Geology
GJBX-(78)-34

GJBX-34(78)

NURE AERIAL GAMMA RAY AND MAGNETIC RECONNAISSANCE SURVEY

THORPE AREA
WILLIAMSPORT NK18-7 QUADRANGLE

VOLUME I - NARRATIVE REPORT

CAUTION - - ADVANCE RELEASE
HOLD FOR RELEASE UNTIL May 10
NO PART OF THIS PUBLICATION, OR INFORMATION BASED ON IT, IS TO BE GIVEN OUT PUBLICLY BEFORE THE RELEASE TIME

LKB RESOURCES, INC.
55 BUCK ROAD
HUNTINGDON VALLEY, PENNSYLVANIA 19006

MARCH 1978

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

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

TABLES

SECTION 1.0

INTRODUCTION

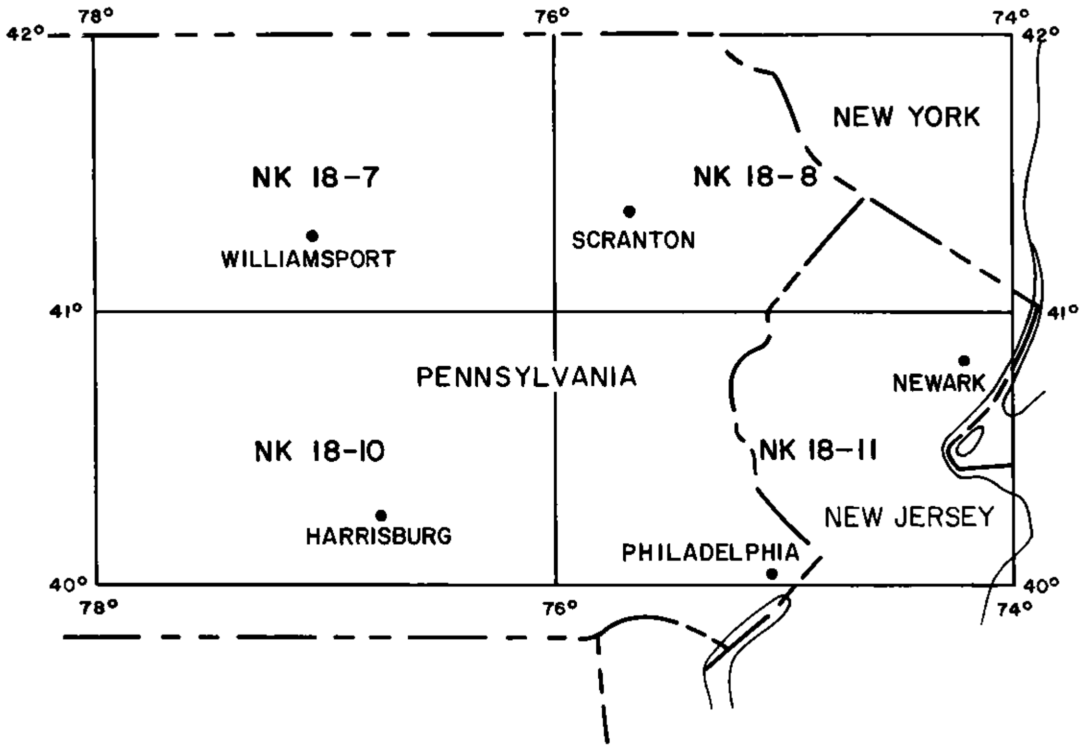
1.1 GENERAL

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 – I AREA MAP DELINEATING 1976 AND 1977 FLYING

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.

