

Airborne Gamma - Ray Spectrometer and Magnetometer Survey

Lund Quadrangle
(Nevada)

Ely Quadrangle
(Nevada)

Final Report
Volume I

prepared by

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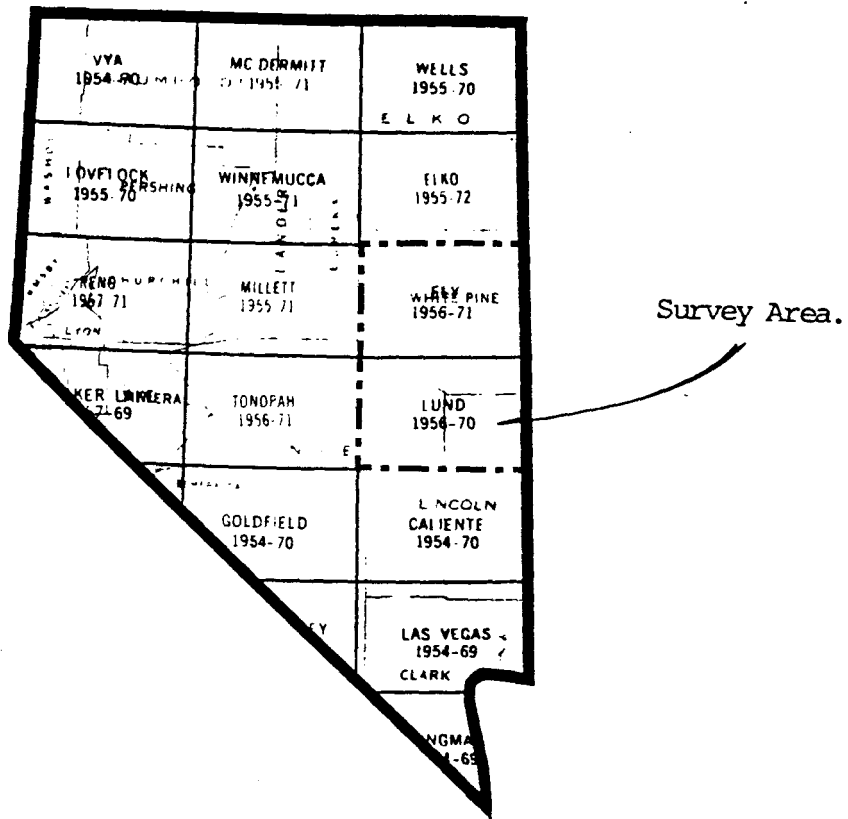
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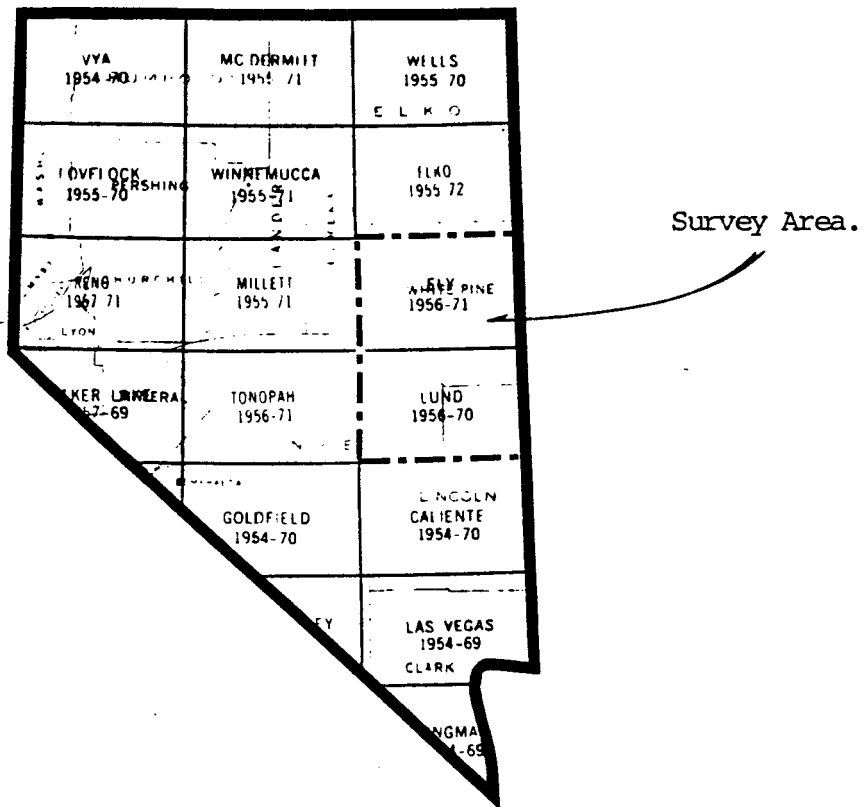
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Location Map
Lund Quadrangle, Nevada
Scale: 1:7,500,000



Location Map
Ely Quadrangle, Nevada.

Scale: 1:7,500,000

ABSTRACT

An airborne combined radiometric and magnetic survey was performed for the Department of Energy (DOE) over the area covered by the Ely and Lund 1:250,000 National Topographic Map Series (NTMS quadrangle maps. The survey was part of DOE's National Uranium Resource Evaluation (NURE) Aerial Radiometric Reconnaissance program.

Data were collected by a helicopter equipped with a gamma-ray spectrometer having a large crystal volume, and a high sensitivity proton precession magnetometer. The radiometric system was calibrated at the Walker Field Calibration pads and the Lake Mead Dynamic Test range. Data quality was ensured during the survey by daily test flights and equipment checks.

Radiometric data were corrected for live time, aircraft and equipment background, cosmic background, atmospheric radon, Compton scatter, and altitude dependence. The corrected data were statistically evaluated, plotted, and contoured to produce anomaly maps based on the radiometric response of individual geological units. The maps were interpreted and an anomaly interpretation map produced.

Volume I contains a description of the systems used in the survey, a discussion of the calibration of the systems, the data processing procedures, the data display format, the interpretation rationale, and interpretation methodology. Volume II contains the data displays for a quadrangle and the interpretation results.

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INTRODUCTION

As part of the National Uranium Resource Evaluation (NURE) program of the United States Department of Energy (DOE), High-Life Helicopters Inc./QEB Inc. have completed an airborne combined gamma-ray spectrometer and magnetometer survey of the Ely, and Lund, Nevada 1° X 2°, 1:250,000 National Topographic Map Series (NTMS) quadrangles.

The objectives of the NURE program are:

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

The National Airborne Radiometric Reconnaissance program, in which this survey was flown, was designed to provide a semi-quantitative evaluation of radioelement distribution in the United States as an aid in detecting areas of anomalously high radioactivity, which could be indicative of uraniferous geochemical provinces.

An Aerospatiale Lama 315B helicopter (Registration No. N49504) equipped with a gamma-ray spectrometer and a magnetometer was used in the survey. Data reduction, analysis, and interpretation were done at the High-Life/QEB computer facility in Hayward, California. Volume I of this report describes the data collection system, the survey methods, data reduction methods, data analysis, and interpretation techniques. Volume II presents the individual results for each quadrangle in written, tabular, and graphic form.

SUMMARY

High-Life Helicopters Inc. and its subsidiary QEB Inc. conducted an airborne high-sensitivity radiometric and magnetic survey of the Ely and Lund, Nevada, $1^{\circ} \times 2^{\circ}$ NTMS quadrangles for the Department of Energy (DOE). An Aerospatiale Lama helicopter (U.S. Registry No. N49504) equipped with a gamma-ray spectrometer and a proton precession magnetometer collected the data. The gamma-ray spectrometer had a total of 2364 cubic inches of sodium iodide crystal detectors (2048 cubic inches, downward-looking and 256 cubic inches, upward-looking). The magnetometer had a sensitivity of 0.25 gammas. In both quadrangles east-west traverse lines were flown at three-mile intervals, and north-south tie-lines were flown at eighteen mile intervals. A total of 3073.7 line miles of radiometric and magnetic data was collected in the Ely quadrangle and 3110.5 line miles in the Lund quadrangle. Appendix B summarizes the daily production for each area. Visual techniques were used in navigation, and flight path film was obtained for subsequent precise position recovery.

The key steps in the data processing were: The correction of the raw radiometric data for altitude dependence (common level reference), for cosmic or Compton scatter, and for atmospheric radon (Bi-air); and the testing of the data for statistical adequacy. Products of the data processing consist of magnetic tapes containing raw field data, single record data, averaged record data, magnetic data, and the results of the statistical analysis; stacked corrected profiles of all radiometric data (Bi-air, total count, potassium, uranium, thorium, eU/eTh, eU/K, eTh/K), magnetic data, radar and barometric altimeter data, and air temperature data; pseudo-contour maps for potassium, uranium, thorium, and magnetic data; statistical anomaly maps for the radiometric variables; and interpretation maps showing

preferred anomalies, major cities, and magnetic features.

SYSTEMS

AIRCRAFT

The aircraft used to carry the gamma-ray spectrometer, the magnetometer and associated electronic equipment was an Aerospatiale SA 315 Lama helicopter, (U.S. Registry No. N49504). The Lama is manufactured in France by Societe National Industrielle, and is designed to haul heavy loads in rugged terrain. It operates economically and safely under the most rigorous requirements, so is an ideal aircraft for gamma-ray spectrometer surveys, which must be conducted with heavy payloads, at low speed, and low altitudes.

The Lama is powered by an 870 SHP Turbomeca Artouste IIIB turboshaft engine, fueled from a 151.3 U.S. gallon (573 liter) fuel tank mounted in the center section of the fuselage. The main rotor is driven through a planetary gearbox with provision for free wheel on autorotation. A take-off drive for the tail rotor is mounted at the lower end of the main gearbox, and a torque shaft connects the latter to a small gearbox that houses the pitch control mechanism, and on which the tail rotor is mounted. Cyclic and collective pitch are power-controlled. Rotors consist of a three-blade main rotor and an antitorque rotor. The main blades are all metal, are of constant chord, have hydraulic drag-hinge dampers, and are mounted on articulated hinges.

The light metal framework cabin is glazed, but the center and rear of the fuselage behind the cabin have an open triangular framework. The cabin seats a pilot and one passenger side by side and three more passengers behind the pilot. The landing gear is made up of skids with removable wheels. Provision

is also made for pneumatic floats for operation on water, and for inflatable emergency flotation gear. The aircraft can carry crystal packs weighing up to 2,204 lbs. (1000 Kg.) mounted on external slings. The Lama is a versatile aircraft, which can be adapted for use in rescue operations, liason duties, training, agriculture, and aerial photography. External dimensions, performance, and weight specifications are listed below.

