	*****
CH	164	(1.938 MEV)	1.250	CPS	*****
CH	165	(1.950 MEV)	1.189	CPS	*****
CH	166	(1.962 MEV)	0.943	CPS	*****
CH	167	(1.974 MEV)	0.798	CPS	*****
CH	168	(1.986 MEV)	0.929	CPS	*****
CH	169	(1.998 MEV)	0.725	CPS	*****
CH	170	(2.009 MEV)	0.840	CPS	*****
CH	171	(2.021 MEV)	0.694	CPS	*****
CH	172	(2.033 MEV)	0.673	CPS	*****
CH	173	(2.045 MEV)	0.665	CPS	*****
CH	174	(2.057 MEV)	0.810	CPS	*****
CH	175	(2.069 MEV)	0.728	CPS	*****
CH	176	(2.080 MEV)	0.797	CPS	*****
CH	177	(2.092 MEV)	0.930	CPS	*****
CH	178	(2.104 MEV)	1.006	CPS	*****
CH	179	(2.116 MEV)	1.035	CPS	*****
CH	180	(2.128 MEV)	1.280	CPS	*****
CH	181	(2.139 MEV)	1.183	CPS	*****
CH	182	(2.151 MEV)	1.333	CPS	*****
CH	183	(2.163 MEV)	1.619	CPS	*****
CH	184	(2.175 MEV)	1.607	CPS	*****
CH	185	(2.187 MEV)	1.433	CPS	*****
CH	186	(2.199 MEV)	1.555	CPS	*****
CH	187	(2.210 MEV)	1.444	CPS	*****
CH	188	(2.222 MEV)	1.503	CPS	*****
CH	189	(2.234 MEV)	1.555	CPS	*****
CH	190	(2.246 MEV)	1.428	CPS	*****
CH	191	(2.258 MEV)	1.164	CPS	*****
CH	192	(2.269 MEV)	1.277	CPS	*****
CH	193	(2.281 MEV)	0.984	CPS	*****
CH	194	(2.293 MEV)	0.793	CPS	*****
CH	195	(2.305 MEV)	0.820	CPS	*****
CH	196	(2.317 MEV)	0.670	CPS	*****
CH	197	(2.329 MEV)	0.564	CPS	*****
CH	198	(2.340 MEV)	0.495	CPS	*****
CH	199	(2.352 MEV)	0.463	CPS	*****
CH	200	(2.364 MEV)	0.383	CPS	*****
CH	201	(2.376 MEV)	0.477	CPS	*****
CH	202	(2.388 MEV)	0.510	CPS	*****
CH	203	(2.399 MEV)	0.456	CPS	*****
CH	204	(2.411 MEV)	0.519	CPS	*****
CH	205	(2.423 MEV)	0.548	CPS	*****
CH	206	(2.435 MEV)	0.438	CPS	*****
CH	207	(2.447 MEV)	0.472	CPS	*****
CH	208	(2.459 MEV)	0.554	CPS	*****
CH	209	(2.470 MEV)	0.453	CPS	*****
CH	210	(2.482 MEV)	0.459	CPS	*****
CH	211	(2.494 MEV)	0.438	CPS	*****
CH	212	(2.506 MEV)	0.445	CPS	*****
CH	213	(2.518 MEV)	0.404	CPS	*****
CH	214	(2.529 MEV)	0.453	CPS	*****
CH	215	(2.541 MEV)	0.371	CPS	*****
CH	216	(2.553 MEV)	0.413	CPS	*****
CH	217	(2.565 MEV)	0.358	CPS	*****
CH	218	(2.577 MEV)	0.407	CPS	*****
CH	219	(2.589 MEV)	0.402	CPS	*****
CH	220	(2.600 MEV)	0.438	CPS	*****
CH	221	(2.612 MEV)	0.436	CPS	*****
CH	222	(2.624 MEV)	0.423	CPS	*****
CH	223	(2.636 MEV)	0.388	CPS	*****
CH	224	(2.648 MEV)	0.402	CPS	*****
CH	225	(2.660 MEV)	0.421	CPS	*****
CH	226	(2.671 MEV)	0.290	CPS	*****
CH	227	(2.683 MEV)	0.289	CPS	*****
CH	228	(2.695 MEV)	0.312	CPS	*****
CH	229	(2.707 MEV)	0.285	CPS	*****
CH	230	(2.719 MEV)	0.230	CPS	*****
CH	231	(2.730 MEV)	0.164	CPS	*****
CH	232	(2.742 MEV)	0.166	CPS	*****
CH	233	(2.754 MEV)	0.116	CPS	*****
CH	2				

DERIVED COSMIC SPECTRUM FROM PACIFIC OCEAN DATA

DOWNWARD-LOOKING CRYSTAL SPECTRUM FOR LINE COSMIC, DATED 111376

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

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

CH	0	(0.000 MEV)	0.000	CPS	X
CH	1	(0.012 MEV)	0.000	CPS	X
CH	2	(0.024 MEV)	0.000	CPS	X
CH	3	(0.036 MEV)	0.000	CPS	X
CH	4	(0.047 MEV)	0.000	CPS	X
CH	5	(0.059 MEV)	0.000	CPS	X
CH	6	(0.071 MEV)	0.000	CPS	X
CH	7	(0.083 MEV)	0.000	CPS	X
CH	8	(0.095 MEV)	0.000	CPS	X
CH	9	(0.106 MEV)	0.000	CPS	X
CH	10	(0.118 MEV)	0.000	CPS	X
CH	11	(0.130 MEV)	0.000	CPS	X
CH	12	(0.142 MEV)	0.000	CPS	X
CH	13	(0.154 MEV)	0.000	CPS	X
CH	14	(0.165 MEV)	0.000	CPS	X
CH	15	(0.177 MEV)	0.000	CPS	X
CH	16	(0.189 MEV)	0.000	CPS	X
CH	17	(0.201 MEV)	0.000	CPS	X
CH	18	(0.213 MEV)	172.114	CPS	*****
CH	19	(0.225 MEV)	176.829	CPS	*****
CH	20	(0.237 MEV)	154.959	CPS	*****
CH	21	(0.248 MEV)	137.500	CPS	*****
CH	22	(0.260 MEV)	125.113	CPS	*****
CH	23	(0.272 MEV)	122.587	CPS	*****
CH	24	(0.284 MEV)	118.613	CPS	*****
CH	25	(0.296 MEV)	105.747	CPS	*****
CH	26	(0.307 MEV)	104.835	CPS	*****
CH	27	(0.319 MEV)	102.027	CPS	*****
CH	28	(0.331 MEV)	86.545	CPS	*****
CH	29	(0.343 MEV)	84.171	CPS	*****
CH	30	(0.355 MEV)	80.732	CPS	*****
CH	31	(0.367 MEV)	78.279	CPS	*****
CH	32	(0.378 MEV)	85.291	CPS	*****
CH	33	(0.390 MEV)	78.825	CPS	*****
CH	34	(0.402 MEV)	70.956	CPS	*****
CH	35	(0.414 MEV)	73.614	CPS	*****
CH	36	(0.426 MEV)	76.877	CPS	*****
CH	37	(0.437 MEV)	78.956	CPS	*****
CH	38	(0.449 MEV)	78.315	CPS	*****
CH	39	(0.461 MEV)	86.096	CPS	*****
CH	40	(0.473 MEV)	96.117	CPS	*****
CH	41	(0.485 MEV)	108.620	CPS	*****
CH	42	(0.497 MEV)	109.491	CPS	*****
CH	43	(0.509 MEV)	113.727	CPS	*****
CH	44	(0.520 MEV)	107.962	CPS	*****
CH	45	(0.532 MEV)	105.747	CPS	*****
CH	46	(0.544 MEV)	64.157	CPS	*****
CH	47	(0.556 MEV)	51.713	CPS	*****
CH	48	(0.568 MEV)	15.025	CPS	*****
CH	49	(0.579 MEV)	42.061	CPS	*****
CH	50	(0.591 MEV)	33.769	CPS	*****
CH	51	(0.603 MEV)	31.001	CPS	*****
CH	52	(0.615 MEV)	32.399	CPS	*****
CH	53	(0.627 MEV)	31.137	CPS	*****
CH	54	(0.638 MEV)	34.748	CPS	*****
CH	55	(0.650 MEV)	35.389	CPS	*****
CH	56	(0.662 MEV)	37.459	CPS	*****
CH	57	(0.674 MEV)	31.659	CPS	*****
CH	58	(0.686 MEV)	29.947	CPS	*****
CH	59	(0.697 MEV)	29.947	CPS	*****
CH	60	(0.709 MEV)	31.901	CPS	*****
CH	61	(0.721 MEV)	29.149	CPS	*****
CH	62	(0.733 MEV)	28.988	CPS	*****
CH	63	(0.745 MEV)	25.855	CPS	*****
CH	64	(0.756 MEV)	28.488	CPS	*****
CH	65	(0.768 MEV)	25.907	CPS	*****
CH	66	(0.780 MEV)	27.685	CPS	*****
CH	67	(0.792 MEV)	25.313	CPS	*****
CH	68	(0.804 MEV)	29.799	CPS	*****
CH	69	(0.816 MEV)	26.652	CPS	*****
CH	70	(0.827 MEV)	19.049	CPS	*****
CH	71	(0.839 MEV)	24.796	CPS	*****
CH	72	(0.851 MEV)	29.017	CPS	*****
CH	73	(0.863 MEV)	23.568	CPS	*****
CH	74	(0.875 MEV)	25.874	CPS	*****
CH	75	(0.887 MEV)	23.469	CPS	*****
CH	76	(0.899 MEV)	20.142	CPS	*****
CH	77	(0.910 MEV)	20.440	CPS	*****
CH	78	(0.922 MEV)	22.125	CPS	*****
CH	79	(0.935 MEV)	19.789	CPS	*****
CH	80	(0.946 MEV)	18.444	CPS	*****
CH	81	(0.957 MEV)	16.881	CPS	*****
CH	82	(0.969 MEV)	20.895	CPS	*****
CH	83	(0.981 MEV)	23.598	CPS	*****
CH	84	(0.993 MEV)	19.973	CPS	*****
CH	85	(1.005 MEV)	22.230	CPS	*****
CH	86	(1.017 MEV)	20.641	CPS	*****
CH	87	(1.028 MEV)	20.892	CPS	*****
CH	88	(1.040 MEV)	18.040	CPS	*****
CH	89	(1.052 MEV)	21.165	CPS	*****
CH	90	(1.064 MEV)	21.564	CPS	*****
CH	91	(1.076 MEV)	18.433	CPS	*****
CH	92	(1.087 MEV)	18.311	CPS	*****
CH	93	(1.099 MEV)	15.744	CPS	*****
CH	94	(1.111 MEV)	16.970	CPS	*****
CH	95	(1.123 MEV)	15.104	CPS	*****
CH	96	(1.134 MEV)	14.600	CPS	*****
CH	97	(1.146 MEV)	13.177	CPS	*****
CH	98	(1.158 MEV)	16.271	CPS	*****
CH	99	(1.170 MEV)	17.509	CPS	*****
CH	100	(1.182 MEV)	17.487	CPS	*****
CH	101	(1.194 MEV)	17.838	CPS	*****
CH	102	(1.206 MEV)	19.030	CPS	*****
CH	103	(1.217 MEV)	14.178	CPS	*****
CH	104	(1.229 MEV)	18.193	CPS	*****
CH	105	(1.241 MEV)	18.241	CPS	*****
CH	106	(1.253 MEV)	15.496	CPS	*****
CH	107	(1.265 MEV)	14.376	CPS	*****
CH	108	(1.277 MEV)	15.190	CPS	*****
CH	109	(1.288 MEV)	13.926	CPS	*****
CH	110	(1.300 MEV)	15.915	CPS	*****
CH	111	(1.312 MEV)	15.690	CPS	*****
CH	112	(1.324 MEV)	15.981	CPS	*****
CH	113	(1.336 MEV)	13.433	CPS	*****
CH	114	(1.347 MEV)	16.528	CPS	*****
CH	115	(1.359 MEV)	15.344	CPS	*****
CH	116	(1.371 MEV)	14.814	CPS	*****
CH	117	(1.383 MEV)	15.920	CPS	*****
CH	118	(1.395 MEV)	13.883	CPS	*****
CH	119	(1.407 MEV)	14.397	CPS	*****
CH	120	(1.419 MEV)	10.884	CPS	*****
CH	121	(1.430 MEV)	16.133	CPS	*****
CH	122	(1.442 MEV)	10.102	CPS	*****
CH	123	(1.454 MEV)	12.508	CPS	*****
CH	124	(1.466 MEV)	15.394	CPS	*****
CH	125	(1.477 MEV)	10.998	CPS	*****
CH	126	(1.489 MEV)	14.453	CPS	*****
CH	127	(1.501 MEV)	12.642	CPS	*****
CH	128	(1.513 MEV)	15.430	CPS	*****
CH	129	(1.525 MEV)	15.116	CPS	*****
CH	130	(1.537 MEV)	13.989	CPS	*****
CH	131	(1.548 MEV)	16.111	CPS	*****
CH	132	(1.560 MEV)	14.320	CPS	*****
CH	133	(1.572 MEV)	17.051	CPS	*****
CH	134	(1.584 MEV)	13.349	CPS	*****
CH	135	(1.596 MEV)	13.793	CPS	*****
CH	136	(1.608 MEV)	14.310	CPS	*****
CH	137	(1.619 MEV)	3.485	CPS	*****
CH	138	(1.631 MEV)	11.972	CPS	*****
CH	139	(1.643 MEV)	12.681	CPS	*****
CH	140	(1.655 MEV)	4.290	CPS	*****
CH	141	(1.667 MEV)	13.829	CPS	*****
CH	142	(1.678 MEV)	11.729	CPS	*****
CH	143	(1.690 MEV)	1.918	CPS	*****
CH	144	(1.702 MEV)	12.025	CPS	*****
CH	145	(1.714 MEV)	14.498	CPS	*****
CH	146	(1.726 MEV)	2.799	CPS	*****
CH	147	(1.738 MEV)	10.698	CPS	*****
CH	148	(1.749 MEV)	9.880	CPS	*****
CH	149	(1.761 MEV)	10.666	CPS	*****
CH	150	(1.773 MEV)	9.306	CPS	*****
CH	151	(1.785 MEV)	9.212	CPS	*****
CH	152	(1.797 MEV)	12.055	CPS	*****
CH	153	(1.808 MEV)	11.861	CPS	*****
CH	154	(1.820 MEV)	9.780	CPS	*****
CH	155	(1.832 MEV)	11.915	CPS	*****
CH	156	(1.844 MEV)	9.863	CPS	*****
CH	157	(1.856 MEV)	10.289	CPS	*****
CH	158	(1.868 MEV)	12.619	CPS	*****
CH	159	(1.879 MEV)	10.527	CPS	*****
CH	160	(1.891 MEV)	11.111	CPS	*****
CH	161	(1.903 MEV)	10.913	CPS	*****
CH	162	(1.915 MEV)	10.659	CPS	*****
CH	163	(1.927 MEV)	1.127	CPS	*****
CH	164	(1.938 MEV)	10.898	CPS	*****
CH	165	(1.950 MEV)	10.456	CPS	*****
CH	166	(1.962 MEV)	11.140	CPS	*****
CH	167	(1.974 MEV)	10.627	CPS	*****
CH	168	(1.986 MEV)	10.712	CPS	*****
CH	169	(1.998 MEV)	10.880	CPS	*****
CH	170	(2.009 MEV)	10.003	CPS	*****
CH	171	(2.021 MEV)	9.218	CPS	*****
CH	172	(2.033 MEV)	10.580	CPS	*****
CH	173	(2.045 MEV)	10.742	CPS	*****
CH	174	(2.057 MEV)	9.416	CPS	*****
CH	175	(2.069 MEV)	9.929	CPS	*****
CH	176	(2.080 MEV)	11.359	CPS	*****
CH	177	(2.092 MEV)	9.484	CPS	*****
CH	178	(2.104 MEV)	9.442	CPS	*****
CH	179	(2.116 MEV)	8.592	CPS	*****
CH	180	(2.128 MEV)	9.467	CPS	*****
CH	181	(2.139 MEV)	10.618	CPS	*****
CH	182	(2.151 MEV)	10.421	CPS	*****
CH	183	(2.163 MEV)	9.586	CPS	*****
CH	184	(2.175 MEV)	10.214	CPS	*****
CH	185	(2.187 MEV)	11.148	CPS	

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

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

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

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

KC = uncorrected system count rate for the K channel
 UC = uncorrected system count rate for the U channel
 TC = uncorrected system count rate for the T channel
 K = the percent differential concentration of potassium
 U = ppm differential concentration of uranium
 T = ppm differential concentration of thorium

We also define the following:

ζ_{kk} = sensitivity of KC to concentrations of K
 ζ_{ku} = sensitivity of KC to concentrations of U
 ζ_{kt} = sensitivity of KC to concentrations of T

ζ_{uk} = sensitivity of UC to concentrations of K
 ζ_{uu} = sensitivity of UC to concentrations of U
 ζ_{ut} = sensitivity of UC to concentrations of T
 ζ_{tk} = sensitivity of TC to concentrations of K
 ζ_{tu} = sensitivity of TC to concentrations of U
 ζ_{tt} = sensitivity of TC to concentrations of T

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

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

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

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

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

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

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

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

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

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

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

Separating these equations into consistent groups we get

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

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

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

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

The equations can be expressed in matrix form

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

Where the K, U and T subscripts represent the K, U and T pads.

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

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

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

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

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

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

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

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

$$\begin{aligned} K_m &= \Delta_{kk} \left(KC_m + \frac{\Delta_{ku}}{\Delta_{kk}} UC_m + \frac{\Delta_{kt}}{\Delta_{kk}} TC_m \right) \\ U_m &= \Delta_{uu} \left(UC_m + \frac{\Delta_{ut}}{\Delta_{uu}} TC_m + \frac{\Delta_{uk}}{\Delta_{uu}} KC_m \right) \\ T_m &= \Delta_{tt} \left(TC_m + \frac{\Delta_{tu}}{\Delta_{tt}} UC_m + \frac{\Delta_{tk}}{\Delta_{tt}} KC_m \right) \end{aligned}$$

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

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

$$\begin{aligned} S_{ku} &= - \frac{\Delta_{ku}}{\Delta_{kk}} \quad (\text{effect of uranium on potassium}) \\ S_{kt} &= - \frac{\Delta_{kt}}{\Delta_{kk}} \quad (\text{effect of thorium on potassium}) \\ S_{ut} &= - \frac{\Delta_{ut}}{\Delta_{uu}} \quad (\text{effect of thorium on uranium}) \\ S_{uk} &= - \frac{\Delta_{uk}}{\Delta_{uu}} \quad (\text{effect of potassium on uranium}) \end{aligned}$$

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

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

ATMOSPHERIC RADON CORRECTION

Consider the crystal configuration shown below:

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

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

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

therefore
$$I_2 = \ell I_g + m I_a + A_2 + C_2$$

Where m is the detector geometry constant for 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 describing I_1 and I_2 . 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
$$\ell = \frac{I_2}{I_1}$$

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" (i.e. gamma rays from the surrounding terrain bypassing the shielding) on the test pads, as altitude increases, ℓ should decrease, thus $\ell = f(h)$.