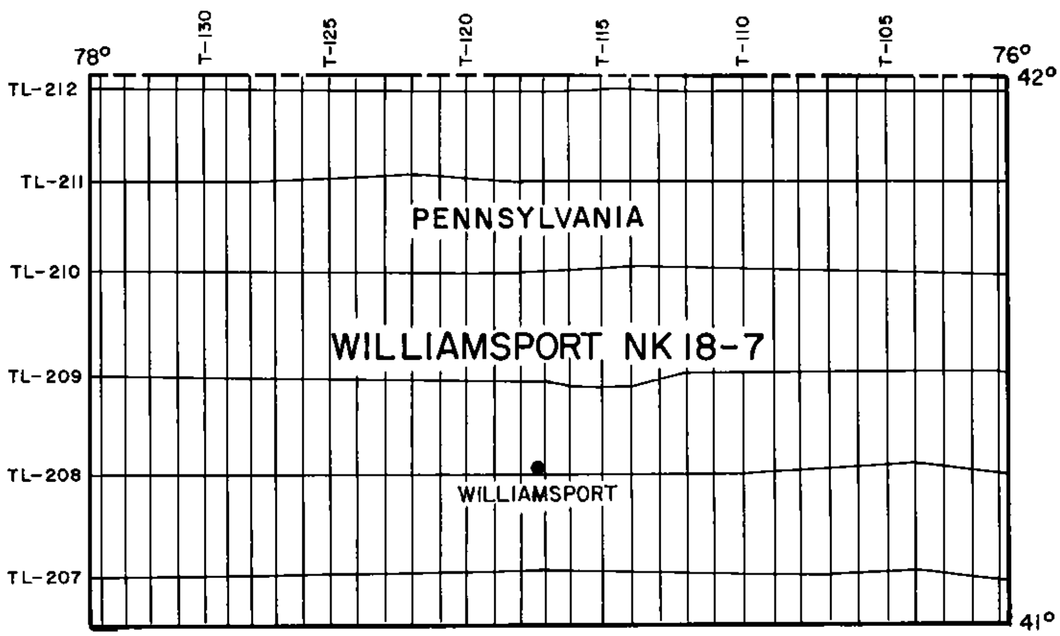


FIGURE-2 INDIVIDUAL QUADRANGLE INDEX TO TRAVERSES

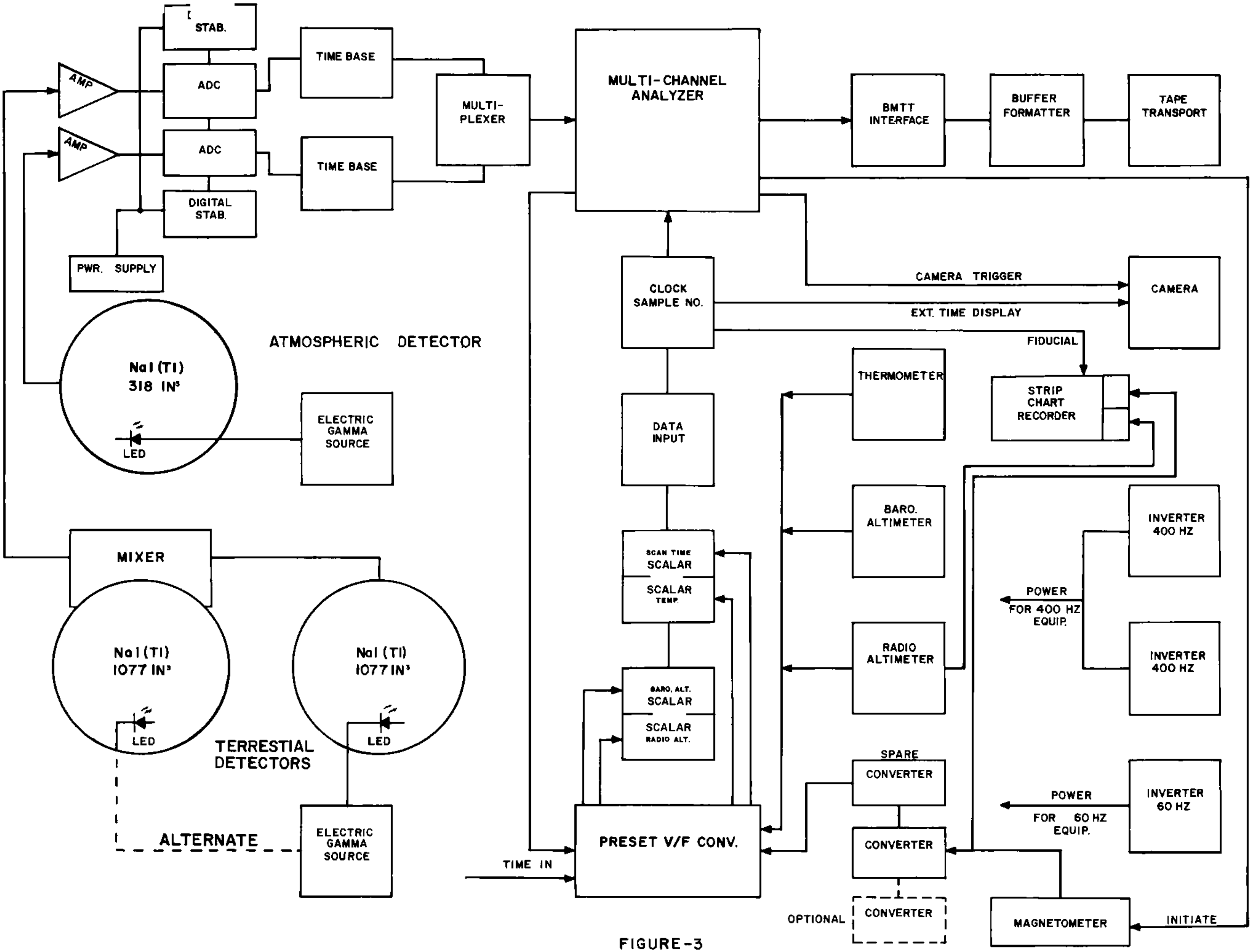


FIGURE-3
SYSTEM BLOCK DIAGRAM

FIGURE 4 S-58 HELICOPTER

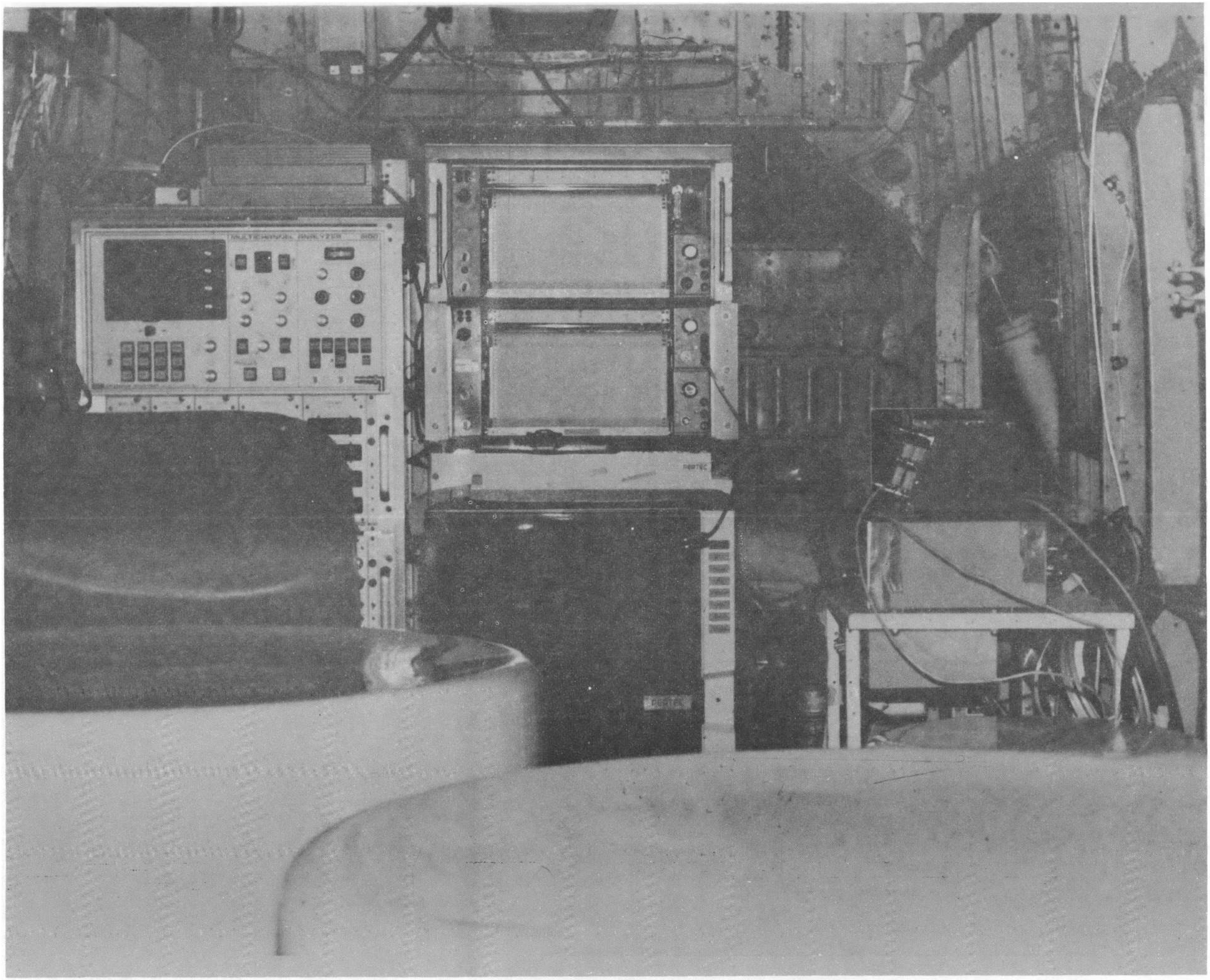


FIGURE - 5 S-58 HELICOPTER (CABIN LAYOUT)

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 ± 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 ± 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°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

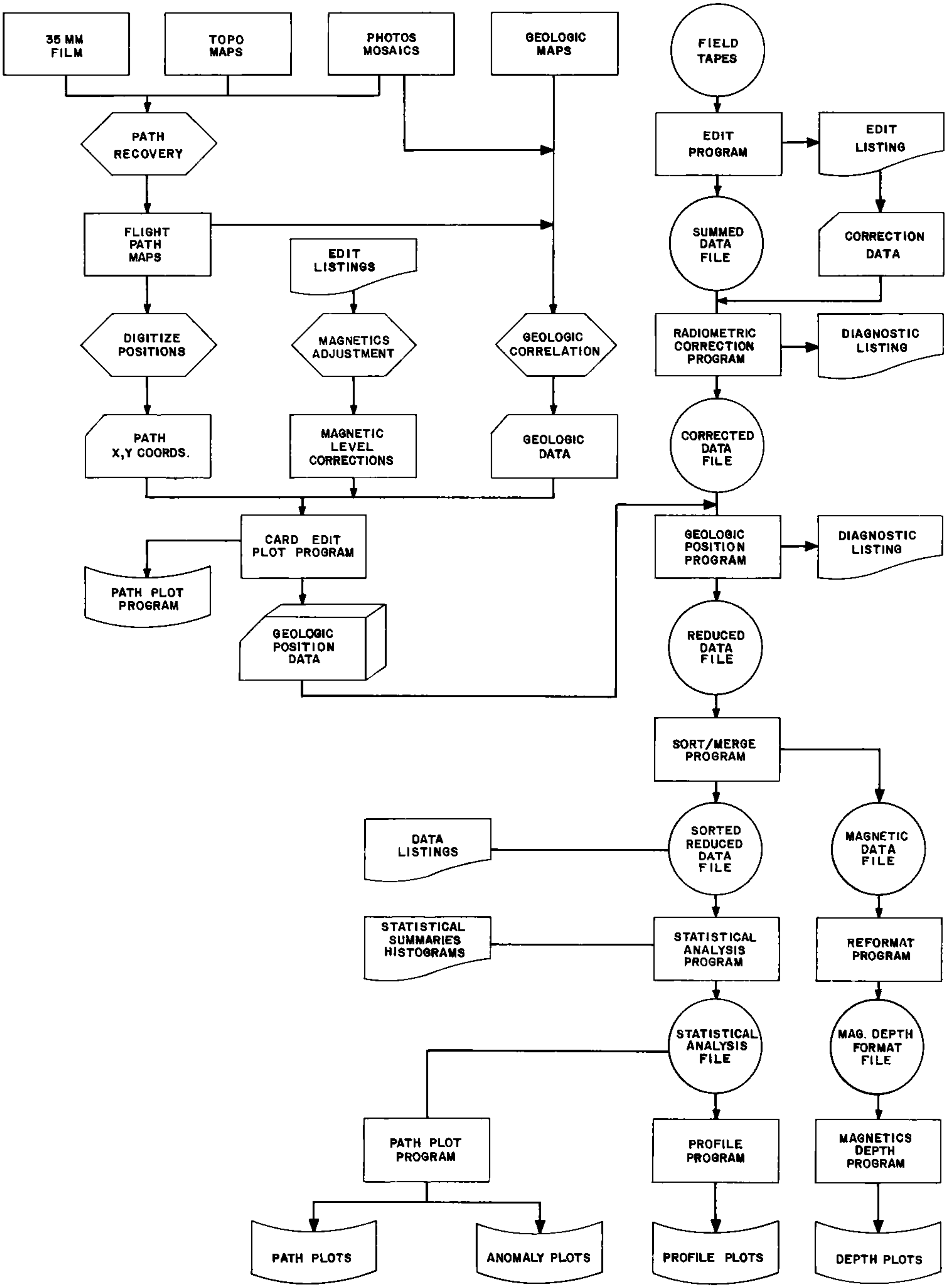


FIGURE-6

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:

$$L_C = 2.33 \times (\text{background})^{1/2}$$

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 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 progessively 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 Williamsport Quadrangle

In contrast to the other portions of the Thorpe Area, the Williamsport NK 18-7 Quadrangle encompasses portions of only two of the major physiographic provinces present in this region, the Paleozoic Folded Appalachians belt and the Allegheny Plateau. Accordingly, considerably less diversity in geological as well as geophysical character is evidenced in this area than elsewhere in the Thorpe region.

The Allegheny Plateau province occupies the major portion of the quadrangle, extending over the northern three quarters of the sheet. The geologic units comprising the bedrock in this zone consist of gently dipping, middle to upper Paleozoic sediments which are largely of Devonian age in the east and Mississippian through Pennsylvanian age in the west. The units of upper Devonian through Pennsylvanian age, which occupy the largest areas of outcrop, are principally of continental origin. However, significantly large expanses of upper Devonian rocks of marine origin occur in the south along the northern margin of the Folded Appalachians province.

While the relationship between geomorphology and structure in this area is, of course, not as apparent as in the Folded Appalachians belt, gently plunging folds and undulations persist across most of the region. These folds are particularly evident in the western part of the sheet where Mississippian and Pennsylvanian rocks containing coal measures are widely exposed along the axes of broad, subtle synclines.

The Paleozoic Folded Appalachians province, occupying the southern quarter of the quadrangle, is comprised of Paleozoic sediments which are typically older than those to the north in the Allegheny Plateau region. They are roughly divided into two general groups by the

West Branch of the Susquehanna River: a western group comprised of marine sediments ranging from lower Ordovician to middle Devonian in age, and an eastern group comprised mainly of continental sediments of upper Devonian to Pennsylvanian age.

These rocks are exposed in strongly east to northeast-trending bands of folded sediments which are associated with pronounced topographic relief. In the eastern region of more broadly folded, younger rocks, Lee Mountain and Nescopeck Mountain comprise prominent topographic features which are formed by resistant formations outcropping on the southern flanks of the Wyoming Valley syncline and the northern flanks of the Eastern Middle synclinorium, respectively. In the west, the topographic relief becomes more pronounced, comprising three principal ridges distributed across a broad fold belt lying south of the Susquehanna River. Bald Eagle Mountain forming the northern margin of Nittany Valley, is composed of Silurian Tuscarora sandstones and quartzites. Nittany Mountain, on the southern flank of the fold belt, is formed by the Oswayo sandstone of Ordovician age. Big Mountain, lying between these two important topographic features, is again formed by the Tuscarora sandstone, occurring as an erosional remnant in the central part of a broad syncline.

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 Pennsylvanian-New Jersey border by completing the Pennsylvania units 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 Oswayo 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 State)

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, Burlingron 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, unually 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.

Inclused 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.

Trgc 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 Pennsulvania; 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; numberous 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; Connoquenssing 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 "Oswayo" 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 sandstone; 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 pebble 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).

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 UNTIS
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 think 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. Myerstone-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 - shert, 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); unconformity.

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 FORMATION (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 Allenton 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 (CAMBRAIN)
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 TONSTOWN 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 frangments 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)

gm 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 doninant; 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, quarts-feldspar gneiss, calcsilicate rock.

gtlg 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.

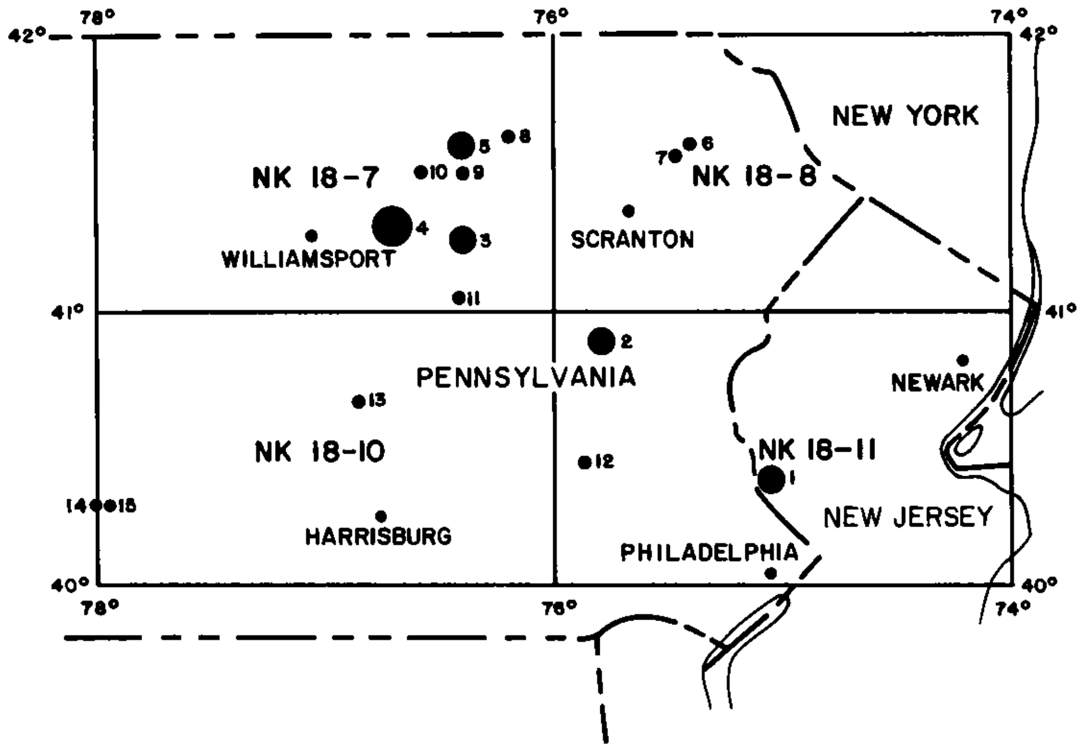
McCauley (1961) describes forty-three occurrences, all located in the eastern part of Pennsylvania and near the Delaware River in New Jersey. The occurrences are in rocks of four different ages: Triassic, Mississippian, Devonian and Precambrian. The great majority are in the Catskill Formation of Devonian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

The sandstone occurrences are in may 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 occurence in Triassic beds, the samples all showed significant depletion in S^{34}, strongly suggesting that the sulfur contained in the occurrences is derived from oganically 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 classification, 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 catagory 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 Williamsport 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 Williamsport 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.

