Prepared for the U. S. Department of Energy
Grand Junction Office, Colorado

GJB X-207 82

DPST-81-141-23

MASTER

A GEOCHEMICAL ORIENTATION SURVEY OF STREAM SEDIMENT, STREAM WATER AND GROUND WATER NEAR URANIUM PROSPECTS, MONTICELLO AREA, NEW YORK

DO NOT MICROFILM
COVER

NATIONAL URANIUM RESOURCE
EVALUATION PROGRAM

CAUTION
This is a time release report.
Do not release any part of this
publication before

ARTHUR W. ROSE, ARTHUR T. SMITH,
AND DAVID WESOLOWSKI

E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808

PREPARED FOR THE U. S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-76SR00001

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

— **DISCLAIMER** —

This report was prepared by E. I. du Pont de Nemours and Company (Du Pont) for the United States Department of Energy under Contract DE-AC09-76SR00001 and is an account of work performed under that Contract. Neither the United States, the United States Department of Energy nor Du Pont, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed herein, or represents that its use will not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, mark, manufacturer, or otherwise does not necessarily constitute or imply endorsement, recommendation, or favoring of same by Du Pont or by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

**A GEOCHEMICAL ORIENTATION SURVEY OF
STREAM SEDIMENT, STREAM WATER, AND
GROUND WATER NEAR URANIUM PROSPECTS,
MONTICELLO AREA, NEW YORK**

MASTER

**NATIONAL URANIUM RESOURCE
EVALUATION PROGRAM**

Arthur W. Rose, Arthur T. Smith, and David Wesolowski
726 Edgewood Circle
State College, Pennsylvania 16801

Approved by

C. E. Coffey, Research Manager
Analytical Development Division

Publication Date: August 1982

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

NOTICE

PORTIONS OF THIS REPORT ARE ILLEGIBLE.

**It has been reproduced from the best
available copy to permit the broadest
possible availability.**

**E. I. du Pont de Nemours & Co.
Savannah River Laboratory
Aiken, SC 29808**

PREPARED FOR THE U. S. DEPARTMENT OF ENERGY UNDER CONTRACT DE-AC09-76SR00001

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

ABSTRACT

A detailed geochemical test survey has been conducted in a 570 sq km area around six small copper-uranium prospects in sandstones of the Devonian Catskill Formation near Monticello in southern New York state. This report summarizes and interprets the data for about 500 stream sediment samples, 500 stream water samples, and 500 ground water samples, each analyzed for 40 to 50 elements.

The groundwater samples furnish distinctive anomalies for uranium, helium, radon, and copper near the mineralized localities, but the samples must be segregated into aquifers in order to obtain continuous well-defined anomalies. Two zones of uranium-rich water (1 to 16 parts per billion) can be recognized on cross sections; the upper zone extends through the known occurrences. The anomalies in uranium and helium are strongest in the deeper parts of the aquifers and are diluted in samples from shallow wells.

In stream water, copper and uranium are slightly anomalous, as in an ore factor derived from factor analysis. Ratios of copper, uranium, and zinc to conductivity improve the resolution of anomalies.

In stream sediment, extractable uranium, copper, niobium, vanadium, and an ore factor furnish weak anomalies, and ratios of uranium and copper to zinc improve the definition of anomalies. The uranium/thorium ratio is not helpful.

Published analyses of rock samples from the nearby stratigraphic section show distinct anomalies in the zone containing the copper-uranium occurrences.

This report is being issued without the normal detailed technical and copy editing, to make the data available to the public before the end of the National Uranium Reconnaissance Evaluation program.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

<u>CONTENTS</u>	<u>page</u>
Acknowledgements	11
List of Symbols and Abbreviations	11
Introduction	13
Geology and Mineral Occurrences	14
Stratigraphy and Sedimentology	14
Mineral Occurrences	16
Geochemistry of Stratigraphic Section	21
Sample Collection	29
Analytical Methods	31
Interpretation and Statistical Methods	32
Groundwater	46
Basic Statistics and Water Character	46
Factor Analysis	56
Relations to Conductivity	58
Interpretation of Uranium	62
Helium	71
Radon	71
Tests of Mineralized Area vs Nonmineralized Area	75
Stream Water	79
Data Manipulation	79
Factor Analysis	84
Element Distributions	89
Summary	92

<u>CONTENTS (cont'd)</u>	<u>page</u>
Stream Sediments	98
Data Manipulation	98
Factor Analysis	99
Factor Scores	105
Element Distribution	108
Summary	118
Conclusions	118
Bibliography	124

LIST OF FIGURES

page

Figure

1	Idealized paleoenvironmental model for the upper Catskill Formation	15
2	Idealized stratigraphic section of the Catskill Formation . .	17
3	Geological map of the Monticello area	18
4	Histogram of whole rock U, K, and Th analyses	24
5	Plot of stratigraphic thickness versus whole rock U, K, and Th analyses for conglomerates	25
6	Plot of stratigraphic thickness versus whole rock U, K, and Th analyses for sandstones	26
7	Plot of stratigraphic thickness versus whole rock U, K, and Th analyses for siltstones	27
8	Plot of stratigraphic thickness versus whole rock U, K, and Th analyses for mudstones	28
9	Cross section along Rte. 17	30
10	Format for areal plots	50
11	Histograms of ground water variables	55
12	Plots of Ca, Na, and U versus conductivity	59
13	Plots of He, Li, and Mo versus conductivity	60
14	Plots of Ni, Zn, and Zr versus conductivity	61
15	Histogram of unlogged U in ground water	63
16	Histogram of logged U in ground water	63
17	Cumulative frequency plot for U in ground water	64
18	Map of log U in ground water	65
19	Map of log U in well samples only	66
20	Projected cross-section of log U	67
21	Map of log (U/cond.) for ground water	69

LIST OF FIGURES (cont'd)

	page
<u>Figure</u>	
22 Map of residuals from regression equation for log U	70
23 Map of log He in ground water	72
24 Projected cross-section of log He	73
25 Map of Rn in ground water	74
26 Projected cross-section of log Na	76
27 Map of log Cu in ground water	77
28 Projected cross-section of log Cu	78
29 Histograms of stream-water variables	80
30 Map of Factor 1 for stream water	85
31 Map of Factor 2 for stream water	87
32 Map of Factor 5 for stream water	88
33 Map of log Cu for stream water	90
34 Map of log U in stream water	91
35 Map of log Zn for stream water	93
36 Map of log (Cu/cond.) for stream water	94
37 Map of log (Zn/cond.) for stream water	95
38 Map of log (U/cond.) for stream water	96
39 Map of log Mo for stream water	97
40 Histograms of sediment variables	100
41 Plot of log Ca versus log Fe in sediments	104
42 Map of Factor 1 in sediments	106
43 Map of Factor 4 in sediments	107
44 Map of log (extractable U) in sediments	109
45 Map of log Se in sediments	11

LIST OF FIGURES (cont'd)

page

Figure

46	Map of log Mo in sediments	111
47	Map of log Nb in sediments	112
48	Map of log V in sediments	113
49	Map of log Cu in sediments	114
50	Map of log Zn in sediments	115
51	Map of log (extractable U/Zn) in sediments	116
52	Map of log (Co/Zn) in sediments	117
53	Plot of log U versus log Th in sediments	119
54	Plot of log U versus log Hf in sediments	120
55	Plot of log (U/Th) versus log (extractable U) in sediments . . .	120
56	Map of log (U/Th) in sediments	121

LIST OF TABLES

page

Table

1.	Characteristics of the Glen Wild uranium occurrences.....	19
2.	Thicknesses of Rte 17 stratigraphic section.....	22
3.	Summary of K, U, and Th analyses of rock samples collected and reported by Way (1972) along Rte. 17 section near Glen Wild	23
4.	Statistical data for groundwaters.....	33
5.	Statistical data for surface waters	34
6.	Basic statistics for sediment data	35
7.	Correlation coefficients for ground water data generated by MINITAB program, Penn State University Computer Library	36
8.	Correlation coefficients for stream water data generated by STPAC program, Penn State University Computer Library	39
9.	Correlation coefficients for sediment data generated by the SAS program, SAS Institute, Inc.....	42
10.	Factor loadings for logged ground water data, VARIMAX rotated	47
11.	Factor loadings for surface water data, VARIMAX rotated ...	48
12.	Factor loadings for sediment data, VARIMAX rotated	49
13.	Constituents of ground water significantly different between mineralized area and remainder of the area, based on t-tests	51
14.	Constituents of surface water significantly different between mineralized area and remainder of area, based on t-tests	52
15.	Constituents of sediments significantly different between mineralized area and remainder of area, based on t-tests	53

ACKNOWLEDGEMENTS

This survey was planned and directed by Van Price and James Heffner of Savannah River Laboratory, to whom the writers are indebted for assistance during both sampling and interpretation. James Cook also aided in compiling and furnishing the data base. Thanks are also due to many individuals at Savannah River Laboratory and their contractors for the enormous amount of analytical work represented by this report.

SYMBOLS AND ABBREVIATIONS USED IN THE FIGURES AND TABLES OF THIS REPORT:

Cond. or con. = conductivity	sf = stream flow
Alk. - alkalinity	vd = vegetation density
ss = stream size	rf - relief
sw = stream width	scint. = scintillometer
sl = stream level	D. O. = dissolved oxygen

Symbols on maps (areal plots):

* = missing values
▲ = Cu-U locality

Symbols on bivariate plots:

* = single observation
2, 3, ..., 9 = number of overlapping points
+ = more than 9 overlapping points

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

A GEOCHEMICAL ORIENTATION SURVEY OF STREAM SEDIMENT,
STREAM WATER, AND GROUND WATER NEAR URANIUM PROSPECTS,
MONTICELLO AREA, NEW YORK

INTRODUCTION

The National Uranium Resource Evaluation (NURE) of the U. S. Department of Energy was intended to furnish a better evaluation of the uranium resources of the United States, in order to aid planning for future energy needs. The hydrogeochemical and stream sediment reconnaissance has been a major segment of the NURE project. In order to plan and interpret the regional surveys, it is essential to know which elements and attributes are anomalous in and near known uranium districts, as well as the extent and intensity of anomalous values. Because different types of uranium deposits are expected to have different geochemical signatures, test surveys covering a variety of deposit types are needed.

This report discusses a detailed orientation survey in the vicinity of uranium and copper-uranium occurrences in the Upper Devonian Catskill Formation near Monticello, Sullivan County, New York. The occurrences are relatively typical of other uranium occurrences in the Catskill Formation in adjacent Pennsylvania (McCauley, 1961; Sevon et al., 1978). The Catskill occurrences are among the more promising types of uranium occurrences in the eastern United States. This orientation survey was conceived by personnel of the Pittsburgh office of Bendix Field Engineering Corp. and the Savannah River Laboratory (SRL), operated by E. I. du Pont de Nemours for the U. S. Department of Energy.

Field work for the survey was accomplished by the authors of this report during the summer of 1979. A total of about 500 stream sediments, 500 stream waters, and 500 ground waters were collected by standard Savannah River Laboratory procedures in an area of 570 sq km surrounding the known uranium occurrences near Glen Wild, about 5 mi east of Monticello (Plate 1). In addition, 500 samples of eastern hemlock twigs and a special set of ground water samples for helium analysis and field radon and dissolved oxygen measurements were collected. A gamma-ray spectrometry survey along roads was also conducted. The samples were analyzed by SRL and its contractors.

This report discusses and interprets the analytical data for the survey. The main emphasis is on recognition of elements and parameters useful in detecting other similar deposits in the Catskill Formation. Also, because the set of data for this survey is much more complete than most geochemical surveys, the authors have spent considerable effort on testing various interpretation methods and trying to understand the variation in the elements. The magnitude of this task is indicated by the fact that for each of the three sample types, about 50 elements and variables in 500 samples are available for interpretation. Because of the large amount of data, computer and statistical techniques have been extensively used.

GEOLOGY AND MINERAL OCCURRENCES

The study area (Plate 1) is located along the eastern portion of the Appalachian Upland physiographic province. The Upper Devonian Catskill Formation is exposed throughout the area, which is bounded to the east by the Catskill Front and the Basher Kill River. The rocks in the area dip to the west-northwest at 45° in the eastern and 0 to 4° in the central and western portions of the area. The elevation ranges from about 500 to 1650 ft. Local relief is about 200 ft in the main part of the area, which is characterized by many lakes and swamps. In the eastern section, along the Catskill front, local relief increases to nearly 1000 ft along the major streams. The area is cut by three large south-flowing drainages: Basher Kill, the Neversink River, and the Mongaup River.

STRATIGRAPHY AND SEDIMENTOLOGY

The Upper Devonian Catskill Formation crops out throughout the study area. It is composed of gray and red mudstones, siltstones, sandstones, and conglomerates. Within the study area, the overlying Mississippian Pocono Formation has been completely eroded. The Catskill Formation is underlain by the marine rocks of the Middle Devonian Chemung facies and the Lower Devonian Portage facies. Both are composed of black shales with minor limestones and sandstones.

The Catskill Formation extends throughout New York and Pennsylvania, reaching a maximum thickness of greater than 2400 m near Jim Thorpe (Epstein et al., 1974) and in the Catskill Mountains approximately 30 km north of the study area. In all areas, it thins to the west-northwest to less than 800 m in western New York and Pennsylvania.

The source area for the Catskill Formation is considered to be to the east-southeast (Lucier, 1966; Fletcher, 1963; Burtner, 1963; Ayrton, 1963; Willard, 1939). The sediments were derived from erosion of the rising Acadian highlands (Mencher, 1939; Krynine, 1940, 1941).

Many paleoenvironmental models have been proposed for the deposition of the Catskill sediments (Barrell, 1913, 1914; Chadwick, 1931, 1936; Willard, 1939; Allen and Friend, 1968; Walker and Harms, 1971; Humphreys and Friedman, 1975; Sevon and others, 1978; Rahmanian, 1979). In general, it is considered to be a series of westward prograding deltas. Figure 1 is an idealized model, based on work in Pennsylvania by Rahmanian (1979), which is a good summary of the important features of the previous models. Close to the Acadian highlands, the sediments become dominated by coarse, fluvial sandstones and conglomerates. To the west, marine shales and tidal deposits intertongue with the alluvial plain and deltaic deposits. Insufficient regional stratigraphic work has been done in the study area to determine accurately where in this model the stratigraphic section representing the Glen Wild area occurs, but observations by the authors indicate that the study area must be in the eastern part of the model, with relatively abundant fluvial deposits.

Figure 1. Idealized paleoenvironmental model for the upper Devonian Catskill Fm., after Rahmanian, 1979. Assumed location of survey area indicated.

The Catskill Formation in southeastern New York has been divided into eight different formations (Fletcher, 1963, 1967): the Slide Mtn., Walton, Middlesex, Oneonta, Grand Gorge, Manorkill, Potter Hollow, and Plattekill Formations (Fig. 2). Way (1972) measured a section along Rte. 17 which bisects the study area in an east-west direction. From his work and the New York State geologic map, it is probable that the uranium localities near Glen Wild are within the Walton Formation. Way's section contains 760 m of exposed outcrop with nearly 1700 m of covered intervals (mostly due to the shallow dips in the western portion of the area). He found the section to be composed primarily of green, gray, and red siltstones and sandstones with interbedded mudstones and conglomerates. From Way's work there is no reason to suggest that the model for the depositional environment of the sediments in the study area is significantly different from that presented in Figure 1.

The distribution of geologic units is illustrated by Figure 3, based on the New York State geologic map, which is the best available for the area. The various formations making up the Catskill Formation trend NNE across the area, with very shallow dips in the west and central areas, and steeper dips in the east. Redbeds predominate in most of the sampled area, but gray-green marine reducing clastic sediments come to the surface near the eastern margin of the area, and as local lenses elsewhere.

The area has been glaciated, and most of the flatter areas in the central and western parts of the sampled area are mantled with till. The glaciation and till cover are responsible for the lakes, swamps, and poorly developed drainage pattern in much of the area. The till also doubtless affects the nature of stream sediments and waters.

MINERAL OCCURRENCES

Plate 1 shows the location of the six known uranium and copper-uranium localities within the study area. The occurrences are typical of other uranium and copper-uranium localities found within the Catskill Formation in Pennsylvania (McCauley, 1961; Sevon and others, 1978). Table 1 is a compilation of general characteristics of the six occurrences, based on work by Baillieul and Indelicato (1978).

All of the occurrences have several features in common:

- 1) The host rock is always a gray to grayish-red, medium to coarse grained, poorly sorted sandstone with interbedded, lenticular conglomeratic zones.
- 2) Where visible, the basal contact of the sandstone with the underlying mudstone or siltstone is erosive.
- 3) The host rocks are always basal units in fining-upward cycles.

Figure 2. Idealized stratigraphic section of the Catskill Fm. in southeastern New York, after Fletcher, 1963.

Figure 3. Geological map of Monticello area, Cu-U localities and area of sampling. Oag=Austin Glen Fm.;

Table 1. Characteristics of the Glen Wild uranium occurrences. Localities 1-6 are shown on Plate 1.

Locality	North Latitude	West Longitude	U.S.G.S. 7.5' Quad.	Maximum U (ppm) and radioact.	Visible Min.	Host Rock	Assoc. Facies	Size & Shape	Comments
1. Gibber Egg Farm	41.6687	74.6023	Woodridge	9980 (reddish ss) (>20,000 cts/s)	Uranophane	m-g to c-g, gr ss with cgl lenses	Red mst	a. 70 m long x 3 m high b. 210 m long x 3 m high	Six fining-up cycles with 2 uraniferous beds; mineralization greatest at mst-ss contact
2. Feldman Quarry	41.6509	74.6222	Woodridge	6 (reddish ss with org) (5,000 cts/s)	Malachite	m-g to c-g, ss with cgl		2.0 m long, 0.46 m high	ss exposed is 7.6 m thick
3. Lucky #1 (Zucker's Hotel)	41.5530	74.5906	Woodridge	1530 (cgl lens) (12,000 cts/s)	Malachite		ssst, mst	<0.3 m thick and lenticular	Braided stream deposits
4. Goodwin #1	41.5624	74.6033	Woodridge	1060 (reddish ss with org) (>1000 cts/s)		gr + red ss and cgl		>61 m outcrop	Only ss exposed
5. Taylor Road	41.5533	74.5540	Woodridge	2880 (reddish ss)	Malachite and Uranophane (?)	c-g ss with hematite staining		plan: 3.4 m ²	Exposed in road bed
6. Church Road	41.6728	74.5534	Woodridge	(>1000 cts/s)		c-g ss		lenticular	In ledges east of house

NOTE: m-g = medium grained
c-g = coarse
org = organics
gr = gray
ss = sandstone
ssst = siltstone
cgl = conglomerate
mst = mudstone

- 4) Highest values of uranium are found in association with organic matter, most commonly fossil plant remains.
- 5) The mineralized area is lenticular in cross-section, and possibly in plan view (e.g., locality 5).

These common characteristics indicate that the occurrences are not roll-front uranium deposits, but are similar to the occurrences in the Catskill of north-central Pennsylvania (McCauley, 1961; Smith, 1980).

Secondary minerals associated with the occurrences include uranophane, malachite, and azurite(?). In some of the Pennsylvania localities, copper sulfides, chalcocite, bornite, and djurleite are present but very fine-grained and rarely visible in hand specimen. Uraninite has been found at one locality (R. C. Smith II, personal communication).

The localities are all of limited extent and are non-economic under present conditions. Analyses of samples by Baillieul and Indelicato (1978) are mostly in the range of hundreds to 2000 ppm U, although higher values have been obtained on picked material. The anomalous radioactivity can be traced along strike for up to a few hundred feet. The small size of the known localities thus furnishes a very difficult target for exploration methods.

Stratigraphically, the localities all occur within a 100 m interval of the upper portion of the Catskill Formation, as shown in later figures. Sedimentologically, the host rocks appear in almost all cases to be meandering stream deposits. There are no reported marine deposits in this part of the section, nor have the facies hosting mineralization been placed into a concise stratigraphic framework, due to the lack of good and extensive exposure.

Since very little work has been done on the localities themselves, no model for the formation of these uranium and copper-uranium occurrences has been formulated, though several have been proposed (McCauley, 1961; Sevon and others, 1978). Recent work in Pennsylvania has suggested that a diagenetic model is likely for the formation of the copper-uranium occurrences there (Smith, 1980). This model requires uranium (and copper) to be adsorbed onto the abundant red clays found in the Catskill. With burial, pore water, which is in equilibrium with hematite and is slightly oxidizing, would be expelled, mobilizing the uranium (and copper if it is a saline water; Rose, 1976) in solution. The ore-bearing solution would migrate along the path of greatest permeability, a sandstone or conglomerate, and when a reducing environment was encountered, deposition of uranium (and copper) would follow. This reducing environment is produced by sulfate-reducing bacteria associated with plant remains.

GEOCHEMISTRY OF STRATIGRAPHIC SECTION

As discussed previously, Way (1972) measured a stratigraphic section along Rte. 17, which bisects the study area. The section is entirely within the Catskill Formation and consists of approximately 760 m of exposed section and approximately 1700 m of covered section. Table 2 lists the thickness and stratigraphic interval occupied by each exposed interval. The thickness of the covered intervals is very approximate because of possible errors in the thickness calculation due to very low dips (1° - 2°) and lack of knowledge of the structure at depth. The discussion that follows is based entirely on the analyses, sample description, and stratigraphic data reported by Way (1972).

A total of 326 rock samples were collected by Way to represent lithologic units in the Rte. 17 section. Originally he defined eight lithologies: conglomerate, coarse, medium, and fine-grained sandstones, coarse, medium, and fine-grained siltstones, and mudstones. All samples were analyzed for uranium, potassium and thorium using a gamma-ray spectrometer (Adams and others, 1958). The results of these analyses are reported in Appendix F of Way (1972). For simplicity, we have reduced the number of lithologic types to four: conglomerate, sandstone, siltstone, and mudstone. Each sample was classified by color: gray, green, brown, and red.

For the purposes of this report, the uranium, thorium, and potassium data have been plotted against the stratigraphic section measured by Way (and described in Appendix A, Way, 1972). The data shown on Figures 5, 6, 7, and 8 are in the same order as reported by Way, except for the sections between Road Markers 17-9609-1329 and 17-9609-1326 and Road Markers 17-9609-1334 and 17-9609-1332, which were reversed to correspond with the sequence seen in the field and reconstructed by cross-sectional methods. The sections in question are only 13 and 13.1 m thick, respectively.

Table 3 lists the means, standard deviations, and number of samples for the following groups: uranium, potassium, and thorium, regardless of lithology or color; uranium, potassium, and thorium by lithology; and uranium, potassium and thorium by color. Mudstones have the highest concentration of uranium, potassium and thorium with concentrations decreasing with increasing grain size. The highest thorium and potassium concentrations occur in red rocks, while the highest uranium is found in gray rocks. The histograms of the logged values for each of the elements are shown in Figure 4. Though the distributions appear lognormal, there are several anomalous values, especially in the uranium population.

Plots of uranium, potassium, and thorium vs. stratigraphic position are shown for each of the four rock types in Figures 5, 6, 7, and 8. It should be noted that for the sake of scale, missing intervals are not shown in the plots.

Table 2. Thickness of Rte 17 Stratigraphic Section (Way, 1972)

Interval	Thick. (m)	Interval	Thick. (m)	
Base: A	255	J*	13.1	
Covered	244	Covered	0	
B	37.8	I*	13	
Covered	79.2	Covered	0	--- **
C	39.8	K	23.7	↑
Covered	171.0	Covered	76.2	
D	61.1	L	31.8	
Covered	25	Covered	46	U-rich interval
E	188.5	M	5.2	↓
Covered	823	Covered	55	
F	10	N	16	---
Covered	129	Covered	55	
G	4.0	O	4.1	
Covered	3.0	Covered	0	
H	29	P	6.8	
Covered	54.3	Covered	0	
		Top: Q	<u>19.7</u>	
		Total	2518 m	

* Sections reversed for this study.

