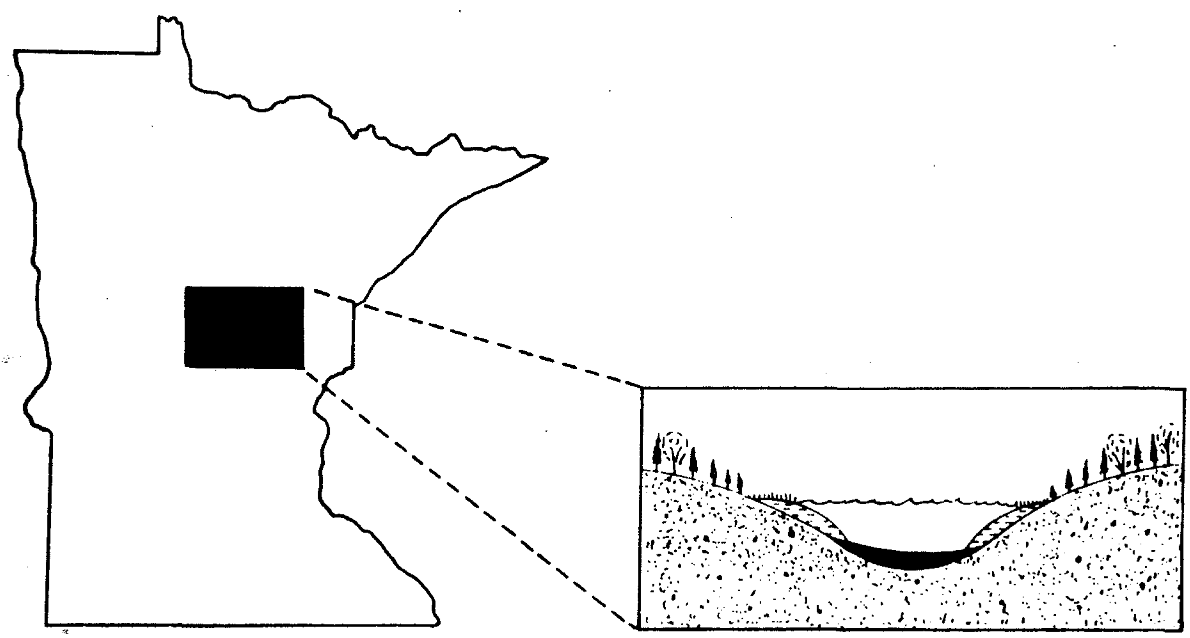
Lake Sediment Geochemical Survey of East-Central Minnesota

Minnesota Department of Natural Resources
Division of Minerals
Hibbing, Minnesota

Report 236



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ABSTRACT

A reconnaissance scale organic-rich lake sediment geochemical survey was conducted over portions of Cass, Crow Wing, Aitkin and Carlton Counties in east-central Minnesota. The goal of this survey was to examine the usefulness of lake sediment geochemistry over thick, glaciated overburden for mineral potential evaluation. In particular, the east-central Minnesota survey area contains overburden that was deposited by several different glaciations of contrasting till types. The survey area is underlain by both older Archean granite-greenstone-gneisses and younger Proterozoic basin sediments, metavolcanic, igneous, and metamorphic rocks.

Six hundred eighteen samples were collected from 463 lakes encompassing an area of 3,150 mi^2 *(8,160 km*^{2}*). Unashed samples were analyzed by atomic absorption spectrophotometry for Ag, Co, Cu, Pb, Ni, Zn, Fe, and Mn after being partially digested using a 4M* HNO_3*/1M HCl mixture. Arsenic was leached by using concentrated* HNO_3*/30% hydrogen peroxide solution followed by analysis in an arsine generator and uranium was determined by using a 4M* HNO_3 *solution and a Scintrex uranium analyzer. Finally, organic content was estimated by ashing (Loss-On-Ignition).*

Review of statistical analyses revealed that Zn-Cu-Ni and Ni-Co-Cu correlate positively, suggesting an interdependent relationship. Also, as might be expected, Fe and Mn correlate strongly. No meaningful positive associations between the trace elements and LOI were observed, suggesting that scavenging and organic complexing leading to false anomalies is not indicated from statistical trace element analyses. In fact, most LOI correlations are slightly negative, indicating some trace element enrichment in the inorganic fraction of the lake sediment.

Particular attention was addressed to superimposed dispersion trains, drainage patterns, ice directions, trace element mobility, variation of trace element background with bedrock types, and physical and chemical composition of glacial till lithologies. Results of the survey suggest that the chemistry of the bedrock geology is reflected in the organic-rich lacustrine environment. Therefore, under favorable chemical, geologic, and hydrologic conditions, trace element analysis of lake sediments should reflect possible economic mineralization. In the study area at least six locations exhibit multi-element anomalies.