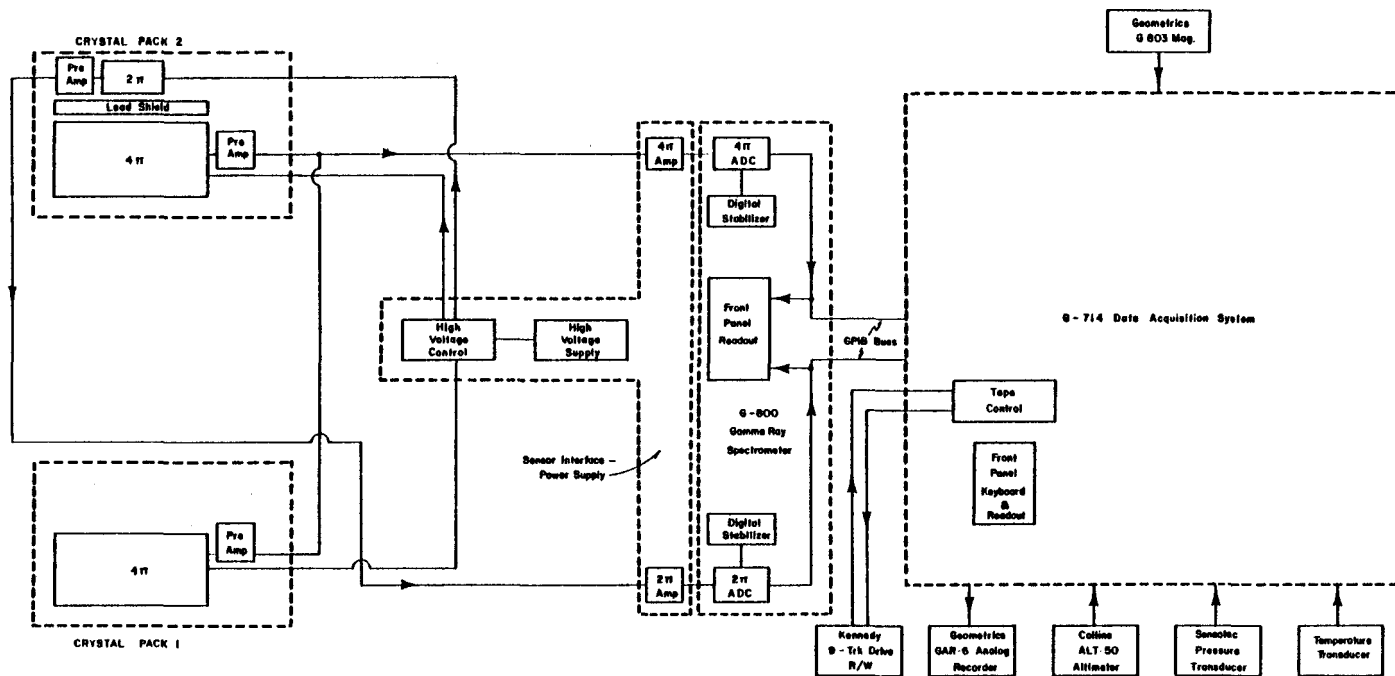
EXTERNAL DIMENSIONS

Main Rotor diameter	36' 1-3/4"
Tail Rotor diameter	6' 3-1/2"
Main Rotor Blade chord (constant)	13.8"
Length overall; both rotors turning	42' 4-3/4"
Length of fuselage	33' 8"
Height overall	10' 1-3/4"
Skid track	7' 9-3/4"

GENERAL PERFORMANCE SPECIFICATIONS

BASED ON SEA LEVEL STANDARD CONDITIONS

		Internal		External	
		<u>Average</u>	<u>Maximum</u>	<u>Average</u>	<u>Maximum</u>
At Gross Weight	lb	3,310	4,310	4,200	5,070
Empty Weight	lb	2,216	2,216	2,216	2,216
Useful Load	lb	1,094	2,084	1,984	2,854
Sling Load (Max)	lb	-	-	-	2,500
Cruise Speed	mph	118	-	55	75
Top Speed, Vne	mph	-	130	-	-
Useable Fuel US	gal	146	146	46	46
Service Ceiling	ft	(23,000)	17,000	18,000	10,800
HIGE Ceiling	ft	(23,000)	16,000	17,000	9,220
HOGE Ceiling	ft	(23,000)	15,170	16,100	5,000



High Life Helicopters, Inc. / QEB Inc.

System Block Diagram

Lama Helicopter N 49504

FIGURE 1

WEIGHT SPECIFICATIONS FOR GEOPHYSICAL SURVEYS

	Weight (lbs)
LAMA empty weight	2,216
Maximum useable fuel	900
Sensor Electronics	850
Pilot	160
Navigator	<u>160</u>
TOTAL	<u><u>4,286</u></u>

SENSORS

A summary of the principal components of the airborne geophysical sensor system (shown schematically in Figure 1) is presented below:

Geophysical Sensors

1. Crystal Gamma-Ray detectors -Downward-looking; eight (8) sodium iodide crystals manufactured by Harshaw Chemical Co., Solon, Ohio. These are arranged in two packs, each containing four (4) crystals, mounted fore and aft on the underside of the aircraft on bomb shackles fitted with a quick-release mechanism. Each crystal has a volume of 256 cubic inches for a total volume of 2048 cubic inches in the downward-looking detector.
2. Crystal Gamma Ray detectors - Upward looking; one (1) sodium iodide crystal with a volume of 256 cubic inches mounted atop the aft downward-looking crystal pack.
3. Towed-bird proton precession magnetometer with a sensitivity of 0.25 gammas.

Ancillary Equipment

1. Radar Altimeter - Collins ALT-50
2. Barometric Altimeter - Sensotec pressure Transducer
3. Recording Temperature Transducer
4. Tracking Camera - Automax 35mm Framing Camera (Automax Industries, Woodland Hills, California).

Geophysical Console Equipment

1. A Geometrics G-714 Airborne Data Acquisition system is used to digitize and process all data from the sensors. The G-714 provides, along with its support equipment, analog to digital conversion, analog and digital gain stabilization, and formatting for the magnetic tape equipment.
2. Geometrics G-800 Gamma-Ray Spectrometer System
3. Geometrics G-900 Sensor Interface and Power Supply
4. Geometrics G-803 Magnetometer with 0.25 gamma sensitivity

Recording Equipment

1. Kennedy 9-track digital tape deck recording at 800 bpi.
The system records:
 - a) 512 Channels of gamma-ray spectrometer data (256 down and 256 up),
 - b) Total magnetic intensity,
 - c) Fiducial number from data system and camera,
 - d) Altitude from radar and barometric altimeters,

- e) Time (days, hours, minutes, seconds),
- f) Outside temperature
- g) "Label" information - date, survey area, and flight line number.

2. Geometrics GAR-6 channel analog chart recorder.

DATA PROCESSING

QEB uses a remote terminal connection to Information Systems Design, Inc., a computer service organization in Santa Clara, California. A Harris Cope 1620 Modem is used to communicate with a UNIVAC 1108 system.

The UNIVAC 1108 is the hub of ISD's computer service complex. This large scale, drum-oriented system combines high speed batch processing with remote capabilities.

The 1108 central processor has a 65,536 36-bit word ferrite core memory with a 750 nanosecond cycle time, and with a corebank overlap feature which gives an effective 375 nanosecond cycle time during program execution. In addition to the main core memory, there are 128 integrated circuit registers with 125 nanosecond cycle time providing multiple accumulators, index registers, I/O access control registers, and special use registers. A repertoire of over 120 instructions, a real-time clock, floating point and double precision hardware, and 16 general purpose I/O channels are the other main features of this processor.

The 1108 was used exclusively in processing both the Ely and Lund data. Other peripheral equipment used in the processing of these data include:

- a) Calcomp 936 Drum Plotter (34" plot width)
- b) Calcomp 915 Plotter Controller
- c) Talos BL648B Digitizer

The Calcomp 936 Drum Plotter can be operated either remotely from the ISD facility, or locally at QEB from the Calcomp 915 Plotter Controller. The latter is a programmable device consisting of a central processing unit (CPU), a memory unit, a

read-write magnetic tape cartridge unit, and a read-only magnetic tape unit (MTU). The 915 can accommodate as many as five peripheral input/output devices on-line.

At QEB, the MTU reads a data tape created by the 1108 computer. The CPU and a system program read into memory from a tape cartridge, then convert the data on the tape into commands that drive an output device.

The Talos BL648B Digitizer converts the physical position of a pen or cursor on an activated Digitizer surface into a digital output that can be entered directly into the 1108 system through the remote terminal. The Talos has an active digitizing area of 48 X 36 inches.

SYSTEM CALIBRATION

COSMIC AND BACKGROUND

Background effects due to the natural radioactivity of the aircraft frame, geophysical equipment and other ancillary devices may be calculated from a series of high altitude sorties. To demonstrate this, consider the count rate at Energy E due to Compton scattering from a higher energy photon E' . For a constant elevation Z , we may write:

$$I(E, Z) = R(E'; E, Z) + I_B(E) \quad (1)$$

where:

- | | |
|---------------|---|
| $I(E, Z)$ | is the count rate at energy E and altitude Z |
| $R(E', E, Z)$ | is the count rate at energy E and altitude Z due to a higher energy photon E' , |
| $I_B(E)$ | is the desired aircraft background (independent of Z). |

For a given channel Ch , we may write for the high altitude test:

$$\int_{Ch} I(E, Z) dE = \int_{Ch} \int_{3MEV}^{6MEV} R(E'; E, Z) dE dE' + \int_{Ch} I_B(E) dE \quad (2)$$

where the double integral term on the right hand side of (2) represents the cosmic contribution of the count rate measured in channel Ch . We must now specify the functional form for $R(E'; E, Z)$ in order to solve for the cosmic and background effects. We make two assumptions regarding this function:

- a) R is a function of the difference between the photon at energy E' and the lower energy level E,

$$R(E'-E, Z) = R'(E'-E, Z) \quad (3a)$$

- b) R' can be separated into the product of two functions

$$R'(E'-E, Z) = P(E', Z)Q(E) \quad (3b)$$

Assumption (3a) postulates that the effect at lower energies depends only upon the energy difference between E' and E. A suggested functional form for R' is exponential, i.e:

$$R'(E'-E, Z) = f'(Z) \exp (C(E'-E)) \quad (4)$$

The form (4) seems to be born out experimentally. Whatever the relative merits of assumption (a), assumption (b) is critical to our analysis. We assume that R' can be separated into the product of a function of E' and Z with a function only of E. This assumption will allow us to treat the cosmic correction and background as a linear effect.