Only the factor m remains to be determined. This unfortunately can not 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

$$I_1 = I_g + I_a + A_1 + C_1$$

$$I_2 = \ell I_g + m I_a + A_2 + C_2$$

Over water $I_g = 0$

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

Remove the A's and C's from the over water data and we are left with

$$I_1 = I_a$$

$$I_2 = m I_a$$

The constant for the detector geometry, m , is best determined if Radon is 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 .

$$I_1 = I_g + I_a$$

$$I_2 = \ell I_g + m I_a$$

$$m I_a = I_2 - \ell I_g$$

but $I_g = I_1 - I_a$

then $I_a (m-l) = I_2 - lI_1$

or $I_a = \frac{I_2 - lI_1}{m - l} = \text{Bi Air}$

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

DATA PREPARATION

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

Data Recording

The data recorded on a digital recording system on a geophysical survey aircraft always include data parameter values and fiducial numbers, the latter synchronized with the camera. In addition to these variables, other data are recorded including radar and barometric altitude, temperature, time, manually inserted data such as flight line number, direction, and survey designation.

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 about the peak channel of that window. The data are also checked for correct scan lengths, proper justification of data fields within each scan and live time calculations are made. During this process, the desired window data fields are compared with the sum over the same windows in the spectra and then extracted from each scan and re-written as a reformatted copy tape.

The reformatted tape data are then edited, checked and corrected. The data for an entire flight line are read into memory (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 printed out and further checked 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 tying.

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 digitized data are then computer plotted at the same scale as the base map. This map is compared to the recovered flight path map and any errors are corrected. The fiducial numbers at each spotted location are then merged with the digitized data and again checked by calculating the distance per fiducial (ground speed) between each pair of digitized locations.

RADIOMETRIC DATA REDUCTION

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

1. Field data verification and edit
2. Spectrum stabilization
3. Dead time correction
4. Data summing to present 1.0 second sample interval (data were collected at 0.5 second sample interval).
5. Aircraft and cosmic background correction
6. Compton stripping
7. Radon correction
8. Statistical Adequacy Test
9. Altitude correction
10. Data plots
11. Statistical analysis

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

Total count - 0.4 to 3.0 MeV

K - 1.32 to 1.64 MeV

U - 1.05 to 1.32 MeV
1.64 to 2.41

T - 2.41 to 2.79 MeV

Cosmic - 3 to 6 MeV

DATA PROCESSING FLOW DIAGRAM

Figure 10

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

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

of statistically adequate data

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

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

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

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

$$S_{ku} = 0.339$$

$$S_{kt} = 0.171$$

$$S_{ut} = 1.39$$

$$S_{uk} = 0.55$$

$$S_{tu} = 0.021$$

$$S_{tk} = -0.011$$

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

All parameters except for S_{ut} are considered constants. S_{ut} was considered an altitude dependent parameter utilizing the following expression (after Grasty 1975).

$$S_{ut} = S_{ut_0} + 0.0076h \quad \text{where } h \text{ is the altitude in hundreds of feet.}$$

Altitude attenuation coefficients used are defined as follows:

$$\mu_{TC} = (-0.00165) \text{ per foot}$$

$$\mu_K = (-0.00244) \text{ per foot}$$

$$\mu_U = (-0.00113) \text{ per foot}$$

$$\mu_T = (-0.00179) \text{ per foot}$$

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

$$\exp[\mu_i (400-h)]$$

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

Bi Air calculations are made using the following expression:

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

where R_{up} = count rate from upward detectors

ℓ = crystal coupling constant

m = crystal geometric factor

$C'_{uk}, C'_{ut}, C'_{uu}$ = crystal coupling 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} , C'_{ut} , and C'_{uu} are given below:

$$C'_{uk} = 0.03554$$

$$C'_{uu} = 0.05540$$

$$C'_{ut} = 0.1066$$

$$l = 0.0666 - 0.0000318 (h), \text{ where } h \text{ is in feet}$$

$$m = 0.325 - 0.00005 (h), \text{ where } h \text{ is in feet}$$

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

MAGNETIC DATA REDUCTION

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

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

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

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

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

STATISTICAL ANALYSIS

STATISTICAL ADEQUACY TEST

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

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

Setting of these actual levels in counts per second for each elemental window is difficult at best since a full analysis of all parameters affecting the resultant count rate is virtually impossible (i.e., all parameters are not known to a sufficient degree of certainty). We do know, however, that in general, most of the errors which accumulate in the data can be ascribed to the corrections applied, if these corrections are a significant portion of the count rate. The corrections applied to these data are distributed in a Poisson manner and the following assumptions concerning these are made:

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

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

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

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

The results of this statistical adequacy test are then utilized to determine an optimum interval over which the data should be averaged (e.g., 5 second or 7 seconds, etc.) in order to reduce the number of statistically inadequate samples to 5% or lower. In the case of this project, the resulting averaging sample interval was 5 seconds. This resulted in 97% or better of all data defined to be statistically adequate, exclusive of those data which were outside of altitude specifications. (The overall altitude specification was maintained at the 95% level).

HYPOTHESIS TESTING

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

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

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

In addition to this hypothesis test, all data are plotted in histogram format and the mean, median, and standard deviation of that histogram distribution calculated. Each radiometric parameter for a given geologic type is then classified as either a normal or log normal distribution. The measure of central tendency and dispersion for each of these distributions is then utilized as a basis for determining which data are anomalous within a given unit. A sample of such a histogram and distribution is presented in Figure 11.

BIG BEND AREA - GEOMETRICS

1977

Figure 11. Sample Histogram

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 a group of data presented in the form of radiometric profiles, flight path recovery maps, anomaly maps and histograms. Microfiche data listings are contained in Appendix G of this volume and data tapes are available separately.

RADIOMETRIC PROFILES

Stacked profiles were prepared for the averaged data for each traverse and tie line. These stacked profiles, plotted at a linear scale of 1:250,000, contain the following parameters; corrected Total Count, corrected Potassium, corrected Uranium, corrected Thorium, U/TH, U/K and TH/K ratios, Bi Air, radar altimeter, and magnetometer data. Each of the stacked profile sheets contains a plot of the flight path superimposed on a topographic strip with geology over which the aircraft flew. The geologic information was obtained from the published map sheets for this area. 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 that specific flight line within the boundaries of the specified NTMS Quadrangle sheet.

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

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

MAGNETIC PROFILES

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

Figure 12 Plotter Step Value Labeling

FLIGHT PATH MAPS

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

ANOMALY MAPS

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

These maps have been generated at a scale of 1:250,000 for each of the NTMS sheets and are superimposed on the geologic maps of the survey area. In addition, these anomaly maps are presented in Volume II of this report at a reduced scale of approximately 1:500,000.

HISTOGRAMS

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

DATA LISTINGS

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

1. Fiducial number
2. Quality - this defines the results of statistical adequacy testing for altitude, potassium, uranium, and thorium. A value of 0 indicates the data are statistically adequate. A value of 1 indicates that the data are statistically inadequate. Data collected in excess of 700 and less than 200 feet are considered statistically inadequate).
3. Time - time presented in hours, minutes and seconds.
4. Altitude - altitude presented in feet above terrain.
5. LAT/LONG - latitude and longitude presented in terms of decimal degrees.
6. Magnetic field expressed in residual gammas.
7. Geology - code representing geologic units.
8. K, U, T - count rate of corrected K, U, T data.
9. U/Th, U/K, Th/K - calculated ratios of the various parameters.
10. Total Count - corrected total count data (0.4 to 3.0 MeV).
11. COS - downward looking cosmic count rate in the 3-6 MeV channel.
12. Uair - atmospheric Bi-214 count rate.
13. Temperature - outside air temperature in degrees centigrade.
14. Press - barometric pressure in inches of mercury.

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

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

3. LAT/LONG - latitude and longitude presented in terms of decimal degrees.
4. Magnetic field expressed in residual gammas.
5. Geology - code representing geologic units.
6. K, U, T - count rate of corrected K, U, T data and the integer number of signal (+) standard deviations from the mean.
9. U/Th, U/K, Th/K - calculated ratios of the various parameters, and the integer number of signal (+) 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 E.

DATA INTERPRETATION

METHODOLOGY

Since the objective of the NURE Program is to evaluate the uranium potential of the United States, a first step in achieving this is to conduct airborne reconnaissance surveys. These reconnaissance surveys provide direct aid in the evaluation of a project area's uranium potential. As a result, the major portion of the interpretation was oriented toward detecting anomalous high concentrations of uranium minerals. To accomplish this, the profile data were located by geological units (as described previously), histograms were produced and statistical analysis performed. Each variable for each rock type was examined for the central tendency for that distribution; that is, the counts most frequently observed over that particular rock unit and variable. No statistical tests were performed on rock units having less than 20 valid samples after testing for statistical adequacy. For many rock units the best estimate of central tendency for a particular variable was the median and not the arithmetic mean. In no case was the mode used as the measure of central tendency unless it was coincident with the median. Each central record of a 5 sample average was plotted with corresponding standard deviation and is presented as the anomaly map for that variable.

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

1. Ten consecutive corrected Bi_{214} samples lying two standard deviations above the mean (median). (Actually two samples from anomaly maps since every fifth point is plotted).
-and....
2. Ten consecutive U/Th ratios lying two standard deviations above the mean (median).
3. The U/Th ratio defined in (2) must have a corresponding thorium value lying at least greater than minus one standard deviation below the mean. If the thorium sample is less than one standard deviation below the mean, the U/Th ratio is considered questionable.

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

Each series of stacked profiles was overlain on the geologic map and anomaly maps to delineate trends and to perform a more detailed analysis of individual anomalies. The interpretation was concentrated on detection of anomalous uranium counts with subtle geological trends as reflected in the gamma ray profiles examined only in a cursory manner. However, the profiles clearly indicate that the spectrometer system is highly sensitive to changes in gross lithology even in areas of low counting rates. For example, changes from limestones to anhydrites within the Permian units such as PCS, PCC, PBC, and PRU are reasonably clear. The system is also sensitive to changes between Quaternary deposits such as QB (bolson deposits) and QF (alluvial fan) deposits and QWS (eolian sand) deposits. Thus, there is a real potential for performing general geochemical analysis on a formation (or soil) basis as opposed to just anomaly hunting for radioactive minerals.

VAN HORN-EL PASO QUADRANGLE

This 1:250,000 quadrangle encompasses two separate and distinct geological structural provinces. The first occupies the eastern third of the quadrangle and corresponds to the westernmost edge of the Permian Delaware Basin which contains sediment thicknesses of up to 10,000 feet dipping to the east. The basin is terminated on the west by the north, north-west trending Delaware anticline (forming the Delaware Mountains). West of this anticlinal structure lies the second major province, the Diablo Platform. A graben-like feature, the Salt Basin, separates the Diablo Platform (in the west) and the Delaware anticline (in the east). Superimposed on the Diablo Platform are the Hueco Mountain uplift in the northwest and the Van Horn uplift in the south. Geological structure within the Diablo Platform trends generally northwest to west-northwest with some north-south faulting in the Hueco Mountains, and thrust faults in the southern portion of the platform.

Outcropping rocks of the Delaware Basin are mostly thick sections of anhydrites, gypsum, limestones, and marls with lesser amounts of sandstones, shales and siltstones. The Salt Basin (Salt Flat) which cuts the quadrangle approximately in half, is an intermontaine basin with Quaternary alkaline flats, bolson type deposits and extensive wind blown sand deposits. West of the Salt Basin, the uplifted Diablo Platform contains thick sequences of Cretaceous sediments (mostly limestones), and some exposed Permian and older Paleozoic sediments (Hueco Mountains). Within the south central portions of the platform, Precambrian rocks are exposed in the Carrizo Mountains and Beach Mountains. A small outcrop of Precambrian rhyolites lies south of the Sierra Pintá. Quaternary deposits account for approximately 50% or more of the exposures west of the Delaware Mountains compared to the predominant Permian exposures lying to the east.

Within the Diablo Platform there are several exposures of Tertiary intrusive rocks and some associated volcanics. Examples are: Quitman Mountains, the Sierra Blanca, Little Round Top, Sierra Prieta, Red Hill, Granite Mountain, Cerro Diablo, Sierra Pintá and Dog Mountain.

INTERPRETATION-DISCUSSION & RESULTS (VAN HORN)

This interpretation was conducted as described in the methodology section. The resultant Uranium Anomaly/Interpretation Map is shown in Figure 13. Uranium anomalies depicted are summarized in Table 1. Figures 14 through 17 present the Pseudo contour maps prepared for the regional overview (Tables 2 and 3 show print Character Value). All geologic symbol definitions are presented in Appendix A. Statistical tables defining the distribution type, measure of central tendency and standard deviation data for these rock types are shown in Appendix B.

In general, the area east of the Delaware Mountains comprising the Permian Delaware Basin had relatively low counting rates in all respective channels and attendant high ratios due to statistical noise. Occasional high counting rates within the limestone (Permian and Cretaceous) and evaporite sections are probably correlateable with shale units within the formations and are not indicative of any worthwhile radioactive concentrations (for example note the elevated counts over Kbs on line 2-0). On the eastern end of line 6-0 crossing the Reeves-Berson County line, large variable ratios due to low counting rates abruptly change to low, uniform ratios over higher counting rates. This particular area is interesting as the corresponding rocks (Qao, Qal) suggest no lithologic change.

Uranium anomalies displayed on the interpretation map in the eastern area are questionable indicators of uranium mineralization due to the low counting rates and corresponding lithologies present but are included as they meet the minimum requirements.

Lines 12-0, 15-0 and 16-0 have high atmospheric bismuth count rates of 175 to 200 counts per second which correspond to a topographic low in the Salt Basin against the western Sierra Diablo Mountains. The generally erratic, high amplitude ratios over the Salt Basin are due to low counting rates and accompanying statistical noise.

The highest count rates observed in the quadrangle are over Tertiary Intrusives and volcanics (which is to be expected). Some examples are: the Sierra Prieta with a uranium high of 291 counts per second, thorium high of 169 counts per second which implies approximately 6 ppm equivalent uranium and 26 ppm equivalent thorium or roughly the normal 4 to 1 ratio expected within acidic rocks. Over the Tertiary Intrusives crossed by profile 23-0, corresponding to San Antonio Mountain, Chatfield Mountain, Wasburn Mountain, etc., a uranium high of 668 counts per second and a thorium high of 427 counts per second were recorded which yield 14 ppm equivalent uranium and 65 ppm equivalent thorium. The rough 4 to 1 normal ratio is still present but the actual ppm are somewhat anomalous compared with other Tertiary Intrusive units such as at Dog Mountain and Sierra Tinaja Pinta.

Anomalously low thorium to potassium anomalies are present over several of the Tertiary Intrusives (See interpretation map. Figure 13). The most promising one, anomaly #4 (lines 20-0) is over the Sierra Tinaja Pinta and indicates potassium enrichment and possible hydrothermal alterations. Over Granite Mt (line 12-0)

— INFERRED MAGNETIC FAULTS
 + MAGNETIC BASEMENT HIGHS
 U Th/K U+Th
 [] MAGNETIC BODY

INTERPRETATION MAP

BIG BEND AREA, TEXAS

U.S. DEPARTMENT OF ENERGY

TABLE 1

VAN HORN - EL PASO URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Geology Type	Number of Data Samples (X5) With Defined σ																
				-5 σ	-4 σ	-3 σ	-2 σ	-1 σ	0	1 σ	2 σ	3 σ	4 σ	5 σ	6 σ	7 σ	8 σ	9 σ	10 σ	11 σ
* 1a	U&Th	7-0	Qao, Qal								7	5	4	1	3	1	1	2	4	
b	U&Th	8-0	Kf?, Qao, Qal								1	2	3		1	2				
1a	Th	7-0	Kf?, Qao, Qal							2	2	7	11	6		3	3			2
b	Th	8-0	Kf?, Qal, Qal							3	1	2	2	1	2	1	1	1	1	3
* 2	U & Th/K	12-0	Qal, Kcx, Ti			1		6		1	1	1								
* 3	U	1004-0	K, Qal, Pl							5	3									
* 4	U	1004-0	Qao								2									
5	U	4-1	Qao							1			1							
6	Th/K	1-0	Pccs, Pcci					5												
7	U	2-0	Qf							1	3									
8	U	1006-0	Qal, Pcv							3	1		1							
9	U	2-0	Qf							3	3									
10	U	4-1	Qws									3								
11	U	3-1	Qws							3	4									
12	Th/K	5-1	Ti					1	2											
13	U	4-1	Qc, Pcn								2									
14	U	3-1	Qao, Qal							2	2		2	1	1					
15	U	6-1	Qws							2	1									
16	U	4-1	Qal										3	3	1					
17	U	5-1	Qal							2	2									
18	U	1004-0	Kf, Qal							1	3	1								
19	U	7-0	Qal								1	1	1	1						
20	U	6-1	Ph, Pch							2	2	1								
21	U	2-0	Qws							3	4									
22	U	3-0	Qao, Kf?								1		1							
23	U	3-0	Qao, Kcx?							1	2									
24	U	6-1	Ph, Pbs -							2	1	1								
25	U	1007-0	Qb							1	3									
26	U	13-1	Pdb							1	1	2								

TABLE 1

VAN HORN - EL PASO URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Geology Type	Number of Data Samples (X5) With Defined σ																
				-5 σ	-4 σ	-3 σ	-2 σ	-1 σ	0	1 σ	2 σ	3 σ	4 σ	5 σ	6 σ	7 σ	8 σ	9 σ	10 σ	11 σ
27	U	1005-0	Qal								2	1								
28	U/Th	10-1	Pcs								1	2	1							
29	U/Th	12-0	Qb								2		1							
30	U	1006-0	Qws							1	4									
31	U	12-0	Pdb								2	2	1							
32	U	1008-0	Qal, Pbc								5	1								
33	U	1007-0	Pcc							2	2	2	1							
34	U	1007-0	Pcc							1	2	1								
35	U	1007-0	Pcc							1	2									
36	U	19-0	Pcc, Pdb				1			2	1	1								
37	U	20-0	Qal, Pcc, Pdb								3									
38	U	21-0	Pcs							3	2									
39	U	21-0	Qal, Pcs							2	2									
40	U	1004-0	Pvc, Qal							1	2									
41	U	1003-0	Kcg							2	2									
42	U	21-1	Qal, Ph							1	3									
43	U	22-0	Qal, Ph							2	2									
44	U	22-0	Qal, Qws							2	1	1								
45	U	23-0	Pvc							2	2									
46	Th/K	1003-0	Ti, Ql				1	2												
47	Th/K	20-0	Ti, Ph				2	3												
48	Th/K	4-1	Pca, Pch				2	3												
49	Th/K	1006-0	Pcv, Qal ?				2	1

Figure 15. Van Horn Quadrangle Uranium Pseudo-Contour Map*

Figure 16. Van Horn Quadrangle Thorium Pseudo-Contour Map*

TABLE 2
Print Character Values For
Pseudo-Contour Maps - K, U, T

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

TABLE 3

Print Character Value For
Pseudo-Contour Maps - Magnetic

<u>Print Character</u>	<u>Value (gammas)</u>
0	Less than -400
Blank	-400 - -350
1	-350 - -300
Blank	-300 - -250
2	-250 - -200
Blank	-200 - -150
3	-150 - -100
Blank	-100 - -50
4	-50 - 0
Blank	0 - 50
5	50 - 100
Blank	100 - 150
6	150 - 200
Blank	200 - 250
7	250 - 300
Blank	300 - 350
8	350 - 400
Blank	400 - 450
9	450 - 500
Blank	Greater than 500

anomaly #2 is a combination of a small uranium peak and a negative thorium to potassium ratio. This is a promising correlation for possible mineralization but not necessarily uranium. Anomaly #3 over Qal, Permian limestones and undivided Cretaceous sediments is near the Red Hill Tertiary Intrusive which is a potential uranium source rock.

