NURE AERIAL GAMMA RAY AND MAGNETIC RECONNAISSANCE SURVEY

THORPE AREA

NEWARK NK18-11 QUADRANGLE

VOLUME I - NARRATIVE REPORT

LKB RESOURCES, INC.
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NOVEMBER 1977

WORK PERFORMED UNDER
BENDIX FIELD ENGINEERING CORPORATION GRAND JUNCTION OPERATIONS
SUBCONTRACT NO. 76-032-S 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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SECTION 1.0

INTRODUCTION

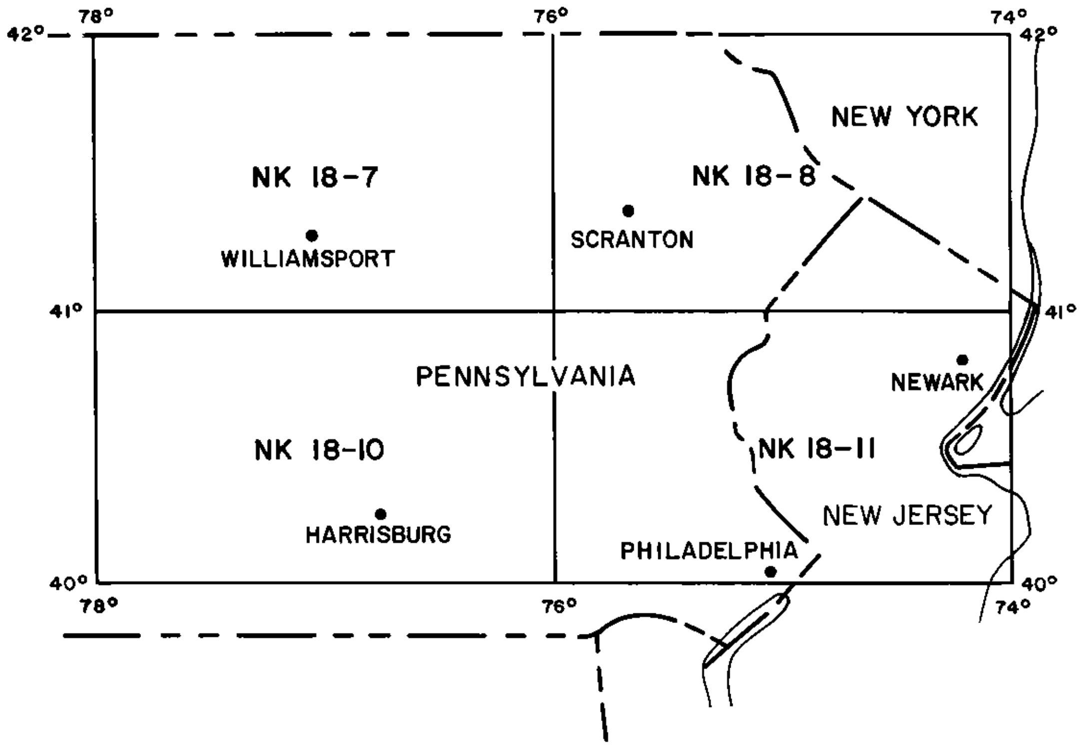
1.1 GENERAL

During the flying seasons of 1976 and 1977 L K B Resources, Inc. conducted a rotary wing combined airborne high sensitivity gamma-ray and magnetic survey of four 1:250,000 quadrangles covering portions of the States of Pennsylvania, New Jersey and New York. The quadrangles covered by the survey are shown on Figure 1.

All flying, data reduction, interpretation and reporting was performed for the Grand Junction Office of Bendix Field Engineering Corporation under subcontract #76-032-S and is part of the DOE National Uranium Resource Evaluation (NURE) Program.

Map sheet names and accompanying reports conform to the NTMS 1:250,000 scale topographic map series. Consult Figure 1 for the sheet index.

Locations of individual traverses for each quadrangle are indicated on Figure 2.



SCALE 1:2,500,000

FIGURE – 1 AREA MAP DELINEATING 1976 AND 1977 FLYING

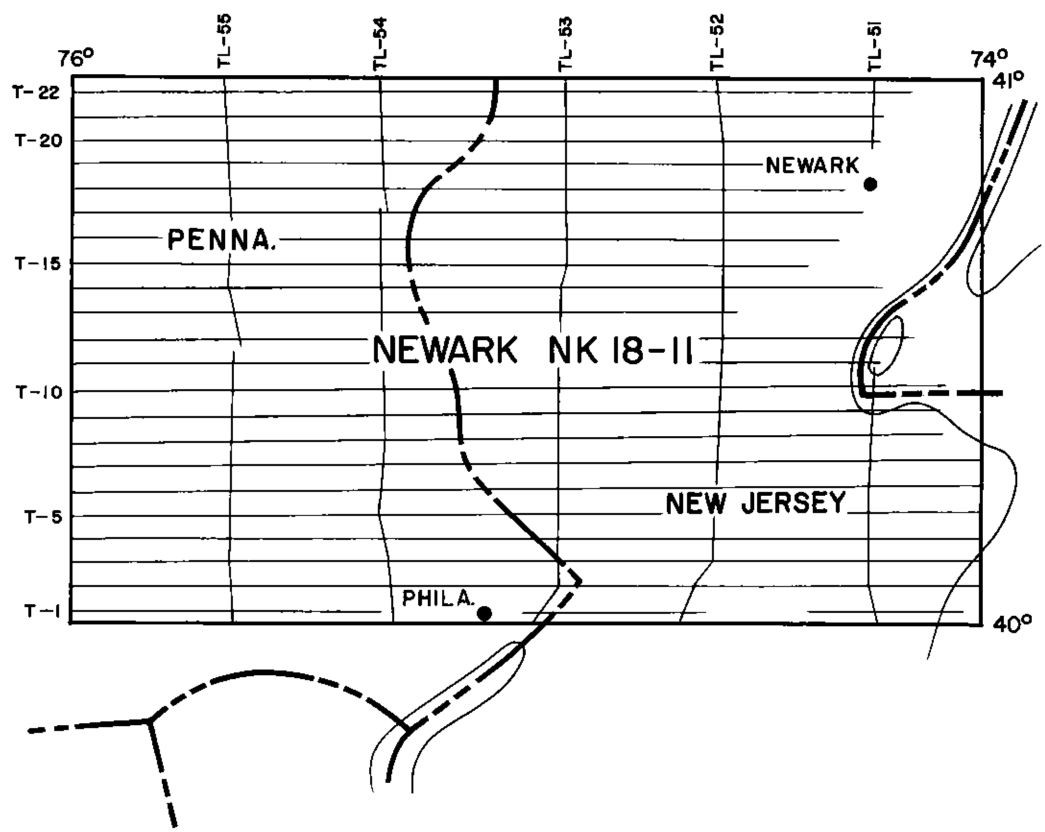


FIGURE-2 INDIVIDUAL QUADRANGLE INDEX TO TRAVERSES

SECTION 2.0

THE AIRBORNE SYSTEM

2.1 HELICOPTER

The airborne platform used for the survey was a piston engine Sikorsky S-58 helicopter (Figures 4 and 5), especially modified for high sensitivity gamma-ray surveys. Additional modifications were made to increase the performance and range of the helicopter.

2.2 INSTRUMENTATION

2.2.1 Gamma-ray Sensors

Figure 3 is a block diagram of the airborne high sensitivity gamma-ray and magnetometer system.

2.2.1.1 Terrestrial Sensors

This sub-system consists of two identical sensors each containing seven NaI (Tl) crystals measuring 7 inches in diameter by 4 inches thick. The total volume of the fourteen crystals is 2154 in^3.

Each sensor incorporated an ultra-stable high voltage supply, seven pre-amplifiers, a temperature control unit and a detector signal mixing circuit. The detectors are housed in appropriately insulated containers. Heating elements inside each container provided continual temperature stabilization to maintain detector balance.

2.2.1.2 Atmospheric Detector

This sub-system consists of one sensor containing one 9 inch diameter by 5 inch thick NaI (Tl) crystal. The total volume of the crystal is 318 in^3.

A heating element inside the insulated container provided continuous temperature stabilization to maintain detector balance.

The atmospheric detector was mounted directly over a three inch thick lead shield to eliminate terrestrial gamma-ray contributions.

2.2.2 Magnetometer

A total field fluxgate magnetometer was used to measure the earth's magnetic field. The sensor was rigidly mounted to the helicopter and compensated to eliminate heading effects.

Sensitivity of the magnetometer is 0.1 gammas.

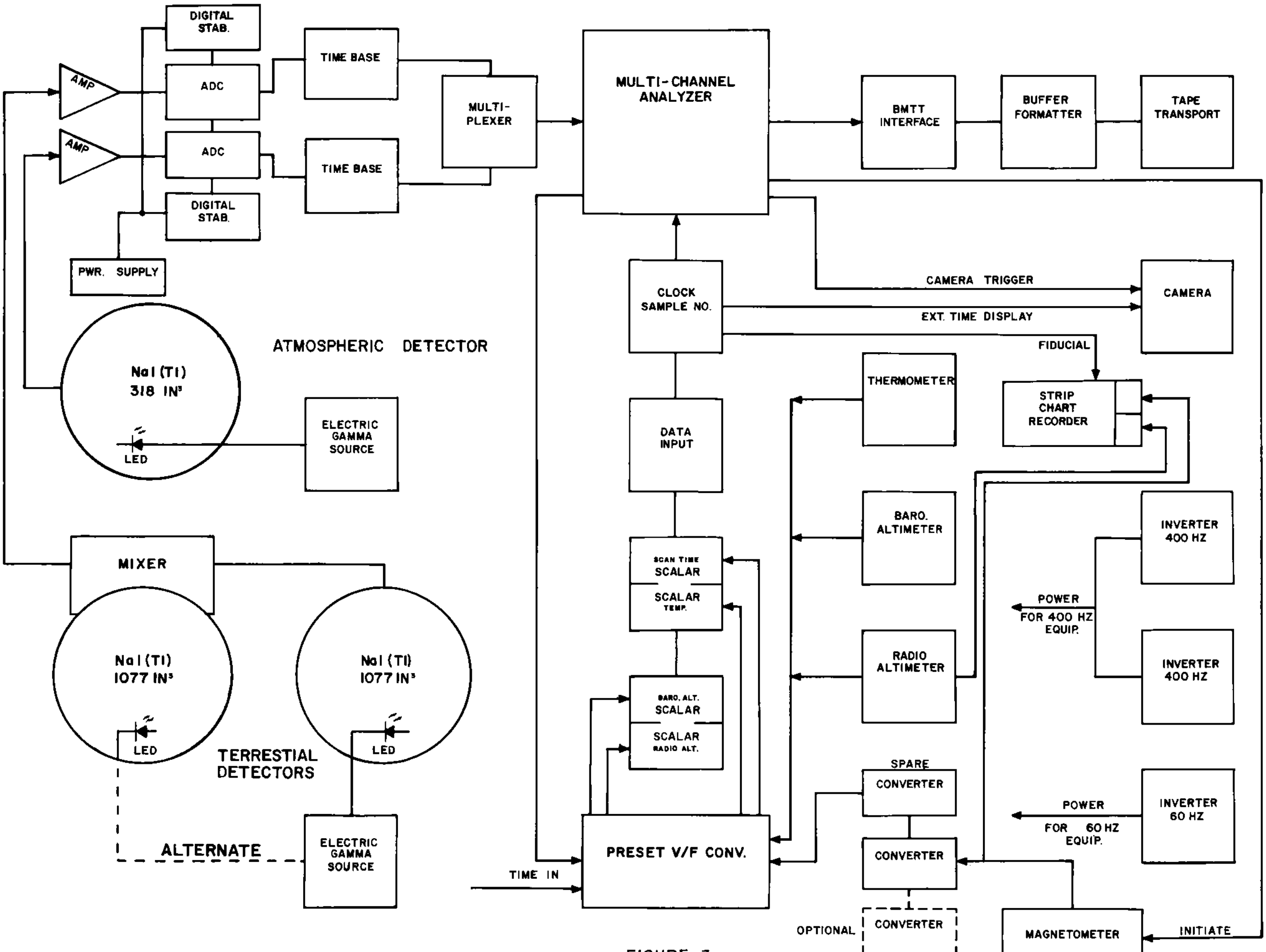


FIGURE-3
SYSTEM BLOCK DIAGRAM

FIGURE - 4 S - 58 HELICOPTER

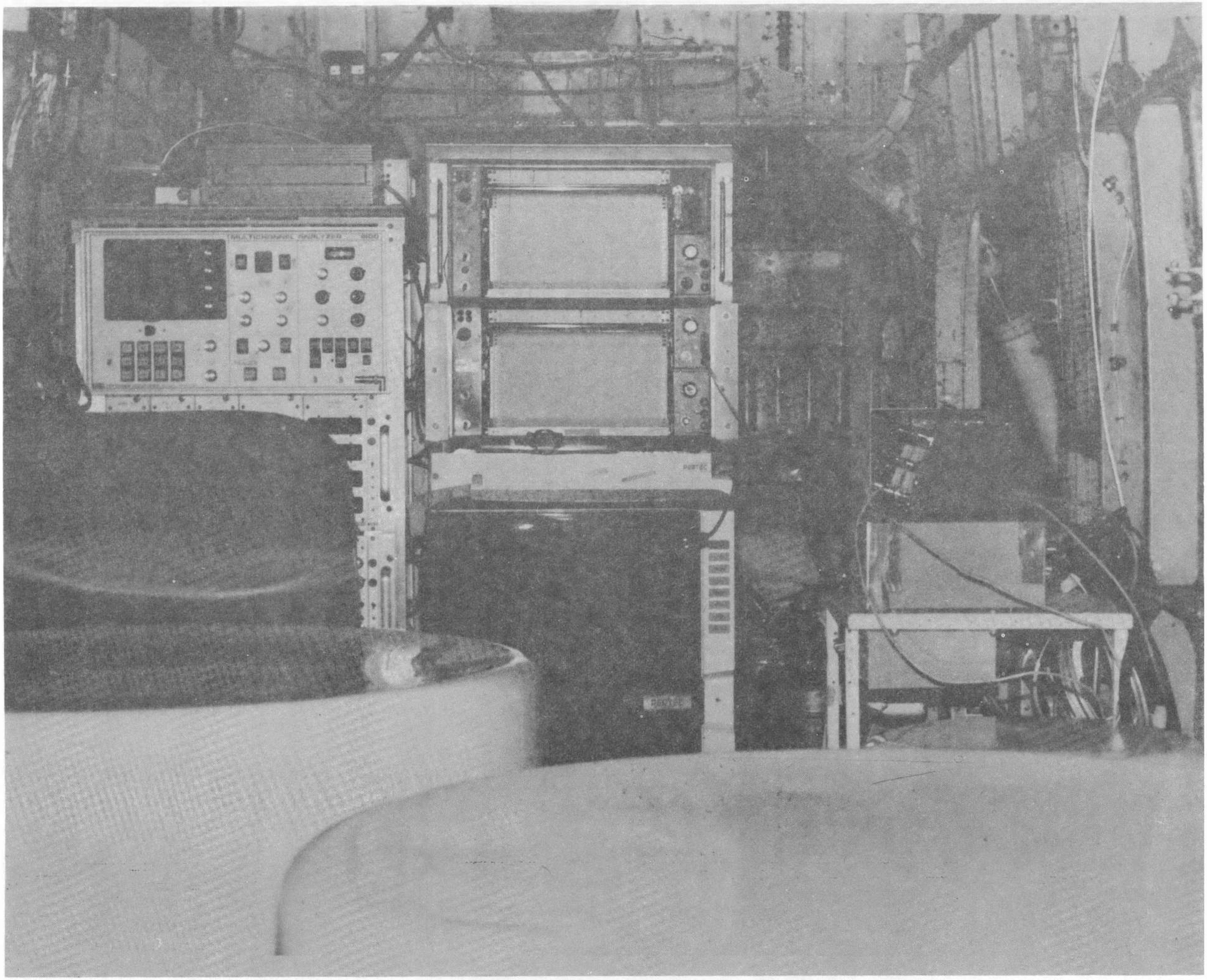


FIGURE-5 S-58 HELICOPTER (CABIN LAYOUT)

2.2.3 Barometric Altitude Transducer

The barometric pressure instrumentation consisted of an elastic pressure sensing element acting as a prime mover for positioning an electro-mechanical transducer. Altitude measurements were recorded to $\pm$ 1.0 foot.

2.2.4 Radar Altimeter

A Minneapolis Honeywell altimeter was used to measure helicopter to ground distance. The antennae were mounted on the underside of the tail boom as seen in Figure 4. Altitude measurements were recorded to 1.0 foot. The altitude range was 0-5,000 feet with an accuracy of $\pm$ 5 feet + 3% at actual altitude.

2.2.5 Temperature Sensor

A platinum resistance thermometer was utilized to record outside air temperature with an accuracy of 0.01^{o}C.

2.2.6 Data Acquisition System

Signals from the terrestrial and atmospheric detector packages are amplified, digitized and stored in the digital processor contained in the 1024 channel pulse height analyzer. Each detector package calibration is such that a 400 channel block contains gamma-ray intensity information for the energies 0-3 MeV and 3-6 MeV. The last 112 channels in each block are reserved for storing the stabilization pulses for the individual LED's. Two independent digital stabilizers are latched onto their appropriate LED pulse to achieve stability of the entire gamma-ray energy calibration. An oscilliscope display is available to monitor the accumulation of gamma-ray pulses during each 1 second acquisition period.

Data from the magnetometer, temperature probe, barometric altimeter, radar altimeter, clock and the preset data is fed through an A/D converter into the 1024 channel digital processor.

2.2.7 Recording System

From the digital processor, all collected data was fed through a magnetic tape control to the tape unit.

The tape unit can accommodate 2,400 foot rolls of tape. Data was recorded on 7 track NRZ format with 556 BPI density. After each readout cycle, the system was automatically reset and started a new data acquisition cycle.

A permanent record of the following information was obtained for each acquisition cycle:

1. Acquisition Identification
   Four sets of six digit presettable data for
   a. Julian Day
   b. Line Number
   c. Reference Number (Job No.)
   d. Azimuth
2. Sample Number - acquisition identification
3. Time of Day (correlates with camera fiducials)
4. Temperature
5. Barometric Altitude
6. Radar Altimeter
7. Scan Time (elapsed real time for each data acquisition)
8. Magnetometer Reading
9. Live Time Counting for each sensor package
10. Full Gamma-ray Spectrum for each sensor package

SECTION 3.0

FIELD OPERATIONS

3.1 GENERAL

Flight testing was performed over the Chesapeake Bay area in November 1976. The initial test flight of the complete system was performed on November 3, 1976. An additional test flight was performed on April 14, 1977.

The survey data was collected during the period from November 8, 1976 through April 15, 1977.

3.2 SURVEY SPECIFICATIONS AND MILEAGE

For the Newark and Scranton quadrangles, the primary traverse lines were flown east-west at 3.125 mile (5 kilometers) intervals, and tie lines north-south at 12.5 mile (20 kilometers) intervals. For the Harrisburg and Williamsport quadrangles the primary traverse lines were flown north-south at 3.125 mile (5 kilometers) intervals, and tie lines east-west at 12.5 mile (20 kilometers) intervals. The accompanying map, Figure 2, indicates the approximate location of each traverse and tie line within the individual 1:250,000 scale National Topographic Map Series.

Nominal terrain clearance was held as close to 400 feet as flight safety and helicopter performance dictated. Eleven thousand, four hundred seventy one (11,471) linear miles of survey data were collected and processed.

3.3 PERSONNEL

The field personnel consisted of a field manager, two electronic technicians, pilot, navigator, two mechanics and a data analyst. The data analyst was responsible for timely inspection of the data, processing the 35mm flight path film, on-site path recovery, and dispatching tapes to our computer center and other data to our Pennsylvania office.

3.4 PERIOD OF PERFORMANCE

Flight operations were conducted from November 8, 1976 to April 15, 1977. Production was suspended on January 8, 1977 due to an excessive amount of snow on the ground. Production was resumed on February 9, 1977 and continued until April 15, 1977.

3.5 PROCEDURE

Prior to each day's flying, external 28 volt DC power was applied and the entire system was checked. This required approximately one hour to complete.

A test line was flown both prior to and immediately after each day's production. The purpose of this test, flown at survey altitude and speed, was to demonstrate day-to-day repeatability of the entire system relative to ground moisture conditions and atmospheric radon corrections, and to detect equipment malfunctions.

3.6 SPECIAL FLIGHTS

3.6.1 Background Calibration Flights

The contribution of non-terrestrial radiation sources to the airborne measurements was established by high altitude flights flown over the Chesapeake Bay area. The data collected was analyzed to determine the contributions of high energy cosmic radiation and onboard aircraft background to the individual energy band count rates.

SECTION 4.0

DATA REDUCTION

4.1 GENERAL

Figure 6 is a flow chart indicating all data reduction operations. A brief discussion of each of the significant operations follows.

4.2 FLIGHT PATH RECOVERY

The actual location of the survey data was accomplished by locating the fiducials from the 35mm flight path film on 1:24,000 scale USGS topographic maps. The X and Y coordinates of the fiducials were digitized and merged with the survey data digital records.

4.3 GAMMA-RAY PROCESSING

4.3.1 Digital Edit

The field data is summed and any shift in the spectrum is determined by calculating the channel locations for the thorium and potassium photopeaks and adjusting the spectrum accordingly.

The summed counts are normalized to counts per second.

The ancillary data (radar, barometric, etc.) are all converted to appropriate units and then tested for validity. All samples exceeding the various test thresholds are flagged.

4.3.2 Aircraft Background Corrections

The background radiation from sources aboard the aircraft are assumed constant for each spectral window and are subtracted from the observed spectral sums.

4.3.3 Cosmic Correction

The cosmic radiation is summed and its contribution to the specific energy band is determined by the appropriate cosmic ratio.

4.3.4 Atmospheric Bi^{214} Correction

The atmospheric data is averaged so as to increase its precision relative to the terrestrial detector. The data is then corrected for background and high energy interference, and is compensated for the effects of geometry and shielding. The Bi^{214} correction is then determined assuming uniform distribution of Bi^{214} in the atmosphere within the immediate measurement range.

DATA PROCESSING FLOW CHART

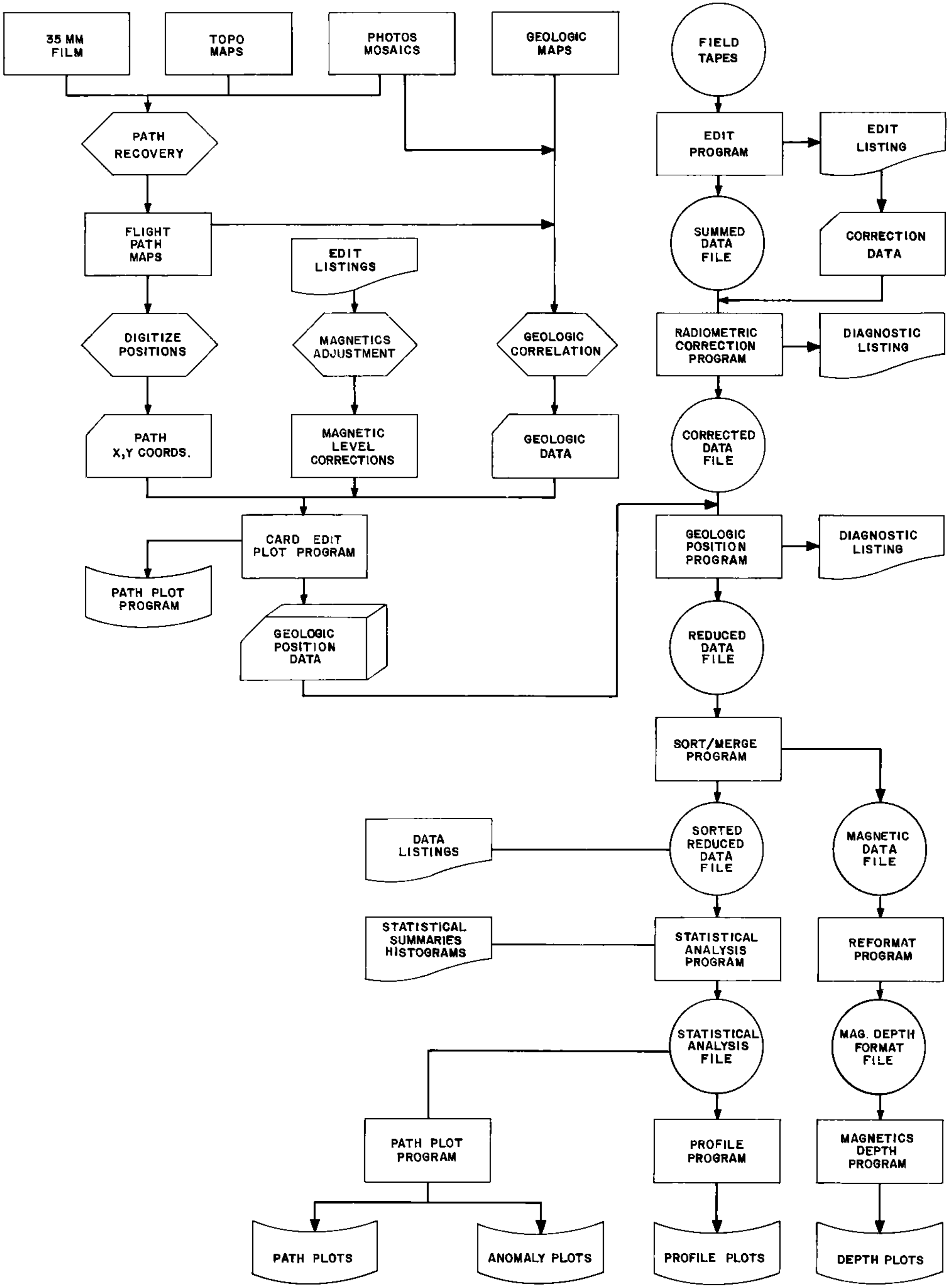


FIGURE-6

4.3.5 Compton Scattering Correction

The scattering of the higher energy levels into the lower energy spectral windows is corrected by using the spectral stripping method. The spectral stripping factors were determined by calibration on the Walker Field Test Pads. The increase of the stripping ratios with altitude was determined by multi-altitude flights over a pre-selected course in the Chesapeake Bay area.

4.3.6 Altitude Normalization

The fully corrected spectral data is normalized to a constant reference altitude of 400 feet. The primary energy spectra, K, U and Th are reduced using the appropriate mass attenuation coefficients modified for the variation of air density.

4.3.7 Statistical Analysis

The reduced data corresponding to a given geologic unit is tested for precision. Records exceeding the specified precision index are flagged.

The ratios U/K, U/Th, and Th/K are computed for all records. The records which have been determined statistically adequate are further evaluated to determine the interval over which they were to be averaged. Averaged records are computed for all elements and ratios.

Statistical parameters describing the distribution of each element and ratio were computed for each lithologic unit. The standard deviation of each averaged record was determined and frequency distribution histograms and statistical summaries were generated for all lithologic units.