** Interval (maximum) that includes anomalous U values in cgl, ss and mst.

Table 3. Summary of K, U, and Th analyses of rock samples collected and reported by Way (1972) along Rte. 17 section near Glen Wild

	N	Mean	Std. Dev.
<u>Total:</u>			
log K (%)	326	0.351 (2.44)	0.190 (0.988)
log U (ppm)	326	0.468 (3.45)	0.280 (3.84)
log Th (ppm)	326	1.100 (13.4)	0.137 (4.25)
<u>K, rock type:</u>			
cgl	49	0.241 (1.91)	0.202 (0.818)
ss	121	0.259 (1.92)	0.158 (0.556)
sst	82	0.372 (2.45)	0.133 (0.715)
mst	74	0.549 (3.65)	0.102 (0.841)
<u>U, rock type:</u>			
cgl	49	0.414 (2.97)	0.217 (1.88)
ss	121	0.394 (3.24)	0.234 (5.50)
sst	82	0.516 (3.38)	0.118 (0.835)
mst	74	0.572 (4.19)	0.181 (3.48)
<u>Th, rock type:</u>			
cgl	49	1.02 (11.2)	0.161 (3.65)
ss	121	1.04 (11.78)	0.132 (5.30)
sst	82	1.14 (4.27)	0.093 (2.79)
mst	74	1.21 (16.4)	0.059 (1.85)
<u>K, color:</u>			
gray	240	0.340 (2.36)	0.181 (0.876)
green	47	0.338 (2.44)	0.208 (1.24)
brown	15	0.353 (2.51)	0.213 (1.07)
red	24	0.479 (3.23)	0.184 (1.16)
<u>U, color:</u>			
gray	240	0.479 (3.57)	0.205 (4.33)
green	47	0.457 (3.22)	0.212 (1.94)
brown	15	0.433 (3.41)	0.272 (2.59)
red	24	0.404 (2.76)	0.188 (1.14)
<u>Th, color:</u>			
gray	240	1.11 (13.4)	0.121 (3.27)
green	47	1.06 (12.4)	0.158 (3.85)
brown	15	1.11 (15.3)	0.239 (12.4)
red	24	1.12 (14.0)	0.150 (3.94)

cgl = conglomerate
ss = sandstone
sst = siltstone

mst = mudstone
N = number of samples
() = unlogged values

EACH * REPRESENTS 5 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	A) log(U,ppm)
-0.2	0	
0.0	9	**
0.2	20	****
0.4	125	*****
0.6	142	*****
0.8	21	*****
1.0	3	*
1.2	2	*
1.4	3	*
1.6	0	
1.8	1	*

EACH * REPRESENTS 5 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	B) log(K,%)
-0.8	0	
-0.6	1	*
-0.4	0	
-0.2	4	*
0.0	17	****
0.2	52	*****
0.4	155	*****
0.6	88	*****
0.8	8	**
1.0	1	*

EACH * REPRESENTS 5 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	C) log(Th,ppm)
0.5	1	*
0.6	0	
0.7	4	*
0.8	13	***
0.9	16	****
1.0	64	*****
1.1	104	*****
1.2	95	*****
1.3	27	*****
1.4	1	*
1.5	0	
1.6	0	
1.7	0	
1.8	1	*

Figure 4. Histograms of whole rock U, K and Th analyses for rock samples collected by Way(1972) along Rte. 17 near Glen Wild.

Figure 5. Plot of stratigraphic thickness versus whole rock U,K and Th analyses for conglomerates. Samples were collected by Way(1972) along Rte. 17 near Glen Wild.

Figure 6. Plot of stratigraphic thickness versus whole rock U,K and Th analyses for sandstones. Samples were collected by Way(1972) along Rte. 17 near Glen Wild.

Figure 7. Plot of stratigraphic thickness versus whole rock U, K and Th analyses for siltstones. Samples were collected by Way(1972) along Rte. 17 near Glen Wild.

Figure 8. Plot of stratigraphic thickness versus whole rock U, K and Th analyses for mudstones. Samples were collected by Way (1972) along Rte. 17 near Glen Wild.

Among the three elements uranium has the greatest variability in the conglomerates (Fig. 5), while thorium varies somewhat and potassium is essentially constant. The greatest degree of scatter is in the upper part of the section.

For the sandstones (Fig. 6), uranium has a large amount of scatter in the upper part of the section. There is one anomalously high thorium value, but otherwise thorium and potassium have a very narrow range throughout the section. The zone of large scatter for uranium occurs in nearly the same stratigraphic interval as for the conglomerates.

Siltstones (Fig. 7) show very little scatter for any of the three elements. Several samples appear depleted in uranium, and none are enriched.

Mudstones show no variation or scatter for potassium and thorium, but there is tremendous scatter in the upper portion of the section for uranium (Fig. 8). The interval of large variation is the same as that having the greatest scatter for uranium in the sandstones and conglomerates.

The rock samples appear to be anomalously high in uranium only in 150-200 m in the upper portion of the measured section. This interval is defined in Table 2 and Figure 9. Since the 100 m thick section containing the known uranium and copper-uranium localities near Glen Wild occurs within and immediately below this interval (Fig. 9), rock sampling might be used to define uranium-rich horizons in the stratigraphy. It also means that the Glen Wild localities occur in a well defined stratigraphic interval which might also be picked up by one or another of the geochemical methods to be discussed later.

SAMPLE COLLECTION

During the summer of 1979, the authors collected a total of 500 stream sediments, 500 surface water, 500 vegetation, and 500 ground water samples in an area of 570 sq km centered over the Glen Wild uranium occurrences (Plate 1). This area was selected to encompass the known occurrences and to sample a large thickness of the Catskill stratigraphic section. A 1-km grid was stenciled on U.S. Geological Survey 7 1/2' topographic maps (Woodridge, Monticello, Yankee Lake, Hartwood, Ellenville, Wurtsboro, and White Lake), and samples were collected as close to the center of the grid squares as possible. All sampling was conducted using standard SRL equipment and procedures described in Price and Jones (1979).

Whenever possible, streams that originated within a few km of the sample site were sampled. At the stream site, a composite of at least five sediment samples was combined and sieved to -40 mesh. About 500 g of the -40 mesh fraction was placed in a paper sack and dried prior to

Figure 9. Cross section along Rte. 17, showing interval of anomalously high U (K, L, M, and N) in rock samples, and projected positions of known Cu-U occurrences. Vertical scale is in feet. Length of section is 6.4 miles.

shipment. At the same site 2 liters of stream water were collected and filtered to remove suspended solids. A portion of this water was acidified and 1 liter was reacted with a high purity cation-anion exchange resin for subsequent analysis. Measurements of pH, alkalinity, conductivity, and dissolved oxygen were made at the sample site immediately after sample collection.

Ground water samples were taken from private and public wells whenever possible and from springs where necessary to fill in the sampling grid (137 sites). Ground water samples were treated in the same way as surface water samples. Additionally, a glass bottle was filled, capped, and stored inverted for subsequent helium determination, and an onsite radon analysis was conducted using equipment and methods described below.

Second-year twigs from eastern hemlock trees were collected at the stream sites whenever possible or along secondary roads to fill in the sample grid. New growth was stripped off, and the twigs containing needles were packed into paper sacks. These samples have not yet been analyzed. A radiometric survey was also conducted using a car-borne gamma-ray spectrometer but the results of this survey are not yet available. Fortunately, average radiation levels were determined at each groundwater and stream site using identical hand-held scintillometers that had been calibrated using the same radiation source.

ANALYTICAL METHODS

Most analytical methods are those used in other NURE reports from Savannah River Laboratories, for example those listed in Appendix D of Jones (1979). Measurements of pH, alkalinity (milliequivalents of H_2SO_4 to an endpoint of pH 4.5), temperature, and conductivity of waters were performed by standard methods. Dissolved oxygen was measured at the sample site using a Yellow Springs Instruments Model 57 dissolved oxygen meter.

The stream sediments and the resins contacted with the water samples were analyzed for a large suite of trace and major elements by neutron activation analysis procedures described in previous SRL reports. Supplemental sediment analyses for extractable uranium, copper, lead, zinc, silver, nickel and cobalt were by HNO_3 - $HClO_4$ digestion followed by atomic absorption (or laser-induced fluorescence for U). Other supplemental analyses used pyrosulfate fusions and HF dissolution.

Filtered and acidified portions of the water samples were analyzed at Oak Ridge National Laboratory by an inductively coupled plasma emission spectrometric method similar to that described by Cagle (1977, p. 146). These determinations are termed "supplemental" in some of the following discussions.

Samples for helium in the 2 cu cm volume left in the top of soft drink bottles were analyzed mass spectrometrically for helium and are

reported as ppm by volume (cu cm of He [STP] per 1000 liters of air). The air left in the top of the bottles contained 5.2 ppm He, the content in normal air. Any helium exsolved from the sample would therefore result in values greater than 5.2 ppm; lower values result from analytical error or unusually large amounts of other exsolved gases in the sample.

Radon was measured at most sample sites using the Model PD-100 radon detector described by Korner and Rose (1977) and Allen (1976). A liter of water was degassed by bubbling air through the sample, and the alpha activity of the gas was counted in a scintillation chamber. At a few sites, an EDA model R200 portable radon detector was used for these measurements. The counting rates were converted to picoCuries/liter (pCi/l) by calibration of the two instruments with solutions containing about 1800 pCi/l radium.

INTERPRETATION AND STATISTICAL METHODS

The ground water, stream water, and sediment samples were treated as separate data sets due to the vastly different geochemical characteristics and residence times in the environments that were sampled. Standard descriptive statistics were computed using the MINITAB program, P.S.U. Computer Center Library, and are summarized in Tables 4 through 6. These results were examined and elements which were constant or had no values above detection limits were rejected. Also, values below detection limits and zero values were modified and described below in order to log the values and do meaningful statistical analyses.

The SAS statistical analysis program, SAS Institute, Inc., and the STPAC program, P.S.U. Computer Library, were employed to generate correlation matrices for the three data sets (Tables 7 through 9). The Pearson correlation method was used, and observations containing missing values were not deleted. Only those individual comparisons that involved missing values for a particular variable were rejected.

Three main methods were used to discover variables that might be useful in detecting uranium occurrences:

- 1) Maps of the distribution of most elements were plotted and examined for clusters in or near the known uranium localities.
- 2) A "mineralized" area around the known uranium prospects was outlined, and all variables were tested by comparison of the mean within this area to the mean of samples outside this area.
- 3) A factor analysis was conducted, and factors were examined for a possible combination of elements forming an ore factor.

From the correlation matrices, the STPAC program was used to extract varying numbers of factors. Factor analysis extracts groups of variabl

Table 4. Statistical data for Groundwaters.

	N ¹	Det. Lim. ²	N. det. ³	No. < D.L. ⁴	Form ⁵	Blank ⁶	Mean	Std. dev.	Lowest	10% ile	Median	90% ile	Highest	Geom. Mean
Field														
pH ⁸	499	—	—	0	N	7.5	6.64	0.812	4.1	5.6	6.6	7.6	9.1	
Conductivity (µmho)	499	—	—	0	L	10	104.	78.9	20.	31.	90.	192.	940.	83.7
Alkalinity (meq.)	499	0.0	0.1	1	L	0.12	0.614	0.563	0.0	0.08	0.40	1.40	4.40	.376
Scint. Rds. (c/s)	499	—	—	0	N	—	33.72	7.12	12.	25.	33.	43.	64.	33.0
Neutron Activation														
U (ppb)	499	0.002	0.01 ⁷	163	L	.003	0.855	1.80	<0.002	<0.002	0.20	2.1	15.6	.071
Br (ppb)	499	7	2.0	396	L	<7	54.19	271.3	<7	<7	<7	29.5	3150.	5.49
Cl (ppm)	498	—	—	0	L	4.7	10.25		1.40		6.20	21.80	145.90	7.37
F (ppb)	499	15	5.0	117	L	415	49.39	45.94	15	15	41	100.	438	30.3
Dept. (ft)	426	—	—	—	L	—	147.8	142	0.	0.	135	335	680.	33.6
Temp. (°C)	499	—	—	0	N	—	15.34	2.75	9.	12.	19	15.	27.	15.1
Be (ppm)	499	3.7	1.0	8	L	5	19.23	71.40	<31	4.70	5.70	11.0	780.	7.03
Mn (ppb)	499	10	5.0	34	L	33	108.4	179.7	<10	32.	75	139.	2251.	67.7
Na (ppm)	499	—	—	0	L	2.75	8.23	6.432	1.74	3.15	6.37	14.01	58.55	6.69
V (ppb)	499	0.1	0.05	449	L	<0.1	0.261	3.44	<0.1	<0.1	<0.1	<0.1	<0.1	0.05
Al (ppb)	499	79	40.	491	L	<79	44.0	33.9	<79.	<79.	<79.	<79.	445	41.2
Dy (ppb)	499	0.02	0.01	493	L	<0.02	0.0216	0.138	<0.02	<0.02	<0.02	<0.02	2.80	0.011
Hg (ppb)	273	—	—	—	L	N	2912	1788	660	1180	2490	5390	12110	2480
Supplemental														
Tb (ppb)	497	5	2.	368	L	<5	4.14	4.24	<5	<5	<5	11.	22.	2.98
Ag (ppb)	497	2	1.	285	L	<2	3.27	3.59	<2.	<2.	<2.	9.	26	2.04
Al (ppb)	497	10	5.	81	L	68	56.7	100.2	<10.	<10.	28.	124.	1250	19.9
As (ppb)	497	1	.5	360	L	<1	0.904	1.82	<1	<1	<1	<1	35.	.672
B (ppb)	497	4	2	9	L	<4	13.7	14.7	<4	5	10	25	192	10.8
Be (ppb)	497	—	—	0	L	5	82.6	71.4	2	21	64	165	783.	60.1
Ca (ppb)	497	1	0.5	495	L	<1	0.521	0.383	<1	<1	<1	<1	9.	.506
Ce (ppm)	497	—	—	0	L	L	14.3	13.2	1.	3.	12.	27	211.	10.6
Co (ppb)	497	30	15.	480	L	30	15.7	3.79	30	30	30	30	48.	15.3
Co (ppb)	497	2	1.	310	L	<2	1.86	1.43	<2	<2	<2	4	10.	1.51
Cr (ppb)	497	4	2.	471	L	<4	2.16	0.78	<4.	<4	<4	<4	13.	2.09
Cu (ppb)	497	2	1.	33	L	9	11.3	354.	<2.	2.	29	214	3770	27.5
Fe (ppb)	497	1	0.5	41	L	23	139	484	<1	10	34.5	212	5815	33.3
K (ppm)	497	0	0.1	97	L	<0	1.04	1.00	0	0	1	2	10	1.12
Li (ppb)	497	2	1	127	L	<2	11.3	31.1	<2	<2	4	24	502	4.28
Hg (ppm)	497	0	0.1	10	L	0	2.53	1.77	0	1	2	5	10	2.08
Mn (ppb)	497	2	1	17	L	<0	76.2	224	<2	3	13.	154	2158	16.4
Mo (ppb)	497	4	2	327	L	<4	4.27	3.91	<4	<4	<4	10	24	3.18
Na (ppm)	497	0	0.1	3	L	0	6.09	8.86	0	1	4	12	91	3.62
Nb (ppb)	497	4	2	384	L	<4	3.02	2.18	<4	<4	<4	6	15	2.57
Ni (ppb)	497	4	2	280	L	4	4.34	3.41	<4	<4	<4	9	24	3.39
P (ppb)	497	40	20	334	L	<40	51.8	100.	<40	<40	<40	88	1073	31.4
Sc (ppb)	497	1	0.5	448	L	<1	.564	.366	<1	<1	<1	<1	8	.340
Se (ppb)	497	07	0.1	370	L	1	.265	.460	0	0	0	1	2	1.00
Si (ppm)	497	0	0.1	2	N	0	3.54	1.11	0	2	4	5	7	3.35
Sr (ppb)	497	—	—	L	L	6	273	395	5	18	99.	838	2289	108.
Ti (ppb)	497	2	1	378	L	<2	1.50	2.01	<2	<2	<2	3	40	1.26
V (ppb)	497	4	2	410	L	<4	2.74	1.90	<4	<4	<4	5	15	2.41
Y (ppb)	497	1	0.5	313	L	<1	0.784	0.605	<1	<1	<1	1	8	.685
Zn (ppb)	497	4	2	4	L	<4	273.	885	<4	11	55.	581	11000	65.2
Zr (ppb)	497	2	1	287	L	<2	2.57	2.47	<2	<2	<2	6	17	1.81
Radon (PCI/L)	497	2	1	14	L	—	1022	1184	0	43	680	2350	15930	449
Diss. Oxygen (ppm)	497	—	—	0	P	—	7.69	2.01	2.8	4.8	7.9	10.2	12.2	7.39

¹ Number of samples considered for mean, standard deviation, median, etc.² Detection limit.³ Value assigned for samples below detection limit.⁴ Number of samples with determinations of not detected.⁵ Form of frequency distribution - N = Normal, L = Lognormal, P = Positively Skewed⁶ Value for de-ionized water sample adsorbed to resin (DSGW-999):⁷ 0.001 assigned for mean; std. dev., 0.01 for logged values.⁸ Not logged.

Table 5. Statistical Data for Surface Waters

	N ¹	Det. Lim. ²	N. Det. ³	N<Det. ⁴	Form ⁵	Blank ⁶	Mean	St. Dev.	Lowest	10th	Median	90th	Highest	Geom. Mean
<u>Field</u>														
pH	496			0	N	7.5	6.70	0.845	3.8	5.5	6.8	7.7	9.1	6.64
Cond.	496			0	L	90	68.5	64.2	5.	28.	50.0	115	590.	54.3
Alkalinity	496			0	L	0.12	0.184	0.221	0.0	0.04	0.12	0.84	1.90	0.121
Temp. (°C)	496			0	N	22	18.3	2.94	9.0	15.	18.0	22.	25.0	18.1
<u>Neutron Activation</u>														
U (ppb)	496	.002	.001	484	L	.003	0.150	1.06	<.002	<.002	<.002	0.10	14.8	0.0021
Br (ppb)	496	7	1.0	369	L	<.7	62.0	324.	1.	1.0	1.0	37.	4268.	2.69
Cl (ppb)	496	--	--	0	L	4700.	10649.	17328	1400	3400	6200.	17800.	216600	7292.
F (ppb)	496	15	1.0	116	L	<15	42.89	61.7	1.	1.0	35.0	75.	911.	18.5
Mn (ppb)	496	10	1.0	17	L	13	155.	257	1.	35.	90.0	295.	2640.	87.6
Na (ppb)	495	--	--	0	L	2150	6840.	8005.	2140.	3120	4890.	10440.	103140.	5456.
V (ppb)	496	.1	.1	469	L	<.1	0.191	.540	0.1	0.10	0.10	0.10	8.0	0.115
Al (ppb)	495	--	--	0	L	<79	198.8	123.	41.	94.	162.	344.	899.	171.
Dy (ppb)	496	.001	.001	493	L	<.02	0.00341	.0453	<.001	<.001	0.001	<.001	1.0	0.00103
Mg (ppb)	495	--	1.0	336	L	---	655.1	1120.	10.0	10.0	10.0	2190.	6470.	53.8
<u>Supplemental</u>														
Th (ppb)	496	5	2	352	L	<5	4.36	4.37	<5	<5	<5	11.	22.	3.12
Ag (ppb)	496	2	1	290	L	<2	3.01	3.15	<2	<2	<2	8.	16.	1.95
Al (ppb)	496	10	5	13	L	68	127.	146.	<10	25	85.	273.	1370.	81.6
As (ppb)	496	1	.5	439	L	<1	0.565	0.202	<1	<1	<1	1.	2.	.544
B (ppb)	496	4	2	11	L	<4	10.9	12.9	<4	5.	9.	17.	230.	8.96
Ba (ppb)	496	2	1	1	L	5	50.8	27.3	<2	21.	46.	83.	186.	44.08
Ca (ppm)	496	0	1	1	L	1	6.31	3.96	0	3.	3.	11.	27.	5.37
Ce (ppb)	496	30	15	477	L	<30	15.8	4.31	<30	<30	<30	30	43.	15.5
Co (ppb)	496	2	1	309	L	<2	1.99	1.67	<2	<2	<2	4.	13.	1.56
Cr (ppb)	496	4	2	467	L	<4	2.12	0.499	<4	<4	<4	<4	5.	2.08
Cu (ppb)	496	2	1	112	L	9	6.22	9.19	<2	<2	3.	14.	85.	3.49
Fe (ppb)	496	10	5	6	L	23	405.	638.	<10	22.	200.	988.	7472.	174.
K (ppm)	496	0	.1	173	L	<0	0.950	1.10	0	0	1.	2.	9.0	.509
Li (ppb)	496	2	1	388	L	<2	1.43	1.82	<2	<2	<2	2.	31.	1.21
Mg (ppm)	496	0	.1	24	L	0	1.31	0.745	0	1.	1.	2.	6.	1.11
Mn (ppb)	496	2	1	3	L	<0	146.	326.	<2	6.	54.	399.	3621.	50.8
Mo (ppb)	496	4	2	362	L	<4	3.58	3.27	<4	<4	<4	8.	22.	2.82
Na (ppb)	496	0	1	1	L	0	4.40	8.53	0	1.	2.	8.	94.	2.46
Nb (ppb)	496	4	2	402	L	<4	2.82	1.99	<4	<2	2.	5.	17	2.46
Ni (ppb)	496	4	2	290	L	4	4.24	3.31	<4	<2	2	9.	22.	3.33
P (ppb)	496	40	20	380	L	40	69.2	194.	<40	<40	<40	99.	2748.	33.3
Sc (ppb)	496	1	.5	453	L	<1	0.553	0.282	<1	<1	<1	<1	6.	0.532
Se (ppb)	496	0	.1	446	L	1	0.190	0.271	0	.1	.1	.1	1.	0.126
Si (ppm)	496	0	1	6	L	0	2.31	0.835	0	1.	2.	3.	5.	2.14
Sr (ppb)	496	2	1	1	L	6	39.6	39.9	<2	14	30.	73.	636.	30.7
Ti (ppb)	496	2	1	345	L	<2	1.67	1.92	<2	<2	<2	3.	27.	1.35
V (ppb)	496	4	2	402	L	<4	2.66	1.54	<4	<4	<4	5.	11	2.40
Y (ppb)	496	1	.5	335	L	<1	0.699	0.343	<1	<1	<1	1.	2.	.642
Zn (ppb)	496	4	2	21	L	<4	16.7	18.1	<4	5.	12.	29.	221.	12.1
Zr (ppb)	496	2	1	315	L	<2	2.42	2.38	<2	<2	<2	6.	11.	1.70

¹Number of samples considered for simple statistics²Detection limit

Value assigned for samples below detection limit

Number of samples with determination of not detected

⁵Form of frequency distribution: N = Normal; L = Lognormal

Table 6. Basic statistics for sediment data.