Over the Bonanza Mine (line 5-1) the negative thorium to potassium anomaly may be correlatable with possible mineralization, but not uranium mineralization.

The negative thorium to potassium ratios (Anomalies 6 and 48) present over the Carrizo Mountains coincide with high potassium counting rates. These correlate with Precambrian units (PCCI, PCCS, PCA, PCH) and probably indicate the metamorphic grade of the rocks. Uranium anomaly #8, between #6 and 48 is possibly indicative of uranium enrichment, but may only be a relative concentration of Precambrian detritus in alluvium.

The maximum counting rates (anomaly #1) within the quadrangle are on line 7-0 within QAO, (older alluvium) on the Blanca Flats between Sierra Blanca and Round Top Mountain (Tertiary Intrusives). A uranium counting peak of 1250 counts per second and a thorium peak rate of 1042 counts per second imply 26 ppm equivalent uranium, and 160 ppm equivalent thorium. The corresponding uranium/thorium ratios are normal and imply no relative enrichment of uranium. The very high count rates and ppm indicate this is a thorium rich alluvial deposit. It may possibly be composed of mechanically concentrated grains of monazite or thorium rich zircon (thorite) and other heavy minerals eroded from nearby igneous intrusions. A very high Bi Air count rate of 216 counts per second accompanies this major anomaly. The anomaly can also be seen on lines 6-1, 8-0, 1003-0 and thus has a large areal extent. It lies on a steep magnetic gradient, offset to the east where a second higher amplitude magnetic anomaly occurs over the alluvial flats east of the main radiometric anomaly. Thus the potential source rock, the igneous intrusive, may extend to the east and be downfaulted, but at a relatively shallow depth below the alluvial surface.

Quaternary unit Qws, windblown sand, has several minimal uranium anomalies within this quadrangle. This may be due to concentrations of coarser material in lag deposits as well as reflecting nearby sources. A good example is Anomaly #44 near a small outcrop of Ti (Tertiary Intrusive).

The magnetic contour map (Figure 17) indicates the majority of the Tertiary Intrusives fall on a north-west trending inferred magnetic fault. The uplifted Hueco Mountains, of Paleozoic age, are on a magnetically high, perhaps up faulted, basement block. The north, north-west trending structure of the Delaware Mountains is quite clear on the magnetic map and the very low gradients commencing immediately to the east reflect the beginning of the deep Delaware Basin. In the southeast corner of the magnetic map at approximately $31^{\circ} 15'$ north and $104^{\circ} 15'$ west, a north trending, positive magnetic anomaly is indicative of relatively shallow magnetic basement and may be a continuation of the Tertiary volcanic exposed in the very southeast corner.

PECOS QUADRANGLE

Three discrete structural provinces lie within the 1:250,000 Pecos Quadrangle. The western third of the quadrangle is occupied by the deepest portion of the northwest-southeast trending Permian Delaware Basin. Sediment thicknesses range up to 20,000+feet and generally dip toward the basin axis. This basin is terminated to the east by the Central Basin Platform, a structural high which occupies the center of the map. This feature, subparallel to the Delaware Basin, comprises a number of subset structural highs and lows. East of the platform lies the third province, the western margin of the Permian Midland Basin. The margin is characterized by a series of subparallel normal faults, structural depressions and up-lifts. These structures are not readily apparent from an examination of the surficial geology, as most faulting and other structural details were derived from intensive subsurface exploration.

Very little of the thick Cretaceous and older sections of limestone, sandstone, shales, and siltstone are exposed within the quadrangle. Where outcrops do occur, they are usually windows within a pervasive mantle of alluvium. Surficial geology is characterized by several subdivisions of Recent through Pliocene materials. The central portion of the Delaware basin is essentially an alluvial flat exhibiting limited dissection, while the flanks of the basin exhibit more dissection.

The Central Basin Platform is likewise covered by predominantly Recent to Pliocene sediments such as extensive windblown sand, gypsite and caliche. Outcrops of Triassic shales, siltstones and sandstones occur predominantly on the western third of the quadrangle. The boundary between the Central Basin Platform and eastern Midland Basin is marked by a northwest-southeast trending narrow exposure of Cretaceous Fredricksburg Group and Antlers Sand. In the southeast corner of the quadrangle a complex of Mesozoic material is exposed on King Mountain and the mesas to the south. The Midland Basin is surficially typified by extensive wind-blown sand and calichified alluvium with scattered small exposures of Mesozoic material.

INTERPRETATION DISCUSSION & RESULTS (PECOS)

This interpretation was conducted as described in the methodology section. The resultant Uranium Anomaly/Interpretation Map is shown in Figure 18. Uranium anomalies depicted are summarized in Table 4. Figures 19 through 22 present the Pseudo contour maps prepared for the regional overview. All geologic symbol definitions are presented in Appendix C. Statistical tables defining the distribution type, measure of central tendency and standard deviation data for these rock types are shown in Appendix D.

Overall the Pecos sheet is typified by relatively low counting rates in all channels and artificially high ratios as a result of statistical noise. Despite the presence of a thick Mesozoic and Paleozoic sedimentary section and a number of structural complexities, exposed units are predominantly Pleistocene or younger. Scattered

SURVEY AND
COMPILED BY:
geometrics

INTERPRETATION MAP

BIG BEND AREA, TEXAS

U.S. DEPARTMENT OF ENERGY

TABLE 4

PECOS QUADRANGLE URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Geology Type	Number of Data Samples (X5) With Defined σ												
				-4 σ	-3 σ	-2 σ	-1 σ	0	1 σ	2 σ	3 σ	4 σ	5 σ	6 σ	7 σ	8 σ
* 1	U/Th	6-0	Qal						2	4	3					
* 2	U/Th	5-0	Qao, Qg, Qal, Qcc						5	7	2	1				
* 3	U/Th	21-0	Qs, Qcc						2	5						
4	U	2-0	Qal, Qt						1	2	2	2	2			
5	U	22-1	Qsd, Qsu						0	5	4	3	1			
6	U	22-1	Qsd, Qsu						1	1	3	4				
7	U	21-0	Qs, Qcc, Qg						3	2	2					
8	U	21-0	Qs						2	4						
9	U	21-0	Qsd, Qsu								3	7	5	1		
10	U	21-0	Qsd, Qsu						1	1	2	3	4			
11	U	20-0	Qcc, Qal						1	3						
12	U	20-0	Qsd, Qsu						1	4	3					
13	U	14-0	Qsd, Qsu						0	2	1	1				
14	U	14-0	Qsd						2	7	2					
15	U	14-0	Qsd						0	4	3					
16	U	13-0	Qsd						0	3	1					
17	U	13-0	Qsd, Qsu						2	24						
18	U	13-0	Qsd, Qsu						1	2	4	11	1			
19	U	13-0	Qsd						1	2	1	2				
20	U	12-0	Qsd, Qsu						1	1	5	1				
21	U	11-0	Qsd						0	5	11	7				
22	U	10-0	Qsd, Qp						0	0	0	0	1	0	0	1
23	U	10-0	Qs						1	3	1					
24	U	10-0	Qs						0	2	3					
25	U	9-1	Kfr, Qal, Qcs						2	4						
26	U	8-0	Qsd, Qta						0	0	2	1	2			
27	U	3-0	Qau, Qal						2	8	2					
28	U	2-0	Qao, Qal						5	7	2					
29	U	2-0	Qao, Qal						1	9	4					

TABLE 4

PECOS QUADRANGLE URANIUM AND THORIUM ANOMALY SUMMARY

Anomaly Number	Type	Line Number	Geology Type	Number of Data Samples (X5) With Defined σ												
				-4 σ	-3 σ	-2 σ	-1 σ	0	1 σ	2 σ	3 σ	4 σ	5 σ	6 σ	7 σ	8 σ
30	U	2-0	Qag, Qal, Qau, Kw						2	21	29	2				
31	U	2-0	Qal						2	20	5					
32	U	2-0	Qal						2	6						
33	U	2-0	Qal, Qau						3	21	5					
34	U	2-0	Qal, Qau						1	4						
35	U	1-0	Qag, Qal						0	5						
36	U	1-0	Qag, Kbo, Qal						4	5						
37	U	1-0	Qao, Qal						3	7	1					
38	U	1-0	Qao, TV						2	3						
39	U	1-0	Qao, Qal						2	16	18	1				
40	U	1-0	Qal						0	8	2					
41	U	1-0	Qao, Qal						0	3	1					
42	U	1-0	Qal						0	5	1					
43	U	1-0	Kfr, Qao, Qal						3	3	1					
44	U	1-0	Qs, Kfr, Qao						2	1	3	1				
45	U	1020-0	Qcc, Qcs, Qp						0	4	2	1				
46	U	1020-0	Qcc, Kfr						1	4	2					
47	U	1020-0	Ka, Qau, Qal						6	2	4	1				
48	U	1013-0	Qao, Qal						0	5						
49	U	1018-0	Qsd, Qsu					0	0	0	4					

* Preferred Anomaly (meets specification criteria)

Note: This Anomaly Summary presents a significant number of "non-preferred" anomalies which do not meet the defined criteria for anomaly selection. That is, no relative uranium enrichment exists. These are presented for information purposes only.

When U and Th anomalies overlap (and the U/Th shows no anomaly) only the U standard deviation values are reported.

Figure 19. Pecos Quadrangle Potassium Pseudo-Contour Map

Figure 20. Pecos Quadrangle Uranium Pseudo-Contour Map*

Figure 21. Pecos Quadrangle Thorium Pseudo-Contour Map

instances of relatively high counting rates are likely to be related to dissection of the alluvial cover and exposure of underlying shale or siltstone units within the predominantly carbonate section. Specifically, the uranium anomalies delineated on the interpretation map are questionable indicators of mineralization because of the surficial geology and low overall counting rates. They are displayed because they fit minimum anomaly recognition criteria. Conversely, portions of the southwest quadrangle corner with higher counting rates which do not directly fit the requirements are also included on the interpretation map.

Most of the Central Basin Platform and Midland Basin are radiometrically uninteresting, even over irregular terrain in the southeast such as King Mountain. It should be noted that structural provinces do exhibit contrasting radiometric behavior as displayed on the rough contour maps. Differences in counting rates within similar units are explainable if mapped units are so broadly defined that formations at one location differ lithologically from similar units elsewhere. Examination of the histograms, particularly for the potassium channel, clearly shows that multiple lithologies are present under several given formational designations such as Qal, Qao and Qau. This is best seen from the commonly bimodal nature of the potassium and thorium channels (See Figure 23). Such distributions create difficulties for statistical as well as qualitative analysis.

The degree to which underlying geology differs in structural and overall lithologic character from the surficial distributions is well illustrated by the contrast between magnetic contours (Figure 22) and the base map geology or even the uranium and thorium contours. Generally, magnetic trends obliquely transcend surficial geologic boundaries. On the other hand, the distribution of magnetic anomalies and the overall grain fit the structural provinces described in the geological summary. The northwest-southeast trend of the Delaware Basin axis is indicated by very long low gradients bordered by steeper gradients on the edges. The Central Basin Platform tends to be a broad magnetic high with a number of parallel and transverse anomalies superimposed on it. The Midland Basin appears to be more structurally complex and shallower than the Delaware Basin.

Based upon the stated criteria for statistically significant enrichment of eU over eTh, several preferred anomalies were culled from the Pecos sheet data. Anomaly 1, a well defined circular pattern on the uranium contour maps, occurs over unbroken alluvium (QAL) on line 6-0. Maximum count rates of 299 and 46 cps imply eU and eTh values of 6.3 ppm and 7.0 ppm respectively. This anomaly is characterized by a uranium peak about three times background. It is centered directly over a "plant" adjacent to the Blair Oil & Gas field and the Jamison Pollard Oil field. Either the air above the plant is relatively high in uranium or the "plant" associated materials have entered the adjacent soil. As the Bi Air count is not anomalous, the latter case is more likely. It is also possible that the anomaly predates the "plant". Note that not all "plants" shown on the Pecos sheet exhibit such phenomena, even those similarly associated with oil fields. If each processes oil only from a given field, then the oil (were it a source for this anomaly) may reflect a relatively enriched uranium reservoir rock worthy of further study if outcrops exist. However, this is pure speculation.

BIG BEND AREA - GEOMETRICS

1977

Figure 23. Bimodal Distribution
for K_{40}

Anomaly 2, on line 5-0, has relatively low count rates of 259 and 40 cps representative of 5.5 and 6.1 ppm eU and eTh respectively. It corresponds to Quaternary deposits of Qal, Qao, Qg and Qap. Possible sources within the alluvial deposits are the igneous and volcanic cobbles noted to be in conglomerates within the deposits.

Uranium anomalies lying within Quaternary Caliche deposits (Qcc) such as Anomaly 3 on line 21, are worthy of further research in light of the large uranium deposit discovered by Western Mining in Calcrete deposits of Western Australia.

Anomaly 4 however, does not meet the preferred criteria as a negative thorium anomaly is present ($< -1\sigma$), but is associated with a broad positive statistical uranium anomaly ($+5\sigma$) and may indicate relative thorium depletion. The uranium contour map shows a relative high which corresponds to three units of alluvium (Qao, Qal, and Qt). The maximum counts of 393 and 35 cps imply eU and eTh values of 8.3 and 5.4 ppm respectively. The presence of terrace deposits (Qt) indicates possible mechanical concentration of more radioactive minerals as a genetic process.

It should be noted that the ribbon like band of Kfr and Ka stretching northwest-southeast across the northeast corner of the map exhibits minor radiometric contrast with respect to the alluvial units on either side and roughly correlates with a linear offset of magnetic gradients near the edge of the Midland Basin.

Overall the highest uranium count rates occur in the southwestern corner of the quadrangle (lines 1-0 and 2-0) over older Quaternary alluvium, (Qao, Qal). Although these features are not statistically significant, they probably indicate relative enrichment of the alluvium from detritus derived from Tertiary extrusives.

Anomaly 35, the Qao basin in the extreme southwest corner, has a maximum uranium count rate of 200 cps which corresponds to an eU of 4.2 ppm. Anomaly 37 on the dissected slope east of Wild Cherry Canyon has a higher maximum uranium count rate of 220 cps which corresponds to an eU of 4.6 ppm. Tiny outliers or erosional remnants of Tertiary volcanics (Tv) occurring within the Qao are perhaps associated with relative eU enrichment or the anomalies may be related to detritus from the extensive Davis Volcanic field to the south of the quadrangle.

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APPENDIX A
Geologic Legend - Van Horn
Quadrangle

**THE UNIVERSITY OF TEXAS AT AUSTIN
BUREAU OF ECONOMIC GEOLOGY**

**TO ACCOMPANY MAP—VAN HORN—EL PASO SHEET—
GEOLOGIC ATLAS OF TEXAS**

GEOLOGIC ATLAS OF TEXAS

VAN HORN - EL PASO SHEET

E. RUSSELL LLOYD MEMORIAL EDITION

VIRGIL E. BARNES, Project Director

**MARCH 1968
Second Printing, December 1975**

EXPLANATION

Qws
Qwsd

Windblown sand

Qwsd, areas of large dunes

Qaf

Alkali flat deposits

Alkali and salt impregnated clay, dolomite, and very fine-grained sand; some intermittent salt lakes

Qalr	Qal	Qb	Qf
------	-----	----	----

Young Quaternary deposits

Qalr, alluvium along the Rio Grande

Qal, alluvium and low terrace deposits along other streams

Qb, lacustrine and fluvial deposits of clay, silt, sand, and gypsum in bolsons

Qf, colluvium and fans

Qao	Qgt
-----	-----

Old Quaternary deposits

Qao, alluvium, colluvium, caliche, and gypsite on surfaces dissected by modern drainage.

KENT AREA: includes Gozar and Bigtank Gravels. Terraces along Rio Grande. SIERRA

BLANCA AREA: includes Balluco, Ramey, Gills, Madden, and Miser Gravels

Toy Limestone, Qgt, fresh-water limestone, mostly in southwestern Reeves County

Ql

Landslide deposits

Displaced bouldery masses of rock

QTb

Bolson deposits

Clay, sand, and gravel, in part gypsiferous, some caliche; includes Gatuna Formation of Kent area

Tv

Extrusive igneous rocks

QUITMAN MOUNTAINS: interbedded flows and pyroclastic rocks of the Square Peak Volcanics. SNEED (COX) MOUNTAIN AND WEST OF VICTORIO PEAK: small basalt flow remnants. KENT AREA: rhyolite including Star Mountain Rhyolite in the Davis Mountains

QUATERNARY

TERTIARY

Buda Limestone, Kbu. DEVIL RIDGE AREA: limestone, very fine grained, nodular, thin, bedded, light brownish gray; weathers very pale orange to pale yellowish brown; thickness 240 feet. KENT AREA: fossiliferous limestone and sandstone. Limestone thin to thick bedded, very hard (upper 40 feet); thin to thick bedded, argillaceous (middle 60 feet); coquinoid, clastic (lower 40 feet). Sandstone locally at base, fine to medium grained, hard, quartzitic, some phosphatic nodules, shark teeth, and quartz pebbles. Thickness 140 feet

Loma Plata Limestone, Klp, mostly limestone and interbedded marl, very fine grained, thin bedded, medium light gray to brownish gray, some black shale and thin nodular limestone interbeds near base; weathers very pale orange; marine megafossils; thickness 2,200 ± feet

Boracho Formation composed of two members.