4.3.7.1 Anomaly Detection

The mean and its standard deviation were computed for each element and ratio of each lithologic unit. Only those averaged samples determined to be statistically adequate were used.

The standard normal deviate (Z) was computed for each averaged sample.

$$Z = (X - M)\ \text{Sigma}_m$$

where the mean (M) and the averaged sample (X) correspond to the same lithologic unit.

Standard normal deviations greater than $\pm$ 1 are considered potentially anomalous and are plotted on the anomaly maps.

4.4 MAGNETIC DATA PROCESSING

4.4.1 Magnetic Datum Correlation

The magnetic datum was adjusted utilizing the control lines and traverse lines. An analysis of the residual differences was made and these corrections were applied to the data.

4.4.2 Geomagnetic Field

The regional magnetic gradient was computed from the IGRF 1965 tables (ESSA Technical Report C & GS 38, E. B. Fabiano and N. W. Priddie) updated to 1976/1977 and removed from the observed magnetic data. A datum of 54,000 gammas was added after removal of the IGRF to approximate the original observed total field values.

SECTION 5.0

GAMMA-RAY AND MAGNETIC DATA PRESENTATION

5.1 GRAPHIC DATA PRESENTATION

All graphic data is organized according to individual NTMS 1:250,000 sheets. In the presentation of the survey results, we have used the quadrangle name and number.

5.2 RADIOMETRIC MULTIPLE-PARAMETER STACKED PROFILES

Profiles have been produced at 1:250,000 and 1:500,000 scales. The 1:500,000 scale profiles are presented in Volume II and contain the following information:

Flight Line Number
Appropriate Title Information
Fiducial Numbers
Residual Magnetic Profile
Radar Altimeter
Gamma-Ray Count per second - Total Count
Bismuth Correction
Gamma-Ray Counts per second - Bismuth 214
Gamma-Ray Counts per second - Thallium 208
Gamma-Ray Counts per second - Potassium 40
Ratio of Bismuth 214 to Potassium 40
Ratio of Bismuth 214 to Thallium 208
Ratio of Thallium 208 to Potassium 40
Geologic Strip Map with Flight Path

Flags appearing under the K, Tl, and Bi traces indicate that the computed average record value for the corresponding element has failed the calculated statistical significance test. The statistical test is based upon the criteria as specified by Currie (1968) and is defined as the critical level:

$$L_C = 2.33 \text{ X } (\text{background})^{\frac{1}{2}}$$

The probability of the reduced count exceeding the critical level and yet being actually non-significant is .05 or 5%.

5.3 MAGNETIC MULTIPLE PARAMETER STACKED PROFILES

Profiles have been produced at 1:250,000 and 1:500,000 scales. The 1:500,000 scale profiles are presented in Volume II and contain the following information:

Flight Line Number
Appropriate Title Information
Fiducial Numbers
Barometric Altitude
Temperature
Radar Altimeter
Diurnal Profile
Residual Magnetic Profile
Geologic Map Strip with Flight Path

The radar altimeter profile is the common trace related to all other measured quantities. It was therefore selected as the most appropriate trace to identify records which are considered suspect due to data quality considerations, i.e. recorder malfunctions. The flag appearing at the bottom of the altimeter trace identifies either excessive altitude deviations or records of suspect data quality.

5.4 ANOMALY MAPS

Anomaly maps have been produced at 1:250,000 and 1:500,000 scales. The 1:500,000 scale maps are contained in Volume II. The anomaly maps generated are Uranium, Uranium/Thorium, Uranium/Potassium, Thorium, Potassium and Thorium/Potassium. The mean and its standard deviation were computed for each element and ratio of each lithologic unit. Only those averaged samples determined to be statistically adequate were used. Standard normal deviations greater than $\pm$ 1 were considered potentially anomalous and were plotted.

5.5 HISTOGRAMS

The histograms for the count rate distribution of Uranium, Uranium/Thorium, Uranium/Potassium, Thorium, Potassium and Thorium/Potassium for each lithologic unit were computed for each quadrangle and are included in Volume II.

5.6 DATA LISTINGS

The data listings from the reduced data tapes covering each NTMS 1:250,000 sheet are produced on Microfiche and included in this report.

5.6.1 Single Record Reduced Data Listings

The following elements are listed for each record.

HEADING	DESCRIPTION
REC	Record Identification Number
AF	Altitude Flag (specifications exceeded)
KF	Potassium Flag (failed significance test)
UF	Uranium Flag (failed significance test)
TF	Thorium Flag (failed significance test)

HEADING	DESCRIPTION
UNIT	Rock Unit
LAT	Latitude in Degrees
LONG	Longitude in Degrees
TEMP	Temperature in Degrees Centigrade
BARM	Barometric Pressure Height in Feet
RADR	Radar Terrain Clearance
MAG	Total Magnetic Field in Gammas
GROSS	Total Count (.4 to 3.0 MeV)
K	Potassium Counts/Second
U	Uranium Counts/Second
T	Thorium Counts/Second
U/K	Ratio Uranium/Potassium
U/T	Ratio Uranium/Thorium
T/K	Ratio Thorium/Potassium
COS	Cosmic Count (3 to 6 MeV)
Bi	Atmospheric Bismuth Correction CPS

5.6.2 Averaged Record Data Listings

The following elements are listed for each averaged record.

HEADING	DESCRIPTION
REC	Record Identification Number
AF	Altitude Flag (specifications exceeded)
KF	Potassium Flag (failed significance test)
UF	Uranium Flag (failed significance test)
TF	Thorium Flag (failed significance test)
UNIT	Rock Unit
LAT	Latitude in Degrees
LONG	Longitude in Degrees
RADR	Radar Terrain Clearance
MAG	Total Magnetic Field in Gammas
TC	Total Count (.4 to 3.0 MeV)
K	Potassium Counts/Second
U	Uranium Counts/Second
T	Thorium Counts/Second
U/K	Ratio Uranium/Potassium
U/T	Ratio Uranium/Thorium
T/K	Ratio Thorium/Potassium
COS	Cosmic Counts/Second (3.0 to 6.0 MeV)
Bi	Atmospheric Bismuth Correction CPS
K	Potassium Standard Deviation units from the mean
U	Uranium Standard Deviation units from the mean
T	Thorium Standard Deviation units from the mean
U/K	Ratio Standard Deviation units from the mean
U/T	Ratio Standard Deviation units from the mean
T/K	Ratio Standard Deviation units from the mean

SECTION 6.0

GEOLOGY AND URANIUM DEPOSITS OF THE THORPE AREA

6.1 GEOLOGY

6.1.1 General Geology of the Thorpe Area

The geology of eastern Pennsylvania, northern New Jersey and southeastern New York State contains an unusually complete record of the geologic column from the Precambrian to the present. The rocks occur in a variety of structural forms and display many geologic processes. Therefore, it is not by accident that the eastern part of the United States, including both the Appalachians and the coastal plain, has been studied in great detail for over 100 years.

The southeastern portion of the Thorpe area, from the coastal plain northwestward, is underlain by a thick sequence of Tertiary and Mesozoic sediments. The coastal plain lies essentially in the southeast portion of the Newark Quadrangle east of the Delaware River. It is partially flanked to the northwest by a Triassic basin, structurally a graben, containing a thick sequence of continental sandstones and shales with diabasic intrusives. This basin extends diagonally in a northeastward direction through the southeast part of the Harrisburg sheet and the center of the Newark sheet. The northeast end of the basin is referred to as the Newark Basin and the southwestern portion the Gettysburg Basin.

In the southern part of the Newark Quadrangle and extending westward into the southeastern part of the Harrisburg Quadrangle, a wedge of early Paleozoic to Precambrian rocks, for the most part metamorphosed, is located between the Triassic basin and the coastal plain sediments. Collectively referred to as the Taconian allochthon, this wedge of rocks contains the Glenarm series, for which there continues to be controversy concerning both its age and position in the section. The older members of this crystalline province underlie the New Jersey coastal plain, with the exception of a small zone of serpentine which outcrops in New York on Staten Island.

Another Precambrian crystalline complex outcrops along the entire northwest boundary of the Newark basin, extending across both the Newark quadrangle and the Scranton quadrangle to the north. These rocks are collectively referred to in Pennsylvania as the Reading Prong, while east of the Delaware River they are known as the New Jersey Highlands. In New York State to the northeast, they comprise the Hudson Highlands.

Northwest of the Precambrian belt, the folded and commonly thrust-faulted lower Paleozoic rocks first plunge rapidly northwestward toward the early Paleozoic axis of the folded Appalachian geosyncline. They form large, northeast-trending anticlines and synclines in the northwest part of the Newark sheet, in virtually all of the Harrisburg sheet, and along the southern edge of the Williamsport sheet. Further to the north beyond this folded belt, the area is underlain by younger Paleozoic rocks which are essentially flat-lying, or only gently folded at best, forming the Allegheny plateau. The Paleozoic units generally become progressively younger toward the north and west across the plateau with Devonian rocks accounting for most of the bedrock geology within the Scranton quadrangle, and Mississippian and Pennsylvania rocks occurring beyond the Allegheny front on the Williamsport sheet. These younger Paleozoic rocks form extensive outcrops in the deeply incised valleys of this region.

6.1.2 Geology of the Newark Quadrangle

The Newark NK 18-11 Quadrangle encompasses portions of all of the major physiographic provinces present in the Thorpe area, with the exception of the Allegheny Plateau.

A line extending southeast to northwest across the quadrangle, accordingly, first traverses the gently-dipping sediments of the New Jersey coastal plain from the Atlantic coast to the Delaware River. The next unit encountered is the lower Paleozoic/Precambrian crystalline province of the Taconian allochthon, followed by the Triassic sedimentary and igneous complex of the Newark/Gettysburg Basin, the Precambrian crystallines of the New Jersey and Pennsylvania highlands, and finally the folded lower to middle Paleozoic rocks of the Appalachians.

The coastal plain province, confined to the southeastern portion of the quadrangle, is underlain by both consolidated and unconsolidated sediments ranging from Cretaceous to late Tertiary in age. The unconsolidated materials of the Pliocene and younger formations are essentially sands and gravels in terrace and beach deposits, as well as Pleistocene sands and gravels of glacial origin. The older semi-consolidated to consolidated rocks consist of marls and glauconitic sandstones and clays. The well-sorted sands and gravels of the coastal plain are, of course, valuable materials for the building industry, and many extensive quarries are located in this area. The pit excavations themselves, together with the associated overburden dumps, can extend over a mile or more of surface area, thus comprising significant localities of fresh exposure.

The next major province, to the northwest, is the Triassic Lowlands of the Newark and Gettysburg Basins. The rocks in this region consist chiefly of a series of poorly sorted, interbedded continental sandstones and shales which are typically divided into three units. The lowermost member, depending on the location, is known as the Gettysburg Formation, the Stockton Formation or the New Oxford Formation. The middle member usually is referred to as the Lockatong Formation, while the uppermost member is the Brunswick Formation. In some parts of the Triassic belt these three units are reasonably distinct, while in other areas structural complexities are present which make their definition difficult. Each of the principal units usually exhibits a basal conglomerate, and coarse deltaic deposits occur along the margins of the basin.

The igneous rocks of the Triassic include the numerous basalt flows, dikes and sills found in the central part of the Newark sheet. Characteristically, these units have produced hornfels and argillites in the surrounding sedimentary areas. These igneous rocks as well as the sediments surrounding the intrusions are prized as building materials, particularly within a few miles' radius of their occurrence, and are extensively quarried.

The early Paleozoic and Precambrian rocks of the Taconian allochthon, lying immediately southeast of the Triassic Lowlands, comprise three principal sub-divisions:

a) Paleozoic and younger rocks of known ages: This category includes basal Cambrian sediments and Cambro-Ordovician carbonates. The older members of this group of rocks are weakly metamorphosed, containing some greenschist facies.

b) Intermediate to high grade metamorphic pelitic volcanic and volcano-clastic rocks with some calcareous zones, metamorphosed from greenschist to granulite facies of unknown age, but possibly of Late Precambrian to Ordovician: These rocks overlie the Grenville Basement and include some rocks, notably the Glenarm Series, which may correlate in age with those of (a) above although this series is more intensely metamorphosed. The ultramafic to granodioritic bodies which occur in these rocks are also strongly metamorphosed.

c) Grenville Basement of amphibolite and granulite facies exhibiting the most extensive metamorphism: These rocks are also cut by diabase dikes of perhaps the same composition as the intrusives noted in (b) above.

Flanking the Triassic Lowlands to the northwest is the broad Precambrian metamorphic complex comprising the New Jersey and Pennsylvania highlands. Erosional remnants of lower Paleozoic sediments, predominantly limestones, shales and conglomerates, occupy the topographic depressions in this region, although the bulk of the exposures are Precambrian granitoid gneissic rocks characterized by extreme structural complexity. Subsequent intrusions of these rocks were accompanied by the emplacement of extensive pegmatite lenses and dikes, many of which contain uraninite and thorite mineralization.

Beyond the Precambrian highlands, in the northwest corner of the quadrangle, lower Paleozoic rocks of the Valley and Ridge province prevail, marking the eastern margin of the folded Appalachian Mountains. The rocks in this region are consolidated sediments ranging from Cambrian to Pennsylvanian in age, the youngest members of which contain extensive coal measures. In Carbon County, a number of occurrences of uranium mineralization are present in rocks ranging in age from Upper Devonian through Upper Mississippian.

6.2 GEOLOGIC MAP AND LEGEND COMPILATION

The following references were used for the geologic compilation of the Thorpe area:

a) Geologic Map of New Jersey; Lewis & Kummel, 1910-1912, 1:250,000

b) Geologic Map of Pennsylvania; Department of Environmental Resources; 1960, 1:250,000

c) Geologic Map of New York; Lower Hudson, Hudson-Mohawk, Finger Lakes, Niagara, and Generalized Tectonic-Metamorphic sheets; Fisher, Isacksen, Rickard, 1970-1971, 1:250,000 (4 geologic maps and legends)

For the most part, the geologic unit symbols on the New York and New Jersey state maps were changed to accommodate equivalently mapped units on the Geologic Map of Pennsylvania. Accordingly, the information supplied by the Pennsylvania map has remained essentially unchanged except for those areas supplemented by the New York state border-overlaps, where the streambed geology of the Devonian has been mapped in greater detail.

There are several areas along the state borders between Pennsylvania, New Jersey and New York where the geologic tie-ins that have been inferred on the final compiled maps do not perpetuate a single unit symbol or formation name. For example, the Catskill Formation (Dck) of northeastern Pennsylvania divides into three more specific units at the New York border - the Honesdale Formation (Dwh), the upper Walton Formation (Dww) and the Oneonta Formation (Dgo). This implies that in this region, the more generalized unit Dck ranges over several definite formational boundaries which are not accounted for by the Pennsylvania mapping. It should be noted then, that the occurrence of apparently abrupt changes in lithologic units across state lines are generally the result of retaining the more specific interpretations contained on the more detailed state geologic map. This situation is almost exclusively limited to the large number of Devonian and Ordovician units that are mapped in the Thorpe area.

An additional objective of the geologic compilation was to retain the continuity of smaller, single-unit outcroppings along the Pennsylvania-New Jersey border by completing the Pennsylvania unit across the state line. This frequently resulted in slightly more specific unit descriptions replacing generalized units in the border region, i.e., the oligoclase mica schist of the Wissahickon Formation (Xw) in Pennsylvania replaces the term Wissahickon Mica Gneiss applied to the equivalent unit mapped in New Jersey. In some instances, however, a more generalized term may have been employed. For example, the Onondaga Formation (Don), which includes the Esopus grit and shale in Pennsylvania and New York, has been extended to include both the Onondaga and the Esopus in New Jersey, where they are mapped separately over small outcrop areas.

Because each of the New York geologic sheets contains a unique geologic legend, compilation of the master legend for the Thorpe area required that six separate legends be edited and merged, making the task of preserving a strict time-stratigraphic listing of the individual lithologic units and facies involved difficult.

The framework of the final compiled legend was adapted from the Geologic Map of Pennsylvania legend, edited to exclude those units occurring beyond the Thorpe area and its margins. Into this framework additional units from the edited New York and New Jersey geologic legends were incorporated. Small age differences were encountered between similar sedimentary facies from state to state. For the most part, these differences were made to conform with the age reported for the Pennsylvania units. These modifications have been accounted for in Section 6.3 of this text, "Description of Map Units."

Parallel listings in the Upper Devonian are presented to show a general west to east spatial distribution of the New York units. The purpose of bracketed listings, however, is to graphically identify units of general equivalence to one another, i.e., the Susquehanna Group (Ds) is generally equivalent to the Oswego Formation (Doo), the Catskill Formation (Dck), the Honesdale Formation (Dwh), the upper Walton Formation (Dww), and the Chemung and Portage Marine beds (Dm). The major difficulty in compiling this legend was, for the most part, in recognizing the association between identical sedimentary facies on each of the source maps. There are numerous sandstone, limestone, shale, etc., facies which have acquired several names from state to state which could understandably be the same unit. Particular attention should be given to the Devonian and to a larger extent, the Ordovician sedimentary units in relation to this problem.

Finally, the unit Ob has presented itself as somewhat of an enigma in the task of stratigraphically cataloging the Ordovician units of the Thorpe area. "Ob" is a limestone-dolomite unit, late Cambrian to Ordovician in age, which was a laterally-migrating facies of the Appalachian geosyncline. It is composed of essentially three members; the Kittatinny limestone in New Jersey, the Wappinger Group in New York, and the Beekmantown Group in Pennsylvania. Long periods of stability during the Cambrian account for the absence of limestone beds of that age far out in the geosyncline. The Cambro-Ordovician sea eventually did spread far eastward during its maximum transgressive phase, however, thus accounting for two facets of the Ob unit, the Cambro-Ordovician Kittatinny limestone of New Jersey, and east of this, the lower Ordovician Wappinger Group of New York. Each of these is the product of a migrating depositional environment as a result of marine transgression. Toward the close of the Ordovician, the Taconic disturbance affected the eastern border of the geosyncline, causing the limestone depositional facies associated with the trough to spread westward, producing the Beekmantown Group of Pennsylvania. This is the final facet of the Ob unit. These three members of the Ob unit are listed separately in the text, although they appear as one in the master legend.

6.3 DESCRIPTION OF MAP UNITS

STRATIFIED SEDIMENTARY ROCKS - IN PART METAMORPHOSED

Qs SANDS OF PRESQUE ISLE (RECENT)

Q GLACIAL AND ALLUVIAL DEPOSITS (PLEISTOCENE)
Underlying bedrock geology unknown
(Mapped in New York and New Jersey)

Qcm CAPE MAY FORMATION (PLEISTOCENE)
Sands and gravels with clay and silt at the base locally; includes areas of Recent alluvium and swamp deposits (Wisconsin Stage)

Qp PENSAUKEN FORMATION (PLEISTOCENE)
Deeply weathered gravels and sandy gravels. (Illinois Stage)

Tbh BEACON HILL GRAVEL (PLIOCENE)
Quartz gravel with some chert and sandstone pebbles.

Tbm BYRN MAWR FORMATION (PLIOCENE)
High level terrace deposits; sand and gravel with some silt.

Tch COHANSEY SAND (MIOCENE OR PLIOCENE)
Chiefly quartz sand with local beds of clay and gravel.

Tkw KIRKWOOD SAND (MIOCENE)
Fine micaceous sands with local beds of dark clay.

Tsr SHARK RIVER MARL (EOCENE)
Mixture of greensand (glauconite) and light colored earth, chiefly north of Asbury Park.

Tmq MANASQUAN MARL (EOCENE)
Dark green glauconitic marl overlain by an ash-like mixture of fine quartz sand and grayish white clay.

Tvt VINCENTOWN SAND (EOCENE)
Glauconitic quartz sand alternating with beds of lime sand (coral fragments, etc.), the latter mostly consolidated.

Tht HORNERSTOWN MARL (EOCENE)
Dark green glauconitic marl with varying amounts of quartz, fine earth, and clay. Marked shell bed at the top. South of Sykesville rests on Navesink marl below.

Km COASTAL PLAIN DEPOSITS (CRETACEOUS)
Monmouth Group, Matawan Group, and Magothy Formation-silty clay, glauconitic sandy clay, sand, gravel (Mapped in New York)

Krb RED BANK AND TINTON SANDS (CRETACEOUS)
Coarse rusty sand, consolidated in places by iron oxide. In Monmouth County overlain by a bed of hard green clayey and sandy loam (Tinton). The Red Bank is not found south of Sykesville, Burlington County.

Kns NAVESINK MARL (CRETACEOUS)
Dark green glauconitic marl with shell bed at the base. South of Sykesville underlies the Hornerstown marl above.

Kmw MOUNT LAUREL AND WENONAH SANDS (CRETACEOUS)
Coarse glauconitic sand (Mount Laurel) overlying fine micaceous sand (Wenonah).

Kmt MARSHALLTOWN FORMATION (CRETACEOUS)
Black sandy clay to clayey glauconitic marl.

Ket ENGLISHTOWN SAND (CRETACEOUS)
White and yellow sand with little mica and glauconite and local thin layers of clay.

Kwb WOODBURY CLAY (CRETACEOUS)
Black to dove-colored clay, usually nonglauconitic.

Kmv MERCHANTVILLE CLAY (CRETACEOUS)
Black sandy clay, usually glauconitic.

Kmr MAGOTHY AND RARITAN FORMATIONS (CRETACEOUS)
Dark lignitic sand and clay, containing some glauconite near the top (Magothy), overlying with slight unconformity variable sands and clays, chiefly light colored (Raritan).

Kr COASTAL PLAIN DEPOSITS (CRETACEOUS)
Raritan Formation - clay, silty clay, sand, gravel. (Mapped in New York)

Kp PATAPSCO? FORMATION (CRETACEOUS)
Highly colored clay with some sand.

Trg-Trb BRUNSWICK FORMATION (TRIASSIC)
Soft red shale with sandstone beds.
In Pennsylvania: Brunswick, and Gettysburg (Trg) to the west, are red to brown, fine to coarse grained quartzose sandstones with red shale interbeds.

Includes Trhc, Trbg, Trba, Trbss, Trlc, Trqc and Trh.

Trhc HAMMER CREEK FORMATION (TRIASSIC)
Conglomerate Member of the Brunswick Formation (Trg-Trb)

Trbg SANDSTONE AND CONGLOMERATE (TRIASSIC)
Member of the Brunswick Formation (Trg-Trb)

Trba MUDSTONE, SANDSTONE AND ARKOSE (TRIASSIC)
Member of the Brunswick Formation (Trg-Trb)

Trbss SANDSTONE, SILTSTONE AND MUDSTONE (TRIASSIC)
Member of the Brunswick Formation (Trg-Trb)

Trlc SHALE AND LIMESTONE CONGLOMERATE (TRIASSIC)
of the Brunswick or Gettysburg Formations.

Trqc QUARTZ PEBBLE CONGLOMERATE (TRIASSIC)
Member of the Brunswick or Gettysburg Formations (Trg-Trb)

Trh HEIDLERSBURG MEMBER BRUNSWICK FORMATION (TRIASSIC)
Gray arkosic sandstone with interbedded red shale quartz pebble conglomerate and limestone conglomerate.

Trc CONGLOMERATE BEDS OF THE BRUNSWICK, LOCKATONG, AND STOCKTON FORMATIONS OF NEW JERSEY (TRIASSIC)
Contains quartzite or limestone pebbles in red matrix along its northwestern border.

Trl LOCKATONG FORMATION (TRIASSIC)

In Pennsylvania; dark gray to black, thick bedded argillite with occasional zones of thin bedded black shale; locally has thin layers of impure limestone or calcareous shale.

In New Jersey; hard dark argillite with local thin beds of sandstone.

Trs-Trn STOCKTON FORMATION (TRIASSIC)

In Pennsylvania; Stockton and New Oxford (Trn) are light gray to buff, coarse grained arkosic sandstone and conglomerate; red and brown fine grained, siliceous sandstone, and red shale.

In New Jersey; gray feldspathic sandstone (arkose), conglomerate, and red shale.

In New York; arkose, conglomerate and mudstone.

Pa ALLEGHENY GROUP (PENNSYLVANIAN)

Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals; limestones thicken westward;

Vanport Limestone in lower part of section; includes Freeport, Kittanning, and Clarion Formations.

Ppp POST-POTTSVILLE FORMATIONS (PENNSYLVANIAN)

Brown or gray sandstones and shales with some conglomerate and numerous mineable coals.

Pp POTTSVILLE GROUP (PENNSYLVANIAN)

Light gray to white, coarse grained sandstones and conglomerates with some mineable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

In New York; Connoquenessing Formation - sandstone, shale; Sharon Formation - shale, sandstone, conglomerate; Olean Conglomerate 50-100 feet (15-30 m.)

Mmc MAUCH CHUNK FORMATION (MISSISSIPPIAN)

Red shales with brown to greenish gray flaggy sandstones; includes Greenbrier Limestone in Fayette, Westmoreland, and Somerset counties; Loyathanna Limestone at the base in southwestern Pennsylvania.

Mp POCONO GROUP (MISSISSIPPIAN)

Predominantly gray, hard, massive, cross-bedded conglomerate and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Cusseqago, Corry, and Knapp Formations: includes part of "Oswego" of M. L. Fuller in Potter and Tioga counties.

In New York; Cuyahoga Formation - shale, sandstone; Corry Sandstone; Knapp Formation 60-100 feet (20-30 m.) - shale, conglomerate.

Ds SUSQUEHANNA GROUP (UPPER DEVONIAN)

Includes Dck, Dm and Doo units as well as the Nunda Formation-- sandstone, shale, West Hill Formation- shale, siltstone, and Corning shale in the west of New York grading into the "New Milford" Formation- sandstone, shale, in the east of New York.

Doo OSWAYO FORMATION (UPPER DEVONIAN)

Brownish and greenish gray, fine and medium grained sandstones with some shales and scattered calcareous lenses; includes red shales which become more numerous eastward. Relation to type Oswayo not proved.

Dck CATSKILL FORMATION (UPPER DEVONIAN)

Chiefly red to brownish shales and sandstones; includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, Delaware River and Upper Walton.

In New York, includes parts of Oswayo and Venango Formations - shale, siltstone, sandstone; replaced eastwardly by Catteraugus Formation - shale, sandstone, conglomerate.

Includes Dwh and Dww

Dwh HONESDALE FORMATION (UPPER DEVONIAN)

Sandstone, shale.

Dww UPPER WALTON FORMATION (UPPER DEVONIAN)

Shale, sandstone, conglomerate.

Dm MARINE BEDS (UPPER DEVONIAN)

Gray to olive brown shales, graywackes, and sandstones; contains "Chemung" beds, and "Portage" beds including Burket, Brallier, Harrell, and Trimmers Rock; Tully Limestone at base.

In New York; Germania Formation- shale, sandstone; Whitesville Formation- shale, sandstone; Hinsdale Sandstone; Wellsville Formation-- shale, sandstone; Cuba Sandstone. Locally grades into Dck units in Pennsylvania.