INTRODUCTION

During the summer of 1983 an organic-rich lake sediment pilot survey was conducted in east-central Minnesota by the Division of Minerals to identify possible relationships between trace element analysis of the sediments and the underlying bedrock. The survey was initiated, in part, to test the applicability of lake sediment geochemistry over thick, glacially-derived overburden. Previous surveys in northeastern Minnesota (Vadis and Meineke, 1982a, 1982b) and Ontario, Canada (Hornbrook and Coker, 1977; Coker and Shilts, 1979), have been successful in reflecting bedrock geology by means of organic-rich lake sediments. Funding for this project was provided by the Legislative Commission on Minnesota Resources (LCMR).

The survey area includes portions of Cass, Crow Wing, Aitkin, and Carlton Counties in east-central Minnesota (Fig. 1). Brainerd and Aitkin are the two major cities in the reconnaissance area. The former iron mining district known as the Cuyuna Range lies within the western part of the study area.

The lake sediment samples were composed of gyttja, a dark, gelatinous, organic-rich mud, that was deposited or precipitated in waters abundant in oxygen and nutrients (Jonasson, 1976; Coker et al., 1979). The samples were analyzed for trace element concentrations at the Division of Minerals in Hibbing, Minnesota, under the direction and supervision of A. W. Klaysmat, Research Scientist. Relationships and characteristics were identified with the aid of computer statistical software. Interpretation of survey parameters were used for purposes of mineral potential evaluation.

GEOLOGY

Geologic History

The following brief geologic review is inferred largely from aeromagnetic, gravity, and other geophysical data due to thick glacial overburden and relative lack of outcrop in the survey area. The bedrock geology consists mainly of rocks dating from Archean to Proterozoic in age, however, some overlying Cretaceous sedimentary units have escaped complete erosion. Geologic knowledge of the study area has recently been updated with new drill hole information. As a result, the Minnesota Geological Survey is reinterpreting portions of the east-central Minnesota bedrock geology map (Southwick, 1984). References to location, glacial till, and bedrock lithology lie within the boundaries of the lake sediment geochemical survey area in east-central Minnesota (Plate 1 & 2, in pocket, inside back cover).

The following brief overview is adapted from Morey et al. (1977, 1984a,b):

The east-central Minnesota geochemical survey area overlaps onto greenstone-granite (2.7 b.y.) and gneissic terrane (3.0 b.y.) on the north and south, respectively (Morey, 1973; Peterman, 1966). Much of the survey area lies within the Animikie basin (Marsden, 1972). This basin was formed by repeated differential vertical movement and extensional tectonic forces operating in northwest and southeast directions (approximately 2.1-2.0 b.y.). The northern part of the Animikie basin consists of a 2-3 km thick sequence of predominately sedimentary rocks (Animikie Group). The southern part, however, consists of a 6 km thick sequence of sedimentary and volcanic rocks (Animikie and Mille Lacs Group, Fig. 2).

Initial subsidence of the basin was followed by deposition of quartz-rich clastic sediments. Volcanism occurred next, followed by the accumulation of quartzite, siltstone, carbonaceous lutite, dolomite, argillite, and carbonate-oxide-sulfide-silicate-facies iron formation, completing the filling of the basin (the Mille Lacs Group). After a period of uplift and subsequent erosion, the basin again subsided and deposition of the Animikie Series began. This sequence includes quartzite, siltstone, argillite, and precipitates of oxide and silicate facies iron formation with deposition of carbonaceous lutite taking place in the deep-water parts of the shelf. During the last phase of basin deposition, flysch-facies clastic rocks were deposited by southward flowing turbidity currents.

Following Animikie deposition, a period of compressional tectonism during the Penokean Orogeny (1.9-1.8 b.y.) resulted in the deformation of stratified and igneous rocks (VanSchmus, 1980, Goldich et al., 1961; Morey, 1984a). Two contrasting zones of deformation are present, a relatively undeformed northern zone and a deformed southern zone (Fig. 3). In the northern zone, the sedimentary beds dip gently to the south and show little evidence of deformation. In contrast, the southern zone was more tectonically active with a higher heat flow. During this time, the McGrath gneiss was also uplifted and deformed. Following deformation, granodioritic, monzonitic, and granitic plutons were emplaced into the Animikie stratified rocks. All lithologies were later variably intruded by dikes, sills, and intrusions of mafic to felsic and lamprophyric affinity. While many of these dikes are thought to have been emplaced during Early and Middle Keweenawan time, some could possibly be Phanerozoic in age (Morey, 1984b). Upper Cambrian and Upper Cretaceous sedimentary rocks were deposited over the Precambrian rocks; most have since been removed by erosion. Presently, the entire survey area is covered with Pleistocene glacial deposits and locally, Holocene peat.