San Martine Limestone, Kbs, limestone thin to thick bedded, argillaceous, thin interbeds of calcareous shale; prominent 30-foot ledge at base in some localities; marine megafossils throughout; thickness 230 feet

Levinson Limestone, Kbl, limestone, marl, shale and sandstone. Upper two-thirds—limestone, thin to thick bedded, light gray to light olive gray; interbeds of yellowish marl and shale. Lower one-third—shale, light to dark gray; a few thin to thick beds of limestone; sandstone locally near base. Abundant marine megafossils include species found in Kiamichi, Duck Creek, and Fort Worth Formations of north Texas; thickness 150 ± feet

Kf

Finlay Formation

Limestone, marl, shale, and sandstone. DEVIL RIDGE AREA: mostly limestone, very fine grained, thin to thick bedded, nodular, medium gray; weathers pale yellowish brown; a few thin beds of shale, siltstone, and very fine-grained sandstone near base; thickness 600 ± feet. FINLAY MOUNTAINS: mostly limestone and marl, proportion of marl increases from one-fourth in west to one-half in east; limestone, thick bedded and massive in caprock, mostly medium to thin bedded and nodular, gray; thin sandstone beds near base; abundant marine micro- and macrofossils; thickness 200 ± feet. DIABLO PLATEAU: mostly limestone in rimrock northwest of the Finlay Mountains; sandstone in uppermost part west of Tepee Butte, marl increases eastward, sandstone increases northeastward; thickness 175 feet, feathers out northeastward; locally includes small outcrops of Cox Sandstone and Campagrande Formation at base of mesa scarp and on north side of Diablo Plateau. KENT AREA: sandstone, sandy limestone, and massive coarse-grained limestone; thickness 15–40 feet, thins northward

Kcx

Cox Sandstone

Quartz sandstone, conglomerate, limestone, and shale. DEVIL RIDGE AREA: mostly quartz sandstone, fine to medium grained, thin bedded, cross-bedded, ripple marked, various shades of gray, brown, orange, and pink; a few thin beds of fossiliferous sandy limestone and yellowish shale; conglomeratic at base; thins along Devil Ridge from 1,700 feet at southeast end to 550 feet at northwest end. FINLAY MOUNTAINS AND DIABLO PLATEAU WEST OF GUNSIGHT HILLS: mostly siltstone and shale; sandstone and fossiliferous limestone concentrated in upper half; siltstone, shale, and limestone decrease and sandstone increases eastward, thickness 50–700 feet, thins northeastward. DIABLO PLATEAU EAST OF GUNSIGHT HILLS: mostly sandstone, interbeds of marl and shale in lower part, well-rounded pebbles of chert and quartz sprinkled throughout sandstone and concentrated in lenses; thickness 135–450 feet, thins northeastward. KENT AREA AND NORTHWARD: mostly sandstone, fine to medium grained, thin to thick bedded, cross-bedded in part, pebbly in part; interbeds of silty marl and quartz-pebble conglomerate; outcrops north of Cottonwood Draw probably in part equivalent to Finlay Formation; preserved in numerous collapse structures within outcrop area of Castle and Rustler, small outcrops not separately mapped; thickness 25–170 feet, highly variable in northern outcrops because of irregular topography at time of deposition; thins northward

Diablo Plateau
Finlay Mountains

Devil Ridge area
Quitman Mountains

Kent area
Apache Mountains

Kcg

Kbm

Kye

Campagrande, Bluff Mesa, and Yearwood Formations

Campagrande Formation, Kcg, limestone, marl, conglomerate, sandstone, siltstone, and shale; thins northeastward. FINLAY MOUNTAINS: upper 200-250 feet, alternating marl and limestone, thin to thick bedded, gray; abundant marine megafossils and foraminifers; lower part interbedded sandstone, fossiliferous limestone, siltstone, sandy shale, conglomerate composed of limestone and chert; thickness 375-800 feet. **NORTH-WESTERN DIABLO PLATEAU:** mostly varicolored limestone- and chert-pebble conglomerate, in upper part interbedded limestone and calcareous shale; thickness 50-300 feet. **TRIPLE HILL:** limestone, in part sandy, thick bedded, gray; thickness 315+ feet. **SIERRA PRIETA:** limestone, conglomeratic in lower part, mostly thin bedded, nodular, gray, commonly yellow and red mottled; some marl and clay interbeds; thickness 80± feet. **SNEED (COX) MOUNTAIN AREA:** interbedded limestone, shale, and marl; conglomerate locally at base, up to 80 feet thick, rests on irregular surface; thickness 180 feet maximum

Bluff Mesa Formation, Kbm, limestone, sandstone, and sandy shale. Mostly limestone, very fine grained, sandy, oolitic near middle, thin to thick lenticular beds; lenses of quartz sandstone, fine to coarse grained, calcareous and siliceous; some interbeds of sandy shale; abundant marine megafossils and foraminifers; thickness 1,100-1,470 feet

Yearwood Formation, Kye, limestone and interbedded shale, thin to thick bedded, light gray, conglomerate up to 55 feet thick at base; thickness 160 feet, feathers out northward

Kyu

Yucca Formation

Limestone, sandstone, siltstone, shale, and conglomerate. Mostly limestone, aphanitic to fine grained, in part sandy, in part dolomitic, thin bedded, dark gray to brown to red. Quartz sandstone, fine grained, indistinctly cross-bedded, commonly spotted with iron oxide; in part calcareous, white and gray, weathers brown, in part siliceous, gray, purple, and green. Shale and quartz siltstone, thin partings to 3-foot beds, bright red to purple. Drab limestone- and chert-pebble conglomerate. Sandstone proportionately less downward, proportionately more southward. Over-all appearance a distinctive red brown. Marine megafossils in a few beds. Thickness 600 feet at Eagle Spring to 5,500+ feet in Quitman Gap, wedges out northeastward

Lower Cretaceous

CRETACEOUS

Upper Jurassic

Jm

Malone Formation

Limestone, shale, siltstone, sandstone, gypsum, and conglomerate. Upper part—mostly limestone, aphanitic, beds 3 to 7 feet thick, black, weathers gray; up to 25 feet of brownish-yellow sandstone and limestone at top. Lower part—complexly interfingered sandstone, siltstone, shale, limestone, and conglomerate in various proportions, some impure gypsum; short-distance lateral facies changes common. Sandy shale and siltstone, mostly calcareous, massive, beds up to 15 feet thick, pink through red and brown to black; sandstone, mostly calcareous, fine to coarse grained, thin bedded, in part cross-bedded, gray to brownish yellow; limestone conglomerate common at base and top; limestone, sandy, mostly thin bedded, a few beds up to 3 feet thick. Mostly sandy shale and siltstone at northwest end of Malone Mountains, grades southeastward to mostly sandstone. Marine megafossils. Thickness 150–1,000+ feet

JURASSIC

Pgrc

Gypsum of Rustler and Castile Formations undivided

Gypsum in collapse structures, white, banded with thin layers of brown calcite; brecciated as much as 30 feet below the surface, mostly from uppermost part of Rustler Formation; may include gypsum and limestone residual from Salado Formation

Ochoa

Pru

Rustler Formation

Limestone, siltstone, sandstone, gypsum, and clay. NEAR KENT: limestone, dolomitic, thin bedded, light greenish gray to yellowish gray, some beds brecciated; thickness 140+ feet. NEAR COTTONWOOD DRAW: Upper part—limestone and dolomitic limestone similar to that near Kent; thickness 100–140 feet. Lower part—siltstone and fine-grained sandstone, thin to medium bedded, yellowish gray; thickness 0–50 feet. NEAR LAT. 31°50': Upper part—limestone and dolomitic limestone, thickness 50+ feet. Middle part—siltstone and sandstone, yellowish gray, thickness 50–70 feet. Lower part—siltstone and fine-grained sandstone, thin to medium bedded, red; interbeds of earthy to sparry red gypsum; a few beds of red and greenish-gray clay; thickness 50+ feet. Small outcrops collapsed into Castile Gypsum not separately mapped

Pcs

Castile Formation

Gypsum, anhydrite, and limestone. Mostly anhydrite at depth and gypsum at surface, banded, commonly 5 to 30 alternating laminae of brown calcite and white gypsum per inch, gypsum layers 3 to 20 times as thick as calcite; highly contorted, commonly brecciated as much as 30 feet below surface. Limestone units scarce, thin to medium bedded, dark brown to black, mostly less than 10 feet thick. At base, near southwest margin of outcrop up to 100 feet of dolomitic limestone, thick bedded, massive. Thickness 1,500–2,000 feet. Within outcrop area younger rocks are preserved in numerous unmapped collapse structures, may include gypsum and limestone residual from Salado Formation

PERMIAN

Pbcd

**Bell Canyon, Cherry Canyon,
and Brushy Canyon Formations undivided**
Western part of Delaware Mountains

Guadalupe Mountains

Delaware Mountains

Apache Mountains

**Carlsbad Group, Capitan, Bell Canyon, Tansill,
Yates, and Seven Rivers Formations**

Carlsbad Group, Pcb, limestone and sandstone, three units not separately mapped—Tansill Formation, Yates Formation, and Seven Rivers Formation. Limestone, mostly dolomitic, in part pisolitic, thin bedded, light gray to white becoming varicolored northwestward (shelfward). Some quartz sandstone, fine grained, thin bedded, gray; proportion increases northwestward, becomes somewhat shaly, brownish yellow and red. Grades to massive Capitan Limestone southeastward (reefward). Thickness up to 1,000 feet

Capitan Limestone, Pc. **GUADALUPE MOUNTAINS:** reef limestone, in shelfward part dolomitic, massive, beds mostly 15 to 100 feet thick, white, light gray, grayish yellow, brownish yellow; grades to Carlsbad Group shelfward, to Bell Canyon Formation basinward (southeastward); marine fossils; thickness 1,000–2,000 feet. **APACHE MOUNTAINS:** reef limestone and dolomite, medium to coarse grained, indistinctly to thickly bedded, very light to dark gray; grades to Bell Canyon Formation basinward (northward), to Yates and Seven Rivers Formations shelfward (southward); marine megafossils; thickness up to 900 feet

Bell Canyon Formation, Pbc, sandstone and limestone. Mostly sandstone, very fine grained, very thin to thick bedded, in part massive, brownish yellow. Limestone, five units not separately mapped (from top—Lamar, McCombs, Rader, Pinery, and Hegler), fine grained, mostly thin bedded, dark gray to black, thicknesses of individual units 10–40 feet in basin, 50–100 feet near Capitan reef; fossils scarce except near Capitan reef. Grades into Capitan Limestone. Thickness 670 feet near Capitan reef, 1,000+ feet in basin

Tansill Formation, Pt, mostly dolomite, fine grained, very thick to medium bedded, pale yellowish brown; weathers very pale orange, small anhydrite crystal molds common on weathered surfaces; some fossiliferous limestone in northern Apache Mountains; thickness 75–100+ feet

Yates Formation, Py, siltstone, shale, limestone, and dolomite. In southern area siltstone, very fine-grained sandstone, and shale, thin to medium bedded, some thin beds of sandy limestone, dolomite, and locally redbeds; grades to limestone and dolomite northward (reefward) and in turn to Capitan Limestone, a few thin beds of siltstone, thin to thick bedded; forms light-colored moderate slope between dark-colored bluffs of adjacent formations; thickness up to 290 feet

Seven Rivers Formation, Psr, dolomite, some dolomitic limestone, fine grained, medium to thick bedded, light gray to very pale orange; grades to Capitan Limestone northward (reefward); marine microfossils; thickness 440 feet

Guadalupe Mountains
Sierra Diablo

Delaware Mountains

Apache Mountains

Goat Seep, Cherry Canyon, and Munn Formations

Goat Seep Limestone, Pgs, (tongue of Cherry Canyon sandstone at base not separately mapped). Upper unit (Goat Seep Limestone)—mostly limestone, in part dolomitic, in part sandy, mostly thick bedded, massive, light gray to brownish yellow; sandstone interbeds more abundant downward; poorly preserved marine fossils; thickness 200+–1,200 feet. Lower unit (sandstone tongue of Cherry Canyon Formation)—mostly sandstone, very fine to fine grained, soft, brownish yellow to pink; some units of

Guadalupe

PERMIAN

limestone, cherty, sandy, thin bedded, brown, limestone more abundant in Guadalupe Mountains; forms moderate slope; silicified marine fossils; thickness 150-300 feet. Cherry Canyon Formation, Pcc, sandstone, siltstone, and limestone. Mostly very fine-grained quartz sandstone and siltstone, mostly noncalcareous, in part shaly, mostly thin bedded, some varvelike bedding and ripple marks, irregularly bedded channel fillings common in lower two-thirds. Locally persistent thin quartzite beds in lower part. Sandy limestone in thin beds, lenses, and nodules in a few places. Limestone, three units not separately mapped (from top—Manzanita, South Wells, and Getaway), thin to thick bedded, some sandstone interbeds. WESTERN APACHE MOUNTAINS: interbedded dolomite, limestone, and fine- to very fine-grained dolomitic sandstone; basal 50 feet exposed. Thickness 1,000 feet.

Munn Formation, Pm, dolomite, limestone, siltstone, and sandstone. Upper part—mostly dolomite and limestone, fine to coarse grained, in part oolitic, medium to thick bedded, white to grayish orange; some siltstone and fine-grained quartz sandstone, proportion increases southward. Lower part—mostly dolomite and dolomitic limestone, fine grained, very thick bedded, light brownish gray to pale yellowish brown, weathers a distinctive brown; thin beds of siltstone and fine-grained sandstone scarce, more numerous northward. Marine megafossils and microfossils. Thickness 450+ feet.

Pdb

Brushy Canyon Formation

Mostly sandstone (discontinuous Pipeline Shale Member at base not separately mapped). Sandstone, in part medium grained, thick bedded, a few persistent massive units, brownish yellow, yellowish gray; in part fine grained, thin bedded, beds in part varvelike, brownish yellow to brownish gray; a few sandy, fossiliferous limestone lenses; a few thin beds of green siliceous shale and chert. Pipeline Shale Member—up to 150 feet of shale, sandstone, limestone, and conglomerate; shale, siliceous, platy, black; sandstone, shaly; limestone, many thin beds, gray and black; conglomerate at base up to 25 feet thick; marine megafossils. Thickness 1,000 ± feet.

Malone Mountains Finlay Mountains Sierra Diablo Delaware Apache Mountains
Diablo Plateau Guadalupe Mountains Mountains Wylie Mountains

Pbg

Pl

Pco
Pvc
Pbs

Pbs

Pvc

Briggs, Cutoff, Victorio Peak, and Bone Spring Formations, and Leonardian rocks undivided

Briggs Formation, Pbg, mostly gypsum; some carbonate rocks. Gypsum, sparry, granular, white. Carbonate rocks: in upper part—limestone and pisolitic dolomite interbedded with gypsum; at base, persistent 25-foot unit of brownish-yellow, sandy dolomite; in middle part—mostly dolomite, fine grained, thick bedded with laminations, dark gray; some breccia masses; locally at base, pale brown to gray, fine-grained limestone; in lower part—limestone, fine grained, cherty, dark gray, marine megafossils. Thickness 630 feet, base not exposed.

Leonardian rocks undivided, Pl, locally includes Wolfcampian Hueco Limestone. FINLAY MOUNTAINS: marlstone, limestone, limestone-pebble conglomerate; mostly marlstone, in part silty, well indurated, thin bedded and laminated, large-scale cross-bedding in places, weathers light gray; limestone, in part dolomite, cherty in upper part, medium to thick bedded, dark gray, large-scale cross-bedding, abundant in upper part, scattered discontinuous beds in lower part, marine megafossils; limestone-pebble conglomerate distributed throughout, more abundant in upper 200 and lower 900 feet; thickness 1,650+ feet, base not exposed. NORTHERN DIABLO PLATEAU: mostly light-colored limestone and dolomite equivalent to Victorio Peak and Bone Spring Limestones, includes some beds equivalent to Hueco Limestone.

Cutoff Shale, Pco, shale, siltstone, sandstone, and limestone; meager marine megafossils. WEST SIDE OF GUADALUPE MOUNTAINS: discontinuous outcrops mapped with Victorio Peak Limestone; mostly shale, in part siliceous and black, in part sandy and brown; some soft sandstone; some cherty limestone, thin bedded, black, brownish yellow, and gray; thickness 230 feet maximum. NORTH OF SIERRA DIABLO: interbedded limestone, shale, and sandstone; limestone, thin bedded or platy, gray to black; shale, siliceous, sandy, brown; sandstone, fine grained, thin bedded; some thin layers of earthy gypsum; thickness 250-275 feet. NORTHWEST END OF APACHE MOUNTAINS: mostly clay shale and siltstone, thin bedded, yellowish brown; some limestone, thin to medium bedded, dark gray to black, weathers light gray; thickness 230 feet.

Leonard

Victorio Peak Limestone, Pvc, limestone, dolomite, sandstone, and siltstone; includes at top Cutoff Shale, described above, along west side of Guadalupe Mountains and at north-west end of Apache Mountains. GUADALUPE MOUNTAINS: upper part—limestone, thick bedded, light gray to white; middle part—mostly limestone, thin bedded, some interbedded sandstone; lower part—dolomitic limestone, fine grained, thick bedded, grayish brown; abundant marine fossils; thickness 800 feet. SIERRA DIABLO: along east-facing escarpment—mostly limestone, in part slightly dolomitic, thick bedded, light gray, abundant marine megafossils; southwest of escarpment—mostly dolomite and dolomitic limestone, thin to medium bedded, white to gray, rare ghosts of marine fossils; thickness 900–1,500 feet. NORTHWESTERN END OF APACHE MOUNTAINS: upper part—limestone and dolomitic limestone, very thick bedded, light brownish gray, marine fossils; lower part—interbedded grayish-orange siltstone and fine-grained, very pale orange to pale red dolomite, thin bedded; thickness 280+ feet. WYLIE MOUNTAINS: four units not separately mapped, from top downward: (1) mostly dolomite, medium grained, porous, pale brownish gray, abundant fusulinids; (2) marl, poorly exposed, thin but distinctive because of slope break; (3) mostly limestone, some dolomite, fine grained, thin to medium bedded, yellowish gray to light brownish gray; thin interbeds of marl abundant near base; (4) interbedded marly limestone, marl, red silty shale, and limestone-pebble conglomerate; thickness 1,600 feet

Bone Spring Limestone, Pbs, limestone, dolomite, sandstone, and shale. Mostly limestone, in part cherty, thin bedded, dark gray to black, marine megafossils scarce; some beds of siliceous shale and shaly limestone; a few thin beds of platy, fine-grained, calcareous, quartz sandstone. NEAR NORTH END OF SIERRA DIABLO, AT VICTORIO PEAK, AND IN BAYLOR MOUNTAINS: interbedded deposits marginal to basin, mostly limestone and dolomite, thick bedded, massive, gray, abundant marine megafossils and fusulinids. Thickness 800–1,700 feet, grades to Victorio Peak Limestone southwestward

Ph

Hueco Limestone

Limestone, dolomite, sandstone, shale, mudstone, and conglomerate. HUECO MOUNTAINS: five units not separately mapped, from top down: (1) Upper member of Alacran Mountain Formation—limestone, medium to very thick bedded, olive gray, thickness 750 feet; (1a) Deer Mountain Red Shale Member of Alacran Mountain Formation—mudstone, light to medium olive gray, weathers reddish brown, and limestone, medium bedded, in part cherty, medium light gray, thickness 180 feet; (2) Cerro Alto Limestone—limestone, medium to thick undulatory beds, medium light to dark gray, some marl interbeds, thickness 250–450 feet; (3) upper member of Hueco Canyon Formation—limestone, medium to very thick bedded, somewhat cherty, olive gray, maximum thickness 660 feet; and (3a) Pourwaw Conglomerate Member of Hueco Canyon Formation—calcareous mudstone, marl, and limestone-pebble conglomerate, thickness 0–100 feet. Maximum thickness 1,500 feet. FRANKLIN MOUNTAINS: three units not separately mapped, limestone, fine grained, medium to thick bedded, light colored; thickness 2,200 feet. CORNUDAS MOUNTAINS, SIXTEEN MOUNTAINS, AND SIERRA TINAJA PINTA: black, thin-bedded, petroliferous limestone; grades upward into light-colored dolomite; base not exposed. SIERRA DIABLO AREA: mostly dolomitic limestone and dolomite, aphanitic, thin bedded, dark gray, cliff forming, abundant fusulinids; grades southwestward into mostly limestone, in part cherty, in part dolomitic, thin to thick bedded, gray, many partings of marl, weathers to alternating bluffs and slopes, abundant marine megafossils. In lower part—marl and thin beds of limestone, gray and yellowish gray, marine megafossils; grades downward to shale, sandstone, and conglomerate, mostly red and brown; generally poorly exposed; thickness, absent to 250 feet. Thickness 300–1,100 feet, feathers out in northern Baylor Mountains. WYLIE AND EAGLE MOUNTAINS: mostly limestone, in part cherty, thin to thick bedded, aphanitic, gray, cliff forming. In lower part—marl and fossiliferous limestone, grades downward to shale, siltstone, sandstone, and poorly consolidated pebble-to-boulder conglomerate; thickness, absent to 200+ feet

IPm

Magdalena Formation

Limestone, shale, and marl. FRANKLIN MOUNTAINS: four units not separately mapped (from top—unnamed unit, Bishops Cap, Eerino, and La Tuna), mostly limestone, mostly fine grained, in part cherty particularly in basal unit, very thick bedded, basal unit massive, light gray to black; some interbedded shale; thickness 2,700 feet. HUECO MOUNTAINS: three units not separately mapped. Upper unit—limestone, including one reef, interbedded marl, some conglomerate. Middle unit—marl, shale, and some limestone. Lower unit—coralline limestone, thick bedded, maximum thickness 1,300 feet. SIERRA DIABLO: two units in different exposures, with undetermined relations. In northern exposure, limestone, cherty, dark gray, overlain by shale, gray to black,