Dcy MACHIAS FORMATION (UPPER DEVONIAN)

Shale, siltstone; Rushford Sandstone; Caneadea, Canisteo, and Hume Shales; Canaseraga Sandstone; South Wales and Dunkirk Shales;

In Pennsylvania; Towanda Formation- shale, sandstone. Generally equivalent of Dm and Dck units in Pennsylvania.

Dj WISCOY FORMATION (UPPER DEVONIAN)

Sandstone, shale; Hanover and Pipe Creek Shales.

Dwn NUNDA FORMATION (UPPER DEVONIAN)

Sandstone, shale.

Dwg WEST HILL AND GARDEAU FORMATIONS (UPPER DEVONIAN)
Shale, siltstone; Roricks Glen Shale; upper Beers Hill Shale; Grimes Siltstone.

Dwm BEERS HILL SHALE: GRIMES SILTSTONE: DUNN HILL, MILLPORT AND MORELAND SHALES (UPPER DEVONIAN)

Dwr LOWER BEERS HILL SHALE: DUNN HILL, MILLPORT, AND MORELAND SHALES (UPPER DEVONIAN)

Dwrg GARDEAU FORMATION (UPPER DEVONIAN)
Shale, siltstone; Roricks Glen Shale.

Dws SLIDE MOUNTAIN FORMATION (UPPER DEVONIAN)
Sandstone, shale, conglomerate.

Dsc In west: Cashaqua and Middlesex Shales (UPPER DEVONIAN) In east: Rye Point Shale; Rock Stream ("Enfield") and Kattel sandstone and siltstone; Pulteney, Sawmill Creek, Johns Creek, and Montour Shales.

Dsw LOWER WALTON FORMATION (UPPER DEVONIAN)
Shale, sandstone, conglomerate.

Dg WEST RIVER SHALE: (UPPER DEVONIAN)
Genundewa Limestone; Penn Yan and Geneseo Shales; all except Geneseo replaced eastwardly by Ithaca Formation-shale, siltstone and Sherburne Siltstone.

Dgo ONEONTA FORMATION (UPPER DEVONIAN)
Shale, sandstone, conglomerate. Grades into Dck and Dm units in Pa.

Dgu UNADILLA, LAURENS, NEW LISBON, AND GILBOA FORMATIONS (UPPER DEVONIAN)
Shale, siltstone, sandstone.

Dt TULLY LIMESTONE (UPPER DEVONIAN)

Dhmo MOSCOW FORMATION (MIDDLE DEVONIAN)
In west; Cooperstown and Portland Point shale and sandstone Members; in east: "Manorkill" and Portland Point shale and sandstone Members.

Dhpl PLATTEKILL FORMATION (MIDDLE DEVONIAN)
Shale, sandstone; Ashokan Formation - shale, sandstone.

Dsk SKUNNEMUNK CONGLOMERATE (MIDDLE DEVONIAN)
Coarse white quartz pebbles in purple-red matrix with frequent beds of red sandstone. (North central area of New Jersey).

Dbp BELLVALE SANDSTONE AND PEQUANAC SHALE (MIDDLE DEVONIAN)
Gray sandstone and sandy shale (Bellvale) overlying dark slaty shale (Pequanac). (North central area of N.J.)

Dkn KANOUSE SANDSTONE (MIDDLE DEVONIAN)
Greenish sandstone above and light colored fine-grained conglomerate below (North central area of N. J.)

Dh HAMILTON GROUP (MIDDLE DEVONIAN)
Includes Dmh, Dhm and Marcellus Formation
The MARCELLUS FORMATION consists of black, fissile, carbonaceous shale with thick, brown sandstone (Turkey Ridge) in parts of central Pennsylvania.
In N. Y. generally equivalent to Dsk and Dbp of N. J.

Dmh MAHANTANGO FORMATION (MIDDLE DEVONIAN)
Brown to olive shale with interbedded sandstones which are dominant in places (Montebello); highly fossiliferous in upper part; contains "Centerfield coral bed" in eastern Pennsylvania.

Dhm UNDIFFERENTIATED LOWER HAMILTON GROUP - (MIDDLE DEVONIAN)
Panther Mountain, Mount Marion, Stony Hollow, and Union Springs shales and sandstones.

Don ONONDAGA FORMATION (LOWER TO MIDDLE DEVONIAN)
Greenish blue, thin bedded shale and dark blue to black, medium bedded limestone with shale predominant in most places; includes Selinsgrove Limestone and Needmore Shale in central Pennsylvania and Buttermilk Falls Limestone and Esopus Shale in easternmost Pennsylvania; in Lehigh Gap area includes Palmerton Sandstone and Bowmanstown Chert. Includes Esopus Grit of N. West N. J.; dark coarse sandstone with strong cleavage. At Delaware River, below Port Jervis; fissile black shale with overlying thin-bedded cherty limestone.

Dmo Includes MARCELLUS FORMATION of MIDDLE DEVONIAN and Don of LOWER DEVONIAN

Dho Includes MIDDLE and LOWER DEVONIAN units: Dh, Dmh, Dhm, Don, The Marcellus Formation and Dmo

Doh LOWER DEVONIAN UNITS
Do and Dhb

Do ORISKANY FORMATION (LOWER DEVONIAN)
White to brown, fine to coarse grained, partly calcareous, locally conglomeratic, fossiliferous sandstone (Ridgeley) at the top; dark gray, cherty limestone with some interbedded shales and sandstones below (Shriver).

Do Cont'd In New Jersey, Siliceous Oriskany limestone with sandstone coming in southward, separated from the gray cherty Becraft limestone below by a formation (presumably Port Ewen shale) which is everywhere concealed by heavy glacial drift (Northwestern area).

Dhb HELDERBERG FORMATION (LOWER DEVONIAN)
Dark gray, calcareous, thin bedded shale (Mandata) at the top, equivalent to Port Ewen Shale and Becraft Limestone in the east; dark gray, cherty, thin bedded fossiliferous limestone (New Scotland) with some local sandstones in the middle; and, at the base, dark gray, medium to thick bedded, crystalline limestone (Coeymans), sandy and shaly in places with some chert nodules.

In New Jersey, hard cherty limestone and limy shale (New Scotland) overlying light-gray limestone (Coeymans) and separated southward by a thin sandy bed (Stormville).

In New York, west of Albany: Alsen, Becraft, New Scotland, Kalkberg, Coeymans, and Manlius Limestones; Rondout Dolostone. South of Albany: Port Ewen, Alsen through Manlius Limestones; Rondout Dolostone.

DS PORT EWEN THRU MANLIUS LIMESTONES: (SILURIAN-UPPER DEVONIAN)
Rondout Dolostone; Binnewater Sandstone; High Falls Shale; Decker Limestone; Poxono Island Formation-shale, dolostone; Longwood Shale; Green Pond conglomerate.

Skw SILURIAN UNITS
Skt and Sw

Skt KEYSER FORMATION (SILURIAN)
Dark gray, highly fossiliferous, thick bedded, crystalline to nodular limestone; passes into Manlius, Rondout, and Decker Formations in the east.

In New Jersey, dark thin-bedded limestone (Manlius), earthy shale and limestone (Rondout), thin beds of limestone and shale, becoming sandy southward (Decker), banded bluish-gray limestone (Bossardville), and buff or greenish limy shale (Poxono Island).

TONOLOWAY FORMATION (SILURIAN)
Gray, highly laminated, thin bedded, argillaceous limestone; passes into Bossardville and Poxono Island beds in the east.

Sw WILLS CREEK FORMATION (SILURIAN)
Greenish gray, thin bedded, fissile shale with local limestone and sandstone zones; contains red shale and siltstone in the lower part.

Sbm BLOOMSBURG FORMATION (SILURIAN)
Red, thin and thick bedded shale and siltstone with local units of sandstone and thin impure limestone; some green shale in places.

McKENZIE FORMATION (SILURIAN)
Greenish gray, thin bedded shale interbedded with gray, thin bedded, fossiliferous limestone; shale predominant at the base; intraformational breccia in the lower part. Absent in Harrisburg quadrangle and to the east.

HIGH FALLS FORMATION (SILURIAN)
Hard red sandstone and soft red shale, the latter more abundant near the top (Northwestern area of New Jersey).

Skm SILURIAN UNITS
Skw, Skt, Sw, Sbm and Swm

Swm SILURIAN UNITS
Sw and Sbm

Sd DECKER LIMESTONE AND LONGWOOD SHALE (SILURIAN)
Impure siliceous and shaly limestone (Decker) above soft red shale with irregular slaty cleavage (Longwood). (North central area of New Jersey)

Sgp GREEN POND CONGLOMERATE (SILURIAN)
Conglomerate of white quartz pebbles in hard reddish-brown matrix, with beds of coarse hard sandstone.

Sc CLINTON GROUP (SILURIAN)
Predominantly Rose Hill Formation- Reddish purple to greenish gray, thin to medium bedded, fossiliferous shale with intertonguing "iron sandstones" and local gray, fossiliferous limestone; above the Rose Hill is brown to white quartzitic sandstone (Keefer) interbedded upward with dark gray shale (Rochester).

St TUSCARORA FORMATION (SILURIAN)
White to gray, medium to thick bedded, fine grained, quartzitic sandstone, conglomerate in part.

Ss SHAWANGUNK FORMATION (SILURIAN)
Light gray to tan, thick bedded, impure quartzitic sandstone and conglomerate with thin shale interbeds; eastern Penna. only.

In New York, includes undifferentiated Silurian rock.

In New Jersey, conglomerate of white quartz pebbles in hard bluish matrix, red toward the top, with beds of coarse hard sandstone.

OS UNDIFFERENTIATED ORDOVICIAN AND SILURIAN ROCKS
In fault slices only.

Oj JUNIATA FORMATION (ORDOVICIAN)
Red, fine grained to conglomeratic, quartzitic sandstone with well developed cross-bedding and with interbedded red shale in places.

Obe BALD EAGLE FORMATION (ORDOVICIAN)
Gray to greenish gray, fine grained to conglomeratic, thick bedded sandstone; often iron-speckled and cross-bedded; some greenish gray shale in places.

Ojb ORDOVICIAN UNITS
Oj and Obe

Or REEDSVILLE FORMATION (ORDOVICIAN)
Dark gray, olive weathering shale with thin silty to sandy interbeds; black shale of Antes Formation at the base.

Ocn COBURN FORMATION (ORDOVICIAN)
Dark gray to black, thin bedded limestone with black shale interbeds.

SALONA FORMATION (ORDOVICIAN)
Dark gray, thin bedded, dense limestone.

NEALMONT FORMATION (ORDOVICIAN)
Bluish gray, finely crystalline, fossiliferous limestone; lower part grades laterally into Curtin Formation.

Ovl CURTIN FORMATION (ORDOVICIAN)
Gray, impure limestone; bluish gray, fine grained, high calcium limestone with some larger calcite grains (Valentine Member at the top).

BENNER FORMATION (ORDOVICIAN)
Gray, mottled, dolomitic limestone and coarse granular limestone.

HATTER FORMATION (ORDOVICIAN)
Dark gray, impure, fossiliferous limestone.

LOYSBURG FORMATION (ORDOVICIAN)
Dense limestone over irregularly banded dolomitic limestone.

Ocl ORDOVICIAN UNITS
Ocn and Ovl

Om MARTINSBURG FORMATION (ORDOVICIAN)

Includes Oms, Ome and Omls facies - Gray to dark gray, light gray to olive weathering shale Om with thick sandstone interbeds Oms; east of Susquehanna River contains interbedded red shale, gray to brown sandstone, and thin bedded limestone Omls; has associated andesite lavas Ome in Lebanon County.

(Om units of New Jersey generally equivalent to Om and Oms of Pennsylvania, and Oag and Ok of New York).

Oc-Ohm CHAMBERSBURG FORMATION (ORDOVICIAN)

Dark gray, thin bedded limestone (Oranda) at the top; gray, argillaceous limestone (Mercersburg) in the middle; dark gray, cobbly and thin, irregularly bedded limestone (Shippensburg) below. Occurs southwest of Susquehanna River only.

HERSHEY AND MYERSTOWN FORMATIONS (ORDOVICIAN)

Hershey-Dark gray to black, thin bedded, argillaceous limestone. Myerstown-Medium to dark gray, platy, medium crystalline limestone; carbonaceous at base. Unit also called Jacksonburg in eastern Pennsylvania and New Jersey.

Osp-Oan ST. PAUL GROUP AND ANNVILLE FORMATION (ORDOVICIAN)

Buff colored, even grained, magnesian limestone containing numerous layers of blocky chert. Annville Formation (upper St. Paul) Oan, light gray, massive, high calcium limestone mottled at base; east of Susquehanna River.

Obf BELLEFONTE FORMATION (ORDOVICIAN)

Gray, cream to tan weathering, medium bedded dense dolomite.

Oa AXEMANN FORMATION (ORDOVICIAN)

Bluish gray, medium bedded, impure limestone.

On NITTANY FORMATION (ORDOVICIAN)

Gray, thick bedded, coarsely crystalline dolomite.

Os STONEHENGE-LARKE FORMATION (ORDOVICIAN)

Stonehenge- Bluish gray, finely crystalline limestone and dark gray, laminated limestone with abundant "edgewise" conglomerate.

Larke- Dark, coarsely crystalline dolomite; equivalent to Stonehenge.

In the east, fine crystalline limestone and dark gray laminated limestone with numerous "edgewise" conglomerate beds.

Oba ORDOVICIAN UNITS
Obf and Oa

Ons ORDOVICIAN UNITS
On and Os

Oo ONTELAUNEE FORMATION (ORDOVICIAN)
Light to dark gray, very fine to medium crystalline dolomite with interbeds of bluish gray limestone; interbedded and nodular dark gray chert at base.

Oe EPLER FORMATION (ORDOVICIAN)
Very fine crystalline, bluish gray limestone interbedded with gray dolomite; coarse crystalline limestone lenses present.

Ori RICKENBACH FORMATION (ORDOVICIAN)
Gray, very fine to coarse crystalline, laminated dolomite; dark gray chert in irregular beds, stringers, and nodules; bands of quartz sand grains in lower half.

Oor ORDOVICIAN UNITS
Oo, Oe and Ori

Ob BEEKMANTOWN GROUP (ORDOVICIAN) OF PENNSYLVANIA
Includes Obf, Oa, On, Os, Oba, Ons, Oo, Oe, Ori and Oor

Oco COCALICO FORMATION (ORDOVICIAN)
Gray shale; highly phyllitic in places; some interbedded red shale and argillaceous and quartzose sandstone.

Ocs CONESTOGA FORMATION (ORDOVICIAN)
Bluish gray, thin bedded, impure, contorted limestone with shale partings; conglomeratic at base, in Chester Valley includes upper micaceous limestone, middle phyllite and lower alternating dolomite and limestone.

TRENTON GROUP (Oqu, Oag, Ok, Oba, Otm, OCs)

Oqu QUASSAIC QUARTZITE (ORDOVICIAN)
Quartzite, sandstone, conglomerate.

Oag AUSTIN GLEN FORMATION (ORDOVICIAN)
Graywacke, shale.

Ok NORMANSKILL SHALE (ORDOVICIAN)
Minor mudstone, sandstone.

Oba BALMVILLE LIMESTONE (ORDOVICIAN)
Vermont: Whipple limestone.

Otm TACONIC MELANGE (ORDOVICIAN)
Chaotic mixture of Early Cambrian through Middle Ordovician pebble to block-size angular to rounded clasts in a pelitic matrix of Middle Ordovician (Barneveld) age. Rims and floors earlier submarine gravity slides of Taconian Orogeny.

OCs CAMBRIAN THROUGH MIDDLE ORDOVICIAN (BARNEVELD)
Carbonate rocks occurring as slivers caught along thrusts of later allochthones, or carbonate blocks in Taconic Melange.

Ow COPAKE FORMATION (ORDOVICIAN)
(Columbia County) limestone, dolostone; Rochdale Limestone; Halcyon Lake Formation - chert, calc-dolostone.

Ob WAPPINGER GROUP (ORDOVICIAN) OF NEW YORK
(Including Fishkill Limestone and Dolostone)
Limestone, dolostone, shale, locally cherty.

Omi MOUNT MERINO AND INDIAN RIVER FORMATIONS (ORDOVICIAN)
Shale, slate, chert.

Osf STUYVESANT FALLS FORMATION (ORDOVICIAN)
South of Troy - shale, siltstone.

OCe ELIZAVILLE FORMATION (CAMBRO-ORDOVICIAN)
Shale, argillite, quartzite.

Ob "KITTATINNY" LIMESTONE (CAMBRO-ORDOVICIAN) OF NEW JERSEY
Upper - Thin and thick, gray or blue cherty magnesian limestone (Beekmantown); unconformity.

Middle - Light and dark, medium bedded limestones with cryptozoon heads (Upper Cambrian); unconfomity.

Lower - Massive blue, blue-gray limestone with yellowish or silvery shale (Lower Cambrian). (South of Greenwood Lake includes a narrow band of Hardyston sandstone). Lower part equivalent to Clv of Pennsylvania (Entire unit equivalent to Ob and Cs in New York).

Cs STISSING FORMATION (CAMBRIAN)
Dolostone, shale.

Cpg POUGHQUAG QUARTZITE (CAMBRIAN)
Locally conglomeratic.

Cgt GERMANTOWN FORMATION (CAMBRIAN)
Shale, limestone, conglomerate.

?Cn NASSAU FORMATION (CAMBRIAN)
Shale, quartzite.

?Cev EVERETT FORMATION (CAMBRIAN)
Locally with minor meta-graywacke lenses.

Cm MINES FORMATION (CAMBRIAN)
Bluish gray crystalline dolomite; largely oolitic with much oolitic chert.

Cg GATESBURG FORMATION (CAMBRIAN)
Bluish gray, coarse crystalline dolomite with many sandstone interbeds; cryptozoon reefs common.

Cmg CAMBRIAN UNITS
Cm and Cg

Cr RICHLAND FORMATION (CAMBRIAN)
Gray dolomite in part oolitic, interbedded with medium gray limestone, and dark gray, partly oolitic chert.

Cms MILLBACH AND SCHAEFFERSTOWN FORMATION (CAMBRIAN)
Millbach - Pink to white and gray, finely laminated limestone with interbedded fine crystalline dolomite; numerous cryptozoon reefs.

Schaefferstown - Gray limestone with siliceous and argillaceous laminae.

Csb SNITZ CREEK AND BUFFALO SPRINGS FORMATIONS (CAMBRIAN)
Snitz Creek - Gray, thick bedded, medium to coarse crystalline dolomite in part oolitic with laminated limestone interbeds and several sandstone interbeds.

Buffalo Springs - Light blue gray to pinkish gray, fine to coarse crystalline limestone with interbedded dolomite; cryptozoon reefs near top of unit; thin sandy beds in places; may include some Elbrook.

Cc- Cal CONOCOCHEAGUE GROUP (CAMBRIAN)
Gray limestone with siliceous and argillaceous bands and laminae and dark to light gray dolomite; sandy in lower part; cryptozoon reefs; called Allentown Formation Cal east of Schuykill River.

Includes Cambrian units - Cr, Cms and Csb

Cw WARRIOR FORMATION (CAMBRIAN)
Bluish gray, fine grained dolomite with shaly partings.

Cp PLEASANT HILL FORMATION (CAMBRIAN)
Dark gray, thick bedded limestone and thin bedded, shaly limestone.

Cwb WAYNESBORO FORMATION (CAMBRIAN)

Green and red shale, sandstone, and conglomerate. To the east, interbedded red to purple shale and sandstone with some beds of dolomite and impure limestone.

Ce ELBROOK FORMATION (CAMBRIAN)

Light gray to yellowish gray, fine laminated, siliceous limestone with interbeds of dolomite; weathers to earthy buff soil.

Cl LEDGER FORMATION (CAMBRIAN)

Light gray, locally mottled, massive, pure, coarse crystalline dolomite; siliceous in middle part.

Ck KINZERS FORMATION (CAMBRIAN)

Dark brown shale at the base; above this is gray and white spotted limestone and marble with irregular partings grading to sandy limestone which weathers to fine porous sandstone.

Cv VINTAGE FORMATION (CAMBRIAN)

Dark gray, knotty argillaceous dolomite with impure light gray marble at the base.

Ct-Clv TOMSTOWN FORMATION (Ct) or LEITHSVILLE FORMATION (Clv) (CAMBRIAN)

Massive dolomite with thin shaly interbeds. Includes Cl, Ck and Cv.

Cch-Cwl CHICKIES FORMATION OR WEVERTON FORMATION (CAMBRIAN)

Chickies - Light gray, hard, massive, scolithus - bearing quartzite and quartz schist; thin interbedded dark slate at top: conglomerate (Hellam Member) at base.

Weverton - Equivalent to Chickies: gray to purplish gray, feldspathic quartzite and quartzose conglomerate in hard resistant beds containing rounded pebbles; sericitic slate and purplish gray, crumbly, poorly sorted, arkosic sandstones and conglomerates (Loudoun Formation) at base.

Cha HARDYSTON FORMATION (CAMBRIAN)

Variable hard sandstone usually containing feldspar; local beds of conglomerate and slate. Includes small areas of Chickies quartzite at Trenton; (South of Greenwood Lake, a narrow band of Hardyston is combined on map with Ob) Includes Cah, Ca, Ch and Cch-Cwl.

VOLCANIC ROCKS - MAINLY SUBAERIAL

Trbs BASALT FLOWS (TRIASSIC)
Fine-grained trap rock in extensive flows, chiefly in the Watchung Mountains; in part vesicular.

bb BASIC VOLCANIC BRECCIA (CAMBRIAN)
Numerous fragments of slate, limestone and gneiss enclosed in a matrix of basic lava (ouachitite) filling old volcanic necks (Sussex County).

FELSIC ROCKS

Dpgr UPPER DEVONIAN INTRUSIVES
Muscovite-biotite granite of Peekskill pluton.

Dpgd UPPER DEVONIAN INTRUSIVES
Muscovite-biotite granodiorite of Peekskill pluton.

Od DIABASE (ORDOVICIAN)

Xpg PEGMATITE (PROBABLY LOWER PALEOZOIC)

gd GRANODIORITE (PRECAMBRIAN)

qm QUARTZ MONZONITE (PRECAMBRIAN)

gr GRANITE (PRECAMBRIAN)
Coarse-grained, rudely foliated hornblende granite, rich in zircon, titanite, and allanite (Northern border of Sussex County).

hgg HORNBLENDE GRANITE AND GRANITIC GNEISS (PRECAMBRIAN)
Includes subordinate leucogranite

MAFIC ROCKS

Trd DIABASE (TRIASSIC)
Dark gray, medium to coarse grained; composed chiefly of gray plagioclase feldspar and black or green augite. Chiefly intrusive sheets in the Newark Formations.

Trp PALISADE DIABASE (TRIASSIC)
(Includes Landentown diabase and basaltic lava).

KJd MESOZOIC INTRUSIVES (LOWER CRETACEOUS AND JURASSIC)
Lamprophyre, diabase, and albite-basalt dikes; not shown in Proterozoic terrane.

CORTLANDT AND SMALLER MAFIC COMPLEX (ORDOVICIAN)
(Oban, Od, Ohn, Oh, Oopx, Opx and Ogb)

Oban — Biotite augite norite

Od — Diorite (Mapped in Scranton Quadrangle only)

Ohn — Hornblende norite; hornblende is poikilitic

Oh — Hornblendite

Oopx — Olivine pyroxenite, in part with poikilitic hornblende; local peridotite.

Opx — Pyroxenite

Ogb — Rock complex ranging in composition from gabbro or norite to hornblende diorite with minor pyroxenite; Croton Falls and Peach Lake complexes.

ns — NEPHELITE SYENITE (CAMBRIAN)
Intrusive mass of gray coarse to fine-grained rock in Sussex County.

gb — GABBRO(PRECAMBRIAN)
Including hypersthene gabbro and norite (about Trenton)

ULTRAMAFIC ROCKS

KJk — MESOZOIC INTRUSIVES (LOWER CRETACEOUS AND JURASSIC)
Kimberlite and alnoite dikes and diatremes.

a — ANORTHOSITE (PRECAMBRIAN)
Honeybrook area only.

METAMORPHIC ROCKS

TRENTON GROUP (Owl and ?Omf)

Owl — WALLOOMSAC FORMATION (ORDOVICIAN)
Slate, phyllite, schist, metagraywacke.

?Omf — MANHATTAN FORMATION UNDIVIDED (ORDOVICIAN)
Pelitic schists, amphibolite; units ?Omb, ?Omc, and ?Omd may be Cambrian eugeosynclinal rocks thrust upon Oma; ?Omd - sillimanite-garnet-muscovite-biotite-plagioclase-quartz gneiss; ?Omc - sillimanite-garnet-muscovite-biotite-quartz-plagioclase schistose gneiss, sillaminite nodules, local (quartz-rich) layers; ?Omb - discontinuous unit of amphibolite and ?Omc-type schist; Oma - sillimanite-garnet-muscovite-biotite-quartz-plagioclase schists; calcite marble and calcsilicate rock at base.

?Ohr HARRISON AND RAVENSWOOD GNEISS (ORDOVICIAN)
Biotite-hornblende-quartz-plagioclase gneiss with accessory garnet and sphene; plagioclase commonly occurs as augen.

?Oht HARTLAND FORMATION (ORDOVICIAN)
Basal amphibolite overlain by pelitic schists.

sp SERPENTINE (POST ORDOVICIAN)
From hydration of basic igneous rocks (Hoboken and Staten Island).

OCi INWOOD MARBLE (CAMBRO-ORDOVICIAN)

Ca ANTIETAM FORMATION (CAMBRIAN)
Gray, buff weathering quartzite and quartz schist.

Ch-Cma HARPERS FORMATION (CAMBRIAN)
Dark greenish gray phyllite and schist with thin quartzite layers; includes Montalto Member Cma, gray quartzite.

Cah CAMBRIAN UNITS
Ca and Ch-Cma.

Xs SERPENTINITE (PROBABLY LOWER PALEOZOIC)
Includes serpentine, steatite, and associated products of alteration of peridotites and pyroxenites.

Xc COCKEYSVILLE MARBLE (PROBABLY LOWER PALEOZOIC)
White to light bluish gray marble.

Xsq SETTERS FORMATION (PROBABLY LOWER PALEOZOIC)
White feldspathic quartzite to gray mica gneiss and schist.

WISSAHICKON FORMATION (Xw, Xwc, Xwm, Xww, Xwv)

Xw OLIGOCLASE MICA SCHIST (PROBABLY LOWER PALEOZOIC)
Includes some hornblende gneiss members and some augen gneiss, and quartz-rich and feldspar-rich members showing various degrees of granitization. Includes Wissahickon mica gneiss.

Xwc ALBITE CHLORITE SCHIST (PROBABLY LOWER PALEOZOIC)
Includes Octararo-Phyllite and some hornblende gneiss and granitized member. Includes Xwm, Xww and Xwv.