The Williamsport Quadrangle encompasses a highly dissected upland terrain which is heavily forested and sparsely populated, particularly in the west. Accordingly, as revealed by an examination of Table 2, both culture and agricultural activity are considerably less prevalent here than in the other portions of the Thorpe area, and with the possible exception of local areas of concentration in the east and southeast, are unlikely to have a significant influence on the radiometric data. The minor surface water and high water table category, however, has a relatively high incidence of occurrence throughout the area and may be expected to have considerable local effect on the data. The prevalence of this category despite the well-drained nature of the terrain in most areas undoubtedly relates to the early spring season during which this survey was flown.

Certain categories listed clearly reflect local distributions. A persistent decrease in culture and agricultural activity from east to west across the quadrangle is clearly indicated, reflecting the relative restriction of these categories to the eastern half of the area, as mentioned above. Conversely, the mining activity category displays an increase in occurrence from east to west, reflecting the wider distribution of coal bearing formations in the western portion of the region.

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 Williamsport Quadrangle used in the radiometric survey evaluation is illustrated in Figure 8. The majority of the soils are glacial in origin, extending over the eastern and northern portions. Those in the southwestern quarter of the area, in contrast, are predominantly of fluviatile origin with minor amounts of residual types.

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 of 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.

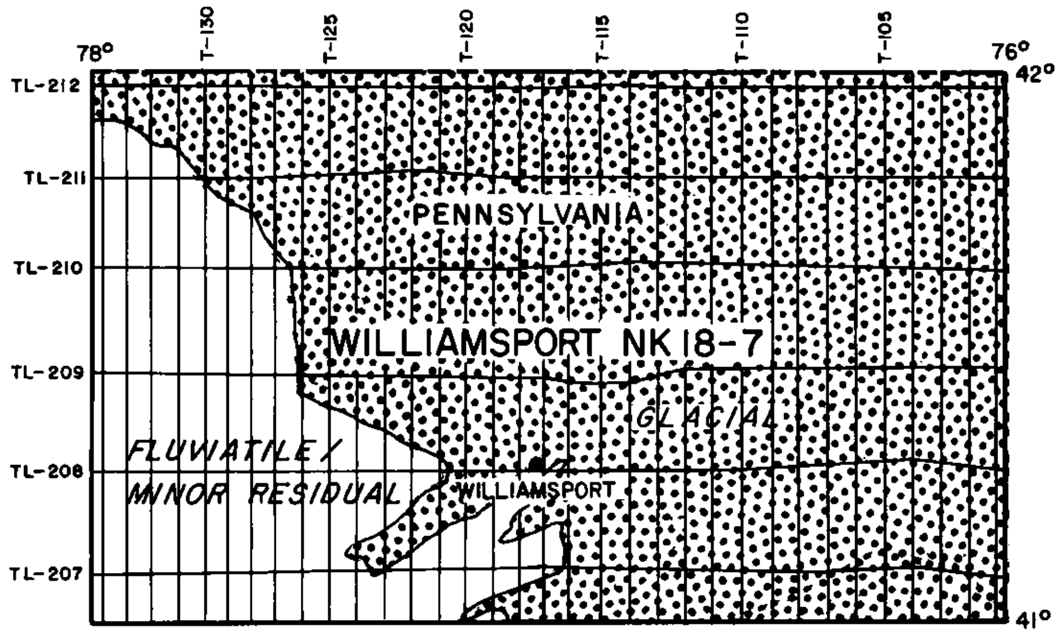


FIGURE-8 MAJOR SOIL TYPES—WILLIAMSPORT QUADRANGLE

TABLE 2 - SUMMARY OF PHOTOGEOLOGIC ENHANCEMENT

THORPE AREA - WILLIAMSPORT 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
100	15	< 1	13	5	14	1	100	0	0
101	27	1	7	9	12	16	100	0	0
102	19	2	9	2	11	1	100	0	0
103	14	0	11	1	11	5	100	0	0
104	12	< 1	13	3	6	2	100	0	0
105	13	< 1	23	< 1	13	5	100	0	0
106	17	< 1	23	3	9	6	100	0	0
107	15	< 1	21	2	10	7	100	0	0
108	*	*	*	0	7	*	100	0	0
109	14	0	24	1	14	5	100	0	0
110	*	*	*	1	*	*	100	0	0
111	*	*	*	2	*	*	100	0	0
112	*	*	*	3	*	*	100	0	0
113	*	*	*	2	*	*	100	0	0
114	*	*	*	0	*	*	100	0	0
115	*	*	*	3	*	*	99	1	0
116	*	*	*	6	*	*	96	4	0
117	*	*	*	14	*	*	88	12	0
118	13	< 1	11	4	12	*	86	14	0
119	9	1	15	6	7	*	79	21	0
120	*	*	*	2	*	*	79	21	0
121	*	*	*	1	*	*	69	31	0
122	13	< 1	15	4	12	2*	64	36	0
123	7	< 1	8	5	7	1*	65	35	0
124	12	< 1	11	4	11	< 1*	58	42	0
125	17	< 1	9	5	14	3	56	44	0

TABLE 2 - SUMMARY OF PHOTOGEOLOGIC ENHANCEMENT

THORPE AREA - WILLIAMSPORT QUADRANGLE

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

Line	Minor Surface Water, High Water Table	Major Surface Water	Agricul-tural Activity	Mining Activity	Culture	Outcrop and/or Float	Major Soil Type		
							Glacial, Residual	Fluviatile, Residual	Marine, Littoral, Residual
126	14	< 1	10	12	12	3	51	49	0
127	23	< 1	10	11	10	4	33	67	0
128	16	< 1	5	6	6	8	26	74	0
129	17	0	3	6	5	4	24	76	0
130	18	< 1	9	11	6	11	18	82	0
131	6	0	4	11	6	11	14	86	0
132	19	< 1	< 1	17	3	4	8	92	0
133	17	0	2	14	10	5	9	91	0
134	12	0	0	17	3	*	9	91	0
207	*	*	*	10	*	*	56	44	0
208	*	*	*	6	*	*	56	44	0
209	4*	0*	2*	12	3*	1*	76	24	0
210	9	< 1	13	12	8	4	79	21	0
211	9	< 1	27	1	8	*	88	12	0
212	15	< 1	25	2	15	2	100	0	0

* - Data incomplete or unrecoverable

SECTION 8.0

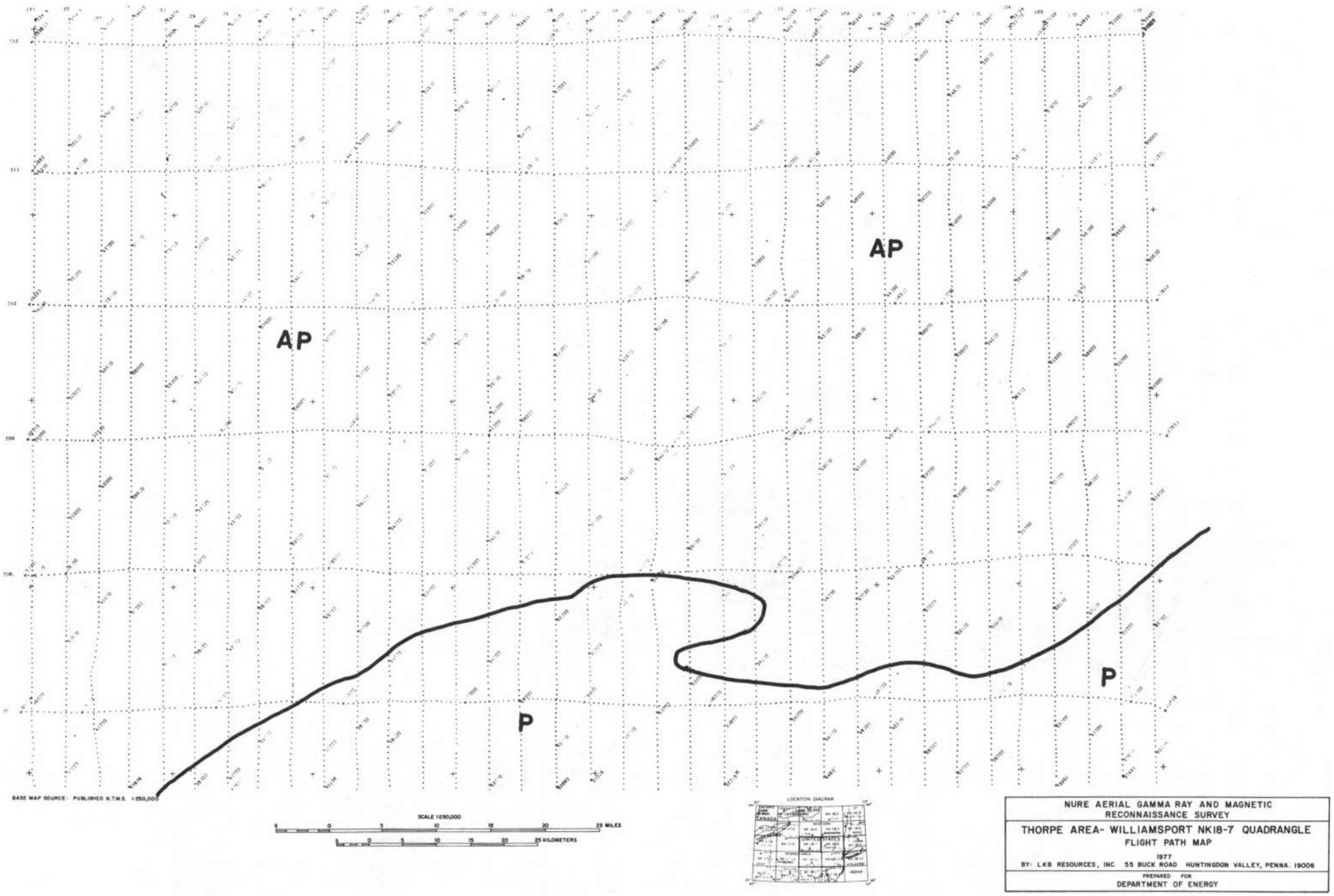
DATA INTERPRETATION

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.



LEGEND

P - PALEOZOIC (FOLDED) APPALACHIANS
AP - ALLEGHENY PLATEAU

FIGURE 9 - MAJOR GEOLOGIC PROVINCES - WILLIAMSPORT QUADRANGLE

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 Paleozoic (Folded) Appalachians

This province, which occupies only a limited area in the southern portion of the quadrangle, is crossed by the southern ends of Profiles 100 through 129 and the eastern end of Profile 207. The principal bedrock exposures in the west are marine sediments of lower Paleozoic age, distributed in relatively tight, east-west trending folds. In the east, the folding becomes more open and involves younger formations ranging from Silurian up to Pennsylvanian in age.

The magnetic response over these Paleozoic units exhibits an almost featureless magnetic profile at the presentation scale. Detailed magnetic surveys flown previously in this area have, of course, revealed the presence of local magnetic anomalies arising from the basement, but these features are not amenable to study in the present data set.

The radiometric response over the area is, in contrast, highly variable as a result of the rapidly changing lithology along the flanks of the numerous folds. In this regard, all three spectral channels display a general difference in regional character over the folded Appalachians as contrasted with the Allegheny plateau. Since this difference is often quite subtle, it is of possibly minimal value at the line spacing and data presentation scales of the present survey. However, it may well be of considerable use from the standpoint of geochemical differentiations of lithologic units in the context of larger scale maps and more detailed survey data sets.