PERMIAN

PENNSYLVANIAN

Wolfcamp

abundant megafossils; thickness undetermined, overlies Mississippian, top truncated. In southern exposure, limestone, gray, thick bedded, fossiliferous, forms prominent ledges; thickness 170 feet, base not exposed and top truncated

DM

Devonian and Mississippian rocks undivided

Limestone, shale, and chert. FRANKLIN MOUNTAINS: five units not separately mapped (Mississippian—(1) Helms Shale, (2) Rancheria Formation, (3) Las Cruces Limestone; Devonian—(4) Percha Shale, (5) Canutillo Formation), from the top down: (1) gray and green shale, sandstone, impure fossiliferous limestone, thickness 150 feet; (2) limestone, argillaceous, bituminous, cherty, black; weathers rusty brown; thickness 250 feet; (3) limestone, aphanitic, evenly bedded, black; weathers gray; sparsely fossiliferous; thickness 60 feet; (4) shale, black; thickness 40 feet; (5) fossiliferous limestone, in part cherty, light brown and light gray; some sandstone, black, weathers brown; thickness 135 feet. HUECO MOUNTAINS: Mississippian rocks, upper part—shale, sandy shale, and nodules of fossiliferous limestone grading downward to brown-weathering, flaggy, sandy limestone; lower part—gray, thin- to medium-bedded limestone, upper half cherty; thickness 500 ± feet. Devonian rocks, upper part—blue shale; lower part—mostly bedded chert, white, gray, brownish yellow and brown; some interbedded limestone; thickness 150+ feet. SIERRA DIABLO: Mississippian rocks—mostly shale, black, purplish, and dark gray; lenses and beds of fossiliferous, earthy limestone; small phosphatic and pyritic nodules in shale; maximum exposed thickness 135 feet (Barnett Shale of P. B. King). Devonian rocks—mostly bedded chert, yellowish brown, brown, white, gray, black, and green; thin interbeds of black and brown siliceous shale in upper part, dolomitic limestone in lower part; thickness 125 ± feet

Sf

Fusselman Dolomite

Dolomite, dolomitic limestone, and locally limestone, aphanitic to coarse grained, thick to very thick bedded, massive, white to light gray, some beds medium dark gray; marine fossils in a few limestone beds. Thickness—Franklin Mountains, 600–900+ feet; Hueco Mountains, 630+ feet; Sierra Diablo and Baylor Mountains, 300–450 feet

Om

Montoya Dolomite

Dolomite, limestone, and sandstone, four units not separately mapped—Cutter Member, Aleman Chert Member, Upham Member, and Cuble Canyon Sandstone Member. Upper part—dolomite and limestone, aphanitic to medium grained, thin to thick bedded, white to dark gray, cherty. Lower part—limestone and dolomite, aphanitic to very coarse grained, light to medium gray, local mottled zones near base, chert scarce to absent, thin sandstone bed locally at base. Thickness—Franklin Mountains, 250–430 feet; Hueco Mountains, 320 ± feet; Sierra Diablo, 250–500 feet. SOUTHEASTERN BAYLOR MOUNTAINS: includes Middle Ordovician Simpson Group rocks not separately mapped.

PENN.

DEVONIAN & MISSISSIPPIAN

SILURIAN

ORDOVICIAN

Middle Silurian

Middle & Upper
Ordovician

Lower Ordovician

Oe

El Paso Formation

Limestone, dolomite, and sandstone. FRANKLIN MOUNTAINS: upper 1,050 feet—mostly limestone, inequigranular, in part cherty; lower 540 feet—dolomite, in part sandy; thickness 1,590 feet. HUECO MOUNTAINS: upper two-thirds—mostly limestone, granular, impure; lower one-third—mostly dolomite, some sandy intervals; thickness 1,300 ± feet. BEACH MOUNTAIN: mostly dolomite; upper 50 feet—earthy, locally sandy; next 813 feet—very fine grained to microgranular, scattered sand grains in several beds, in part cherty; lower 252 feet—sandstone, limestone, and dolomite; thickness 1,115 feet

ORDOVICIAN

pEv

Van Horn Sandstone

Feldspathic sandstone, arkose, and conglomerate. Upper part—mostly sandstone and arkose, medium to coarse grained, thick bedded, cross-bedded, yellowish brown to purplish red; scattered pebbles and cobbles; a few beds of conglomerate. Lower part—mostly conglomerate, well-rounded pebbles to boulders, closely packed to widely dispersed in an arkosic sandy matrix; some sandstone beds. Shows angular discordance with overlying Bliss. Thickness variable, maximum 800 feet

pEr

Rhyolite

FRANKLIN MOUNTAINS: rhyolite, porphyritic, feldspar and quartz phenocrysts, widely spaced but well-defined layering, massive, dark red to black, rounded quartzite pebbles near base; thickness 1,400 feet maximum. PUMP STATION HILLS: rhyolite porphyry, phenocrysts of pink feldspar up to 1 cm across and clear, glassy quartz, aphanitic groundmass, massive, maroon to dark red; base not exposed

PRECAMBRIAN

Van Horn area

Hazel Formation, pCh, interbedded sandstone and conglomerate. Mostly indistinctly bedded sandstone in northern outcrops, conglomeratic in basal part; mostly conglomerate in southern outcrops, sandstone in upper part. Sandstone, mostly fine to very fine grained, mostly tightly cemented, brick red to maroon red. Conglomerate, poorly sorted, composed of slightly rounded pebbles to angular blocks more than 6 feet across, derived mostly from Allamoore Formation. Thickness 5,000 ± feet

Van Horn area

Allamoore Formation (possibly in part correlative)

Allamoore Formation, pCa, interbedded cherty limestone, limestone-pebble conglomerate, phyllite, pyroclastic rock, and lava flows; numerous shallow intrusions of igneous rock; thickness several thousand feet

Carrizo Mountain Group

Meta-igneous rocks, pEci, include granodiorite, amphibolite, and metarhyolite. Granodiorite, fine grained, brown to bronze, cataclastically altered, small outcrops. Amphibolite, fine to coarse grained, massive to schistose, green to black; intrudes metasedimentary rock and metarhyolite. Metarhyolite, blocky and slabby, red, pink, brown, brownish yellow, and gray, cataclastically altered, some mylonitized zones; intrudes metasedimentary rock. Thickness 7,700 ± feet

Metasedimentary rocks, pEcs, include units of limestone, fine grained, hard, brown; chlorite-quartz-albite-calcite rock; phyllite, locally slaty, blue gray; feldspathic meta-quartzite and meta-arkose; chlorite-mica schist, mostly fine grained, dark colored; and units of interlayered sericite schist, metaquartzite, chert, phyllite, slate, and limestone; thickness 19,000 ± feet

PRECAMBRIAN

APPENDIX B
Statistical Analysis - Van Horn
Quarangle

ROCK UNIT QWS

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	48.4085	73.2056	98.0028	122.8000	147.5972	172.3944	197.1915
BI214	DIST NORMAL	.6092	23.4061	46.2031	69.0000	91.7969	114.5939	137.3908
TL208	DIST LOG	11.0252	15.3498	21.3708	29.7536	41.4245	57.6734	80.2959
U/K	DIST LOG	.1500	.2303	.3536	.5428	.8333	1.2792	1.9637
U/TH	DIST LOG	.6393	.9628	1.4499	2.1836	3.2886	4.9526	7.4587
TH/K	DIST LOG	.1045	.1394	.1860	.2482	.3312	.4419	.5897

ROCK UNIT QWSO

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	92.3379	104.6586	116.9793	129.3000	141.6207	153.9414	166.2621
BI214	DIST NORMAL	3.7122	20.9081	38.1041	55.3000	72.4959	89.6919	106.8878
TL208	DIST LOG	13.7425	16.4683	19.7347	23.6490	28.3397	33.9607	40.6967
U/K	DIST NORMAL	-.0434	.1169	.2773	.4376	.5980	.7583	.9187
U/TH	DIST NORMAL	-.0986	.7233	1.5453	2.3672	3.1892	4.0111	4.8331
TH/K	DIST NORMAL	.0809	.1167	.1525	.1882	.2240	.2598	.2956

ROCK UNIT QAF

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	7.4814	12.6964	21.5468	36.5664	62.0558	105.3132	178.7242
BI214	DIST LOG	14.3618	21.1177	31.0516	45.6585	67.1365	98.7180	145.1555
TL208	DIST LOG	2.6412	4.2688	6.8995	11.1515	18.0236	29.1309	47.0831
U/K	DIST LOG	.1893	.3559	.6690	1.2575	2.3640	4.4440	8.3541
U/TH	DIST LOG	.6533	1.2079	2.2336	4.1301	7.6368	14.1210	26.1108
TH/K	DIST LOG	.0852	.1323	.2055	.3190	.4952	.7689	1.1938

ROCK UNIT QALR

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	38.0028	47.8999	65.5216	86.0338	112.9675	148.3331	194.7701
BI214	DIST LOG	27.0150	32.1654	38.2977	45.5992	54.2927	64.6436	76.9679
TL208	DIST NORMAL	22.9848	30.7565	38.5283	46.3000	54.0717	61.8435	69.6152
U/K	DIST LOG	.2705	.3631	.4873	.6541	.8790	1.1784	1.5817
U/TH	DIST NORMAL	.4672	.9619	1.4566	1.9513	2.4460	2.9406	3.4353
TH/K	DIST NORMAL	.1626	.2259	.2892	.3526	.4159	.4792	.5425

ROCK UNIT QAL

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	1.6179	37.4453	73.2726	109.1000	144.9274	180.7547	216.5821
RI214	DIST NORMAL	-6.5775	21.4100	49.3975	77.3850	105.3725	133.3600	161.3475
TL208	DIST NORMAL	-6.0558	8.7158	23.4874	38.2590	53.0306	67.8022	82.5738
U/K	DIST NORMAL	-.3408	.0236	.3879	.7522	1.1165	1.4808	1.8451
U/TH	DIST NORMAL	0.07907	0.76389	1.44871	2.13353	2.81835	3.50317	4.18799
TH/K	DIST NORMAL	-.0434	.0880	.2194	.3508	.4822	.6137	.7451

ROCK UNIT QB

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	10.9173	20.5067	38.5191	72.3532	135.9062	255.2821	479.5144
RI214	DIST NORMAL	-20.5885	10.4743	41.5372	72.6000	103.6628	134.7257	165.7885
TL208	DIST LOG	3.8829	7.1662	13.2260	24.4099	45.0510	83.1462	153.4546
U/K	DIST NORMAL	-1.1179	-.4604	.1971	.8546	1.5121	2.1697	2.8272
U/TH	DIST NORMAL	-3.2889	-1.3967	.4955	2.3877	4.2799	6.1722	8.0644
TH/K	DIST NORMAL	.0206	.1332	.2458	.3584	.4710	.5836	.6962

ROCK UNIT QF

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	27.6348	42.6664	65.8745	101.7064	157.0287	242.4431	374.3180
RI214	DIST NORMAL	-11.1752	19.7165	50.6083	81.5000	112.3917	143.2835	174.1752
TL208	DIST NORMAL	-7.5800	5.7467	19.0733	32.4000	45.7267	59.0533	72.3800
U/K	DIST LOG	.1653	.2726	.4493	.7407	1.2210	2.0127	3.3179
U/TH	DIST NORMAL	-1.2095	-.0264	1.1567	2.3397	3.5228	4.7059	5.8890
TH/K	DIST NORMAL	.0323	.1299	.2276	.3253	.4230	.5206	.6183

ROCK UNIT QAN

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	19.0619	33.1961	57.8109	100.6773	175.3288	305.3340	531.7373
RI214	DIST NORMAL	-242.9822	-136.9841	-30.9861	75.0120	181.0101	287.0081	393.0062
TL208	DIST LOG	6.0418	11.2940	21.1119	39.4644	73.7709	137.8998	257.7761
U/K	DIST LOG	.1707	.2856	.4776	.7989	1.3362	2.2350	3.7383
U/TH	DIST LOG	.5764	.8776	1.3364	2.0348	3.0984	4.7178	7.1837
TH/K	DIST LOG	.1012	.1590	.2498	.3925	.6166	.9686	1.5217

ROCK UNIT QGT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	48.9242	61.9746	78.5062	99.4475	125.9749	159.5785	202.1457
BI214	DIST	NORMAL	4.0013	24.5342	45.0671	65.6000	86.1329	106.6658	127.1987
TL208	DIST	LOG	23.8273	29.4357	36.3642	44.9235	55.4974	68.5602	84.6978
U/K	DIST	LOG	.1801	.2724	.4122	.6237	.9437	1.4279	2.1604
U/TH	DIST	LOG	.3785	.5828	.8973	1.3816	2.1272	3.2752	5.0427
TH/K	DIST	NORMAL	.1991	.2859	.3728	.4597	.5466	.6335	.7204

ROCK UNIT QL

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	35.8417	61.9791	107.1772	185.3359	320.4916	554.2091	958.3644
BI214	DIST	LOG	34.8600	54.1562	84.1336	130.7046	203.0544	315.4523	490.0666
TL208	DIST	LOG	14.3813	26.2871	48.0494	87.8280	160.5379	293.4420	536.3732
U/K	DIST	LOG	.1629	.2655	.4327	.7052	1.1494	1.8733	3.0530
U/TH	DIST	LOG	.3905	.6100	.9528	1.4882	2.3245	3.6309	5.6714
TH/K	DIST	LOG	.2225	.2862	.3683	.4739	.6097	.7845	1.0094

ROCK UNIT QTR

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	6.9185	44.8790	82.8395	120.8000	158.7605	196.7210	234.6815
BI214	DIST	LOG	17.8037	28.1923	44.6426	70.6918	111.9409	177.2591	280.6907
TL208	DIST	NORMAL	-15.6028	.7742	17.1571	33.5400	49.9229	66.3058	82.6888
U/K	DIST	NORMAL	-.5916	-.1789	.2338	.6465	1.0592	1.4719	1.8846
U/TH	DIST	NORMAL	-.5472	.3596	1.2664	2.1732	3.0799	3.9867	4.8935
TH/K	DIST	NORMAL	-.1629	-.0125	.1379	.2884	.4388	.5892	.7397

ROCK UNIT TV

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	137.8676	175.3953	223.1382	283.8767	361.1484	459.4535	584.5174
BI214	DIST	LOG	61.6945	81.0695	106.5291	139.9843	183.9459	241.7136	317.6230
TL208	DIST	NORMAL	25.0724	52.7816	80.4908	108.2000	135.9092	163.6184	191.3276
U/K	DIST	NORMAL	.2190	.3134	.4078	.5021	.5965	.6909	.7853
U/TH	DIST	LOG	.5083	.7037	.9741	1.3485	1.8667	2.5841	3.5772
TH/K	DIST	NORMAL	.1498	.2243	.2988	.3733	.4478	.5223	.5968

ROCK UNIT TI

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-17.7253	71.0165	159.7582	248.5000	337.2418	425.9835	514.7253
B1214	DIST	LOG	40.1184	66.8468	111.3827	185.5900	309.2371	515.2626	858.5500
TL208	DIST	LOG	11.9950	24.0249	48.1196	96.3792	193.0387	386.6389	774.4025
U/K	DIST	LOG	.1796	.2967	.4902	.8099	1.3381	2.2109	3.6528
U/TH	DIST	LOG	.6820	.9639	1.3624	1.9256	2.7217	3.8469	5.4372
TH/K	DIST	LOG	.0887	.1490	.2503	.4206	.7067	1.1873	1.9949

ROCK UNIT KG

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	55.9893	98.8262	141.6631	184.5000	227.3369	270.1738	313.0107
B1214	DIST	NORMAL	37.3738	67.6492	97.9246	128.2000	158.4754	188.7508	219.0262
TL208	DIST	NORMAL	41.9462	56.6975	71.4487	86.2000	100.9513	115.7025	130.4538
U/K	DIST	LOG	.2764	.3766	.5133	.6996	.9535	1.2994	1.7710
U/TH	DIST	LOG	.6597	.8620	1.1263	1.4717	1.9231	2.5128	3.2833
TH/K	DIST	LOG	.3137	.3603	.4138	.4753	.5460	.6271	.7204

ROCK UNIT KBO

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-57.4320	11.2120	79.8560	148.5000	217.1440	285.7880	354.4320
B1214	DIST	NORMAL	-28.6553	10.5965	49.8482	89.1000	128.3518	167.6035	206.8553
TL208	DIST	NORMAL	-13.6482	13.8346	41.3173	68.8000	96.2827	123.7654	151.2482
U/K	DIST	NORMAL	-.4929	-.1274	.2381	.6036	.9691	1.3346	1.7001
U/TH	DIST	NORMAL	-.3415	.2422	.8260	1.4097	1.9934	2.5772	3.1609
TH/K	DIST	LOG	.2617	.3224	.3972	.4893	.6028	.7427	.9151

ROCK UNIT K

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	52.5595	64.0058	77.9449	94.9196	115.5910	140.7642	171.4195
B1214	DIST	NORMAL	-10.2073	16.6031	43.4136	70.2240	97.0344	123.8449	150.6553
TL208	DIST	LOG	21.9843	25.6473	29.9207	34.9060	40.7221	47.5072	55.4228
U/K	DIST	NORMAL	-.2009	.1185	.4378	.7572	1.0766	1.3959	1.7153
U/TH	DIST	NORMAL	-.2186	.5630	1.3446	2.1262	2.9078	3.6894	4.4710
TH/K	DIST	LOG	.2125	.2552	.3063	.3677	.4415	.5300	.6363

ROCK UNIT KBL

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	1.5288	21.1859	40.8429	60.5000	80.1571	99.8141	119.4712
BI214	DIST NORMAL	11.7610	29.9407	48.1203	66.3000	84.4797	102.6593	120.8390
TL208	DIST NORMAL	.1418	12.3279	24.5139	36.7000	48.8861	61.0721	73.2582
U/K	DIST NORMAL	-.7672	-.0828	.6016	1.2861	1.9705	2.6549	3.3393
U/TH	DIST NORMAL	-1.1229	-.0385	1.0459	2.1303	3.2146	4.2990	5.3834
TH/K	DIST NORMAL	.3198	.4174	.5151	.6128	.7105	.8081	.9058

ROCK UNIT KBU

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-71.3055	-27.3704	16.5648	60.5000	104.4352	148.3704	192.3055
BI214	DIST NORMAL	-6.4645	21.0236	48.5118	76.0000	103.4882	130.9764	158.4645
TL208	DIST NORMAL	-20.8835	-4.3457	12.1922	28.7300	45.2678	61.8057	78.3435
U/K	DIST LOG	.3033	.4693	.7259	1.1231	1.7374	2.6877	4.1580
U/TH	DIST NORMAL	-.3852	.5878	1.5608	2.5338	3.5068	4.4798	5.4528
TH/K	DIST LOG	.2071	.2758	.3673	.4891	.6513	.8673	1.1549

ROCK UNIT KBUS

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	23.0315	39.0877	55.1438	71.2000	87.2562	103.3123	119.3685
BI214	DIST NORMAL	-13.6181	19.4213	52.4606	85.5000	118.5394	151.5787	184.6181
TL208	DIST LOG	17.3830	21.4801	26.5429	32.7991	40.5298	50.0826	61.8870
U/K	DIST NORMAL	-.1761	.2927	.7615	1.2302	1.6990	2.1677	2.6365
U/TH	DIST LOG	.7754	1.1287	1.6429	2.3914	3.4809	5.0668	7.3752
TH/K	DIST LOG	.2451	.3053	.3803	.4737	.5900	.7349	.9154