Xwm MARBURG SCHIST (PROBABLY LOWER PALEOZOIC)
Gray-green mica chlorite quartzite schist; mapped west of Susquehanna River only.

Xww WAKEFIELD MARBLE (PROBABLY LOWER PALEOZOIC)
Light gray coarse crystalline marble.

Xwv METAVOLCANICS (PROBABLY LOWER PALEOZOIC)
Altered basaltic flows, some amygdaloidal; green, schistose with hornblende, epidote, chlorite and quartz.

Xgr GRANITE GNEISS AND GRANITE (PROBABLY LOWER PALEOZOIC)
Includes Springfield Granodiorite (granitized Wissahickon) and related rocks.

Xhg HORNBLENDE GNEISS (PROBABLY LOWER PALEOZOIC)
Includes rocks of probable sedimentary origin; may be equivalent to hg.

Xmg METAGABBRO (PROBABLY LOWER PALEOZOIC)
Ranges from altered gabbro to hornblende gneiss.

Xpb PEACH BOTTOM SLATE (PROBABLY LOWER PALEOZOIC)
Bluish-black slate
CARDIFF CONGLOMERATE (PROBABLY LOWER PALEOZOIC)
Quartz conglomerate with sericite-chlorite matrix.

Xpc PETERS CREEK SCHIST (PROBABLY LOWER PALEOZOIC)
Chlorite-sericite schist with quartzite.

s SERPENTINITE (PRECAMBRIAN)
Includes serpentine, steatite, and associated products of alteration of peridotites and pyroxenites; may be equivalent to Xs.

md METADIABASE (PRECAMBRIAN)

gn GRANITE GNEISS (PRECAMBRIAN)

mb METABASALT (PRECAMBRIAN)

mr METARHYOLITE (PRECAMBRIAN)

vs GREENSTONE SCHIST (PRECAMBRIAN)

hg HORNBLENDE GNEISS (PRECAMBRIAN)
Includes rocks of probable sedimentary origin; may be equivalent to Xhg.

g GABBROIC GNEISS AND GABBRO (PRECAMBRIAN)
Includes rocks of probable sedimentary origin; may be equivalent to Xhg.

Note: md, gn, hg, g and gg constitute the Baltimore Gneiss in the Philadelphia area.

gg GRAPHITIC GNEISS (PRECAMBRIAN)
Includes Pickering Gneiss and small areas of marble.

lgn LOSEE GNEISS (PRECAMBRIAN)
White granitoid gneiss composed of oligoclase, quartz, and occasionally orthoclase, pyroxene, hornblende and biotite.

bgn BYRAM GNEISS (PRECAMBRIAN)
Gray granitoid gneiss composed of microcline, microperthite, quartz, hornblende or pyroxene, and sometimes mica. Includes small areas of Baltimore gneiss of Trenton. Generally equivalent to gn and gg.

pgn POCHUCK GNEISS (PRECAMBRIAN)
Dark granular gneiss composed of pyroxene, hornblende, oligoclase and magnetite. Probably igneous in part.

amg INTERLAYERED AMPHIBOLITE AND GNEISS (PRECAMBRIAN)
Interlayered amphibolite and granitic, charnockitic, mangeritic, or syenitic gneiss.

lg LEUCOGRANITIC GNEISS (PRECAMBRIAN)
Sodic plagioclase ranges from generally subordinate to locally dominant; locally with biotite, hornblende, pyroxene, garnet, sillimanite, disseminated magnetite; commonly contains metasedimentary layers, amphibolite, migmatite; plagioclase-rich variety is host to magnetite ore bodies in eastern Adirondacks.

bg BIOTITE GRANITIC GNEISS (PRECAMBRIAN)

am AMPHIBOLITE, COMMONLY BIOTITIC: (PRECAMBRIAN)
Garnetiferous, pyroxenic in and adjacent to central massif of Adirondacks.

fl FRANKLIN LIMESTONE (PRECAMBRIAN)
Coarse white marble, magnesian in part, containing graphite, chrondodite, pyroxene and other minerals. Contains zinc ores in Sussex County. Includes some gneiss near Phillipsburg, New Jersey.

f FORDHAM GNEISS UNDIVIDED (PRECAMBRIAN)
fe - garnet-biotite-quartz plagioclase gneiss and amphibolite.
fd - sillimanite-garnet schistose gneiss, quartzite.
fc - biotite-hornblende-quartz plagioclase gneiss, quartz-feldspar lenses, amphibolite, biotite and/or hornblende-quartz-feldspar gneiss.
fb - amphibolite, biotite and/or hornblende-quartz-garnet-plagioclase gneiss.
fa - garnet-biotite-quartz plagioclase gneiss, amphibolite, biotite-hornblende-quartz-plagioclase gneiss, quartz-feldspar granulite.

y YONKERS GNEISS (PRECAMBRIAN)
Biotite and/or hornblende-quartz-feldspar gneiss.

bqpc BIOTITE-QUARTZ-PLAGIOCLASE GNEISS (PRECAMBRIAN)
with subordinate biotite granitic gneiss, amphibolite, calcsilicate rock.

cs CALCSILICATE GNEISS

qtcs GARNET-BIOTITE-QUARTZ-FELDSPAR GNEISS (PRECAMBRIAN)
Quartzite, quartz-feldspar gneiss, calcsilicate rock.

qtlg GARNET-BEARING GNEISS AND INTERLAYERED QUARTZITE: (PRECAMBRIAN)
Contains varying amounts of biotite, garnet, sillimanite; minor marble, amphibolite, rusty paragneiss.

rg RUSTY AND GRAY BIOTITE GNEISS (PRECAMBRIAN)
Rusty and gray biotite-quartz-feldspar gneisses; rusty facies contains variable amounts of garnet, sillimanite, cordierite, graphite, sulfides; minor marble and calcsilicate rock.

sc SILLIMANITE GNEISS (PRECAMBRIAN)
Sillimanite-cordierite-almandine-biotite-quartz-feldspar gneiss.

6.4 URANIUM OCCURRENCES

The principal uranium occurrences in the Thorpe area are shown in Figure 7 and listed in Table 1. Many of the individual occurrences reported fall within discrete districts, while others occur as apparently isolated prospects. To date, these occurrences have been only superficially investigated, and no satisfactory grade and tonnage measurements have been made.

McCauley (1961) describes forty-three occurrences, all located in the eastern part of Pennsylvania and near the Delaware River in New Jersey. The occurrences are in rocks of four different ages: Triassic, Mississippian, Devonian and Precambrian. The great majority are in the Catskill Formation of Devonian age and are of the "sandstone type." Those in the Mississippian and Triassic rocks are similar in nature.

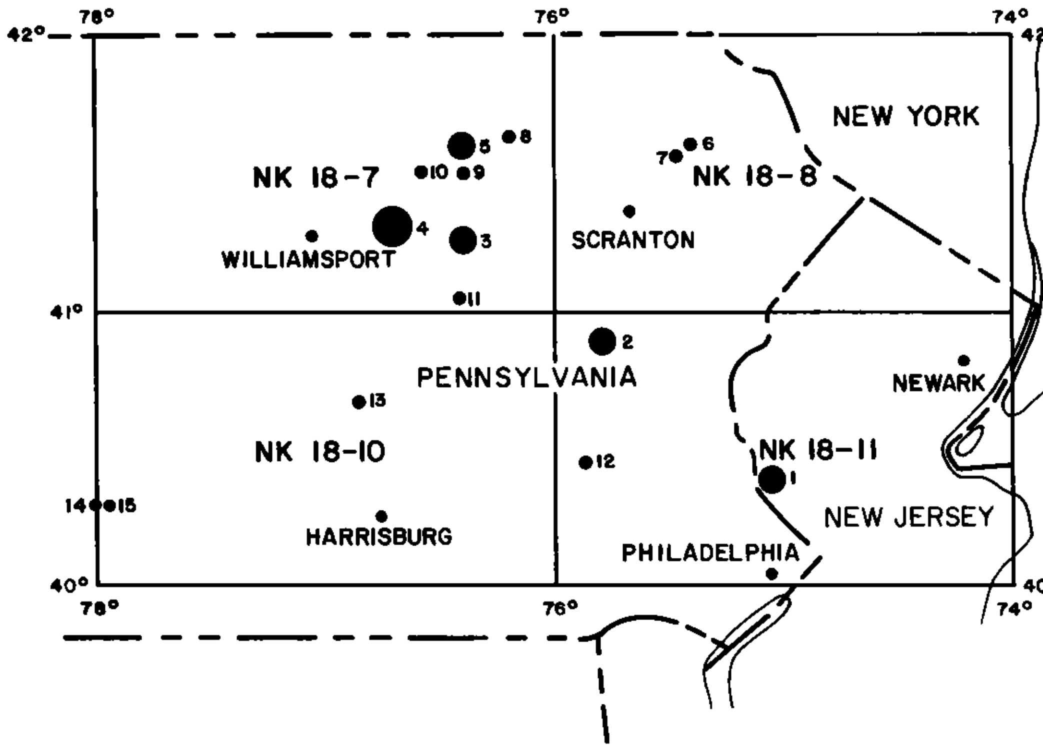
The sandstone occurrences are in many ways similar to the Colorado Plateau deposits. The mineralization typically occurs in gray to green zones within red bed formations of continental origin, and is commonly associated with carbonaceous material in the form of plant fragments. Although the secondary uranium arsenate minerals,

uranospinite $Ca(UO_2)_2(AsO_4)_2 \cdot 10H_2O$
and metazeunerite $Cu(UO_2)_2(AsO_4)_2 \cdot 8H_2O$, have been identified from the Devonian occurrences, no primary uranium minerals have been found to be present. It is believed the primary uranium occurs either as a urano-organic compound or as an oxide very finely disseminated throughout the carbon.

X-ray spectrographic analyses show that uranium, vanadium, iron, copper, lead, zinc, barium and arsenic are present in varying quantities in the majority of the sandstone occurrences. Uranium is the most abundant element in the Triassic occurrences, while the Mississippian prospects are characterized by uranium and vanadium and the Devonian by copper and uranium.

Sulfur isotope ratio studies were also conducted on several of the sandstone occurrences, primarily from the Devonian (McCauley, 1961). With the exception of one sample from an occurrence in Triassic beds, the samples all showed significant depletion in S^{34}, strongly suggesting that the sulfur contained in the occurrences is derived from organically produced hydrogen sulfide, rather than from magmatic solutions. While the sulfur isotope data appears to favor a ground water hydrothermal theory of emplacement, the possibility that some or all of the metals in these occurrences are derived from magmatic sources by lateral migration cannot be excluded.

In contrast to the sandstone type deposits, the uranium occurrences in the Precambrian igneous and metamorphic rocks of the crystalline highlands of New Jersey, New York and Pennsylvania are all characterized by the presence of uraninite and thorite in pegmatitic lenses of an injection gneiss. In many places they are associated with magnetite ores which are generally considered to be hydrothermal in origin.



SCALE 1:2,500,000

FIGURE-7 KNOWN URANIUM PROSPECTS — THORPE AREA

TABLE 1 - URANIUM PROSPECTS - THORPE AREA

MAP NO. (FIGURE 7)	NAME	AGE OF HOST ROCK
1	Hendricks Island, Prallsville, Raven Rock Occurrences	Triassic
2	Carbon County District (Mt. Pisgah, Mauch Chunk Ridge, Penn Haven Junction, Butcher Hallow Occurrences)	Upper Devonian-Mississippian
3	Central District	Devonian
4	Beaver Lake District	Devonian
5	New Albany District	Devonian
6	Robinson Pond Prospect	Devonian
7	Mt. Cobb Prospect	Devonian
8	Forkston Prospect	Devonian
9	Dushore Prospect	Devonian
10	Loyalsock Creek Prospect	Devonian
11	Orangeville Prospect	Devonian
12	Pikesville Prospect	Precambrian
13	Herndon Prospect	Devonian
14	Round Knob Prospect	Mississippian
15	Elliot Run Prospect	Devonian

SECTION 7.0

PHOTOGEOLOGIC ENHANCEMENT STUDY OF THE THORPE AREA

7.1 SCOPE OF STUDY

As a supplemental phase of the analysis of the airborne radiometric data, an interpretation was made of the 35mm infra-red strip film used for flight path recovery. The purpose of this interpretation, termed Photogeologic Enhancement, or P.G.E., was to identify and weigh certain specific surficial conditions, including manmade as well as natural variants which may or may not follow geological principals, lithological boundaries or established criteria, that might be expected to alter the radiometric data accumulated to meet the prime survey goals. Thus, correlation of such variations in surface condition with the radiometric response provides an extremely pertinent, additional set of criteria by which to evaluate the relative significance of radiometric anomalies.

The photointerpretation data retrieved during the course of the study was grouped into two main classes. Natural variants were grouped due to hydrologic, minor glacial or eolian causation, and classed by outcrop occurrence, water table condition, major soil type, and surface water occurrence. Manmade variants were grouped according to culture, agriculture, mining and radioactive sources.

7.2 PROCEDURES

Following acquisition of the survey data and development of the rolls of aircraft path recovery film corresponding to each survey flight, a data log for each roll of film and a cross index of each flight line to the film rolls was compiled. A system of selection criteria for each P.G.E. data category was then established, as outlined in the following section of this report.

The film was interpreted on a frame-by-frame basis at a magnification of 29:1 using a specially constructed viewer. Each data category was retrieved and enumerated by recording the fiducials (data reference numbers) at the start and stop of each data sequence. No notation was made for zero state categories or unretrievable data.

Special data classifications, such as soil type and mining, were mapped as units and collateral data from existing publications were used to augment or replace film analysis. In the case of mining, this was done to present the data in the most accurate fashion. As for the soil type, the scale of the film was found to be too small for accurate and/or sufficiently rapid determination, and prime data effect considerations directed the study to a much broader classification system than direct retrieval would generate.

7.3 SELECTION CRITERIA FOR P.G.E. CATEGORIES

The distribution of eight principal categories of surficial conditions deemed significant in terms of potential effect on the radiometric survey data were recorded during the course of the study. The definition of these categories, and the criteria for their selection and recognition are enumerated below, together with pertinent comments on their potential significance to the radiometric data.

Category 1 - Minor Surface Water, High Water Table

Three water table conditions are grouped together into this data set. The first of these categories is standing or running surface water which covers less than 50% of any given frame. The recovery of this data category is simple visual identification.

The second water table condition which was recorded is where a permanent or semi-permanent high water table is developed. Examples of these conditions are swamps, marshes, bogs, and areas where exfiltration from streams or lakes induces saturated zones of soil or rock. Included in this category are areas where a frozen zone prevents a downward migration of precipitation and induces a surface or near surface zone of saturation. Recognition of this type of saturated zone is based on topographic expression, vegetation, soil type and permeability relationships, and hydrology.

The third class of water table data which was recorded is where a seasonal high water table is induced through seasonal changes in transpiration, evaporation and/or precipitation. Identification of these areas is difficult. Vegetation will vary in species but not with great enough difference to identify the changes from 35mm aerial photography. Topography may or may not give sufficient data for identification. Usage is probably the most reliable clue, particularly in areas of intense agriculture. Reliable identification of these areas calls for integration of soil and rock profiles and all hydrologic variants. This last class of water table data is an area where it is felt field work on a test area would be most useful. When it is considered that the perched water table condition may change from surface saturation to four or five feet of freely draining and/or drained soil in a distance of a few tens of feet, and that these conditions may or may not correlate with lithology, many criteria are left in an undefined state.

Category 2 - Major Surface Water

Major surface water was defined as covering greater than 50% of the image area on any given frame. In the case of both Categories 1 and 2, particular attention was given to saturated zones and/or zones of inundation due to their extreme attenuating effect on the radiometric data.

Category 3 - Agricultural Activity

All frames which show active or seasonally active agriculture were recorded. The use of fertilizers and the overturning of natural soil zones, the plow zone, may affect radiometric data. The duration and surficial extent, including the effect on surrounding drainage basins, may be of considerable magnitude. Field tests over known potential sources are necessary to evaluate the full extent of the effects of this data category on the radiometric survey.

Category 4 - Mining Activity

All mining activity, including waste piles, stock piles and areas where wastes are used for extensive filling was recorded. These areas of extreme geologic disorientation were included in an attempt to isolate unnatural and possibly exaggerated anomalies in the radiometric data. Since mine wastes are often used for road material and other construction purposes, the effect of major mining activities may extend far beyond the actual mine. In an attempt to document these effects, major mining areas should be considered as zones instead of single frame occurrences and be mapped as potential nonnatural prime data sources.

Category 5 - Culture

All culture activities and occurrences were documented. Since culture is defined as construction, and products of the stone and mineral industry are the prime construction materials, it is felt that the extent of millions of tons of product from varying geologic settings may have varying effects on prime (radiometric) data acquisition. Additional field studies are suggested to try and determine relative values for constructed areas, such as 100% heavy urban vs. undeveloped.

Category 6 - Radioactive Sources

This category was primarily designed to encompass such manmade radioactive sources as nuclear power plants, although it would include other sources related to industrial usage as well, such as stock piles of certain ore processing plants, etc., to the extent recognizable on the film or from other information sources. In the case of the Thorpe area, no occurrences of this category were recognized during the course of the study and although three operating nuclear plants are located in this general region, none are located within the boundaries of the survey area proper.

Category 7 - Outcrop and/or Float

Outcrops and/or float were recorded where image definition allowed identification.

This data set is presented as an initial step in attempting to examine the relative attenuation effects of soil cover and hydrologic conditions on the airborne data as opposed to actual outcrop areas. Considerable field work would be required to fully assess these data, however.

Category 8 - Major Soil Type

Soil types were mapped by principal deposition methods, employing primarily data from existing publications.

The major types defined are: a) principally of glacial origin, but with some areas of residual soils developed on bedrock, b) principally of fluviatile and residual origin, and c) soils of marine, littoral and fluviatile origin.

Minor areas of varying types will be found in any mapped unit. This type of categorizing was selected in an attempt to differentiate major changes in depth of profile, density, and potential effect on prime data sources. A further consideration with this data category is the soil density relation with particular respect to migrating seasonal water tables. This is another area where field correlation would be most useful.

7.4 SUMMARY OF RESULTS

The overall results of the Photogeologic Enhancement study in the Newark Quadrangle are summarized in Table 2, in terms of the percentage of each flight line in the quadrangle covered by each category. Used in conjunction with the anomaly maps and stacked profile data, this summary permits a sub-regional evaluation of the relative effects of each category from flight line to flight line, as well as from the Newark area to adjacent quadrangles. In addition, as presented in the following section of this report on Data Interpretation, each significant uranium anomaly recorded in the area is correlated with the P.G.E. factors present at its location, and evaluated in the context of these factors as well as bedrock geology and radiometric response characteristics.

Examination of Table 2 reveals that both culture and agricultural activity are particularly prevalent throughout the area, and may be expected to have a significant influence on the radiometric data in many localities of exceptional concentration. Similarly, the minor surface water and high water table category may be expected to have considerable local effect. The relatively high incidence of occurrence of this category undoubtedly relates to the late Fall and early Spring seasons during which this survey was flown.

Certain categories listed clearly reflect local distributions. The abrupt increases in mining activity on Line 2, and again on Lines 18 through 22, for example, reflect the presence of extensive sand and gravel operations in southern New Jersey, and coal mining in the northwest corner of the quadrangle, respectively.

As discussed previously, the soils classification appearing in the Table is based on principal mode of deposition or formation, and soil distributions are primarily derived from published information. To preserve continuity, these data have been integrated with the balance of the P.G.E. categories and presented as a function of occurrence on a line-by-line basis. Additional comments on the distribution of these soils on an areal basis are presented below.

7.5 DISTRIBUTION OF MAJOR SOIL TYPES

The distribution of the major soil types in the Newark Quadrangle used in the radiometric survey evaluation is illustrated in Figure 8. The soils in this quadrangle differ from those in the remainder of the Thorpe area in that all three major types are represented, and in roughly equivalent proportions in terms of area of occurrence.

7.6 COMMENTS AND RECOMMENDATIONS

The retrieval of data in this type of program is dependent on film resolution and the interpreter's skill. Accordingly, film and image resolution of high degree should be a program criteria, and all interpreters should be experienced surficial geologists.

The high degree of accuracy and detail obtainable by this technique for the resolution and mapping of surficial conditions has resulted in a volume of accumulated data which cannot be adequately portrayed within the scope of the present program. Accordingly, for future applications it is strongly suggested that the accumulated data be digitized for subsequent computer processing and preparation of a variety of analog presentations. A particularly useful application would be a series of P.G.E. category maps, plotted on quadrangle overlays, which could be used to visually clarify radiometric data on a regional basis as well as by specific (anomalous) locality.

In addition, digital retrieval would readily permit the accumulation of statistical values for use in identifying particularly significant variants in surficial conditions as they affect the radiometric data. If sufficient field work would be done, actual values for different surficial features could be applied to radiometric data plots, and an attempt made to reduce readings to a base level which would be comparable for any equivalent area.

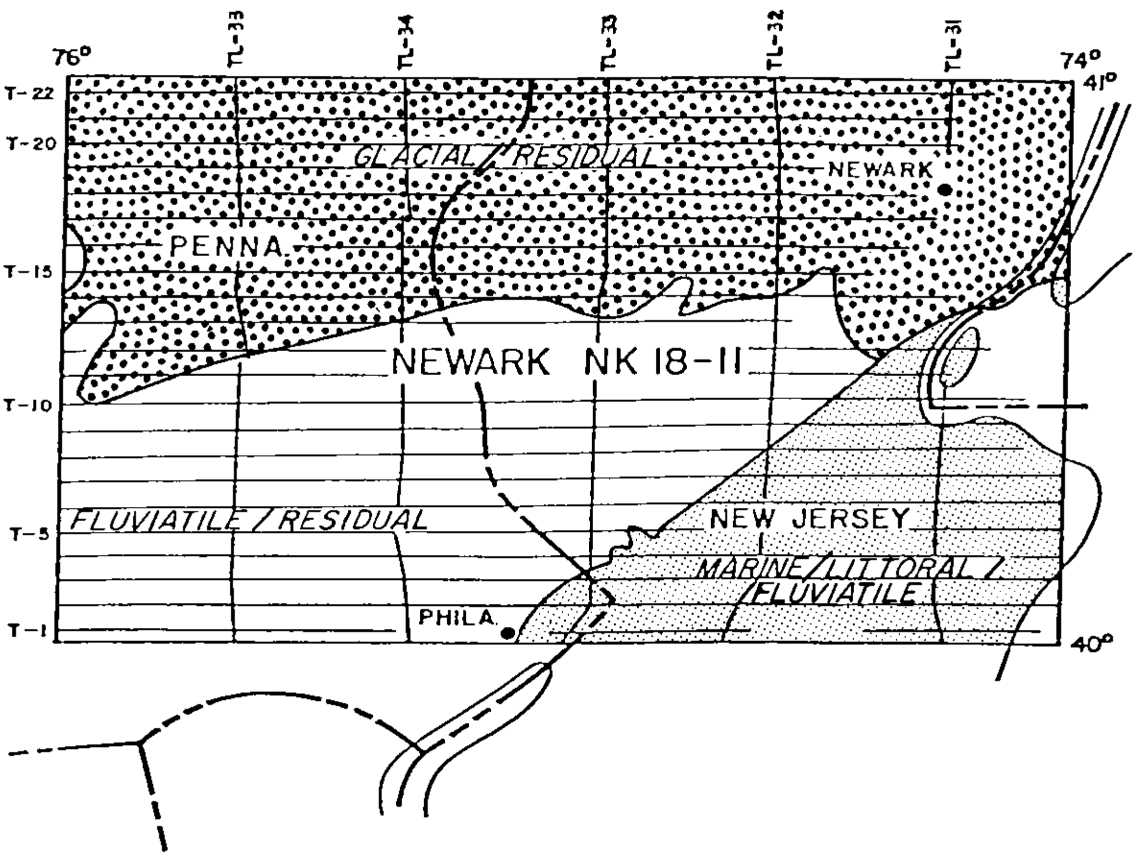


FIGURE-8 MAJOR SOIL TYPES — NEWARK QUADRANGLE

TABLE 2 - SUMMARY OF PHOTOGEOLOGIC ENHANCEMENT

THORPE AREA - NEWARK QUADRANGLE

P.G.E. CATEGORY - PERCENTAGE FREQUENCY OF OCCURRENCE

							MAJOR SOIL TYPE		
Line	Minor Surface Water, High Water Table	Major Surface Water	Agricultural Activity	Mining Activity	Culture	Outcrop and/or Float	Glacial, Residual	Fluviatile, Residual	Marine, Littoral, Residual
1	10	2	15	1	29	<1	0	47	53
2	15	<1	27	4	37	1	0	47	53
3	14	<1	23	1	39	<1	0	51	49
4	20	<1	24	2	43	4	0	58	42
5	16	<1	25	1	33	9	0	60	40
6	15	<1	33	1	35	5	0	64	36
7	18	<1	34	<1	43	1	0	68	32
8	12	<1	34	<1	46	4	0	75	25
9	18	<1	33	2	38	6	0	78	22
10	17	<1	33	0	38	5	8	73	19
11	14	3	36	0	28	6	15	77	8
12	8	<1	25	0	35	4	27	64	9
13	11	<1	37	2	29	12	58	42	0
14	12	<1	17	<1	39	9	78	22	0
15	19	2	34	<1	26	7	94	6	0
16	9	0	36	<1	31	6	96	4	0
17	16	0	35	1	35	13	100	0	0
18	21	0	32	6	27	25	100	0	0
19	19	0	21	5	34	29	100	0	0
20	15	<1	15	2	34	7	100	0	0
21	15	1	12	8	38	14	100	0	0
22	17	1	13	9	27	14	100	0	0
51	15	10	17	2	44	<1	0	0	100
52	7	0	31	<1	36	4	40	26	34
53	11	2	28	<1	29	6	37	51	12
54	13	0	25	<1	40	3	41	59	0
55	18	0	31	0	38	3	52	48	0

SECTION 8.0

DATA INTERPRETATION

8.1 GENERAL

The interpretation of the airborne gamma-ray spectrometer survey comprises an integrated analysis of the radiometric data with basic data from several disciplines. From the viewpoint of final interpretation, the geologic map, the photogeologic enhancement, and the recorded aeromagnetic profile are the most useful auxiliary parameters. The other pertinent quantities, including altitude, barometric pressure, temperature and atmospheric radon measurements, are integrated with the data in the analytical stage previous to the interpretation.

In the following discussions, this analysis is divided into two principal sections dealing with the stacked radiometric and magnetic profiles, and the radiometric anomaly maps. It is considered that a comprehensive evaluation must encompass study of both these principal data sets, inasmuch as they are mutually complementary to the extent that neither by itself can convey the full significance of the survey results. Several examples of the complementary nature of the anomaly maps and profiles will illustrate this point. The anomaly maps comprise the ideal medium for the definition of anomalous zones within discrete geologic units, while in contrast, information regarding regional background radiation levels pertinent to the delineation of metallogenic districts can only be derived from the profile data. Thirdly, anomalous situations exceeding three sigma can only be evaluated on the profile maps.

