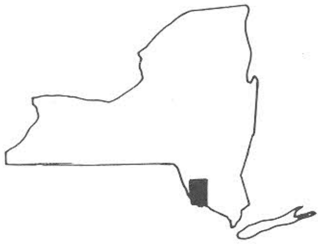

Geochemical Reconnaissance of Surficial Materials in the Vicinity of Shawangunk Mountain, New York

R. Lynn Moxham

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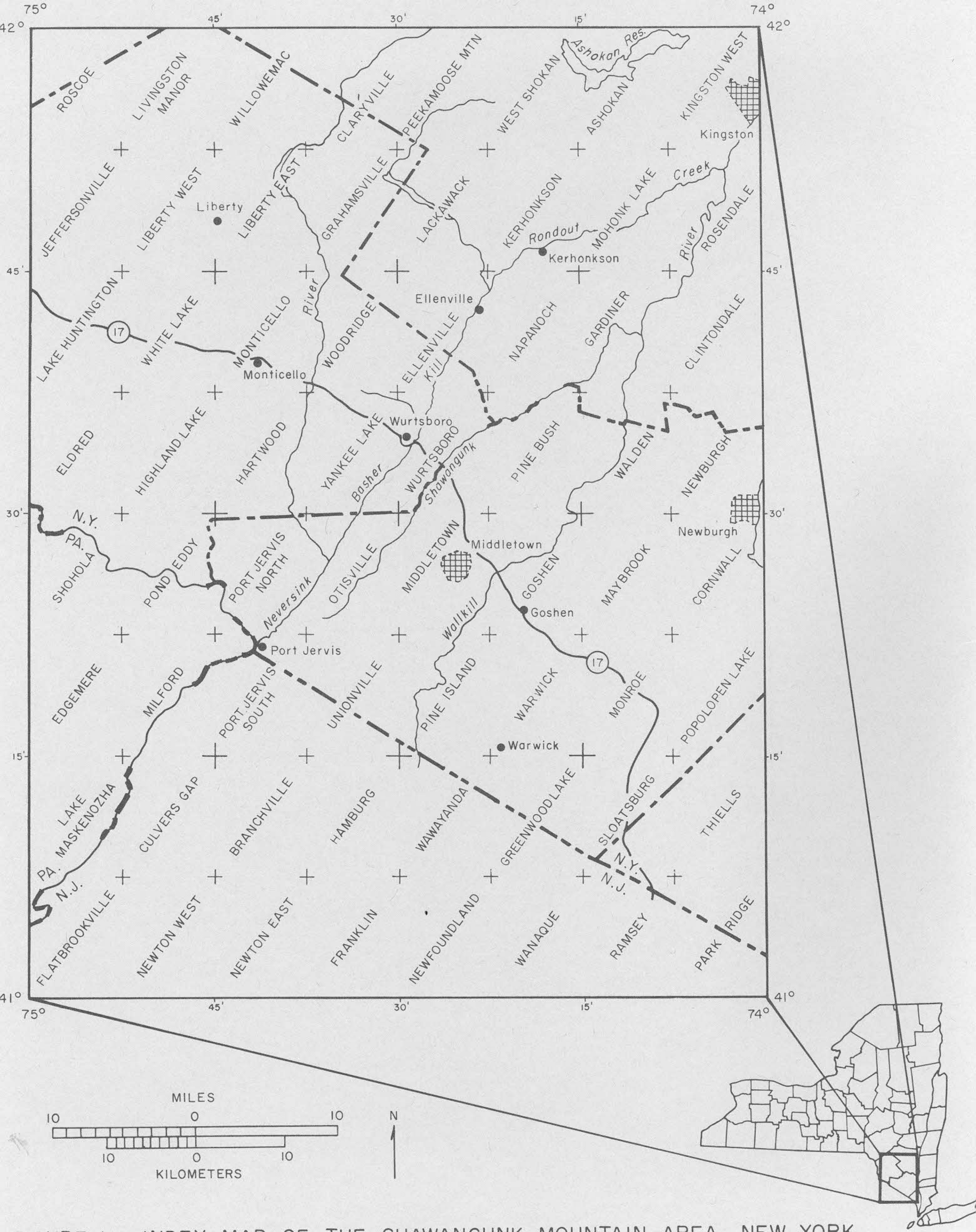

FIGURE I. INDEX MAP OF THE SHAWANGUNK MOUNTAIN AREA, NEW YORK

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Geochemical Reconnaissance of Surficial Materials in the Vicinity of Shawangunk Mountain, New York[1]

by R. Lynn Moxham[2]

ABSTRACT

A reconnaissance survey of stream waters, stream sediments, and soils in the vicinity of Shawangunk Mountain, Ulster, Orange, and Sullivan Counties, New York, was made for combined heavy metals (copper, lead, zinc) using dithizone field methods and other supporting laboratory techniques.

A number of anomalous areas are defined by the drainage system. High concentrations were observed in the vicinity of the old lead-zinc mines and prospects that have been long known in the valley, and a number of new anomalies, or extensions of the previously recognized areas of mineralization, were observed. These are discussed and located on the accompanying maps. Soil surveys on the valley floor showed some anomalous profiles, but difficulty in reproducing the data led to abandonment of this approach.

Waters in a few small streams in the vicinities of Wurtsboro and Otisville contain potentially toxic concentrations of lead; surface and ground waters in these areas should be analyzed before use as a water supply.

[1] Manuscript submitted for publication August 22, 1972.

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Introduction

At least as early as 1820, settlers in the Rondout Valley of south-central New York were aware of the existence in Shawangunk Mountain of mineral deposits that were exploitable as sources of lead and zinc, making these occurrences among the earliest mines worked in this country. Local tradition holds that the deposits were worked by the Indians as a source of lead for bullets in colonial times. Whether or not this is fact, Mather (1843, p. 358) records that a mine was opened at Ellenville in 1820, and that a mine, later known as the Shawangunk Mine, was opened at Wurtsboro and operated from 1830 to 1840. From that time forward, these and other occurrences — notably the Guymard Mine near Guymard, the Washington Mine near Otisville, and the Ulster Mine above Spring Glen — were operated sporadically until about 1917. Their heyday seems to have been around the time of the Civil War.

Another occurrence of extensive lead-zinc mineralization was found during the excavation of the Delaware Aqueduct Tunnel near Wawarsing, New York in 1941 (Fluhr, 1953). All these deposits occur as fracture-fillings of sphalerite, galena, and quartz in the Shawangunk Quartzite, which forms the east wall of the valley.

In a program of investigation of mineral deposits of critical and essential minerals, the United States Bureau of Mines in 1948 examined the old Shawangunk Mine and found sufficient evidence to justify an intensive study of this deposit. Subsequently 24 surface and underground drill holes were cored, and the workings were intensively sampled with a view to delineating and extending the deposit. This work is described in detail by the supervising engineer, N. A. Eilertson, (1950).

For a more complete review of the history of the deposits, the reader is referred to Mather (1843), Newland (1921), Eilertson (1950), and Gray (1960).

The deposits are of interest to geologists as representative of the "Appalachian type" of lead-zinc deposit, but occurring in uncommon geological surroundings. According to Gray (1960) and others, the principal criteria of the Appalachian lead-zinc deposits are:

1) occurrence in sedimentary rocks, usually carbonate rocks;
2) simple paragenesis and mineralogy;
3) occurrence of the ore as fracture- and breccia-filling, plus some replacement;
4) strong structural and stratigraphic control on ore emplacement.