With regard to associated anomalous uranium responses, there are similarities between the folded Paleozoics on the Williamsport sheet and those on the Harrisburg sheet to the south, in that most of the anomalous response occurs in the eastern part of the province where younger formations of continental origin prevail.

The Allegheny Plateau

This province occupies the major part of the Williamsport quadrangle, underlying the entire northern and western portions of the area. It is traversed by the northern ends of Profiles 100 through 129, the western end of Profile 207, and Profiles 130 through 134 and 208 through 212 in their entirety.

The magnetic profiles across this province display a series of very broad anomalies which obviously arise from crystalline basement rocks beneath the Paleozoic section. The breadth of the anomalies indicates that they arise from sources at depths in excess of 10,000 feet. Progressing northward and westward across the area, the magnetic profiles become somewhat more expressive, corresponding to the regional rise of the basement surface.

The most obvious characteristic of the radiometric profile data across this province is the pronounced decrease in background count rate over the younger Paleozoic Pocono and Pottsville Formations, which have widespread occurrence in the central and western portions of the area. Taken as a whole, these units exhibit a background which is considerably lower, both in the total count and in the spectral channels, than that of the Devonian rocks flanking them. Nevertheless, several important anomalous zones occur within these younger sediments. For example, a series of very strong anomalous spikes occurring on the northern portions of traverses 116, 117, 118, and perhaps 119 (which includes the significant eU anomalies 34 and 36) forms a zone probably in excess of 12 miles in length and perhaps a half a mile in width. The maximum excusion of the anomalies on these traverses exceeds three sigma in all three spectral channels. A similar anomaly occurs in a similar geologic situation to the southwest on Profile 125 (Anomaly 95).

All of the known occurrences of uranium mineralization in the Williamsport quadrangle are located in the east-central part of the area in three principal localities. They have been grouped into districts by the Pennsylvania State Geological Survey, as shown in Figure 10 of this report. All of these occurrences are in upper Devonian rocks, principally within the Catskill Formation. In addition to these localities, four other individual occurrences have been noted within the general vicinity of the main districts.

These include the Loyalsock Creek occurrence in Sullivan County, in the Catskill Formation; the Forkston occurrence in Wyoming County, probably also located in the Catskill although in this area the Catskill is included in the Susquehanna Group; the Orangeville occurrence in Columbia County, again in the Catskill Formation; and the Dushore occurrence in Sullivan County, again in the Catskill Formation. With the exception of several moderate responses in the general vicinity of the Beaver Lake and New Albany districts, no anomalous airborne response is observed over any of these known occurrences. This may be the result of an insufficient flight line spacing covering the area, but perhaps the more realistic reason for this lack of response is that these deposits are very low grade and are confined to very limited areas. However, the possibility certainly exists that approximate map locations of the occurrences combined with local inaccuracies of flight path positioning may be at fault, and more detailed mapping could well develop direct relationships between these known occurrences and their radioactive response.

8.3 URANIUM ANOMALY MAPS

8.3.1 Selection of Uranium Anomalies

Through an examination of the equivalent uranium anomaly map, a total of 209 significant eU anomalies have been determined in the Williamsport Quadrangle area, as shown in Figure 11 and listed in Table 3. 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 (Open-File 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 geologic maps, the photogeologic enhancement study data, the supporting data tables, the stacked profiles, 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 3.

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, two aspects of the study are of particular interest in the Williamsport area. In the eastern portions of the quadrangle, a very useful criterium is that of widespread agricultural activity, since the gamma radiation from potassium and phosphate fertilizers can produce significant background radiation over short distances. In the west, extensive coal measures occur which, particularly where mined, can similarly influence the airborne data, and such areas can readily be defined in this study. Also observable in this data set is the fact that cultural activity in this quadrangle is not nearly as much of a hindrance to exploration and mining activities as has been noted in the other three quadrangles of the Thorpe area. This sheet encompasses some of the most sparsely settled land in the state of Pennsylvania.

8.3.3 Discussion of Anomalies

Of the total of 209 statistically significant eU anomalies shown in Figure 11 and listed in Table 3, forty-six 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 such as the post-Pottsville rocks of Pennsylvania age occurring in the Wyoming Valley, and the Poxono Island Formation of Devonian age, which lack statistical adequacy. Cases of extreme contrasts in sampling frequency are more prevalent in this quadrangle because most of the geologic units present occupy extensive areas. In the case of the Devonian formations, for example, several thousand samples are frequently available for statistical analysis.

More than half of the preferred eU anomalies discussed below (24 out of a total of 46) occur in upper Devonian units. A breakdown of the preferred anomaly occurrences by source rock age is tabulated below. Note that in some cases anomalies occur at the contact between two formations, and thus are listed for each formation age in this tabulation, resulting in a larger number than the total number of preferred anomalies actually present.

Mississippian	11	anomaly	associations
Upper Devonian	29	"	"
Lower Devonian	7	"	"
Silurian	5	"	"
Ordovician	1	"	"

In contrast to the circumstances observed in the Harrisburg quadrangle to the south, where only three preferred eU anomalies were recognized in the Mississippian formations, this area contains eleven preferred eU anomalies over what is perhaps an equivalent total area of outcrop. Perhaps the increase in the outcrop area of the Pocono Formation and the decrease in the outcrop area of the Mauch Chunk Formation in this quadrangle as contrasted with the Harrisburg quadrangle could account for this difference, since it will be noted that the Pocono Formation is identified with all eleven of the Mississippian anomalies while the Mauch Chunk Formation is identified with only two.

Some additional comparisons might be useful in the context of the regional evaluation of this area. The upper Devonian formations in this quadrangle are as yet inadequately differentiated, and judging by the uniformity of the geochemical implications inherent in the statistical data, this task will be quite difficult. For example, the uniformity of the Devonian formations is well depicted in the histograms by the lack of multi-modal situations, particularly in the potassium channel. This suggests that considerable difficulty will be encountered in defining both formational boundaries and facies changes in these areas of extensive Devonian outcrop.

Two sampling categories in particular should be noted in these upper Devonian rocks. The first of these is the Catskill Formation within which quite a few significant eU anomalies occur, while the second is the broad unit designated as the Susquehanna Group, which also produces numerous anomalies. However, the Susquehanna group, where it is mapped, includes not just the Catskill but older and younger formations as well.

The Marine Beds of upper Devonian age appear to be considerably less significant in this quadrangle with regard to associations with significant eU anomalies than they were in the Harrisburg Quadrangle to the south, but this may be the result of the fact that much of the Marine Beds are grouped with the Catskill formation under the general heading of the Susquehanna group.

The number of anomalies in Silurian rocks in the Williamsport Quadrangle is comparable to the number noted in the Harrisburg Quadrangle, but the number of anomalies in Ordovician rocks differs considerably. Nineteen anomalies were noted in Ordovician rocks in the Harrisburg Quadrangle, most of which were associated with limestones. In this quadrangle, in contrast, only one anomaly is identified with Ordovician rocks and in this case the unit involved is composed of sandstones and conglomerates.

The following notes comprise specific comments on the preferred anomalies noted in Table 3 with regard to geologic setting, surficial conditions and structural associations, where applicable.

Anomalies 12, 33, 72, 79 and 129

All of these anomalies are identified with the Pocono formation. Anomalies 12 and 33 are quite sharply defined in the stacked profiles. Anomalies 72 and 129 apparently occur at the base of the Pocono formation along the contact with the Oswayo formation of Devonian age. Both cultural and agricultural activity is noted in the areas of these two anomalies. All of these anomalies are characterized by a weak or non-existent anomalous thorium response.

Anomalies 32, 128 and 170

These three anomalies occur at or near the contact of the Pocono formation with the Mauch Chunk formation of Mississippian age. The Mauch Chunk formation is typically an interbedded sandstone and shale. Anomalies 32 and 128 are both associated with mining activities and a high water table (excessive moisture near the surface is in evidence in both of these instances). All three of these anomalies are rather sharp features occurring over a limited area.

Anomalies 77, 112 and 113

These three anomalies occur at or near the base of the Pocono formation near the contact with an upper Devonian unit. Anomaly 77 is a weak anomaly occurring over a limited area. Anomalies 112 and 113 are somewhat more extensive and occur very close together on Profile 113, suggesting that the two zones may be related. Anomaly 112 in particular is one of the most interesting features in the Williamsport area. In profile form the uranium response is clearly anomalous, but could be overlooked in this zone of numerous anomalous responses. The ratio of uranium to thorium on the profile does, however, produce a very pronounced anomaly. One detracting circumstance should be noted. Traverse 113 appears to be more anomalous at its southern end than the traverses on either side (Profiles 112 and 114), suggesting a possible minor level shift in the data which could lower the total amplitude of these two anomalies, but certainly could not eliminate them.

Anomalies 25, 27, 38, 44, 45, 56, 66, 76, 78, 85, 114, 115, 120, 122, 123, 124, 125, 126, 155, 159, 167, 196 and 203

These anomalies all occur in upper Devonian sandstones and shales. Where these units are mapped individually they consist of the Catskill formation, the Marine Beds and the Oswayo formation.

However, frequently they are collectively mapped as the Susquehanna group. Several of the anomalies occurring on the traverses are rather extensive, suggesting the presence of broad zones of increased equivalent uranium concentration. Examples of these would be Anomalies 25 and 124. Others in this group appear only on tie lines and must at this time be considered, at least in part, the result of datum shifts (e.g., Anomalies 44, 45, 56, 66, 122 and 123). Anomaly 126 occurs on both tie line 208 and traverse 100 at their intersection, which lends strong support to the validity of this response.

Since Profile 100 appears to be significantly more anomalous than the adjacent lines (Profiles 101 and 102), the anomalies occurring on this profile are considered as being possibly somewhat excessive in their apparent anomalous response. This would include Anomalies 25, 124 and 125, all rather broad zones for the most part not exceeding two standard deviations. Thus, if this traverse has a somewhat higher datum level than the remainder of the traverses on this sheet, the relative importance of these three anomalies could be considerably reduced.

The most interesting anomalies in this group are considered to be those occurring near the transition zone between the tightly folded Paleozoic rocks and the gently folded rocks of the Allegheny Plateau. This would include Anomalies 114, 115, 120, 155, 159, 167 and 196.

Several of the anomalies are identified with a high water table (e.g., Anomalies 25, 45, 56, 66, 126 and 203). Both cultural and agricultural activities are also frequently noted in the areas of these anomalies, and in the case of Anomaly 27, outcrop is noted in the vicinity. Finally, on examination of the stacked profiles, both Anomalies 66 and 85 are seen to display significant excursions in excess of 3 sigma.

Anomaly 209

Anomaly 209 is located in the north-central part of the quadrangle on tie line 212. It occurs in the Wiscoy formation, an upper Devonian unit that perhaps underlies the Marine Beds. Since a correlation between the Devonian formations mapped in New York State and those mapped in Pennsylvania has not as yet been officially attempted, there is some doubt at this writing as to the precise age relationship of the unit. Although the anomaly is located in an area of agricultural activity, there is minimal associated thorium and potassium response.

Anomalies 157, 180, 184, 189 and 190

These anomalies occur in middle and lower Devonian rocks. All but Anomaly 157 occur in the southeastern part of the sheet. While Anomalies 157 and 180 occur over limited areas, the remainder of this group form rather broad zones. Anomaly 180 produces a rather significant potassium response, and this has to be considered a qualifying factor. Anomalies 184 and 189 both produce rather strong eU/eTh ratios.