The correct interpretation of the gamma-ray spectrometer data depends on a thorough understanding of the principles and theory of the survey and data processing techniques. While the major part of this required information is included in the previous sections of this report, a number of additional factors peculiar to airborne survey operations in general, and gamma-ray spectrometer surveys in particular, should also be appreciated from the standpoint of their effects on the collected data. Such factors include the random variability of count rate statistics as a result of local terrain clearance variations which are often unavoidable in airborne surveys; similar variations in count rates over equivalent geologic units caused by surface condition variants such as degree of water saturation and soil thicknesses; inaccurate statistical accumulations due to geologic unit misclassifications; and false recordings caused by locally anomalous atmospheric conditions, particularly temperature inversions accompanied by atmospheric radon concentrations. These factors have been well-documented in previous reports on the airborne reconnaissance phases of the NURE program published by DOE, and additional comments in this text are considered redundant.

8.2 COMMENTARY ON RADIOMETRIC AND MAGNETIC PROFILES

This section is intended to call attention to specific conditions present in the stacked radiometric profiles that are not readily apparent on the radiometric anomaly maps. These conditions pertain primarily to level shifts and to broad radiometric background conditions over the larger or major geological provinces as delineated on Figure 9. The magnetic data acquired on this survey is particularly useful in defining these major geological provinces, and in essence it is the integration of the magnetic data with the radiometric data that permits the accurate definition of these boundaries. The geologic map, of course, provides the basis for the provincial boundaries but this map provides only the surface form of the contact. Both shallow and deep subsurface variations of these contacts carry potential significance which are often well-documented in the magnetic and radiometric profiles.

The Taconian Allochthon

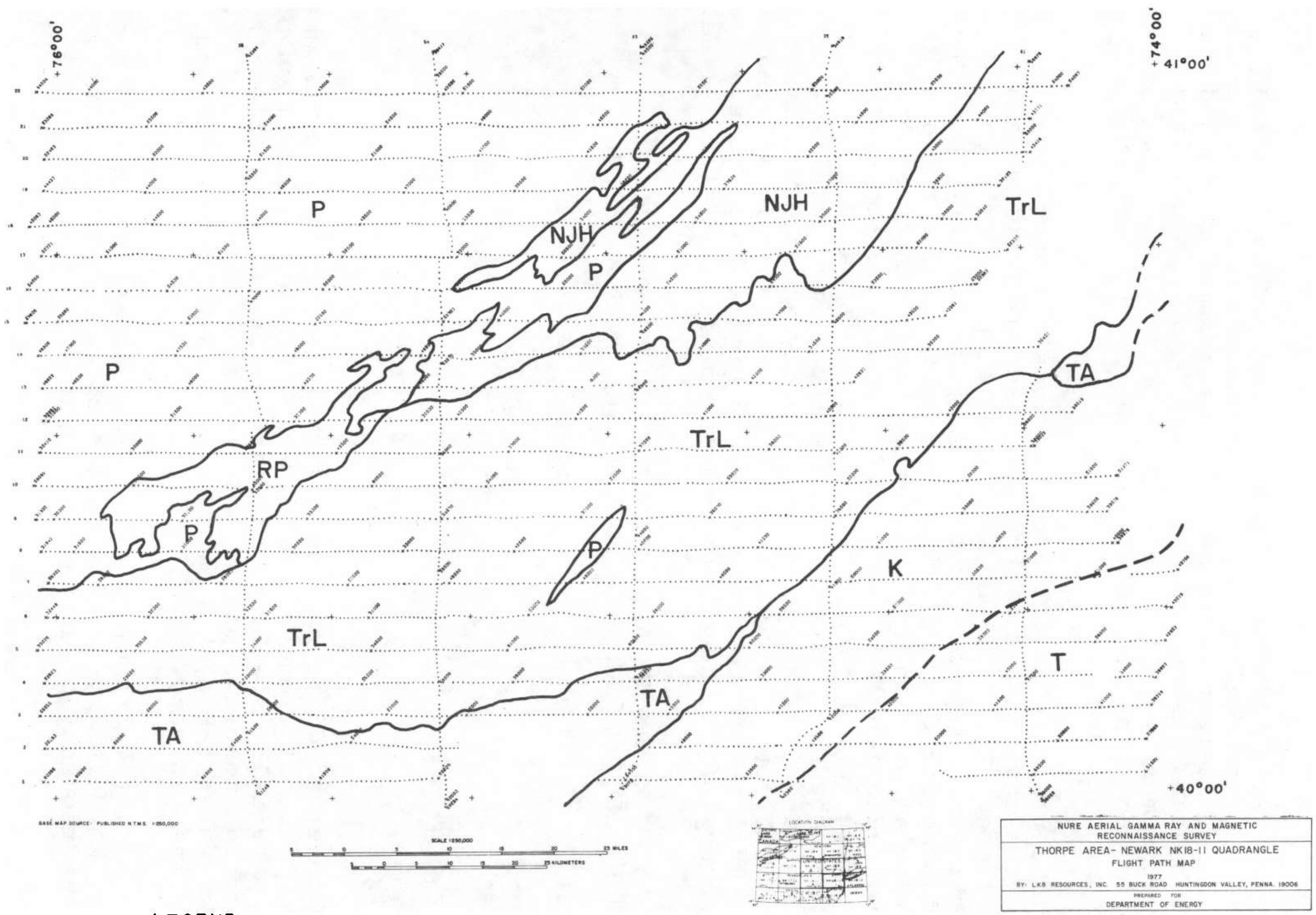
This province is crossed by significant portions of the western ends of Profiles 1 through 4, and the southern ends of Profiles 53, 54, and 55.

The magnetic data defines this zone as weakly magnetic from the point of view of a crystalline rock province. Although the magnetic response seldom exceeds 200 to 300 gamma in local amplitude, a few anomalous exceptions occur over the ultrabasic units such as the serpentines and gabbros present within this complex.

The radiometric data characterizes this province as one of rather high potassium response and low uranium response over most of the geologic units. The zone is strikingly different in its radiometric response from that of other crystalline rocks of the Newark Quadrangle, and only a few significant uranium anomalies were recorded, most of which also produce a high thorium channel response as well. These stronger anomalies almost invariably correspond to the Precambrian granites and granite gneisses of the province.

The Cretaceous and Tertiary Coastal Plain

The Cretaceous portion of the coastal plain province is crossed by the eastern ends of Profiles 1 through 12, and the southern ends of Profiles 51 and 52. The Tertiary portion is covered only by the eastern ends of Profiles 1 through 7. The magnetic response



LEGEND

T-TERTIARY COASTAL PLAIN
K-CRETACEOUS COASTAL PLAIN
TA--TACONIAN ALLOCHTHON
TrL-TRIASSIC LOWLANDS
RP, NJH-READING PRONG, NEW JERSEY HIGHLANDS
P-PALEOZOIC APPALACHIANS

FIGURE 9 – MAJOR GEOLOGIC PROVINCES – NEWARK QUADRANGLE

over these provinces produces somewhat longer period anomalies than those of the crystalline belt, an anomalous pattern resulting from crystalline basement rocks beneath the coastal plain sediments. The basement beneath the coastal plain is, in all probability, composed for the most part of the older members of the Taconian allochthon incorporating the lower portions of the complex known to be Precambrian in age.

The radiometric response in the area provides the justification for dividing the coastal plain into a Cretaceous province and a Tertiary province. The Cretaceous in general produces a considerably more active radiometric response than the Tertiary, and this is clearly demonstrated by Profiles 1 through 7. The table below lists the fiducial on each profile where this prominent change in background radiation level occurs. In most cases the level shift can be seen in all three spectral channels as well as in the total count channel. However, the shift is most obvious in the potassium channel. The shift is unusually sharp and persistent considering the frequent occurrences of Tertiary erosional remnants lying to the west of the boundary shown on Figure 9, and the similar frequency of Cretaceous exposures to the east of the line.

TABLE 3 - LOCATIONS OF THE RADIOMETRIC DIVISION BETWEEN THE CRETACEOUS AND TERTIARY PORTIONS OF THE COASTAL PLAIN

Profile	Fiducial
1	53300
2	49550
3	41950
4	39650
5	59100
6	57600

Perhaps the observed difference in the average radiometric response is due in part to differences in the degree of water saturation of the surface materials as well as differences in the compaction of the sediments in these two major units. The Tertiary unit may have a higher water table, but because of limited compaction would be better drained in many cases.

On a local basis, the frequency of anomalous response in excess of one sigma in the Tertiary portion of the coastal plain is considerably less than the frequency of anomalous response in the Cretaceous portion.

The Triassic Lowlands

This geologic province is traversed by the western portions of Profiles 5 through 7, the central portions of Profiles 8 through 12, and the eastern portions of Profiles 13 through 22. The lithology of the Triassic lowlands is primarily one of sandstones, shales and argillites. These units are often highly indurated, particularly in the vicinity of the diabase dikes, sills and basaltic flows that constitute the remainder of the rocks in the area.

The magnetic response over most of this province is rather uniform, consisting of a gently increasing field from the northwest to the southeast, except where the basic intrusives or extrusives are encountered. In these instances, of course, the magnetic anomalies attain high local amplitudes. For the most part, the magnetic anomalies over the dikes and sills are recognizable by a distinct anomalous shape not characteristic of the responses over the crystalline belts. For example, on the western side of Traverse 5 at fiducial 33800, a typical anomaly over a diabase sill is noted. Another example occurs on Profile 10 at fiducial 60600.

The radiometric response in this area is somewhat diverse. On lines 5 through 7 a significant decrease in the radiometric data can be observed at the far western end, roughly west of tie line 55. This decrease, in all probability, results from an increased number of igneous bodies in this part of the Triassic basin. In contrast, the potassium response immediately to the east of Profile 55 increases sharply over a unit of basal conglomerates occupying this area.

On the east side of these lines, a moderate change in background can be observed crossing from the Triassic province into the Coastal Plain province. This can be expressed as a reasonably sharp difference in background radiation, such as on lines 5 and 6, or a more moderate change as expressed on line 7. The change in each case is a decrease in the background as the profile passes into the Cretaceous rocks to the east. Profiles 9 and 11 produce additional examples of the radiometric response over diabase. On Profile 9, between fiducials 33250 and 33450, the response drops by more than 50% of the count rate observed on either side of the diabase. On Profile 11, the diabase outcrops in two locations centered at fiducials 36850 and 49200. The Brunswick shales occur between these two zones and on either side of them. Aside from these specific characteristics of the radiometric pattern over units within the Triassic, the background level in general is somewhat lower than that over the Precambrian crystalline rocks further to the northwest, and somewhat higher than that of the Cretaceous rocks to the southeast.

Discrete uranium anomalies occur in the central and southern parts of the Triassic Lowland. They are concentrated in the general area between tie lines 52 and 54.

The Reading Prong and New Jersey Highlands Crystalline Belt

This province is traversed by the eastern portions of Profiles 16 through 22, the central portions of Profiles 12 through 15 and the western portions of Profiles 8 through 11.

The regional magnetic signature over this crystalline belt is consistently strong, with local anomalies exceeding 500 gammas in amplitude being quite common. The magnetic response over this crystalline belt is significantly different from the magnetic response over the crystalline belt in the southwestern part of the Newark quadrangle, where Precambrian crystallines and Precambrian to Lower Paleozoic metamorphic rocks are much less anomalous.

The regional radiometric response throughout this area is typically one of abrupt fluctuations and of generally increased background count rate as compared with that of the Triassic lowlands to the southeast. Due to the frequent occurrence of Paleozoic sediments in this highland province, particularly limestones in the valleys between the ridge-forming gneisses, the average background count rate is rather variable. Low background counts are typically displayed over the sediments, particularly in the case of the limestones, and high counts over the gneisses which sometimes form rather narrow topographic features with considerable relief.

This province produces the greatest concentration of significant uranium anomalies in the Newark quadrangle. These zones occur mainly in the gneisses, and often near the contacts of the gneisses with the Ordovician limestones. Of the various gneissic units in the area, the Byram gneiss produces the strongest response and the most frequent anomalies.

The Paleozoic Appalachian Province

This province is crossed by the western ends of Traverses 11 through 22 and the northern ends of tie lines 54 and 55. The magnetic response over this area is characterized by exceptionally smooth gradients. One persistent magnetic anomaly, located over the Cambrian limestones immediately northwest of the Precambrian crystalline complex, appears to result from a positive basement axis or a pediment-like situation developed on the steeply dipping southeast flank of the Appalachian geosyncline.

The lower Paleozoic rocks in this area attain their greatest thickness as they plunge toward this early Paleozoic geosynclinal axis, which crosses the northwest part of the Newark Quadrangle.

Cambrian,Ordovician and Silurian rocks outcrop on the southeast side of this zone and plunge steeply northwestward. Beyond these narrow bands of lower Paleozoic rocks, Devonian through Pennsylvanian sediments form the flanks of the folds in the northwest corner of the sheet. The composition of the lower Paleozoic rocks from the Cambrian through the lower Ordovician is primarily limestone. The middle Ordovician through Pennsylvanian sediments constituting the remainder of the surface outcrops in this region are primarily shales and sandstones with subsidiary interbedded limestones.

The general background level of the radiometric response over these rocks is lower than that measured over the Precambrian crystalline province to the southeast. It is quite variable however, depending upon the lithology at any given location. As one might expect, it appears that the sandstone and shale units are somewhat more radioactive than the limestones, but specific relationships are difficult at the map scale employed for this study because the lithologic units are narrow and rapidly changing. Finally, within the upper members of the section in this portion of the area, some of the important coal formations of Pennsylvania occur. These coal formations also appear to be somewhat more radioactive than the enclosing clastic sediments.

Immediately to the northwest of the Precambrian crystalline rocks a narrow belt of Paleozoic formations occurs, lithologically composed of Cambrian and lower Ordovician limestone, in which there is a pronounced absence of significant uranium anomalies. Beyond this band the frequency of occurrence of significant anomalies increases progressively to the northwest across the Ordovician through Pennsylvanian sediments.

In summarizing the anomalous conditions in the Newark area, an unusual pattern on the uranium anomaly map becomes apparent. From northwest to southeast across the area, there is a concentration of uranium anomalies in the Paleozoic section from near the western boundary of the quadrangle to Profile 54. In the Reading Prong and New Jersey Highlands province, there is a concentration of anomalies between tie lines 55 and 53. In the Triassic Lowlands, a similar concentration is seen between tie lines 54 and 52, and, finally, a concentration also occurs in the Coastal Plain province in the area from tie line 51 to just west of 52.

Thus, the zones of concentration of significant eU anomalies in each of the provinces collectively form a northwest-southeast trending belt which is perpendicular to the regional geologic strike. This perpendicular trend suggests some fundamental control not readily apparent in the regional geology and it is certainly not the only potentially important linear that has been noted in the geologic literature of the Appalachians.

8.3 URANIUM ANOMALY MAPS

8.3.1 Selection of Uranium Anomalies

Through an examination of the equivalent uranium anomaly map, a total of 189 significant eU anomalies have been determined in the Newark quadrangle area, as shown in Figure 10 and listed in Table 4. This selection was accomplished by identifying all individual, or groups of, statistically high data points on the anomaly map on the basis of a system of statistical reliability criteria. A very adequate set of criteria was developed in a previous airborne survey by Texas Instruments for the NURE program and subsequently published by DOE (Document No. GJBX-18(77)).

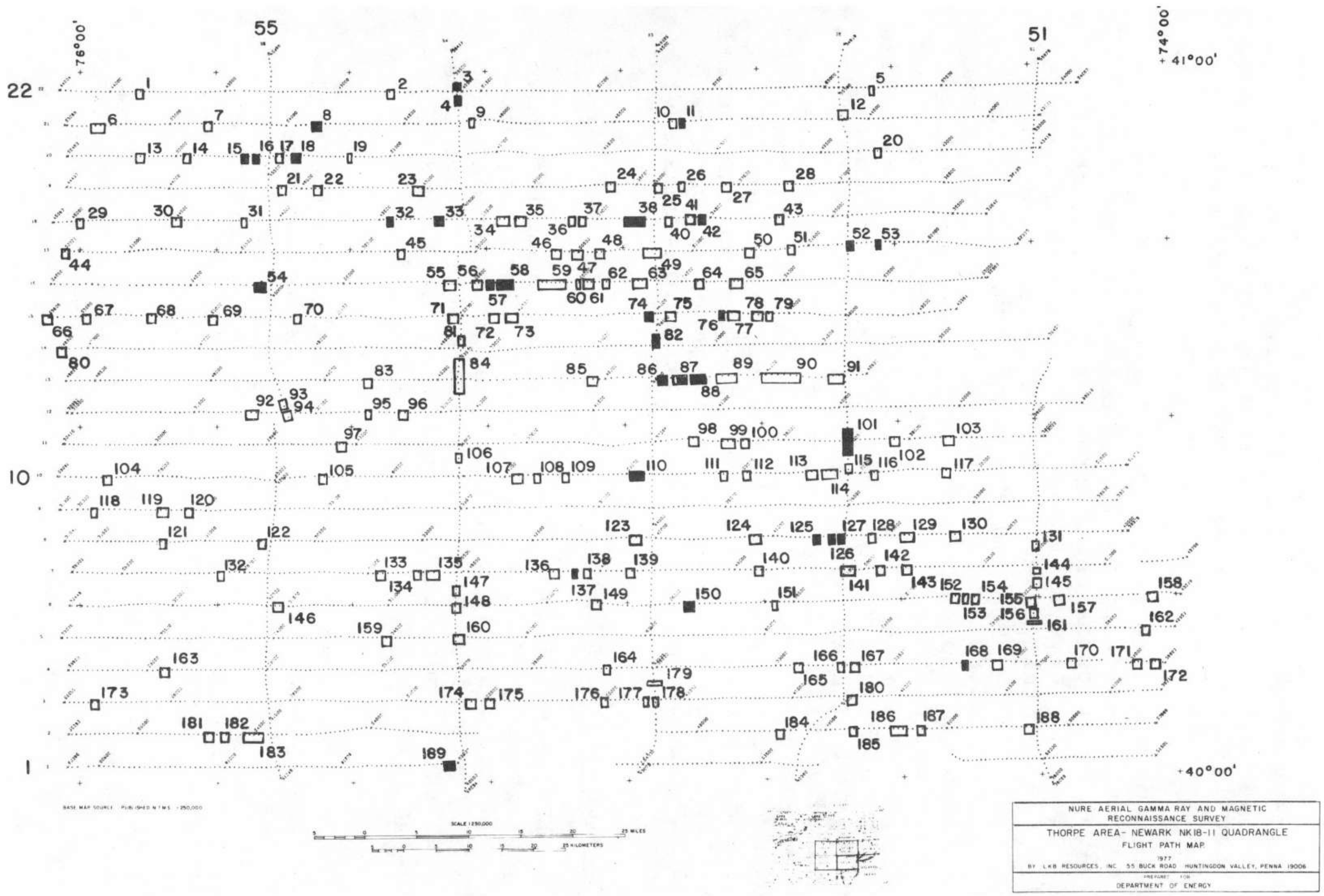
Accordingly, the definition of a reliable anomaly is based on certain groupings of adjacent statistically high or low points more than one standard deviation from the mean. Of these, the acceptable significant eU anomalies or anomalous zones were selected according to one or more of the following criteria:

1) One (averaged) data point 3 or more standard deviations (sigma) above the mean.
2) Two adjacent (averaged) data points between 2 and 3 sigma above the mean.
3) Three adjacent (averaged) points where two are between 1 and 2 sigma, and one is between 2 and 3 sigma above the mean.
4) Four adjacent (averaged) points between 1 and 2 sigma above the mean.

While the above criteria may be refined in the course of future analyses, they have produced satisfactory results in the case of the present survey as well as previous projects in other areas, and have the additional advantage of affording some degree of continuity and standardization with regard to the evaluation of airborne survey anomalies in the context of the NURE program.

8.3.2 Evaluation of Anomalies

Following the selection of significant eU anomalies on the uranium anomaly map, a transparent overlay of the outlined anomalous zones was prepared and examined in conjunction with the topographic and



LEGEND

(open box) STATISTICALLY SIGNIFICANT eU ANOMALIES

(solid box) PREFERRED ANOMALIES SUPPORTED BY STATISTICALLY HIGH eU/eTh AND eU/K VALUES

FIGURE - 10 EQUIVALENT URANIUM ANOMALY MAP - NEWARK QUADRANGLE geologic maps, the photogeologic enhancement study data, the supporting data tables, and the balance of the statistically derived anomaly maps to evaluate each eU anomaly in terms of its potential as an indication of true uranium enrichment deserving further investigation. The essential results of these comparative analyses are summarized in Table 4.

During this phase of the interpretation, the photogeologic enhancement study of the flight path film comprised important additional evaluation criteria which have not been available in the case of previous surveys of this type. At the present stage of application of this data, particularly in the eastern portion of the Thorpe area, perhaps the most useful criterium is that of the widespread agricultural activity, since the gamma radiation from potassium and phosphate fertilizers can produce significant background radiation over short distances. For example, several anomalies in the southern part of the crystalline complex of the Appalachian structural front (i.e., the Reading Prong) are identified with active agricultural areas, while others, particularly in the northern part of this crystalline complex, are not identified with agriculture. Thus, one can conclude with some certainty that while the northeast part of this crystalline complex is indeed an area of stronger than normal radioactivity, the anomalous responses in the southern part may be compromised to some degree by surficial conditions related to manmade activity.

8.3.3 Discussion of Anomalies

Of the total of 189 statistically significant eU anomalies shown in Figure 10 and listed in Table 4, 31 preferred anomalies have been selected which show significant relative enrichment of eU over eTh and K. It should be noted that this selection has taken into account statistical adequacy of sampling as well, and thus excludes anomalies correlating with sparsely sampled geologic units.

The geologic units associated with the preferred anomalies fall into three principal groups: the Precambrian gneisses of the crystalline highlands belt, particularly the Byram gneiss; the Stockton and Lockatong formations of the Triassic Lowlands; and the Ordovician through Devonian shales and sandstones along the margins of the folded Appalachians.

In addition to these units, the Brunswick Formation of Triassic age also exhibits a considerable amount of anomalous radioactivity in this area. Inasmuch as the significant uranium anomalies noted over this unit are generally accompanied by some degree of thorium and potassium response as well as low eU/eTh and eU/K ratios, they have not been included in the preferred anomaly category except for the particularly strong response at Anomaly 101. However, the widespread anomalous conditions associated with the Brunswick suggest that it may deserve some consideration as a potential host for uranium mineralization in the context of follow-up investigation programs.

The following notes comprise specific comments on the preferred anomalies noted in Table 4 with regard to geologic setting, surficial conditions, and structural associations, where applicable.

Anomalies 3 and 4 - Situated on Profile 54 over Devonian shales of the Hamilton Group. Moderate uranium responses distinguished by a lack of corresponding significant thorium and potassium response. Strong eU/eTh and eU/K ratios are present.

Anomaly 8 - Occurrence in Devonian shales and sandstones of the Catskill Formation. Characterized by weak anomalous response.

Anomaly 11 - Situated in Ordovician limestone at the contact with an extensively fractured area of Byram and Pochunk gneisses and the Franklin limestone (marble). Outcrops are common in the area. Displays moderate to strong anomalous conditions.

Anomaly 15 - Weak anomaly located in the Pocono Group of Mississippian age in an area of known mineralization. The uranium prospects of Mt. Pisgah are located a few miles to the southwest. Outcrops are noted in the area.

Anomaly 16 - Moderate uranium response situated in the Catskill Formation of Devonian age, in an area of known mineralization.

Anomaly 18 - Weak anomaly located in Devonian shales and sandstones. There are no known uranium prospects in these formations of the Devonian. Both culture and extensive agriculture are observed in this area.

Anomalies 32 and 33 - Moderate responses located in Ordovician shales of the Martinsburg Formation. Active agriculture and culture are noted in the immediate area of these anomalies.

Anomaly 38 - Elongate anomalous zone situated primarily over Ordovician dolomites, but also associated with the contacts of Byram gneiss with Cambrian quartzites and the dolomites.

Anomaly 42 - Weak uranium anomaly located in the Precambrian Byram gneiss complex near the contact with a unit of Losee gneiss. Possible pegmatitic occurrence.

Anomalies 52 and 53 - Relatively isolated uranium responses in Precambrian gneisses, distiguished by strong eU/eTh ratios.

Anomaly 54 - Moderate response over Ordovician shales of the Martinsburg Formation, on strike with Anomalies 32 and 33 to the north.

Anomalies 57 and 58 - An extensively faulted zone of Byram gneiss, bringing Leithsville shales and dolomites along with other Precambrian gneisses into contact with the Byram.

Anomalies 74 and 76 - Moderately strong responses situated in Precambrian gneisses at or near contacts with Ordovician limestones and Triassic conglomerates, respectively.

Anomaly 82 - Strong, extensive zone of uranium response situated in undifferentiated units of the Ordovician Martinsburg Formation.

Anomalies 86, 87 and 88 - Relatively concentrated group of strong uranium responses over Triassic continental sediments of the Lockatong Formation.

Anomaly 101 - Extensive zone of strong uranium response compromised to some degree by corresponding anomalous activity in the thorium and potassium channels. Situated in the Brunswick Formation of Triassic age in an area of diabase intrusions. Outcrops are noted in the zone.

Anomaly 110 - Strong uranium anomaly in the Triassic Stockton Formation.

Anomalies 125, 126 and 127 - Probably in a basal conglomerate of the Stockton Formation near the Cretaceous Coastal Plain contact.

Anomaly 137 - Located on a Paleozoic-Triassic contact. This unique Paleozoic wedge lies well within the Triassic Lowland. It is fault controlled on its southern and eastern sides and the anomaly occurs near the fault bounding the southern edge of the zone.

Anomaly 150 - Exceptionally sharp anomaly in the Triassic Stockton Formation in an agricultural area containing outcrops.

Anomaly 168 - Moderate uranium response located in Tertiary sands of the Coastal Plain. Possible heavy mineral concentration.

Anomaly 189 - Sharp, isolated anomaly over lower Paleozoic metamorphics of the Wissahickon Formation near a major fault contact.

8.4 CONCLUSIONS

The results of the gamma-ray spectrometer survey indicate that the Newark Quadrangle portion of the Thorpe area can be considered as a uraniferous province, although the character of both the known uranium occurrences as well as those potentially defined by the airborne survey suggest that the mineralization is low grade and relatively widely distributed. The present survey indicates the preferred host rocks for mineralization to be the Precambrian gneisses of the crystalline highlands belt, particularly the Byram gneiss; the older members of the Triassic Lowlands series, i.e. the Stockton and Lockatong Formations; and the Ordovician through Devonian shales and sandstones along the margins of the folded Appalachians.

In addition, considering the distribution of all significant and preferred uranium anomalies in the area as a whole, a curious concentration is observed along a persistent, northwest-southeast trending linear zone which suggests the possible presence of some fundamental structural control not readily apparent in the regional geology. Further investigations are undoubtedly required to assess this hypothesis.