In Shawangunk Mountain, which forms the east rampart of the valley throughout from Port Jervis to Kerhonkson, the deposits show these characteristics, with the exception that the ores occur in quartzite, rather than in carbonate rocks.

Shawangunk Mountain consists of a westward-dipping monocline of quartzite, conglomerate, and lesser shale. Tunnel data, outcrop occurrences, and geological extrapolation from areas north and south of the valley indicate that this quartzite slab is overlain by younger shales and carbonate rocks of considerable thickness, which form the bedrock valley floor. On the west valley wall, this sequence is overlain by younger, shallower-dipping beds of marine and fluvial clastic sediments, presumably more resistant to weathering than the carbonates and shales of the valley floor.

The valley floor is thickly mantled by overburden. A useful method of exploration in areas showing the types of mineralization shown in Shawangunk Mountain has been the use of stream water and stream sediment as geochemical indicators. The concentrations of the so-called "heavy metals" — copper, lead, and zinc — measurable in the waters and muds of the surficial drainage system can serve to delineate areas of prime interest very readily. Moreover, should the ground or surface waters pass over bedrock containing significant amounts of the metals concerned (Pb and Zn) it would be of interest to public health and agriculture to know the concentration levels that were attained in waters used in human and animal consumption, and in soils in which forage and market crops are raised. The epidemiology of Pb and Zn, while incompletely known, indicates that while a certain level of Zn appears to be necessary in mammals, Pb can reach toxic levels quite readily, depending on the consuming mammal and on the food-chain path by which it reaches the consuming mammal. Hence it is desirable to be aware of the levels attained by these metals in the natural environment.

Accordingly, in the summer of 1967 the Geological Survey initiated a field program in the Rondous-Neversink valley, to sample and analyze stream waters, stream sediments, and soils of the valley for Pb, Zn, and Cu. The field area is shown in Figure 1.

The field methods consisted of field colorimetric determinations of total (Pb, Zn, and Cu) heavy metals using the dithiocarbazone method. These tests, applied to stream waters and stream sediments, were monitored by atomic absorption spectroscopy. Soil samples were taken in the field on selected profiles across the valley.

The field test results for stream waters are compiled on Plate 1. Results of stream sediment tests are compiled on Plate 2.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the field work of Stephen J. Kowall, who was responsible in large part for the field chemical determinations, and to Paul J. Westbrook who ably assisted in the field and laboratory. Valuable advice and data on the hydrology of the valley's surface and ground waters and surficial deposits were provided by Michael J. Frimpter and Paul Plummer of the Water Resources Branch of the United States Geological Survey.

We are indebted to the staff of the Department of Earth and Atmospheric Sciences of the State University of New York at Albany, in particular George W. Putman, for the use of the facilities of the Department's geochemical laboratories for the atomic absorption analytical work, and to Mrs. Mary E. Bartiett, Department technician, for her help and guidance in the course of that work.

LOCATION

The area examined in the survey consisted of the linear valley belt extending in a northeast-southwest direction from the vicinity of Kerhonkson, New York to the confluence of the Neversink and Delaware Rivers at Port Jervis, New York. This belt is 35 miles long and varies in width, depending on local topographic and geologic control.

Some field tests were made on the Wallkill drainage to the east of Shawangunk Mountain in the nature of background control, and some were made similarly in the drainage in the hills on west side of the valley. The survey extended a short distance south of Port Jervis into neighboring streams in New Jersey and Pennsylvania.

The area of examination is shown on the index map (Figure 1) as delineated by sampling points used in the survey. The names of, and the outlines of the pertinent topographic quadrangle maps are shown for reference.

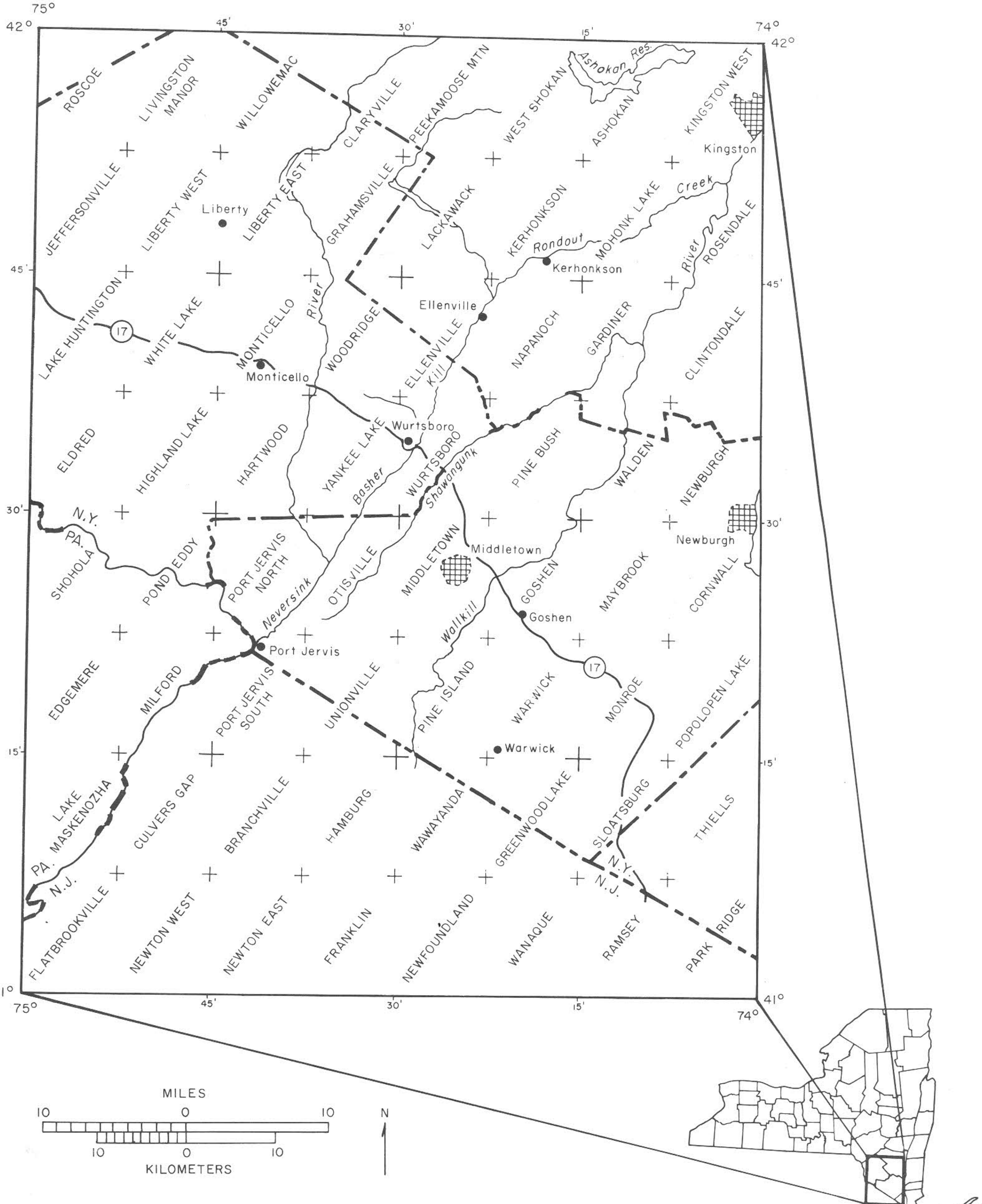

FIGURE I. INDEX MAP OF THE SHAWANGUNK MOUNTAIN AREA, NEW YORK

Topography

The topography of the region is dominated by the prominent linear ridge of Shawangunk Mountain, which forms a narrow monocline whose ridge is at approximately 1,300 feet above sea level (ASL) from Port Jervis to Ellenville, and which has a width of about 2 miles throughout this distance. In the vicinity of Ellenville, the ridge becomes higher, and at the same time broader, so that east of Ellenville it achieves an elevation of almost 2,300 feet and is about 6 miles wide. Northeast and east of Ellenville, from that town to the vicinity of Kerhonkson, Accord and Minnewaska, the mountain bends eastward, and becomes a series of prominent valleys and ridges, which diminish and eventually die out in the Rosendale vicinity. The mountain is the outcrop expression of the Shawangunk Quartzite.