Substituting equation (3b) into (2), we find:

$$\int_{Ch} I(E, Z) dE = \int_{3MEV}^{6MEV} P(E', Z) dE' \int_{Ch} Q(E) dE + \int_{Ch} I_B(E) dE \quad (5)$$

Equation (5) can be written in the functional form for any channel:

$$Y = A * X + B \quad (6)$$

where

$$Y = \int_{Ch} I(E, Z) dE \quad \text{Is the measured count rate at altitude} \quad (13)$$

Z in channel Ch.

$X = \int_{3\text{MEV}}^{6\text{MEV}} P(E'Z)dE'$ is the measured cosmic count rate at altitude Z.

$A = \int_{\text{Ch}} Q(E)dE$ is dimensionless quantity which weights the cosmic count rate to indicate the integral count rate within a channel Ch due to cosmic energies. A is also referred to as the cosmic correction ratio.

$B = \int_{\text{Ch}} I_B(E)dE$ is the background in counts per second.

The quantities A and B are determined by a least squares analysis of channel data over the suite of five flight altitudes.

SYSTEMS CONSTANTS

System constants were determined at the DOE Walker Field test pads and at the Lake Mead Test Range. The test areas at these sites contain known concentrations of potassium, uranium, and thorium. The concentrations of elements in the five pads at Walker Field are shown in the table below:

ELEMENT CONCENTRATION IN THE WALKER FIELD PADS

Pad	K	U	Th
1. Background/Matrix	1.45%	2.19 ppm	6.26 ppm
2. (K)	5.14%	5.09 ppm	8.48 ppm
3. (U)	2.03%	30.29 ppm	9.19 ppm
4. (Th)	2.10%	5.14 ppm	45.33 ppm
5. Mixed	4.11%	20.39 ppm	17.52 ppm

Full spectral data were measured and digitally recorded above each of the calibration pads at Walker Field. Data were collected over each pad during a five minute interval. A sample rate of one full scan per second - 256 channels for the down-crystal, and 256 channels for the up-crystal - gave a total of 300 spectral measurements per calibration pad. Since the calibration measurements were taken over a comparatively short time period, it was assumed that the individual pad measurements contain not only the effects of the pad itself; but the aircraft background - constant for a particular aircraft; cosmic background - constant over the measurement period; and the local background Bi-air etc. When the Background/Matrix pad count rate values were subtracted from the values obtained over the other pads; the aircraft, the cosmic, and the local backgrounds were eliminated. The pad concentrations were similarly modified by subtracting the Background/Matrix concentration from each of the remaining four pads to give the differential element concentration.

DIFFERENTIAL ELEMENT CONCENTRATIONS
WALKER FIELD PADS

	Pad	K	U	Th
K - Matrix	2-1	3.69%	2.90 ppm	2.22 ppm
U - Matrix	3-1	0.58%	28.10 ppm	2.93 ppm
Th - Matrix	4-1	0.56%	2.95 ppm	39.07 ppm
Mixed - Matrix	5-1	2.66%	18.20 ppm	11.26 ppm

The count rate over pads 2 through 5 could then be related directly to the differential concentrations of the elements in these pads.

Sensitivity Coefficients - Theory

It can be demonstrated that the observed count rate of a spectrometric system is a function not only of the mean ground level abundance of radioactive elements, but also of other parameters such as crystal geometry, flight altitude, equivalent optical path length, etc.

Consider the response of an ideal spectrometer (one with infinitely precise resolving power) to gamma-ray excitation from a radioactive ground source.

For a given monochromatic energy E_0 :

$$I(E_0) = \epsilon \int_s \frac{I' A e^{-\mu R}}{R^2} dS \quad (1)$$

where

$I(E_0)$	Is the theoretical count rate at energy E_0 .
ϵ	Is the photo-detector efficiency at energy E_0 .
A	Is the solid angle response of the spectrometer system.
μ	Is the attenuation constant of the medium through which the photon of energy E_0 passes.
R	Is the distance from an elemental ground surface of area dS to the photo-detector.
I'	Is the surface count rate which is propor-

tional to the ground level abundance of radioactive elements at Energy E_0 .

The relative simplicity of (1) is deceiving, since complicated interactions such as Compton scatter in the ground and in the air are assumed to be approximated by the simple exponential attenuation coefficient μ . A further complication is that any spectrometer system has less than ideal resolving power. Thus, the more or less monochromatic energies from ground sources are "smeared" over a broad range of energy levels. This "smearing" is due to photon-crystal interactions (Compton scatter), amplifier drift, thermal effects, etc. The observed spectra can now be written as:

$$I'(E_0;E) = I(E_0)R(E_0;E) \quad (2)$$

where

$I'(E_0;E)$	Is the observed count rate at energy E due to monochromatic source at energy E_0 .
$I(E_0)$	Is the intensity of the monochromatic emitter.
$R(E_0;E)$	Is the crystal response function due to a monochromatic input photon.

Sensitivity Coefficients Applicable to the Walker Field Test Pads

Let us now relate this theoretical discussion to the Walker Test Field Test Facility measurements. Assuming that the air attenuation constant was invariant over the measurement period

and that the pad geometries were similar, then from equation (1) we may write:

$$I(E_0) = C(E_0)\rho(E_0) \quad (3)$$

where

$C(E_0)$ Is a proportionality constant for a given energy E_0 .

$\rho(E_0)$ Is the ground level concentration of radioactive elements of energy E_0 .

Let us consider the expected count rates from the Walker Field pads.

From Equations (2) and (3), we may write:

$$I'_j(E_k, E_u, E_T; E) = C(E_k)R(E_k; E)\rho(E_k, j) + C(E_u)R(E_u; E)\rho(E_u, j) + C(E_T)R(E_T; E)\rho(E_T, j) + B(E) \quad (4)$$

where

$$E_k = 1.46 \text{ MeV (K}_{40} \text{ Photopeak),}$$

$$E_u = 1.76 \text{ MeV (Bi}_{214} \text{ Photopeak),}$$

$$E_T = 2.62 \text{ MeV (Tl}_{208} \text{ Photopeak),}$$

$\rho(E_k, j)$ = Concentration of K_{40} in the j pad,

$\rho(E_u, j)$ = Concentration of U_{238} in the j pad,

$\rho(E_T, j)$ = Concentration of Th_{232} in the j pad,

$B(E)$ = Background Count rate

$I'(E_k, E_u, E_T; E)$ = Observed Count Rate at E Due to concentrations of K_{40} , U_{238} , and Th_{232} .

If we let

${}^k I'_j$ = Count Rate of K channel measured on pad j .

${}^u I'_j$ = Count Rate of U channel measured on pad j .

${}^T I'_j$ = Count Rate of Th channel measured on pad j .

Then we may write a set of 3 matrix equations for each channel measurement

K CHANNEL

$$\begin{pmatrix} k_{I', 2} \\ k_{I', 3} \\ k_{I', 4} \\ k_{I', 5} \end{pmatrix} = \begin{pmatrix} \rho(E_k, 2) & \rho(E_u, 2) & \rho(E_T, 2) \\ \rho(E_k, 3) & \rho(E_u, 3) & \rho(E_T, 3) \\ \rho(E_k, 4) & \rho(E_u, 4) & \rho(E_T, 4) \\ \rho(E_k, 5) & \rho(E_u, 5) & \rho(E_T, 5) \end{pmatrix} \begin{pmatrix} k_{s_k} \\ k_{s_u} \\ k_{s_t} \end{pmatrix} + B_k \quad (5a)$$

U CHANNEL

$$\begin{pmatrix} u_{I', 2} \end{pmatrix} = \begin{pmatrix} \rho(E_k, 2) & \rho(E_u, 2) & \rho(E_T, 2) \end{pmatrix}$$

$$\begin{pmatrix} u_{I' 3} \\ u_{I' 4} \\ u_{I' 5} \end{pmatrix} = \begin{pmatrix} \rho(E_k, 3) & \rho(E_u, 3) & \rho(E_T, 3) \\ \rho(E_k, 4) & \rho(E_u, 4) & \rho(E_T, 4) \\ \rho(E_k, 5) & \rho(E_u, 5) & \rho(E_T, 5) \end{pmatrix} \begin{pmatrix} u_{s_k} \\ u_{s_u} \\ u_{s_t} \end{pmatrix} + B_u \quad (5b)$$

Th CHANNEL

$$\begin{pmatrix} T_{I' 2} \\ T_{I' 3} \\ T_{I' 4} \\ T_{I' 5} \end{pmatrix} = \begin{pmatrix} \rho(E_k, 2) & \rho(E_u, 2) & \rho(E_T, 2) \\ \rho(E_k, 3) & \rho(E_u, 3) & \rho(E_T, 3) \\ \rho(E_k, 4) & \rho(E_u, 4) & \rho(E_T, 4) \\ \rho(E_k, 5) & \rho(E_u, 5) & \rho(E_T, 5) \end{pmatrix} \begin{pmatrix} T_{s_k} \\ T_{s_u} \\ T_{s_T} \end{pmatrix} + B_T \quad (5c)$$

where

$$L_{S_M} = \int_L C(E_M) R(E_M; E) dE$$

$$L, M = K, U, T \quad (6)$$

We can interpret (6) as the weighted sum of the crystal response in channel L, due to an elemental input photon in channel M. Clearly, if L is of higher energy than M, we would expect a value of (6) to be nearly zero. The units of L_{S_M} are counts/sec/elemental concentration.

The set of matrix equations (5a) through (5c) represents a set of 12 equations with 9 unknown variables L_{S_M} . To solve these equations the count rates measured on pads 2 through 5 were fit in a least square sense. The background values B_k , B_u , B_{Th} , were estimated from averaged measurements from pad 1.

The differential concentrations, as supplied by Bendix Field Corporation, are tabulated on page 15. Only data for the down crystals were used in the least squares analysis.