Anomalies 144, 154, 185, 186 and 188

These five anomalies all occur in the upper portions of the Silurian section above the Clinton formation. For the most part, these rocks consist of limestones with some sand and shale members. Both Anomalies 144 and 154 occur at the top of the Silurian near its contact with lower Devonian sediments. All five of these anomalies are relatively weak, but do exhibit favorable eU/eTh ratios and low thorium values.

Anomaly 149

This anomaly occurs in Ordovician rocks at the contact of the Juniata formation with the Bald Eagle formation (both fine to coarse grained sandstones). The anomaly displays a rather significant spike in the stacked profile data.

8.4 CONCLUSIONS

The results of the gamma ray spectrometer survey indicate that the Williamsport Quadrangle portion of the Thorpe area cannot be considered as a highly prospective area from the standpoint of economic uranium mineral concentrations. However, the survey data has produced some unexpected results, notably the large number (209) of significant eU anomalies which have been delineated. The distribution of anomalies over the western part of the area produces some ambiguity in that the significant eU anomalies are principally restricted to occurrences on east-west tie lines, suggesting the possibility of a regional difference in datum levels between the traverses and the tie lines in this region. Accordingly, additional information might be obtained from this data set by further processing in two parts i.e., one data set consisting of the statistical evaluation of only the traverses and a second data set consisting of the statistical evaluation of only the tie lines.

In addition, certain predictable results are also apparent in the data obtained over this area, such as the fact that the greatest number of preferred eU anomalies (28) are associated with upper Devonian units, including the Oswayo formation, the Catskill formation and the Marine Beds. Furthermore, the majority of the preferred anomalies are located in the southeastern part of the quadrangle, more or less on strike with the most interesting zones defined by the data in both the Scranton and Newark Quadrangles. As noted in other NURE reports on the Thorpe survey area, this anomalous belt appears to extend southeastward through the Scranton and Newark quadrangles, generally normal to the regional geologic strike.

8.5 SUGGESTIONS FOR FURTHER WORK

One suggestion for further work is essentially described in the conclusions above, involving alternate processing of the existing data. Additional follow-up work in the area should incorporate stream sediment and ground water geochemical surveys, with particular emphasis on the southeast corner of the quadrangle. This geochemical work will clarify some of the fundamental implications of the uranium deposition within this large Paleozoic basin, particularly as it applies to the concentration of airborne anomalies within a limited zone in the southeast part of the quadrangle, and will undoubtedly lead to more economical applications of detailed follow-up airborne surveys.

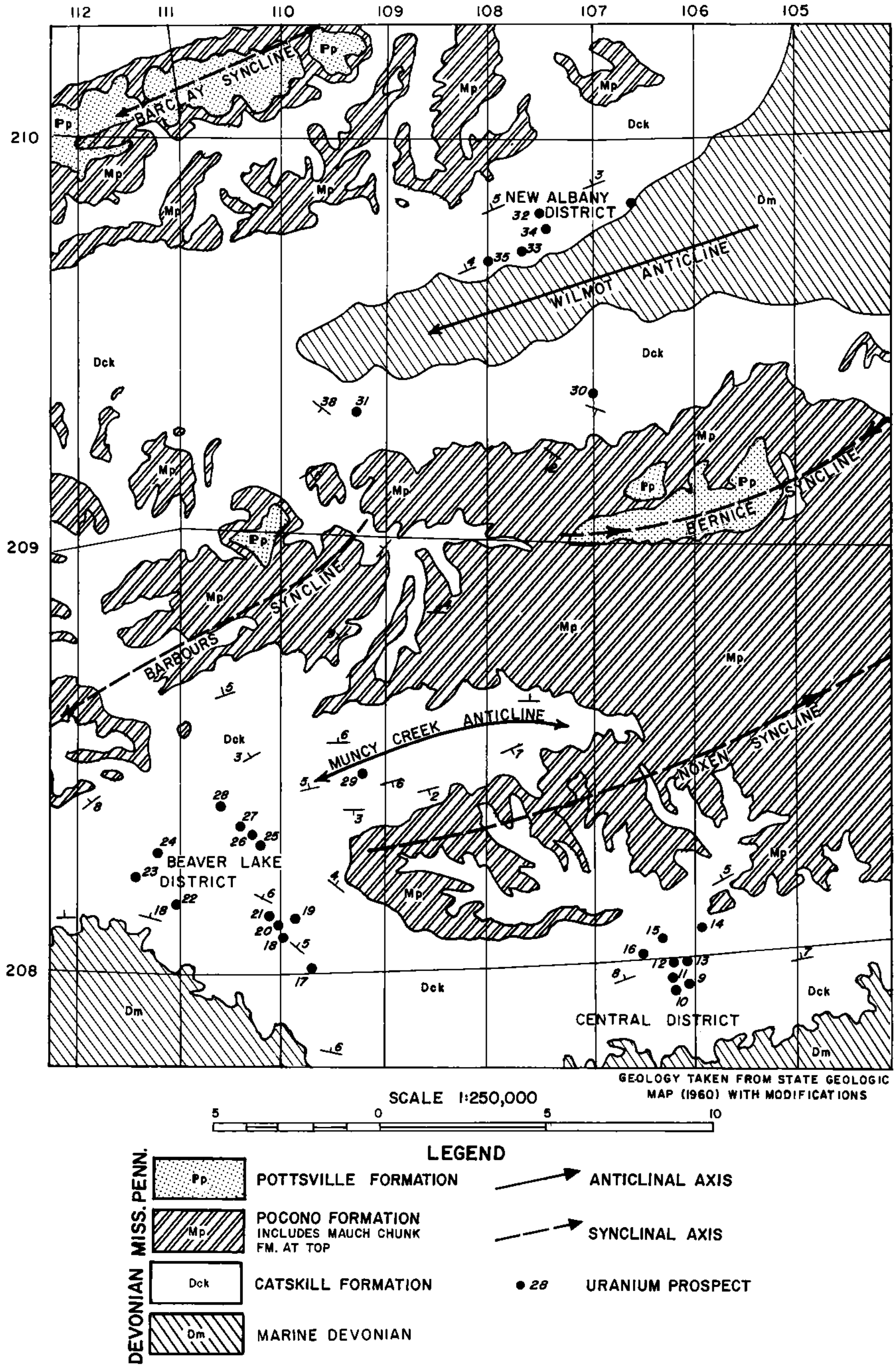
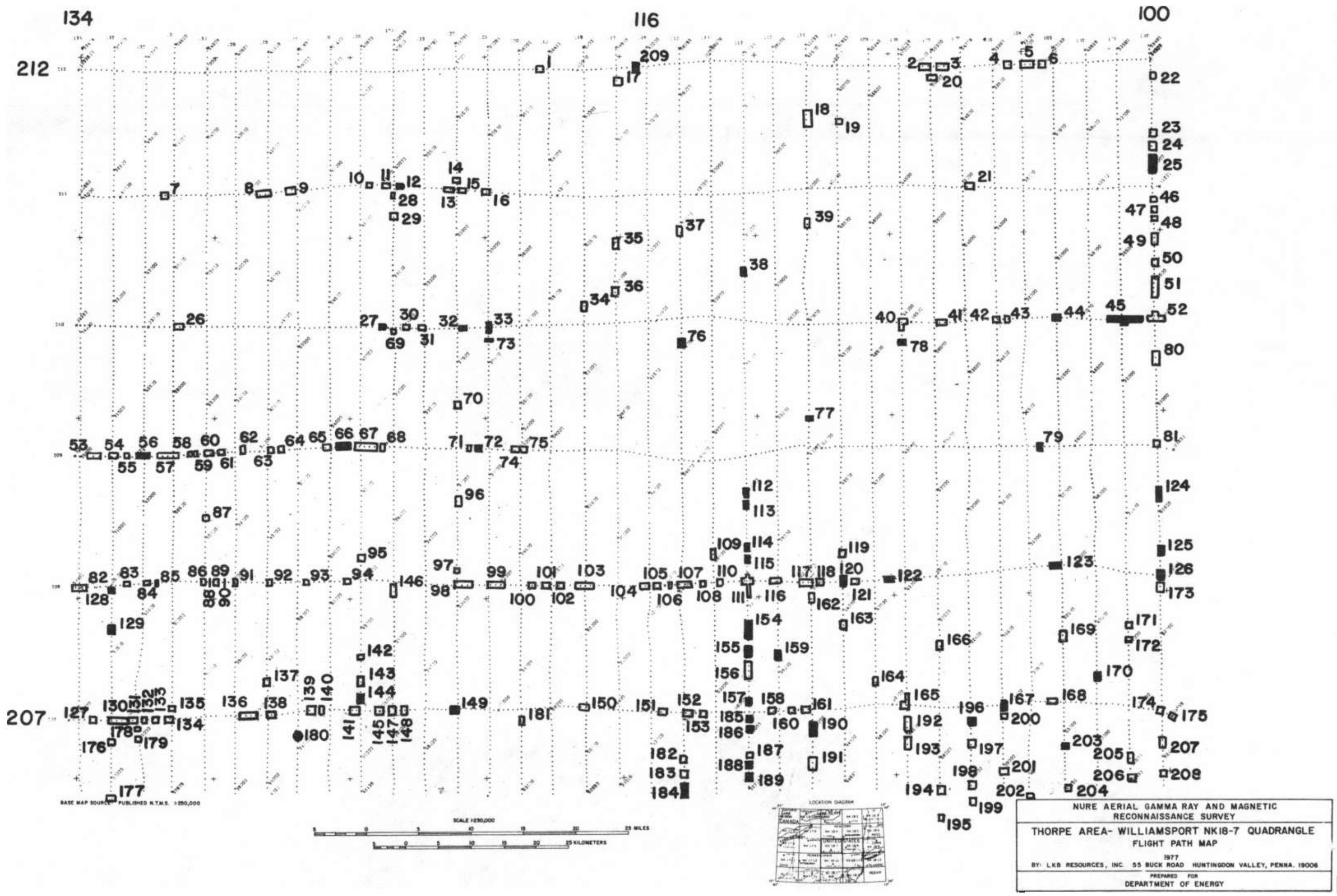