East of the mountain ridge is the broad, rolling valley of the Wallkill, which lies generally between 400 and 700 feet ASL.

Immediately west of the ridge is the well-defined valley feature along which US Route 209 is the principal thoroughfare, passing through the towns of Port Jervis, Wurtsboro, Ellenville, Kerhonkson and ending at Kingston. This valley drains in two directions — to the Hudson River, and to the Delaware River. Northeastward from Phillipsport, surface waters drain to the Hudson via Sandburg and Rondout Creeks. Southwestward from Phillipsport, drainage is to the Delaware Basin via Basher Kill and the Neversink River, which joins the Delaware at Port Jervis.

Hydrology and Surficial Deposits

The hydrologic system of the Rondout-Neversink Valley is governed by the nature of its surface topography, bedrock surface, and unconsolidated deposits.

The water table of the valley floor is very close to the surface. Stream courses are shallow, gradients are low, and the streams are in a mature stage of development. A large area in the south-central part of the valley is under water at least part of the year. Water loss from the valley is by runoff of surface waters, evapo-transpiration from the land surface, and by ground water seepage into the drainage system.

The valley acts as a catchment basin for the considerable area of the slopes of its east and west sides. This implies a net ground waterflow that leads from the flanks to the sediment prism.

The bedrock of the valley walls is also charged with water. In the Shawangunk Mine, both upper and lower workings showed considerable drainage, even in midsummer, when visited by the writer.

The east side of the valley, marked by the ridge of Shawangunk Mountain is only thinly covered with soil. This is most readily seen in the rock quarry in the pass at Otisville, where Route 211 crosses the old New York, Ontario, and Western Railroad right-of-way. Frequently, as near Ellenville, there are large patches of rock outcrop visible on the dip slope. From a patchy thin mantling of soil near the summit, the cover in general thickens as one proceeds westward down the slope to the valley floor, until near the inflection point at which the floor meets the foot of the slope, a thickness of several scores of feet is common.

Scattered data from wells in various parts of the valley indicate that depths to bedrock range from zero to over 180 feet on the east flank of the valley; from 140 to over 600 feet in the axial portions, and from zero to over 130 feet on the west flank.

The drift is thickest near the topographic high of the valley floor near Phillipsport. The deepest portion of the valley floor, probably well below sea level, is somewhat removed from this position and probably located in the area of Napanoch or Wawarsing.

The materials constituting the surficial deposits are principally poorly-sorted glacial sands and tills, whose particle-size ranges from fine-sand through cobble. Deposits of this material are readily seen at many places throughout the valley, principally on the west and east slopes (where in many places they have been excavated for road and construction fill) and on the valley floor in the region of Phillipsport-Summitville. Drilling data available do not explain in detail the nature of the buried drift in the valley floor, but it can be said that the largest volume of sediment in the valley consists of weakly stratified gravels and sands, with gravels predominating near the bedrock floor, and occasional sequences of clay and silty sand. The valley profiles described above show irregular, discontinuous bedding, with no consistent stratigraphy of sediment types discernible in the unconsolidated materials.

The post-glacial drainage is divided into two systems — a north-flowing one and a south-flowing one. This drainage has, of course, altered the nature of the unconsolidated material near the surface on the valley floor. The stream systems, meandering across the valley floor, and cutting down the few hummocks of unsorted glacial material that remain in the valley, have leveled the floor, with the exception of the topographically high area between Phillipsport and Summitville, and have reworked the glacial drift until now the soil of the valley consists of a surface veneer of sandy loam. Presumably, the immediate post-glacial topography of the great part of the valley was a hummocky irregular valley floor of kame deposits and kettle lakes, with kame terraces paralleling the east and west walls. Fluvial erosion has demolished this early landscape, except in the Phillipsport-Summitville area, where lack of stream energy has preserved a remnant of it at the topographic height-of-land between the north and south drainages.

Bedrock Geology

The bedrock geology need only be briefly reviewed here. The formations outcrop in NE-SW striking belts, the oldest toward the southeast and the youngest toward the northwest.

The Wallkill highland, east of Shawangunk Mountain, is underlain by the Martinsburg Formation, a thick sequence of dark shales and graywackes more or less deformed. Overlying these beds at an angular unconformity is the Shawangunk Quartzite; a resistant clastic formation which includes various conglomerate, sandstone, and red shale members. The Wawarsing Formation, a friable, shaly limestone that is not known to outcrop anywhere in the area, overlies the Shawangunk. In the water supply tunnel at Wawarsing this formation is about 120 feet thick and dips about 35° to 45° to the northwest; it disappears between Wawarsing and High Falls.

The Wawarsing is overlain in the tunnel by the High Falls shale, which consists of some 80 feet of well-bedded red shales and limy shales.

Superposed on the High Falls is the Binnewater sandstone, 80 feet of red and gray limy and sandy shales.

TABLE 1. Geologic Section of Rocks Present in Area of Examination.

Age	Group	South Portion		North Portion
Medial Devonian	Hamilton		Marcellus Formation — shales, siltstones	
	—		Onondaga Limestone	
Early Devonian	Ulster		Schoharie Limestone	
			Carlisle Center Shale	
			Esopus Shale	
			Glenerie Limestone	
	Helderberg		Port Ewen Limestone	
			Alsen Limestone	
			Becraft Limestone	
			New Scotland Limestone	
			Kalkberg Limestone	
			Coeymans Limestone	
			Manlius Limestone	
			Rondout Formation	
Silurian	(no group name)			Binnewater Sandstone
		Decker Formation		High Falls Shale
		Bossardville Limestone		Wawarsing Limestone
		Poxono Island Formation		
		Bloomburg Formation	Guymard Quartzite	Shawangunk Formation
			Otisville Shale	
			Shawangunk Formation	
Late Ordovician —			Martinsburg Formation	

This formation is very porous and permeable; prominent solution cavities were noted in the limestone at the time of construction of the Delaware Watershed Aqueduct. Next in the succession are the structurally more competent beds of the Helderberg Group, which at the village of Wawarsing is some 400 feet thick and dips 45–60° NW. Outcrops of the Helderberg are scattered throughout the length of the valley.