Variable	N ¹	D.L. ²	N. Det. ³	N<Det. ⁴	No. Missing	Form ⁵	Mean ppm	St. Dev.	Lowest	10% ile	Median	90% ile	Highest	Geom. Mean
<u>Field</u>														
Sed. Size	491			0	0	N	3.03	0.819	2	2	2	4	5	
Str. Width	491			0	0	N	4.92	1.12	1	4	5	6	7	
Str. Depth	491			0	0	N	3.19	1.07	1	2	3	5	7	
Str. Level	491			0	0	N	2.85	0.603	1	2	3	4	4	
Veg. Dens.	491			0	0	N	2.06	0.297	1	2	2	2	3	
Relief	491			0	0	N	2.26	0.66	1	2	2	3	4	
Scint. (c/s)	491			0	0	N	32.0	7.21	9.0	24.0	32.0	40.0	62.0	
<u>Neutron Activation (ppm)</u>														
U	491			0	0	L	3.97	1.47	0.3	2.50	3.8	5.50	17.3	3.75
Th	474	4-5	2	2	17	N	9.87	4.36	1.07	5.0	10.0	14.0	45.0	9.59
Hf	445	--	--	0	46	L	35.0	23.3	1.0	17.0	31.0	56.0	344.0	30.3
Al	487	--	--	0	4	N	27208.0	8925.0	2200.0	17500.0	26300.0	37500.0	71500.0	25781.0
Ce	473	2 to 8	1/2 D.L.	44	18	L	83.0	43.1	<2	36.0	85.0	121.0	557.0	59.2
Fe	475	100	50	33	16	L	14541.0	7908.0	<100	3500.0	14500.0	23200.0	64100.0	9341.1
Mn	481	40 or 100	20,50	36	10	L	674.3	865.0	<40	120.0	430.0	1460.0	8790.0	404.6
Na	473	100	50	2	18	N	4525.8	1650.0	<100	2600.0	4400.0	6600.0	10600.0	4159.1
Sc	487	2.0	1.0	9	4	N	3.45	1.54	0.3	1.70	3.40	5.2	11.80	3.00
Ti	436	--	--	0	55	N	4356.0	13.26	100.0	2900.0	4400.0	5900.0	13600.0	4133.3
V	490	--	--	0	1	N	32.6	12.0	1.0	20.0	30.0	50.0	80.0	29.7
Dy	485	2.0	1.0	179	6	L	3.40	3.36	0.8	1.0	2.50	7.0	36.2	2.41
Eu	366	1.0	0.5	84	125	L	1.68	1.05	<1.0	0.5	1.90	3.1	6.4	1.37
La	442	1	1	1	49	L	42.04	16.1	<1	27.0	42.0	57.0	230.0	39.4
Sn	436	--	--	0	55	L	7.03	3.68	2.0	4.0	7.0	10.0	51.0	6.46
Yb	476	2.0	1.0	126	15	L	3.06	1.61	0.8	1.0	3.0	4.9	14.9	2.65
Lu	476	.3,.6,.7	.1,.3	3	15	L	0.495	0.247	<0.3	0.0	0.50	0.8	2.9	0.427
<u>Supplemental (ppm)</u>														
U (ext.) ⁶	489	.1	.1	15	0	L	0.984	0.789	<0.1	0.4	0.9	1.90	7.2	0.752
Ag	489	.1	.1	206	0	L	0.195	0.196	<0.1	<0.1	0.1	0.3	2.2	0.155
As	489	1.0	--	17	0	L	3.70	2.35	1.0	1.0	3.0	7.0	15.0	3.09
Ba	489	5	2	34	0	L	16.7	13.7	<5.0	5.0	13.0	30.0	160.0	12.7
Be	489	.3	--	4	0	L	1.40	0.795	0.3	0.5	1.0	2.5	6.5	1.22
Ca	489	100	50	167	0	L	192.2	1001.0	<100.0	<100.0	100.0	400.0	22000.0	107.9
Co	489	5	2	48	0	L	8.04	4.39	<5.0	<5.0	7.0	12.0	27.0	6.94
Cr	489	5	--	2	0	L	24.4	14.7	5.0	15.0	25.0	30.0	287.0	22.7
Cu	489	2	1	17	0	L	6.44	6.70	<2.0	3.0	5.0	11.0	100.0	5.15
K	489	1000	500	6	0	N	6677.9	3373.0	0	2000.0	6000.0	11000.0	20000.0	5624.7
Li	489	4	--	4	0	L	26.6	8.13	4.0	19.0	26.0	34.0	84.0	25.4
Mg	489	450	--	4	0	N	2371.7	780.0	450.0	1500.0	2350.0	3300.0	4950.0	2219.2
Mo	489	2	1	364	0	L	2.17	5.12	<2.0	<2.0	<2.0	3.0	52.0	1.36
Nb	489	5	2	92	0	L	9.76	6.43	<5.0	<5.0	10.0	15.0	40.0	7.46
Ni	489	5	2	25	0	L	10.3	5.47	<5.0	5.0	10.0	17.0	57.0	9.00
P	489	20	10	15	0	L	453.1	266.0	<20.0	200.0	400.0	700.0	3500.0	375.6
Pb	489	10	5	56	0	L	24.8	27.9	<10.0	<10.0	20.0	40.0	500.0	19.2
Se	489	1.0	.5	338	0	L	0.915	1.98	<1.0	<1.0	1.0	2.0	41.0	0.022
Sn	489	5	2	405	0	L	4.23	6.57	<5.0	<5.0	5.0	10.0	60.0	2.71
Y	489	5	2	261	0	L	5.74	4.64	<5.0	<5.0	5.0	10.0	30.0	4.25
Zn	489	5	--	8	0	L	64.9	52.7	<5.0	23.0	53.0	115.0	550.0	51.0

¹ Number of samples considered for simple statistics.² Detection limit.³ Value assigned for samples below detection limit.

Table 7. Correlation coefficients for ground water data generated by MINITAB program,
Penn State University Computer Library.

	PH	COND	ALK	U	SCINT	BR	CL	F	HE	MN	NA	AL	DY	MG
COND	0.485													
ALK	0.684	0.772												
U	0.450	0.609	0.672											
SCINT	0.056	0.108	0.105	0.233										
BR	0.026	0.117	0.066	0.080	-0.091									
CL	-0.025	0.587	0.266	0.233	0.135	0.116								
F	0.260	0.026	0.244	0.262	-0.036	-0.054	-0.285							
HE	0.345	0.308	0.347	0.325	0.035	0.164	0.184	0.159						
MN	-0.200	-0.011	-0.149	-0.131	-0.113	0.045	0.036	-0.028	-0.128					
NA	0.388	0.665	0.542	0.498	0.128	0.123	0.562	0.035	0.471	0.002				
AL	-0.097	-0.148	-0.190	-0.016	-0.061	-0.026	-0.080	-0.040	-0.018	0.132	-0.094			
DY	-0.098	0.039	-0.045	0.030	-0.014	0.083	0.118	-0.106	-0.029	0.091	0.080	0.126		
MG	0.235	0.560	0.444	0.371	0.093	-0.023	0.347	-0.020	0.096	0.005	0.375	-0.024	0.098	
DEPTH	0.414	0.660	0.699	0.599	0.215	0.058	0.356	0.110	0.231	-0.173	0.516	-0.198	0.033	0.300
T	-0.088	-0.006	-0.149	-0.149	-0.219	0.037	-0.040	-0.076	-0.019	0.156	-0.118	0.117	0.005	-0.071
RN	0.188	0.378	0.410	0.378	0.146	0.038	0.154	0.097	0.101	-0.148	0.287	-0.129	0.006	0.199
D.O.	-0.197	-0.309	-0.358	-0.353	0.305	-0.095	-0.102	-0.212	-0.322	-0.125	-0.365	-0.013	0.001	-0.243
TH	-0.067	-0.051	-0.029	-0.041	0.117	-0.093	0.021	-0.034	-0.075	0.079	-0.073	-0.037	-0.073	-0.050
AG	-0.110	-0.042	-0.044	-0.049	0.333	-0.024	-0.043	0.002	-0.049	-0.013	-0.082	-0.002	-0.012	0.038
AL	-0.286	-0.221	-0.298	-0.168	-0.113	0.026	-0.067	-0.097	-0.016	0.063	-0.098	0.185	0.040	-0.026
AS	0.284	0.286	0.274	0.271	0.024	0.047	0.017	0.191	0.269	-0.048	0.255	-0.006	-0.074	0.103
B	0.241	0.565	0.450	0.352	0.069	-0.016	0.396	-0.028	0.369	-0.005	0.527	-0.073	-0.042	0.253
BA	-0.082	0.329	0.199	0.358	0.126	-0.040	0.396	-0.063	0.093	-0.037	0.257	-0.018	-0.011	0.098
BE	-0.052	-0.010	-0.035	0.019	0.023	-0.112	0.029	-0.060	-0.028	0.036	0.013	-0.003	-0.132	0.066
CA	0.501	0.787	0.755	0.595	0.114	-0.025	0.371	0.069	0.175	-0.052	0.449	-0.132	-0.030	0.485
CE	0.014	-0.060	-0.033	-0.041	-0.019	-0.204	-0.079	-0.002	0.003	-0.005	-0.375	-0.004	-0.200	-0.035
CO	-0.059	0.029	-0.035	0.014	0.089	-0.059	0.101	-0.087	0.016	0.076	-0.012	0.020	-0.028	0.009
CR	-0.004	-0.029	0.010	-0.006	0.031	-0.180	-0.037	-0.013	-0.011	0.005	-0.055	-0.016	-0.164	0.020
CU	-0.058	0.248	0.181	0.147	0.214	-0.028	0.214	-0.108	-0.088	-0.057	0.194	-0.153	0.051	0.016
FE	-0.289	-0.228	-0.308	-0.280	-0.076	-0.048	0.005	-0.156	-0.124	0.266	-0.133	0.221	0.014	-0.140
K	0.150	0.524	0.402	0.418	0.204	0.063	0.355	-0.044	0.149	-0.026	0.416	0.006	0.075	0.243
LI	0.441	0.595	0.648	0.653	0.178	0.069	0.324	0.226	0.546	-0.219	0.615	-0.117	-0.097	0.278
MC	0.408	0.671	0.621	0.459	0.116	-0.045	0.322	0.053	0.035	-0.022	0.326	-0.113	-0.038	0.632
MN	-0.342	-0.111	-0.257	-0.246	-0.093	-0.004	0.124	-0.109	-0.128	0.540	-0.082	0.155	0.078	-0.014
MO	-0.097	-0.069	-0.049	-0.030	-0.010	-0.102	-0.069	-0.037	-0.019	0.039	-0.072	0.052	-0.100	-0.034
NA	0.367	0.771	0.603	0.490	0.135	0.063	0.646	0.022	0.441	-0.104	0.769	-0.207	-0.026	0.359
NB	-0.035	-0.011	-0.003	0.031	0.078	-0.055	0.034	-0.004	0.065	0.023	0.010	-0.003	-0.061	0.003
NI	-0.113	-0.024	-0.048	-0.023	0.061	0.015	0.059	-0.111	0.015	0.039	0.009	0.005	0.021	-0.096
P	-0.099	0.062	0.020	0.012	0.100	-0.064	0.053	0.012	-0.044	0.086	0.063	0.031	-0.079	0.040
SC	0.010	0.014	0.000	-0.027	-0.010	-0.131	-0.003	-0.050	-0.033	0.106	-0.018	-0.033	-0.116	0.049
SE	-0.030	0.069	0.051	0.032	-0.049	0.051	0.074	0.013	0.071	-0.066	-0.010	-0.061	-0.069	0.110
SI	0.314	0.339	0.412	0.272	0.018	-0.073	0.015	0.154	0.135	-0.161	0.183	-0.089	-0.200	0.173
SR	0.441	0.627	0.582	0.686	0.238	0.004	0.324	0.144	0.392	-0.182	0.539	-0.143	-0.060	0.292
TI	-0.049	-0.012	-0.054	-0.066	-0.087	-0.099	-0.019	-0.098	-0.087	0.151	-0.074	-0.002	-0.089	0.037
V	-0.075	-0.073	-0.059	-0.046	0.021	-0.039	-0.016	-0.077	-0.025	-0.009	-0.044	0.007	-0.131	-0.098
Y	-0.152	0.030	-0.055	0.031	0.095	-0.022	0.136	-0.105	-0.063	0.150	0.009	0.046	0.141	0.001
ZN	0.136	0.316	0.320	0.244	0.076	-0.028	0.118	0.055	-0.031	-0.024	0.243	-0.090	-0.019	0.057
ZR	-0.047	-0.003	0.022	0.013	0.099	-0.078	0.085	-0.003	-0.018	0.026	0.012	-0.053	-0.085	0.014

Table 7. continued.

	DEPTH	T	RN	D.O.	TH	AG	AL	AS	B	BA	BE	CA	CE	CO
T	-0.251													
RN	0.552	-0.218												
D.O.	-0.225	-0.095	-0.138											
TH	-0.022	-0.070	0.009	0.055										
AG	0.037	0.032	0.024	0.077	0.251									
AL	-0.336	0.175	-0.214	-0.032	-0.123	-0.015								
AS	0.202	0.074	0.135	-0.220	0.008	0.045	-0.045							
B	0.408	0.000	0.160	-0.228	0.143	0.059	-0.032	0.296						
BA	0.276	-0.063	0.171	-0.167	0.080	0.096	0.139	0.254	0.461					
BE	0.021	0.027	-0.017	0.024	0.199	0.102	0.152	0.112	0.283	0.309				
CA	0.631	-0.109	0.389	-0.243	0.067	0.044	-0.187	0.225	0.597	0.482	0.214			
CE	-0.043	0.042	-0.053	0.063	0.443	0.210	0.099	0.175	0.388	0.376	0.525	0.303		
CO	0.014	0.052	-0.029	0.011	0.398	0.164	-0.040	0.043	0.233	0.139	0.286	0.113	0.337	
CR	0.019	0.017	-0.021	0.050	0.534	0.223	0.034	0.122	0.304	0.299	0.564	0.270	0.772	0.296
CU	0.513	-0.070	0.252	0.000	0.081	0.098	-0.126	0.027	0.265	0.264	0.213	0.304	0.168	0.071
FE	-0.251	0.213	-0.275	-0.094	0.090	0.038	0.323	-0.110	0.013	0.012	0.149	-0.184	0.187	0.165
K	0.443	-0.150	0.267	-0.190	0.092	0.018	-0.095	0.182	0.541	0.433	0.105	0.522	0.081	0.116
LI	0.644	-0.151	0.353	-0.359	0.011	0.039	-0.127	0.415	0.610	0.442	0.154	0.547	0.149	0.074
MG	0.522	-0.095	0.396	-0.117	0.048	0.015	-0.216	0.124	0.426	0.308	0.183	0.820	0.203	0.066
MN	-0.241	0.231	-0.270	-0.223	0.095	0.029	0.349	-0.020	0.086	0.214	0.159	-0.100	0.173	0.131
MO	-0.105	0.057	-0.027	0.023	0.146	0.057	0.103	0.063	0.128	0.135	0.189	0.059	0.277	0.173
NA	0.598	-0.080	0.303	-0.311	0.017	-0.007	-0.088	0.340	0.704	0.472	0.174	0.651	0.176	0.126
NB	-0.020	0.029	-0.021	-0.022	0.349	0.182	0.042	0.070	0.192	0.209	0.218	0.136	0.431	0.255
NI	0.086	0.022	0.058	0.011	0.202	0.021	0.092	0.037	0.154	0.195	0.251	0.077	0.315	0.159
P	0.138	0.057	0.089	-0.014	0.205	0.133	0.052	0.194	0.248	0.265	0.391	0.193	0.378	0.123
SC	-0.022	0.035	-0.063	0.049	0.336	0.097	-0.130	0.071	0.271	0.110	0.621	0.192	0.416	0.321
SE	-0.009	-0.027	-0.000	-0.001	-0.008	0.007	-0.064	0.251	0.039	0.127	0.012	0.018	0.015	-0.016
SI	0.435	-0.130	0.330	-0.091	0.136	0.122	-0.118	0.242	0.410	0.281	0.310	0.543	0.454	0.097
SR	0.651	-0.161	0.376	-0.315	0.044	0.057	-0.140	0.344	0.648	0.560	0.169	0.739	0.260	0.107
TI	-0.087	0.119	-0.058	0.052	0.311	0.067	0.071	0.031	0.238	0.079	0.360	0.115	0.355	0.260
V	-0.024	-0.030	-0.101	0.015	0.448	0.203	0.121	0.002	0.162	0.195	0.227	0.094	0.472	0.259
Y	0.031	0.004	0.001	0.013	0.648	0.163	0.010	-0.061	0.197	0.180	0.371	0.111	0.364	0.392
ZN	0.488	-0.087	0.218	-0.167	0.047	0.083	-0.100	0.087	0.303	0.294	0.145	0.398	0.225	0.089
ZR	0.052	-0.027	0.009	0.075	0.635	0.165	-0.127	-0.041	0.129	0.074	0.158	0.081	0.341	0.333

Table 7. continued.

	CR	CU	FE	K	LI	MG	MN	MO	NA	NB	NI	P	SC	SE
CU	0.160													
FE	0.127	-0.074												
K	0.098	0.363	-0.057											
LI	0.152	0.183	-0.199	0.460										
MG	0.203	0.292	-0.212	0.419	0.394									
MN	0.091	-0.040	0.556	0.020	-0.155	-0.101								
MO	0.265	0.023	0.182	0.048	0.031	0.048	0.084							
NA	0.144	0.271	-0.094	0.520	0.737	0.519	0.005	0.018						
NB	0.167	0.088	0.056	0.081	0.108	0.083	0.098	0.101	0.130					
NI	0.246	0.200	0.158	0.091	0.126	0.066	0.163	0.136	0.123	0.195				
P	0.370	0.528	0.096	0.210	0.094	0.165	0.171	0.145	0.136	0.166	0.198			
SC	0.501	0.116	0.100	0.132	0.041	0.174	0.115	0.153	0.080	0.165	0.171	0.234		
SE	-0.004	-0.053	-0.047	0.012	0.055	0.018	-0.001	0.076	0.054	-0.007	0.006	0.074	-0.042	
SI	0.403	0.220	-0.164	0.218	0.472	0.513	-0.144	0.128	0.403	0.208	0.176	0.194	0.241	-0.009
SR	0.235	0.279	-0.184	0.562	0.864	0.543	-0.156	0.089	0.710	0.136	0.158	0.137	0.072	0.038
TI	0.376	0.024	0.224	0.092	-0.011	0.094	0.162	0.190	0.018	0.145	0.089	0.162	0.587	-0.142
V	0.470	0.084	0.119	0.099	0.102	-0.004	0.109	0.204	0.048	0.350	0.234	0.223	0.164	0.009
Y	0.473	0.117	0.142	0.197	0.016	0.091	0.214	0.145	0.081	0.324	0.257	0.217	0.383	-0.082
ZN	0.162	0.459	0.054	0.340	0.331	0.353	0.093	0.036	0.331	0.061	0.157	0.175	0.042	-0.041
ZR	0.420	0.069	0.091	0.113	0.059	0.068	0.022	0.160	0.080	0.310	0.215	0.147	0.260	-0.021
	SI	SR	TI	V	Y	ZN								
SR	0.451													
TI	0.169	0.055												
V	0.185	0.125	0.155											
Y	0.069	0.062	0.297	0.349										
ZN	0.283	0.427	0.020	0.109	0.079									
ZR	0.107	0.083	0.268	0.423	0.565	0.068								

Table 8. Correlation coefficients for stream water data generated by STPAC program,
Penn State University Computer Library.

CORRELATION COEFFICIENTS												
	1	2	3	4	5	6	7	8	9	10	11	12
	PH	COND	ALK	TH	AG	AL	AS	B	BA	CA	CE	CO
2 COND	0.3892											
3 ALK	0.6055	0.6553										
4 TH	0.0046	-0.0095	-0.0191									
5 AG	-0.0299	0.0647	-0.0198	0.2413								
6 AL	-0.5002	-0.1969	-0.3921	-0.0739	0.0242							
7 AS	-0.0433	0.1343	0.0852	0.0599	0.0533	0.1474						
8 B	0.2755	0.6114	0.4117	0.0909	0.1328	-0.0369	0.1369					
9 BA	-0.1714	0.2076	-0.1071	-0.0081	0.0127	0.3218	0.0700	0.1338				
10 CA	0.5392	0.8161	0.7197	-0.0065	0.0574	-0.3040	0.0867	0.5563	0.1936			
11 CE	-0.0134	-0.0485	-0.0380	0.4040	0.1752	-0.0090	0.0579	-0.0016	0.0360	-0.0114		
12 CO	-0.0126	0.0211	0.0460	0.4649	0.2428	0.0000	0.0482	0.0662	-0.0613	0.0115	0.2680	
13 CR	-0.0430	-0.0331	-0.0276	0.5184	0.1864	0.0038	0.0775	0.0514	0.0253	-0.0523	0.4494	0.2726
14 CU	-0.0405	-0.0133	-0.0631	-0.0170	0.0020	0.2282	0.0466	0.2523	-0.0701	-0.0267	0.0405	0.1230
15 FE	-0.2066	0.1203	-0.0086	0.0211	0.0325	0.6472	0.2937	0.2196	0.2534	-0.0121	-0.0156	0.0612
16 K	0.2197	0.4996	0.3625	-0.0389	0.0580	0.0854	0.1662	0.5742	0.2993	0.5287	-0.0139	0.0313
17 LI	0.1117	0.4349	0.1939	0.0553	0.0165	0.1532	0.1488	0.4854	0.2150	0.3131	0.0005	0.0222
18 MG	0.4002	0.5803	0.5118	0.0136	0.0185	-0.2537	0.0784	0.4194	0.2633	0.7310	-0.0163	0.0562
19 MN	-0.2779	0.2008	-0.0125	0.0389	0.0756	0.5369	0.2960	0.2434	0.3958	0.0542	-0.0409	0.0792
20 MO	-0.0300	0.0149	0.0104	0.0762	0.0759	0.0391	0.0969	0.0695	0.0350	0.0551	0.0491	0.0734
21 NA	0.2955	0.7896	0.4556	0.0129	0.0587	0.0257	0.1702	0.6097	0.3215	0.6496	-0.0351	-0.0199
22 NB	0.0651	0.0486	0.0434	0.3153	0.1033	0.0607	0.0813	0.1426	-0.0096	0.0631	0.1132	0.2337
23 NI	-0.0422	-0.0027	-0.0723	0.1214	0.0464	0.0200	-0.0110	0.0313	0.0934	-0.0030	0.1080	0.0549
24 P	0.0571	0.3238	0.2638	0.0336	0.0529	0.2501	0.2705	0.4854	0.0869	0.3137	-0.0085	0.0645
25 SC	-0.0212	-0.0128	0.0439	0.1446	-0.0044	-0.2433	0.0258	0.0530	-0.2034	-0.0276	0.0441	0.1607
26 SE	0.0472	0.1119	0.0875	0.0267	-0.1027	-0.0477	0.1122	0.0923	0.0449	0.0833	0.0099	-0.0049
27 SI	0.0181	0.1601	0.1073	-0.0211	0.0351	-0.1085	-0.0815	0.0013	0.0445	0.1990	0.0154	0.0827
28 SR	0.3925	0.6973	0.5084	0.0114	0.0106	-0.0759	0.1363	0.5547	0.4290	0.7718	-0.0005	-0.0035
29 TI	-0.0951	-0.1235	-0.0896	0.0966	0.0026	0.1592	0.0033	0.1280	-0.0863	-0.0403	0.0653	0.0762
30 V	-0.0266	0.0216	-0.0259	0.3904	0.1674	0.1217	0.0653	0.0131	-0.0105	-0.0321	0.1670	0.3388
31 Y	-0.0260	0.0153	-0.0668	0.7469	0.2931	0.0187	0.0725	0.1046	0.0411	-0.0115	0.3946	0.4527
32 ZN	-0.4158	-0.1127	-0.3032	0.0376	0.0585	0.4796	0.0834	0.1182	0.1766	-0.2173	0.0256	0.0765
33 ZR	0.0841	0.0291	-0.0024	0.6614	0.2278	-0.1333	0.0072	0.1440	-0.0175	0.0579	0.3456	0.3459
34 U	-0.0452	0.0490	0.0158	-0.0080	-0.0078	0.1383	0.0132	0.0734	0.1183	0.0835	-0.0081	0.0399
35 BR	-0.0028	0.0500	0.0354	-0.0184	-0.0387	-0.0239	-0.0418	0.0404	-0.0657	0.0168	0.0332	0.0141
36 CL	0.2285	0.6920	0.3714	0.0080	0.0541	0.0389	0.1423	0.5122	0.3477	0.5277	-0.0317	-0.0410
37 F	-0.0396	-0.2182	-0.0957	0.0427	-0.0275	0.0988	0.0446	-0.0419	-0.1159	-0.1706	0.0301	-0.0141
38 MN	-0.1734	0.1689	0.0109	0.0267	0.0262	0.3023	0.1528	0.1524	0.2768	0.0684	-0.0675	0.0794
39 NA	0.2820	0.7484	0.4303	0.0212	0.0527	-0.0001	0.1731	0.5643	0.2770	0.5827	-0.0430	-0.0128
40 DY	0.0221	0.1341	0.0780	-0.0476	-0.0024	0.0309	0.0962	0.0687	0.0733	0.0821	-0.0151	-0.0318
41 SW	0.1835	0.1127	0.1051	0.0288	0.0393	-0.1189	-0.0397	0.1456	-0.0585	0.0939	0.0017	0.0052
42 SD	0.0572	-0.0205	-0.0705	0.0206	-0.0450	0.0653	0.0719	0.0983	0.0703	-0.0587	-0.0079	-0.0120
43 SL	-0.0076	-0.1159	-0.1193	0.1446	0.0100	0.1011	0.0155	0.0331	0.0816	-0.0610	0.0926	0.0390
44 SF	0.1496	-0.0066	0.0173	0.0893	0.0096	-0.0105	-0.0774	0.0945	-0.0296	0.0051	0.0829	0.0245
45 T	0.1235	0.1955	0.1779	0.0246	0.0253	-0.1139	0.0828	0.0926	-0.1221	0.0999	-0.0984	-0.0191

Table 8. continued.