ROCK UNIT KBS

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	13.1385	20.9112	33.2822	52.9718	84.3097	134.1868	213.5710
BI214	DIST NORMAL	-9.5976	14.1616	37.9208	61.6800	85.4392	109.1984	132.9576
TL208	DIST LOG	9.6680	14.1024	20.5706	30.0055	43.7678	63.8423	93.1242
U/K	DIST LOG	.2463	.4084	.6770	1.1223	1.8604	3.0841	5.1127
U/TH	DIST NORMAL	-.8455	.1936	1.2327	2.2717	3.3108	4.3499	5.3889
TH/K	DIST LOG	.2030	.2860	.4028	.5674	.7993	1.1260	1.5862

ROCK UNIT KCG

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	21.5959	50.3639	79.1320	107.9000	136.6680	165.4361	194.2041
BI214	DIST NORMAL	1.7255	24.8837	48.0418	71.2000	94.3582	117.5163	140.6745
TL208	DIST NORMAL	12.5160	20.7440	28.9720	37.2000	45.4280	53.6560	61.8840
U/K	DIST NORMAL	-.1713	.1048	.3810	.6571	.9332	1.2094	1.4855
U/TH	DIST NORMAL	-.0664	.5726	1.2135	1.8545	2.4954	3.1364	3.7774
TH/K	DIST LOG	.1862	.2304	.2851	.3528	.4366	.5403	.6686

ROCK UNIT KBM

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-171.7328	-84.4586	2.8157	90.0900	177.3643	264.6386	351.9128
BI214	DIST LOG	19.1016	30.6478	49.1733	78.8967	126.5870	203.1042	325.8733
TL208	DIST NORMAL	-30.0763	-8.7949	12.4866	33.7680	55.0494	76.3309	97.6123
U/K	DIST LOG	.1915	.3152	.5189	.8540	1.4057	2.3137	3.8083
U/TH	DIST LOG	.8172	1.1316	1.5671	2.1700	3.0049	4.1611	5.7622
TH/K	DIST LOG	.1217	.1800	.2661	.3936	.5820	.8606	1.2725

ROCK UNIT KYE

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	41.2773	45.8515	50.4258	55.0000	59.5742	64.1485	68.7227
BI214	DIST LOG	18.5807	27.8985	41.8889	62.8952	94.4356	141.7927	212.8982
TL208	DIST LOG	10.6280	14.7032	20.3411	28.1408	38.9312	53.8592	74.5112
U/K	DIST LOG	.2140	.3809	.6777	1.2058	2.1454	3.8174	6.7924
U/TH	DIST LOG	.4725	.7924	1.3290	2.2289	3.7383	6.2696	10.5151
TH/K	DIST LOG	.1941	.2742	.3872	.5469	.7725	1.0912	1.5412

ROCK UNIT KYU

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	8.4031	17.7943	37.2815	78.1102	163.6519	342.8740	718.3699
BI214	DIST LOG	27.0146	38.6319	55.2451	79.0025	112.9766	161.5609	231.0382
TL208	DIST LOG	8.3522	13.0367	20.3485	31.7613	49.5752	77.3804	120.7805
U/K	DIST LOG	.1337	.2630	.5176	1.0184	2.0038	3.9426	7.7576
U/TH	DIST NORMAL	-.7541	.4093	1.5727	2.7361	3.8995	5.0629	6.2263
TH/K	DIST LOG	.1165	.1783	.2728	.4174	.6387	.9773	1.4954

ROCK UNIT KCU

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	76.8376	86.1917	95.5459	104.9000	114.2541	123.6083	132.9624
BI214	DIST NORMAL	36.5898	45.3932	54.1966	63.0000	71.8034	80.6068	89.4102
TL208	DIST LOG	27.7124	30.2054	32.9226	35.8843	39.1124	42.6309	46.4659
U/K	DIST LOG	.3416	.4115	.4956	.5970	.7191	.8661	1.0432
U/TH	DIST LOG	.9885	1.1933	1.4405	1.7389	2.0991	2.5339	3.0587
TH/K	DIST LOG	.2439	.2734	.3063	.3433	.3847	.4312	.4832

ROCK UNIT KLP

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-2.3660	24.5227	51.4113	78.3000	105.1887	132.0773	158.9660
BI214	DIST NORMAL	10.3302	32.0535	53.7767	75.5000	97.2233	118.9465	140.6698
TL208	DIST LOG	11.9845	14.1401	21.7366	29.2737	39.4243	53.0944	71.5047
U/K	DIST LOG	.2074	.3476	.5824	.9759	1.6352	2.7399	4.5909
U/TH	DIST LOG	.8239	1.1843	1.7024	2.4471	3.5176	5.0563	7.2683
TH/K	DIST LOG	.1429	.2012	.2832	.3988	.5615	.7907	1.1133

ROCK UNIT KF

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	8.3830	40.3220	72.2610	104.2000	136.1390	168.0780	200.0170
BI214	DIST NORMAL	-1.1357	23.3429	47.8214	72.3000	96.7786	121.2571	145.7357
TL208	DIST NORMAL	-6.4376	8.4083	23.2541	38.1000	52.9459	67.7917	82.6376
U/K	DIST LOG	.1871	.2900	.4494	.6964	1.0793	1.6726	2.5920
U/TH	DIST LOG	.5117	.9896	1.2938	1.8816	2.7365	3.9797	5.7879
TH/K	DIST NORMAL	-.1057	.0504	.2065	.3627	.5188	.6750	.8311

ROCK UNIT KCX

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	13.4330	21.3364	33.8697	53.8289	85.4993	135.8033	215.7037
BI214	DIST NORMAL	-6.7592	14.9272	36.6136	58.3000	79.9864	101.6728	123.3592
TL208	DIST LOG	11.2016	15.2392	20.7321	28.2050	38.3715	52.2025	71.0188
U/K	DIST LOG	.2071	.3493	.5692	.9940	1.6767	2.8283	4.7710
U/TH	DIST NORMAL	-.6958	.2429	1.1816	2.1203	3.0590	3.9977	4.9364
TH/K	DIST LOG	.1916	.2681	.3752	.5251	.7349	1.0285	1.4394

ROCK UNIT JM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	13.2818	20.1290	30.5061	46.2328	70.0672	106.1888	160.9322
BT214	DIST	NORMAL	22.5341	43.2561	63.9780	84.7000	105.4220	126.1439	146.8659
TL208	DIST	LOG	6.7246	9.6591	13.8743	19.9289	28.6256	41.1176	59.0608
U/K	DIST	NORMAL	-.8318	.1232	1.0781	2.0330	2.9879	3.9428	4.8977
U/TH	DIST	LOG	.7647	1.3405	2.3499	4.1193	7.2211	12.6583	22.1896
TH/K	DIST	NORMAL	.1020	.2164	.3309	.4454	.5598	.6743	.7887

ROCK UNIT PGRG

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	9.7652	29.8101	49.8551	69.9000	89.9449	109.9899	130.0348
BT214	DIST	LOG	12.3448	18.6613	28.2098	42.6441	64.4641	97.4489	147.3112
TL208	DIST	LOG	10.8650	15.2209	21.3231	29.8717	41.8474	58.6244	82.1273
U/K	DIST	LOG	.1476	-.2395	.3886	.6306	1.0232	1.6603	2.6939
U/TH	DIST	LOG	.3177	.5234	.8621	1.4201	2.3392	3.8531	6.3468
TH/K	DIST	NORMAL	-.0022	.1531	.3083	.4636	.6188	.7740	.9293

ROCK UNIT PRU

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	17.7838	26.3613	39.0760	57.9233	85.8611	127.2741	188.6615
BT214	DIST	LOG	14.4093	22.1297	33.9865	52.1962	80.1625	123.1128	189.0755
TL208	DIST	LOG	9.2986	12.7832	17.5734	24.1588	33.2120	45.6577	62.7672
U/K	DIST	LOG	.1857	.3142	.5316	.8994	1.5215	2.5741	4.3547
U/TH	DIST	LOG	.4951	.8079	1.3182	2.1509	3.5027	5.7268	9.3445
TH/K	DIST	LOG	.1666	.2262	.3072	.4171	.5664	.7692	1.0444

ROCK UNIT PCS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	9.5996	15.7527	25.8500	42.4196	69.6100	114.2291	187.4484
BT214	DIST	LOG	11.0867	17.3166	27.0475	42.2464	65.9862	103.0662	160.9829
TL208	DIST	NORMAL	-5.2473	2.3625	9.9842	17.6000	25.2158	32.8315	40.4473
U/K	DIST	LOG	.2003	.3363	.5647	.9481	1.5917	2.6723	4.4865
U/TH	DIST	NORMAL	-7.6870	-6.0722	-4.4573	-2.8424	-1.2275	.3873	2.0022
TH/K	DIST	NORMAL	-.0372	.1095	.2562	.4029	.5496	.6963	.8430

ROCK UNIT PBCD

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	36.6788	45.7605	57.0910	71.2269	88.8628	110.8655	138.3161
B1214	DIST	LOG	27.8030	39.8768	57.1939	82.0312	117.6545	168.7476	242.0288
TL208	DIST	NORMAL	7.2805	12.3203	17.3602	22.4000	27.4398	32.4797	37.5195
U/K	DIST	NORMAL	-.2029	.2834	.7697	1.2560	1.7423	2.2286	2.7149
U/TH	DIST	LOG	1.1355	1.6920	2.5212	3.7568	5.5980	8.3416	12.4297
TH/K	DIST	NORMAL	.0724	.1538	.2352	.3165	.3979	.4792	.5606

ROCK UNIT PBC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	19.3395	43.1597	66.9798	90.8000	114.6202	138.4403	162.2605
B1214	DIST	NORMAL	9.4929	34.0286	58.5643	83.1000	107.6357	132.1714	156.7071
TL208	DIST	NORMAL	9.5938	16.5292	23.4646	30.4000	37.3354	44.2708	51.2062
U/K	DIST	LOG	.2899	.4234	.6182	.9028	1.3183	1.9250	2.8110
U/TH	DIST	NORMAL	-.1690	.8318	1.8326	2.8334	3.8342	4.8350	5.8359
TH/K	DIST	NORMAL	.0990	.1810	.2629	.3448	.4267	.5086	.5905

ROCK UNIT PC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	10.8306	16.6061	25.4616	39.0393	59.8576	91.7776	140.7193
B1214	DIST	LOG	14.2182	21.3291	31.9963	47.9985	72.0038	108.0148	162.0358
TL208	DIST	LOG	5.1874	7.4984	10.8387	15.6672	22.6467	32.7353	47.3183
U/K	DIST	LOG	.2168	.3886	.6968	1.2493	2.2398	4.0158	7.1999
U/TH	DIST	LOG	.6506	1.0977	1.8520	3.1249	5.2725	8.8960	15.0099
TH/K	DIST	LOG	.1052	.1645	.2574	.4025	.6296	.9849	1.5405

ROCK UNIT PY

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	22.3701	29.9854	40.1931	53.8757	72.2162	96.8002	129.7532
B1214	DIST	LOG	19.6937	28.1178	40.1453	57.3177	81.8357	116.8414	166.8210
TL208	DIST	LOG	9.5271	12.8906	17.4415	23.5991	31.9307	43.2036	58.4565
U/K	DIST	LOG	.2527	.4082	.6595	1.0655	1.7215	2.7813	4.4935
U/TH	DIST	NORMAL	-.5674	.5219	1.6112	2.7005	3.7898	4.8791	5.9683
TH/K	DIST	NORMAL	-.1802	.0208	.2217	.4227	.6237	.8247	1.0256

ROCK UNIT PCB

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	20.0888	34.2592	48.4296	62.6000	76.7704	90.9408	105.1112
BI214	DIST LOG	13.1143	20.8371	33.1077	52.6044	83.5824	132.8030	211.0089
TL208	DIST NORMAL	1.9754	8.0170	14.0585	20.1000	26.1415	32.1830	38.2246
U/K	DIST LOG	.2013	.3221	.5152	.8241	1.3184	2.1090	3.3737
U/TH	DIST LOG	.6869	1.0958	1.7482	2.7890	4.4494	7.0983	11.3242
TH/K	DIST LOG	.0920	.1381	.2072	.3110	.4667	.7004	1.0511

ROCK UNIT PSR

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	13.2866	19.2579	27.9126	40.4570	58.6390	84.9923	123.1892
BI214	DIST LOG	16.8086	25.1979	37.7743	56.6278	84.8912	127.2611	190.7781
TL208	DIST NORMAL	2.1764	8.2509	14.3255	20.4000	26.4745	32.5491	38.6236
U/K	DIST LOG	.4277	.6372	.9494	1.4144	2.1072	3.1394	4.6773
U/TH	DIST NORMAL	-1.0670	.4293	1.9255	3.4218	4.9180	6.4142	7.9105
TH/K	DIST LOG	.1224	.1918	.3006	.4711	.7382	1.1567	1.8126

ROCK UNIT PT

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	1.3500	14.5334	27.7167	40.9000	54.0833	67.2666	80.4500
BI214	DIST NORMAL	14.6258	30.4372	46.2486	62.0600	77.8714	93.6828	109.4942
TL208	DIST LOG	9.4840	12.4120	16.2439	21.2588	27.8219	36.4112	47.6523
U/K	DIST NORMAL	-.9298	-.0696	.7906	1.6507	2.5109	3.3711	4.2313
U/TH	DIST NORMAL	-.3101	.8628	2.0357	3.2086	4.3815	5.5544	6.7273
TH/K	DIST LOG	.1441	.2253	.3524	.5512	.8620	1.3481	2.1084

ROCK UNIT PCC

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	25.6351	49.1234	72.6117	96.1000	119.5883	143.0766	166.5649
BI214	DIST NORMAL	7.6424	31.3616	55.0808	78.8000	102.5192	126.2384	149.9576
TL208	DIST NORMAL	9.7757	16.9171	24.0586	31.2000	38.3414	45.4829	52.6243
U/K	DIST NORMAL	-.2047	.1546	.5140	.8733	1.2326	1.5919	1.9512
U/TH	DIST NORMAL	-.3185	.6152	1.5488	2.4824	3.4160	4.3497	5.2833
TH/K	DIST LOG	.1752	.2156	.2654	.3267	.4021	.4950	.6093

ROCK UNIT PGS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	33.4287	42.2513	53.4025	67.4968	85.3109	107.8266	136.2847
BI214	DIST	LOG	19.3526	28.2520	41.2438	60.2101	87.8981	128.3187	187.3269
TL208	DIST	NORMAL	3.0803	10.3535	17.6268	24.9000	32.1732	39.4465	46.7197
U/K	DIST	LOG	.3474	.4782	.6583	.9061	1.2473	1.7169	2.3633
U/TH	DIST	LOG	1.0292	1.3814	1.8540	2.4884	3.3399	4.4826	6.0164
TH/K	DIST	NORMAL	.1354	.2106	.2858	.3609	.4361	.5113	.5864

ROCK UNIT PM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-4.4552	22.6299	49.7149	76.8000	103.8851	130.9701	158.0552
BI214	DIST	NORMAL	5.9744	28.2163	50.4581	72.7000	94.9419	117.1837	139.4256
TL208	DIST	NORMAL	7.3864	12.8909	18.3955	23.9000	29.4045	34.9091	40.4136
U/K	DIST	LOG	.1453	.2726	.5114	.9594	1.7999	3.3769	6.3355
U/TH	DIST	LOG	.7641	1.2017	1.8900	2.9724	4.6748	7.3521	11.5627
TH/K	DIST	LOG	.1320	.1785	.2414	.3265	.4415	.5972	.8076

ROCK UNIT PDB

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	47.8266	67.0177	86.2089	105.4000	124.5911	143.7823	162.9734
BI214	DIST	LOG	33.7457	40.6816	49.0430	59.1230	71.2748	85.9241	103.5845
TL208	DIST	LOG	8.7154	11.8079	15.9977	21.6741	29.3648	39.7844	53.9012
U/K	DIST	LOG	.1352	.2186	.3534	.5713	.9235	1.4929	2.4133
U/TH	DIST	LOG	.6835	1.0823	1.7137	2.7134	4.2964	6.8028	10.7715
TH/K	DIST	LOG	.0800	.1102	.1518	.2091	.2880	.3967	.5464

ROCK UNIT PBG

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	12.9084	23.2236	41.7818	75.1698	135.2386	243.3086	437.7383
BI214	DIST	LOG	27.7182	36.8726	48.6990	64.3187	84.9481	112.1942	148.1791
TL208	DIST	LOG	7.4390	11.8092	18.7466	29.7595	47.2421	74.9951	119.0518
U/K	DIST	LOG	.1723	.2940	.5016	.8556	1.4597	2.4901	4.2481
U/TH	DIST	LOG	.5827	.9019	1.3962	2.1613	3.3456	5.1790	8.0170
TH/K	DIST	LOG	.2024	.2531	.3166	.3959	.4951	.6192	.7744

ROCK UNIT PL

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	54.9496	67.7723	83.5873	103.0928	127.1501	156.8211	193.4161
BI214	DIST	NORMAL	19.1771	39.4847	59.7924	80.1000	100.4076	120.7153	141.0229
TL208	DIST	NORMAL	13.2979	20.5986	27.8993	35.2000	42.5007	49.8014	57.1021
U/K	DIST	LOG	.2738	.3830	.5357	.7493	1.0481	1.4661	2.0508
U/TH	DIST	LOG	.7714	1.1008	1.5708	2.2416	3.1988	4.5648	6.5140
TH/K	DIST	LOG	.1972	.2351	.2804	.3343	.3986	.4752	.5667

ROCK UNIT PCO

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	6.3834	27.1223	47.8611	68.6000	89.3389	110.0777	130.8166
BI214	DIST	NORMAL	14.8204	33.9803	53.1401	72.3000	91.4599	110.6197	129.7796
TL208	DIST	LOG	10.7968	14.2818	18.8916	24.9894	33.0553	43.7247	57.8380
U/K	DIST	LOG	.2991	.4565	.6966	1.0630	1.6222	2.4755	3.7778
U/TH	DIST	LOG	.8771	1.2878	1.8908	2.7760	4.0758	5.9841	8.7859
TH/K	DIST	LOG	.1936	.2430	.3050	.3828	.4805	.6031	.7570

ROCK UNIT PVC

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	6.0742	32.2162	58.3581	84.5000	110.6419	136.7838	162.9258
BI214	DIST	NORMAL	9.7275	31.0183	52.3092	73.6000	94.8908	116.1817	137.4725
TL208	DIST	NORMAL	4.0334	13.0222	22.0111	31.0000	39.9889	48.9778	57.9666
U/K	DIST	LOG	.2403	.3702	.5703	.8785	1.3532	2.0845	3.2111
U/TH	DIST	LOG	.7146	1.0653	1.5882	2.3677	3.5298	5.2622	7.8448
TH/K	DIST	LOG	.1978	.2440	.3010	.3713	.4580	.5649	.6969

ROCK UNIT PB3

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	11.8520	19.8131	33.1218	55.3701	92.5629	154.7385	258.6782
BI214	DIST	NORMAL	-9.0609	15.2927	39.6464	64.0000	88.3536	112.7073	137.0609
TL208	DIST	LOG	5.0390	7.6720	11.6809	17.7844	27.0771	41.2255	62.7668
U/K	DIST	LOG	.1118	.2363	.4998	1.0568	2.2347	4.7256	9.9926
U/TH	DIST	LOG	.5133	.9599	1.7949	3.3562	6.2756	11.7347	21.9425
TH/K	DIST	NORMAL	-.0748	.0685	.2118	.3551	.4985	.6418	.7851