Overlying the Helderberg limestones is the Early Devonian Glenerie-Schoharie interval, represented here by some 250 feet of very sandy black shale. This formation, more competent than the limestones above and below it, tends to form a subsurface ridge from High Falls southwest to the central part of the valley, as revealed by well data. At West Brookville, the Esopus emerges from the valley floor and forms a secondary ridge on the east flank of the valley.

Above the early Devonian interval is the Onondaga Limestone, a massive, light gray cherty well-bedded rock which dips approximately 35° NW in the Wawarsing Tunnel. It occurs in scattered outcrops throughout the valley; the Onondaga occasionally has been observed to carry small amounts of sulphide in outcrop (P. Hudec, personal communication).

The Onondaga Limestone is overlain by the Marcellus Formation of the Hamilton Group. These rocks consist of black and brown sandy shales, monotonous in character, and several hundred feet thick.

This brief description of the succession of formations that form the valley walls and bedrock floor is intended to serve only as a resume, and moreover, is only applicable to the section in the vicinity of Wawarsing. The stratigraphy differs to the southwest and northeast, as suggested in the table.

The structural setting appears to be a relatively simple one in the main linear portion of the valley. The monoclinal Shawangunk Formation has a gently sinuous strike varying generally a few degrees from N35E, with the exception of a short portion (about 2 miles) near Summitville, where the strike is about N10E. Dip of the Shawangunk grit is generally within the range 35–45° NW; the strikes and dips of the Esopus, where observed, generally parallel the Shawangunk within a few degrees. The Hamilton (Marcellus) shales dip more shallowly and, within a mile or two of the valley, are practically flat lying. Thus the valley appears to be a linear locus of folding, with the "hinge" confined almost to the width of the valley itself. By any measurement, this linear "kink" is a structural feature of some magnitude and its narrow width (about 2 miles) compared to its length (over 50 miles) is remarkable.

There are irregular zones of contortion and deformation in the formations involved, and some bedding plane thrust-faulting was observed in the Wawarsing Tunnel. In all cases where relative motion is noted, the west (stratigraphically higher) side is moved up-dip (eastward).

Economic Geology

The occurrence, structure, mineralogy, and extent of the lead-zinc deposits of the Shawangunk lead-zinc district have been described by Gray (1960), Eilertson (1950), Ingham (1940), Sims and Hotz (1951), and others. The mining has been limited to the Shawangunk Formation.

The principal deposits are located as follows. Mines are identified on Plates I and II by means of a crossed hammers symbol.

1. Shawangunk Mine. 2.4 miles N77E of junction of Route 209 and old Route 17; 1.5 miles east of Route 209. Lower workings 40′ above valley floor. Upper workings directly upslope at 1200′ ASL.
2. Washington Mine (also called Wallkill Mine). Located 6,600′ S80W of the old Otisville rail depot, on the east side of the abandoned (upper) Erie Railroad right-of-way, about 60′ above track level.
3. Guymard Mine. Located 1,600′ north of Graham Station on the Erie Railroad. The old property abuts the railroad on the east side, at the turn of the county road.
4. Ulster Mine. Located near a rough road on Shawangunk Mountain, east of Spring Glen, and 3.7 miles S13E of the center of the town of Ellenville. The vein intersects a horseshoe curve in the road.
5. Ellenville Mine. This is directly at the foot of the mountain, one block north of New York Route 52, near the Ellenville fire department training tower, in the east part of the town.
6. Wawarsing Tunnel. During construction of the Delaware Aqueduct Tunnel, a fracture zone was encountered in the upper Shawangunk Formation. This fracture zone, some 50 feet thick across strike was highly mineralized.

The individual characters of the old mines are described by the authors mentioned above. Their locations are described here only as an aid to discussion and description. The mineralized areas known are all on the northwest face of the ridge; the principal characteristics of the deposit are:

1. simple mineralogy — sphalerite, galena, some pyrite, occasional chalcopyrite;
2. occurrence of ore as breccia-and fracture-filling, with some replacement near joints;
3. absence of any apparent source of hydrothermal solutions;
4. control of ore by structure (joints and fracture systems) and by stratigraphy within the Shawangunk Formation.

These features are characteristic of other Appalachian-type lead-zinc deposits. The striking difference in the Shawangunk Mountain deposits is that the ores occur in quartzites and quartz-pebble conglomerates, rather than in carbonate rocks.

The mode of occurrence of the ore is as fracture-fillings and healings. These faults and fractures occur in two principal modes:

1. reverse faults, parallel to the strike, on which the west side is upthrown, as seen from local stratigraphy offset, drag-folding, and slickensiding. The faults may or may not be parallel to bedding; their age is not known. This is the case in the Shawangunk Mine at Wurtsboro (lower and upper workings), the Washington Mine (southwest of Otisville), at the Ulster Mine (east of Spring Glen), and in the mineralized zone in the Wawarsing Tunnel;
2. as vertical and steeply-dipping cross-faults and fractures. These faults do not have a large displacement; they occur at moderate to high angles to the strike and dip of the local beds. They may be interpreted as tensional features (Gray, 1953). The ore occurs in such a structural milieu in the Ellenville Mine (east edge of town of Ellenville) and at the Guymard Mine (near Graham station).

Mineralization is thus a tectonic or post-tectonic event, in which solutions capable of transporting the ore metals and of dissolving quartz were able to migrate, by means of zones of dilatancy into the deformed quartzite mass, then to precipitate their dissolved load of metal ions.

The enigma of the Shawangunk ores is the lack of an apparent source of such hydrothermal solutions. Gray (1960) suggests as possible sources three igneous/metamorphic events in post-Silurian times, to wit, the metamorphism of Cambro-Ordovician rocks of western Dutchess County, and the emplacement of the granites of Mount Adam and Eve in Orange County, and the emplacement of the Beemerville sill near Sussex, New Jersey; all are quite distant. Ingham (1940) also considered the mineralization to be of hypogene origin, as did Eilertson (1950), although neither suggested an igneous source or a source bed for the metals of the deposit. The role of hypersaline solutions, as proposed in some more recent models for the origin of the Pine Point, N.W.T., deposits, for example, may well have been a significant one, in view of the proximity of the Silurian evaporite basin.

The point to which this leads is that in the face of the provisionally accepted modes of origin of the deposits, there is no reason why mineralization need be restricted to the quartzite and quartz-conglomerate beds of the Shawangunk Formation. If, as postulated by Gray, the deformation of the Silurian-Devonian sequence was accompanied, or followed shortly, by the mineralization of the quartzite, the weak limestones were simultaneously deformed and crushed. While granting that the competence and brittle nature of the quartzite would beget clean, open dilation channels, the physical weakness, and chemical reactivity of the abutting limestones would seem to favor them equally as loci of depositional activity.

Field and Laboratory Methods

SAMPLING

Stream waters of the valley and its environs were sampled at half mile intervals, wherever possible. An effort was made to avoid taking samples below occupied areas, metal culverts, or other cultural emplacements. In areas of interest and of anomalous values, samples were taken as closely as every 100 yards. All water samples were taken in the same field season; none were taken within 3 days after rains.

Stream sediments were sampled with the same frequency, most often at the same location, except in some locations where coarse sediment or gravel prevented meaningful sampling. As a matter of consistency, samples were taken in muds at the water's edge.

Stream waters and stream sediments were sampled at about 325 locations, in the valley watersheds, and the adjacent (Wallkill) watershed to the east.