For each pad measurement, a matrix equation may be written relating the observed count rate to the elemental concentration by the least squares sensitivity matrix. Thus, from (5a), (5b), and (5c):

$$\begin{pmatrix} k_{I',j} \\ u_{I',j} \\ T_{I',j} \end{pmatrix} = S \cdot \begin{pmatrix} \rho(E_k; j) \\ \rho(E_u; j) \\ \rho(E_T; j) \end{pmatrix} \begin{pmatrix} B_k \\ B_u \\ B_T \end{pmatrix} \quad (7a)$$

where

$$S = \begin{pmatrix} k_{s_k} & k_{s_u} & k_{s_T} \\ u_{s_k} & u_{s_u} & u_{s_T} \\ T_{s_k} & T_{s_u} & T_{s_T} \end{pmatrix} \quad (7b)$$

Upon inverting (7a), the elemental concentrations may be solved for in terms of the observed count rates.

$$\begin{aligned} \rho(E_k, j) &= S_3 \left((k_{I',j} - B_k) - {}^k\phi_u (u_{I',j} - B_u) - {}^k\phi_T (T_{I',j} - B_T) \right) \\ &= S_3^k \text{ I corr} \end{aligned} \quad (8a)$$

$$\rho(E_u, j) = S_2 \left((u_{I',j} - B_u) - {}^u\phi_T (T_{I',j} - B_T) - {}^u\phi_k (k_{I',j} - B_k) \right)$$

$$= S_2 {}^u I_{\text{corr}} \quad (8b)$$

$$\begin{aligned} \rho(E_T, j) &= S_1 (({}^T I'_j - B_T) - {}^T \phi_k ({}^k I'_j - B_k) - {}^T \phi_u ({}^u I'_j - B_u)) \\ &= S_1 {}^T I_{\text{corr}} \quad (8c) \end{aligned}$$

Where ${}^k I'_{\text{corr}}$, ${}^u I'_{\text{corr}}$, and ${}^T I'_{\text{corr}}$ are the Compton and background corrected count rates for k, u, and T respectively; S_3 , S_2 , and S_1 are the inverse sensitivities of the crystal packs relative to k, u, and T, respectively. The quantities ${}^M \phi_L$ are the full stripping Compton coefficients (dimensionless) which relate the effect in channel M of a photon in channel L.

Both Compton coefficients and sensitivities are determined from a least squares regression on count rates measured on pads 2 through 5. Pad 1 is used as a reference pad to establish the background count rates.

ATMOSPHERIC RADON CORRECTION

For notational purposes, we designate the count rates measured at Lake Mead in the following form:

$$\text{Count Rate} = (U.D.) (K,U,T,C) (L,W)$$

Where K, U, and T refer to the Potassium, Bismuth, and Thallium channels respectively.

The superscripts (U.D) refer to the up (2π) and down (4π) crystals respectively. The subscripts (L,W) refer to count rates measured over land and water respectively. The prime (') indicates that the count data are corrected for background and stripped. The raw data are unprimed.

For example, ${}^u U_W$ refer to the raw data in the Bismuth channel

measured by the 2π crystal over water.

Consider the four experimental situations encountered at Lake Mead.

WATER

$$D_{U_w} = Bi_A + D_{B_u} + \dots + u\phi_k (D_{K_w} - D_{B_k}) + u\phi_T (D_{T_w} - D_{B_T}) + \text{Cosmic } 4\pi \quad (2a)$$

$$u_{U_w} = \phi_B Bi_A + u_{B_u} + \text{Cosmic } 2\pi$$

LAND

$$D_{U_L} = Bi_A + D_{B_u} + U_G + u\phi_k (D_{K_L} - D_{B_k}) + u\phi_T (D_{T_L} - D_{B_T}) + \text{Cosmic } 4\pi \quad (3a)$$

$$u_{U_L} = \phi_B Bi_A + B_u + \dots + B_o (z) D_{U'_L} + C_o D_{T'_L} + \text{Cosmic } 2\pi \quad (3b)$$

Where Bi_A is the count rate due to atmospheric bismuth within the channel. It is assumed that the Bi_A level is invariant over land or water (perfect atmospheric mixing). Bi_A can; however, vary with survey altitude.

$(U,D)_{B(k,u,T)}$ are the up and down backgrounds (established by the high altitude tests).

Cosmic 2π (4π) are the cosmic corrections for the Bi channel.

U_G is the count rate in the Bi channel due to ground sources,
 $B_o(Z), C_o$ are the counts observed in the upward-looking Bi channel per downward-looking count in "stripped" U and T respectively,
 ϕ_B is the fraction of Bi_A detected by the 2π crystals with respect to the 4π crystals,

B and C are the fraction of U_G detected by the 2π crystals, with respect to the 4π crystals.

To determine Bi_A over land, we first calculated ϕ_B from the over water data. From equations (2a) and (2b) we have:

$$\phi_B = \frac{U_{UW} - U_{BU} - \text{Cosmic } 2\pi}{D_{UW} - D_{BU} - \text{Cosmic } 2\pi} \quad (4)$$

A linear least squares fit established the altitude of ϕ_B

$$\phi_B = 0.2154 - 0.0000487 * Z \text{ (STP feet)} \quad (5)$$

Similarly, we can determine the altitude dependence of B and C.

The value of $B_o(0)$ and $C_o(0)$ were established at the Walker Field Test Facility.

$$B_o(0) = 0.04416 \quad (6)$$

$$C_o(0) = 0.0211 \quad (7)$$

With B_o and C_o estimated, the air effect on the bismuth channel may be written:

$$Bi_A = \frac{U_{up} - B_o (Z) U'_L - C_o T'_L}{\phi_B (Z) - B_o (Z)} \quad (8)$$

Where:

U_{up} is the count rate from the upward-looking detector corrected for cosmic and background effects.

DATA COLLECTION

PRODUCTION SUMMARY

A total of 6184.2 line miles (exclusive of reflights) was flown in the two NTMS quadrangles of this project; (1) 3073.7 miles in the Ely quadrangle and (2) 3110.5 miles in the Lund quadrangle. Details of the production flights are shown in Appendix B.

The airport at Ely, Nevada was used as a base for both the Ely and Lund surveys. Data Collection for the Ely quadrangle began on August 1, 1979 and was completed on August 16, 1979. Data collection for the Lund quadrangle began on August 14, 1979 and was completed on August 26, 1979.

Average ground speed throughout the project was 82 m.p.h. This produced an average crystal volume/average speed (V/v) of 25.1 cubic inches per mile per hour.

A sample statistical distribution of altitude is shown in Figure 2. Over 98.7% of the project data collected were within the altitude specification limits.

FLIGHT PROCEDURES

Operating Parameters

The survey was performed with the following operating parameters:

1. Data sampling rates of the various system elements are displayed below:

ASS

CLASS INTERVAL	4	FREQUENCY	6.0	AVERAGE VALUE	289.167
CLASS INTERVAL	5	FREQUENCY	20.0	AVERAGE VALUE	305.664
CLASS INTERVAL	6	FREQUENCY	42.0	AVERAGE VALUE	329.253
CLASS INTERVAL	7	FREQUENCY	129.0	AVERAGE VALUE	349.111
CLASS INTERVAL	8	FREQUENCY	282.0	AVERAGE VALUE	367.679
CLASS INTERVAL	9	FREQUENCY	377.0	AVERAGE VALUE	387.967
CLASS INTERVAL	10	FREQUENCY	431.0	AVERAGE VALUE	407.711
CLASS INTERVAL	11	FREQUENCY	345.0	AVERAGE VALUE	427.075
CLASS INTERVAL	12	FREQUENCY	246.0	AVERAGE VALUE	447.044
CLASS INTERVAL	13	FREQUENCY	174.0	AVERAGE VALUE	467.263
CLASS INTERVAL	14	FREQUENCY	118.0	AVERAGE VALUE	486.607
CLASS INTERVAL	15	FREQUENCY	15.0	AVERAGE VALUE	507.778
CLASS INTERVAL	16	FREQUENCY	11.0	AVERAGE VALUE	529.983
CLASS INTERVAL	17	FREQUENCY	8.0	AVERAGE VALUE	546.053
CLASS INTERVAL	18	FREQUENCY	13.0	AVERAGE VALUE	567.824
CLASS INTERVAL	20	FREQUENCY	43.0	AVERAGE VALUE	704.014

SAMPLE ELEMENT	SAMPLE RATE
8 Downward-looking crystals (total volume of 2048 cubic inches)	1.0 second (256 channels and cosmic)
1 Upward-looking crystals (shielded) (Total volume of 256 cubic inches)	10.0 seconds (256 channels and cosmic)
Live time (4π system)	1.0 second (Binary output)
Live time (2π system)	10.0 seconds (Binary output)
Geometrics G-803 Magnetometer (0.25 gamma sensitivity)	1.0 second (BCD output)
Ancillary sensors	1.0 second (Binary output)
Collins ALT-50 Transducer	
Temperature Transducer	
Radar Altimeter	
Clock (hours, minutes, seconds)	1.0 second (Binary) output)
Automax 35 mm framing camera	3.0 seconds

2. At the end of a line, the summed spectra for both the 4π system and the 2π system were written to magnetic tape.

The purpose was to ensure channel resolution and photopeak stability in subsequent processing.

3. Lama nominal ground speed was 90 m.p.h. with a downward crystal volume of 2048 cubic inches - the ratio $V/v = 22.8$ cubic inches/m.p.h. This average speed was not exceeded except when dictated by aircraft safety.

DAILY SYSTEM CALIBRATION

Pre-flight checks

- a) Cesium sources were positioned at the same point on both the 4π and the 2π detector crystals each day to peak each photomultiplier tube. The G-800 has a digital split window detector to indicate optimal peak setting. Output from this detector is displayed on the G-800 front panel when operating in "calibration mode".
- c) Thorium sources were used to verify the high energy end of the spectrum for the upward-looking and downward-looking crystals. The output is again displayed on the G-800 front panel.
- d) The full thorium spectrum for the downward-looking crystals was displayed to verify the location of the K_{40} and the Th_{238} photopeaks.

In-flight Checks

- a) Each day, prior to production flying, a test line approximately 5 miles long was flown at the planned survey altitude. Data from the test line were examined to ensure + 20% repeatability of the total radiometric counts.

Post-flight Checks

- a) Pre-flight checks were repeated to ensure that no malfunction in the data system occurred during the data collection.

FLIGHT PATH RECOVERY

Aircraft track was established by visual in-flight identification of prominent ground features by the operator. At the end of each production flight, all mislocations were adjusted by correlating the 35mm. photos with USGS topographic map sheets. Final posting of flight track pick-points was done on 1:250,000 scale NTMS quadrangle sheets.