ROCK UNIT PH

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	26.3100	39.9435	60.6417	92.0655	139.7725	212.2008	322.1603
BT214	DIST	NORMAL	10.4270	32.1180	53.8090	75.5000	97.1910	118.8820	140.5730
TL208	DIST	LOG	10.6356	15.1485	21.5763	30.7316	43.7716	62.3448	88.7989
U/K	DIST	LOG	.1826	.2969	.4827	.7849	1.2761	2.0750	3.3739
U/TH	DIST	LOG	.6308	.9781	1.5167	2.3517	3.6465	5.6541	8.7671
TH/K	DIST	NORMAL	.0823	.1692	.2561	.3430	.4299	.5168	.6037

ROCK UNIT IPM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	22.0921	27.9353	35.3239	44.6668	56.4808	71.4194	90.3093
BT214	DIST	LOG	27.7428	34.8417	43.7570	54.9536	69.0153	86.6750	108.8535
TL208	DIST	NORMAL	2.4103	8.2069	14.0034	19.8000	25.5966	31.3931	37.1897
U/K	DIST	LOG	.5374	.7083	.9335	1.2303	1.6215	2.1371	2.8167
U/TH	DIST	LOG	1.1276	1.5448	2.1163	2.8993	3.9720	5.4416	7.4549
TH/K	DIST	NORMAL	.0549	.1904	.3159	.4414	.5669	.6924	.8179

ROCK UNIT DM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	24.2538	33.9894	47.6329	66.7530	93.5481	131.0989	183.7227
BT214	DIST	NORMAL	6.8577	26.8051	46.7526	66.7000	86.6474	106.5949	126.5423
TL208	DIST	NORMAL	9.4448	15.1632	20.8816	26.6000	32.3184	38.0368	43.7552
U/K	DIST	NORMAL	-.4700	.0467	.5633	1.0800	1.5967	2.1133	2.6300
U/TH	DIST	NORMAL	-.0676	.8302	1.7281	2.6260	3.5238	4.4217	5.3196
TH/K	DIST	LOG	.1952	.2457	.3093	.3894	.4902	.6170	.7768

ROCK UNIT SF

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	19.5369	27.0386	37.4209	51.7896	71.6757	99.1975	137.2871
BT214	DIST	LOG	12.7576	19.8448	30.8691	48.0177	74.6929	116.1868	180.7316
TL208	DIST	LOG	8.7383	11.4382	14.9723	19.5982	25.6535	33.5796	43.9547
U/K	DIST	LOG	.2147	.3497	.5694	.9273	1.5101	2.4591	4.0046
U/TH	DIST	LOG	.5389	.8934	1.4813	2.4560	4.0719	6.7512	11.1933
TH/K	DIST	NORMAL	.1126	.2049	.2971	.3894	.4816	.5739	.6661

ROCK UNIT OM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	27.1667	36.3913	48.7480	65.3005	87.4735	117.1753	156.9624
BI214	DIST	LOG	15.9025	23.7365	35.4298	52.8834	78.9352	117.8207	175.8623
TL208	DIST	NORMAL	4.0855	10.2903	16.4952	22.7000	28.9048	35.1097	41.3145
U/K	DIST	NORMAL	-.0947	.2346	.5640	.8933	1.2227	1.5520	1.8814
U/TH	DIST	LOG	.8286	1.1900	1.7091	2.4546	3.5253	5.0630	7.2716
TH/K	DIST	LOG	.1540	.1994	.2581	.3340	.4324	.5597	.7244

ROCK UNIT OE

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	23.5599	32.7606	45.5545	63.3446	88.0823	122.4807	170.3125
BI214	DIST	NORMAL	.7474	19.5649	38.3825	57.2000	76.0175	94.8351	113.6526
TL208	DIST	LOG	7.7038	10.7905	15.1140	21.1699	29.6522	41.5332	58.1747
U/K	DIST	LOG	.2575	.3826	.5685	.8446	1.2549	1.8645	2.7702
U/TH	DIST	LOG	.7273	1.0983	1.6584	2.5041	3.7811	5.7093	8.6210
TH/K	DIST	LOG	.1549	.2000	.2581	.3331	.4300	.5550	.7163

ROCK UNIT PCV

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-18.4872	64.5152	147.5176	230.5200	313.5224	396.5248	479.5272
BI214	DIST	LOG	55.9238	71.5796	91.6182	117.2666	150.0952	192.1141	245.8961
TL208	DIST	NORMAL	4.4085	18.0724	31.7362	45.4000	59.0638	72.7276	86.3915
U/K	DIST	LOG	.1566	.2537	.4110	.6657	1.0784	1.7467	2.8294
U/TH	DIST	LOG	1.0760	1.4718	2.0133	2.7540	3.7672	5.1531	7.0489
TH/K	DIST	LOG	.0982	.1326	.1790	.2417	.3264	.4408	.5953

ROCK UNIT PCR

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	111.7618	118.9639	126.6301	134.7903	143.4763	152.7221	162.5637
BI214	DIST	LOG	25.8729	35.8730	49.7382	68.9623	95.6167	132.5732	183.8136
TL208	DIST	NORMAL	24.7528	32.1352	39.5176	46.9000	54.2824	61.6648	69.0472
U/K	DIST	NORMAL	.0314	.2001	.3688	.5375	.7062	.8749	1.0436
U/TH	DIST	LOG	.5579	.7739	1.0736	1.4892	2.0658	2.8657	3.9753
TH/K	DIST	NORMAL	.1913	.2434	.2954	.3475	.3995	.4516	.5037

ROCK UNIT PCM

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	38.6317	79.4435	120.2552	161.0670	201.8788	242.6905	283.5023
BI214	DIST	NORMAL	33.0703	56.2802	79.4901	102.7000	125.9099	149.1198	172.3297
TL208	DIST	NORMAL	10.8014	21.7009	32.6005	43.5000	54.3995	65.2991	76.1986
U/K	DIST	NORMAL	-.3334	.0081	.3497	.6912	1.0327	1.3742	1.7158
U/TH	DIST	LOG	.9524	1.2928	1.7550	2.3824	3.2342	4.3904	5.9599
TH/K	DIST	LOG	.1545	.1919	.2384	.2961	.3679	.4570	.5676

ROCK UNIT PCA

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	15.3670	56.1114	96.8557	137.6000	178.3443	219.0886	259.8330
BI214	DIST	LOG	38.8783	49.1926	62.2434	78.7564	99.6504	126.0876	159.5384
TL208	DIST	LOG	12.6749	16.6414	21.8491	28.6866	37.6638	49.4502	64.9251
U/K	DIST	LOG	.2643	.3573	.4829	.6526	.8821	1.1921	1.6112
U/TH	DIST	LOG	1.0615	1.4571	2.0001	2.7454	3.7684	5.1727	7.1002
TH/K	DIST	LOG	.0965	.1304	.1761	.2377	.3210	.4333	.5851

ROCK UNIT PCCI

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-87.3942	31.0372	149.4686	267.9000	386.3314	504.7628	623.1942
BI214	DIST	NORMAL	16.9578	55.6385	94.3193	133.0000	171.6807	210.3615	249.0422
TL208	DIST	NORMAL	5.0512	21.4342	37.8171	54.2000	70.5829	86.9658	103.3488
U/K	DIST	LOG	.2040	.2811	.3874	.5339	.7357	1.0140	1.3974
U/TH	DIST	NORMAL	.9010	1.4399	1.9788	2.5177	3.0566	3.5955	4.1344
TH/K	DIST	LOG	.0992	.1288	.1672	.2171	.2818	.3659	.4750

ROCK UNIT PCCS

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	32.6693	59.8220	109.5424	200.5874	367.3033	672.5833	1231.5933
BI214	DIST	LOG	36.2004	53.1519	78.0412	114.5854	168.2420	247.0243	362.6978
TL208	DIST	LOG	22.8847	29.9682	39.2442	51.3914	67.2984	88.1291	115.4075
U/K	DIST	LOG	.1922	.2763	.3973	.5712	.8213	1.1809	1.6979
U/TH	DIST	NORMAL	.6108	1.1738	1.7369	2.3000	2.8630	3.4261	3.9891
TH/K	DIST	LOG	.0798	.1178	.1737	.2562	.3779	.5574	.8221

APPENDIX C

Geologic Legend - Pecos Quadrangle

Qao

Qgt

Other Quaternary deposits and Toy Limestone

Other Quaternary deposits, Qao, in eastern and central areas, mostly boulders, cobbles, and pebbles of Cretaceous limestone and chert, locally overlain by brown silt, probably equivalent to "Qs3" of Seymour Formation of Abilene, Big Spring, and San Angelo Sheets. In western area includes material from a greater diversity of sedimentary and igneous formations and includes alluvium, colluvium, caliche, and gypsite on surfaces dissected by modern drainage, equivalent to "Old Quaternary deposits, Qao," of Van Horn-El Paso Sheet

Toy Limestone, Qgt, fresh-water limestone near western boundary of area; may be older than Qao; thickness 30 feet

Qta

Tahoka Formation

Lacustrine clay, silt, sand, and gravel, locally calcareous, selenitic. Clay and silt, sandy, indistinctly bedded to massive, weakly coherent, various shades of light gray and bluish gray, reddish brown. Sand, fine- to coarse-grained quartz, indistinctly bedded to massive, friable, gray, grades to gravel at margins of deposits. Molluscan fossils. Thickness up to about 40 feet (Wisconsinan)

Qcc

Caliche

Caliche stripped of covering materials mapped separately; several ages; thickness up to 35 feet

Qcs

Windblown cover sand

Fine- to medium-grained quartz, silty, calcareous, caliche nodules, massive, grayish red; thickness 20 feet, feathers out locally (mostly Illinoian, may include younger deposits)

Qg

Gatuña Formation

Sand, marl, conglomerate, gypsum, silt, shale, and limestone. Sand, fine to coarse, yellow, yellowish to reddish orange, brown, red, pink; locally with worn Cretaceous fossils. Marl, gypsiferous, green, gray, pale olive, pinkish, red. Conglomerate, pebbles of chert, quartz, quartzite, limestone, and igneous rock. Gypsum, laminated to massive, gray and red. Silt and shale, red, dark yellow-orange, green, purplish. Limestone, locally with chalcedony. Thickness 450 feet; included in "Bolson deposits, QTb," on Van Horn-El Paso Sheet

EXPLANATION

Recent (Holocene)

Qal

Alluvium

Includes low terrace deposits along streams, and sandy silts on pediments locally modified by sheetwash action

Qsd	Qsu
Qs	

Windblown sand

Sand and silt in sheets, Qs, locally includes cover sand; dunes and dune ridges, Qsd; and sand sheets, dunes, and dune ridges undivided, Qsu

Qgy

Gypsite

Granular gypsum, white to light gray, of several ages

Qau	Qap
-----	-----

Alluvium and other Quaternary deposits

Intimately associated alluvium and Qao deposits undivided, Qau, in dissected areas
Siliceous and igneous pebbles in deposits of uncertain age, Qap, in valleys of Toyah Creek and Barilla Draw

Qt

Fluviatile terrace deposits

Gravel, sand, and silt; gravel, commonly with pebbles and cobbles of chert, quartzite, igneous rock, metamorphic rock, caliche, and at higher levels abraded *Gryphaea*; quartz sand, crossbedded to massive, lenticular, reddish brown, pink, gray to light gray. Contiguous terraces of different ages separated by solid line

Qp

Playa deposits

Clay and silt, sandy, light to dark gray, in shallow depressions; those of Wisconsinan age usually covered by thin deposit of Recent sediment
Note: Water in depressions not shown

Qun

Pond deposits

Gastropod-bearing sandy silt and silty clay, gray to light gray, deposited in ponds and shallow swales, locally may include Tahoka deposits

Qu

Pleistocene surficial deposits undivided

Brown and grayish-brown silty sand and sandy silt deposited as broad, gently sloping sheets

QUATERNARY

Kbo

Boquillas Limestone

Limestone, marl, and shale, flaggy, light gray, light grayish orange, dark grayish orange near base; upper and lower parts only crop out within area of Pecos Sheet

Washita and Fredericksburg Groups

- Buda Formation, Kbu; Boracho Formation represented by San Martine, Kbs, and Levinson, Kbl, Limestone Members; Finlay Formation, Kf; Buda Formation and San Martine Member undivided, Kbus, and San Martine Member and Finlay Formation undivided, Kbsf, in collapsed areas; Washita Group, Kw; Fredericksburg Group, Kfr; Segovia Formation, Ks; Fort Terrett Formation, Kft; and Antlers Sand, Ka
- Buda Formation, Kbu, limestone, upper 40 feet, very hard, thin to thick bedded; middle 60 feet, argillaceous, thin to thick bedded; lower 40 feet, bioclastic, coquinoïd; thickness 140 feet
- San Martine Limestone Member, Kbs, argillaceous, thin to thick bedded, thin interbeds of calcareous shale; prominent 30-foot ledge at base in some localities; marine megafossils throughout; thickness 230 feet

Washita Group, Kw, lime tone and marl. Limestone, mostly in upper part, massive, fine to coarse grained, crossbedded calcarenite locally, minor marly limestone, white, gray, yellowish gray; forms ledges; abundant rudistids and other molluscs. Marl, in lower part (locally gypsiferous), thick, dark greenish gray, gray; weathers yellow; abundant molluscs, *Gryphaea navia* at base; grades to limestone along eastern boundary of area. Thickness 230 feet

Fredericksburg Group, Kfr, limestone, dolomite, chert, and minor marl. Limestone, nodular, aphanitic, marly, gray, yellow, white, pink. Dolomite, fine grained, gray. Chert, in thin layers and nodules. Marl, locally gypsiferous, gray, yellowish gray. Abundant *Exogyra texana*, some beds made almost entirely of *Gryphaea* sp. Thickness 135 feet

Fort Terrett Formation, Kft, limestone and dolomite. In upper part—cherty limestone and dolomite; limestone in part porcellaneous, aphanitic, in part miliolid, shell fragment, and rudistid-bearing, light to dark gray; dolomite, medium brownish gray. In lower part—limestone, argillaceous, thin shale interbeds, nodular and irregularly bedded to thick bedded, light gray, grayish yellow, yellowish brown; marine megafossils. Thickness 120 feet

Antlers Sand, Ka, sandstone, fine to coarse grained, white, gray, tan, purple, soft, friable, commonly crossbedded, upper part calcareous, silty; thickness 90 feet

VIRGIL E. BARNES, PROJECT DIRECTOR

Geologic mapping mostly by G. K. Eifler, Jr., Bureau of Economic Geology, The University of Texas at Austin, with contributions gratefully acknowledged from Shell Development Company, Cities Service Petroleum Company, and sources shown on Index of Geologic Mapping. Geology compiled on high-altitude aerial photographs by G. K. Eifler, Jr. Map scribed by J. W. Macon. Geologic mapping reviewed by J. B. Brown, West Texas Geological Society, Geologic Atlas Committee.

APPENDIX D
Statistical Tables - Pecos Quadrangle

ROCK UNIT KA

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-23.7669	1.4221	26.8110	52.2000	77.5890	102.9779	128.3669
RI214	DIST NORMAL	-6.7886	15.2976	37.3838	59.4700	81.5542	103.6424	125.7286
TL208	DIST NORMAL	2.5641	10.2694	18.0347	25.8000	33.5653	41.3306	49.0959
U/K	DIST LOG	.1671	.3435	.6307	1.1579	2.1260	3.9033	7.1666
U/TH	DIST LOG	.5541	.8936	1.4413	2.3246	3.7492	6.0469	9.7527
TH/K	DIST LOG	.1906	.2633	.3637	.5024	.6940	.9586	1.3242

ROCK UNIT KBO

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	48.3316	67.4520	94.1367	131.3782	183.3527	255.8889	357.1211
RI214	DIST LOG	66.0978	77.7831	91.5341	107.7162	126.7591	149.1685	175.5396
TL208	DIST LOG	23.7373	30.7494	39.8330	51.5999	66.8428	86.5886	112.1674
U/K	DIST LOG	.3179	.4360	.5979	.8199	1.1243	1.5418	2.1143
U/TH	DIST NORMAL	.6777	1.1667	1.6556	2.1446	2.6335	3.1225	3.6114
TH/K	DIST LOG	.2516	.2919	.3386	.3928	.4556	.5285	.6131

ROCK UNIT KBU

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	13.7554	23.9092	41.5580	72.2347	125.5556	218.2362	379.3303
RI214	DIST LOG	32.7930	44.5210	60.4433	82.0599	111.4075	151.2509	205.3437
TL208	DIST LOG	13.4811	18.9501	26.2482	36.3571	50.3592	69.7539	96.6179
U/K	DIST LOG	.2743	.4405	.7074	1.1360	1.8243	2.9296	4.7046
U/TH	DIST NORMAL	.5151	1.1209	1.7268	2.3326	2.9385	3.5443	4.1502
TH/K	DIST LOG	.1716	.2644	.3648	.5033	.6945	.9583	1.3222

ROCK UNIT KBUS

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-22.8730	15.4180	53.7090	92.0000	130.2910	168.5820	206.8730
RI214	DIST NORMAL	20.2755	47.5170	74.7585	102.0000	129.2415	156.4830	183.7245
TL208	DIST LOG	15.9658	21.1523	28.0237	37.1272	49.1880	65.1669	86.3364
U/K	DIST LOG	.3164	.4873	.7504	1.1556	1.7796	2.7406	4.2204
U/TH	DIST LOG	.9606	1.3472	1.8894	2.6499	3.7166	5.2125	7.3106
TH/K	DIST NORMAL	.1338	.2382	.3426	.4470	.5514	.6558	.7602

ROCK UNIT KB3

			-3	-2	-1	0	+1	+2	+3
K40	DIST	LOG	23.2834	33.1535	47.6167	68.3895	98.2245	141.0750	202.6191
BT214	DIST	NORMAL	9.3718	32.0146	54.1573	76.3000	98.4427	120.5854	142.7282
TL208	DIST	LOG	11.7510	16.3244	22.6778	31.5039	43.7650	60.7982	84.4605
U/K	DIST	LOG	.3742	.5305	.7521	1.0662	1.5115	2.1429	3.0379
U/TH	DIST	LOG	.9402	1.2695	1.7142	2.3146	3.1253	4.2200	5.6981
TH/K	DIST	LOG	.2593	.3140	.3803	.4606	.5579	.6757	.8183

ROCK UNIT KFR

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-11.2980	9.8680	31.0340	52.2000	73.3660	94.5320	115.6980
BT214	DIST	NORMAL	-.7557	22.4602	46.4841	70.1040	93.7239	117.3438	140.9637
TL208	DIST	NORMAL	1.7655	9.5437	17.3218	25.1000	32.8782	40.6563	48.4345
U/K	DIST	LOG	.2831	.4881	.8414	1.4507	2.5011	4.3120	7.4341
U/TH	DIST	LOG	.7876	1.2159	1.8773	2.8983	4.4748	6.9086	10.6663
TH/K	DIST	LOG	.2076	.2787	.3742	.5025	.6747	.9060	1.2165