Soil samples were taken along eight traverses across the valley floor, in the vicinity of known occurrences of Pb-Zn mineralization in the nearby ridge, and at other locations where sampling was practicable. Large portions of the valley floor, between Wurtsboro and West Brookville are inundated for parts of the year, and in other regions cultural overprint prevents meaningful soil sampling.

A total of some 150 soil samples were taken for analysis of lead, zinc, and copper content. Samples were all taken whenever possible from the bottom of the A soil horizon; about $\frac{1}{2}$ kg of soil was collected from this horizon at each site and stored in a polyethylene bag for transport to the laboratory.

ANALYTICAL WORK

Stream waters were sampled and analyzed on site in the field, using the colorimetric dithizone method. In this method, 50 ml of water are sampled and a dithizone solution in an organic solvent is added to it. After shaking and subsequent clarification, the color of the organic layer is compared visually with colors produced by prepared standard solutions. Details of the method are given by Ward et al. (1963) and by Huff (1948). A number of the most anomalous water samples were checked in the laboratory by atomic absorption, with results that supported the field findings.

The stream sediments were analyzed at the field location using the test for ammonium citrate-soluble ~~bearing~~ metals outlined by Ward et al. and by Bloom (1955). In this test the number of milliliters of dithizone solution used is a measure of the combined citrate-soluble heavy metals in the sample. In this study, the relationship is such that 1 ml of reagent indicates a heavy metal content of approximately 25 ppm zinc equivalent.

Selected anomalous samples were also analyzed by atomic absorption, using a hot nitric acid leach treatment.

Soil samples were treated by the same hot nitric leach method, and the resultant sample solutions were analyzed for copper and zinc by atomic absorption spectophotometry. Lead could not be determined at the concentration generally encountered in the leach solutions by this method. To survey lead abundances in the soils, powdered aliquots of the soil samples were analyzed by emission spectroscopy.

Results

The data are displayed on Plates 1 and 2, showing respectively the data for stream waters and stream sediments. Not all points are shown — some of the lower background values were removed to eliminate crowding. Coverage in anomalous areas is, however, complete.

A frequency analysis of the values shows that the histogram of values for the stream sediments approaches a lognormal distribution (fig. 2). Most frequent values lie between 25 and 75 ppm combined citrate-soluble heavy metals; a very few values are lower than 5 ppm and like number lie above 250 ppm. Approximately 18% of values lie above 150 ppm, 5% lie above 250 ppm, and 1% lie above 500 ppm; arbitrarily we decided to let values of 125 ppm (5 ml of dithizone reagent) — that is, values in the upper 18% of the frequency distribution — be deemed anomalous. Accordingly, they are marked by a small triangle on the accompanying sheet showing stream sediment values.

The stream-water values show a highly skewed lognormal distribution — at least at the levels to which the field analytical method was suitable (fig. 2). An examination of the values found shows that approximately 16% of values exceed .025 ppm, about 7% exceed .1 ppm and 3 values, or approximately 1%, exceed 1 ppm of combined heavy metals. Again, arbitrarily, values exceeding .025 ppm were deemed anomalous and are so marked by a small triangle on the sheet showing stream-water values.

Stream-water and sediment analysis are complimentary to each other; for this reason they are most usefully done at the same time, the practice followed in the present survey. Water anomalies tend to rise very quickly near the point of their source, to values that may be 50 to 100 times background value. Downstream, they quickly degenerate, as more water enters the stream to dilute them, and as the stream waters interact with ground water. Hence they are most useful in pinpointing anomalous locations. Stream-sediment anomalies on the other hand may seldom exceed 10 times normal background, but tend to be more persistent downstream. They are less affected by stream-water flow-rate, but the method is dependent to a degree on the nature of the stream sediment. For this reason the survey should insofar as possible be consistent in the type of sediment sample used. To meet this requirement we used the clay portion of the sediment, insofar as practicable.

WATER ANOMALIES

The reader is referred to Plate 1 for the location of the anomalies listed in this section.

1. Two small streams entering the north side of Rondout Creek at Kerhonkson. This is not a strongly anomalous area, but is noteworthy in that a detailed survey of stream sediment conducted in this vicinity by a private group showed a number of low local anomalies in streams to be apparently associated with the upper or lower contacts of the Esopus Formation. Our reconnaissance stream-sediment survey of these brooks did not show anomalous values.

2. The small swift stream that enters the eastern limits of Ellenville from the so-called North Gully of Shawangunk Ridge shows a pronounced anomaly about 200 yards east of Route 52. An old prospect is reported in this area but examination in the summer of 1967 failed to find the cause for the high values. The old Ellenville Mine (Gray, 1960) is nearby, about 2,000 feet to the northeast; it is well downstream of the anomaly.

3. A small local anomaly, near Route 55, 3 miles south of Kerhonkson, near Granite. This area is underlain by folded Shawangunk conglomerates.

4. Ulster Mine. Drainage from the vicinity of the old Ulster Mine east of Spring Glen produces a strong local anomaly.

5. Phillipsport. Two small intermittent streams paralleling the old road that leads eastward over Shawangunk Mountain from Phillipsport carry highly anomalous values. Local inhabitants report the presence of mineral prospects in the area, but none could be specifically verified.