8.5 SUGGESTIONS FOR FURTHER WORK

Further work can be considered in three general categories:

a) airborne follow-up
b) ground studies
c) sub-surface studies

Airborne follow-up using gamma-ray detectors is indicated in at least four of the six geologic provinces delineated on Figure 9 of this report. A magnetometer should certainly be incorporated into the airborne instrumentation, but perhaps an equally valuable project should be completed first. Accordingly, it is suggested that a compilation of all the available airborne magnetic data in the area should be initiated. This compilation could start with the readily available, low level magnetic data over much of the Newark Quadrangle and the southern third of the Harrisburg quadrangle that has already been published by the U.S.G.S., supplemented with Coastal Plain surveys and others that exist in the files and archives of state and federal agencies, as well as from private sources. A good magnetic compilation of New Jersey, eastern Pennsylvania and western New York would resolve many of the regional questions concerning structural relationships raised by this survey.

Several of the eU anomalies noted in this survey are worthy of field investigation to evaluate their significance as zones of uranium enrichment. Furthermore, those occurrences in the Triassic and Paleozoic provinces should be investigated in the field to determine if there are any structural or stratigraphic correlations with, or extrapolations into, the known uranium prospects occurring in these two zones.

The implementation of alpha detectors for sub-surface investigation in many of the suspected uraniferous districts would be particularly useful in Pennsylvania and New Jersey because of the destructive effects of glacial overburden and mine or quarry tailings spread over large portions of the area.

Finally, a program of radon analysis of water wells and springs would be invaluable, also because of the overburden problems.

TABLE 4 EQUIVALENT URANIUM ANOMALIES - NEWARK QUADRANGLE

Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	Number of Points: eU +	eU ++	eU +++	eTh +	eTh ++	eTh +++	K +	K ++	K +++	eU/eTh +	eU/eTh ++	eU/eTh +++	eU/K +	eU/K ++	eU/K +++
1	22	Ppp/Pp	4	2	2	–	2	1	1	2	–	–	–	–	–	1	–	–
2	22	Dck	1,3P,5	4	–	–	3	–	–	1	–	–	1	–	–	–	–	–
3*	54	Dh	1,3P,5	2	1	–	1	–	–	–	–	–	–	1	1	1	–	2
4*	54	Dh	1,3P	5	–	1	–	–	–	–	–	–	–	2	1	1	1	1
5	22	Sgp	7	–	–	1	–	1	–	–	–	1	–	–	1	–	–	1
6	21	Pp/Ppp	4,5,7	6	2	1	3	2	–	4	3	–	1	–	–	1	–	–
7	21	Mp	1,7	2	1	–	1	–	–	2	–	–	1	–	–	–	–	–
8*	21	Dck	1,5	2	2	–	–	–	–	1	–	–	1	1	–	1	–	–
9	21	Doh	3P,5	–	–	2	–	2	–	–	–	2	–	–	2	–	–	2
10	21	fl/bgn/pgn/lgn	7	2	2	–	1	1	1	–	–	–	–	–	–	1	1	–
11*	21	Ob	7	–	–	1	–	1	–	–	–	1	–	–	1	–	–	1
12	21 & 52	Sd/Sgp	–	2	–	1	–	–	–	–	–	1	1	1	1	3	–	1
13	20	Mp	5	2	1	–	3	–	–	2	–	–	–	–	–	1	–	–
14	20	Mp	5,7	2	1	–	3	–	–	2	–	–	–	–	–	1	–	–
15*	20	Mp	5,7	3	1	–	1	–	–	3	–	–	–	–	–	–	–	–
16*	20	Dck	1,5	2	1	–	–	–	–	–	–	–	–	2	–	2	–	–
17	20	Dck	3,5	3	1	–	3	1	–	2	–	–	–	–	–	–	–	–
18*	20	Dm/Dh	3,5	6	–	–	–	–	–	–	–	–	2	–	–	4	–	–
19	20	Dck	3,5	–	2	–	2	–	–	2	–	–	–	–	–	–	–	–
20	20	lgn	5	1	1	1	–	–	1	–	–	–	1	1	–	–	1	2
21	19	Dck	3P	2	1	–	–	–	–	–	–	–	–	–	–	–	–	–
22	19	Dck/Dm	3C	3	2	–	3	–	–	4	–	–	–	1	–	–	–	–
23	19	Sbm/Ss	–	5	1	–	–	–	–	1	–	–	3	–	–	1	1	–
24	19	Ob	3,5	5	–	–	–	–	–	–	–	–	–	–	–	1	–	–
25	19 & 53	Ob/bgn	1,5,7	5	2	–	2	–	–	5	–	–	–	–	–	–	–	–
26	19	Cha/bgn	1,3,5,7	4	–	–	2	1	1	2	1	–	–	–	–	–	–	–
27	19	Ob/bgn	1,3,5,7	4	–	–	1	–	–	1	–	–	1	–	–	–	–	–
28	19	Q	3P,5,7	4	–	–	2	2	–	–	–	–	–	–	–	3	–	–
29	18	Ppp	4,5,7	2	1	–	1	–	–	2	–	–	–	–	–	1	–	–
30	18	Dh	1,7	3	2	–	3	–	–	1	–	–	–	1	–	1	–	–
31	18	Dh	3,7	1	2	–	1	–	–	1	1	–	–	–	–	–	–	–
32*	18	Oms	3,5	–	2	1	–	–	–	–	–	–	2	1	–	1	–	–
33*	18	Oms	3,5	3	3	1	1	–	–	–	–	–	–	2	1	4	1	–

TABLE 4 EQUIVALENT URANIUM ANOMALIES - NEWARK QUADRANGLE

Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	Number of Points: eU +	eU ++	eU +++	eTh +	eTh ++	eTh +++	K +	K ++	K +++	eU/eTh +	eU/eTh ++	eU/eTh +++	eU/K +	eU/K ++	eU/K +++
34	18	Om	1,3P,5,7	7	-	-	3	-	-	2	-	-	-	-	-	-	-	-
35	18	Om	2,3P,5,7	6	-	-	1	-	-	-	-	-	1	-	-	-	-	-
36	18	bgn/Cha	3P,5,7	1	3	-	1	1	-	-	-	-	-	-	-	-	2	-
37	18	bgn	3C	-	-	3	-	1	2	-	-	-	-	-	-	-	-	3
38*	18	bgn/Cha/Ob	1,3,5,7	8	3	1	1	1	1	6	-	-	5	2	-	-	-	-
39	53	bgn/Cha	1,5,7	1	2	-	3	-	-	5	-	-	-	-	-	-	-	-
40	18	Om	1,5,7	1	2	-	-	-	-	2	-	-	1	1	-	-	-	-
41	18	Ob	1,2,3P,5	4	-	-	3	-	-	3	-	-	1	-	-	-	-	-
42*	18	bgn	3	2	1	-	-	-	-	1	-	-	1	1	-	-	1	-
43	18	Cha/bgn	1,5,7	4	-	-	1	-	-	2	-	-	-	-	-	-	-	-
44	17	Mmc	3,5	1	-	1	1	-	-	2	-	-	1	1	-	1	-	-
45	17	Om	1,3P,5	4	-	-	2	1	-	3	-	-	-	-	-	-	-	-
46	17	bgn	1,5,7	4	1	-	-	-	-	4	-	-	1	-	-	-	-	-
47	17	bgn	1,3,5,7	2	2	-	-	-	-	1	3	-	3	-	-	-	-	-
48	17	Ob	1,3	4	-	-	2	-	-	3	1	-	-	-	-	-	-	-
49	17 & 53	Ob	1,3P,5	9	1	-	9	1	-	6	-	-	-	-	-	-	-	-
50	17	bgn	1,5	3	1	-	1	2	-	1	-	-	-	-	-	-	-	-
51	17	lgn	7	2	1	-	-	3	-	-	-	-	-	-	-	-	-	-
52*	52	bgn	1,3P,5	3	2	-	-	-	-	-	-	-	1	1	2	-	1	-
53*	17	lgn	5	1	-	1	-	-	-	-	-	-	-	1	1	-	-	2
54*	16	Oms	-	5	1	-	-	-	-	-	-	-	1	-	1	-	-	-
55	16	Ob	1,3,5	4	-	-	-	-	-	-	-	-	2	-	-	-	2	-
56	16	Cal	3P,5	4	2	-	1	-	-	1	-	-	2	1	-	1	2	-
57*	16	Clv/bgn/gn	1,3P,5	-	2	3	2	-	-	1	-	1	4	-	-	3	-	-
58*	16	Clv/gn/bgn/ Cal/Cha	1,5,7	6	2	3	4	3	-	2	-	-	5	-	2	6	2	1
59	16	Ob	1,3P,5	8	9	1	12	2	1	10	5	-	2	-	-	-	-	-
60	16	Ob	3	2	1	-	2	-	-	1	-	-	-	-	-	-	-	-
61	16	gn	3P,5,7	6	2	-	1	5	-	-	2	6	-	-	-	-	-	-
62	16	Ob/Ohm/Om	3,5	4	1	-	1	2	-	2	2	-	-	-	-	-	-	-
63	16	bgn	1,3P,3	1	5	3	2	4	2	-	-	-	-	-	-	5	1	3
64	16	lgn	1,3P	1	1	1	2	-	1	-	-	-	1	-	-	-	1	2
65	16	bgn	1,3,5,7	5	1	-	3	1	-	-	-	-	-	-	-	-	2	-
66	15	Sbm	5	3	1	-	-	4	-	3	1	-	-	-	-	-	-	-

TABLE 4 EQUIVALENT URANIUM ANOMALIES - NEWARK QUADRANGLE

				Number of Points														
				eU			eTh			K			eU/eTh			eU/K		
Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	+	++	+++	+	++	+++	+	++	+++	+	++	+++	+	++	+++
67	15	Ss	3P	1	2	-	-	1	-	1	-	1	-	-	-	-	-	-
68	15	Om	5	4	-	-	-	-	-	3	-	-	-	-	-	-	-	-
69	15	Oms	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70	15	Om	3,7	3	1	-	-	-	-	2	-	-	1	1	-	-	-	-
71	15	Cal	3,5	4	-	-	2	-	-	-	-	-	1	1	-	-	-	-
72	15	Cah/Cha	1,3P,5	3	2	-	1	1	-	2	1	2	-	-	-	-	-	-
73	15	gn	1,5,7	4	2	-	2	1	-	4	-	1	1	-	-	-	-	-
74*	15	gn	1,3,5	-	1	1	1	-	-	-	-	-	-	-	1	1	-	1
75	15	bgn	1,3P,5	2	2	-	1	-	-	1	-	-	1	-	-	1	-	-
76*	15	lgn	1,3P,5	1	-	1	1	-	-	1	1	-	-	-	1	-	-	-
77	15	Trc/Trb	1,5	2	3	1	4	-	-	4	1	-	2	-	-	-	-	-
78	15	Trb	5	6	-	-	-	-	-	4	-	-	3	-	-	-	-	-
79	15	Trb	3C	2	1	-	-	-	-	-	-	-	3	-	-	1	-	-
80	14	Sbm	1,3P,5,7	2	1	-	2	1	-	1	2	-	1	-	-	-	-	-
81	54	hg/gn	-	3	1	-	-	-	-	2	-	-	3	-	-	-	-	-
82*	53	Om	1,2,3P,5	4	-	3	-	-	-	2	3	2	1	1	4	-	-	-
83	13	Clv/Cha	5,7	1	4	-	1	2	-	1	-	-	-	-	-	2	-	-
84	54	gn/hg/Cha/Clv	1,5,7	13	3	2	6	5	-	7	-	-	4	-	-	-	-	-
85	13	Trb	1,3	4	-	-	-	-	-	-	-	-	2	1	-	1	-	-
86*	13	Trl	3,5	1	1	1	-	-	-	2	-	-	1	-	2	-	1	-
87*	13	Trl	3,5,7	4	2	1	1	-	-	1	-	-	5	-	1	3	-	1
88*	13	Trl/Trd	1,3P,7	3	3	1	2	-	-	2	-	-	3	1	-	1	-	2
89	13	Trb	1,3,5	5	3	-	-	-	-	2	-	-	5	-	-	-	-	-
90	13	Trb	3P,5,7	14	3	-	5	-	-	7	-	-	4	1	-	-	-	-
91	13	Trb	5	5	-	-	-	-	-	-	-	-	3	-	1	1	2	-
92	12	Cal	3C	6	1	-	2	-	-	1	-	-	1	-	-	-	3	-
93	55	Ob/Cal	1,3,5	3	1	-	3	-	-	1	-	-	1	-	-	-	-	-
94	55	Cal/Clv	3,5	2	3	-	4	-	-	6	1	1	1	1	-	-	-	-
95	12	gn	3	-	-	1	1	1	-	-	-	-	-	-	-	-	-	1
96	12	gn/Clv/Trb	1,3P,5	2	1	1	1	1	-	1	1	-	-	1	-	1	-	-
97	11	hg/gn/Cha	3,5	2	2	-	1	3	-	2	-	-	-	-	-	-	-	-
98	11	Trb	3C	3	1	-	2	1	-	1	-	1	-	-	-	-	-	-
99	11	Trb	3,5	5	3	-	4	-	-	4	-	-	2	-	-	2	-	-

TABLE 4 EQUIVALENT URANIUM ANOMALIES - NEWARK QUADRANGLE

				Number of Points														
				eU			eTh			K			eU/eTh			eU/K		
Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	+	++	+++	+	++	+++	+	++	+++	+	++	+++	+	++	+++
100	11	Trb	1,3	3	1	-	3	-	-	3	1	-	-	-	-	-	-	-
101*	11 & 52	Trb	1,3,7	7	4	5	9	-	-	9	3	-	5	2	1	6	-	-
102	11	Trb	3P	3	1	-	-	-	-	1	-	-	3	-	-	1	-	-
103	11	Trb/Kmr	5	3	1	-	-	-	-	1	2	-	1	1	-	-	1	-
104	10	Ori/Os/Cal	3C	1	-	2	-	2	-	1	-	2	1	-	1	-	-	2
105	10	Trb	3	-	2	-	1	-	-	2	-	-	1	-	-	-	-	-
106	54	Trb	3,5	4	2	-	2	-	-	-	-	-	2	-	-	3	-	-
107	10	Trb	1,3	3	2	-	2	-	-	1	1	-	1	1	-	1	-	-
108	10	Trl/Trb	1,3P,5	1	2	-	2	-	-	3	-	-	2	-	-	-	-	-
109	10	Trl	1,3,5	3	1	-	-	-	-	-	-	-	3	-	1	-	-	-
110*	10	Trs	1,3P,5	3	1	3	-	-	-	-	-	-	2	1	3	2	2	-
111	10	Trb	1,5	-	2	-	1	-	-	-	-	-	1	-	-	1	-	-
112	10	Trd	5,7	2	1	-	1	-	-	-	-	-	1	1	-	1	1	-
113	10	Trb	1,3P,5	4	4	-	3	-	-	4	1	-	4	-	-	2	-	-
114	10	Trb	3C	2	3	2	4	-	-	2	4	-	5	-	-	-	-	-
115	52	Trb	3C	2	3	2	3	-	-	3	-	-	2	2	-	2	1	-
116	10	Trb	3,5	2	1	-	1	-	-	1	-	-	1	-	-	1	-	-
117	10	Kmr	5	1	1	1	-	-	-	1	-	-	2	1	-	2	-	-
118	9	Oe/Ori	5	1	-	1	-	1	-	-	-	1	-	-	1	1	-	1
119	9	hg/gn	1,3P,7	2	1	3	-	1	3	-	-	-	1	2	-	1	1	3
120	9	gn/Om	3P,5	3	-	2	2	1	1	-	-	-	2	-	-	1	1	2
121	8	gn	5	2	1	-	1	-	2	1	-	-	-	-	-	-	-	-
122	8	gg	3P,5	-	1	1	-	-	2	1	-	-	-	-	-	1	-	1
123	8	Trb	3P,5	3	2	-	4	1	-	1	-	-	1	-	-	-	-	-
124	8	Trb	1,3P,5	1	3	-	1	-	-	-	-	-	2	-	-	1	1	-
125*	8	Trs	3P,5	1	1	1	-	-	-	-	-	-	1	1	1	-	1	1
126*	8	Trs	1,3P	2	1	-	-	-	-	-	-	-	-	2	-	-	-	-
127*	8	Trs	1,3P	1	2	-	-	-	-	-	-	-	3	-	-	2	-	-
128	8	Kmr	3C	2	1	-	1	1	-	2	-	-	-	-	-	-	-	-
129	8	Kmr	3P,5	3	2	2	4	2	-	4	-	-	1	1	-	2	-	-
130	8	Kwb	3C	2	-	1	3	1	-	-	-	-	1	-	-	1	1	-
131	51	Kmw	1,3,5	-	-	1	-	-	-	1	-	1	1	-	-	-	-	-
132	7	Trb	1,3	-	2	-	-	-	-	-	-	-	1	-	-	2	-	-

TABLE 4 EQUIVALENT URANIUM ANOMALIES - NEWARK QUADRANGLE

Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	eU +	eU ++	eU +++	eTh +	eTh ++	eTh +++	K +	K ++	K +++	eU/eTh +	eU/eTh ++	eU/eTh +++	eU/K +	eU/K ++	eU/K +++
				Number of Points														
133	7	Trb/Trl	1,3P,5	2	1	1	3	-	-	4	-	-	1	-	-	-	-	-
134	7	Trb	1,3,5	1	2	-	2	-	-	2	-	-	1	-	-	-	-	-
135	7	Trb	3,5	3	2	-	4	-	-	1	-	-	-	-	-	1	-	-
136	7	Trs/Trqc	1,3P,5	4	-	-	3	-	-	2	1	-	-	-	-	-	-	-
137*	7	Trs	5	-	-	2	-	2	-	-	-	2	-	-	2	-	-	2
138	7	Trb	3,5	-	-	1	1	1	-	2	-	-	1	-	-	1	-	-
139	7	Trb	3P,5	2	3	-	3	-	-	-	-	-	3	-	-	3	-	-
140	7	Trl	1,3P,5	1	2	-	-	-	-	-	-	-	3	-	-	2	-	-
141	7 & 52	Kmr	3P,5	4	1	-	-	-	-	1	-	-	-	1	-	-	-	-
142	7	Kmr	3,5	-	2	1	1	-	-	2	-	-	1	-	-	2	1	-
143	7	Kwb	1,3P,5	1	1	1	2	-	-	1	-	-	-	1	-	2	1	-
144	51	Tht	1,3P	1	-	3	1	-	-	1	-	-	-	-	-	-	-	-
145	51	Tht/Krb/Tvt	1,3P,5	5	1	1	3	1	-	1	1	-	-	-	-	-	-	-
146	6	Trb	5	4	1	-	2	1	1	2	-	-	1	-	-	-	-	-
147	54	Trb	1,3,5	2	1	-	4	-	-	-	-	-	-	-	-	1	-	-
148	54	Trb	3	2	2	-	1	-	-	-	-	-	1	-	-	1	-	-
149	6	Trl/Trs	3,5	3	1	-	1	-	-	1	1	1	1	-	-	-	-	-
150*	6	Trs	1,3,5,7	-	1	3	-	-	-	-	-	-	1	1	2	2	1	1
151	6	Xw/gb	5	-	-	2	-	2	-	-	-	2	-	2	-	-	-	2
152	6	Krb/Kns	3	4	-	-	-	-	-	-	-	-	1	1	-	-	-	-
153	6	Kns	3P,5	-	2	1	-	-	-	2	1	-	-	1	1	-	-	-
154	6	Kns/Kmw	3P,5	-	1	1	-	-	-	-	-	2	-	1	-	-	-	-
155	6	Krb/Tht	3,5	3	2	-	3	2	-	1	-	-	-	-	-	-	-	-
156	51	Krb/Tht/Tvt	3,5	3	2	-	1	-	-	-	1	-	1	-	-	2	-	-
157	6	Tkw	3,5	1	2	1	3	-	1	-	2	1	-	-	-	-	-	-
158	6	Tkw	1,3P,5	3	1	-	-	-	-	3	-	-	2	-	-	-	-	-
159	5	Trb	1,5,7	4	-	-	2	-	-	-	-	-	1	-	-	1	-	-
160	5 & 54	Trb/Trl	1,3P,5	3	-	1	2	-	-	-	-	-	1	-	-	5	-	-
161	51	Tvt	3,5	1	-	1	2	1	-	2	-	-	-	-	-	-	-	-
162	5	Tkw	-	2	1	-	1	1	-	-	-	-	-	-	-	1	-	-
163	4	Cv/Trs/Cch/ Trd	1,3P,5	1	3	-	2	-	-	1	1	-	1	-	-	1	-	-
164	4	Trs/gn	5	-	-	1	-	1	-	-	-	1	-	1	-	-	-	1

TABLE 4 EQUIVALENT URANIUM ANOMALIES - NEWARK QUADRANGLE

Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	Number of Points eU +	eU ++	eU +++	eTh +	eTh ++	eTh +++	K +	K ++	K +++	eU/eTh +	eU/eTh ++	eU/eTh +++	eU/K +	eU/K ++	eU/K +++
165	4	Kmv/Kwb	5	2	2	-	2	-	-	1	-	-	2	-	-	1	1	-
166	4 & 52	Ket	3C	3	2	-	1	-	-	1	1	-	2	-	-	2	-	-
167	4	Ket/Kmt	1	1	4	-	3	1	-	1	-	-	-	-	-	-	-	-
168*	4	Tch	1,5	-	1	1	-	-	-	-	-	-	1	-	1	-	-	-
169	4	Tkw	-	2	1	-	-	-	-	-	-	-	-	-	-	-	1	2
170	4	Tkw	5	3	1	-	2	-	-	-	-	-	1	-	-	-	3	-
171	4	Tkw	3,5	1	1	1	2	2	-	2	-	-	1	-	-	-	-	-
172	4	Tkw	5	4	1	-	-	-	-	-	-	-	2	-	-	-	-	-
173	3	Ce	1	2	1	-	2	-	-	3	-	-	-	-	-	-	-	-
174	3	Cch	1,3P,4,5	4	1	-	-	-	-	-	-	-	3	1	-	2	-	-
175	3	Cch	-	4	-	-	1	2	-	-	-	-	-	-	-	1	-	-
176	3	Xw	-	1	2	-	-	1	-	-	-	-	2	-	-	1	-	1
177	3	Xw/Qp	3C	2	2	-	4	-	-	-	-	-	1	-	-	3	1	-
178	3	Qp	3,4,5	2	1	-	-	-	-	-	-	-	2	-	-	2	-	-
179	53	Xw/Xhg	3C	-	-	1	-	-	1	1	-	-	-	-	-	1	-	-
180	3	Kns	1	1	2	-	-	-	-	-	2	1	1	1	-	-	-	-
181	2	qm/g	1	2	1	-	-	-	-	1	-	-	2	-	-	1	-	-
182	2	gg/md	1	-	-	1	-	1	-	-	-	1	-	-	-	-	-	1
183	2	gg/qm/g/gd	1,3P,5,7	3	1	7	2	2	6	5	1	-	-	-	-	5	1	1
184	2	Ket	1,3,5	1	2	-	2	1	-	1	-	-	-	-	-	-	-	-
185	2	Tch/Tkw	3	-	1	1	1	-	-	-	2	-	-	1	-	-	-	-
186	2	Tkw	3P,5	3	4	2	2	2	-	1	3	-	3	1	-	-	-	-
187	2	Tch	3,5	2	1	-	-	-	-	-	-	-	1	1	-	2	-	1
108	2	Tch	5	3	1	-	2	-	-	-	-	-	1	-	-	-	1	-
189*	1	Xw	-	-	-	2	-	2	-	-	-	2	-	-	2	-	-	2

* PREFERRED ANOMALY

** SEE SECTION 7.3 FOR EXPLANATION OF P.G.E. CATEGORY CODES. THE LETTER "P" AND "C" INDICATE PARTIAL OR COMPLETE COVERAGE BY AGRICULTURAL ACTIVITY IN THE ANOMALOUS ZONE.