DATA PROCESSING FLOW CHART

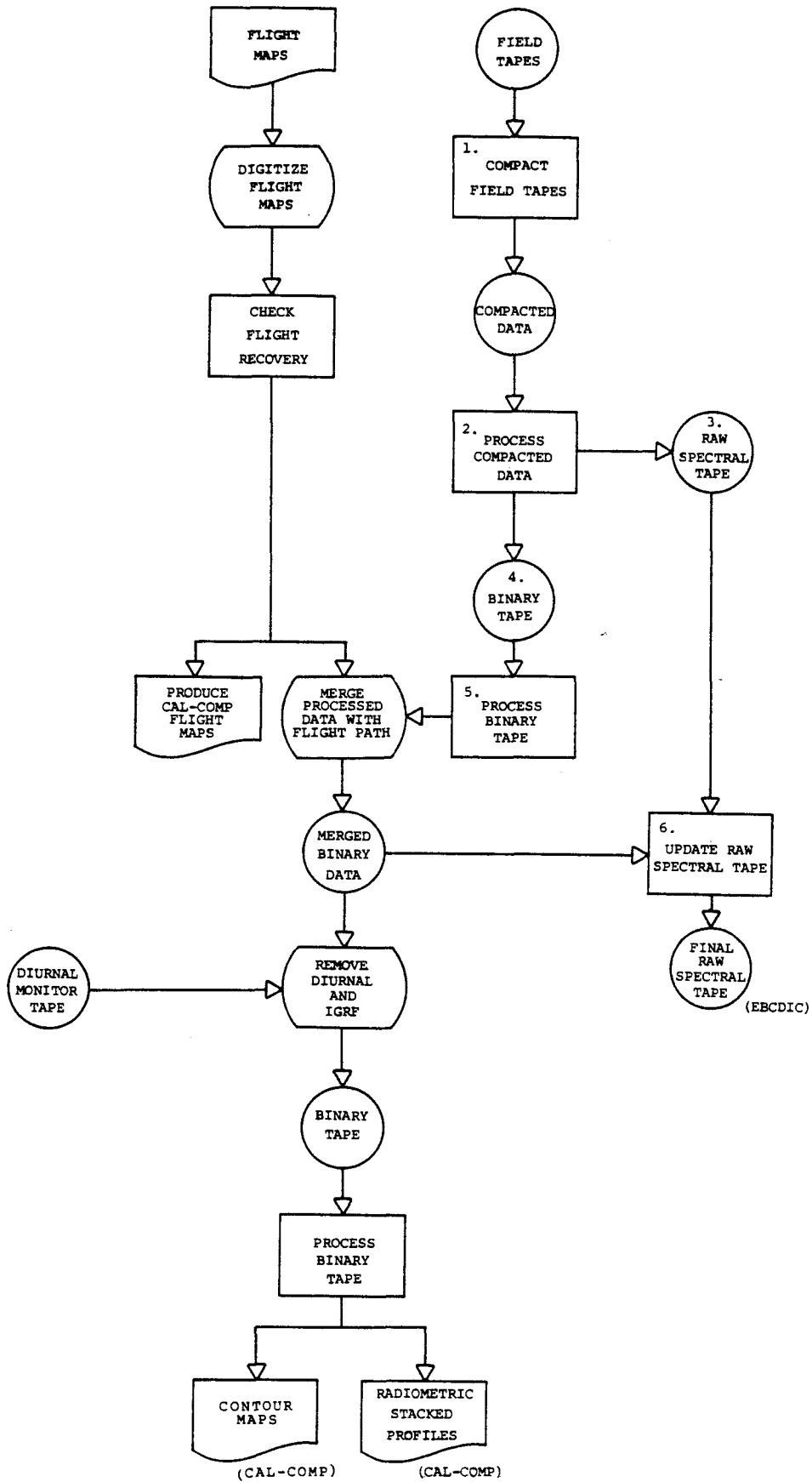


FIGURE 3

DATA PROCESSING

PRE-PROCESSING

By "pre-processing", we refer to those procedures that are applied to the field data and flight line locations to prepare them for final processing, merging and output. Steps in this "pre-processing" stage included field data tape editing and compacting, flight line location verification, and generation of preliminary data reports. The reader is referred to the data processing flow chart, Figure 3, which accompanies this report, and which illustrates the steps described below.

Field Tape Compacting and Editing

A check of the field data tapes by computer is necessary to verify data collection and recording quality. The summed spectral data for both 4π and 2π crystals were first read from a series of merged field tapes. The centroids of channel photopeaks for each flight line were next calculated from these data, and a linear equation that relates the photo energy, in MeV to the channel number was derived from the centroid calculation. The equation for this calculation is of the form:

$$E = E(0) + dE/dch \times ch$$

Where $E(0)$ is the apparent energy at channel zero, and ch is the channel number (0-255). This procedure was not applied if the survey line was too short (less than 10 minutes duration) to establish adequately smooth summed spectral data for photopeak calculations. Next the summed or "stacked" spectral data were used to calculate the resolution for k, u, Th photopeaks. Both photopeak linearity and resolution were used to establish the acceptability of the spectrometer data.

Next, the data within each flight line were checked for correct one (1) second and ten (10) second scan lengths. Erroneous scan lengths were flagged, and the spectral data for the erroneous scans were not used in the subsequent data analysis. In addition to these editing steps, the ancillary data (altimeter, pressure, and temperature) were computed from the transducer analogue voltage output. The data from each scan were used to extract one second channel window data fields, and these data fields were corrected for system "dead time". At the end of this stage of the data processing, two computer tapes were written (items 3 and 4 of Figure 3). Item 3 is a partially written RAW SPECTRAL TAPE (see Appendix A) containing all of the required data entries exclusive of the location information. Item 4 is a tape written in interval UNIVAC 1108 binary code. This tape contains all of the required entries for further processing. Full spectral data were not written on this tape, as these are contained on the partial RAW SPECTRAL TAPE.

In producing item 4, a series of computer generated histograms (see Figure 3) was produced for each survey line. Typically, these histograms summarize data recorded on the k , u , and T_h channels (4π and 2π), together with ancillary data (altimeter, pressure, and temperature).

Editing was next performed on the binary tape. Further checking consisted of rereading (with unnecessary flight data removed); and searching for and removing unrealistic gradients, transients, spikes, etc. The acceptability of questionable data segments was reviewed and corrections performed. The result of this procedure was an edited tape, which has "clean" data available for step 5 of the data processing (Figure 3).

Flight Line Recovery

Determining actual flight-line location is a crucial task in the data processing. It is accomplished primarily by using photographs taken in flight. After the flight film is developed, a photo interpreter correlates the photo-data with the flight navigator's visual location picks on the NTMS map sheets. Actual aircraft locations were determined from the flight films and transferred to a base map with the fiducial numbers of the corresponding photographs. Once data transfer to the base map was complete, fiducial numbers and locations along each flight line were digitized, and an automated computer routine checked the consistency of these data. This was done by calculating the average distance between fiducials, and establishing that this distance was approximately constant along a given flight line. After computer verification, map coordinates for each photo pick point and the beginning and ending points of each flight line were calculated and a computer plot of these points made and checked against the field plot. Any discrepancies were noted, and the misplaced pick points relocated from the flight film. The procedure was repeated until consistency was achieved.

Once the flight line data was verified, a mylar transparency of the flight lines was prepared on the Cal Comp 915 at a scale of 1:250,000. This transparency was then overlain on the geologic base map and each map unit digitized so that each sample fell within a single unit.

RADIOMETRIC DATA PROCESSING

The "cleaned" data require a number of corrections and statistical evaluation before data plots and statistical summaries can be produced. These are done in step 5 (Figure 3) and include:

1. Aircraft and cosmic background correction,
 2. Compton stripping,
 3. Atmospheric radon correction,
 4. Altitude correction
 5. Statistical adequacy criteria.
-

1. Aircraft and Cosmic Background Correction.

Aircraft background and cosmic correction ratios for the Lama over the channel windows are listed below:

AIRCRAFT AND COSMIC BACKGROUND - N49504

7 - 8 - 79

CHANNEL WINDOW	AIRCRAFT BACKGROUND COUNTS/SEC	COSMIC CORRECTION RATIO (DIMENSIONLESS)
K-40 (4 π)	17.78	0.1045
Bi-214 (4 π)	4.69	0.0799
Tl-208 (4 π)	2.31	0.1029

TOTAL COUNT	107.92	3.2359
Bi 214 (2 π)	1.11	.2116

2. Compton Stripping

Compton Scattering corrections to the 4 π data were made using the following stripping coefficients:

$${}^k\phi_u = 0.818443$$

$${}^k\phi_{Th} = 0.140265$$

$${}^u\phi_{Th} = 0.266203$$

$${}^u\phi_k = 0.0$$

$${}^{Th}\phi_k = 0.62189$$

$${}^{Tl}\phi_k = 0.0$$

3. Atmospheric Radon Correction

The Bi-air (Radon) contribution to the counts measured in the 4 π bismuth channel are approximated by:

$$Bi_A = \frac{U_{up} - B_o(z_{stp}) * U'_L - C_o T_L}{\phi_B(z_{stp}) - B_o(z_{stp})}$$

where

U_{up} = Count Rates in Bi channel from 2 π detector

U'_L = Compton Scatter corrected Bi count rate (4 π detector)

T_L = Compton Scatter corrected Th count rate (4π detector)

$\phi_B (Z_{stp})$ = 4π to 2π geometric ratio (height dependent)

$B_o (Z_{stp})$ = 4π to 2π bismuth coupling factor

C_o = 4π to 2π thallium coupling factor (constant)

Values for these factors were established at the Lake Mead Dynamic Test Range and the Walker Field Test Facility:

$$B_o (Z) = 0.037892 - 0.000042164 * Z$$

$$C_o = 0.015790$$

$$\phi_B (Z) = 0.205074 - 0.0000439 * Z$$

4. Altitude Correction

The altitude attenuation coefficients used in the correction of the data are listed below:

ALTITUDE ATTENUATION COEFFICIENTS

$$\mu_{TC} = -0.0020772 \text{ ft}$$

$$\mu_K = -0.0026525 \text{ ft}$$

$$\mu_U = -0.0020816 \text{ ft (least squares fit)}$$

$$\mu_U = -0.0024773 \text{ ft (Interpolated value)}$$

$$\mu_T = -0.0019881 \text{ ft}$$

These coefficients are employed to reduce the measured count rate at any elevation to 400 feet (at STP of 0°C - 760 mm. Hg). The reduction formula is given by:

$$\text{COUNTS NORMALIZED} = \text{COUNTS MEASURED} * \text{EXP} (+ \mu_i * (Z_{\text{STP}} - 400))$$

$$Z_{\text{STP}} = Z_{\text{MEAS}} * \frac{P * 273.15}{760 * (273.15 + T)}$$

where

- μ_i is the channel attenuation constant
- P is the measured atmospheric pressure (mm. of Hg)
- Z_{MEAS} = Radar altimeter altitude
- T is the temperature in degrees Celsius

The reduction to STP is necessary to correct for air density change along the ground-detector optical path.

5. Statistical Adequacy Criteria

To determine the statistical adequacy of raw count data R_j , subject to a subtracted correction term C_j , a number of assumptions are required concerning the statistical properties of both R_j and C_j . Further, the statistical effects of filtering (smoothing) R_j must be taken into account.