6. Summitville. The stream draining Shawangunk Mountain via the windgap known as Roosa Gap, 1 mile

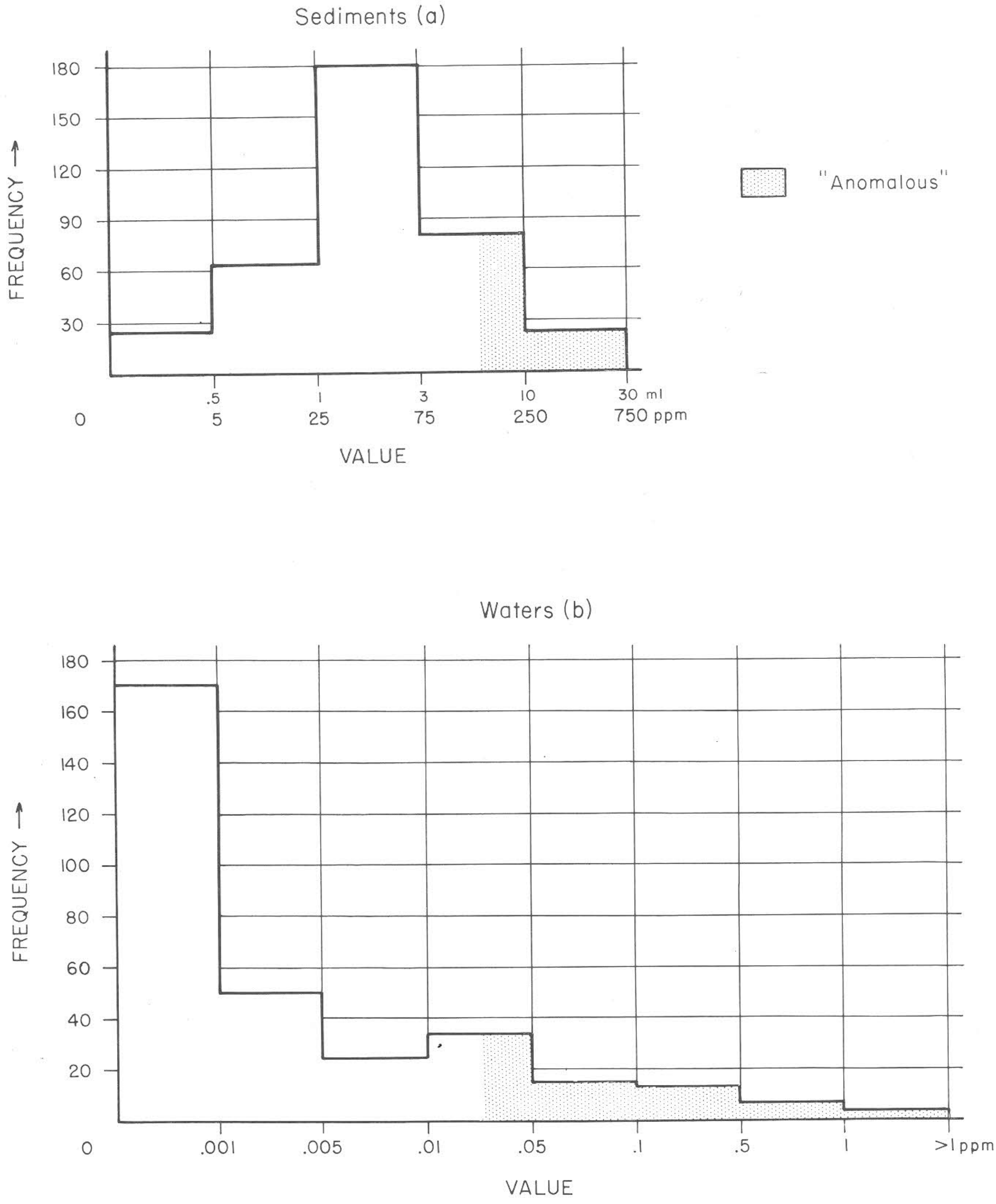

FIGURE 2. FREQUENCY DISTRIBUTION DIAGRAMS for combined heavy metals in stream sediments and stream waters.

south of the village of Summitville carries anomalous values for lead and zinc. This stream cuts the ridge approximately 1.5 miles north of the Shawangunk Mine. No mineralization was observed; anomalous values were found dispersed all along the stream to its source.

7. The Shawangunk Mine contributes heavily laden drainage waters to the upper reaches of the Basher Kill, which from this point south to Cuddebackville is the main drainage trunk on the valley floor. Three other small streams drain the mountain in the stretch between Wurtsboro airport and the village of Wurtsboro, all of which show anomalous values. This group of small streams produce anomalous heavy metal values in the Basher Kill which persist southward as far as the crossing of the new Route 17, where the Basher Kill enters an area of swamp.

8. Haven area, east side of the valley. A small stream here shows values 30 to 40 times normal background.

9. Washington Mine area, Otisville. Streams in the vicinity of the Washington Mine area are, needless to say, heavily laden with lead and zinc. Two other small streams, respectively 4,000 and 7,000 feet south of the old mine, show similar high values. No mineralization or other surface manifestation was found to explain these very high values, which rise to several hundred times normal background.

10. Cuddebackville prospect. Approximately 1 mile south of the village of Cuddebackville, just north of the confluence of the Basher Kill and the Neversink River, a small stream system enters the Basher Kill from the east, draining Shawangunk Mountain and cutting through the Esopus Ridge. This stream has very high metal values which originate at an elevation about 100 feet above the upper (unused) Erie Railroad right-of-way. Local inhabitants refer to an old prospect in the ravine, the remains of which are now apparently overgrown.

11. Guymard Mine. Drainage of two small brooks in the vicinity of the Guymard Mine watershed show very high values.

12. Rutgers Creek area. Stream waters here in two locations showed quite high values — .06 ppm, which is 10 to 60 times normal background. These were the only anomalous values found on the Ordovician terrain.

STREAM-SEDIMENT ANOMALIES

Plate 2 indicates locations of the anomalies referred to in this section.

1. Lyon Lake area. This area, at the north end of the belt, is interesting because it represents the only anomalous area underlain by the Devonian terrigenous sequence. According to Fluhr (personal communication, 1969) numerous small cavity fillings of sphalerite and/or galena have been observed in these rocks in the course of excavations for the New York City Board of Water Supply.

2. Ellenville. This anomaly is the same as that described under (2) of the stream-water anomalies.

3. Near Granite, 3 miles southeast of Kerhonkson, near Route 55. A number of small streams in this area, notably Sanders Kill, bear sediment that carries somewhat high lead-zinc values.

4. Ulster Mine. Sediment carries levels of heavy metals that are 5 to 10 times normal.

5. Phillipsport. Very high values were encountered in the sediments of the streams described under (5) of stream-water anomalies.

6. Roosa Gap. As with stream waters, stream muds throughout the length of this small stream yield high values.

7. Summitville Mine. Sediments show values that are 20 times normal. The anomaly persists downstream and is detectable in the sediments 4 to 5 miles south at the crossing of new Route 17, as was observed in the stream water.

8. Haven area, east side of valley. This stream, referred to under (8) of stream-water anomalies, carries slightly anomalous sediment values as well.

9. Washington Mine area, Otisville. Values of about 10 times background levels are observed in the drainage of the mine area.

10. Cuddebackville Prospect, described under (10) of stream-water anomalies, shows stream-sediment values of the same order as those seen for the Washington Mine, to the north, and stronger than those observed in the drainage of the Guymard Mine, to the south.

11. Guymard Mine. The presence of the old prospect is confirmed in the stream sediments.

12. Shin Hollow, on the east side of the valley, approximately 3 to 4 miles northeast of the city of Port Jervis. Here two small unnamed streams draining the Shawangunk monocline demonstrate high stream-sediment values. In the more southern of the two ravines, at a distance above the Erie Railroad track, a prospect pit has been opened at some time in the past, and a small gossan area can be observed.

SOIL SAMPLING

Soil samples were taken along transverse lines examined at several places along the length of the valley — namely at Wawarsing, Ellenville, Wurtsboro Airport, MacDonald's Road (Wurtsboro), Roses Point, Cuddebackville, and Spring Glen. The samples were analyzed for copper and zinc by atomic absorption, and for lead by optical emission spectroscopy as mentioned earlier.

The results indicated that anomalous zones could be delineated by soil samples, and apparent anomalies whose values were 10 to 20 times background were found. It turned out, however, to be difficult to duplicate the data satisfactorily, and further efforts to sample the soils on a grid system, to extend coverage in two dimensions in these areas, were abandoned.

Whether the inability to duplicate the soil results can be ascribed to true randomness in local distribution of these metals is not known at this time. The great depth of overburden in many parts of the valley would seem to mitigate against the use of soil sampling, since ground water percolation of metal ions from the bedrock requires such long upward transport. This in turn would tend to produce weak, or diffuse areas of metal adsorption in surface soils, that may not be easily related to any bedrock source.

Discussion

ANOMALIES

Inspection of the list of stream-water and stream-sediment anomalies defines various groups of areas that manifest unusual concentrations of dithizone-reactable heavy metals.

Group 1. The Ulster Mine, the Shawangunk (Summitville) Mine, the Washington Mine, and the Guymard Mine. This group of previously known and exploited occurrences all show their effect in both sediments and waters of their local drainages. The Ellenville Mine, near the valley floor, lies in an area of strong cultural overprint (the Ellenville dump) and consequently its effect upon local drainage cannot be properly assessed.