		CORRELATION COEFFICIENTS														
		13	14	15	16	17	18	19	20	21	22	23	24			
		CR	CU	FE	K	LI	MG	MN	MO	NA	NB	NI	P			
14	CU	0.0471														
15	FE	0.0485	0.2621													
16	K	-0.0025	0.1833	0.3202												
17	LI	0.0520	0.1793	0.2535	0.3235											
18	MG	-0.0067	-0.0687	-0.0524	0.4131	0.2642										
19	MN	0.0293	0.1583	0.7514	0.2895	-0.2392	0.0471									
20	MO	0.0652	0.0691	0.1087	0.0908	0.0846	0.0445	0.1103								
21	NA	-0.0281	0.0013	0.2558	0.5563	0.4539	0.4482	0.3276	0.0067							
22	NB	0.2453	0.0722	0.1287	0.0576	-0.2040	0.0546	0.0934	0.1556	0.1132						
23	NI	0.0707	0.1425	-0.0027	0.0049	0.0598	0.0200	-0.0057	0.0406	0.3024	-0.0184					
24	P	0.0423	0.2784	0.4384	0.4712	0.4663	0.1847	0.3456	0.1840	0.3445	0.2057	0.0004				
25	SC	0.1001	0.0153	-0.0977	-0.0342	-0.0390	-0.0608	-0.0489	0.0323	-0.1128	0.0306	-0.0374	-0.0464			
26	SE	-0.0287	-0.0085	0.1097	0.1698	0.0687	0.1167	0.0941	0.0601	0.1063	-0.0795	-0.0183	0.0759			
27	SI	-0.0595	-0.0365	-0.2835	-0.0753	0.1829	0.1957	-0.1579	0.0562	0.3024	0.0201	0.0086	-0.0598			
28	SR	0.0216	0.0816	0.2114	0.6276	-0.5226	0.6608	0.2224	0.0855	0.5730	0.1432	0.0265	0.4212			
29	TI	0.1524	0.2235	0.0821	0.0825	-0.0209	-0.0428	-0.0147	-0.0192	-0.1086	0.0271	-0.0213	0.1074			
30	V	0.3322	0.0941	0.1025	-0.0004	0.1170	-0.0601	0.0635	0.1204	0.3500	0.2392	0.0887	0.1558			
31	Y	0.4256	0.0452	0.0738	0.0049	0.0822	0.0293	0.0698	0.0681	0.3190	0.2686	0.1785	0.0845			
32	ZN	0.0297	0.4401	0.3398	0.0567	0.2255	-0.1741	0.3877	0.0406	-0.3399	0.0170	0.1130	0.1278			
33	ZR	0.4163	-0.0116	-0.0163	-0.0250	0.0712	0.0590	-0.0377	0.1159	0.3433	0.2395	0.1950	0.0518			
34	U	-0.0526	0.2018	0.1325	0.0576	0.1158	0.0158	0.1144	0.0199	0.3475	0.0219	0.0169	0.0861			
35	BR	0.0068	0.0070	-0.0408	-0.0638	-0.0708	-0.0252	-0.0359	-0.0346	-0.3254	-0.0602	-0.0198	-0.0862			
36	CL	0.0161	-0.0164	0.3024	0.4992	0.3544	0.3967	0.3406	0.0081	0.3278	0.0460	0.0339	0.2609			
37	F	0.1155	0.1346	0.0411	-0.0575	0.0511	-0.1057	-0.0223	0.0343	-0.2165	0.0279	-0.0504	0.1117			
38	MM	0.0013	0.0303	0.4628	0.2290	0.1458	0.0809	0.6581	0.1091	0.1865	-0.0592	0.0291	0.2071			
39	NA	0.0056	0.0146	0.2889	0.4959	0.4410	0.4530	0.3321	0.0063	0.3567	0.1091	0.0032	0.3243			
40	DY	-0.0212	-0.0067	0.0661	0.0060	-0.0043	0.0640	0.1218	-0.0453	0.1433	-0.0348	-0.0164	-0.0427			
41	SW	-0.0075	-0.0207	0.0762	0.1116	0.0177	0.0471	-0.0833	0.0017	0.1222	0.0489	0.0762	0.0762			
42	SD	-0.0117	0.0663	0.2327	0.1253	0.0672	-0.0309	0.0650	-0.0222	0.1225	0.0366	-0.0225	0.1278			
43	SL	0.0849	0.0157	0.1356	0.0680	-0.1073	0.0068	0.0979	-0.0241	-0.3126	0.0537	0.0782	0.0549			
44	SP	0.0307	0.0283	0.0205	0.0364	-0.0223	0.0051	-0.0714	-0.1105	0.3458	0.0307	0.0640	0.0327			
45	T	-0.0033	-0.0162	0.1401	0.0731	0.0196	0.0296	0.0948	0.0528	0.3899	0.0208	-0.1191	0.0944			

Table 8. continued.

CORRELATION COEFFICIENTS														
	25	26	27	28	29	30	31	32	33	34	35	36		
	SC	SE	SI	SR	TI	V	Y	ZN	ZR	U	BR	CL		
26 SE	0.0308													
27 SI	0.0665	0.0019												
28 SR	-0.1317	0.1247	0.0813											
29 TI	0.3428	-0.0189	-0.0582	-0.0429										
30 V	-0.0168	-0.0509	0.0023	-0.0208	0.0455									
31 Y	0.0863	0.0363	0.0095	0.0344	0.1574	0.4240								
32 ZN	0.0379	-0.0207	0.0375	-0.0631	0.1919	0.0671	0.0850							
33 ZR	0.0660	0.0277	-0.0147	0.0553	0.0546	0.3099	0.5986	-0.0076						
34 U	-0.0378	0.0257	0.1094	0.1480	0.1038	0.0202	-0.0225	0.1402	-0.0288					
35 BR	0.0483	0.0200	0.0859	-0.0558	0.0584	-0.0146	-0.0081	0.0303	-0.0627	0.0419				
36 CL	-0.0647	0.1104	-0.0229	0.5645	-0.0711	0.0135	0.0005	0.0174	0.0442	0.0469	0.0164			
37 F	0.0141	0.0332	-0.0438	-0.0840	0.0451	0.1173	0.0220	0.0507	0.0146	0.0458	-0.0021	-0.1850		
38 MN	0.0368	0.1014	-0.0512	0.1606	0.0188	0.0436	0.0380	0.2482	-0.0129	0.0899	0.0250	0.2844		
39 NA	-0.0645	0.1119	0.0358	0.6355	-0.0747	0.0608	0.0398	0.0071	0.0488	0.0441	0.0059	0.8872		
40 DY	0.0468	-0.0238	0.0116	0.0765	-0.0015	-0.0348	-0.0125	0.0264	-0.0550	0.0880	0.1207	0.1701		
41 SW	-0.0291	0.0292	-0.1867	0.0831	-0.0799	0.0100	-0.0049	-0.1974	0.0346	-0.0867	0.0187	0.1385		
42 SD	-0.0675	0.0470	-0.2918	0.1053	-0.0095	0.0360	0.0236	-0.0576	0.0170	-0.0254	-0.0914	0.1320		
43 SL	-0.0599	0.0551	-0.2281	-0.0513	0.0695	0.0554	0.1691	-0.0199	0.1104	-0.0344	-0.0590	0.0055		
44 SF	-0.0396	-0.0062	-0.1475	-0.0015	0.0045	0.0554	0.1285	-0.0895	0.1425	-0.0368	-0.0523	0.0263		
45 T	0.0507	0.0937	-0.2281	0.0570	-0.0853	0.0412	0.0151	-0.0932	0.0073	-0.0124	-0.0351	0.0815		

		CORRELATION COEFFICIENTS											
		37	38	39	40	41	42	43	44				
	F	MN	NA	DY	SW	SD	SL	SF					
38 MN	-0.0359												
39 NA	-0.1766	0.2906											
40 DY	-0.0377	0.1216	0.1780										
41 SW	0.0388	-0.1011	0.1156	-0.0779									
42 SD	0.1238	-0.0062	0.1109	-0.0505	0.5628								
43 SL	-0.0009	0.0546	-0.0028	-0.0501	0.2123	0.3564							
44 SF	0.0011	-0.0299	0.0289	-0.0720	0.2591	0.3354	0.5209						
45 T	0.1129	0.0475	0.1023	-0.0487	0.1846	0.1158	-0.0818	-0.0342					

Table 9. Correlation coefficients for sediment data generated by the SAS program,
SAS Institute, Inc. Pearson Correlation Method used.

	CORRELATION MATRIX										
	UEXT	AG	AS	BA	BE	CA	CO	CR	CU	K	LI
UEXT	1.00000	0.27392	0.06567	0.13677	0.31614	0.21034	0.27878	-0.09012	0.33847	0.22225	0.38282
AG	0.27392	1.00000	0.10998	0.13093	0.46430	0.32724	0.29785	0.03642	0.41631	0.15763	0.23042
AS	0.06567	0.10998	1.00000	0.02880	0.20309	0.07117	0.31526	0.27648	0.24741	0.12805	0.09876
BA	0.13677	0.13093	0.02880	1.00000	0.26428	0.14638	0.18240	-0.07277	0.13739	0.17411	0.18977
BE	0.31614	0.46430	0.20309	0.26428	1.00000	0.21014	0.40737	0.00197	0.41506	0.49597	0.58659
CA	0.21034	0.32724	0.07117	0.14638	0.21014	1.00000	0.12591	-0.07588	0.19020	0.16649	0.09638
CO	0.27878	0.29785	0.31526	0.18240	0.40737	0.12591	1.00000	0.17993	0.59860	0.28691	0.41455
CR	-0.09012	0.03642	0.27648	-0.07277	0.00197	-0.07588	0.17993	1.00000	0.17649	-0.02883	0.00580
CU	0.33847	0.41631	0.24741	0.13739	0.41506	0.19020	0.59860	0.17649	1.00000	0.29430	0.38173
K	0.22225	0.15763	0.12805	0.17411	0.49597	0.16649	0.28691	-0.02883	0.29430	1.00000	0.49431
LI	0.38282	0.23042	0.09876	0.18977	0.58659	0.09638	0.41455	0.00580	0.38173	0.49431	1.00000
MG	0.32675	0.25710	0.13846	0.11440	0.51949	0.24365	0.37431	-0.14729	0.39239	0.51694	0.60960
MO	-0.10469	-0.01825	0.04696	0.01477	0.06672	0.04368	-0.10563	-0.00711	-0.07936	0.06859	0.00222
NB	-0.08635	-0.19407	-0.08423	0.02252	-0.24290	-0.16247	-0.07807	0.08050	-0.08579	-0.14497	-0.06910
NI	0.26976	0.15310	0.16907	0.13502	0.09784	0.05592	0.53703	0.11010	0.50673	0.06795	0.27763
P	0.20263	0.14485	0.12344	0.25823	0.34835	0.04388	0.35242	-0.07108	0.30246	0.27654	0.50467
PB	0.14155	0.31562	0.23024	0.13041	0.39914	0.26628	0.28720	0.00000	0.39613	0.36112	0.33608
Y	0.06564	0.11717	0.05038	0.09857	0.11696	0.04469	0.01873	-0.06317	0.05134	0.06785	-0.01235
ZN	0.28734	0.31796	0.16428	0.18313	0.33953	0.17377	0.68616	0.13153	0.72345	0.25765	0.38543
SE	-0.06991	-0.08538	0.02949	-0.00482	-0.02175	0.00642	-0.09138	0.05308	-0.07287	-0.02507	0.03601
U	0.16156	0.12850	0.07662	0.05524	0.31298	0.06616	0.12990	0.13780	0.01704	0.25344	0.25185
TH	0.02787	0.02566	-0.01804	0.01733	0.10043	0.02186	-0.01361	0.08835	-0.01266	0.09805	0.02619
HF	-0.06828	-0.12557	-0.05543	-0.02822	-0.00654	-0.03278	-0.06326	0.04200	-0.21189	0.09740	-0.09870
AL	0.21860	0.30507	0.27628	0.20430	0.47669	0.08938	0.48085	0.23310	0.39938	0.40051	0.37013
CE	-0.03499	0.01954	0.00454	-0.02064	0.01775	0.01589	-0.09728	0.09126	-0.09331	-0.02294	-0.04729
FE	0.00423	0.07169	0.09454	0.01020	0.09121	0.04939	0.08506	0.18493	0.14216	0.03032	0.03727
MN	0.07665	0.12258	0.28579	0.06290	0.12779	0.05888	0.56281	0.28003	0.28690	0.06762	0.19969
NA	0.12356	0.13873	0.01150	0.11002	0.31924	0.09945	0.15123	-0.15073	0.09715	0.31899	0.24926
SC	0.00595	0.09356	0.06823	0.06654	0.16659	0.00118	0.09491	0.23036	0.13770	0.08061	0.12499
TI	0.05339	0.02380	0.05055	-0.00160	0.20431	0.07353	0.09887	0.02196	0.08834	0.20126	0.11678
V	0.13615	0.22165	0.24724	0.09887	0.29217	0.10666	0.31824	0.21963	0.31950	0.20143	0.19391
DY	-0.02002	-0.04715	-0.09234	0.01563	0.01147	-0.03586	-0.16062	-0.00272	-0.13587	-0.03042	-0.02265
LA	0.01238	-0.03838	-0.01443	-0.07548	0.12891	0.05983	0.03613	0.02629	-0.12859	0.14226	0.07515
SM	-0.02557	-0.07398	-0.02517	0.05770	0.05442	-0.01177	-0.02320	0.08143	-0.15917	0.07791	0.02456
YB	0.02652	0.03797	-0.01237	-0.01086	0.10220	0.05907	-0.00079	0.08196	-0.01725	0.08048	0.03998
LU	-0.00466	0.04007	0.01620	-0.02649	0.09713	0.03850	-0.02085	0.11898	-0.06102	0.07696	0.01381
SS	0.01042	0.06660	-0.01189	0.06226	0.10493	0.03853	-0.13318	-0.08018	0.00794	0.05982	0.02825
SW	-0.10194	-0.07774	-0.13908	-0.02774	-0.12835	-0.07277	0.02674	0.05796	-0.06477	-0.01688	-0.11155
SD	-0.07236	0.07143	-0.10389	0.05724	0.04438	0.06711	-0.01389	-0.00457	0.01836	0.10401	-0.07400
SL	-0.00421	0.08735	-0.11215	0.07829	-0.01564	0.09052	-0.03935	-0.02215	-0.07481	-0.04150	-0.12982
VD	0.00124	-0.05362	-0.03406	-0.01704	-0.08515	0.04342	-0.07228	0.00699	-0.08858	0.04372	-0.05179
RF	0.16056	-0.07275	-0.04876	-0.06558	-0.11146	-0.09850	0.02736	0.05355	-0.00073	-0.07094	0.09920
I	0.10112	0.12424	0.10317	0.09377	0.29690	0.06279	0.25683	0.03570	0.20170	0.28982	0.25577

Table 9. continued.

	CORRELATION MATRIX										
	MG	MO	NB	NI	P	PB	Y	ZN	SE	U	TH
UEXT	0.32675	-0.10469	-0.08635	0.26976	0.20263	0.14155	0.06564	0.28734	-0.06991	0.16156	0.02787
AG	0.25710	-0.01825	-0.19407	0.15310	0.14485	0.31562	0.11717	0.31796	-0.08538	0.12850	0.02566
AS	0.13846	0.04696	-0.08423	0.16907	0.12344	0.23024	0.05038	0.16428	0.02949	0.07662	-0.01804
BA	0.11440	0.01477	0.02252	0.13502	0.25823	0.13041	0.09857	0.18313	-0.00482	0.05524	0.01733
BE	0.51949	0.06672	-0.24290	0.09784	0.34835	0.39914	0.11696	0.33953	-0.02175	0.31298	0.10043
CA	0.24365	0.04368	-0.16247	0.05592	0.04388	0.26628	0.04469	0.17377	0.00642	0.06616	0.02186
CO	0.37431	-0.10563	-0.07807	0.53703	0.35242	0.28720	0.01873	0.68616	-0.09138	0.12990	-0.01361
CR	-0.14729	-0.00711	0.08050	0.11010	-0.07108	0.00000	-0.06317	0.13153	0.05308	0.13780	0.08835
CU	0.39239	-0.07936	-0.08579	0.50673	0.30246	0.39613	0.05134	0.72345	-0.07287	0.01704	-0.01266
K	0.51694	0.06859	-0.14497	0.06795	0.27654	0.36112	0.06785	0.25765	-0.02507	0.25344	0.09805
LI	0.60960	0.00222	-0.06910	0.27763	0.50467	0.33608	-0.01235	0.38543	0.03601	0.25185	0.02619
MG	1.00000	-0.03150	-0.10642	0.21663	0.33517	0.47229	0.09945	0.33095	-0.10575	0.13566	0.05135
MO	-0.03150	1.00000	-0.00769	-0.19856	-0.00552	0.01460	0.08844	-0.08168	0.26359	0.03081	0.05190
NB	-0.10642	-0.00769	1.00000	0.03809	-0.02551	-0.20031	-0.02027	-0.04474	-0.03757	0.03603	-0.00140
NI	0.21663	-0.19856	0.03809	1.00000	0.21543	0.13110	-0.01137	0.56474	-0.06938	-0.04617	-0.06968
P	0.33517	-0.00552	-0.02551	0.21543	1.00000	0.16045	0.03919	0.36845	-0.03611	0.05438	0.05318
PB	0.47229	0.01460	-0.20031	0.13110	0.16045	1.00000	0.02252	0.30516	-0.04249	0.00933	-0.04218
Y	0.09945	0.08844	-0.02027	-0.01137	0.03919	0.02252	1.00000	0.01784	-0.02779	-0.00374	0.02195
ZN	0.33095	-0.08168	-0.04474	0.56474	0.36845	0.30516	0.01784	1.00000	-0.09321	-0.00168	-0.03181
SE	-0.10575	0.26359	-0.03757	-0.06938	-0.03611	-0.04249	-0.02779	-0.09321	1.00000	-0.03913	0.01977
U	0.13566	0.03081	0.03603	-0.04617	0.05438	0.00933	-0.00374	-0.00168	-0.03913	1.00000	0.31718
TH	0.05135	0.05190	-0.00140	-0.06968	0.05318	-0.04218	0.02195	-0.03181	0.01977	0.31718	1.00000
HF	-0.03130	0.02211	0.08672	-0.17353	-0.09409	-0.20984	-0.05403	-0.12342	0.04837	0.56849	0.53277
AL	0.27760	-0.01840	-0.09508	0.24171	0.22078	0.24061	0.01336	0.37536	-0.09941	0.51437	0.12860
CE	-0.03602	0.06081	-0.00652	-0.06171	0.01277	-0.04153	-0.01559	-0.09576	0.05835	0.10999	0.80607
FE	0.07539	0.04429	-0.02887	0.09042	0.09102	0.03532	0.00618	0.09512	0.00027	0.01741	0.74111
MN	0.09663	-0.06500	-0.00695	0.37340	0.16854	0.18427	-0.11592	0.46198	-0.04343	0.11902	-0.00692
NA	0.25861	0.00508	-0.11126	-0.00897	0.20993	0.13881	0.02936	0.17178	-0.05968	0.29447	0.12146
SC	0.04343	0.01001	0.03454	0.08055	0.13811	0.02990	-0.02653	0.11636	-0.02927	0.13426	0.56796
TI	0.18292	0.05676	0.00221	0.01467	0.09378	0.09309	0.04025	0.11047	-0.04481	0.37477	0.18405
V	0.19577	0.01495	0.07853	0.23791	0.14774	0.16513	0.03100	0.26934	-0.03512	0.30288	0.07858
DY	-0.02177	0.07928	0.06844	-0.09649	-0.06351	-0.11351	-0.06088	-0.15079	0.04409	0.22763	0.11567
LA	0.11173	0.00879	0.04190	-0.09182	0.01869	0.02486	0.01231	-0.04880	0.00499	0.58262	0.63395
SM	0.01963	-0.00592	0.03692	-0.08729	-0.01219	-0.06021	-0.02193	-0.07596	0.01495	0.48805	0.47390
YB	0.05704	-0.06896	0.04031	-0.01274	0.04221	-0.02151	-0.00536	-0.01522	-0.05920	0.31734	0.53351
LU	0.01211	0.04098	0.02788	-0.05778	0.04661	-0.07422	0.00005	-0.07106	0.06388	0.31629	0.78653
SS	-0.06180	0.08542	-0.06952	-0.08987	0.11277	0.08704	0.03254	-0.08603	-0.08021	-0.05906	-0.02947
SW	-0.02817	-0.01515	-0.03756	-0.04426	-0.06674	-0.13234	-0.06270	0.09457	-0.04830	-0.01648	0.07989
SD	0.11052	0.05355	-0.04075	-0.09014	-0.04121	0.07202	0.07205	0.06412	-0.09916	0.04893	0.04820
SL	-0.03798	-0.08108	0.08746	-0.01618	-0.05016	-0.02610	-0.01086	-0.02018	-0.03881	0.03415	0.01189
VD	0.02761	-0.04032	0.04431	-0.06209	-0.02245	0.04139	0.05860	-0.08107	-0.02340	-0.04213	-0.04577
RF	-0.00167	-0.04254	0.15190	0.11994	-0.06371	-0.11886	-0.11882	0.03162	0.02183	0.01441	-0.00671
SCINT	0.13989	0.05862	-0.11370	0.07347	0.21172	0.10907	-0.05095	0.19282	0.08540	0.20076	0.04362

Table 9. continued.