We assume, at any data point j , that R_j and C_j are both random variables on the same sample space. Further, we assume that

the statistical properties of both R_j and C_j (e.g. the mean and the variance) can be approximated by averaging spatial samples over statistically similar geologic areas rather than by holding j constant, and averaging over time (an obviously impractical procedure).

Let the corrected count rate R_j' be expressed as:

$$R_j' = W * (R_j - C_j) \quad (1)$$

where W is a set of filter weights convoluted with the corrected count rate:

$$W = (W_{-N}, W_{-N+1}, \dots, W_{-1}, W_0, W_1, \dots, W_{N-1}, W_N)$$

We define a heuristic criterion for determining the statistical adequacy of a given sample:

Let σ be the standard deviation of the correction applied to the raw count rate, and let μ be the statistical average or mean of the correction applied. If R_j represents the count rate (raw data unfiltered) measured at spatial point j , then if the following inequality holds:

$$R_j > C_j + k\sigma; C_j = C_j(\mu; \sigma) \quad (2)$$

the sample R_j is said to be statistically adequate. The quantity k is an empirically derived constant. Inequality (2) states that the corrected count rate must exceed the uncertainty in the corrections applied to correct the raw counting data. If the corrections were perfectly determined, the inequality (2) simply states that negative count rates are

stastically unreliable (hardly an unexpected result). Applying inequality (2) to equation (1), we have:

$$R'_j = W * (R_j - C_j) > k \sqrt{\text{var} (W * C_j)} \quad (3)$$

Define the spatial sequence of random variables R and C as

$$R = (R_0, R_1, \dots, R_{j-1}, \dots, R_{m-1}, R_m)$$

$$C = (C_0, C_1, \dots, C_{j-1}, \dots, C_{m-1}, C_m)$$

We assume that both R and C are positive statistically independent random variables. Then, (3) can be written as:

$$R'_j > K \sqrt{W_{-N}^2 \text{VAR} (C_{j-N}) + W_{-N+1}^2 \text{VAR} (C_{j-N+1}) + \dots + W_0^2 \text{VAR} (C_j) + \dots + W_N^2 \text{VAR} (C_{j+N})} \quad (4)$$

Let us specialize inequality (4) to the determination of statistical reliability for averaged count rate data. We assume that both R and C are Poisson distributed, so that $\text{VAR} (C_j) = \text{Mean Value of } C_j$ and that $\text{VAR} (R_j) = E (R_j) = \text{Mean Value of } R_j$. Since the filtering operation defined by W will always be zero phase shift (i.e. symmetric), then:

$$R'_j > K \sqrt{\mu_{-N}^2 (E(C_{j-N})) + \mu_{-N+1}^2 (E(C_{j-N-1}) + E(C_{j+n-1})) + \dots + \mu_0^2 E(C_j)} \quad (5)$$

Where $E(C_j)$ is the statistical mean of C determined at point j.

The above inequality is used to ensure the statistical adequacy of averaged or filtered channel data and to ensure that computed ratios using these data are themselves meaningful. Data from Set 5 (Figure 3) are subjected to this criteria. Data failing to meet this test are flagged on the binary tape for later posting to the export EBCDIC tapes (see Appendix A). A seven-point, central weighted "parabolic" filter was employed to smooth the data prior to testing.

$$W = (-.09524, .14286, .28571, .33333, .28571, .14286, -.09524)$$

After the processing of step 5 (Figure 3), the binary tape is merged with the corrected flight line data and next with the edited geological base map data. These steps establish an X-Y (Lat-Long) base for the magnetic and radiometric data, together with the corresponding geologic type for that location.

MAGNETIC DATA PROCESSING

Steps in reduction of the magnetic data consisted of diurnal variation correction, common magnetic datum tying, and removal of regional magnetic fields defined by the International Geomagnetic Reference Field (IGRF).

The IGRF model used to correct the observed data was that adopted by the International Association of Geomagnetism and Aeronomy, Division I study group at Grenoble, France on September 4, 1975. The spherical harmonic coefficients adopted by IAGA were used to generate the theoretical magnetic field at 20 points in each quadrangle. A theoretical least squares polynomial surface in UTM coordinates was then set to fit the theoretical reference field. Letting X = Easting and Y = Northing, the theoretical IGRF field was fitted to a residual error of less than 0.1 gammas by the following series expansion in X and Y:

$$T_{IGRF} = 40060.35 + 0.91443 (X - 740.73) + 3.8216(Y-2974.4) \\ \text{gammas.}$$

The residual magnetic field (T_{RES}) is defined as:

$$T_{RES} = T_{OBS} - T_{IGRF}$$

where

T_{OBS} is the observed field.

A ground based magnetometer monitored diurnal variations of the magnetic field during the airborne operation. Data

were sampled at 4-second intervals at a sensitivity of one quarter gamma and were recorded along with time code on analogue tapes. Editing was performed to remove data spikes, man-made magnetic events, and extraneous readings. A profile display was made as a check to determine visually that all necessary editing had been performed. The edited, compacted diurnal data were time coded to match the airborne data, (see Figure 3) densified to a one (1) second sample interval and subtracted from the airborne data.

Magnetic differences in the resultant diurnally corrected plots between tie lines and flight lines at intersections were treated by a tying program. Individual line biases were calculated for both tie and profile lines. These biases were caused by changes of ground based magnetometer location, aircraft magnetization, and effects due to differential aircraft heading.

As a final check on the validity of the magnetic data, a lister plot map was generated and analyzed to locate exceptional tying and/or location errors.

Both the IGRF and diurnal corrections were then applied to the merged binary tape. This completed the data processing stage of the analysis. Data on the merged binary tape was then ready for display and final presentation.

DATA DISPLAY

Data and information obtained in this project are displayed in a number of formats. These include flight path location maps, stacked profiles, discrete magnetic profiles, histograms for each of the geologic units, statistical anomaly maps for all channels, pseudo-contour maps of potassium (K), equivalent uranium (eU), equivalent thorium (eTh); and uranium anomaly interpretation maps. This information is presented in Volume II for each quadrangle of the project. All maps and profiles were originally plotted at a scale of 1:250,000, but have been reduced to 1:500,000 for inclusion in Volume II. Microfiche data listings for both quadrangles of the project are presented in Appendix C. Data tapes are submitted under separate cover.

FLIGHT PATH LOCATION MAPS

The actual flight path position for each flight line and tie line as utilized in the data analysis, is displayed for each quadrangle of the project. Geologic quadrangle maps at a scale of 1:250,000 are utilized as the base map for superpositioning of flight lines. Ancillary information consisting of flight and tie line numbers, and fiducial number of located positions is also printed on these maps.

STACKED PROFILES

The stacked profiles consist of:

- (1) flight path superimposed on geologic strip map
(including fiducials),
- (2) corrected Total Count,

- (3) Corrected Bi 214 in eU parts per million (ppm)
- (4) Corrected Potassium 40 in percent,
- (5) Corrected Tl 208 in eTh ppm,
- (6) eU/eTh ratio,
- (7) eU/K ratio
- (8) eTh/K ratio
- (9) Bi-air,
- (10) radar altimeter,
- (11) magnetometer data,

Plotted at a scale of 1:250,000, these profiles are representative of processed data along a given flight/tie line over the specified map area, and can be directly superimposed on the flight path maps, topographic maps, etc., at a scale of 1:250,000.

MAGNETIC PROFILES

A separate set of profiles containing:

- (1) flight path position superimposed on 1:250,000 geologic strip map,
- (2) residual magnetic data (corrected), and IGRF removed,
- (3) radar altimeter,
- (4) barometric pressure,
- (5) diurnal magnetic station data, and
- (6) temperature data.

HISTOGRAMS

Histograms, generated via the computer, display the count rate distribution for each of the requested radioelement parameters as a function of the geologic unit. Standard deviation as calculated from the mean, and total number of samples producing the distribution are annotated on each histogram.

ANOMALY MAPS

Based on the population distribution within each unit and specific criteria discussed under processing, a determination of the degree of anomalousness of each sample on every flight line has been made. This data is displayed as a set of six anomaly maps (Potassium 40, eU, eTh, eU/eTh, eU/K, and eTh/K ratios) for each NTMS quadrangle of the study project. Only data which are determined to be statistically adequate are utilized in the maps. In particular, this means that sample gaps occurring over water and in areas where data fail to meet the altimeter specification (between 200 and 700 feet) are not included.

Notation on the maps is pertinent to statistics and is the same on each map. Small dots above or below a given flight line indicate the number of standard deviations from the mean of an averaged sample at that point on the flight line. The anomaly maps must be oriented in standard format (north away from the interpreter) to discern whether the sample has a positive or negative deviation. North side of flight lines (east-west oriented) is defined as positive, and south is negative. Tie lines (north-south oriented) have positive deviations to the west and negative deviations to the east. Each project area has a set of maps generated at a scale of 1:250,000 displayed as projected onto the flight line map. Reduced scale 1:500,000 maps are presented in Volume II.

PSEUDO-CONTOUR MAPS

Printer plots or pseudo-contour maps are generated to indicate relative regional highs and lows of radioelement distribution, and residual magnetic intensity. One pseudo-contour map is

presented for each radioelement parameter, and the residual magnetic intensity. The magnetic interpretation is performed directly on the pseudo-contour map, while the radioelement maps serve only as ancillary data.

INTERPRETATION MAP

Interpretation of the data plotted on the profiles, anomaly maps, histograms, and pseudo-contour maps is shown in the Interpretation Map, Figure 3 in Volume II. This map uses a 1:250,000 flight-line base map to show uranium high anomalies, postulated sources of magnetic discontinuities. The scale of this map has been reduced to 1:500,000 for presentation in Volume II.

DATA LISTINGS

The formats of the data, recorded on microfiche in Appendix C of Volume I of this report, are indicated below:

1. Fiducial number
2. Quality - 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 above 700 feet and below 200 feet are considered statistically inadequate.
3. Time - in hours, minutes, and seconds
4. Altitude - in feet above terrain.

5. LONG/LAT - 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, - equivalent percent or parts per million of corrected k,u,T, data
9. eU/eTh, eU/K, eTh/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. Bi-air - atmospheric Bi-214 count rate.
13. Temperature - outside air temperature in degrees centigrade.
14. Press - barometric pressure in inches of mercury.

The format of the averaged record (statistical analysis) data listings included in microfiche in Appendix C are summarized below:

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

value of 1 indicates that the data are statistically inadequate.

3. LONG/Lat - 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 number of positive standard deviations from the mean.
7. eU/eTh , eU/K , eTh/K - calculated ratios of the various parameters, and the number of positive 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. Bi-air - atmospheric Bi-214 count rate.

DATA TAPES

Data tapes 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. Five separate sets of data tapes are presented: raw spectral data tapes, single record reduced data tapes, statistical analysis tapes, magnetic data tapes, and statistical analysis summary tapes. Detailed descriptions of the data tape formats are presented in Appendix A.