SECTION 9.0

REFERENCES

9.1 GENERAL BIBLIOGRAPHY

Adams, J. A. S., Kline, M. C., Richardson, K. A., and Rogers, J. J. W. THE CONWAY GRANITE OF NEW HAMPSHIRE AS A MAJOR LOW-GRADE THORIUM RESOURCE National Academy of Sciences Bulletin, Vol. 48, No. 11, p. 1898-1905, November 1962

Adams, John S. and Gasparini, Paolo - GAMMA-RAY SPECTROMETRY OF ROCKS - Elsevier Publ. Co. N. Y., 1970

Adkinson, C. W. and Reimer, G. M. - HELIUM AND RADON-EMANATION BIBLIOGRAPHY - U. S. Geol. Survey Open-File Report 76-860, 1976

Anderson, Paul L., and Cho, Namok - ANALYSIS OF COPPER, LEAD, AND ZINC BY ATOMIC ABSORPTION SPECTROPHOTOMETRY - Alaska State Division of Mines and Geology, Laboratory Report No. 2, May 1969

Anderson, Paul L., and Mitchell, Michael Jr., - A RAPID RADIOMETRIC ANALYSIS FOR EQUIVALENT URANIUM - Alaska State Division of Mines and Geology, Laboratory Report No. 1, May 1969

Ashley, G. H. - GENERAL INFORMATION ON COAL - 1928 (2nd printing, 1961) Part 1 in BITUMINOUS COAL FIELDS OF PENNSYLVANIA - Penna. State Geol. Survey Mineral Resource Report M 6

Baird-Atomic Applications Laboratory - SCINTILLATION COUNTING - Technical Report AL - 3A, June 1966

Beck, M. E. Jr. and Mattick, R. E. - INTERPRETATION OF AN AEROMAGNETIC SURVEY IN WESTERN PENNSYLVANIA AND PARTS OF EASTERN OHIO, NORTHERN WEST VIRGINIA AND WESTERN MARYLAND - Penna. State Topographic & Geol. Survey Inform. Circ. 52, 1964

Bowie, S. H. U., Davis, Michael and Ostle, Dennis (editors) - URANIUM PROSPECTING HANDBOOK - publ. by The Institution of Mining and Metallurgy, London 1972 (reprinted 1974)

Breiner, S., Lindow, J. T., and Kaldenbach, R. J. - GAMMA-RAY MEASUREMENT AND DATA REDUCTION CONSIDERATIONS FOR AIRBORNE RADIOMETRIC SURVEYS - Abstract, Paper No. 34, Internat'l Symposium on Exploration of Uranium Ore Deposits, Vienna March 29 - April 2, 1976

Briggs, R. P. - ENVIRONMENTAL GEOLOGY, ALLEGHENY COUNTY AND VICINITY, PENNSYLVANIA - U. S. Geol. Survey Circular C-747, 1977

Burrus, Walter R. - UNSCRAMBLING SCINTILLATION SPECTROMETER DATA - IRE Transactions on Nuclear Science, p. 102-110, approx. 1960

Cooper, F. D. - THE MINERAL INDUSTRY OF PENNSYLVANIA IN 1970 - Penna. Geol. Survey Inform. Circular IC 73, 1972

____________ - THE MINERAL INDUSTRY OF PENNSYLVANIA IN 1971 - Penna. Geol. Survey Inform. Circular IC 74, 1974

____________ - THE MINERAL INDUSTRY OF PENNSYLVANIA IN 1972 - Penna. Geol. Survey Inform. Circular IC 78, 1975

____________ - THE MINERAL INDUSTRY OF PENNSYLVANIA IN 1973 - Penna. Geol. Survey Inform. Circular IC 81, 1976

Curtiss, Leon F. - MEASUREMENTS OF RADIOACTIVITY - Nat'l Bureau of Standards Circular 476, October 15, 1949

Drake, A. A. Jr., and Epstein, J. B. - THE MARTINSBURG FORMATION (MIDDLE AND UPPER ORDOVICIAN) IN THE DELAWARE VALLEY, PA. - N. J. - U. S. Geol. Survey Bull. 1244-H, p. H1 - H16, 1967

Edmunds, W. E. and Koppe, E. F. - COAL IN PENNSYLVANIA - Penna. Geol. Survey, Educ. Series ES 7, 1976

Epstein, A. G., Spink, W. J. and Jennings, D. S. - UPPER SILURIAN AND LOWER DEVONIAN STRATIGRAPHY OF NORTHEASTERN PENNSYLVANIA, NEW JERSEY, AND SOUTHEASTERNMOST NEW YORK, U. S. Geol. Survey Bull. 1243, 1967

Freedman, Jacob - GEOCHEMICAL PROSPECTING FOR ZINC, LEAD, COPPER, AND SILVER, LANCASTER VALLEY, SOUTHEASTERN PENNSYLVANIA - p. C1 - C49, 1972

Gabelman, John W. - MIGRATION OF URANIUM AND THORIUM-EXPLORATION SIGNIFICANCE - Studies in Geology 3, AAPG, 1977

Geodata International Incorp. - THE DEVELOPMENT OF AN ATMOSPHERIC 214/Bi MEASURING INSTRUMENT - Prepared for U.S. ERDA, November 7, 1965

Geyer, A. R. and McGlade, W. G. - ENVIRONMENTAL GEOLOGY FOR LAND-USE PLANNING - Penna. Geol. Survey Report EG 2, 1972

Glaeser, J. D. - PROVENANCE, DISPERSAL, AND DEPOSITIONAL ENVIRONMENTS OF TRIASSIC SEDIMENTS IN THE NEWARK-GETTYSBURG BASIN - Penna. Geol. Survey Report G 43, 1974 (2nd printing)

Goldak, G. R. - HELIUM-4 MASS SPECTROMETRY FOR URANIUM EXPLORATION - Tech. paper 74-L-44, AIME Annual Meeting, February 1974

Goodwin, B. K. - GUIDEBOOK TO THE GEOLOGY OF THE PHILADELPHIA AREA - Penna. Geol. Survey G 41, 1964

Grasty, R. L. - A CALIBRATION PROCEDURE FOR AN AIRBORNE GAMMA-RAY SPECTROMETER - Geol. Survey of Canada, Tech. paper

____________ - ATMOSPHERIC ABSORPTION OF 2.62 MEV GAMMA-RAY PHOTONS EMITTED FROM THE GROUND - Geophysics, Volume 40, No. 6, p. 1058-1065, December 1975

____________ - THE CIRCLE OF INVESTIGATION OF AIRBORNE GAMMA-RAY SPECTROMETERS - Geol. Survey of Canada Project 720084

____________ - THE 'FIELD OF VIEW' OF GAMMA-RAY DETECTORS - A DISCUSSION - Project 720084, Geol. Survey of Canada

____________ - URANIUM MEASUREMENTS BY AIRBORNE GAMMA-RAY SPECTROMETRY - Geophysics, Vol. 40, No. 3 - p. 503-519, June 1975

____________ - URANIUM STRIPPING DETERMINATION AU NATUREL FOR AIRBORNE GAMMA-RAY SPECTROMETRY - Geol. Survey of Canada, Paper 75-1, Part A

Grasty, R. L., and Darnley, A. G. - THE CALIBRATION OF GAMMA-RAY SPECTROMETERS FOR GROUND AND AIRBORNE USE - Geol. Survey of Canada, Paper 71-17, 1971

Greenman, David W. - GROUND WATER RESOURCES OF BUCKS COUNTY, PENNSYLVANIA - Penna. State Topographic & Geol. Survey Bull. W-13, 1961

Gross, W. H. - RADIOACTIVITY AS A GUIDE TO ORE - Economic Geology, Volume 47, No. 7, November 1952

Hall, G. M. - GROUND WATER IN SOUTHEASTERN PA - Pennsylvania State Geol. Survey Ground-water Resource Report W 2, 1934 (2nd printing 1967)

Harriss, Robert C. and Adams, John A. S. - GEOCHEMICAL AND MINERALOGICAL STUDIES ON THE WEATHERING OF GRANITIC ROCKS - American Journal of Science, Volume 264, p. 146-173, February 1966

H. E. W. Division of Radiological Health - RADIOLOGICAL HEALTH HANDBOOK - p. 144-146, September 1960

Hollowell, Jerrald R. - HYDROLOGY OF THE PLEISTOCENE SEDIMENTS IN THE WYOMING VALLEY, LUZERNE COUNTY, PENNSYLVANIA - Penna. State Topographic & Geol. Survey Water Resource Report 28, 1971 - With Plates 1-4, scale 1:24,000

Holmberg, P., Blomster, K., and Rieppo, R. - CALCULATION OF YIELD CURVES FOR AIR-BORNE GAMMA-RAY SPECTROMETERS - Geoexploration, Elsevier Scientific Publ. Co., Amsterdam, The Netherlands, December 1974

Hubbell, J. H., and Scofield, N. E. - UNSCRAMBLING OF GAMMA-RAY SCINTILLATION SPECTROMETER PULSE-HEIGHT DISTRIBUTIONS - IRE Transactions on Nuclear Science, p. 156-158, December 1958

Hultqvist, Bengt - CALCULATION OF THE IONIZATION DUE TO RADIOACTIVE SUBSTANCES IN THE GROUND -Quarterly Journal of Geophysics, February 1952

Itter, H. A. - THE GEOMORPHOLOGY OF THE WYOMING-LACKAWANNA REGION - Penna. Geol. Survey Report G 9, 1938, 2nd printing 1959

Jaffe, Howard W., Gottfried, David, Waring, Claude I., and Worthing, Helen W. - LEAD-ALPHA AGE DETERMINATIONS OF ACCESSORY MINERALS OF IGNEOUS ROCKS (1953-1957), STUDIES IN GEOCHRONOLOGY - U. S. G. S. Bulletin 1097-B, 1959

Khattab, Mansour M. Khattab - ANALYSIS OF URANIUM AND THORIUM AND THEIR DAUGHTER NUCLIDES IN URANIUM-THORIUM ORES BY HIGH-RESOLUTION GAMMA-RAY SPECTROMETRY - A thesis in geochemistry, The Graduate School of the Pennsylvania State University, March 1970

Killeen, P. G. and Carmichael, C. M. - GAMMA-RAY SPECTROMETER CALIBRATION FOR FIELD ANALYSIS OF THORIUM URANIUM AND POTASSIUM - Prof. Paper from the Canadian Journal of Earth Science, Volume 7, p. 1093-1098, 1970

King, Dhi-Yu - RADON EMANATION ON ACTIVE FAULTS - U. S. Geol. Survey Open-File Report 76-875, 1976

Klemic, Harry - URANIUM OCCURRENCE IN SEDIMENTARY ROCKS IN PENNSYLVANIA - U. S. Geol. Survey Bull. 1107-D, p. 243-287, 1962

Klemic, Harry and Baker, R. C. - OCCURRENCES OF URANIUM IN CARBON COUNTY, PA. - U. S. Geol. Survey Circular 350, 1954

Klemic, Harry, Warman, J. C. and Taylor, R. R. - GEOLOGY AND URANIUM OCCURRENCES OF THE NORTHERN HALF OF THE LEHIGHTON, PA. QUADRANGLE AND ADJOINING AREAS - U. S. Geol. Survey Bull. 1138, 1963

Lapham, D. M. - INTERPRETATION OF K-Ar AND Rb-Sr ISOTOPIC DATES FROM A PRECAMBRIAN BASEMENT CORE, ERIE COUNTY - Penna. Geol. Survey Inform. Circular IC 79, 1975

Lapham, D. M. and Root, S. I. - SUMMARY OF ISOTOPIC AGE DETERMINATIONS IN PENNSYLVANIA - Penna. Geol. Survey Inform. Circular IC 70, 1971

Lapham, D. M. and Gray, Carlyle - GEOLOGY AND ORIGIN OF THE TRIASSIC MAGNETITE DEPOSIT AND DIABASE AT CORNWALL - (includes geol. map scale 1:24,000), Penna. Geol. Survey Mineral Resource Report M 56, 1973

Leverett, Frank - GLACIAL DEPOSITS OUTSIDE THE WISCONSIN TERMINAL MORAINE IN PENNSYLVANIA - Penna. State Topographic and Geol. Survey Bull. G 7, 1934 (2nd printing 1958)

Lohman, Stanley W. - GROUND WATER IN NORTHEASTERN PENNSYLVANIA - Penna. State Topographic & Geol. Survey Ground Water Resource Report W 4, 1937 (2nd printing 1957) with Plate 1, scale 1:380,160

__________________ - GROUND WATER IN SOUTH-CENTRAL PENNSYLVANIA - Penna. State Topographic & Geol. Survey, Ground Water Report W 5, 1938 (2nd printing 1968) with Plates 1 and 2, scale 4½" = 25 miles

__________________ - GROUND WATER IN NORTH-CENTRAL PENNSYLVANIA - Penna. State Topographic & Geol. Survey Water Resource Report 6, 1939 (2nd printing 1973) with Plates 1 and 2, scale 1:380, 160

__________________ - GROUND WATER RESOURCES OF PENNSYLVANIA - Penna. State Topographic & Geol. Survey, Ground Water Report W 7, 1941

Lovborg, L., Kirkegaard, P., Christiansen, E. Mose - THE DESIGN OF NaI (Tl) SCINTILLATION DETECTORS FOR USE IN GAMMA-RAY SURVEYS OF GEOLOGICAL SOURCES - Danish Atomic Energy Commission Research Establishment, Denmark - Paper presented at IAEA/NEA - Vienna, April 1976

Lytle, William S. - UNDERGROUND GAS STORAGE IN PENNSYLVANIA - Penna State Geol. Survey Mineral Resource Report M 46, 1963

Marshall, R. R. - COSMIC RADIATION AND THE K^{40} - Ar^{40} "AGES" OF IRON METEORITES - Tech. Report No. 32-147, Jet Propulsion Lab., Cal. Inst. of Tech., August 10, 1961

McCauley, J. F. - URANIUM IN PENNSYLVANIA - Penna. State Geol. Survey Mineral Resource Report M 43, 1961

McGlade, W. G. et - ENGINEERING CHARACTERISTICS OF THE ROCKS OF PENNSYLVANIA - Penna. Geol. Survey, EG 1, 1972

McSharry, P. J. - REDUCING ERRORS IN AIRBORNE GAMMA-RAY SPECTROMETRY - Bulletin Austr. Soc. Exploration Geophys. Vol. 4, No. 1, p. 31-41, March 1973

McSharry, P. J. and Emerson, D. W. - THE COLLECTION AND PROCESSING OF GAMMA-RAY SPECTROMETER DATA - Paper delivered at 2nd Internat'l Conference on Geophys. of the Earth and Oceans - Sydney, Australia, January 1973

Merian, R. F., Lackev, J. G., and Hand, J. E. - AERIAL RADIOLOGICAL MONITORING SYSTEM. 1. THEORETICAL ANALYSIS, DESIGN, AND OPERATION OF A REVISED SYSTEM - CEX-59.4, Civil Effects Test Operations, U. S. AEC, February 1961

Miller, B. M. - A SUMMARY OF OIL AND GAS PRODUCTION AND RESERVE HISTORIES OF THE APPALACHIAN BASIN, 1859-1972 U. S. Geol. Survey Bull. 1409, 1975

Newport, Thomas G. - GROUND WATER RESOURCES IN MONTGOMERY COUNTY, PENNSYLVANIA - Penna. State Geol. Survey Water Resource Report W 29, 1971 (2nd printing 1973)

O'Neill, B. J. Jr. - LIMESTONES AND DOLOMITES OF PENNSYLVANIA, 1964; Part 1 in ATLAS OF PENNSYLVANIA'S MINERAL RESOURCES - Penna. State Geol. Survey Mineral Resource Report M 50

Pearre, N. C. and Heyl, A. V. - THE HISTORY OF CHROMITE MINING IN PENNSYLVANIA AND MARYLAND - Penna. Geol. Survey Inform. Circular IC 14, 1959, 3rd printing 1974

Reese, J. F. and Sisler, J. D. - COAL RESOURCES - 1928, Part III in BITUMINOUS COAL FIELDS OF PENNSYLVANIA - Penna. State Geol. Survey Mineral Resource Report M 6

Reimer, G. M. - FIXED-VOLUME GAS INLET SYSTEM FOR AN ALPHA-SENSITIVE CELL ADAPTED FOR RADON MEASUREMENT - U. S. Geol. Survey Open-File report 77-409, 1977

Rima, Donald R., Meisler, Harold and Longwill, Stanley - GEOLOGY AND HYDROLOGY OF THE STOCKTON FORMATION IN SOUTHEASTERN PENNSYLVANIA - Penna. State Topographic & Geol. Survey, Bull. W-14, 1962 With Plates 1-4, Scale 1:24,000

Rose, A. W. - METAL MINES AND OCCURRENCES IN PENNSYLVANIA - 1970, Part 3 in ATLAS OF PENNSYLVANIA'S MINERAL RESOURCES - Penna. State Geol. Survey Mineral Resource Report M 50

Rudd, Neilson - SUBSURFACE LIQUID WASTE DISPOSAL AND ITS FEASIBILITY IN PENNSYLVANIA - PENNA. Geol. Survey Report EG 3, 1972

Shepps, V. C. - PENNSYLVANIA AND THE ICE AGE - Penna. Geol. Survey, Educ. Series ES 2, -962, repr. 1973

Sisler, J. D. - DETAILED DESCRIPTION OF COAL FIELDS - 1926 (4th pringing, 1973) Part II in BITUMINOUS COAL FIELDS OF PENNSYLVANIA, Penna. State Geol. Survey Mineral Resource Report M 6

Socolow, Arthur A. - GEOLOGIC INTERPRETATION OF AEROMAGNETIC MAPS OF SOUTHEASTERN PENNSYLVANIA - Penna. State Topographic & Geol. Survey Inform. Circular IC 77, 1974

Tammenmaa, J., Grasty, R. L. and Peltoniemi - THE REDUCTION OF STATISTICAL NOISE IN AIRBORNE RADIOMETRIC DATA - Abstract from the Canadian Journal of Earth Science in Press.

Tsusue, Akio - MINERAL ASPECTS OF THE GRACE MINE MAGNETITE DEPOSIT - Penna. State Topographic & Geol. Survey Mineral Resources Report M 49, 1964

U. S. Bureau of Mines - COAL ANALYSES - 1925, 2nd ed., 1928, in BITUMINOUS COAL FIELDS OF PENNSYLVANIA, Penna. State Geol. Survey Mineral Resource Report M 6

U. S. Geol. Survey and the U. S. Bureau of Mines - MINERAL RESOURCES OF THE APPALACHIAN REGION - U. S. Geol. Survey Prof. Paper 580, 1968

Wagner, W. R. and Lytle, W. S. - GEOLOGY OF PENNSYLVANIA'S OIL AND GAS - Penna. Geol. Survey, Educ. Series ES 8, 1969

Willard, Bradford - PALEOZOIC CONTINENTAL PHASES OF SEDIMENTATION IN THE NORTHERN APPALACHIANS - repr. from International Geol. Congress "Report of the Eighteenth Session, Great Britain, 1948" Part IV 1950

Zeller, E. J., Deschhoff, G., Angino, E., Holdoway, K., Hakes, W., Jayaprakash, G., and Crisler, K. - POTENTIAL URANIUM HOST ROCKS AND STRUCTURES IN THE CENTRAL GREAT PLAINS - University of Kansas prep. for ERDA, November 15, 1975

9.2 MAPS

GEOLOGIC MAP OF NEW JERSEY - by J. Volney Lewis and Henry B. Kummel, N. J. State Dep't. of Conservation & Eco. Devel. 1910-1912, Revised by H. B. Kummel, 1931. Revised by M. E. Johnson 1950 (reprinted 1975) Scale 1:250,000

GEOLOGIC OVERLAY MAPS OF NEW JERSEY - N. J. State Dep't. of Conservation. Sheets 21, 22, 23, 25, 26, 27, 28 and 29. Scale 1:63,630

GEOLOGIC MAP OF NEW YORK - Compiled and edited by D. W. Fisher, Y. W. Isachsen, and L. V. Rickard, N. Y. State Museum & Science Service, Map & Chart Series No. 15. Scale 1:250,000. 1970

LOWER HUDSON SHEET
HUDSON-MOHAWK SHEET
FINGER LAKES SHEET
ADIRONDACK SHEET
LOWER HUDSON SHEET

GEOLOGIC MAP OF PENNSYLVANIA - Compiled and edited by Carlyle Gray, V. C. Shepps et al. Penna. State Geol. Survey, Fourth Series, Map 1, 1960 (reprinted 1975) Scale 1:250,000

THE DISTRIBUTION OF LIMESTONES CONTAINING AT LEAST 90 PERCENT $CaCO_3$ IN PENNSYLVANIA - B. J. O'Neill, Jr. scale 1:500,000, 1976 <u>in</u> ATLAS OF PENNSYLVANIA'S MINERAL RESOURCES, Penna. State Geol. Survey Mineral Resource Report M 50, Part 4

PRELIMINARY REPORT ON A REGIONAL STRATIGRAPHIC STUDY OF DEVONIAN ROCKS OF PENNSYLVANIA by T. H. Jones and A. S. Cate, scale 1:1,000,000. Penna. State Geol. Survey Special Bulletin SB 8, 1957

GEOLOGIC QUADRANGLE MAPS
U. S. GEOLOGICAL SURVEY

GQ-28 CARLISLE QUADRANGLE - by G. W. Stose, scale 1:62,500, 1953 (1954)

GQ-133 GEOLOGY OF FRENCHTOWN, N. J. - by A. A. Drake, Jr., D. B. McLaughlin, and R. E. Davis, scale 1:24,000, 1961

GQ-341 - PRE-QUATERNARY GEOLOGY OF THE TRENTON EAST QUADRANGLE, NEW JERSEY - PENNSYLVANIA - by J. P. Owens and J. P. Minard, scale 1:24,000, 1964

GQ-342 - PRE-QUATERNARY GEOLOGY OF THE BRISTOL QUADRANGLE, NEW JERSEY-PENNSYLVANIA - by J. P. Owens and J. P. Minard, scale 1:24,000, 1964

GQ-593 - GEOLOGIC MAP OF THE RIEGELSVILLE QUADRANGLE, PENNSYLVANIA-NEW JERSEY - by A. A. Drake, Jr., D. B. McLaughlin, and R. E. Davis. Scale 1:24,000, 1967

GQ-594 - GEOLOGIC MAP OF THE EASTON QUADRANGLE, NEW JERSEY-PENNSYLVANIA - by A. A. Drake, Jr. Scale 1:24,000, 1967

GQ-665 - GEOLOGIC MAP OF THE BANGOR QUADRANGLE, PENNSYLVANIA-NEW JERSEY - by R. E. Davis, A. A. Drake, Jr., and J. B. Epstein. Scale 1:24,000, 1967

GQ-689 - GEOLOGIC MAP OF THE SWATARA HILL QUADRANGLE, SCHUYLKILL AND BERKS COUNTIES, PA. - by G. H. Wood, Jr., and T. M. Kehn. Scale 1:24,000, 1968

GQ-690 - GEOLOGIC MAP OF THE MINERSVILLE QUADRANGLE, SCHUYLKILL COUNTY, PA. - by G. H. Wood, Jr., J. P. Trexler, and Andy Yelenosky. Scale 1:24,000, 1968

GQ-691 - GEOLOGIC MAP OF THE PINE GROVE QUADRANGLE, SCHUYLKILL, LEBANON AND BERKS COUNTIES, PA. - by G. H. Wood, Jr., and T. M. Kehn. Scale 1:24,000, 1968

GQ-692 - GEOLOGIC MAP OF THE TREMONE QUADRANGLE, SCHUYLKILL AND NORTHUMERLAND COUNTIES, PA. - by G. H. Wood, Jr., and J. P. Trexler. Scale 1:24,000, 1968

GQ-698 - GEOLOGIC MAP OF THE TOWER CITY QUADRANGLE, SCHUYLKILL, DAUPHIN, AND LEBANON COUNTIES, PA. - by G. H. Wood, Jr. Scale 1:24,000, 1968

GQ-699 - GEOLOGIC MAP OF THE VALLEY VIEW QUADRANGLE, SCHUYLKILL AND NORTHUMBERLAND COUNTIES, PA. - by J. P. Trexler and G. H. Wood, Jr. Scale 1:24,000, 1968

GQ-700 - GEOLOGIC MAP OF THE KLINERSTOWN QUADRANGLE, NORTHUMBERLAND, SCHUYLKILL, AND DAUPHIN COUNTIES, PA. - by J. P. Trexler and G. H. Wood, Jr. Scale 1:24,000, 1968

GQ-701 - GEOLOGIC MAP OF THE LYKENS QUADRANGLE, DAUPHIN, SCHUYLKILL, AND LEBANON COUNTIES, PA. - by J. P. Trexler and G. H. Wood, Jr. Scale 1:24,000, 1968

GQ-781 - GEOLOGIC MAP OF THE SHENANDOAH QUADRANGLE, SCHUYLKILL COUNTY, PA. - by G. H. Wood, Jr., and H. H. Arndt. Scale 1:24,000, 1969

GQ-908 - GEOLOGIC MAP OF THE BUSHKILL QUADRANGLE, PENNSYLVANIA-NEW JERSEY - by D. C. Alvord and A. A. Drake, Jr. Scale 1:24,000, 1971

GQ-918 - GEOLOGIC MAP OF THE ASHLAND QUADRANGLE, COLUMBIA AND SCHUYLKILL COUNTIES, PA. - by H. H. Arndt. Scale 1:24,000, 1971

GQ-919 - GEOLOGIC MAP OF THE MOUNT CARMEL QUADRANGLE, COLUMBIA, NORTHUMBERLAND, AND SCHUYLKILL COUNTIES, PA. - by H. H. Arndt. Scale 1:24,000, 1971

GQ-1028 - GEOLOGIC MAP OF THE POTTSVILLE QUADRANGLE, SCHUYLKILL COUNTY, PA. - by G. H. Wood, Jr. Scale 1:24,000, 1973

GQ-1029 - GEOLOGIC MAP OF THE OWRIGSBURG QUADRANGLE, SCHUYLKILL COUNTY, PA. - by G. H. Wood, Jr. Scale 1:24,000, 1973

GQ-1047 - GEOLOGIC MAP OF THE STROUDSBURG QUADRANGLE, PENNSYLVANIA-NEW JERSEY - by J. B. Epstein. Scale 1:24,000, 1973

GQ-1054 - GEOLOGIC MAP OF THE DELANO QUADRANGLE, SCHUYLKILL COUNTY, PA. - by G. H. Wood, Jr. and H. H. Arndt. Scale 1:24,000, 1973 (1974)

GQ-1132 - GEOLOGIC MAP OF THE NESQUEHONING QUADRANGLE, CARBON AND SCHUYLKILL COUNTIES, PA. - by G. W. Wood, Jr. Scale 1:24,000, 1974

GQ-1133 - GEOLOGIC MAP OF THE TAMAQUA QUADRANGLE, CARBON AND SCHUYLKILL COUNTIES, PA. - by G. H. Wood, Jr. Scale 1:24,000, 1974

GEOPHYSICAL INVESTIGATIONS MAPS
U. S. GEOLOGICAL SURVEY

GP-562 - AEROMAGNETIC MAP OF NORTHERN NEW JERSEY AND ADJACENT PARTS OF NEW YORK AND PENNSYLVANIA - by J. R. Henderson and others. Scale 1:250,000, 1966

GP-568 - NATURAL GAMMA AERORADIOACTIVITY MAP OF THE BANGOR QUADRANGLE, NEW JERSEY AND PENNSYLVANIA - by G. R. Boynton, D. R. Pittillo, and G. L. Zandle. Scale 1:24,000, 1966

GP-569 - NATURAL GAMMA AERORADIOACTIVITY MAP OF THE BELVIDERE QUADRANGLE, NEW JERSEY AND PENNSYLVANIA - by G. R. Boynton, D. R. Pittillo, and G. L. Zandle. Scale 1:24,000, 1966

GP-570 - NATURAL GAMMA AERORADIOACTIVITY MAP OF THE BLOOMSBURY AND PART OF THE EASTON QUADRANGLES, NEW JERSEY AND PENNSYLVANIA - by G. R. Boynton, D. R. Pittillo, and G. L. Zandle. Scale 1:24,000, 1966

GP-571 - NATURAL GAMMA AERORADIOACTIVITY MAP OF THE FRENCHTOWN AND PART OF THE RIEGELSVILLE QUADRANGLES, NEW JERSEY AND PENNSYLVANIA - by G. R. Boynton. D. R. Pittillo, and G. L. Zandle. Scale 1:24,000, 1966

GP-572 - NATURAL GAMMA AERORADIOACTIVITY MAP OF PARTS OF THE LAMBERTVILLE, LUMBERVILLE, AND STOCKTON QUADRANGLES, NEW JERSEY AND PENNSYLVANIA - by G. R. Boynton, D. R. Pittillo, and G. L. Zandle. Scale 1:24,000, 1966

GP-577 - AEROMAGNETIC AND GENERALIZED GEOLOGIC MAP OF SOUTHEASTERN PENNSYLVANIA - by R. W. Bromery and Andrew Griscom. Scale 1:125,000

GP-669 - AEROMAGNETIC MAP OF THE HARRISBURG-SCRANTON AREA, NORTHEASTERN PENNSYLVANIA - Scale 1:250,000, 1969

MISC. INVESTIGATIONS SERIES
U. S. GEOLOGICAL SURVEY

I-300 - PALEOTECTONIC MAPS OF THE TRIASSIC SYSTEM - by E. D. McKee and others. 1959

I-552 - GEOLOGIC MAP AND SECTIONS OF PARTS OF THE PORTLAND AND BELVIDERE QUADRANGLES, N. J. - PA. by A. A. Drake, Jr., and others, scale 1:24,000, 1969

I-838 - BEDROCK GEOLOGIC MAP OF THE ANTHRACITE-BEARING ROCKS IN THE WILKES BARRE WEST QUAD., LUZERN COUNTY, PENNSYLVANIA - by M. J. Bergin. Scale 1:12,000, 1976