	CORRELATION MATRIX										
	HF	AL	CE	FE	MN	NA	SC	TI	V	DY	LA
UEXT	-0.06828	0.21860	-0.03499	0.00423	0.07665	0.12356	0.00595	0.05339	0.13615	-0.02002	0.01238
AG	-0.12557	0.30507	0.01954	0.07169	0.12258	0.13873	0.09356	0.02380	0.22165	-0.04715	-0.03838
AS	-0.05543	0.27628	0.00454	0.09454	0.28579	0.01150	0.06823	0.05055	0.24724	-0.09234	-0.01443
BA	-0.02822	0.20430	-0.02064	0.01020	0.06290	0.11002	0.06654	-0.00160	0.09887	0.01563	0.07548
BE	-0.00654	0.47669	0.01775	0.09121	0.12779	0.31924	0.16659	0.20431	0.29217	0.01147	0.12891
CA	-0.03278	0.08938	0.01589	0.04939	0.05888	0.09945	0.00118	0.07353	0.10666	-0.03586	0.05983
CO	-0.06326	0.48085	-0.09728	0.08506	0.56281	0.15123	0.09491	0.09887	0.31824	-0.16062	0.03613
CR	0.04200	0.23310	0.09126	0.18493	0.28003	-0.15073	0.23036	0.02196	0.21963	-0.00272	0.02629
CU	-0.21189	0.39938	-0.09331	0.14216	0.28690	0.09715	0.13770	0.08834	0.31950	-0.13587	-0.12859
K	0.09740	0.40051	-0.02294	0.03032	0.06762	0.31899	0.08061	0.20126	0.20143	-0.03042	0.14226
LI	-0.09870	0.37013	-0.04729	0.03727	0.19969	0.24926	0.12499	0.11678	0.19391	-0.02265	0.07515
MG	-0.03130	0.27760	-0.03602	0.07539	0.09663	0.25861	0.04343	0.18292	0.19577	-0.02177	0.11173
MO	0.02211	-0.01840	0.06081	0.04429	-0.06500	0.00508	0.01001	0.05676	0.01495	0.07928	0.00879
NB	0.08672	-0.09508	-0.00652	-0.02887	-0.00695	-0.11126	0.03454	0.00221	0.07853	0.06844	0.04190
NI	-0.17353	0.24171	-0.06171	0.09042	0.37340	-0.00897	0.08055	0.01467	0.23791	-0.09649	-0.09182
P	-0.09409	0.22078	0.01277	0.09102	0.16854	0.20993	0.13811	0.09378	0.14774	-0.06351	0.01869
PB	-0.20984	0.24061	-0.04153	0.03532	0.18427	0.13881	0.02990	0.09309	0.16513	-0.11351	0.02486
Y	-0.05403	0.01336	-0.01559	0.00618	-0.11592	0.02936	-0.02653	0.04025	0.03100	-0.06088	0.01231
ZN	-0.12342	0.37536	-0.09576	0.09512	0.46198	0.17178	0.11636	0.11047	0.26934	-0.15079	-0.04880
SE	0.04837	-0.09941	0.05835	0.00027	-0.04343	-0.05968	-0.02927	-0.04481	-0.03512	0.04409	0.00499
U	0.56849	0.51437	0.10999	0.01741	0.11902	0.29447	0.13426	0.37477	0.30288	0.22763	0.58262
TH	0.53277	0.12860	0.80607	0.74111	-0.00692	0.12146	0.56796	0.18405	0.07858	0.11567	0.63395
HF	1.00000	0.02012	0.33074	0.16413	-0.09625	0.12542	0.18582	0.18166	-0.06504	0.30923	0.64484
AL	0.02012	1.00000	-0.00994	0.10015	0.32308	0.39108	0.29104	0.23230	0.53040	-0.02278	0.18552
CE	0.33074	-0.00994	1.00000	0.80586	-0.03543	-0.02133	0.57259	0.06499	-0.03666	0.04920	0.36518
FE	0.16413	0.10015	0.80586	1.00000	0.13696	-0.04333	0.67445	0.06600	0.12090	-0.02784	0.10885
MN	-0.09625	0.32308	-0.03543	0.13696	1.00000	0.04602	0.15267	0.11580	0.31763	-0.26671	0.01561
NA	0.12542	0.39108	-0.02133	-0.04333	0.04602	1.00000	0.01221	0.36480	0.31933	0.14151	0.16459
SC	0.18582	0.29104	0.57259	0.67445	0.15267	0.01221	1.00000	0.05253	0.19492	0.03765	0.13329
TI	0.18166	0.23230	0.06499	0.06600	0.11580	0.36480	0.05253	1.00000	0.16177	0.11569	0.47579
V	-0.06504	0.53040	-0.03666	0.12090	0.31763	0.31933	0.19492	0.16177	1.00000	0.07159	0.03407
DY	0.30923	-0.02278	0.04920	-0.02784	-0.26671	0.14151	0.03765	0.11569	0.07159	1.00000	0.22391
LA	0.64484	0.18552	0.36518	0.10885	0.01561	0.16459	0.13329	0.47579	0.03407	0.22391	1.00000
SM	0.50462	-0.03562	0.30960	-0.00770	0.00615	-0.07864	-0.02869	0.42983	-0.09419	0.21279	0.76481
YB	0.37702	0.09182	0.54375	0.43103	-0.04858	-0.02771	0.32230	0.43691	-0.07244	0.06330	0.53327
LU	0.55261	0.08640	0.87358	0.68910	-0.04954	-0.04742	0.52806	0.15767	0.01219	0.14348	0.55201
SS	-0.20208	0.01032	-0.00782	-0.00149	-0.19083	0.02058	0.03809	-0.01707	-0.02231	-0.01363	-0.09640
SW	0.21405	-0.05615	0.03310	0.03154	0.05940	0.03209	0.00897	0.03112	-0.05385	0.02305	0.04881
SD	0.09639	0.03503	-0.01303	-0.02561	-0.07368	0.12829	-0.06398	0.08345	-0.02696	0.06388	0.05794
SL	0.10671	-0.05859	-0.02755	-0.01462	-0.05259	0.05574	-0.04955	-0.00031	-0.02937	0.05787	0.03243
VD	-0.02156	-0.05858	-0.04178	-0.07170	-0.08125	-0.00977	-0.12929	-0.03036	-0.03484	-0.03323	-0.01315
R	-0.00716	-0.01501	0.01738	0.05541	0.14034	-0.19278	0.05609	-0.07048	-0.05040	-0.05202	-0.023
S	0.07115	0.29127	-0.03786	0.02979	0.23497	0.11579	0.14886	0.13584	0.17008	-0.04244	0.085

Table 9. continued.

	CORRELATION MATRIX									
	SM	YB	LU	SS	SW	SD	SL	VD	RF	SCINT
UEXT	-0.02557	0.02652	-0.00466	0.01042	-0.10194	-0.07236	-0.00421	0.00124	0.16056	0.10112
AG	-0.07398	0.03797	0.04007	0.06660	-0.07774	0.07143	0.08735	-0.05362	-0.07275	0.12424
AS	-0.02517	-0.01237	0.01620	-0.01189	-0.13908	-0.10389	-0.11215	-0.03406	-0.04876	0.10317
BA	0.05770	-0.01086	-0.02649	0.06226	-0.02774	0.05724	0.07829	-0.01704	-0.06558	0.09377
BE	0.05442	0.10220	0.09713	0.10493	-0.12835	0.04438	-0.01564	-0.08515	-0.11146	0.29690
CA	-0.01177	0.05907	0.03850	0.03853	-0.07277	0.06711	0.09052	0.04342	-0.09850	0.06279
CO	-0.02320	-0.00079	-0.02085	-0.13318	0.02674	-0.01389	-0.03935	-0.07228	0.02736	0.25683
CR	0.08143	0.08196	0.11898	-0.08018	0.05796	-0.00457	-0.02215	0.00699	0.05355	0.03570
CU	-0.15917	-0.01725	-0.06102	0.00794	-0.06477	0.01836	-0.07481	-0.08858	-0.00073	0.20170
K	0.07791	0.08048	0.07696	0.05982	-0.01688	0.10401	-0.04150	0.04372	-0.07094	0.28982
LI	0.02456	0.03998	0.01381	0.02825	-0.11155	-0.07400	-0.12982	-0.05179	0.09920	0.25576
MG	0.01963	0.05704	0.01211	-0.06180	-0.02817	0.11052	-0.03798	0.02761	-0.00167	0.13989
MO	-0.00592	-0.06896	0.04098	0.08542	-0.01515	0.05355	-0.08108	-0.04032	-0.04254	0.05862
NB	0.03692	0.04031	0.02788	-0.06952	-0.03756	-0.04975	0.08746	0.04431	0.15190	-0.11370
NI	-0.08729	-0.01274	-0.05778	-0.08987	-0.04426	-0.09014	-0.01618	-0.06209	0.11994	0.07347
P	-0.01219	0.04221	0.04661	0.11277	-0.06674	-0.04121	-0.05016	-0.02245	-0.06371	0.21172
PB	-0.06021	-0.02151	-0.07422	0.08704	-0.13234	0.07202	-0.02610	0.04139	-0.11886	0.10907
Y	-0.02193	-0.00536	0.00005	0.03254	-0.06270	0.07205	-0.01086	0.05860	-0.11882	-0.05095
ZN	-0.07596	-0.01522	-0.07106	-0.08603	0.09457	0.06412	-0.02018	-0.08107	0.03162	0.19282
SE	0.01495	-0.05920	0.06388	-0.08021	-0.04830	-0.09916	-0.03881	-0.02340	0.02183	0.08540
U	0.48805	0.31734	0.31629	-0.05906	-0.01648	0.04893	0.03415	-0.04213	0.01441	0.20076
TH	0.47390	0.53351	0.78653	-0.02947	0.07989	0.04820	0.01189	-0.04577	-0.00671	0.04362
HF	0.50462	0.37702	0.55261	-0.20208	0.21405	0.09639	0.10671	-0.02156	-0.00716	0.07115
AL	-0.03562	0.09182	0.08640	0.01032	-0.05615	0.03503	-0.05859	-0.05858	-0.01501	0.29127
CE	0.30960	0.54375	0.87358	-0.00782	0.03310	-0.01303	0.02755	-0.04178	0.01738	-0.03786
FE	-0.00770	0.43103	0.68910	-0.00149	0.03154	-0.02561	-0.01462	-0.07170	0.05541	0.02979
MN	0.00615	-0.04858	-0.04954	-0.19083	0.05940	-0.07368	-0.05259	-0.08125	0.14034	0.23497
NA	-0.07864	-0.02771	0.04742	0.02058	0.03209	0.12829	0.05574	-0.00977	-0.19278	0.11579
SC	-0.02869	0.32230	0.52806	0.03809	0.00897	-0.06398	-0.04955	-0.12929	0.05609	0.14886
TI	0.42983	0.43691	0.15767	-0.01707	0.03112	0.08345	-0.00031	-0.03036	-0.07048	0.13584
V	-0.09419	-0.07244	0.01219	-0.02231	-0.05385	-0.02696	-0.02937	-0.03484	-0.05040	0.17008
DY	0.21279	0.06330	0.14348	-0.01363	0.02305	0.06388	0.05787	-0.03323	-0.05202	-0.04244
LA	0.76481	0.53327	0.55201	-0.09640	0.04881	0.05794	0.03243	-0.01315	-0.02396	0.08554
SM	1.00000	0.53088	0.39418	-0.04938	0.07648	0.03554	-0.02026	0.02823	-0.03047	0.04781
YB	0.53088	1.00000	0.62194	0.05347	-0.02212	-0.02478	-0.00711	0.02316	0.01838	0.01554
LU	0.39418	0.62194	1.00000	-0.02538	0.03789	0.00463	0.04191	-0.02178	0.00407	0.02238
SS	-0.04938	0.05347	-0.02538	1.00000	-0.27100	0.01547	-0.01794	0.13303	-0.22869	-0.07618
SW	0.07648	-0.02212	0.03789	-0.27100	1.00000	0.56356	0.21507	-0.02629	0.03405	-0.02835
SD	0.03554	-0.02478	0.00463	0.01547	0.56356	1.00000	0.36395	0.01599	-0.17406	-0.03581
SL	-0.02026	-0.00711	0.04191	-0.01794	0.21507	0.36395	1.00000	0.02744	-0.17906	-0.07280
VD	0.02823	0.02316	-0.02178	0.13303	-0.02629	0.01599	0.02744	1.00000	-0.07774	-0.06138
RF	-0.03047	0.01838	0.00407	-0.22869	0.03405	-0.17406	-0.17906	-0.07774	1.00000	0.08402
SCINT	0.04781	0.01554	0.02238	-0.07618	-0.02835	-0.03581	-0.07280	-0.06138	0.08402	1.00000

(factors) that are closely related, probably because all variables loaded on a factor are responding to some single underlying master variable or process. These factor patterns were rotated (a procedure that maximized or minimized the loading of each variable on each factor) using the SAS VARIMAX and STPAC VARIMAX routines. The number of significant factors in each data set was selected using criteria that included percent of variance explained and geologic reasonableness. The final rotated factor patterns are shown in Tables 10 through 12. All loadings of 0.1 or greater are listed because they are significant at the 95% confidence level.

The SAS program was then used to calculate factor scores for each data set. The factor scores reflect the relative importance of each of the significant factors in each observation. For this calculation, observations with missing values in any one variable were rejected. Thus, for example, the sediment factor score matrix contains only 280 out of 498 observations.

Histograms, bivariate plots and maps of the raw data, logged data, and factor scores were generated using the MINITAB program. All maps are presented at the same scale as Figure 10, which is a plot of the known uranium localities in the Glen Wild area. The square area outlined was assumed to represent a mineralized zone, and all variables, elemental ratios, and factor scores were tested using the MINITAB t-test subroutine to determine whether they were anomalously high or low inside this area as compared to samples outside the mineralized area. Populations were considered significantly different at the 95% confidence level. The significant variables are summarized in Tables 13 through 15.

Maps of element distribution have been prepared by the MINITAB program. These maps show concentrations by letters, with A=1, B=2, C=3, etc. Concentrations were transformed by multiplication, division, and addition of constants to fall in convenient ranges for this program.

GROUNDWATER

Basic Statistics and Water Character

Table 4 lists a variety of statistical data for groundwaters. A total of 499 samples were reported, but samples 643 and 644 were not analyzed for the supplemental group of elements. Also, no neutron activation analysis for Mg was available for about half the samples, one determination was missing for Cl (assigned the mean of 6200 ppm for statistical purposes), and the well depth was not available for 74 samples.

Detection limits are based on explicit values (for supplemental analyses), or on the lowest determined value for elements having samples reported as not detected. In order to compute statistics,

Table 10. Factor Loadings for Logged Ground Water Data, VARIMAX Rotated

Factor Name	1 Dissolved Solids	2 Insol. Traces	3 Deep Water	4 Reducing	5 Brine	6 Well Contam.	7 Be-Sc-Ti	8 R.E.	9 Br-Mo	10 Se-As-Ag	Communality
pH	.58		.23	.21	.27	-.18		.18	.16	-.16	.63
Conductivity	.86		.23		-.25				.14		.89
Alkalinity	.84		.26	.12	.12				.10		.81
U	.65		.34	.17	.14	.11		-.27	-.17		.71
Gamma Ct.	.10	.14		.34		.24		-.30	-.28		.39
Br			.28	-.10				-.17	.46	.13	.35
Cl	.38		.21		-.69			-.14	.12		.72
F	.17		.20		.70	-.15					.57
He	.17		.76								.65
Mn			-.13	-.69			-.13	-.13			.55
Na	.54		.54		-.29				.12		.71
Al	-.11			-.25	.13	-.16		-.28	-.38	.16	.36
Dy				-.12	-.15			-.57			.38
Mg	.69		-.12		-.19	-.26		-.17	-.11	.19	.69
Depth	.69		.19	.24		.44			.14		.80
Temp.	-.10			-.48		-.13		.30		.24	.43
Rn	.49			.30	.13	.33		-.16			.49
Diss. O ₂	-.34		-.44	.41	-.23			.16			.57
Th		.83					-.13				.72
Ag		.27	-.14							.43	.29
Al	-.30	-.38	.11	-.31	-.20	-.13	.17	-.12	-.39	.18	.50
As	.19	-.34	.49		.20					.42	.54
B	.52		.44		-.37	.12		.20			.68
Ba	.28		.28		-.35	.31	.19		-.33	.19	.56
Be							-.74	-.26		.13	.67
Ca	.91				-.12						.85
Ce		.46				.11	.16	.54	-.34		.67
Co		.48			-.10		-.21				.30
Cr		.56					-.27	.26	-.26	.12	.56
Cu	.22		-.12	.10	-.18	.78				.10	.74
Fe	-.27			.60	-.11			-.21	-.20		.54
K	.20			-.12	-.54	.18		-.12	-.12		.42
Li	.58		.66	.19		.16					.84
Mg	.89		-.15		-.12						.84
Mn	-.16			-.80	-.15	.11		-.11	-.12		.73
Mo								.10	-.46	-.15	.26
Na	.64		.52		-.38	.12					.86
Nb		.50					.17			.26	.36
Ni	-.12	.22	.15		-.11	.38					.25
P				-.14		.58	-.14	.17	-.15	.35	.55
Sc		.18					-.85				.77
Se										.49	.26
Si	.57			.22	.19	.13		.29			.52
Sr	.67		.47	.19		.23	.13		-.18		.82
Ti		.19		-.18			-.59	.22	-.15		.52
V	-.10	.59					.20				.41
Y		.70		-.11	-.12		-.31	-.29			.71
Zn	.38			-.10		.58	.18			-.18	.56
Zr		.77									.61
% of Var.	16.1	7.1	6.5	5.5	4.8	4.8	4.5	3.4	3.0	2.5	
Cum. %	16.1	23.2	29.7	35.2	40.0	44.8	49.3	52.7	55.7	58.2	

Ten factors extracted, lowest eigenvalue 1.20. Program was FANAL followed by VARIMAX, of PSU Computation Center.

Table 11. Factor loadings for surface water data, VARIMAX rotated.

Factor Name	1 Dissolved Solids	2 Acidity	3 Insoluble Traces	4 Stream Discharge	5 Ore	6 Temperature	7 Sc-Se-Ti	8 Mo-Se	Communalities
pH	.54	-.50		.14	-.11	.18			.61
Gond.	.89							-.14	.84
Alk.	.71	-.25				.28	.14		.68
Th			.86						.75
Ag			.42				-.20		.23
Al	-.77	.70			.34	-.17	-.74		.75
As		.38				.25	.12	.16	.28
B	.71		.11	.12	.36				.67
Ba	.28	.49			-.14	-.52		.12	.63
Ca	.89	-.15							.84
Ce			.55			-.19	.11		.36
Co			.62						.40
Cr			.67						.45
Cu					.76				.59
Fe	.14	.77		.21	.25	.17			.76
K	.66	.24		.14	.20		.15	.14	.59
Li	.51	.16			.37		-.23	.21	.54
Mg	.73				.12	-.18	.18	.14	.64
Mn	.18	.86							.79
Mo		.14	.15	-.17		.12		.42	.27
Na	.84	.24					-.19	-.16	.83
Nb	.11		.43		.16	.14		.19	.34
Ni			.18			-.37	-.24		.19
P	.43	.27			.44	.20		.34	.61
Sc		-.11	.16	-.10	.17	.25	.55	-.30	.54
Se	.15	.18			-.14		.49	.26	.38
Si	.15	-.25		-.52		-.32			.46
Sr	.86					-.13		.18	.80
Ti			.12		.51		.47	-.21	.55
V			.57		.11	.11	-.24		.42
Y			.82						.70
Zn	-.16	.45			.56	-.20		-.11	.60
Zr			.75	-.14					.60
U				-.12	.34	-.14			.16
Br								-.44	.22
Cl	.74	.32		.11			-.14	-.27	.77
F	-.19				.27	.26		.34	.29
Mn (Na)	.16	.69					.20		.55
Na (Na)	.80	.27					-.15	-.23	.81
Dy	.13	.16		-.10				-.48	.28
Str. width	.15	-.15		.64		.21	-.15		.53
Str. depth				.75		.11	-.10	.11	.61
Str. level		.10	.11	.68		-.28	.21		.61
Str. flow		-.13		.68		-.22			.55
Temp.	.12			.10	-.12	.66			.48
<hr/>									
Σ Variance Explained	16.36	8.64	8.82	5.54	4.97	3.88	3.13	3.31	

Table 12. Factor loadings for sediment data, VARIMAX rotated.

Factor Name	1 Mica- Clay	2 Heavy Mineral I	3 Heavy Mineral II	4 Ore?	5 Stream Size	6 Mn Oxide	7 Relief- Sediment Size	Communi- cality
U ext.	.53			.24	-.12			.34
Ag	.42			.12		.24	.34	.38
As					-.20	.55	.12	.37
Ba	.34							.13
Be	.73		.13	-.16		.22	.21	.66
Ca	.30			.11			.36	.23
Co	.52			.36		.52	-.17	.70
Cr	-.24	.16				.62		.49
Cu	.56		-.20	.33		.43		.65
K	.65		.18	-.19				.51
Li	.79				-.18		-.15	.69
Mg	.76							.60
Mo				-.56				.34
Nb	-.24		.11	.14			-.24	.15
Ni	.31		-.16	.53		.33	-.21	.57
P	.58							.35
Pb	.49					.18	.34	.40
Y							.31	.11
Zn	.54		-.14	.41	.14	.41	-.15	.70
Se				-.41	-.14		-.20	.26
U	.18		.75	-.16		.29		.70
Th		.82	.41					.80
Hf		.29	.69	-.13	.20		-.21	.61
Al	.43		.21	-.12		.65		.62
Ce		.92	.16					.88
Fe		.92				.13		.85
Mn	.16			.27		.61	-.30	.56
Na	.39	-.10	.25	-.31	.23	.17	.14	.36
Sc		.75		-.12		.26		.61
Ti	.16		.60			.16	.10	.45
V	.21			-.14		.67		.47
Dy			.35	-.28				.21
La		.26	.86					.73
Sm		.15	.81	.18		-.11		.65
Yb		.54	.54	.24	-.12		.11	.71
Lu		.84	.38					.85
Sed. size ¹					-.22		.58	.41
Str. width					.77		-.32	.71
Str. depth					.82		.12	.69
Str. level				.11	.59		.17	.40
Veg. density				.14			.29	.13
Relief				.12	-.23		-.61	.45
Scint.	.37			-.24		.23	-.25	.33
<hr/>								
% of total variance explained	11.85	9.53	8.50	4.30	4.69	7.37	4.54	

¹ - values increase with decreasing grain size.

MONTICELLO

X

Uranium localities:

1. Gibber Egg Farm
2. Feldman Quarry
3. Lucky #1
4. Goodwin #1
5. Taylor Road
6. Church Road

North Latitude

West Longitude

Figure 10. Format for all areal plots presented in this report. Square area represents the "mineralized zone" used for t-test calculations. Latitude and longitude in decimal degrees.

Table 13. Constituents of Ground Water Significantly Different Between Mineralized Area and Remainder of Area, Based on t-Tests

	$\bar{X}_{\min}$	$\bar{X}_{\text{bkg}}$	t	P
U	- .410 (0.39)	- .869 (0.14)	3.43	.07%
Scint.	1.547 (35.0)	1.515 (32.7)	2.36	1.83
He	1.058 (11.5)	0.822 (6.6)	4.44	0.00
Mn	1.674 (47.2)	1.849 (70.6)	-2.91	0.37
Na (NAA)	4.047 (11140)	3.800 (6310)	6.62	0.00
Temp °C	1.115 (13.0)	1.186 (15.3)	-6.57	0.00
Rn	2.868 (738)	2.600 (398)	2.15	3.20
D.O.	0.830 (6.76)	0.873 (7.46)	-2.28	2.30
Al	1.526 (33.6)	1.268 (18.5)	2.20	2.83
Ba	1.976 (94.6)	1.751 (56.4)	3.89	0.01
Be	-0.277 (.528)	-0.302 (.499)	2.30	2.20
Cu	1.679 (47.8)	1.406 (25.5)	2.53	1.17
K	0.008 (1.02)	-0.163 (.687)	2.64	0.87
Li	0.973 (9.40)	0.587 (3.86)	4.90	0.00
Na (flame spec)	0.702 (5.04)	0.532 (3.40)	2.65	0.83
Ni	0.605 (4.03)	0.517 (3.29)	1.99	4.68
Sr	2.35 (224)	1.99 (97.7)	3.91	0.01
Zn	2.01 (102)	1.78 (603)	2.21	2.76

() = Value converted out of logs.

t = t value of t-test for significance of $\bar{X}_{\min} - \bar{X}_{\text{bkg}}$.

P = Probability that two groups are random samples of a single population.

$\bar{X}_{\min}$ = Mean of 52 samples from mineralized area.

$\bar{X}_{\text{bkg}}$ = Mean of 447 samples outside mineralized area.

Table 14. Constituents of surface water significantly different between mineralized area and remainder of area, based on t-tests.