DATA INTERPRETATION

BASIC CONSIDERATIONS

Consistent with the NURE program goals, the interpretation has been oriented towards regional reconnaissance with emphasis placed on the location of areas of anomalously high concentrations of uranium. Attention has also been given to areas of anomalously low concentrations of Uranium, since these can be indicative of rocks from which uranium has been removed by chemical or physical processes and transported elsewhere to form deposits of economic interest. The concentrations of uranium, thorium, and potassium tend to vary sympathetically in geologic materials; however, in uranium deposits, uranium is concentrated relative to thorium and potassium, and in areas where uranium has been leached, thorium and potassium are concentrated relative to uranium. Thus, the ratios of the element concentrations may be of more significance for uranium exploration than the concentrations of the individual elements. The most significant ratio is eU/eTh . In uranium deposits in which uranium is enriched relative to thorium, this ratio is high; in areas in which uranium has been preferentially removed, it is low.

Because of the rapid attenuation of gamma-rays in geologic materials, the measurement recorded by the spectrometer is representative of only the upper 18 inches of the surficial material. Furthermore, each sample is representative of an area not a point. For example, a single sample taken in a survey flown at 400 feet mean terrain clearance at 95 miles an hour is representative of approximately 48,000 square feet. Thus, in the interpretation of airborne radiometric data, due consideration must be given to whether the surficial material sampled is bedrock, residual material derived from the chemical or physical decomposition of the bedrock, material that has been transported from elsewhere and deposited on the bedrock,

or material of non-geologic origin.

INTERPRETATION METHODOLOGY

Materials used for the interpretation of each quadrangle consist of pseudo-contour maps of Potassium, equivalent Uranium (eU), equivalent Thorium (eTh), eU/eTh, eU/K, eTh/K, and the residual total magnetic field; histograms of equivalent parts per million (eppm) distribution within each geologic unit of the quadrangle; flight line maps; stacked profiles, statistical anomaly maps of each channel; 1° X 2° NTMS topographic and geologic maps of the quadrangle; and the flight recovery photos. The interpretation is focused on defining the uranium anomalies from the statistical anomaly maps. The remaining data are used to aid in defining the statistical anomalies and in their interpretation.

The minimum statistical requirements of the basic uranium anomaly to be derived from the statistical maps are described below:

1. Bi 214 map (eU) - two (2) consecutive averaged eU samples each being two (2) or more standard deviations above the mean or three (3) consecutive averaged eU samples, one (1) of which is two (2) or more standard deviations above the mean and two (2) of which are one (1) or more standard deviations above the mean.
2. Bi 214/Tl 208 eU/eTh - two (2) consecutive averaged eU/eTh ratio samples which are one (1) or more standard deviations above mean.
3. Thallium 208 (eTh) - a thorium sample at least minus one (-1) standard deviation below the mean which corresponds to each eU/eTh sample described above. The eU/eTh ratio

is invalidated if the thorium sample does not meet this test.

Statistical anomalies meeting these criteria are considered uranium anomalies regardless of actual count rate or eppm. However, anomalies may be the product of many processes or conditions including:

- (1) actual radiometric mineral accumulation
- (2) variations in surface exposure of a unit within its mapped boundaries (due to soil mantling or vegetation),
- (3) macro-meteorologic effects prior to flight (e.g. rain or snow),
- (4) perturbations in the micro-meteorologic regime within a mapped unit,
- (5) unmapped lithologic variations within a mapped unit, or
- (6) differential weathering of exposures within a mapped unit

The interpretation considers these and other causative agents in treatment of anomalies.

The screened uranium anomaly map is superimposed upon the 1° X 2° NTMS topographic map to determine if cultural features are related to the anomalies. Those which occur atop demonstrably non-geologic features are rejected. Causative agents are noted where appropriate and are included in the anomaly description.

Stacked profiles for each flight line are overlain on the screened uranium anomaly map to determine the count rate or eppm association with specific anomalies. In some instances, the high count rates sampled may fail to meet the statistical criteria but may reinforce regional trends indicated only by statistical anomalies.

Potassium, thorium, uranium, and residual magnetic data, plotted as pseudo-contour maps, are used to develop regional trend information. These are overlain and compared to the geologic base maps, topographic maps, and the statistical anomaly maps. In general only long wavelength features exhibit line-to-line continuity on the pseudo-contour maps, hence only regional trends emerge.

Mean values of percent potassium (%K), equivalent parts per million uranium (ppm eU), and equivalent parts per million thorium (ppm eT) shown on the profile histograms, etc., and utilized in the text are derived from the calibration of the radiometric system over DOE's Lake Mead Dynamic Test Range. Equivalent sensitivities normalized to 400 feet altitude are:

RADIOELEMENT SENSITIVITIES

K	88.4 counts/sec	%K
U	10.8 counts/sec	eppm U
T	5.4 counts/sec	eppm T

APPENDIX A

TAPE FORMATS

RAW SPECTRAL DATA TAPE

REFERENCE: PARAGRAPHS 4.7.5 THROUGH 4.7.5.3, BFEC 1200 C

The RAW SPECTRAL DATA is unlabeled nine track, 2400 foot reel length, 800 BPE, NRZI, odd parity. All data are recorded as EBCDIC characters. Each tape contains identification, header, and data records for no more than one NTMS quadrangle. The block length is 6600 characters.

The first physical block on tape is a literal alphanumeric listing for the Fortran formats and data items. This listing allows a user to unambiguously read and interpret all of the data contained on the tape.

The second physical block is organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
2	A20	NAME OF SUBCONTRACTOR (HIGH-LIFE/QEB)
3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
4	I1	AERIAL SYSTEM IDENTIFICATION CODE
5	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER
6	I3	BFEC CALIBRATION REPORT NUMBER
7	F6.3	4PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS
8	F6.3	2PI SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS
9	I3	NUMBER OF CHANNELS (0-3MEV) FOR 4PI SYSTEM
10	I3	NUMBER OF CHANNELS (0-3MEV) FOR 2PI SYSTEM
11	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
12	I4	FIRST FLIGHT LINE NUMBER ON THIS TAPE
13	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE

14	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE WAS COLLECTED
15-17	I4,I6,I3	REPEAT OF ITEMS 12-14 FOR SECOND FLIGHT LINE ON THIS TAPE
*	*	*
*	*	*
*	*	*
306-308	I4,I6,I3	REPEAT OF ITEMS 12-14 FOR 99TH FLIGHT LINE OF THIS TAPE

The third and following physical blocks are organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	I1	AERIAL SYSTEM IDENTIFICATION CODE
2	I4	FLIGHT LINE NUMBER
3	I6	RECORD IDENTIFICATION NUMBER
4	I6	GMT TIME OF DAY (HHMMSS)
5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
8	F7.1	TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
9	A8	SURFACE GEOLOGIC MAP UNIT CODE
10	I4	QUALITY FLAG CODES
11	F4.1	OUTSIDE AIR TEMPERATURE TO ONE DECIMAL PLACE IN DEGREES CELSIUS
12	F5.1	OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
13	F5.3	LIVE TIME COUNTING PERIOD TO THREE DECIMAL PLACES IN SECONDS
14	I4	SUMMED RAW OUTPUT FROM COSMIC CHANNELS (3-6 MEV) IN COUNTS
15	I4	RAW OUTPUT FROM CHANNEL 1 IN COUNTS

16 I4 RAW OUTPUT FROM CHANNEL 2 IN COUNTS
 * * *
 * * *
 * * *
 270 I4 RAW OUTPUT FROM CHANNEL 256 IN COUNTS

SINGLE RECORD REDUCED DATA TAPE

REFERENCE: PARAGRAPH 4.7.6. AND 4.7.6.1, BFEC 1200-C
 THE SINGLE RECORD REDUCED DATA TAPE is unlabeled nine track, 2400 foot reel length, NRZI, odd parity. All data are recorded in EBCDIC characters. Each tape contains identification, header and data records for one NTMS quadrangle.

The block length is 6900 characters.

The first physical block on tape is literal alphanumeric listing of the Fortran formats and data items. This listing allows a user to unambiguously read and interpret all of the data contained on the tape.

The second physical block is organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
2	A20	NAME OF SUBCONTRACTOR (HIGH-LIFE/QEB)
3	I1	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
4	I1	NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR THIS QUADRANGLE
5	I1	AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM
6	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR FIRST SYSTEM
7	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN CPS PER PERCENT K FOR FIRST SYSTEM
8	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT U

8	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
9	A8	SURFACE GEOLOGIC MAP UNIT CODE
10	I4	QUALITY FLAG CODES
11	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN PERCENT K
12	F4.1	UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL PLACE IN PERCENT K
13	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
14	F4.1	UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
15	F6.1	APPARENT CONCENTRATION OF TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
16	F4.1	UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
17	F6.1	URANIUM-TO-THORIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
18	F6.1	URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
19	F6.1	THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
20	F8.1	GROSS GAMMA (0.4-3.0MeV) COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
21	F6.1	UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
22	F5.1	ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
23	F4.1	UNCERTAINTY IN ATMOSPHERIC BI-214 4PI

CORRECTION TO ONE DECIMAL PLACE IN PPM
EQUIVALENT U

24 F4.1

OUTSIDE AIR TEMPERATURE TO ONE DECIMAL
PLACE IN DEGREES CELSIUS

25 F5.1

OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE
IN MMHG

STATISTICAL ANALYSIS TAPE

REFERENCE: PARAGRAPHS 4.7.1. THROUGH 4.7.7.3, BFED 1200-C

The STATISTICAL ANALYSIS TAPE is unlabeled nine track, 2400 foot reel length, 800 BPI, NRZI, odd parity. All data are recorded in EBCDIC characters. The block length is 8000 characters. Each tape contains identification, header and data records for one NTMS quadrangle. The first physical block on tape is a literal alphanumeric listing of the Fortran formats and data items. This listing allows the user to unambiguously read and interpret all of the data contained on the tape.