FIGURE 10 - GEOLOGIC SKETCH MAP AND FLIGHT PATH OF THE BEAVER LAKE, NEW ALBANY AND CENTRAL URANIUM AREAS



LEGEND

STATISTICALLY SIGNIFICANT eU ANOMALIES

PREFERRED ANOMALIES SUPPORTED BY STATISTICALLY HIGH eU/eTh AND eU/K VALUES

FIGURE 11 - EQUIVALENT URANIUM ANOMALY MAP - WILLIAMSPORT QUADRANGLE

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT 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	212	Dj	1,4,5,7	4	-	-	1	1	2	1	2	-	-	-	-	-	-	-
2	212	Ds	3,5	3	1	-	2	1	-	1	1	-	1	-	-	1	-	-
3	212	Ds,Dwrg	1,3,5	4	3	-	3	1	-	4	-	-	4	-	-	1	-	-
4	212	Ds	1,3	4	1	-	2	-	-	-	-	-	2	-	-	1	-	-
5	212	Ds	1,3,5	5	4	-	6	1	-	6	3	-	3	-	-	-	-	-
6	212	Ds	5	2	2	-	2	1	-	4	-	-	2	-	-	-	-	-
7	211	Doo,Mp,Dck	3	4	-	-	1	-	-	1	-	-	-	-	-	-	-	-
8	211	Dck,Dm	3,5	5	3	-	2	-	-	2	-	-	2	2	2	3	-	1
9	211	Dck,Dm	5	1	3	-	2	-	-	2	-	-	2	1	-	3	-	-
10	211	Mp	1	2	1	1	1	-	-	-	-	-	2	-	-	1	1	-
11	211	Mp	1	1	2	-	2	-	1	1	2	-	-	-	-	-	-	-
12*	211	Mp	-	1	2	1	4	-	-	-	1	-	1	-	-	-	-	-
13	211	Doo,Mp	-	1	4	1	2	2	-	2	-	-	2	-	-	-	-	-
14	122	Mp	1	1	-	1	-	-	-	-	-	-	1	-	-	-	-	-
15	122&211	Mp,Doo,Dck	1	4	1	-	1	-	-	-	-	-	1	-	-	1	-	-
16	211	Doo,Dck	3	4	-	-	2	-	-	2	-	-	-	1	-	-	-	-
17	117	Dj	-	2	1	-	-	-	-	2	-	-	1	-	-	-	-	-
18	111	Dj	-	10	-	-	1	-	-	-	-	-	4	-	-	5	-	-
19	110	Dj	-	2	1	-	-	-	-	1	-	-	2	-	-	-	-	-
20	107	Ds	1,7	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-
21	211	Ds	-	2	1	-	-	-	-	-	-	-	3	-	-	2	-	-
22	100	Dwrg	3,5	1	2	-	1	-	-	1	-	-	-	-	-	-	-	-
23	100	Ds	1,5	4	-	-	2	-	-	1	-	-	1	-	-	-	-	-
24	100	Ds	1	5	-	-	2	-	-	1	-	-	-	-	-	-	-	-
25*	100	Ds	1,3,5	6	4	1	6	-	-	4	1	-	5	-	-	2	-	-
26	210	Doo,Mp	1	4	1	-	3	-	-	3	-	-	1	1	-	1	-	-
27*	210	Dck	1,5,7	1	1	1	-	1	-	2	-	1	1	2	-	-	-	-
28	124	Doo,Mp	1	4	-	-	2	2	-	1	3	-	-	-	-	-	-	-
29	124	Doo,Mp	1	2	1	-	3	-	-	2	-	-	-	-	-	-	-	-
30	210	Doo,Mp	1	1	1	1	1	1	-	2	1	-	1	-	-	-	-	-

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT QUADRANGLE

				Number of Points														
				eU			eTh			K			eU/eTh			eU/K		
Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	+	++	+++	+	++	+++	+	++	+++	+	++	+++	+	++	+++
31	210	Doo	1,5	1	-	1	2	-	-	2	-	-	-	-	-	-	-	-
32*	210	Mp,Mmc,Pp	1,4,5	3	-	1	3	1	-	2	-	-	2	-	-	1	-	-
33*	210	Mp	1	-	-	1	1	-	-	-	1	-	1	-	-	-	-	-
34	118	Pp	4,5	2	1	1	-	1	2	-	1	2	-	-	-	-	-	-
35	117	Doo,Dck	-	4	-	-	1	1	-	1	2	-	-	-	-	-	-	-
36	117	Pp	4	1	3	1	1	1	2	-	1	2	-	-	-	1	-	-
37	115	Mp	-	5	-	-	-	-	-	-	-	-	1	-	-	-	-	-
38*	113	Ds	-	2	1	1	-	-	-	-	-	-	2	1	-	2	2	-
39	111	Ds	-	4	-	-	1	-	-	-	-	-	1	-	-	2	-	-
40	108&210	Mp	-	3	4	1	4	-	-	3	-	-	-	-	-	2	1	-
41	210	Ds	1,3,5	3	2	-	5	-	-	3	-	-	2	-	-	-	-	-
42	210	Ds	1,3	3	1	-	1	-	-	1	-	-	3	1	-	3	1	-
43	210	Ds	3	2	1	-	-	-	-	-	-	-	2	-	-	1	1	-
44*	210	Ds	3,5	1	1	1	1	-	-	1	-	-	1	-	1	-	-	1
45*	210&101	Ds	1,3,5	15	4	1	8	-	-	5	-	-	8	1	-	6	2	-
46	100	Ds	1	1	2	-	2	-	-	2	-	-	1	-	-	-	-	-
47	100	Ds	1,3	1	3	-	1	1	-	3	1	-	2	-	-	-	-	-
48	100	Ds	1,3	3	1	-	3	-	-	2	-	-	2	-	-	-	-	-
49	100	Ds	3,5	5	-	-	1	-	-	3	-	-	1	-	-	-	-	-
50	100	Ds	-	2	1	-	3	-	-	2	-	-	1	-	-	-	-	-
51	100	Ds	1,3,5	10	3	-	8	1	-	8	-	-	2	-	-	1	-	-
52	210&100	Ds	1,3	10	-	1	5	-	-	2	-	-	3	-	-	3	-	-
53	209	Mp,Doo	7	4	-	-	-	-	-	-	-	-	-	1	3	-	1	3
54	209	Mp,Doo	1,5	2	1	3	2	-	-	2	-	-	1	1	4	1	1	4
55	209	Mp	-	-	1	2	1	1	-	1	-	-	2	-	-	2	-	-
56*	209	Doo,Dck	1,5	3	2	7	5	-	-	2	-	-	4	5	3	4	1	4
57	209	Doo,Dck	1,3,5	7	2	1	4	2	-	1	2	-	3	2	-	3	-	1
58	209	Doo	-	-	1	1	-	-	-	-	-	-	-	1	1	1	-	1
59	209	Doo	1	-	2	-	2	-	-	1	-	-	-	-	-	-	-	-
60	209	Doo	-	4	-	-	-	-	-	-	-	-	2	-	-	2	-	-

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT 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 +++
61	209	Doo,Mp	-	6	1	-	2	2	-	4	1	-	1	-	1	-	-	-
62	209	Dck,Doo,Mp	5	1	1	1	1	-	-	-	1	-	2	1	-	1	-	-
63	209	Mp	1	-	1	1	1	-	-	-	1	-	-	1	1	-	-	-
64	209	Doo,Mp	1,5	1	-	1	-	-	-	-	-	-	2	-	-	-	-	-
65	209	Doo,Dck	1	1	1	2	2	-	-	-	-	-	2	2	-	4	-	-
66*	209	Doo,Dck	1	1	1	7	-	-	-	1	-	-	1	1	7	2	-	7
67	209	Doo,Dck,Mp	-	2	6	5	8	1	-	10	-	-	5	1	1	4	1	-
68	209	Mp	-	-	-	1	1	-	-	1	-	-	1	-	1	-	-	-
69	124	Mp	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	-
70	122	Doo,Mp	3,5	4	-	-	1	1	-	-	1	-	1	-	-	-	-	-
71	209	Mmc,Mp	1,4	1	-	2	-	-	-	-	-	-	-	1	2	1	1	-
72*	209	Mp,Doo,Dck	1,3	-	1	4	2	-	-	-	-	-	-	1	4	1	-	4
73	121	Ds	-	-	-	1	1	-	-	-	1	-	1	-	-	-	-	-
74	209	Mp	3	3	-	1	1	-	-	1	1	-	1	1	-	1	1	-
75	209	Mp,Ds	-	2	2	-	3	-	1	3	1	-	-	-	-	-	-	-
76*	115	Ds	-	3	1	-	-	-	-	-	-	-	4	-	-	3	-	-
77*	111	Ds,Mp	-	-	2	-	-	-	-	-	-	-	2	-	-	1	-	-
78*	108	Ds	-	2	2	-	-	-	-	-	-	-	1	1	-	1	2	-
79*	209	Mp	-	2	1	-	-	-	-	-	-	-	-	1	-	-	-	-
80	100	Ds	3	5	1	-	3	-	-	-	-	-	1	-	-	1	-	-
81	100	Ds	-	1	-	1	1	-	-	2	-	-	2	-	-	-	-	-
82	208	Pp	4	3	2	3	-	-	-	-	-	-	3	2	1	3	-	-
83	208	Mp	-	2	1	-	-	-	-	-	-	-	-	1	1	-	1	-
84	208	Doo	-	2	-	1	-	-	-	-	-	-	-	2	1	-	1	-
85*	208	Doo	-	-	-	1	1	-	-	1	-	-	-	1	-	1	-	-
86	208	Doo	-	1	2	-	2	-	-	2	1	-	1	-	-	-	-	-
87	130	Pp,Mmc,Mp	4,5,7	4	-	1	1	1	1	-	1	2	1	-	-	-	-	-
88	208	Doo	-	-	-	1	1	-	-	1	-	-	-	1	-	-	-	-
89	208	Mp	-	4	1	-	4	-	-	4	-	-	-	-	-	-	-	-
90	208	Doo	-	-	-	1	1	-	-	-	-	-	1	-	-	1	-	-

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT 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 +++
91	208	Doo	-	2	1	-	-	-	-	-	-	-	2	-	-	1	1	-
92	208	Mp	-	-	1	1	-	-	-	2	-	-	2	-	-	-	-	-
93	208	Mp	-	2	1	-	1	-	-	1	1	-	1	-	-	-	-	-
94	208	Mp	-	4	-	-	-	-	-	1	1	-	2	1	-	-	1	-
95	125	Pp	4,5	1	-	2	-	-	3	-	1	-	-	-	-	1	-	-
96	122	Doo,Mp	7	4	1	-	1	2	-	3	-	-	1	-	-	-	-	-
97	122	Mp	5	2	1	-	2	-	-	2	-	-	1	-	-	-	-	-
98	208	Mp,Doo	-	3	4	2	3	4	1	3	3	2	2	-	-	1	-	-
99	208	Ds	-	5	4	1	4	3	-	4	3	1	2	-	-	1	-	-
100	208	Ds	-	3	1	-	1	1	1	2	2	-	1	-	-	-	-	-
101	208	Ds	-	3	3	-	5	-	-	5	1	-	1	-	-	-	-	-
102	208	Ds	-	2	2	2	2	2	-	3	2	1	1	-	1	-	-	-
103	208	Ds	-	6	3	2	3	5	1	4	2	3	1	1	-	1	1	-
104	208	Ds	-	3	2	1	6	-	-	5	1	-	-	-	-	-	-	-
105	208	Ds	-	4	4	-	2	-	-	2	1	-	6	-	1	2	-	2
106	208	Ds	-	-	2	-	1	-	-	1	-	-	1	-	-	1	-	-
107	208&115	Ds	-	7	3	2	8	1	-	8	4	-	3	-	-	-	-	-
108	208	Ds	-	3	1	-	2	2	-	1	2	1	-	-	-	-	-	-
109	114	Ds	-	2	2	-	3	-	-	1	2	-	1	-	-	1	-	-
110	208	Ds	-	3	1	-	1	3	-	-	-	4	-	-	-	-	-	-
111	208&113	Ds	-	6	5	3	7	4	1	6	4	1	5	-	1	3	-	-
112*	113	Mp,Ds	-	-	-	4	-	-	-	1	-	-	-	-	4	1	1	2
113*	113	Mp,Ds	-	1	2	2	-	-	-	-	-	-	-	1	4	-	3	1
114*	113	Ds	-	2	2	-	-	-	-	-	-	-	2	-	-	1	-	-
115*	113	Ds	-	2	1	2	2	-	-	1	1	-	1	2	-	3	-	-
116	208	Dm	-	5	1	-	2	1	1	3	1	-	1	-	-	4	-	-
117	208	Dm,Dck	-	7	-	-	2	3	1	3	2	-	-	-	-	3	-	-
118	208	Dck	-	3	1	-	2	2	-	2	1	1	-	-	-	-	-	-
119	110	Ds	-	2	1	-	1	-	-	2	1	-	1	-	-	-	-	-
120*	110	Dck	-	5	-	-	-	1	-	1	-	-	1	2	-	2	-	-