Group 2. This group includes locations showing both unusual water and sediment values, and which have not been clearly reported as sulphide mineral occurrences. We include Ellenville (North Gully), the Granite area, Phillipsport, Roosa Gap, Haven area, and the Cuddebackville prospect. The Ellenville anomaly is geographically quite closely related to the Ellenville Mine area; the Phillipsport and Roosa Gap anomalies to the Shawangunk Mine-Ulster Mine belt. The Cuddebackville prospect is in the Washington Mine-Guymard Mine belt. These anomalies indicate that apparently other mineralization, perhaps not manifested in surface occurrences, is present in areas of known mineralization in the district. The remaining two anomalous areas, the Granite area and the Haven area anomalies, are not near presently known occurrences of mineralization.

Group 3. Kerhonkson area (water anomaly), and Shin Hollow (sediment anomaly). The former does not have notably high values, but evidence from this study and from private sources suggest that local sources are contributing lead and zinc ions to the drainage systems in the area; in the latter case, a concentration of moderately high values suggests an area of potential interest.

Group 4. The Lyon Lake anomaly and the Rutgers Creek anomalies show only moderately high values in areas which, based on experience up to the present time, are not underlain by favorable geological environments. These two anomalies are probably of no further interest.

WATER POTABILITY

The United States Public Health Service Drinking Water Standards handbook (PHS Publication No. 956, 1962) lists the tolerable levels of a number of metals in water used as a constant source of water supply.

Zinc and copper are essential and beneficial elements in human metabolism, and the only objection to their presence, under normal circumstances, is that they impart a metallic flavor to the supply. For this reason limits of 1 and 5 ppm are established for copper and zinc respectively, and it is suggested that this limitation need only constitute grounds for rejection if alternative supplies are available. It should be stated that large amounts of these metals — above 30 ppm — can act as internal irritants.

Lead, however, is another matter. Content of lead in a constant supply should not exceed .05 ppm (50 ppb); otherwise harmful accumulations can accrue in the body. For short periods of a few weeks 2–4 ppm can be tolerated, but 15 ppm in water consumed over a period of weeks can be lethal.

The most heavily laden surface waters found in this study were found in drainage below the Shawangunk and the Otisville (Washington) Mines. These contained 100 to 5000 ppb of combined heavy metals; other streams on the east side of the valley — notably the anomalous streams east of Phillipsport and east of Summitville, contain lead at levels that are marginally toxic — in the range of 12 to 200 ppb of combined heavy metals. Of the three metals — copper, lead, and zinc — zinc generally predominates over lead, and copper is lower than both, in most samples tested; the ratios show some variability, however. This would indicate that the lead contents in some streams in the anomalous areas may be marginally toxic, and a few streams draining areas of known sulfide occurrence are definitely toxic.

In areas of the valley in which domestic water supplies, either surficial or ground water, are derived from drainage from the Shawangunk Ridge itself, it would therefore seem prudent to take steps to insure that the supply does not contain lead in toxic amounts. This possibility also exists for wells on the valley floor of course, but the ground water supply on the valley floor is such that few wells need penetrate the thick overburden to utilize water that may have lain in proximity to bedrock; hence toxic concentrations are more likely to be diluted by more normal waters.

Suggestions for Further Work

To follow up the work outlined in this report, which is intended only as a reconnaissance survey, several steps are necessary to further outline areas of presumed mineralization.

Stream-sediment sampling should be performed on about 100 foot intervals in the anomalous streams referred in under Groups 2 and 3 in the discussion section. The 80 mesh portion of the sediment so obtained should be analyzed for lead and zinc. Zinc, being more mobile in the surface enviroment than lead, may be the more useful indicator of the two elements.

Soil surveys, carried out on grid patterns, might follow such detailed stream surveys in these areas.

Sufficient definition by geochemical methods might well lead to useful application of such geophysical methods as electromagnetic (EM) or induced polarization (IP) surveys, to yield a final definition of extent and (possibly) depth of zones of mineralization.

In this connection it should be recalled that sulfide mineralization was observed in the Wawarsing tunnel during its construction, and occurrences of sulfides have been noted in outcrops of the limestones that underlie the valley floor. In keeping with the remarks made above under Economic Geology, the rocks of the valley floor may well be worthy of investigation using one or more of the electrical methods of mining geophysics.

Conclusions

A number of anomalous areas, heretofore not systematically examined, have been located by the use of dithizone field tests and supporting laboratory analyses, the latter principally by atomic absorption.

The results indicate that areas already exploited are worthy of further examination, using modern systematic methods. These include the localities around the former Ellenville Mine, the Ulster Mine-Shawangunk Mine section, and the Washington Mine-Guymard Mine belt. As well, a number of other more isolated anomalous areas are worthy of more detailed examination by detailed geochemical and geophysical methods. The mountain ridge itself appears to be the locus of most anomalies.

The most useful streams in the survey, from the standpoint of information potential, were the small primary streams draining the west side of the mountain ridge. Streams on the valley floor, probably due to the thick overburden lens, were of limited usefulness.

Principally for the same reason, there are problems in using soil surveys for delineating anomalous areas in the unconsolidated deposits on the valley floor. Other contributing factors that impede their usefulness are the strong possibility of interference by heavy contamination from human cultural sources. Soil surveys may yet turn out to be useful in some areas of the valley floor — for example, in the broad flat area from Summitville to Wurtsboro or in the valley between the Esopus Ridge and the Shawangunk Ridge from Cuddebackville to Port Jervis.

The waters of some of the small streams flowing off Shawangunk Ridge carry concentrations of lead that are potentially harmful to humans. Although in no case was it found that these waters constituted an active water supply, water supplies near the east edge of the valley, especially in the vicinity of Wurtsboro and Guymard, should be assayed for lead content before being used as a permanent supply.