The second physical block is organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
2	A20	NAME OF SUBCONTRACTOR (HIGH-LIFE/QEB)
3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
4	I1	NUMBER OF AERIAL SYSTEMS USED TO COLLECT DATA FOR THIS QUADRANGLE
5	I1	AERIAL SYSTEM IDENTIFICATION CODE FOR FIRST SYSTEM
6	A20	AIRCRAFT IDENTIFICATION BY TYPE AND FAA NUMBER FOR FIRST SYSTEM
7	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN CPS PER PERCENT K
8	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN CPS PER PPM EQUIVALENT U
9	F6.1	NOMINAL ALTITUDE SYSTEM SENSITIVITY RELATIVE TO TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN CPS PER PPM

		EQUIVALENT TH
10	I6	BLANK FIELD (999999)
11	F6.3	4PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM
12	F6.3	2PI-SYSTEM DATA COLLECTION INTERVAL TO THREE DECIMAL PLACES IN SECONDS FOR FIRST SYSTEM
13	I3	NUMBER OF CHANNELS (0-3MeV) IN 4PI SYSTEM FOR FIRST AERIAL SYSTEM
14	I3	NUMBER OF CHANNELS (0-3MeV) IN 2PI SYSTEM FOR FIRST AERIAL SYSTEM
15-24	(SAME)	REPEAT OF ITEMS 5-14 FOR SECOND AERIAL SYSTEM
*	*	*
*	*	*
*	*	*
85-94	(SAME)	REPEAT OF ITEMS 5-14 FOR NINTH AERIAL SYSTEM
95	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
96	I4	FIRST FLIGHT LINE NUMBER ON THIS TAPE
97	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE
98	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE DATA WAS COLLECTED
99-101	I4,I6,I3	REPEAT OF ITEMS 96-98 FOR SECOND FLIGHT LINE ON THIS TAPE
*	*	*
*	*	*
*	*	*
390-392	I4,I6,I3	REPEAT OF ITEMS 96-98 FOR 99TH FLIGHT LINE ON THIS TAPE

The third and following physical blocks are organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	I1	AERIAL SYSTEM IDENTIFICATION CODE

2	I4	FLIGHT LINE NUMBER
3	I6	RECORD IDENTIFICATION NUMBER
4	I6	GMT TIME OF DAY (HHMMSS)
5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
8	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
9	A8	SURFACE GEOLOGIC MAP UNIT CODE
10	I5	QUALITY FLAG CODES
11	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL POTASSIUM (K-40) TO ONE DECIMAL PLACE IN PERCENT K
12	F4.1	UNCERTAINTY IN TERRESTRIAL POTASSIUM TO ONE DECIMAL PLACE IN PERCENT K
13	F5.1	POTASSIUM STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
14	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL URANIUM (BI-214) TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
15	F4.1	UNCERTAINTY IN TERRESTRIAL URANIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
16	F5.1	URANIUM STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
17	F6.1	AVERAGED CONCENTRATION OF TERRESTRIAL THORIUM (TL-208) TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
18	F4.1	UNCERTAINTY IN TERRESTRIAL THORIUM TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
19	F5.1	THORIUM STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED

20	F8.1	GROSS GAMMA (0.4-4.0 MeV) COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
21	F6.1	UNCERTAINTY IN GROSS GAMMA COUNT RATE TO ONE DECIMAL PLACE IN COUNTS PER SECOND
22	F5.1	ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
23	F4.1	UNCERTAINTY IN ATMOSPHERIC BI-214 4PI CORRECTION TO ONE DECIMAL PLACE PPM EQUIVALENT U
24	F6.1	AVERAGED URANIUM-TO-THORIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
25	F5.1	URANIUM-TO-THORIUM RATIO STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
26	F6.1	AVERAGED URANIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
27	F5.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED
28	F6.1	AVERAGED THORIUM-TO-POTASSIUM RATIO TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
29	F5.1	THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION FROM THE MEAN TO ONE DECIMAL PLACE AND ALGEBRAICALLY SIGNED

MAGNETIC DATA TAPE

REFERENCE: PARAGRAPHS 4.7.8 THROUGH 4.7.8.3, BFEC 1200-C
 The MAGNETIC DATA TAPE is unlabeled nine track 2400 foot reel length, 800 EBI NRZI, odd parity. All data are recorded EBCDIC characters. Each tape contains identification, header and data records for one NTMS quadrangle. The block length is 8000 characters.

The first physical block on tape is a literal alphanumeric listing of the Fortran formats and data items. This listing allows a user to unambiguously read and interpret all of the data contained on the tape.

The second physical block is organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION
2	A20	NAME OF SUBCONTRACTOR (HIGH-LIFE/QEB)
3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
4	I3	NUMBER OF FLIGHT LINES ON THIS TAPE
5	I4	FIRST FLIGHT LINE ON THIS TAPE
6	I6	FIRST RECORD NUMBER OF FIRST FLIGHT LINE
7	I3	JULIAN DATE (DAY OF YEAR) FIRST FLIGHT LINE WAS COLLECTED
8	F8.4	LATITUDE OF GROUND BASE STATION TO FOUR DECIMAL PLACES IN DEGREES FOR FIRST FLIGHT LINE
9	F8.4	LONGITUDE OF GROUND BASE STATION TO FOUR DECIMAL PLACES IN DEGREES FOR FIRST FLIGHT LINE
10-14	(SAME)	REPEAT OF ITEMS 5-9 FOR SECOND FLIGHT LINE ON THIS TAPE
*	*	*
*	*	*
*	*	*
495-499	(SAME)	REPEAT OF ITEMS 5-9 FOR 99TH FLIGHT LINE OF THIS TAPE

The third and following physical blocks are organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	I1	AERIAL SYSTEM IDENTIFICATION CODE
2	I4	FLIGHT LINE NUMBER
3	I6	RECORD IDENTIFICATION NUMBER
4	I6	GMT TIME OF DAY (HHMMSS)

5	F8.4	LATITUDE TO FOUR DECIMAL PLACES IN DEGREES
6	F8.4	LONGITUDE TO FOUR DECIMAL PLACES IN DEGREES
7	F6.1	TERRAIN CLEARANCE TO ONE DECIMAL PLACE IN METERS
8	F5.1	OUTSIDE AIR PRESSURE TO ONE DECIMAL PLACE IN MMHG
9	A8	SURFACE GEOLOGIC MAP UNIT CODE
10	F7.1	TOTAL MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
11	F7.1	RESIDUAL (IGRF REMOVED) MAGNETIC FIELD INTENSITY TO ONE DECIMAL PLACE IN GAMMAS
12	F7.1	DIURNAL MAGNETIC INTENSITY VARIATION TO ONE DECIMAL PLACE IN GAMMAS
13	F7.1	MAGNETIC DEPTH-TO-BASEMENT TO ONE DECIMAL PLACE IN METERS (IF REQUIRED)

STATISTICAL ANALYSIS SUMMARY TAPE

REFERENCE: PARAGRAPHS 4.7.9 THROUGH 4.7.93, BFEC 1200-C
The STATISTICAL ANALYSIS SUMMARY TAPE is unlabeled nine track, 2400 foot reel length, 300 BPI, NRZI, odd parity. All data are recorded in EBCDIC characters. Each tape contains identification, header and data records for one NTMS quadrangle. The block length is 7000 characters.

The first physical block on tape is a literal alphanumeric listing of the Fortran formats and data items. This listing allows a user to unambiguously read and interpret all of the data contained on the tape.

The second physical block is organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	A40	QUADRANGLE NAME AS PROJECT IDENTIFICATION

2	A20	NAME OF SUBCONTRACTOR (HIGH-LIFE/QEB)
3	I4	APPROXIMATE DATE OF SURVEY (MONTH, YEAR)
4	I6	NUMBER OF GEOLOGIC MAP UNITS USED FOR THIS QUADRANGLE

The third and following physical blocks are organized as follows:

<u>ITEM</u>	<u>FORMAT</u>	<u>DESCRIPTION</u>
1	A8	SURFACE GEOLOGIC MAP UNIT IDENTIFYING CODE
2	I6	TOTAL RECORDS FOR GEOLOGIC MAP UNIT
3	I6	NUMBER OF POTASSIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
4	F6.1	POTASSIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN PERCENT K
5	F6.1	POTASSIUM CONCENTRATION STANDARD DEVIATION TO ONE PLACE IN PERCENT K
6	A3	POTASSIUM CONCENTRATION DISTRIBUTION CODE
7	I6	NUMBER OF URANIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
8	F6.1	URANIUM CONCENTRATION MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
9	F6.1	URANIUM CONCENTRATION STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U
10	A3	URANIUM CONCENTRATION DISTRIBUTION CODE
11	I6	NUMBER OF THORIUM RECORDS COMPUTED FOR GEOLOGIC UNIT
12	F6.1	THORIUM CONCENTRATION MEAN TO ONE DECIMAL IN PPM EQUIVALENT TH
13	F6.1	THORIUM CONCENTRATION STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH
14	A3	THORIUM CONCENTRATION DISTRIBUTION CODE
15	I6	NUMBER OF URANIUM-TO-THORIUM RATIO RECORDS COMPUTED FOR GEOLOGIC UNIT
16	F6.1	URANIUM-TO-THORIUM RATIO MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER

		PPM EQUIVALENT TH
17	F6.1	URANIUM-TO-THORIUM RATIO STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PPM EQUIVALENT TH
18	A3	URANIUM-TO-THORIUM RATIO DISTRIBUTION CODE
19	I6	NUMBER OF URANIUM-TO-POTASSIUM RATIO RECORDS COMPUTED FOR GEOLOGIC UNIT
20	F6.1	URANIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
21	F6.1	URANIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT U PER PERCENT K
22	A3	URANIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE
23	I6	NUMBER OF THORIUM-TO-POTASSIUM RATIO RECORDS COMPUTED FOR GEOLOGIC UNIT
24	F6.1	THORIUM-TO-POTASSIUM RATIO MEAN TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
25	F6.1	THORIUM-TO-POTASSIUM RATIO STANDARD DEVIATION TO ONE DECIMAL PLACE IN PPM EQUIVALENT TH PER PERCENT K
26	A3	THORIUM-TO-POTASSIUM RATIO DISTRIBUTION CODE

APPENDIX B

PRODUCTION SUMMARY

(B1)

LUND QUADRANGLE

PRODUCTION SUMMARY

DATE	PRODUCTION/REMARKS
8/14/79	101.0
8/17/79	182.7
8/18/79	Weather
8/19/79	Weather
8/20/79	460.0
8/21/79	427.8
8/22/79	602.9
8/23/79	414.0
8/24/79	Equipment Malfunction
8/25/79	577.0
8/26/79	345.1
TOTAL	3,110.5

ELY QUADRANGLE

PRODUCTION SUMMARY

DATE	PRODUCTION/REMARKS
8/1/79	133.2
8/2/79	706.0
8/3/79	355.4
8/4/79	Aircraft Maintenance
8/5/79	336.4
8/6/79	80.0
8/7/79	Weather
8/8/79	240.0
8/9/79	310.2
8/10/79	481.2
8/15/79	310.0
8/16/79	121.3
TOTAL	3,073.7

(B3)

APPENDIX C
MICROFICHE

(C1)