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT QUADRANGLE

				Number of Points														
				eU			eTh			K			eU/eTh			eU/K		
Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	+	++	+++	+	++	+++	+	++	+++	+	++	+++	+	++	+++
121	208	Dck	-	3	1	-	-	4	-	-	3	-	-	-	-	-	-	-
122*	208	Dck,Ds	-	2	1	1	1	-	-	-	-	-	3	1	-	2	-	1
123*	208	Ds	-	5	-	-	-	-	-	-	-	-	4	-	-	3	-	-
124*	100	Ds	3,5	8	-	-	-	-	-	-	-	-	4	-	-	5	3	-
125*	100	Ds	3,5	4	2	-	-	-	-	-	-	-	5	-	-	5	-	-
126*	208&100	Ds	1,5	2	4	-	3	-	-	1	-	-	2	-	-	1	-	-
127	207	Mmc,Pp	4	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-
128*	133	Mp,Mmc	1,4,5	1	-	1	-	-	-	-	-	-	1	-	1	-	1	-
129*	133	Doo,Mp	1,5	2	-	1	-	-	-	-	-	-	1	2	-	1	-	-
130	207&133	Pp,Mmc	1,4,7	4	4	2	2	4	4	3	4	3	-	-	-	-	-	-
131	207	Pp,Pa	4	2	1	2	-	4	-	-	2	3	-	-	-	-	-	-
132	207	Pa,Pp,Mp	4	3	1	1	2	-	-	2	-	-	1	1	-	-	-	-
133	207	Pp,Pa	4	2	-	3	1	1	-	2	2	-	1	-	-	-	-	-
134	207	Pp,Mp,Mmc	4	3	2	1	4	-	-	2	-	-	2	-	-	-	-	-
135	131	Pp	4,7	-	-	1	1	-	-	1	-	-	-	-	-	-	-	-
136	207	Mp,Doo,Dck	-	11	2	-	3	2	-	4	3	-	2	2	1	1	1	-
137	128	Pp	1,4,5,7	2	1	-	-	1	1	-	-	2	-	-	-	-	-	-
138	207	Dck	-	4	2	-	4	1	-	3	3	-	3	-	-	-	-	-
139	207	Dm	-	2	3	1	1	2	-	4	2	-	2	1	-	5	-	-
140	207	Dm	-	2	1	-	1	-	-	1	-	1	2	-	-	2	-	-
141	207	St,Oj	-	1	2	-	3	-	1	2	2	-	-	-	-	-	-	-
142	125	Mp	5	1	-	1	2	-	-	1	-	-	1	-	-	-	-	-
143	125	Dm	1,3,5	1	3	2	-	1	4	-	1	5	-	-	-	-	-	-
144*	125	Doh,Skm	1,3,5	4	-	-	-	-	-	1	-	-	2	1	-	-	-	-
145	207	Obe,Or,Ocl	-	3	1	2	3	2	-	2	2	-	2	-	-	1	-	-
146	124	Mp	3	3	-	2	1	2	1	-	4	-	-	-	-	-	-	-
147	207	Ocl	-	-	3	-	2	-	-	2	1	-	1	2	-	2	-	-
148	207	Ocl	-	4	-	-	3	-	-	-	-	-	1	-	-	4	-	-
149*	207	Obe,Oj	-	1	1	2	1	-	-	-	-	-	2	-	2	1	1	2
150	207	Sc,St	-	3	1	1	2	-	-	1	2	-	1	-	1	-	-	-

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT 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														
151	207	Sc,St	-	2	2	-	2	2	-	-	-	-	-	-	-	1	-	1
152	207&115	Sc	-	3	3	1	4	2	-	3	-	-	-	1	-	-	-	-
153	207	Sc,Sbm	-	4	-	-	2	1	-	1	1	1	-	-	-	-	-	-
154*	113	Skm,Doh,Dho	-	4	5	-	-	-	-	-	-	-	5	3	1	4	3	-
155*	113	Dm	-	3	2	1	1	1	-	2	-	-	4	2	1	3	2	-
156	113	Dm	-	6	2	2	6	1	-	2	-	-	2	-	1	8	1	-
157*	113	Dho	-	1	2	-	-	-	-	-	-	-	1	2	-	2	1	-
158	207	Dho	-	4	1	-	-	-	-	-	-	-	3	1	-	3	1	-
159*	112	Dm	-	1	1	3	4	-	-	1	3	1	3	-	1	3	-	-
160	207	Dho	-	-	2	-	-	-	-	-	-	-	1	1	-	2	-	-
161	207	Dho	-	4	-	-	2	-	-	2	-	-	2	-	-	1	-	-
162	111	Dm	-	2	1	-	1	-	-	1	-	-	1	-	-	2	-	-
163	110	Dm	-	3	1	-	1	1	-	-	2	-	-	1	-	-	1	-
164	109	Dm	1,5	2	1	-	1	-	-	1	-	-	1	-	-	-	-	-
165	207&108	Dm,Dho	-	5	3	-	6	-	-	-	-	-	3	1	-	5	1	-
166	107	Dm	3,5	4	-	-	2	-	-	-	-	-	1	-	-	1	1	-
167*	105	Dck	3,5	4	-	-	-	-	-	-	-	-	1	1	-	2	-	1
168	207	Dck	-	2	1	-	1	-	-	-	-	-	1	-	-	2	-	-
169	103	Ds	-	4	1	-	1	-	-	-	-	-	3	-	-	2	-	-
170*	102	Mmc,Mp	-	2	1	-	-	-	-	2	1	-	1	1	-	-	-	-
171	101	Mp,Mmc	1,2,4,5	2	1	-	1	-	-	-	-	-	-	-	-	-	-	-
172	101	Pp,Ppp	4,7	1	1	1	2	-	1	-	1	1	-	-	-	-	-	-
173	100	Ds	1,3,5	3	1	-	1	1	-	1	-	-	1	-	-	1	-	-
174	207	Dm	-	2	1	-	-	-	-	-	-	-	1	1	-	2	-	1
175	207	Dm,Dck	-	2	2	-	-	-	-	-	-	-	3	1	-	2	-	-
176	133	Pp	1,4,5,7	-	1	1	-	1	-	2	-	-	-	-	-	1	-	-
177	133	Dck	1,3,5	2	1	-	3	-	-	-	-	-	-	-	-	1	-	-
178	132	Mp,Mmc,Pp	4	1	2	-	1	2	-	1	-	2	-	-	-	-	-	-
179	132	Pp,Pa	1,4,7	2	3	-	2	-	-	2	-	-	1	1	-	-	-	-
180*	127	Dho	5	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-

TABLE 3 EQUIVALENT URANIUM ANOMALIES - WILLIAMSPORT QUADRANGLE

				Number of Points														
				eU			eTh			K			eU/eTh			eU/K		
Anom. No.	F/L No.	Geol. Fm.	P.G.E. CATEGORIES**	+	++	+++	+	++	+++	+	++	+++	+	++	+++	+	++	+++
181	120	Oj	-	4	-	-	2	-	-	1	-	-	1	-	-	-	-	-
182	115	Sbm,Sc	-	2	1	-	-	2	-	2	-	-	-	-	-	-	1	-
183	115	Skw,Sbm	-	4	1	-	2	1	-	-	3	1	1	-	-	-	-	-
184*	115	Dho	-	2	2	3	-	-	-	2	-	-	1	2	3	4	3	-
185*	113	Skw	-	-	2	-	-	-	-	-	-	-	1	-	1	-	2	-
186*	113	Skw	-	4	-	-	-	-	-	-	-	-	3	-	-	2	1	-
187	113	Skw	-	2	1	-	2	-	-	-	-	-	1	-	-	-	-	-
188*	113	Skw	-	1	1	-	-	-	-	-	-	-	-	1	1	1	1	-
189*	113	Doh,Dho	-	1	3	1	-	-	-	-	-	-	3	1	1	3	2	-
190*	111	Dho	-	4	-	2	-	-	-	2	-	-	1	2	1	2	2	-
191	111	Dm	-	4	3	1	5	2	-	3	4	-	2	-	-	5	-	-
192	108	Dm,Dck	5	3	6	-	2	5	1	3	5	-	1	1	-	-	1	-
193	108	Dck,Dm	-	5	1	-	3	-	-	4	-	-	2	-	-	1	-	-
194	107	Dck	-	2	1	-	2	-	-	3	-	-	-	-	-	-	-	-
195	107	Dck	-	4	-	-	1	2	-	2	1	-	-	1	-	-	-	-
196*	106	Dck,Dm	3,5	3	1	-	-	-	-	-	-	-	1	1	-	1	1	-
197	106	Sc	3,5	-	2	-	2	-	-	-	2	-	-	-	-	-	-	-
198	106	Dck	-	2	3	-	2	2	-	2	2	-	-	1	-	1	-	-
199	106	Mmc	-	4	1	1	1	1	-	3	-	-	2	-	-	-	-	-
200	105	Dm	1,3,5	2	-	1	2	-	-	-	-	-	1	1	-	2	1	-
201	105	Dck	1,3	2	-	1	1	1	-	1	-	-	-	-	-	2	-	-
202	104	Mmc	-	2	1	-	3	-	-	3	-	-	-	-	-	-	-	-
203*	103	Dm	1,3	2	-	1	1	-	-	1	-	-	2	1	-	2	1	-
204	103	Mmc	-	-	1	1	1	1	-	2	-	-	-	-	-	-	-	-
205	101	Mmc	1,3,5	3	2	1	2	1	-	3	-	-	-	-	-	-	-	-
206	101	Mmc	5	3	1	-	2	2	-	1	2	-	-	-	-	-	-	-
207	100	Mmc	-	3	2	1	2	-	1	2	1	-	-	-	-	-	-	-
208	100	Mmc	-	2	3	-	2	1	1	1	3	1	-	-	-	-	-	-
209*	212	Dj	3	-	-	1	-	-	-	-	-	-	-	1	-	-	1	-

* PREFERRED ANOMALY

** SEE SECTION 7.3 FOR EXPLANATION OF P.G.E. CATEGORY CODES

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>U. S. GEOLOGICAL SURVEY</u>

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>U. S. GEOLOGICAL SURVEY</u>

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>U. S. GEOLOGICAL SURVEY</u>

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	3/18/78
Data Interpretation	1/25/77	3/18/77
	7/15/77	3/18/78

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)

* Quality Flag Code

1 - Record exceeds altitude specifications or read error was encountered.
0 - Record is acceptable.