I-936 - MAPS SHOWING SELECTED DEEP WELLS DRILLED FOR OIL OR GAS IN THE APPALACHIAN BASIN - by L. G. Wallace deWitt, Jr., scale 1:1,000,000, 1975

MISC. FIELD STUDIES
U. S. GEOLOGICAL SURVEY

MF-578-A - MAP SHOWING SLATE QUARRIES AND DUMPS IN THE STROUDSBURG QUADRANGLE, PA.-N.J., WITH A DISCUSSION OF THEIR ENVIRONMENTAL SIGNIFICANCE - by J. B. Epstein, scale 1:24,000, 1974

MR-815 - MAP SHOWING MAJOR FOLD AXES, SATELLITE IMAGERY, LINEAMENTS, ELONGATE AERORADIOACTIVITY, ANOMALIES & LINES OF DISCONTINUITY IN SOUTHWESTERN PA. Scale 1:250,000, 1976

OPEN-FILE REPORTS
U. S. GEOLOGICAL SURVEY

76-843 - MAP SHOWING FAULTS AND SELECTED LINEAMENTS IN THE NORTHERN APPALACHIAN REGION - by P. J. Barosh, scale 1:1,250,000, 1976

77-107 - LAND USE AND LAND COVER AND ASSOCIATED MAPS FOR WILLIAMSPORT, PENNSYLVANIA, AND NEW YORK. Scale 1:1,250,000, 1977

77-108 - LAND USE AND LAND COVER AND ASSOCIATED MAPS FOR SCRANTON, PENNSYLVANIA, AND NEW JERSEY (PA. PORTION ONLY) Scale 1:250,000, 1977

77-109 - LAND USE AND LAND COVER AND ASSOCIATED MAPS FOR HARRISBURG, PENNSYLVANIA - Scale 1:250,000, 1977

77-111 - LAND USE AND LAND COVER AND ASSOCIATED MAPS FOR NEWARK, NEW JERSEY AND PENNSYLVANIA (PA. PORTION ONLY) - Scale 1:250,000, 1977

APPENDIX A

PRODUCTION SUMMARY

APPENDIX A

PRODUCTION SUMMARY

OPERATION	START	END
Flying	11/8/76	1/9/77
	2/10/77	4/11/77
Data Processing	11/14/76	3/18/77
	7/15/77	11/18/77
Data Interpretation	1/25/77	3/18/77
	7/15/77	11/18/77

Total Mileage	11,471
Total Days on Location	123
Production Time	40 percent
Non-Production Time	59 percent
Average Daily Mileage	93
Average Survey Speed	79 MPH
Average Monthly Mileage	2,549

THORPE AREA

TEST LINE DATA SUMMARY

DATE	LINE NO.	% CHANGE	REMARKS
11/30/76	503		Initial test line set up
12/03/76	504		New Test Line
12/04/76	504	7%	
12/05/76	504	14%	
12/06/76	504	4%	
12/08/76	504	-16%	
12/10/76	505	-	New Test Line
12/11/76	505	1%	
01/05/77	506	-	New Test Line
01/06/77	506	13%	
01/08/77	506	15%	
02/10/77	507	-	New Test Line
02/12/77	507	2%	
02/14/77	507	3%	
02/16/77	507	-4%	
02/17/77	507	7%	
02/18/77	507	-1%	
02/19/77	507	2%	
03/01/77	508	-	New Test Line
03/02/77	508	8%	
03/03/77	509	-	New Test Line
03/06/77	509	-3%	
03/07/77	510	-	New Test Line
03/08/77	510	-3%	
03/09/77	511	-3%	
03/10/77	511/512	8%	
03/11/77	512	5%	
03/12/77	513	-	New Test Line
03/16/77	513	-8%	
03/17/77	513	-1%	
03/19/77	513	-11%	
03/21/77	513/514	-1%	
03/23/77	514	-14%	
03/24/77	514	-1%	
03/25/77	514	6%	
03/26/77	514	4%	
03/27/77	508	-12%	
04/08/77	506	2%	
04/09/77	506	5%	
04/10/77	506	3%	
04/11/77	506	7%	

APPENDIX B

TAPE FORMATS

APPENDIX B

TAPE FORMATS

All tape files are 9 track EBCDIC written at a density of 800 BPI and have a fixed word length of 9 characters.

TAPE HEADER

The first record of each tape file is a tape label of 50 words containing the following standard information:

(1) Project Identification
(2) L K B Resources, Inc.
(3) Date of Survey
(4) Sequence of lines in this file

LINE HEADER

A standard 10 word line header preceeds and identifies each line contained in the file.

Word	Definition
1	Line Number
2	Start Record Number
3	End Record Number
4	4 Sampling Interval
5	2 Sampling Interval
6	Date (YYDDD)
7	Number of Samples
8-10	Not used

RAW SPECTRAL DATA FILE

The raw data sub-set will immediately follow the line header and will contain 413 words per logical record.

Word	Definition
1	Record Number
2	Latitude (.0001 degrees)
3	Longitude (.0001 degrees)
4	Time (Seconds past midnight)
5	Magnetic Field (.1 gamma)
6	Terrain Clearance (feet)
7	Barometric Pressure (feet)
8	Temperature (.1 degree C)
9	Quality Flag
10-209	Terrestrial Detector 0 to 3 MeV
210	Terrestrial Detector dead time (millisecs.)
211-410	Atmos. Detector 0 to 3 MeV
411	Atmos. Detector dead time (millisecs.)
412	Terrestrial Detector Cosmic Sum
413	Atmos. Detector Cosmic Sum

SINGLE RECORD DATA FILE

The single record data will be blocked 10 logical records per block. Each logical record will contain 16 words defined as follows:

Word	Definition
1	Record Number
2	Latitude (.0001 Degrees)
3	Longitude (.0001 Degrees)
4	Magnetic Field (.1 Gamma)
5	Terrain Clearance (feet)
6	Geologic Unit Code
7	Quality Flag
8	Terrestrial Cosmic Sum
9	Atmos. Bi^{214} Correction
10	Terrestrial Gross Count
11	Terrestrial Thorium Count
12	Terrestrial Uranium Count
13	Terrestrial Potassium Count
14	Ratio U/K (.1 Count)
15	Ratio U/T (.1 Count)
16	Ratio T/K (.1 Count)

STATISTICAL ANALYSIS TAPE

The statistical data file contains an additional tape header record which identifies the statistical parameters relative to each geologic map unit.

The data associated with a single geologic map unit is considered as one logical record and contains 14 words.

The logical records are blocked 200 thus the physical record is 2800 words.

The statistical header is defined as follows:

Word	Definition
1	Map Unit Code
2	Number of Records
3	K Mean Value
4	K Standard Deviate
5	U Mean Value
6	U Standard Deviate
7	T Mean Value
8	T Standard Deviate
9	U/K Mean Ratio
10	U/K Standard Deviate
11	U/T Mean Ratio
12	U/T Standard Deviate
13	T/K Mean Ratio
14	T/K Standard Deviate

STATISTICAL DATA RECORD

The statistical data record contains the averaged reduced data records. Each averaged record is considered a logical record having 20 words. The logical records are blocked 10 per physical record.

Word	Definition
1	Record Number
2	Latitude (.0001 Degrees)
3	Longitude (.0001 Degrees)
4	Magnetic Total Field (.1 Gamma)
5	Geologic Map Unit Code
6	Quality Flag
7	Gross Count
8	Thorium Count
9	Thorium Standard Deviate
10	Uranium Count
11	Uranium Standard Deviate
12	Potassium Count
13	Potassium Standard Deviate
14	U/T Ratio (.1 Counts)
15	U/T Standard Deviate
16	U/K Ratio (.1 Counts)
17	U/K Standard Deviate
18	T/K Ratio (.1 Counts)
19	T/K Standard Deviate
20	Filler Word

MAGNETIC DATA TAPES

The magnetic data record contains 10 words per logical record and is blocked 50 logical records per physical record.

Word	Definition
1	Record Number
2	Latitude (.0001 degrees)
3	Longitude (.0001 degrees)
4	Time (Seconds past midnight)
5	Terrain Clearance (feet)
6	Barometric Pressure (feet)
7	Geologic Code
8	Observed Magnetic Field (.1 Gamma)
9	Residual Magnetic Field (.1 Gamma)
10	Diurnal Total Intensity (.1 Gamma)

APPENDIX C

STATISTICAL SUMMARY BY GEOLOGICAL UNIT

STATISTICAL SUMMARY

			* * * K * * *		* * * U * * *		* * * T * * *		* * U/K*10 * *		* * U/T*10 * *		* * T/K*10 * *	
CODE	UNIT	RECS	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.
102.	Q	43.0	85.6	22.0	14.4	4.9	22.3	7.4	1.3	.5	6.3	1.8	2.2	.8
103.	QCM	51.0	41.6	15.2	10.7	3.8	25.3	8.5	2.4	1.2	3.9	1.8	6.2	2.0
104.	QP	61.0	59.9	18.1	15.2	5.5	41.8	8.0	2.2	1.0	3.2	1.2	6.8	1.6
107.	TCH	227.0	12.3	8.1	7.0	2.6	13.6	5.7	6.3	3.6	4.6	2.1	14.1	6.0
108.	TKW	366.0	20.1	13.7	9.1	3.9	18.7	6.9	5.5	3.6	4.4	1.9	12.0	6.2
109.	TVT	61.0	32.6	14.0	8.3	3.6	13.3	7.4	2.0	1.0	4.9	2.3	3.9	1.9
110.	THT	93.0	60.0	34.2	12.5	5.3	21.5	8.9	2.3	1.4	5.5	2.3	4.1	2.1
112.	TMQ	11.0	33.6	7.4	8.7	2.2	16.5	3.8	2.2	.9	5.4	1.9	4.7	1.6
202.	KRB	133.0	59.0	21.6	12.6	5.3	23.3	10.0	2.0	1.1	5.6	2.9	3.7	2.1
203.	KNS	106.0	96.0	46.8	16.0	7.0	20.0	9.8	1.6	.7	8.3	4.6	2.3	1.2
204.	KMW	163.0	59.2	28.3	11.5	4.7	20.3	7.0	1.8	.9	5.8	3.3	3.5	1.7
205.	KMT	133.0	47.7	22.7	11.2	4.0	23.7	7.9	2.5	1.9	4.8	2.6	5.3	2.6
206.	KET	165.0	42.8	20.0	10.5	3.9	21.5	7.8	2.4	1.4	4.5	2.0	5.2	2.2
207.	KWB	137.0	51.2	15.9	10.3	4.1	25.3	6.9	1.7	.9	3.7	1.6	4.8	1.6
208.	KMV	89.0	46.9	14.6	11.6	4.2	23.0	7.9	2.1	1.0	4.5	1.7	4.6	1.5
209.	KMR	386.0	43.0	16.5	11.6	5.0	21.4	7.7	2.4	1.3	4.9	2.1	4.9	2.0
214.	TRD	493.0	48.1	20.5	11.0	4.4	21.9	8.5	2.1	1.1	4.7	2.0	4.4	1.5
215.	TRG	2593.0	81.5	26.4	15.7	5.6	36.6	11.4	1.7	.9	4.1	1.9	4.2	1.3
221.	TRGC	179.0	43.2	24.8	10.8	4.1	25.1	9.2	2.5	1.5	4.0	1.6	6.2	2.2
223.	TRC	77.0	67.7	35.0	14.3	6.0	30.1	10.2	2.0	.9	4.4	1.7	4.8	2.1
224.	TRL	665.0	78.6	20.8	16.2	5.1	41.9	8.6	1.8	.8	3.5	1.3	5.1	1.2
225.	TRS	603.0	65.9	18.7	16.1	5.9	40.3	9.3	2.1	1.1	3.7	1.7	5.9	1.5
302.	PPP	74.0	72.7	28.3	15.5	6.4	32.9	11.5	1.9	1.0	4.5	2.0	4.2	1.0
303.	PP	81.0	54.1	24.5	13.3	5.2	26.9	10.7	2.1	.9	4.8	1.6	4.8	1.2
304.	MMC	138.0	55.8	19.2	13.7	5.4	26.3	9.7	2.0	.8	4.7	1.6	4.3	1.1
305.	MP	191.0	41.2	14.1	11.6	4.6	19.4	8.3	2.6	1.2	6.0	2.9	4.3	1.4
308.	DCK	411.0	66.2	25.5	16.4	5.7	33.7	9.3	2.3	1.1	4.6	1.7	5.0	1.3
309.	DM	150.0	89.0	21.5	19.4	5.1	43.2	7.4	1.8	.7	4.1	1.2	4.5	.9
327.	DSK	8.0	160.1	22.9	25.1	8.0	35.2	4.8	1.1	.4	6.5	2.3	1.7	.5
330.	DH	186.0	88.2	29.0	20.1	5.9	41.2	8.6	2.0	1.1	4.6	1.6	4.5	1.0
334.	DON	47.0	38.9	17.9	17.6	5.8	24.5	7.1	4.8	2.2	7.0	2.5	6.7	2.6
335.	DHO	15.0	55.5	24.0	16.5	5.3	29.7	10.0	2.9	1.1	5.4	2.0	5.2	.9
336.	DCH	19.0	43.7	17.0	18.7	4.5	24.4	8.7	4.6	2.5	7.9	3.1	5.5	2.3
341.	SKT	29.0	64.7	32.9	17.6	5.7	28.9	6.1	3.0	2.2	5.8	2.1	4.7	1.9
343.	SEM	111.0	49.3	26.6	14.7	5.0	26.5	8.0	3.2	1.9	5.3	1.9	5.8	2.4
347.	SGP	11.0	63.5	17.2	9.4	3.8	20.6	4.0	1.3	.5	4.4	2.3	2.7	.8
350.	SS	99.0	29.6	16.2	11.0	4.9	20.7	7.0	3.7	2.0	5.0	2.2	7.8	3.2
359.	OM	1243.0	94.4	37.9	16.9	6.3	36.3	10.3	1.7	1.0	4.4	1.7	3.8	1.3
360.	OC	104.0	90.0	28.9	18.4	5.1	34.5	7.4	1.7	.8	4.9	1.5	3.5	1.0
368.	OB	663.0	98.0	33.0	18.6	6.2	30.8	9.3	1.6	.9	5.9	2.2	2.9	1.1
369.	CO	29.0	99.1	25.3	17.9	3.9	33.2	6.8	1.4	.6	5.1	1.8	3.0	1.0
370.	OE	6.0	81.2	21.2	14.5	5.8	33.0	8.9	1.3	.5	4.5	2.3	3.8	1.8
376.	OCS	39.0	84.5	16.7	15.8	4.2	38.7	4.9	1.6	.6	3.8	1.3	4.2	.8
408.	CC	373.0	113.8	40.8	18.3	5.3	35.6	7.0	1.4	.7	4.7	1.5	2.9	1.1
412.	CE	98.0	100.4	49.6	17.3	5.1	34.2	8.4	2.1	1.6	5.2	3.6	3.6	1.6
413.	CL	68.0	113.9	58.8	17.1	5.4	39.3	9.5	1.6	.8	4.0	1.7	3.6	1.6
414.	CK	8.0	129.2	55.8	14.2	4.7	36.6	8.3	1.2	.4	3.5	1.4	2.7	.9
415.	CV	27.0	116.9	69.5	15.6	7.5	32.6	8.3	1.3	.6	4.3	1.8	3.4	2.4
416.	CT	138.0	97.9	32.0	17.3	7.1	36.0	11.3	1.7	1.2	4.6	2.0	3.6	1.8

STATISTICAL SUMMARY

			* * * K * * *		* * * U * * *		* * * T * * *		* * U/K*10 * *		* * U/T*10 * *		* * T/K*10 * *	
CODE	UNIT	RECS	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.
417.	CAH	12.0	94.4	71.1	15.1	4.5	34.4	12.8	3.0	2.7	4.4	1.8	5.4	3.7
419.	CH	34.0	128.9	29.7	21.2	6.9	36.4	9.9	1.4	.6	5.8	2.6	2.4	1.0
420.	CCH	64.0	56.0	28.4	14.5	5.2	29.8	12.1	3.4	3.0	5.0	2.1	6.0	4.2
421.	CHA	124.0	90.7	40.1	15.4	6.8	32.9	15.2	1.8	1.4	4.7	2.4	3.8	2.8
425.	XPG	10.0	70.6	18.0	14.8	3.7	35.5	5.3	1.6	.8	3.8	1.3	4.8	.6
427.	XHG	4.0	65.7	23.1	17.0	9.2	42.5	20.9	2.0	.8	3.2	1.0	6.0	1.6
429.	XS	13.0	73.5	21.0	13.0	3.9	37.8	5.9	1.6	.8	3.0	1.2	4.9	1.0
430.	XPB	11.0	58.9	30.9	16.0	5.3	26.7	7.1	2.6	1.4	5.6	2.0	4.8	2.0
432.	XWC	177.0	77.9	17.4	15.2	5.3	40.7	8.9	1.7	.7	3.4	1.4	5.0	1.6
502.	GD	91.0	66.1	19.6	15.1	5.3	31.3	11.2	2.0	1.0	4.6	1.5	4.5	1.7
503.	HG	95.0	91.6	31.3	12.9	5.1	30.2	10.6	1.4	.7	4.3	2.4	3.2	1.6
505.	GN	404.0	101.3	35.6	14.9	7.9	32.6	15.0	1.5	.9	4.6	2.2	3.2	2.2
510.	QM	95.0	99.1	28.7	12.2	4.9	24.7	12.2	1.3	.6	5.0	2.3	2.4	1.8
514.	G	103.0	58.1	20.1	13.0	5.8	31.3	11.7	2.2	1.2	4.2	2.3	5.1	1.7
515.	A	9.0	61.4	32.7	11.0	3.2	21.4	4.5	2.1	1.4	5.0	1.2	3.8	2.1
516.	GG	140.0	78.9	24.9	17.7	10.1	28.8	11.6	2.1	1.4	6.2	3.1	3.4	1.5
519.	LGN	417.0	94.7	33.5	16.3	9.7	26.8	14.0	1.6	1.1	6.2	3.3	2.6	1.8
520.	BGN	770.0	107.0	34.0	17.4	6.9	28.6	14.1	1.4	.7	6.3	2.8	2.5	1.4
521.	PGN	31.0	77.1	21.0	15.6	7.8	27.9	16.5	2.0	.8	5.5	1.9	3.5	2.3
600.	WATER	118.0	51.0	38.3	12.1	6.1	21.5	11.5	2.2	1.4	5.1	2.7	4.3	2.2

APPENDIX D

STATISTICAL SUMMARY BY LINE

STATISTICAL SUMMARY BY LINE

		* * * K * * *		* * * U * * *		* * * T * * *		* * U/K*10 * *		* * U/T*10 * *		* * T/K*10 * *	
LINE	RECS	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.	MEAN	ST.DEV.
22.	558.	67.0	32.5	12.7	5.5	24.5	10.1	1.7	1.2	5.1	2.7	3.8	2.1
21.	563.	70.7	33.1	14.5	5.9	26.5	10.4	1.9	1.3	5.4	2.8	3.6	2.1
20.	596.	74.6	34.2	15.6	6.5	26.7	10.5	2.0	1.3	5.7	2.9	3.6	2.1
19.	589.	86.4	38.0	16.8	7.0	30.4	11.7	1.8	1.2	5.6	2.8	3.4	2.0
18.	579.	87.1	39.2	19.2	8.9	33.7	14.1	2.0	1.3	5.7	2.9	3.8	2.1
17.	578.	95.2	44.4	17.8	7.8	34.4	14.6	1.6	1.2	5.2	2.7	3.6	2.1
16.	551.	92.5	41.6	20.6	9.2	34.4	13.7	2.0	1.2	5.8	2.7	3.8	2.1
15.	486.	92.5	43.5	19.1	7.9	31.5	11.7	1.9	1.2	6.2	2.9	3.3	2.2
14.	536.	76.1	37.4	12.8	5.3	30.2	11.6	1.6	1.3	4.0	2.5	4.3	2.7
13.	422.	96.9	47.5	16.6	6.0	36.5	14.3	1.4	1.3	4.3	2.5	3.5	2.2
12.	570.	91.7	49.2	14.4	5.5	36.9	13.7	1.3	1.2	3.7	2.4	3.9	2.0
11.	537.	96.0	51.3	15.1	5.6	35.7	13.5	1.3	1.2	3.9	2.4	3.7	2.0
10.	607.	77.6	47.2	15.5	5.6	31.0	12.0	1.9	1.2	4.9	2.4	4.1	2.0
9.	517.	71.5	48.6	14.5	5.5	31.7	12.2	1.7	1.2	4.1	2.4	4.5	2.1
8.	627.	71.7	47.1	15.6	5.5	31.2	11.6	1.9	1.2	4.9	2.3	4.2	2.0
7.	596.	72.4	47.5	15.6	5.5	33.6	12.3	1.9	1.2	4.7	2.3	4.3	2.0
6.	650.	65.4	49.3	13.3	5.9	33.6	13.3	2.0	1.4	3.9	2.4	5.5	2.6
5.	557.	50.5	54.4	12.1	6.0	31.5	12.8	2.3	1.5	3.3	2.5	6.6	3.4
4.	615.	60.4	52.2	13.0	5.9	31.9	12.8	2.6	1.6	3.9	2.4	6.6	3.4
3.	583.	63.8	55.4	13.6	6.0	28.2	12.6	2.3	1.8	4.5	2.4	6.1	3.4
2.	472.	55.3	52.1	13.0	5.8	24.0	14.0	2.8	1.8	5.1	2.7	5.8	3.0
1.	366.	68.1	46.0	11.1	6.1	25.4	12.9	1.8	1.3	3.9	2.7	5.2	2.6
55.	409.	85.2	39.8	15.5	5.5	33.7	12.4	1.5	1.2	4.4	2.5	4.0	2.1
54.	412.	75.2	34.4	16.8	6.0	36.4	14.1	2.1	1.2	4.3	2.5	4.8	2.2
53.	349.	77.8	31.8	16.2	5.9	33.7	12.3	1.8	1.2	4.3	2.4	4.7	1.9
52.	391.	62.9	22.5	13.4	5.4	25.2	10.3	1.8	1.2	5.0	2.7	3.9	2.0
51.	228.	45.7	21.0	10.4	6.8	20.0	13.3	2.7	1.4	4.5	2.4	6.5	2.8

APPENDIX E

NUMBER OF SAMPLES USED TO GENERATE

MEAN AND STANDARD DEVIATION - NEWARK QUADRANGLE

APPENDIX E

NUMBER OF SAMPLES USED TO GENERATE

MEAN AND STANDARD DEVIATION - NEWARK QUADRANGLE

Map Code	K	U	Th
Q	43.0	43.0	43.0
Qcm	61.0	51.0	63.0
Qp	65.0	61.0	65.0
Tbm	2.0	2.0	2.0
Tch	210.0	227.0	372.0
Tkw	386.0	366.0	465.0
Tvt	122.0	61.0	122.0
Tht	99.0	93.0	99.0
Tmq	11.0	11.0	11.0
Krb	143.0	133.0	142.0
Kns	110.0	106.0	110.0
Kmw	176.0	163.0	176.0
Kmt	161.0	133.0	162.0
Ket	191.0	165.0	194.0
Kwb	160.0	137.0	160.0
Kmv	105.0	89.0	106.0
Kmr	472.0	386.0	476.0
Trd,Trp,Trbs	549.0	493.0	549.0
Trg,Trb	2689.0	2593.0	2691.0
Trlc	1.0	1.0	1.0
Trqc	199.0	179.0	199.0
Trc	80.0	77.0	80.0
Trl	673.0	665.0	673.0
Trs,Trn	620.0	603.0	620.0
Ppp	77.0	74.0	77.0
Pp	81.0	81.0	81.0
Mmc	149.0	138.0	149.0
Mp	204.0	191.0	204.0
Dcy	2.0	2.0	2.0
Dck,Dwh,Dww	414.0	411.0	414.0
Dm	151.0	150.0	151.0
Dsk	8.0	8.0	8.0
Dbp	1.0	1.0	1.0
Dh	187.0	186.0	187.0
Don	48.0	47.0	48.0
Dho	15.0	15.0	15.0
Doh	19.0	19.0	19.0
Skt	29.0	29.0	29.0
Sbm	113.0	111.0	113.0
Sd	1.0	1.0	1.0
Sgp	11.0	11.0	11.0
Ss	104.0	99.0	105.0

APPENDIX F

COMPARISON OF GEOLOGIC MAP SYMBOLS

WITH COMPUTER DESIGNATIONS - NEWARK QUADRANGLE

APPENDIX F

COMPARISON OF GEOLOGIC MAP SYMBOLS

WITH COMPUTER DESIGNATIONS - NEWARK QUADRANGLE

Computer Numeric Code	Computer Letter Code	Map Code
102	Q	Q
103	QCM	Qcm
104	QP	Qp
105	TBM	Tbm
107	TCH	Tch
108	TKW	Tkw
109	TVT	Tvt
110	THT	Tht
112	TMQ	Tmq
202	KRB	Krb
203	KNS	Kns
204	KMW	Kmw
205	KMT	Kmt
206	KET	Ket
207	KWB	Kwb
208	KMV	Kmv
209	KMR	Kmr
214	TRD	Trd, Trp, Trbs
215	TRG	Trg, Trb
220	TRLC	Trlc
221	TRQC	Trqc
223	TRC	Trc
224	TRL	Trl
225	TRS	Trs, Trn
302	PPP	Ppp
303	PP	Pp
304	MMC	Mmc
305	MP	Mp
306	DCY	Dcy
308	DCK	Dck, Dwh, Dww
309	DM	Dm
327	DSK	Dsk
328	DPB	Dbp
330	DH	Dh
334	DON	Don
335	DHO	Dho
336	DOH	Doh
341	SKT	Skt
343	SBM	Sbm
346	SD	Sd
347	SGP	Sgp
350	SS	Ss

Computer Numeric Code	Computer Letter Code	Map Code
351	OS	Os
359	OM	Om, Oms, Ome, Omls
360	OC	Oc, Ohm
368	OB	Ob
369	OO	Oo
370	OE	Oe
371	ORI	Ori
375	OCO	Oco
376	OCS	Ocs
408	CC	Cc, Cal
412	CE	Ce
413	CL	Cl
414	CK	Ck
415	CV	Cv
416	CT	Ct, Clv
417	CAH	Cah
419	CH	Ch, Cma
420	CCH	Cch, Cwl
421	CHA	Cha
425	XPG	Xpg
427	XHG	Xhg
429	XS	Xs
430	XPB	Xpb
432	XWC	Xwc, Xwm, Xwv, Xw, Xww
501	MD	md
502	GD	gd
503	HG	hg
505	GN	gn
510	QM	qm
514	G	g
515	A	a
516	GG	gg
518	GB	gb
519	LGN	lgn
520	BGN	bgn
521	PGN	pgn
526	FL	fl

APPENDIX G

MICROFICHE SINGLE RECORD AND AVERAGE RECORD LISTINGS