	$\bar{X}_{\min}$	$\bar{X}_{\text{bkg}}$	t	P (%)
Factor 1: Salinity	-3.720	0.434	-3.88	0.01
Factor 4: Stream Discharge	0.980	-0.114	2.96	0.32
Factor 5: Ore	2.064	-0.241	6.59	0.00
pH	6.39	6.74	-2.86	0.45
log Cond.	1.541	1.756	-5.50	0.00
log Alk.	-1.39	-0.913	-6.69	0.00
log Al	2.158	1.884	4.47	0.00
log As	-0.294	-0.260	-2.16	3.14
log Ba	1.737	1.634	2.90	0.39
log Ca	0.612	0.744	-3.74	0.02
log Ce	1.213	1.188	2.24	2.59
log Cu	0.893	0.504	6.41	0.00
log Mg	-0.042	0.058	-2.41	1.63
log Na	0.204	0.414	-3.65	0.03
log Ni	0.608	0.514	2.25	2.47
log Sc	-0.300	-0.270	-2.10	3.67
log Si	0.276	0.338	-2.42	1.60
log Ti	0.401	0.103	9.54	0.00
log Y	-0.148	-0.197	2.04	4.17
log Zn	1.211	1.069	3.04	0.25
log U	-2.346	-2.715	2.99	0.29
log Cl	3.704	3.873	-3.45	0.06
log Na	3.611	3.748	-3.67	0.03
Stream width	4.60	4.95	-2.13	3.40
Stream depth	3.60	3.15	2.87	0.43
Stream level	3.19	2.81	4.43	0.00
Stream flow	2.92	2.68	2.78	0.57
Temp. (°C)	15.85	18.64	-6.79	0.00
log (U/cond.)	-3.886	-4.470	4.62	0.00
log (Cu/cond.)	-0.648	-1.251	8.59	0.00
log (Zn/cond.)	-0.330	-0.687	5.63	0.00
log U/log Th	-6.187	-7.227	4.45	0.00

t = t value of t-test for significance of $\bar{X}_{\min} - \bar{X}_{\text{bkg}}$.

P = probability that two groups are random samples of a single population.

$\bar{X}_{\min}$ = mean of 52 samples from mineralized area.

$\bar{X}_{\text{bkg}}$ = mean of 446 samples outside mineralized area.

Table 15. Constituents of sediments significantly different between mineralized area and remainder of area, based on t-tests.

	$N_{\min}$	$\bar{X}_{\min}$	N_{bkg}	$\bar{X}_{\text{bkg}}$	t	P (%)
log U (ext.)	52	-0.024	437	-0.136	2.32	2.07
log Ca	52	2.172	433	2.008	3.46	0.06
log K	52	3.895	437	3.733	3.51	0.05
log Mg	52	3.460	437	3.333	5.06	0.00
log Nb	52	1.146	437	0.840	6.28	0.00
log Pb	52	1.446	437	1.265	4.11	0.00
log Y	52	0.723	437	0.6171	2.18	2.96
log Se	52	-0.249	437	-0.155	-2.43	1.55
log Al	51	4.457	436	4.409	2.06	4.01
log V	52	1.541	438	1.463	2.31	2.13
Stream Width	52	4.577	446	4.948	-2.24	2.54
Stream Depth	52	3.538	446	3.148	2.49	1.32
Stream Level	52	3.154	446	2.812	3.93	0.01
Vegetation						
Density	52	2.135	446	2.049	-1.98	4.85
log U	52	0.624	439	0.569	2.60	0.96
log (U ext./Zn)	52	-1.670	437	-1.850	3.20	0.14
log (Cu/Zn)	52	-1.016	437	-1.065	2.64	0.85

t = t value of t-test for significance of $\bar{X}_{\min} - \bar{X}_{\text{bkg}}$

P = probability that two groups are random samples of a single population.

$\bar{X}_{\min}$ = mean of $N_{\min}$ samples from mineralized area.

$\bar{X}_{\text{bkg}}$ = mean of N_{bkg} samples from outside mineralized area.

concentrations below detection limit were assigned a value $1/2$ to $1/3$ the detection limit. Uranium is a special case: Many samples are listed as 0.002 ppb, so for initial statistics they were assigned a value of 0.001. However, when data were logged, it was found that the lowest reported value was 0.1 ppm, so samples below the detection limit were assigned a value of 0.01 ppb. For several elements, values of 0 are reported (alkalinity, depth, K, Mg, Na, Se, Si, Rn). For these determinations a value of 0.1 was assigned during conversion to logs.

For some elements, most values were below detection limits. For example, no V (neutron activation, NA) values were detected, nor were 491 Al(NA), 493 DY(NA), 495 Be, 480 CE, 471 Cr, 448 Sr, or 410 V (supplemental), and more than half of the values were below detection for Br, Th, Ag, As, Co, Mo, Nb, Ni, P, Se, Ti, Y and Zr. Nevertheless, all elements except V(NA) were retained in the statistical studies, because it seemed possible that the few samples in which the element was detected might show a relation to mineralization or other features of interest. Clearly, one cannot apply parametric statistical methods to these elements with any rigor; any inferences must be considered tentative.

Five elements were determined by both neutron activation and supplemental methods: Na, V, Al, Mn, and Mg. As noted, the V(NA) determinations are all below detection limit, many Mg(NA) values are missing, and most Al(NA) values are below detection limit, so these analyses were generally not used. The two methods correlate well for Na ($r=0.88$) and Mn ($r=0.95$), so both sets of values were kept.

Histograms were prepared and examined for all variables. Figure 11 shows histograms of those variables for which areal plots are presented. If the histogram showed distinct skew to high values, it was inferred to be closer to log normality than normality. Most elements are thus skewed, and all data were therefore logged for most statistical steps. An approximately lognormal frequency distribution is indicated for most elements by the similarities between the geometric mean (antilog of mean log) and the median, the large differences between arithmetic mean and median, and the large values of the standard deviations relative to the mean.

The variables showing normal-appearing distributions are: pH, scintillometer counts, temperature, and silicon. The histogram for dissolved oxygen is skewed toward low values, which is not surprising, since few samples become supersaturated with oxygen relative to air, but many approach saturation.

The statistics (medians) show that the typical water in the area is very slightly acid (pH 6.6), and the solids are dilute (conductivity 90 μ mhos, equivalent to about 60 ppm dissolved solids), with about 30 ppm HCO_3^- , 6 ppm Cl^- , 12 ppm Ca, and 6 ppm Na. These waters have obviously undergone only slight evaporation or interaction with soils and rocks. Dissolved oxygen is relatively high (7.9 ppm, compared with about 10 ppm for air saturation). None of the waters of the area contained detectable H_2S .

EACH * REPRESENTS 10 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	A) $\log(\text{He, ppm})$
0.4	6	*
0.6	93	*****
0.8	329	*****
1.0	28	***
1.2	8	*
1.4	7	*
1.6	3	*
1.8	3	*
2.0	4	*
2.2	3	*
2.4	5	*
2.6	6	*
2.8	3	*

EACH * REPRESENTS 5 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	B) $\log(\text{Rn, PCi/l})$
-1.0	14	***
-0.5	0	
0.0	0	
0.5	5	*
1.0	6	**
1.5	39	*****
2.0	41	*****
2.5	116	*****
3.0	179	*****
3.5	96	*****
4.0	2	*

EACH * REPRESENTS 5 OBSERVATIONS

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	C) $\log(\text{Cu, ppb})$
-1.0	2	*
-0.5	0	
0.0	33	*****
0.5	50	*****
1.0	92	*****
1.5	160	*****
2.0	99	*****
2.5	46	*****
3.0	9	**
3.5	7	**

Figure 11. Histograms of the ground water variables He, Rn and Cu. Areal plots are presented for all three.

Some waters depart markedly from typical water; for example, Cl^- is 146 ppm in one sample, the highest pH is 9.1, and the highest alkalinity (4.4 meq. H_2SO_4) is equivalent to about 270 ppm HCO_3^- .

Factor Analysis

The results of an R-mode factor analysis of the groundwater data are listed in Table 10. All data except pH were entered as logged variables for simplicity. Ten factors were extracted, the first having an eigenvalue of 10.01 and the last having an eigenvalue of 1.20. The ten factors were rotated by the VARIMAX procedure. Factor loadings of less than about 0.1 are probably not significant at the 0.5 significance level, so are not shown; values above 0.4 are highly significant and are underlined. The communalities, which express the proportion of variance incorporated in the factors for each variable, tend to be low. In combination with the large number of extracted factors with eigenvalues greater than 1, the low communalities suggest that this is a very complex set of data; extraction of additional factors does not appear useful for the purposes of this report.

The most important factor is designated "Dissolved solids," because most major elements (Na, Mg, Ca, Si, and pH) and several trace elements (U, B, Li, Sr, and Zn) are strongly loaded on this factor, along with such variables as conductivity, alkalinity, depth, and Rn. This factor is interpreted to result from varying degrees of interaction of slightly acid but dilute rainwater with the soils and rocks of the area. Initial rainwater would have very low concentrations of all these constituents, and concentrations of all would tend to increase together as the water dissolved and interacted with soil and rock over time. As expected, deeper wells have more concentrated waters. The strong loadings of U and Rn on this factor suggest that raw U and Rn values may not be directly related to ore; the removal of this dissolved solids effect by ratioing or regression may be desirable for these and other trace components in order to bring out high values related to ore and to suppress high values related to older, more evolved water.

The second factor is designated "Insoluble traces" and is highly loaded on Th, Ce, Co, Cr, Nb, V, Y and Zr. Nearly all of these trace elements have a low solubility in most natural waters and can be termed immobile (though a few can form oxyanions such as vanadate or chromate). Two possibilities seem to exist for this factor:

- 1) It reflects samples bearing elevated concentrations of this group of immobile elements, perhaps as a result of dissolution of monazite, apatite, or similar host minerals; the elements might be in true solution or occur as colloidal material attracted to the exchange resins that were analyzed.
- 2) The elements are impurities introduced in the spectrographic analysis; the single analysis of a blank sample in this study is not adequate to resolve this possibility.

In any case, this group of elements appears to vary completely independently of the major elements, and there is no point in attempting ratios to major elements or conductivity.

A third factor, termed "Deep water," has high loadings on Na, As, B, Li, Sr, and He and a negative loading on dissolved oxygen, with significant loadings on U, Br, Cl, Ba, depth, alkalinity, and other constituents. This factor is considered to result from admixture of deep waters, possibly in part connate, residing in the red-beds or leaking into the Catskill from deeper aquifers. The high values suggest that this water is old and has had time to accumulate much He. As shown later, this water is predominantly found in the deeper aquifers and probably participates only very slowly in the near-surface groundwater flow. The loadings on Ba and Sr suggest low sulfate contents in these waters, as does the negative loading on dissolved oxygen, but the waters are apparently not reducing enough to precipitate U or As. The presence of elevated Na, Br, B, and some Cl suggests seawater or similar concentrated waters as a contributory source (Perel'man, 1977). A similar factor loading on Na, Cl, Ba, and similar elements has been detected in well waters from the Catskill in northwestern Pennsylvania (Applin and Langmuir, 1978) and in Cambrian-Ordovician carbonates in southeastern Pennsylvania (McNally, manuscript). The positive loadings in pH and alkalinity indicate the alkaline nature of this water. A distinct loading of U on this factor is of interest, and will be discussed later.

A fourth factor, termed a "Reducing" factor, is strongly negatively loaded on Fe, Mn, and temperature, and positively on dissolved oxygen. This factor is interpreted to result from waters interacting with organic matter in the Catskill and becoming reducing enough to dissolve Fe and Mn oxides. An origin as slightly acid organic-rich swamp water is also possible, judging from the relations in the surface waters, discussed later. Positive loadings on pH and alkalinity suggest that the Fe-and-Mn-bearing water tends to be slightly acid, as expected from Fe and Mn solubility. A weak loading on Al is also consistent with acidity. A distinct loading of U on this factor is also observed, perhaps reflecting release of U adsorbed on Fe-Mn oxides or organic matter. The waters with elevated Fe and Mn and low dissolved oxygen evidently tend to be shallow waters, judging by the opposite loadings of depth vs Fe-Mn.

Factor five is termed a "Brine" factor. Major loadings are Cl, K, Na, Ba, B(negative) and F(positive). This factor has many similarities to factor 3 (deep water), the major difference being the loadings on F, K and He. It is tentatively assigned as an admixture of a second type of deep water, in this case a water rich in K and Cl but low in F and He.

Factor six, designated "Well contamination," has high loadings on Zn, Cu, P, and depth. Studies in southeastern Pennsylvania indicate that many well waters show high Zn values that decrease on pumping, suggesting the Zn is being dissolved from galvanized pipe on standing

(McNally, manuscript). The deeper wells evidently are more affected by this contamination, and some such plumbing systems contain copper pipe. The significance of P on this factor is not understood.

Factors 7, 8, 9 and 10 contain specific groups of elements. Factor 8 is loaded on rare earths (Ce, Dy, Y), with the small-radius rare earths (Dy, Y) having negative loadings and the large-radius rare earths positive. This may reflect dissolution of different mineral sources enriched in light and heavy rare earths. Selenium, As, and P occur together on factor 10, as might be expected for this group of oxyanions. A loading of Mo and U on factor 9 may be of interest in view of the association of these elements with U deposits.

From the preceding discussion it is clear that the waters of this area are a complex mixture of sources and effects. Major effects are related to increasing dissolved solids, incorporation of insoluble traces, mixtures with two types of deep water, dissolution of Fe and Mn by reducing waters, and contamination from pumps, tanks, and pipes. The background values of U vary as a result of most of these factors, as indicated by significant loadings of U on many factors. If the background variability can be removed, we may be able to recognize the anomalies related to ore with more certainty. Also, the associations of elements may allow better understanding of processes affecting various elements, allowing transfer of concepts to other areas.

Relations to conductivity

Correlations of U with total dissolved solids or conductivity have been suggested by many investigators starting with Lopatkina (1964), and have been useful in interpretation of some geochemical surveys. To test the general applicability of this method, plots against conductivity were made for the elements analyzed in the ground waters of the area. Figures 12 to 14 illustrate the range of variations encountered for Ca, Na, U, He, Li, Mo, Ni, Zn, and Zr.

Calcium and Na show good correlations with conductivity, as might be expected in view of the fact that these two elements make major contributions to determining the conductivity. Uranium and Li show significant relations, but both have a tendency toward triangular distributions of values: a main trend related to conductivity and a set of points with high conductivity but low U or Li. This behavior may result from mixing of waters along the main trend with waters of high conductivity but low Li or U, as suggested in the factor analysis by factor 5 for U and factor 3 for Li. The U plot also indicates a few samples of very high U but moderate conductivity that may be associated with mineralization. Plots for Mo, Ni, and Zr show no relation to conductivity; Zn shows a possible weak relation. The plot for He suggests that no relation to conductivity exists for most of the samples, but a separate group of high He samples has high conductivity.

Figure 12. Plots of Ca, Na and U versus Conductivity

Figure 14. Plots of Ni, Zn and Zr versus Conductivity.

Based on these plots, it is clear that ratios like U/conductivity may be helpful in some surveys, but that the true relations are probably much more complex than can be expressed in this simple ratio. For many trace elements, this method is not useful at all in recognizing unusual waters related to ore.

Interpretation of Uranium

The uranium values in groundwater range from not detected (set equal to <0.01 ppb for statistical work) up to 15.6 ppb. The raw data are strongly skewed (Fig. 15), but are nearly normal after a log transformation (Fig. 16). A cumulative frequency plot (Fig. 17) confirms the nearly lognormal frequency distribution but suggests that high values (>5 ppb) are actually slightly deficient relative to the rest of the population. The population may have a slight excess of values between 2 and 5 ppb. In any case, a clear distinction between anomalous and background samples is not evident on this plot.

The areal distribution of U values is shown on Figure 18. Clusters of high U values are scattered through most of the study area, but some of the larger clusters and higher U values are in the vicinity of the known U occurrences. On this basis, the distribution of U in groundwater may be a useful guide to U mineralization, but clearly there is either much more mineralization in the area or many false anomalies.

Spring samples tend to be much more dilute than wells; the springs have a geometric mean conductivity of 40 compared to 84 for the total population. Therefore, Figure 19 was prepared showing only well water. The clusters of U anomalies are somewhat more continuous on this map, though many U anomalies still occur well outside the mineralized area. Most springs have low U (geometric mean of 0.0023 ppb compared to 0.071 ppb for the total data set), and their distribution is so sparse that no mineralized patterns are formed, but two springs in the southern part of the area do have high U values.

The content of U in groundwater is much more understandable if the waters are separated according to aquifer, as shown on Figure 20. This section was prepared by north-south projections of up to about 2.5 mi to an east-west plane approximately through Glen Wild. In view of the very low dip of the sediments in this area and the approximately north-south strike, the relations shown on this section are believed to be valid.

The section shows that high U values in this central east-west strip through the sampled area are largely confined to two aquifer zones, each about 200 ft thick. An upper zone (Zone I) approximately coincides with the known U occurrences. The highest values, in the range 1 to 7 ppb, lie down dip from the known U occurrences. Evidently more rapid circulation of water near the surface has flushed out much of the U in the near-surface part of this zone, leaving only slightly anomalous values in the range 0.5 to 1 ppb. Down the dip, circulation is slower

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.	325	*****
1.	108	*****
2.	17	**
3.	13	**
4.	12	**
5.	7	*
6.	4	*
7.	6	*
8.	0	
9.	1	*
10.	3	*
11.	1	*
12.	0	
13.	0	
14.	0	
15.	0	
16.	1	*

Figure 15. Histogram of the ground water variable U(unlogged).

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-2.0	162	*****
-1.8	0	
-1.6	0	
-1.4	0	
-1.2	0	
-1.0	41	*****
-0.8	0	
-0.6	99	*****
-0.4	41	*****
-0.2	31	*****
0.0	40	*****
0.2	28	*****
0.4	17	****
0.6	23	*****
0.8	10	**
1.0	5	*
1.2	1	*

Figure 16. Histogram of the ground water variable U(logged).

Figure 17. Cumulative frequency plot for U in groundwater, cumulated from high values downward, after Sinclair(1974). Line is fitted by eye to points below $\log(U) = 0.2$.

Figure 19. Map of log U (ppb) in well samples only. Lower limit A=0.0047 ppb, B=0.0101 ppb, C=0.022 ppb, D=0.047 ppb..... Contoured at H=1 ppb and K=10 ppb.

and higher U values are attained.

The lower zone (Zone II) is 200 to 300 ft below Zone I and includes the highest U values of the survey. As shown later, some of the samples in this zone are high in Na and He, suggesting a greater age and possibly some contamination or admixture from deeper connate waters. However, the waters still contain considerable dissolved oxygen, so they are probably predominantly of surface origin. No U occurrences are known in this zone, and it might be thought that the high U values in the water merely reflect slower circulation. However, samples above and below this horizon have very low U values in the range 0.1 to 0.5 ppb. These waters presumably circulate very slowly also, so it is inferred that the rocks of Zone II must contain more U than those above and below. Drilling into this horizon might be of interest in evaluating the uranium potential of the region.

In comparison of the section with the maps of U distribution (Figs. 18 and 19), it can be seen that the distribution of high U values on the maps is dependent on the distribution of wells tapping Zones I and II, and that one could not expect to obtain a uniform coherent anomaly on a map showing different aquifers.

The ratio U/conductivity, discussed previously, may be helpful in interpreting U in natural waters. Figure 21 illustrates the distribution of this variable. The main cluster of high values is centered a short distance northwest of the known U localities, and three of the six known localities occur within the area of high U/conductivity. Only a few multi-sample anomalies occur outside the main central cluster. Judging from the map, the ratio U/conductivity is a useful variable for recognizing mineralized areas. Deletion of springs slightly improves the continuity of anomalies, but not as markedly as for U alone. A plot of U/conductivity on a cross section like Figure 20 does not show a marked improvement from Figure 20.

A step-up regression equation of U against major elements was calculated, and the residual U values were examined. The equation was:

$$\begin{aligned}\log U = & -2.631 + 0.313 \log \text{alkalinity} + 0.286 \log F + 0.591 \log \text{Na(NA)} \\ & + 0.133 \log \text{depth} - 0.978 \log \text{D.O.} + 0.016 \log \text{Al (Supp.)} \\ & - 0.086 \log \text{Fe} + 0.227 \log \text{K} - 0.157 \log \text{Mn} - 0.238 \log \text{Na(Supp)} \\ & - 0.147 \log \text{P} - 0.399 \log \text{Si.}\end{aligned}$$

This equation explains about 58% of the total variance in U values. A map of the residuals is shown in Figure 22. This map does not appear to be any real improvement over the raw U data, and contains many more anomalies outside the mineralized area than the log U/conductivity map.

Figure 21, Map of log (U/conductivity) for ground water samples. B=-4.33, C=-4.0, ... Contoured at I=-2. and M=-0.66. Lower limit A=-4.66,

Figure 22: Map of residuals from regression equation for log U (ppb). Lower limit A=-1.87, B=-1.62, C=-1.37, D=-1.12, ... Contoured at N=1.38 and Q=2.13.

Helium

Helium is formed when the alpha particles released by decay of U and Th capture electrons. Helium can thus be a guide to U deposits. However, He leakage along deep-seated fracture zones or faults can also form He anomalies, as indicated by Ovchinnikov and others (1973). Samples exposed to the open air rapidly equilibrate with the 5.2 ppm He of normal air, which is a common value for samples in the study area.

The distribution of He values in the groundwaters is shown in Figure 23. One of two large clusters of highly anomalous He values coincides with the three more westerly U occurrences, and the other three occurrences lie along a zone to the east in and near a second large cluster of high He values. Only a few smaller clusters of anomalies are present elsewhere in the map area. A plot of He on a cross section (Fig. 24) shows that the highest He values are concentrated in the aquifers with high U, but have a more limited extent, and do not outline Zone I as well as the U values.

The high He values are clearly a very good guide to mineralized horizons in this area, and would definitely be useful in exploration. However, they do not appear to be as useful as the U values in tracing the mineralization (unless the best ore is actually in the western part of Zone II). The circulation rate or age of the water is apparently more important in determining the He values than it is for U values in this area.

Radon

Radon values cover a large range, from 0 pCi/l (picoCuries/liter) to 2500 pCi/l, with a median of about 635 pCi/l. In a study of Rn in ground waters from the Catskill Formation in central and eastern Pennsylvania, Rose and Korner (1979) suggested that a threshold value of 2000 pCi/l was appropriate for redbeds lacking U, based on their data for mineralized areas. On this basis, 81 samples from the Glen Wild survey area are anomalous, or 16% of the samples. This large a proportion of anomalous samples is similar to the mineralized areas of the Catskill in Pennsylvania studied by Rose and Korner (1979) and indicates similar uranium potential in the Glen Wild area.

The map of Rn distribution (Fig. 25) shows clusters of anomalous samples in all parts of the survey area. However, the highest values lie just south of the cluster of mineralized localities, and several large clusters of anomalous values are in this vicinity. A plot of well samples (springs deleted) slightly improves the continuity of anomalies near the mineralized area. A cross-section of Rn values shows that high values tend to occur in Zone II and the down dip part of Zone I, but the values are much more erratic than for U, and do not allow definition of aquifers.

Although Rn does not appear to pinpoint the U mineralization, it does appear to be generally higher in the vicinity of U mineralization.

Figure 23. Map of log He (ppm) in ground waters. Lower limit A=1.8 ppm, B=3.2 ppm, C=5.6 ppm, D=10 ppm,.... Contoured at G=32 ppm and J=320 ppm.

Figure 25. Map of R_n (pci/L) in ground water. Lower limit $A = 0.1$ pci/L, $B = 0.22$ pci/L, $C = 0.47$ pci/L,..... Contoured at $N = 2200$ pci/L and $O = 4700$ pci/L.

Tests of Mineralized Area vs Non-Mineralized Area

The t-tests comparing means for samples within the mineralized area against the rest of the population showed many elements to be anomalous in the mineralized area (Table 13).

As expected, U, He, and Rn show definite concentrations in the mineralized area. The values for U and He are among the highest values found. The scintillometer counts are also significantly higher in the mineralized area.