APPENDIX C

STATISTICAL SUMMARY BY GEOLOGICAL UNIT

STATISTICAL SUMMARY

CODE	UNIT	RECS	* * * K * * * MEAN	ST.DEV.	* * * U * * * MEAN	ST.DEV.	* * * T * * * MEAN	ST.DEV.	* * U/K*10 * * MEAN	ST.DEV.	* * U/T*10 * * MEAN	ST.DEV.	* * T/K*10 * * MEAN	ST.DEV.
301.	PA	106.0	72.4	33.7	13.4	6.4	34.1	13.2	1.8	1.3	3.6	1.7	4.7	1.7
302.	PPP	39.0	79.1	22.4	17.2	5.0	43.2	12.9	1.7	.6	3.5	.9	5.0	1.2
303.	PP	589.0	38.5	21.8	9.4	4.8	21.1	10.4	2.4	1.5	4.2	2.2	5.6	2.4
304.	MMC	456.0	44.9	21.1	9.5	4.3	22.2	9.6	2.0	1.3	4.2	2.3	4.8	1.7
305.	MP	2871.0	39.1	17.0	8.7	3.7	20.4	8.3	2.1	1.3	4.0	2.0	5.2	1.9
306.	DCY	4.0	19.2	7.3	11.2	2.1	13.0	1.4	6.5	3.3	8.0	1.8	7.2	3.2
307.	DCO	915.0	54.2	16.9	10.1	4.5	29.0	8.1	1.6	.8	3.1	1.5	5.1	1.2
308.	DCK	2086.0	64.0	20.5	11.3	5.1	33.2	8.6	1.5	.8	3.0	1.4	4.9	1.1
309.	DM	1535.0	80.7	20.5	13.2	4.9	38.8	7.7	1.4	.6	3.0	1.2	4.5	1.0
310.	DS	5171.0	65.9	20.1	12.6	4.5	35.0	8.9	1.6	.8	3.3	1.5	5.0	1.2
311.	DJ	360.0	65.8	15.1	12.4	3.6	35.9	6.5	1.5	.6	3.1	1.1	5.1	1.0
314.	DWM	39.0	70.7	14.0	12.2	3.7	34.8	7.6	1.4	.7	3.2	1.3	4.5	.9
316.	DWRG	158.0	73.0	15.8	13.4	4.3	37.8	7.4	1.5	.6	3.2	1.2	4.8	.8
335.	DHC	491.0	83.4	29.4	17.6	6.9	39.6	9.0	1.8	.9	4.1	1.8	4.6	1.2
336.	DCH	53.0	67.5	20.7	14.7	4.9	34.9	6.6	1.9	1.0	3.9	1.5	4.9	1.5
339.	DS	31.0	89.4	20.5	16.2	3.4	41.8	7.6	1.6	.6	3.6	.8	4.3	.7
340.	SKW	189.0	97.1	38.8	17.1	5.5	37.4	7.9	1.8	.9	4.2	1.6	3.8	1.3
343.	SBM	105.0	105.8	34.3	15.9	3.9	42.7	6.6	1.4	.6	3.3	1.1	3.9	1.2
345.	SKM	130.0	53.8	26.9	14.1	5.8	30.1	9.2	2.4	1.2	4.2	1.5	5.9	2.3
348.	SC	189.0	40.3	31.7	11.2	4.8	25.7	11.1	3.3	2.4	3.8	1.6	8.1	4.1
349.	ST	152.0	24.0	18.5	7.6	3.3	16.3	6.7	3.7	2.4	4.4	2.2	8.4	4.4
353.	OJ	226.0	37.6	17.2	7.3	3.1	17.6	5.8	2.0	1.4	4.0	1.9	4.9	2.4
354.	OBE	72.0	43.2	18.3	7.5	3.2	17.2	5.7	1.6	.9	4.2	2.1	3.9	1.2
355.	OR	52.0	56.0	20.6	10.4	4.3	24.5	8.3	1.5	.7	3.9	1.7	4.1	1.3
356.	OCL	102.0	79.3	25.9	12.5	4.9	33.4	7.4	1.3	.5	3.4	1.3	4.0	1.1
357.	OCN	4.0	54.6	5.7	8.0	2.9	24.1	3.2	1.3	.6	3.2	1.5	3.9	.6
358.	OVL	4.0	104.2	26.0	10.0	1.6	35.0	3.6	1.0	.0	2.5	.6	3.0	.9
368.	OB	55.0	119.5	53.1	13.6	4.1	32.0	7.9	1.5	1.0	4.0	1.7	2.7	1.5
402.	OMG	4.0	77.5	54.9	9.5	.6	14.0	3.9	4.0	4.2	6.7	2.2	2.7	2.9
600.	WATER	71.0	39.3	19.0	10.1	4.0	22.4	9.7	2.3	1.4	4.5	2.7	5.5	1.8

APPENDIX D

STATISTICAL SUMMARY BY LINE

STATISTICAL SUMMARY BY LINE

LINE	RECS	* * * K * * * MEAN	ST.DEV.	* * * U * * * MEAN	ST.DEV.	* * * T * * * MEAN	ST.DEV.	* * U/K*10 * * MEAN	ST.DEV.	* * U/T*10 * * MEAN	ST.DEV.	* * T/K*10 * * MEAN	ST.DEV.
212.	570.	82.6	21.7	12.8	5.3	40.7	9.6	1.1	.7	2.7	1.3	4.6	1.1
211.	551.	69.0	25.4	12.4	5.4	35.1	10.9	1.5	.9	3.2	1.5	4.8	1.2
210.	516.	58.7	31.1	12.1	5.2	31.3	12.9	1.7	.9	3.4	1.6	5.0	1.3
209.	521.	51.4	36.7	12.6	5.3	26.9	16.2	2.2	1.4	4.5	2.4	5.0	1.2
208.	551.	71.5	24.0	14.8	6.0	36.2	10.4	1.9	1.1	4.0	2.0	4.9	1.2
207.	606.	66.9	27.3	15.1	6.4	33.2	12.1	2.2	1.4	4.3	2.2	5.4	1.5
134.	258.	47.9	41.9	7.3	5.9	25.3	17.6	1.2	.8	2.6	1.3	5.1	1.1
133.	414.	40.7	45.7	9.3	4.7	23.9	18.0	2.1	1.3	3.8	1.9	5.7	1.6
132.	380.	44.7	43.4	8.5	5.2	23.3	19.0	1.6	1.0	3.4	1.7	5.1	1.3
131.	300.	49.4	39.1	7.5	5.6	25.5	16.8	1.1	.7	2.6	1.2	4.9	1.0
130.	334.	46.7	43.6	8.6	5.2	24.9	18.2	1.7	1.1	3.3	1.6	5.2	1.2
129.	372.	43.0	46.6	8.7	5.1	23.8	19.1	1.9	1.3	3.5	1.8	5.5	1.4
128.	362.	49.2	40.7	9.0	5.0	24.2	18.6	1.6	1.0	3.5	1.8	4.8	1.0
127.	320.	50.3	38.2	8.5	5.0	23.4	18.4	1.5	.9	3.5	1.7	4.6	1.0
126.	351.	49.2	44.8	8.7	5.2	24.5	17.3	1.7	1.1	3.3	1.6	5.3	1.6
125.	329.	57.5	38.9	10.2	4.7	29.3	13.5	1.4	.9	3.1	1.5	5.2	1.6
124.	417.	61.5	35.4	10.7	4.8	28.8	13.5	1.4	1.0	3.4	1.8	4.4	1.4
123.	321.	62.9	34.9	8.9	5.1	29.2	13.5	1.1	.8	2.8	1.4	4.5	1.3
122.	392.	59.2	35.8	10.3	4.4	28.1	13.7	1.4	.9	3.3	1.6	4.6	1.3
121.	413.	63.4	34.0	10.1	4.8	31.1	12.2	1.2	.9	2.9	1.6	4.7	1.7
120.	366.	65.2	32.9	11.0	4.5	31.5	11.6	1.4	.9	3.2	1.6	4.8	1.4
119.	347.	54.5	40.3	9.9	4.7	26.8	15.2	1.6	1.0	3.4	1.6	5.1	1.5
118.	271.	55.1	39.7	8.7	5.1	28.6	13.7	1.0	.8	2.4	1.4	5.2	1.5
117.	351.	58.1	38.5	10.4	4.7	29.0	13.7	1.5	.9	3.3	1.6	5.1	1.5
116.	413.	62.4	40.6	11.6	4.9	30.0	13.0	1.7	1.1	3.5	1.8	5.0	1.5
115.	414.	60.8	35.4	13.9	5.3	30.8	12.0	2.1	1.4	4.2	2.2	5.2	1.5
114.	401.	66.7	31.5	12.3	4.6	33.3	10.4	1.6	1.0	3.4	1.6	5.0	1.4
113.	409.	61.8	35.1	16.3	7.1	32.9	10.8	2.3	1.6	4.7	2.7	5.1	1.5
112.	380.	74.6	29.4	12.9	5.0	32.1	11.5	1.4	.9	3.9	2.0	3.9	1.4
111.	400.	65.4	33.5	14.5	5.9	33.7	10.6	1.9	1.3	4.0	2.1	5.0	1.4
110.	390.	69.1	31.8	13.8	5.5	33.8	10.7	1.8	1.2	3.9	2.0	4.7	1.4
109.	358.	70.4	30.8	10.8	4.6	34.2	10.3	1.1	.8	2.7	1.4	4.6	1.3
108.	366.	60.4	37.2	13.3	5.2	33.7	10.8	1.9	1.2	3.5	1.8	5.4	1.7
107.	379.	58.3	37.3	12.7	4.8	32.4	11.1	1.7	1.1	3.5	1.7	5.3	1.6
106.	387.	54.8	39.4	12.0	4.6	31.3	11.6	1.8	1.1	3.4	1.6	5.5	1.7
105.	342.	50.0	43.7	12.1	4.6	28.9	13.5	1.9	1.3	3.7	1.8	5.6	1.7
104.	401.	55.9	38.2	11.7	4.7	29.1	13.3	1.7	1.1	3.6	1.8	4.9	1.4
103.	404.	49.8	42.6	11.5	4.4	29.5	12.7	2.1	1.3	3.7	1.8	5.8	1.9
102.	389.	58.6	36.2	9.9	4.7	29.7	12.7	1.3	.9	3.0	1.5	4.8	1.4
101.	370.	50.3	44.5	11.5	4.6	30.4	12.7	1.9	1.3	3.4	1.7	5.9	2.0
100.	444.	71.4	29.7	15.8	6.7	40.8	9.9	1.8	1.1	3.5	1.7	5.4	1.6

APPENDIX E

NUMBER OF SAMPLES USED TO GENERATE

MEAN AND STANDARD DEVIATION - WILLIAMSPORT QUADRANGLE

APPENDIX E

NUMBER OF SAMPLES USED TO GENERATE MEAN AND STANDARD DEVIATION

Map Code	K	U	Th
Pa	118	106	119
Ppp	40	39	40
Pp	726	589	728
Mmc	551	456	553
Mp	3618	2871	3637
Dcy	4	4	4
Doo	1069	915	1071
Dck, Dwh, Dww	2298	2086	2298
Dm	1608	1535	1607
Ds	5484	5171	5485
Dj	372	360	372
Dwm	42	39	42
Dwrg	169	158	169
Dho	504	491	504
Doh	55	53	54
DS	31	31	31
Skw	191	189	192
Sbm	106	105	106
Skm	146	130	146
Sc	241	189	244
St	225	152	233
Oj	330	226	330
Obe	109	72	109
Or	75	52	75
Ocl	113	102	113
Ocn	8	4	8
Ovl	6	4	6
On *	1	1	1
Ob	58	55	58
Cmg	4	4	4
(water)	106	71	104

* No mean and standard deviation computed for this unit due to insufficient samples

APPENDIX F

COMPARISON OF GEOLOGIC MAP SYMBOLS

WITH COMPUTER DESIGNATIONS - WILLIAMSPORT QUADRANGLE

APPENDIX F

COMPARISON OF GEOLOGIC MAP SYMBOLS WITH COMPUTER DESIGNATIONS - WILLIAMSPORT QUADRANGLE

Computer Numeric Code	Computer Letter Code	Map Code
301	PA	Pa
302	PPP	Ppp
303	PP	Pp
304	MMC	Mmc
305	MP	Mp
306	DCY	Dcy
307	DOO	Doo
308	DCK	Dck, Dwh, Dww
309	DM	Dm
310	DS	Ds
311	DJ	Dj
314	DWM	Dwm
316	DWRG	Dwrg
335	DHO	Dho
336	DOH	Doh
339	DS	DS
340	SKW	Skw
343	SBM	Sbm
345	SKM	Skm
348	SC	Sc
349	ST	St
353	OJ	Oj
354	OBE	Obe
355	OR	Or
356	OCL	Ocl
357	OCN	Ocn
358	OVL	Ovl
366	ON	On
368	OB	Ob
402	CMG	Cmg
600	WATER	(water)

APPENDIX G

MICROFICHE SINGLE RECORD AND AVERAGE RECORD LISTINGS