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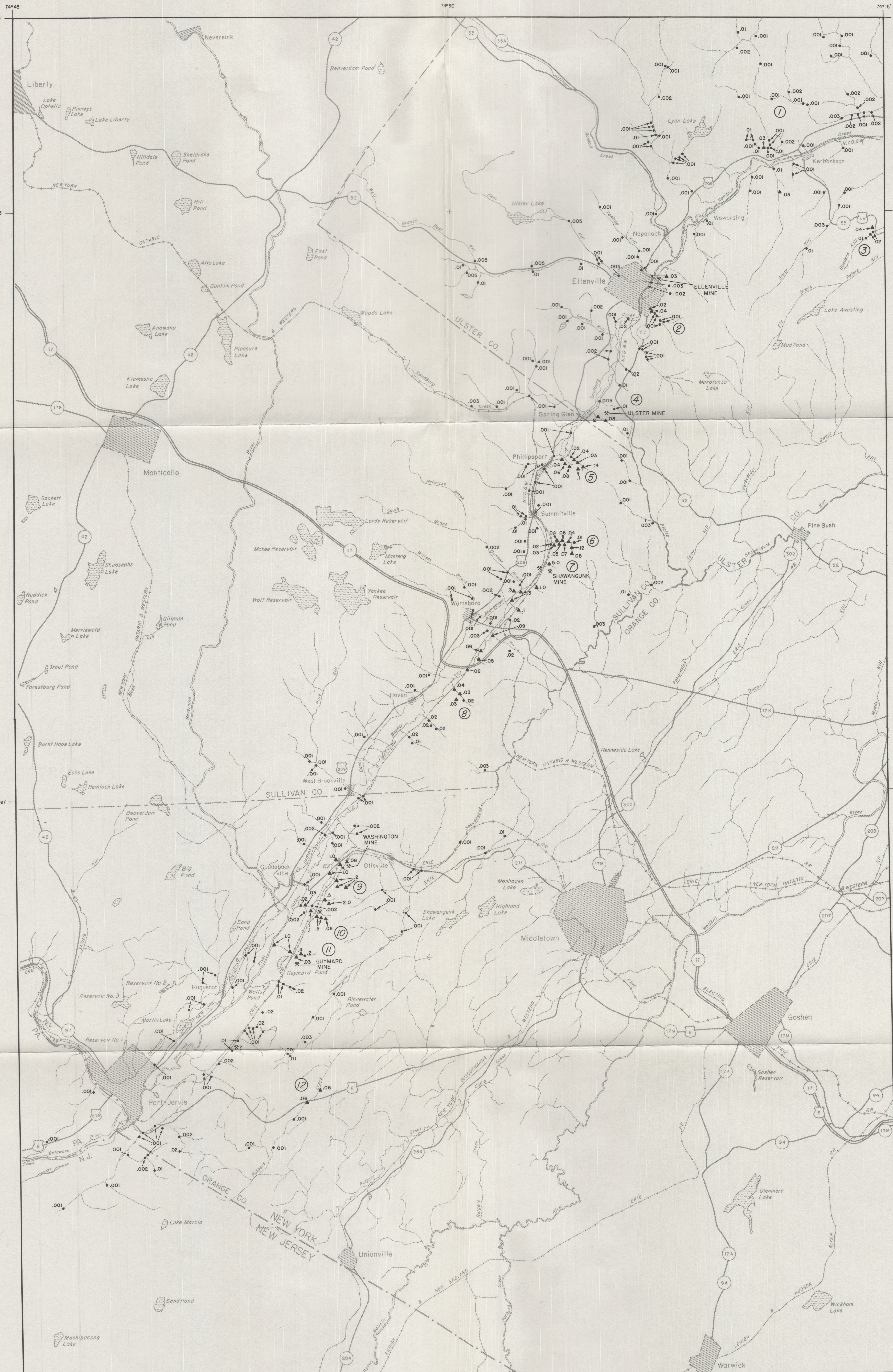


EXPLANATION

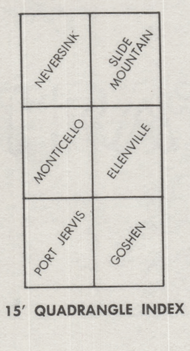
- ● ppm total heavy metals (as Zn)
- ▲ anomalous values > .025 ppm

MILES

KILOMETERS

1970

MAP LOCATION



15' QUADRANGLE INDEX

PLATE I. STREAM WATER RESULTS, SHAWANGUNK MOUNTAIN AREA, NEW YORK

by R. Lynn Moxham

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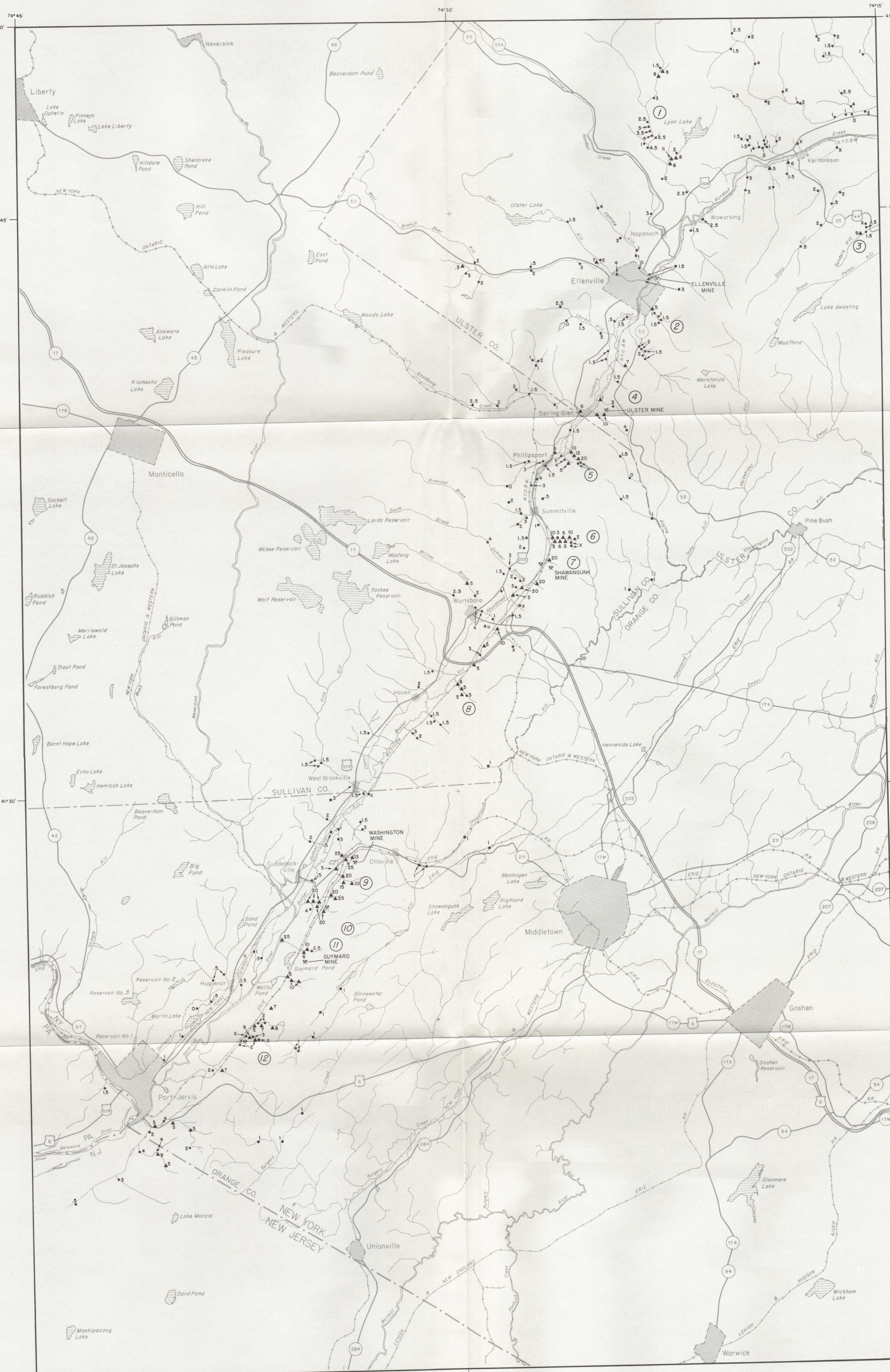

EXPLANATION

● ml. dithizone solution 1 ml. ~ 25 ppm CXHM

▲ anomalous values > 5 ml.

MAP LOCATION

MILES 1 0 1 2 3 4

KILOMETERS 1 0 1 2 3 4 5 6

1970

NEVERSINK	SLIDE MOUNTAIN
MONTICELLO	ELLENVILLE
PORT JERVIS	GOSHEN

15' QUADRANGLE INDEX

PLATE 2. STREAM SEDIMENT RESULTS,
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