ROCK UNIT KFT

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	2.1054	17.3369	32.5685	47.8000	63.0315	78.2631	93.4946
BT214	DIST	NORMAL	11.4535	28.5357	45.6178	62.7000	79.7822	96.8643	113.9465
TL208	DIST	LOG	11.6142	14.8393	18.9600	24.2249	30.9518	39.5467	50.5283
U/K	DIST	LOG	.4364	.6317	.9145	1.3238	1.9162	2.7738	4.0153
U/TH	DIST	LOG	.8871	1.2520	1.7671	2.4940	3.5199	4.9679	7.0115
TH/K	DIST	NORMAL	.1728	.2965	.4202	.5440	.6677	.7914	.9152

ROCK UNIT KW

			-3	-2	-1	0	+1	+2	+3
K40	DIST	NORMAL	-25.5466	3.2356	33.4178	62.9000	92.3822	121.8644	151.3466
BT214	DIST	NORMAL	-12.6003	15.2331	43.0666	70.9000	98.7334	126.5669	154.4003
TL208	DIST	NORMAL	-3.7500	7.0667	17.8833	28.7000	39.5167	50.3333	61.1500
U/K	DIST	LOG	.2809	.4524	.7287	1.1739	1.8909	3.0458	4.9063
U/TH	DIST	LOG	.5991	1.0637	1.6183	2.4622	3.7461	5.6995	8.6715
TH/K	DIST	LOG	.2217	.2866	.3705	.4790	.6193	.8006	1.0351

ROCK UNIT L

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	39.3256	53.6504	67.9752	82.3000	96.6248	110.9496	125.2744
BI214	DIST LOG	30.7674	38.4140	47.9612	59.8810	74.7634	93.3445	116.5436
TL208	DIST LOG	15.1395	17.7008	20.6953	24.1965	28.2901	33.0761	38.6719
U/K	DIST LOG	.2669	.3747	.5259	.7382	1.0361	1.4544	2.0414
U/TH	DIST LOG	1.3767	1.6740	2.0353	2.4748	3.0090	3.6586	4.4485
TH/K	DIST NORMAL	.0623	.1440	.2258	.3075	.3892	.4710	.5527

ROCK UNIT PRU

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	21.5554	38.8036	56.0518	73.3000	90.5482	107.7964	125.0446
BI214	DIST LOG	17.7180	26.8976	40.8331	61.9886	94.1046	142.8597	216.8747
TL208	DIST NORMAL	2.1900	9.6933	17.1967	24.7000	32.2033	39.7067	47.2100
U/K	DIST NORMAL	-.0415	.2884	.6182	.9481	1.2780	1.6078	1.9377
U/TH	DIST NORMAL	.4040	1.1909	1.9778	2.7648	3.5517	4.3386	5.1255
TH/K	DIST NORMAL	.1765	.2329	.2894	.3459	.4024	.4589	.5154

ROCK UNIT QAL

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-17.2592	28.0939	73.4469	118.8000	164.1531	209.5061	254.8592
BI214	DIST NORMAL	-18.9308	18.1461	55.2231	92.3000	129.3769	166.4539	203.5308
TL208	DIST NORMAL	-14.5080	6.1947	26.8973	47.6000	68.3027	89.0053	109.7080
U/K	DIST LOG	.2591	.3724	.5353	.7695	1.1060	1.5899	2.2854
U/TH	DIST LOG	.7004	.9850	1.3853	1.9482	2.7399	3.8534	5.4194
TH/K	DIST LOG	.2249	.2713	.3273	.3948	.4762	.5745	.6930

ROCK UNIT QAN

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-36.4279	19.4147	75.2574	131.1000	186.9426	242.7853	298.6279
BI214	DIST NORMAL	-13.7910	22.3394	58.4697	94.6000	130.7303	166.8606	202.9910
TL208	DIST NORMAL	-13.7138	7.9241	29.5621	51.2000	72.8379	94.4759	116.1138
U/K	DIST LOG	.2348	.3443	.5048	.7401	1.0851	1.5910	2.3326
U/TH	DIST LOG	.6820	.9561	1.3404	1.8792	2.6345	3.6935	5.1781
TH/K	DIST LOG	.2239	.2703	.3264	.3940	.4756	.5741	.6930

ROCK UNIT

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	92.6848	123.8232	154.9616	186.1000	217.2384	248.3768	279.5152
B1214	DIST NORMAL	37.3074	69.7049	102.1025	134.5000	166.8975	199.2951	231.6926
TL208	DIST NORMAL	29.8657	45.8438	61.8219	77.8000	93.7781	109.7562	125.7343
U/K	DIST NORMAL	.2395	.4038	.5682	.7325	.8969	1.0612	1.2256
U/TH	DIST LOG	.8712	1.0929	1.3710	1.7199	2.1577	2.7068	3.3957
TH/K	DIST LOG	.2674	.3097	.3586	.4152	.4808	.5568	.6447

ROCK UNIT QAU

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-90.9173	-34.4115	22.0942	78.6000	135.1058	191.6115	248.1173
B1214	DIST NORMAL	-47.1257	-8.7551	29.6154	67.9860	106.3566	144.7271	183.0977
TL208	DIST NORMAL	-33.7230	-11.8187	10.0857	31.9900	53.8943	75.7987	97.7030
U/K	DIST LOG	.2146	.3292	.5051	.7750	1.1890	1.8243	2.7990
U/TH	DIST NORMAL	-.4681	.3050	1.0781	1.8512	2.6243	3.3973	4.1704
TH/K	DIST NORMAL	.1193	.2173	.3153	.4133	.5112	.6092	.7072

ROCK UNIT QCC

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	14.4879	30.8586	47.2293	63.6000	79.9707	96.3414	112.7121
B1214	DIST NORMAL	-12.1662	8.5292	29.2246	49.9200	70.6154	91.3108	112.0062
TL208	DIST NORMAL	4.7207	11.5472	18.3736	25.2000	32.0264	38.8528	45.6793
U/K	DIST LOG	.1927	.3083	.4933	.7894	1.2632	2.0215	3.2348
U/TH	DIST LOG	.5177	.8109	1.2702	1.9896	3.1165	4.8816	7.6466
TH/K	DIST NORMAL	.0737	.1814	.2892	.3969	.5047	.6124	.7202

ROCK UNIT QCS

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	9.1550	29.2707	49.3853	69.5000	89.6147	109.7293	129.8440
B1214	DIST NORMAL	-2.8484	18.0011	38.8505	59.7000	80.5495	101.3989	122.2484
TL208	DIST NORMAL	6.4348	14.0899	21.7449	29.4000	37.0551	44.7101	52.3652
U/K	DIST LOG	.2223	.3458	.5379	.8368	1.3017	2.0249	3.1498
U/TH	DIST LOG	.5633	.8538	1.2940	1.9613	2.9726	4.5055	6.8288
TH/K	DIST NORMAL	.1032	.2082	.3132	.4181	.5231	.6281	.7331

ROCK UNIT QG

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-22.7792	11.1472	45.0736	79.0000	112.9264	146.8528	180.7792
RT214	DIST LOG	17.2686	27.8047	43.0250	66.5771	103.0215	159.4157	246.6802
TL208	DIST NORMAL	-2.7442	9.4705	21.6853	33.9000	46.1147	58.3295	70.5442
U/K	DIST LOG	.2284	.3503	.5372	.8238	1.2634	1.9376	2.9714
U/TH	DIST LOG	.5937	.7025	1.3719	2.0854	3.1700	4.8187	7.3248
TH/K	DIST LOG	.1940	.2459	.3116	.3948	.5002	.6339	.8032

ROCK UNIT QGT

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	68.9103	79.2997	91.2554	105.0136	120.8461	139.0656	160.0320
RT214	DIST NORMAL	38.3008	56.2006	74.1003	92.0000	109.8997	127.7994	145.6992
TL208	DIST NORMAL	24.0273	30.4849	36.9424	43.4000	49.8576	56.3151	62.7727
U/K	DIST NORMAL	.1907	.4238	.6569	.8901	1.1232	1.3563	1.5894
U/TH	DIST NORMAL	.6574	1.1588	1.6583	2.1577	2.6571	3.1565	3.6560
TH/K	DIST LOG	.2507	.2951	.3472	.4086	.4809	.5659	.6659

ROCK UNIT QGY

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-23.8673	5.3885	34.6442	63.9000	93.1558	122.4115	151.6673
RT214	DIST LOG	13.3348	20.4608	31.3949	48.1721	73.9150	113.4147	174.0228
TL208	DIST LOG	4.2620	7.1205	11.8962	19.8747	33.2045	55.4743	92.6802
U/K	DIST LOG	.1840	.3060	.5089	.8465	1.4079	2.3416	3.8946
U/TH	DIST LOG	.5865	.9284	1.4695	2.3262	3.6823	5.8289	9.2269
TH/K	DIST LOG	.1410	.1925	.2627	.3585	.4892	.6677	.9112

ROCK UNIT QP

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	1.6002	22.5501	43.5001	64.4500	85.3999	106.3499	127.2998
RT214	DIST LOG	16.5801	24.5205	36.2636	53.6306	79.3149	117.2996	173.4755
TL208	DIST LOG	12.2456	16.0842	21.1261	27.7485	36.4467	47.8717	62.8780
U/K	DIST LOG	.2391	.3605	.5435	.8194	1.2352	1.8622	2.8074
U/TH	DIST LOG	.6014	.8867	1.3072	1.9271	2.8410	4.1884	6.1747
TH/K	DIST NORMAL	.1522	.2460	.3397	.4335	.5272	.6210	.7148

ROCK UNIT 08

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	8.5807	23.2538	37.9269	52.6000	67.2731	81.9462	96.6193
BI214	DIST NORMAL	-10.1686	7.5543	25.2771	43.0000	60.7229	78.4457	96.1686
TL208	DIST NORMAL	2.3211	7.3807	12.4404	17.5000	22.5596	27.6193	32.6789
U/K	DIST LOG	.1843	.2972	.4790	.7722	1.2448	2.0067	3.2349
U/TH	DIST LOG	.5751	.9143	1.4534	2.3104	3.6727	5.8384	9.2810
TH/K	DIST NORMAL	.0103	.1237	.2370	.3504	.4638	.5771	.6905

ROCK UNIT 090

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-11.0604	2.9931	17.0465	31.1000	45.1535	59.2069	73.2604
BI214	DIST LOG	2.7920	4.0426	5.8533	8.4751	12.2712	17.7675	25.7258
TL208	DIST NORMAL	-1.4214	2.0857	5.5929	9.1000	12.6071	16.1143	19.6214
U/K	DIST LOG	.1836	.3226	.5668	.9959	1.7498	3.0743	5.4014
U/TH	DIST LOG	.7724	1.2757	2.1070	3.4801	5.7480	9.4938	15.6807
TH/K	DIST LOG	.0728	.1172	.1889	.3043	.4902	.7898	1.2724

ROCK UNIT 09U

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-11.6631	4.0913	19.8456	35.6000	51.3544	67.1087	82.8631
BI214	DIST NORMAL	-8.0591	6.2273	20.5136	34.8000	49.0864	63.3727	77.6591
TL208	DIST NORMAL	-.4870	3.4754	7.4377	11.4000	15.3623	19.3246	23.2870
U/K	DIST LOG	.1715	.3028	.5348	.9445	1.6681	2.9460	5.2029
U/TH	DIST LOG	.6218	1.0383	1.7336	2.8946	4.8332	8.0701	13.4746
TH/K	DIST LOG	.0976	.1479	.2241	.3397	.5148	.7802	1.1824

ROCK UNIT 0T

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	9.5428	38.2952	67.0476	95.8000	124.5524	153.3048	182.0572
BI214	DIST NORMAL	-.1205	25.3530	50.8265	76.3000	101.7735	127.2470	152.7205
TL208	DIST NORMAL	-.5613	12.6258	25.8129	39.0000	52.1871	65.3742	78.5613
U/K	DIST NORMAL	-.1160	.1992	.5144	.8296	1.1448	1.4600	1.7752
U/TH	DIST NORMAL	-.2511	.5161	1.2832	2.0504	2.8175	3.5847	4.3519
TH/K	DIST NORMAL	.1577	.2424	.3270	.4116	.4962	.5808	.6655

ROCK UNIT C...

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	-23.2414	2.4724	28.1862	53.9000	79.6138	105.3276	131.0414
BI214	DIST LOG	15.0538	22.9568	35.0087	53.3877	81.4153	124.1570	189.3373
TL208	DIST NORMAL	-12.1016	-.5344	11.0328	22.6000	34.1672	45.7344	57.3016
U/K	DIST LOG	.1843	.3399	.6267	1.1556	2.1309	3.9292	7.2452
U/TH	DIST LOG	.4729	.8567	1.5521	2.8118	5.0941	9.2287	16.7192
TH/K	DIST LOG	.1311	.1933	.2848	.4197	.6185	.9114	1.3432

ROCK UNIT QU

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	42.6678	55.0452	67.4226	79.8000	92.1774	104.5548	116.9322
BI214	DIST NORMAL	36.0020	51.5680	67.1340	82.7000	98.2660	113.8320	129.3980
TL208	DIST NORMAL	25.2850	29.8567	34.4283	39.0000	43.5717	48.1433	52.7150
U/K	DIST NORMAL	.2385	.5154	.7923	1.0692	1.3461	1.6230	1.8999
U/TH	DIST NORMAL	.6253	1.1383	1.6512	2.1642	2.6772	3.1902	3.7031
TH/K	DIST LOG	.2521	.3150	.3935	.4916	.6142	.7673	.9586

ROCK UNIT QUN

		-3	-2	-1	0	+1	+2	+3
K40	DIST NORMAL	25.8336	43.8891	61.9445	80.0000	98.0555	116.1109	134.1664
BI214	DIST NORMAL	5.5188	23.6792	41.8396	60.0000	78.1604	96.3208	114.4812
TL208	DIST LOG	10.0575	13.9549	19.3624	26.8654	37.2759	51.7204	71.7621
U/K	DIST LOG	.3291	.4294	.5601	.7307	.9532	1.2435	1.6221
U/TH	DIST LOG	.8529	1.1560	1.5669	2.1239	2.8788	3.9020	5.2889
TH/K	DIST NORMAL	.1730	.2317	.2905	.3492	.4080	.4667	.5254

ROCK UNIT TRD

		-3	-2	-1	0	+1	+2	+3
K40	DIST LOG	23.3807	32.9002	46.2957	65.1453	91.6695	128.9932	181.5134
BI214	DIST NORMAL	-17.0819	10.0787	37.2394	64.4000	91.5606	118.7213	145.8819
TL208	DIST LOG	9.6977	13.0982	17.6910	23.8943	32.2727	43.5890	58.8733
U/K	DIST LOG	.2257	.3580	.5678	.9005	1.4283	2.2652	3.5927
U/TH	DIST LOG	.6886	1.0478	1.5945	2.4265	3.6926	5.6192	8.5512
TH/K	DIST LOG	.1602	.2112	.2783	.3668	.4834	.6371	.8396

APPENDIX E

Tape Formats

RAW SPECTRAL DATA TAPE

REFERENCE: PARAGRAPHS 4.7.1 AND 6.1.5, PMD 1200-B

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

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

Header Record

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

1. Type of tape. A 32-character field with the text "RAW SPECTRAL DATA" left justified.
2. Project identification. A 32-character field with, for example, the text "NTMS NJ 14-6 HUTCHINSON, KANSAS" left justified. With the exception of special projects, such as the Walker Field Test Pads and Lake Mead Dynamic Test Range, all project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.
3. Subcontractor name. A 10-character field with the text "GEOMETRICS".
4. System Identification. A 6-character field with the aircraft registration number right justified.
5. Flight line number. A 6-character field with the flight line number right justified.
6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the Julian date.
7. Sample period. A 6-character field describing the spectrometer accumulation time. Examples are: 1.0 SEC, 0.5 SEC, etc.

RAW SPECTRAL DATA TAPE

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.

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

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

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

The raw count data, fields 10 and 12, are presented for channels 0 through 254, corresponding to energies from 0 to 3 MeV for both the downward looking (4π) and upward looking (2π) detector arrays. The accumulation periods for the 4π and 2π detectors are identical, so each scan has data for both detectors. The counts in each channel are as observed, with no corrections for ADC dead time

RAW SPECTRAL DATA TAPE

nor conversion to counts per second. Energy per channel is 11.82 KeV. Since the spectrometer does not respond to energies below 200 KeV, the counts in channels 0 through 17 will always be zero.

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

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

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

Trailer Record

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

SINGLE RECORD REDUCED DATA TAPE

REFERENCE: PARAGRAPHS 4.7.2 AND 6.1.5, PMD 1200-B

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

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

Header Record

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

1. Type of tape. A 32-character field with the text "SINGLE RECORD REDUCED DATA" left justified.
2. Project identification. A 32-character field with, for example, the text "NTMS NJ 14-6 HUTCHINSON, KANSAS" left justified. With the exception of special projects, such as the Lake Mead Dynamic Test Range, all project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.
3. Subcontractor name. A 10-character field with the text "GEOMETRICS".
4. System Identification. A 6-character field with the aircraft registration number right justified.
5. Flight line number. A 6-character field with the flight line number right justified.
6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the Julian date. When reflights require the insertion of data from multiple days' flying, the date used is that of the original flight.

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

SINGLE RECORD REDUCED DATA TAPE

Data Record

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

The data scan has eighteen defined data fields.

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

Trailer Record

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

STATISTICAL ANALYSIS TAPE

REFERENCE: PARAGRAPHS 4.7.3 AND 6.1.5, PMD 1200-B

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

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

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

Header Record

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

1. Type of tape. A 32-character field with the text "STATISTICAL ANALYSIS" left justified.
2. Project Identification. A 32-character field with, for example, the text "NTMS NJ 14-16 HUTCHINSON, KANSAS" left justified. All project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.
3. Subcontractor name. A 10-character field with the text "GEOMETRICS".
4. System Identification. A 6-character field with the aircraft registration number right justified.

The additional fields for the averaged record data are:

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

STATISTICAL ANALYSIS TAPE

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

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

Trailer Record

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

Summary Geologic Information Record

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

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

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

STATISTICAL ANALYSIS TAPE

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

Data Record

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

The data scan has twenty defined data fields.

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

MAGNETIC DATA TAPE

REFERENCE: PARAGRAPHS 4.7.4 and 6.1.5, PMD 1200-B

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

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

Header Record

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

1. Type of tape. A 32-character field with the text "MAGNETIC DATA" left justified.
2. Project identification. A 32-character field with, for example, the text "NTMS NJ 14-6 HUTCHINSON, KANSAS" left justified. All project identification fields begin with "NTMS" followed by the sheet number. Additional information may be abbreviated.
3. Subcontractor name. A 10-character field with the text "GEOMETRICS".
4. System identification. A 6-character field with the aircraft registration, number right justified.
5. Flight line number. A 6-character field with the flight line number right justified.
6. Date flown. A 6-character field with the date, expressed as YYJJJ, right justified. YY are the last two digits of the calendar year and JJJ is the Julian date. When reflights require the insertion of data from multiple days' flying, the date used is that of the original flight.

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

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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.

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

Trailer Record

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

APPENDIX F
Daily Production Summary

DAILY PRODUCTION SUMMARY

<u>DATE</u>	<u>REMARKS</u>
1/15/77	Ferry to Midland, Texas.
1/16/77	Weather, slight rain and poor visibility, low clouds.
1/17/77	738 line miles (Begin Project)
1/18/77	672 line miles
1/19/77	664 line miles
1/20/77	730 line miles
1/21/77	646 line miles
1/22/77	Weather, low clouds, poor visibility.
1/23/77	Weather, low clouds, poor visibility.
1/24/77	574 line miles
1/25/77	797 line miles
1/26/77	436 line miles
1/27/77	552 line miles
1/28/77	Weather, low clouds, poor visibility.
1/29/77	804 line miles (Project completed)