Variables showing very high t-values (>3.0) include Na, Ba, Li, Sr, and temperature. The factor analysis indicates that most of these elements tend to be high in waters inferred to be of deep origin. A section showing Na values (Fig. 26) demonstrates that some of the waters of Zone II have high Na and are responsible for anomalous Na in the mineralized area. Based on this pattern, the high Na, K, Li, Ba, and Sr, and the low temperature and dissolved oxygen, are attributed to a coincidence of the mineralized area with several clusters of deep wells in the mineralized area.

Another group of elements averaging significantly higher in the mineralized area includes Cu, Zn, and Ni. The highest Cu values tend to cluster in and near the mineralized area (Fig. 27). In view of the fact that Cu occurs with the U mineralization, it appears likely that at least some of the high Cu values occur in and just below the high U values of Zone I (Fig. 28). Zone II does not contain high Cu. To the west, there is no correlation of Cu with U, although several clusters of high values are evident. This pattern suggests that not all U in the area is associated with Cu, and vice versa. Zinc statistically tends to be enriched in the mineralized area, but very few of the highest values are in the area, and there is no clear association of anomalies with the known localities. On a cross-section, no stratigraphic control of high Zn values is evident, but there is some tendency for high values in deep wells. High Zn is considered to result mainly from contamination, and it is certainly not a useful guide to the occurrence of uranium. Nickel probably falls in the same group as Zn, in view of its association with Zn in the factor analysis, but in any case, the t-test for Ni is barely within the 95% significance level.

Reasons for low Mn and high Al and Be in the mineralized area are not apparent, but these elements do not appear to be useful discriminators.

Figure 27. Map of log Cu (ppb) in ground waters. Lower limit A=0.047 ppb, B=0.1 ppb, C=0.22 ppb, D=0.47 ppb,.... Contoured at L=220 ppb and O=2200 ppb.

STREAM WATER

Data Manipulation

Table 5 lists a variety of statistical data for the surface waters. A total of 498 samples were analyzed for 40 elements. Analyses for sample 066 were missing from the neutron activation data but present in the supplemental data. Latitude, longitude, pH, conductivity, alkalinity, temperature, and stream size and discharge data for sample 310 were present in the stream sediment data, and because the sediment and stream water samples were taken at the same site, the data were transferred to the surface water data set where they seemed more applicable. The mean values for each of the missing variables in the three samples mentioned above were used in the factor analysis. This was done since there were no other data reported as missing, and these modifications allowed the use of a complete data matrix.

The data set included samples with variables with values reported as not detected and below detection limit. These values were assigned a concentration of 1.0 ppb and half the detection limit, respectively. For several elements, variables in the supplemental analyses were reported as 0.0 (e.g., Ca, K, Mg, Na, Se, Si). After the initial statistics were calculated (mean, standard deviations, medians, etc.) these values were changed to 0.1 before conversion to logs.

For 22 elements, most values were below detection limits: 498 U(NA), 469 V(NA), 493 Dy(NA), 439 As(Supp.), 477 Ce(Supp.), 467 Cr(Supp.), 402 Nb(Supp.), 453 Sc(Supp.), 446 Se(Supp.), 402 V(Supp.) and over half of the values for Br(NA), Mg(NA), Th, Co, Li, Mo, Ni, P, Ti, Ag, Y, and Zr (all Supp.). All Be values were below detection limits, so Be was excluded from further analysis. All other elements were retained due to the possibility that they might show a relationship with U mineralization or other relations of interest. Obviously the large number of values below detection limits in this data set can have a drastic dilution effect on the percentage of variance explained by the factor analysis (see below).

Non-quantitative data reported for contamination and rock type (all sandstones) were discarded because they could not contribute to statistical analysis of the data set.

As with the groundwater data, five elements were determined by both neutron activation and spectrographic methods: Na, Al, Mg, V, and Mn. The two methods produced a good correlation for Na(0.885) and Mn(0.66). Both sets of data for these two elements were retained. The correlation coefficients for the remaining three elements were Al(0.6), Mg(0.29) and V(0.09) Table 8). Plots of Al(NA) vs Al(Supp.), Mg(NA) vs Mg(Supp.) and V(NA) vs V(Supp.) showed that the neutron activation method was more sensitive and had lower detection limits. The supplemental data for Al, Mg, and V were discarded.

Histograms of all variables were prepared and examined. Figure 29 contains histograms of these variables for which areal plots are present.

EACH * REPRESENTS 5 OBSERVATIONS

A) Factor 1(salinity)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-20.	1	*
-15.	14	***
-10.	47	*****
-5.	135	*****
0.	140	*****
5.	88	*****
10.	43	*****
15.	16	****
20.	9	**
25.	3	*
30.	2	*

EACH * REPRESENTS 2 OBSERVATIONS

B) Factor 2(acidity)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-12.	2	*
-10.	6	***
-8.	23	*****
-6.	35	*****
-4.	37	*****
-2.	81	*****
0.	99	*****
2.	95	*****
4.	78	*****
6.	25	*****
8.	10	*****
10.	6	***
12.	1	*

Figure 29. Histograms of those stream-water variables for which areal plots are presented.

EACH * REPRESENTS 2 OBSERVATIONS C) Factor 5(ore)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-5.	3	**
-4.	23	*****
-3.	51	*****
-2.	70	*****
-1.	83	*****
0.	88	*****
1.	58	*****
2.	54	*****
3.	31	*****
4.	12	*****
5.	10	*****
6.	7	****
7.	3	**
8.	1	*
9.	1	*
10.	2	*
11.	1	*

EACH * REPRESENTS 5 OBSERVATIONS D) log(Cu,ppb)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	104	*****
0.2	0	
0.4	174	*****
0.6	71	*****
0.8	43	*****
1.0	49	*****
1.2	24	*****
1.4	16	****
1.6	15	***
1.8	1	*
2.0	1	*

EACH * REPRESENTS 10 OBSERVATIONS E) log(U,ppb)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-3.0	430	*****
-2.5	1	*
-2.0	0	
-1.5	0	
-1.0	34	****
-0.5	22	***
0.0	2	*
0.5	4	*
1.0	5	*

Figure 29, continued

EACH * REPRESENTS 5 OBSERVATIONS

F) log(Zn,ppb)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.4	21	*****
0.6	35	*****
0.8	57	*****
1.0	147	*****
1.2	117	*****
1.4	81	*****
1.6	28	*****
1.8	6	**
2.0	3	*
2.2	2	*
2.4	1	*

EACH * REPRESENTS 2 OBSERVATIONS

G) log(Cu/conductivity)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-2.4	3	**
-2.2	7	****
-2.0	20	*****
-1.8	29	*****
-1.6	77	*****
-1.4	91	*****
-1.2	88	*****
-1.0	69	*****
-0.8	30	*****
-0.6	32	*****
-0.4	19	*****
-0.2	15	*****
0.0	7	****
0.2	7	****
0.4	2	*
0.6	2	*

EACH * REPRESENTS 2 OBSERVATIONS

H) log(Zn/conductivity)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-1.8	2	*
-1.6	13	*****
-1.4	26	*****
-1.2	30	*****
-1.0	70	*****
-0.8	89	*****
-0.6	82	*****
-0.4	74	*****
-0.2	54	*****
0.0	33	*****
0.2	18	*****
0.4	2	*
0.6	4	**
0.8	1	*

Figure 29. continued

EACH * REPRESENTS 5 OBSERVATIONS

I) log(U/conductivity)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-6.0	1	*
-5.5	15	***
-5.0	170	*****
-4.5	238	*****
-4.0	6	**
-3.5	6	**
-3.0	12	***
-2.5	28	*****
-2.0	13	***
-1.5	1	*
-1.0	5	*
-0.5	3	*

EACH * REPRESENTS 10 OBSERVATIONS

J) log(Mo,ppb)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.3	362	*****
0.4	0	
0.5	2	*
0.6	20	**
0.7	17	**
0.8	41	*****
0.9	18	**
1.0	17	**
1.1	15	**
1.2	1	*
1.3	5	*

Figure 29. continued.

All of the elements have plots distinctly skewed to high values. This was inferred to mean that all of the distributions for the elemental variables were closer to lognormality than normality. Histograms of the logged data showed this to be the case. Conductivity and alkalinity also showed lognormal distributions because they are, in effect, measures of concentration, with alkalinity measuring dominantly the bicarbonate content and conductivity reflecting the total dissolved solids. Temperature, pH, stream width, stream depth, and stream flow were found to have distributions closer to normality. Therefore, all elemental variables, including conductivity and alkalinity, are treated as lognormal populations while all other variables were left unlogged during the subsequent statistical analysis.

Factor Analysis

The results of an R-mode factor analysis of the stream water data are listed in Table 11. The correlation matrix (Table 8) used in this analysis was determined using the 45 variables retained after rock type, contaminants and supplemental data for V, Al, and Mg were discarded. Up to ten factors were extracted for investigation. Using geologic reasonableness and statistical viability, eight factors were determined to furnish the best description of the data. Eigenvalues ranged from 7.64 for factor 1 to 1.24 for factor 8. Only coefficients greater than 0.1 have been included in Table 11. Values greater than 0.4 are highly significant and are underlined. Communalities and percentages of variance tend to be low, partly due to the large number of values not detected and below detection limits in the original data set. It is also a reflection of the complexity of the data. Omission of the 22 variables with more than half of their values either below detection limits or not detected did not significantly change the character of the factors produced. It did, however, greatly improve the percent variance explained by each factor. Therefore the addition of the 22 variables has more of a dilution effect on the final factors and does not appear to lead to misinterpretation. Therefore all 45 variables were left in the final factor matrix.

The first factor has been called a "Dissolved solids" or "Salinity" factor. Most of the major elements (Ca, K, Mg, and Cl) and some trace elements (B, Li, P, and Sr) are heavily loaded on this factor, along with pH, conductivity, and alkalinity. All of the variables are positively loaded. A part of the variability expressed by this factor probably results from water-rock interactions of the type discussed under ground water, and dilution with rainwater may create some low values. However, the major part appears to represent man-made contamination, as evidenced by high factor scores near Monticello and other populated areas (Fig. 30) and by a significant loading of phosphorous on this factor. Detergents and other man-made contaminants are likely sources of high P, and man-made discharges tend to contain elevated contents of other constituents.

Figure 30. Map of Factor I (Salinity) for stream water. A=-17.506, B=-15.516, ..., Z=32.244. Contours at L=4.384, O=10.354 and U=22.294.

The second factor has been called an "Acidity" factor and has a significant negative loading of Al, Ba, Fe, Mn, and Zn. The only highly significant positive loading is pH, though there are weak positive loadings on this factor. The factor appears to result from acid conditions, perhaps organic acids from swampy areas of man-made acid contamination. The enhanced acidity has led to dissolution of Fe-Mn oxides and Al, along with alkalies, alkaline earths and other elements. A map of factor scores for this factor (Fig. 31) shows that most high values occur in areas of numerous lakes and swamps; areas of greater vertical relief, and along the eastern edge and the Neversink River, have mostly low scores. The highest values are near Monticello and may represent acid contamination.

The third factor, "Insoluble traces," is composed of the same elements as factor 2 described earlier for the groundwater. The heavily loaded elements (Th, Ag, Ce, Co, Cr, Nb, V, Y, Zr) have numerous values not detected in the original data set. The few detectable values of these insoluble elements evidently occur together, perhaps suggesting accumulation of colloidal materials or contamination of the sample some time prior to spectrographic analysis.

Factor 4 is a "Stream discharge" factor. Heavy loadings of the stream characteristics (width, depth, level, and flow) on this factor indicate, as one would expect, that as flow increases so does discharge and stream size. The inclusion of stream level suggests that the factor may include short term fluctuations. Silicon and Fe show minor loadings on this factor, suggesting some sort of colloidal or solubility effect that increases Fe and decreases Si during periods of high river discharge. A map of factor scores shows high values along major drainages, such as the Neversink River.

Factor 5 has been called the "ore" factor, although it is evidently more complex than this. Elements with heavy loadings include Cu, Zn, P, and Ti. Significant loadings are also found for Al, B, Fe, K, Li, U, pH, and F. All loadings are positive. The heavy loading of P and Zn may suggest that there is a contaminant component to this factor. The loadings on Cu and U suggest that drainage from mineralized areas contributes to this factor. The K, Li, B, and F loadings may represent an emergence of the two deep waters found in the groundwater study, although one might expect more of an Na loading if this was dominant.

An areal plot of scores for factor 5 shows highs near the Glen Wild mineralized area and to the northeast (Fig. 32). However, the highest values are again near Monticello, perhaps indicating the contaminant aspect of the factor.

Factor 6 is heavily loaded on temperature and Ba (negative) with significant positive loadings on alkalinity, As, Sc, F, and stream width, and negative loadings on Ni, Si, stream level, and flow rate. This relationship suggests a correlation with larger, slowly flowing streams that have become warm and alkaline; the significance of the other variables is not clear. The factor has generally low scores in the area near the U occurrences. This area was sampled during cool, rainy weather.

Figure 31. Map of Factor 2(Acidity) for stream water. A=-11.827, B=-10.727, ..., Z=13.423. Contours at 0=2.313, R=5.343 and U=8.373.

Factors 7 and 8 are heavily loaded on element groups. Scandium, Se, and Ti are heavily loaded on factor 7. Weak negative loadings by Na, Cl, stream width, and stream depth may suggest that the Sc, Se, and Ti concentrations are increased in purer waters. In factor 8, Mo, P, Br(neg.), and Dy(neg.) are heavily loaded. Sodium, F, Cl(neg.), Se, and Li show significant loadings. This Se-Mo factor may indicate some relationship between Se and Mo similar to that found in U deposits elsewhere. The very low percentage of variance explained by factors 7 and 8 (3 to 4%) makes any interpretation tentative.

The factor analysis has produced several very significant interpretations that may be useful in delineating an ore zone in the sample area. Factor 5, the ore factor, shows good correlation with Cu and U. Also, included as a component in factor 5 is a contamination effect that is also incorporated in factor 1. Also helpful as an ore indicator is factor 8, Se-Mo, but the extent to which factor 8 can be applied is in doubt.

Element distributions

As discussed previously, a mineralized area was defined, using Figure 10. Table 14 shows those variables with significant differences at the 95% confidence level between their means within the mineralized area and outside the mineralized area. The mineralized area consists of 52 samples, and the barren area has 446 samples for all variables.

Aluminum, Ba, Ce, Cu, Ni, Ti, Y, Zn, U, Cu/cond., U/cond., log U/log Th, stream depth, stream level, stream flow, and factors 4 and 5 were all significantly higher within the mineralized area. Variables that are lower within the mineralized area are: Factor 1 (dissolved solids), conductivity, alkalinity, pH, As, Ca, Mg, Na, Sc, Si, Cl, stream width, and temperature.

Nearly all the negative differences are major elements and related variables; evidently the dissolved solids of samples from the mineralized area tend to be lower than from other areas. The considerable local relief defined by the Neversink Valley through the middle of the mineralized area is probably a factor in these negative relations, which are therefore not expected to be related to ore in other areas.

High values of both Cu and U are found in the vicinity of Glen Wild (Figs. 33 and 34). The Cu high tends to be east of the U occurrences, but the U anomaly includes all the occurrences. A relatively small number of highs for Cu and U are scattered over the rest of the area, but the number of samples in individual clusters is much smaller than near the known mineralized localities. The Cu and U values thus furnish relatively good guides to the general location of Cu-U occurrences. As previously noted, Factor 5 (the ore factor) shows a high near the mineralized area, as well as highs near Monticello (Fig. 32).

Figure 33. Map of log Cu for stream water. A=0.0(1.0ppb), B=0.088(1.2ppb), ..., Z=2.193(156ppb). Contours: 0=1.232(17ppb) and U=1.76(57.5ppb).

Figure 34. Map of log U in stream water. A=-3.0(0.001 ppb), B=-2.802(0.002 ppb), ..., Z=1.95(89 ppb).
Contours at K=-1.02(0.095 ppb), R=0.366(2.33 ppb) and U=0.960(9 ppb).

High values of Zn are scattered throughout the map area (Fig. 35), including a cluster in the eastern part of the mineralized area. However, the overall distribution of Zn does not appear to be a useful indicator of Cu and U, and many of the high values are likely to be contamination.

The significance of anomalies for Al, Ba, Ce, Ni, Ti, and Y in the mineralized area is not clear.

Since conductivity loads heavily on factor 1 (Table II), it was thought that conductivity might be used to normalize other elements with respect to dissolved solids and contamination effects. Tests for Cu/cond., Zn/cond., and U/cond. were therefore conducted, and maps were plotted (Figs. 36-38). The U/cond. map is very similar to the U map, mainly because U was not detected in the background samples. High values of the ratio remain concentrated near the mineralized localities. On the Cu/cond. and Zn/cond. maps, the distinct highs in the vicinity of Monticello are greatly suppressed. The extensive highs remaining occur near the mineralized area. As with the raw Cu data, the Cu/cond. high is centered to the east of the mineralized localities, but overlaps the three eastern localities. The highs in the mineralized area for Cu are thought to be related to mineralization. Not all of the occurrences have associated Cu minerals, but four of the six do. Therefore, Cu/cond. seems to be a valid and important ore tracer when dealing with surface waters.

The Zn/cond. high also is offset to the east of the localities and forms the central part of a NNE-trending zone of anomalies along the strike of the stratigraphic units. The reason for the remaining Zn highs is not known. There are no known or described Zn occurrences within the Catskill Formation in the immediate area, so either this ratio is defining areas of Zn mineralization or it is showing additional areas of contamination with low conductivity values.

The areal plot for Mo (Fig. 39) is included because it shows highs peripheral to the mineralized area, as does the Mo plot for the stream sediments (Fig. 46).

Summary

The surface water data suggest that there is a large component of contamination (sewage, detergent, etc.), especially in areas of dense population. This factor is largely eliminated by ratioing to the conductivity, which represents the largest and most important variable in the contamination factor.

The presence of a significant ore factor composed of Cu, U, and Zn may be a useful tool for exploration. The Zn component appears to be real and cannot be discarded as due entirely to contamination. Some highs in the ore factor are not intimately associated with the known mineral occurrences, even after conductivity has been accounted for. These may be areas for further exploration.

Figure 35. Map of log Zn in stream water. $A=0.097$ (1.3 ppb), $B=0.199$ (1.6 ppb), ..., $Z=2.65$ (444 ppb). Contours at $L=1.219$ (16.6 ppb) and $R=1.830$ (68 ppb).

Figure 37. Map of $\log(Zn/conductivity)$ in stream water. $A=-1.86, B=-1.71, \dots, Z=1.71$. Contours at $L=-.286$ and $O=.143$.

re 38. Map of log(U/conductivity) in stream water. A=-6.7, B=-6.3, ..., Z=1.7. Contours at M=-2.7 and R=-1.0.

STREAM SEDIMENT

Data Manipulation

Table 6 lists basic descriptive statistics for the neutron activation and supplemental sediment analyses. Of the 498 samples analyzed, no neutron activation data were available for samples 207, 208, 210, 211, 212, 213, and 216, and no supplemental analyses were available for samples 239, 309, 336, 371, 390, 417, 418, 419, and 421. For several variables, large numbers of observations were reported as missing, notably Eu (125), Ti (55), La (49), Sm (55), and Hf (46). Strontium (no values above detection limits) and W (6 values above detection limits) were deleted from the data set, as were the non-quantitative contaminants and vegetation type variables. Rock type was the same (sandstone) at all sample localities. Subsequent statistical analyses revealed that pH, conductivity, alkalinity, and temperature of the water samples collected at the stream sediment sites had little significant effect on the chemistry of the sediments, and so these parameters were not treated together with the sediment data.

For statistical calculations, most of the numerous determinations reported as not detected or "XX" were assigned values of approximately half the detection limit, as shown in Table 6. For a few elements with only a few values not detected (La, extractable U, Ag), the full value of the detection limit was used. If detection limits were not specifically reported in the data, but some samples were below detection, the lowest reported value was used as the detection limit. Thorium, Sc, and Yb were complicated by detected values less than half the detection limits for other samples; the low determinations were left unchanged but "not detected" was still assigned half the given detection limit. Vanadium, Lu, and K had values of 0.0 in a few samples; these were changed to 1.0, 0.1, and 1.0, respectively, before conversion to logs.

Several variables had large numbers of values below detection limits, such as Dy (179), Yb (126), Ag (206), Ca (167), Mo (364), Se (338), Sn (405), and Y (261). These variables were retained in the correlation and factor analyses to determine if the distribution of values above detection limits showed interesting correlations with other elements. Specifically, Mo and Se were retained because they are common elements in sandstone-type U deposits elsewhere. However, the very large number of artificially assigned values and missing values led to uncertainties in the factor analysis described below. The relatively low total variance explained by the seven factors selected is undoubtedly partly a result of this weakness in the data set.

Histograms of the raw and logged data were examined for all variables, and means, medians, and geometric means were compared (Table 6). All of the field variables (sediment size, stream width, stream depth, stream level, vegetation density, relief, and scintillometer readings) have normal-appearing distributions, and these variables were left unlogged during statistical analysis. Most of the element analyses are lognormally distributed, while Na, Sc, Ti,

V, K, Mg, Th, and Al are more nearly normal. Silver, Ca, Mo, Se, Sn and Y have distributions strongly skewed to high values for both the raw and logged data. This is attributed to the large numbers of values reported as below detection limits for these variables. All element data were logged to facilitate statistical treatment and to decrease the importance of a few high values in the lognormally distributed populations. Figure 40 contains histograms of those variables for which areal distributions are presented.

Factor Analysis

The rotated R-mode factor pattern for the sediment samples is shown in Table 12. The correlation matrix from which this pattern was generated is shown in Table 9. Correlations and loadings above about 0.1 are significant at the 95% confidence level, so only these values are listed. Europium, due to the large number of missing values, and Sn, due to many values below detection limits, were excluded from the factor analysis. Eigenvalues for the seven factors extracted range from 6.5 to 1.5; the total variance explained by the rotated factors is about 51%. The large number of missing values and values below detection limits may contribute to the low proportion of explained variance, as does the extensive cover of glacial debris over the bedrock.

Factor 1, with heavy loadings on Na, Ca, K, Li, Mg, and Al, may represent a mica-clay component in the sediments. Vermiculite-like clays are fairly common in sediments in this region (Rose and Suhr, 1971), and they have sufficient adsorption capacity to explain the heavy loadings on trace elements. An alternative explanation is that this factor, which also has strong loadings on P, Cu, Pb, and Zn, represents, in part at least, a human contamination factor. The fact that sediment size does not load significantly on this factor tends to support the alternate explanation, although the accuracy of visual estimates of grain size in the field can also be questioned.

Factors 2 and 3 explain most of the rare earths, U, Th, Hf, Sc, and Ti. These factors probably represent heavy minerals suites. Factor 2, with strong loadings on Th, Ce, Fe, Sc, Yb, and Lu, could represent variability in monazite or similar minerals, although the absence of a P loading is puzzling. This factor explains nearly all of the Fe variance, suggesting that some heavy mineral is the major Fe-bearing mineral in the sediments. Such an explanation is not credible, considering the red-bed (hematite-rich) source rock for much of the sediments, abundance of Fe oxide coatings seen in the field, and the significant Fe content of chlorites found in Catskill rocks of nearby areas (Pirc, 1979). A plot of Ce vs Fe (Fig. 41) demonstrates a strong correlation between the two elements, with distinct clusters at high and low values of each. The correlation coefficient is 0.8059 (Table 9). This relationship suggests that there may be a problem in the neutron activation determination for Fe; perhaps Ce or some other rare earth interferes with Fe analyses, or vice versa, causing Fe and Ce to closely correlate. The Ce-Fe relationship does not show up in

Figure 40. Histograms of those sediment variables for which areal plots are presented.

EACH * REPRESENTS 5 OBSERVATIONS A) mica-clay(factor 1)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-6.	2	*
-5.	0	
-4.	0	
-3.	1	*
-2.	16	****
-1.	59	*****
0.	141	*****
1.	52	*****
2.	9	**

EACH * REPRESENTS 5 OBSERVATIONS B) ore?(factor 4)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-5.	1	*
-4.	1	*
-3.	3	*
-2.	16	****
-1.	43	*****
0.	132	*****
1.	72	*****
2.	11	***
3.	0	
4.	0	
5.	0	
6.	0	
7.	1	*

EACH * REPRESENTS 5 OBSERVATIONS
9 MISSING OBSERVATIONS

C) log(extractable U, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-1.0	16	****
-0.8	0	
-0.6	28	*****
-0.4	128	*****
-0.2	61	*****
0.0	141	*****
0.2	73	*****
0.4	31	*****
0.6	8	**
0.8	3	*

EACH * REPRESENTS 10 OBSERVATIONS
9 MISSING OBSERVATIONS

Figure 40. continued.
D) log(Se, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-1.0	6	*
-0.8	0	
-0.6	0	
-0.4	332	*****
-0.2	0	
0.0	79	*****
0.2	0	
0.4	69	*****
0.6	0	
0.8	1	*
1.0	1	*
1.2	0	
1.4	0	
1.6	1	*

EACH * REPRESENTS 10 OBSERVATIONS
9 MISSING OBSERVATIONS

E) log(Mo, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	365	*****
0.2	0	
0.4	90	*****
0.6	19	**
0.8	1	*
1.0	3	*
1.2	2	*
1.4	4	*
1.6	4	*
1.8	1	*

EACH * REPRESENTS 5 OBSERVATIONS
9 MISSING OBSERVATIONS

F) log(Nb, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.3	93	*****
0.4	0	
0.5	0	
0.6	0	
0.7	119	*****
0.8	0	
0.9	0	
1.0	104	*****
1.1	0	
1.2	127	*****
1.3	26	*****
1.4	17	****
1.5	2	*
1.6	1	*

Figure 40. continued.

EACH * REPRESENTS 10 OBSERVATIONS
8 MISSING OBSERVATIONS

G) log(V, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	6	*
0.2	0	
0.4	0	
0.6	1	*
0.8	0	
1.0	14	**
1.2	0	
1.4	280	*****
1.6	171	*****
1.8	16	**
2.0	2	*

EACH * REPRESENTS 5 OBSERVATIONS
9 MISSING OBSERVATIONS

H) log(Cu, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.0	20	****
0.2	0	
0.4	84	*****
0.6	158	*****
0.8	126	*****
1.0	69	*****
1.2	21	*****
1.4	7	**
1.6	2	*
1.8	1	*
2.0	1	*

EACH * REPRESENTS 5 OBSERVATIONS
9 MISSING OBSERVATIONS

I) log (Zn, ppm)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
0.6	12	***
0.8	3	*
1.0	9	**
1.2	12	***
1.4	47	*****
1.6	142	*****
1.8	152	*****
2.0	77	*****
2.2	22	*****
2.4	11	***
2.6	1	*
2.8	1	*

EACH * REPRESENTS 2 OBSERVATIONS
9 MISSING OBSERVATIONS

Figure 40. continued.
J) log(extractable U/Zn)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-3.0	3	**
-2.8	5	***
-2.6	13	*****
-2.4	27	*****
-2.2	61	*****
-2.0	95	*****
-1.8	100	*****
-1.6	99	*****
-1.4	53	*****
-1.2	20	*****
-1.0	6	***
-0.8	2	*
-0.6	4	**
-0.4	1	*

EACH * REPRESENTS 5 OBSERVATIONS
9 MISSING OBSERVATIONS

K) log(Co/Zn)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-1.6	8	**
-1.4	12	***
-1.2	46	*****
-1.0	121	*****
-0.8	195	*****
-0.6	82	*****
-0.4	23	*****
-0.2	1	*
0.0	0	
0.2	1	*

EACH * REPRESENTS 5 OBSERVATIONS
24 MISSING OBSERVATIONS

L) log(U/Th)

MIDDLE OF INTERVAL	NUMBER OF OBSERVATIONS	
-0.8	1	*
-0.7	4	*
-0.6	49	*****
-0.5	143	*****
-0.4	148	*****
-0.3	59	*****
-0.2	24	*****
-0.1	7	**
0.0	1	*
0.1	1	*
0.2	3	*
0.3	7	**
0.4	9	**
0.5	7	**
0.6	9	**
0.7	2	*

Figure 41. Plot of $\log(\text{Ce})$ vs $\log(\text{Fe})$ - sediments.

the stream water and groundwater data, where these elements were analyzed by emission spectroscopy. Factor 3, on which U, Th, Hf, and Ti are strongly loaded, is probably a zircon and rutile factor. It is possible that factors 2 and 3 represent the same process (heavy mineral enrichment) and that the splitting into two factors is due to the questionable Ce-Fe relationship.

Factor 4 may represent an ore factor, since it is heavily loaded on extractable U, Co, Cu, Ni, Mo, and Se, all common elements in uranium ore. Curiously, Mo and Se load oppositely to the other elements in this factor. This relationship will be discussed in more detail below. The negative loading on scintillometer counts is surprising. However, ground scintillometer readings are strongly influenced by soil thickness, relief, etc., and are thus unreliable.

Factors 4 and 7 simply reflect the interdependence of stream width, depth, and level (factor 5) and of relief with the sediment size and stream size characteristics (factor 7). No elements load very heavily on these factors.

Factor 6 appears to represent a Mn oxide factor. Manganese and most of the transition elements load rather strongly, and this is the only factor (other than factor 2) which has a significant Fe loading. The amorphous Mn-Fe hydroxides found as grain coatings in most streams are common concentrators of trace elements.

Factor Scores

Factor scores were calculated from the rotated sediment factor pattern, and their areal distributions examined. Factors 2, 3, 6, and 7 do not show any areal consistency. Factor 5, the stream size factor, shows a distinct N-S-trending high in the central portion of the sample area. This probably reflects the unavoidable sampling of major tributaries of the Neversink River.

Figure 42 is an areal plot of factor 1, the mica-clay (?) factor. There is a distinct N-S trending high in the west-central portion of the sample area. This high may correlate with a stratigraphic unit or type of glacial deposit, but the precise cause is not clear.

Factor 4, the ore (?) factor is plotted in Figure 43. There is a high area in the vicinity of the deposits, but the eastern portion of the map area contains most of the high values. This factor is not significantly higher (MINITAB t-test, 95% confidence level) in the mineralized zone (Fig. 10) than in the remainder of the area.

Figure 42. Map of scores for factor 1(mice-clay?) of sediment factor analysis. A=1, B=2, C=3,..., Z=26. Contoured at R=17.

Figure 43. Map of scores for factor 4(ore?) of sediment factor analysis. A=1, B=2, C=3,...., Z=26. Contoured at M=13.

Element distribution

Table 15 lists all those variables and ratios which are significantly higher or lower in the mineralized zone at the 95% confidence level. Elements enriched in sediments of the mineralized zone are U, extractable U, Nb, Mg, Pb, K, Ca, V, and Y; the only element depleted is Se. Stream depth and level are higher in the mineralized zone, and stream width and vegetation density are lower.

The map of extractable U shows a broad irregular high in the mineralized zone, extending to the north and west, and another extensive high in the western part of the area (Fig. 44). The values of extractable U thus seem to be of some aid in detecting the mineralized area, though other zones are equally anomalous. In contrast, a map of total U has high values scattered over the entire map area, and although a four-sample cluster of high values occurs in the western part of the mineralized area, total U in stream sediment does not appear at all useful in recognizing the mineralized area.

Selenium shows the same opposite relation to extractable uranium as was indicated by the factor results for the ore (?) factor. The mineralized zone is marked by a broad area of Se values below detection limits, but high values surround the mineralized area on the west, south, and possibly east (Fig. 45). Molybdenum shows a similar pattern of highs in the area outside the mineralized zone (Fig. 46). In view of the fact that Mo and Se commonly accompany U in sandstone-type uranium deposits, these patterns seem of potential interest. Perhaps the Mo and Se have been dispersed away from the uranium occurrences either during the original formation of the deposits or during recent weathering.

Niobium, loaded positively on the ore(?) factor, has a well-defined high corresponding to the mineralized zone (Fig. 47). Vanadium shows a cluster of highs in the mineralized zone, although it is negatively loaded on the ore factor (Fig. 48). A plot of scintillometer readings taken at each site shows a small high in the mineralized zone and a broad high in the western portion of the sample area.

Copper and Zn (Figs. 49 and 50) both exhibit fairly continuous NNE-trending belts of high values passing through the Monticello area and corresponding roughly with high values for factor 1 (mica-clay?, Fig. 42). These highs appear to be stratigraphically controlled and may represent an interval of abundant shaly units in the Walton Formation (Figures 2 and 3). Since zinc is a fairly abundant element which is strongly adsorbed on clays, it was felt that taking ratios of metals to Zn might remove any effect of shale content of the underlying rocks in the sample area. Since Zn is also a common contaminant in geochemical samples, these ratios would also account for contamination. Areal plots of extractable U/Zn and Co/Zn (Figs. 51 and 52) both show broad belts of discontinuous highs passing through the mineralized zone and having a trend roughly parallel to the regional strike of the underlying rocks (about N30°E). Thus, ratios over Zn may be useful in enhancing anomalies in this area.

Figure 44. Map of log(extractable U) in sediments. $A=-1.4(0.04\text{ppm})$, $B=-1.3(0.05\text{ppm})$, $\dots, Z=1.1(12.59\text{ppm})$. Contours at $P=0.1(1.26\text{ppm})$ and $T=0.5(3.16\text{ppm})$.

Figure 45. Map of $\log(\text{Se})$ in sediments. $A=-1.375(.042\text{ppm})$, $B=-1.250(0.056\text{ppm})$, ..., $Z=1.75(56.2\text{ppm})$. Contours at $K=0.125(.882\text{ppm})$ and $P=0.50(3.16\text{ppm})$.

Figure 46. Map of log(Mo) in sediments. A=-.857(.139ppm), B=-.714(.193ppm), ..., Z=2.714(518ppm).
Contours at I=.286(1.93ppm) and L=.714(5.18ppm).

ure 47. Map of $\log(Nb)$ in sediments. A=1.1(1.26ppm), B=2(1.58ppm), ..., Z=2.6(398ppm). Contoured at M=1.3(20ppm).

ure 51. Map of Log(extractable U/Zn) in sediments. A=-3.36, B=-3.21, ..., Z=.214. Contoured at P=-1.21.

Since U and Th are strongly concentrated in zircon and other resistant heavy minerals, the ratio U/Th should reflect the portion of total U in a sample that is concentrated in these minerals and is thus economically uninteresting. A plot of U vs Th (Fig. 53) indeed shows that most of the U values are directly related to Th values, but that there are a few samples anomalously high in total U. Uranium vs Hf (abundant in zircon) shows a similar relationship (Fig. 54). However, U/Th vs extractable U (Fig. 55) shows no clear correlation, and an areal plot of U/Th (Fig. 56) is distinctly different from that of extractable U, and does not define the mineralized area. It is possible that some other mineral besides zircon has concentrated U in this area, but the lack of a significant U/Th anomaly in the mineralized zone suggests that U/Th is not a useful parameter in this area.

Summary

Factor analysis leads to at least two interesting factors, clay and/or contaminants and an apparent ore factor, which are generally supported by the element distributions. Extractable U, Mo, Se, V, and Nb appear to have successfully delineated the mineralized zone. The negative relationship between Se-Mo and extractable U should be further investigated using analytical methods with lower detection limits. The ratios extractable U/Zn and Co/Zn appear to have delineated anomalous stratigraphic horizons in the sample area, and this relationship also merits further investigation.

CONCLUSIONS

In assessing the results of this study, it must be remembered that the uranium localities in the Glen Wild area are small and non-economic, as far as is known at present. An economic deposit, if exposed to weathering, would be expected to furnish much stronger anomalies than those found in this study, but presumably the same elements and interpretation methods would be useful. The results must, therefore, be considered as a guide to planning and interpretation rather than a basis for quantitative decision making.

Figure 53. Plot of log(U) vs log(Th) - sediments.

Figure 54. Plot of $\log(U)$ vs $\log(Hf)$ - sediments.

Figure 55. Plot of $\log(U/Th)$ vs $\log(\text{extractable } U)$ - sediments.

Figure 56. Map of $\log(U/Th)$ in sediments. $A=-1.857, B=-1.714, \dots, Z=1.714$. Contours at $L=-.286$ and $O=.143$.

Of the methods discussed, it appears that analysis of rock samples collected to represent a stratigraphic section is one of the more effective methods of recognizing localities like Glen Wild. The rock samples from the good exposures along Rte. 17 clearly show anomalous scatter and uranium values higher than normal in the part of the section containing the uranium occurrences. Similar results were obtained by Pirc (1979) and Rose and others (1980) for Catskill sediments near the Jim Thorpe uranium occurrences in northeastern Pennsylvania. The lateral extent of such anomalies in rock is not clear, but the high variability and enhanced uranium were not present in samples from 20 to 70 miles southwest of the Jim Thorpe locality. Nevertheless, several tens to over a hundred samples may be required in a single stratigraphic section to reliably locate the mineralized horizons. Fortunately, gamma-ray spectral analysis of bulk rock samples is both rapid and inexpensive and requires no sample pretreatment.

The groundwater samples seem to furnish the most distinctive anomalies in the Glen Wild area, but it is clear that they must be classified by aquifer in order to really recognize the significance of the high values. Uranium in groundwater gives the best definition of the mineralized horizons, and He shows a very useful anomaly, especially in samples from the deeper aquifers. The ratio U/conductivity slightly improves definition of the anomaly near Glen Wild. Copper and radon in groundwater show patterns clearly related to the known localities. The presence of a significant proportion of values greater than 2000 pCi/l Rn defines the Glen Wild area as anomalous, as it did in numerous similarly mineralized areas in northeastern Pennsylvania studied by Rose and Korner (1979).

In stream water, U and Cu both tend to be high near the Glen Wild occurrences, as does an ore factor composed of Cu, Zn, P, Ti and a group of other elements, including U. Ratios of U, Cu and Zn to conductivity improve definition of the anomalies related to U occurrences, at least partly because these ratios remove the effects of polluted waters.

In stream sediment, extractable U, Cu, Nb, and V furnish anomalies near the Glen Wild localities, but the reason for the Nb and V anomalies is not clear. Selenium and Mo are high in areas peripheral to the localities, and may be of some significance. An ore factor composed of extractable U, Cu, Co, Ni, (-)Mo, and (-)Se also showed high values in the mineralized area, as well as in other localities. Ratios of extractable U and Co to Zn improved the definition of anomalies for these elements, probably by taking into account contamination or variations in clay abundance or both. Total U and U/Th were not found to furnish useful patterns.

The reconnaissance use of these guides can be partly evaluated by comparison with the regional reconnaissance survey of the Scranton quadrangle, which includes the Glen Wild area (Ferguson and Jones, 1978). Comparison with this set of data shows that many areas with equal or higher contents of the various pathfinders are scattered over the large area of Catskill in the Scranton quadrangle. The Glen Wild area was not

clearly detected by any of the parameters measured in the Scranton survey (though it should be noted that He, Rn, extractable U, and the supplemental water analyses were not included in that survey). One must conclude, then, that many areas in the region are as well mineralized as the Glen Wild area, and/or that the resolution and reproducibility of the reconnaissance survey are not good enough to detect mineralized areas like Glen Wild. In view of the small size of the known localities at Glen Wild, this may not be a serious defect, although the two zones of high U in ground water found in this survey are suggested areas for further investigation.

The results of this survey are clearly applicable during the followup and detailed stages of exploration for uranium deposits in sedimentary rocks. The groundwater results seem to allow a good definition of mineralized horizons. The near-surface ground waters are found to be distinctly depleted in U, He, Rn, and other components compared to deeper horizons, but some useful patterns are detected at all levels. A careful evaluation of sources of water and aquifers tapped is of key importance in evaluating the groundwater data.

BIBLIOGRAPHY

- Adams, J.A.S., Richardson, J.E., and Templeton, C.C., 1958, The determination of thorium and uranium in sedimentary rocks by two independent methods: *Geochim. Cosmochim. Acta*, V. 13, p. 270-279.
- Allen, J., 1976, Development of a portable radon detector system: U.S. Department of Energy Open File Report GJBX-50(76), 47 pp.
- Allen, J.R.L., and Friend, P.F., 1968, Deposition of the Catskill facies, Appalachian regions: With notes on some other Old Red Sandstone Basins: Geological Society of America Special Paper 106, p. 21-74.
- Applin, K.R., and Langmuir, D., 1978, Ground water geochemistry as a prospective tool for uranium deposits in Pennsylvania: U.S. Department of Energy Open File Report GJBX-132(78), 145 pp.
- Ayrton, W.G., 1963, Isopach and lithofacies map of the Upper Devonian of northeastern United States: Pennsylvania Geological Survey General Report G 39, p. 3-6.
- Baillieul, T.A., and Indelicato, G.J., 1978, Uranium in the Glen Wild area, Woodridge, New York, 7.5-minute quadrangle: U. S. Department of Energy Open File Report GJBX-46(78), 15 pp.
- Barrell, J., 1913, The Upper Devonian delta of the Appalachian geosyncline: Part I. The delta and its relations to the interior seas: *American Journal of Science*, 4th Series, v. 36, p. 429-472.
- _____, 1914, The Upper Devonian delta of the Appalachian geosyncline: Part II. Factors controlling the present limits of strata: *American Journal of Science*, 4th Series, v. 37, p. 87-109.
- Burtner, R.L., 1963, Sediment dispersal patterns within the Catskill facies of southeastern New York and northeastern Pennsylvania: Pennsylvania Geological Survey, 4th Series, Bulletin G-39, p. 7-24.
- Cagle, G.W., 1977, The Oak Ridge analytical program: U. S. Department of Energy Open File Report GJBX-77(77), p. 146.
- Chadwick, C.H., 1931, The Catskill Formation: Geological Society of America Bulletin., v. 42, p. 242-243.
- Chadwick, G.H., 1936, The name 'Catskill' in geology: New York State Museum Bulletin, no. 307, 116 pp.
- Epstein, J.B., Sevon, W.D., and Glaeser, J.D., 1974, Geology and mineral resources of the Lehigh and Palmerton quadrangles, Carbon and Northampton Counties, Pennsylvania: Pennsylvania Geological Survey, 4th Series, Atlas 195 cd, 460 pp.

- Eremeev, et al., 1973, Application of helium surveying to structural mapping and prospecting for ore deposits: in Geochemical Exploration 1972, Institution of Mining and Metallurgy, London, p. 183-192.
- Ferguson, R.B., and Jones, P.L., 1978, Scranton 1° x 2° NTMS area, New Jersey, New York, and Pennsylvania; Preliminary basic data report: U.S. Department of Energy Open File Report GJBX-2(79), 52 pp. + appendices.
- Fletcher, F.W., 1963, Regional stratigraphy of Middle and Upper Devonian non-marine rocks in southeastern New York: Pennsylvania Geological Survey, 4th Series, Bulletin G039, p. 25-42.
- _____, 1967, Middle and Upper Devonian clastics of the Catskill Front, New York, p. C1-C23: in Waines, R.H., ed., New York State Geological Association 39th Annual Meeting Guidebook.
- Humphreys, M., and Friedman, G., 1975, Late Devonian Catskill Deltaic complex in northcentral Pennsylvania; in Broussard, M.L., ed., Deltas: Models for exploration: Houston Geological Society, p. 369-379.
- Jones, P.L., 1979, Dyersburg 1° x 2° NTMS area, Kentucky, Missouri, Tennessee, and Illinois: U.S. Department of Energy Open File Report GJBX-58(79), Appendix D, p. D-9 to D-26.
- Korner, L.A., and Rose, A.W., 1977, Radon in streams and groundwaters of Pennsylvania as a guide to uranium deposits: U.S. Energy Research and Development Administration Open File Report GJBX-60(77), 152 pp.
- Krynine, P.D., 1940, Appalachian orogeny and sedimentation (abs.): Geological Society of America Bulletin, v. 51, p. 1999.
- _____, 1941, Differentiation of sediments during the life history of a landmass (ads.): Geological Society of America Bulletin, v. 52 p. 1915.
- Lopatkina, A.P., 1964, Characteristics of migration of uranium in the natural waters of humid regions and their use in the determination of the geochemical background for uranium: Geochemistry International, p. 788-795.
- Lucier, W.A., 1966, The petrology of the Middle and Upper Devonian Kiskatom and Kaaterskill sandstones: a vertical profile: unpublished Ph.D. thesis, University of Rochester, New York.
- McCauley, J.F., 1961, Uranium in Pennsylvania: Pennsylvania Geological Survey Bulletin, M-43, 77 pp.
- McNally, J., ms, Draft of M.S. thesis on groundwater geochemistry, Pennsylvania State University.
- Mencher, E., 1939, Catskill facies of New York State: Geological Society of America Bulletin, v. 50, p. 1761-1794.

- Ovchinnikov, L.M., et al., 1973, Gaseous geochemical methods in structural mapping and prospecting for ore deposits: in Geochemical Exploration 1972, The Institution of Mining and Metallurgy, London, p. 177-182.
- Perel'man, A.I., 1977, Geochemistry of elements in the supergene zone: Keter Publishing, Jerusalem, 266 pp.
- Pirc, S., 1979, Uranium and other elements in the Catskill Formation of east-central Pennsylvania: unpub. Ph.D. thesis, Pennsylvania State University, 300 pp.
- Price, V., and Jones, P.L., 1979, Training manual for water and sediment geochemical reconnaissance: U.S. Department of Energy Open File Report GJBX-420(81), 104 pp.
- Rahmanian, V.D.Kh., 1979, Stratigraphy and sedimentology of the upper Devonian Catskill and uppermost Trimmers Rock Formation in central Pennsylvania: unpub. Ph.D. thesis, Pennsylvania State University, 300 pp.
- Rose, A.W., 1976, The effect of cuprous chloride complexes in the origin of red-bed copper and related deposits: Economic Geology, v. 71, p. 1036-1048.
- Rose, A.W., and Korner, L.A., 1979, Radon in natural waters as a guide to uranium deposits in Pennsylvania: in Geochemical Exploration 1978, Association of Exploration Geochemists, Rexdale, Ontario, p. 65-76.
- Rose, A.W., Pirc, S., Tole, M.P., Bell, C.A., Keith, M.L., and Pilione, L.J., 1980, Regional and local anomalies of uranium and thorium in rocks near sandstone-type uranium deposits in Pennsylvania and Colorado: U.S. Department of Energy Open File Report GJBX-126(80), 208 pp.
- Rose, A.W., and Suhr, N.H., 1971, Major element content as a means of allowing for background variation in stream sediment geochemistry: in Geochemical Exploration, Canadian Institute of Mining and Metallurgy, Spec. Vol. 11, p. 587-593.
- Sevon, W.D., Rose, A.W., Smith, R.C., and Hoff, D.T., 1978, Uranium in Carbon, Lycoming, Sullivan, and Columbia counties, Pennsylvania: Guidebook, 43rd Annual Field Conference of Pennsylvania Geologists (Pennsylvania Geological Survey), Harrisburg, 99 pp.
- Sinclair, A.J., 1974, Selection of thresholds in geochemical data using probability graphs: Journal of Geochemical Exploration, v. 3, p. 129-149.
- Smith, A.T., 1980, Stratigraphic and sedimentologic controls for copper and uranium in red-beds of the upper Devonian Catskill Formation in Pennsylvania: unpub. Master's thesis, The Pennsylvania State University, 215 pp.
- Walker, R.B., and Harms, J.C., 1971, The 'Catskill delta', a prograding muddy shoreline in central Pennsylvania: Journal of Geology, v. 79, p. 381).

Way, J.H., Jr., 1972, A more detailed discussion of the depositional environmental analysis Middle and Upper Devonian sedimentary rocks, Catskill Mountain Area, New York: unpub. Ph.D. thesis, Rensselaer Polytechnic Institute, 147 pp.

Willard, B., 1939, The Devonian of Pennsylvania: Pennsylvania Geological Survey, 4th Series, General Report 19, 481 pp.