Descriptive Geology

The northwestern portion of the survey area lies in Archean granite-greenstone terrain, whereas the southeastern portion is encompassed by Archean gneiss terrain. Early and Middle Archean rocks in the northwest are generally quartzo-feldspathic and amphibolitic gneisses, whereas the McGrath gneiss (2.75 b.y.), northeast of Mille Lacs Lake is a pinkish-gray, coarse-grained, locally cataclasized, quartzo-feldspathic gneiss (Morey et al., 1981).

The bedrock geology in the central portion of the survey area north of Mille Lacs Lake is Early to Middle Proterozoic in age and consists of stratified volcanic and sedimentary rocks. These stratified rocks lie unconformably on older Archean basement rocks and are divided by an unconformity into two groups--the older Mille Lacs Group and the younger Animikie Group (Marsden, 1972).

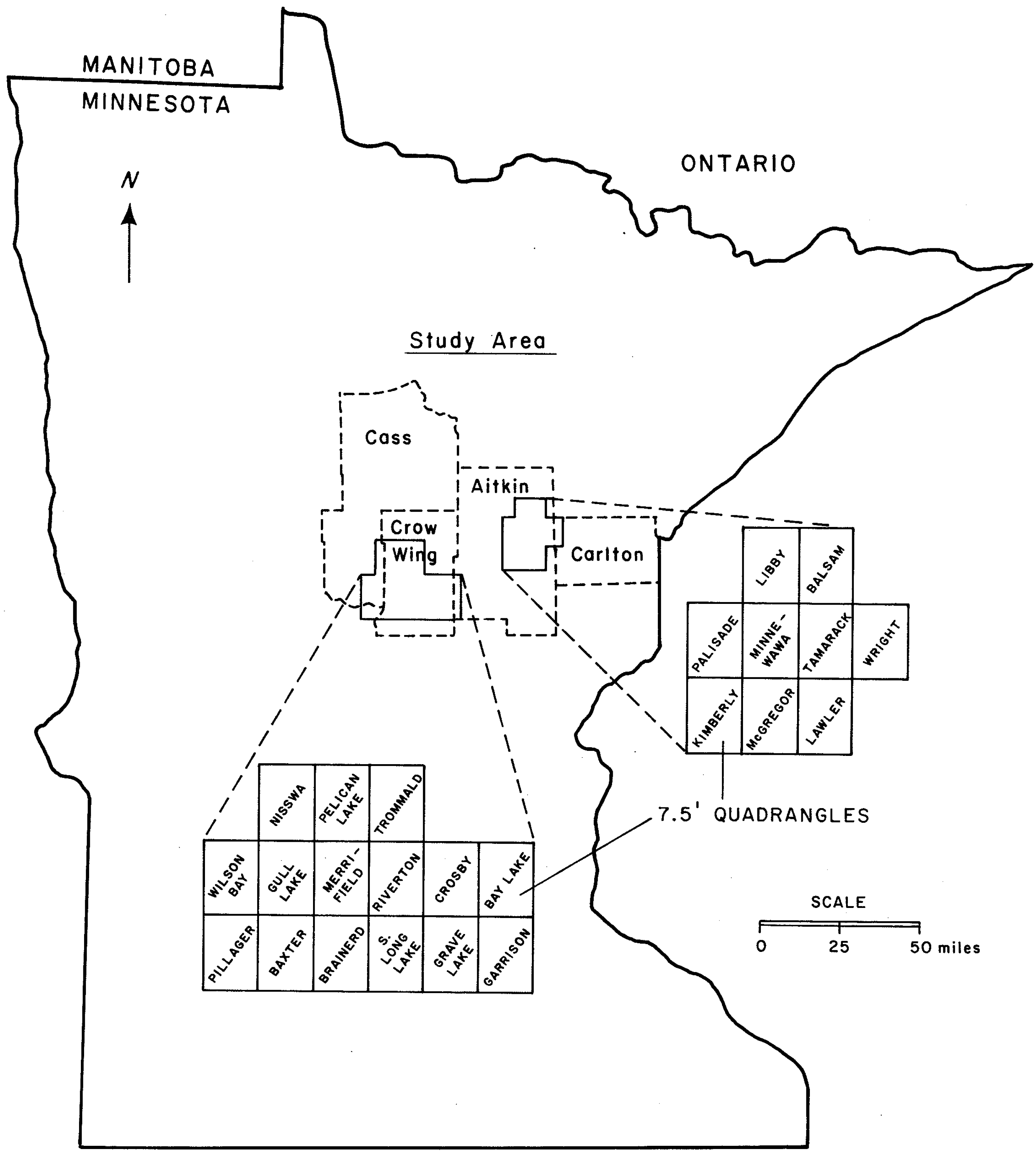


FIGURE 1: Index map of study area.

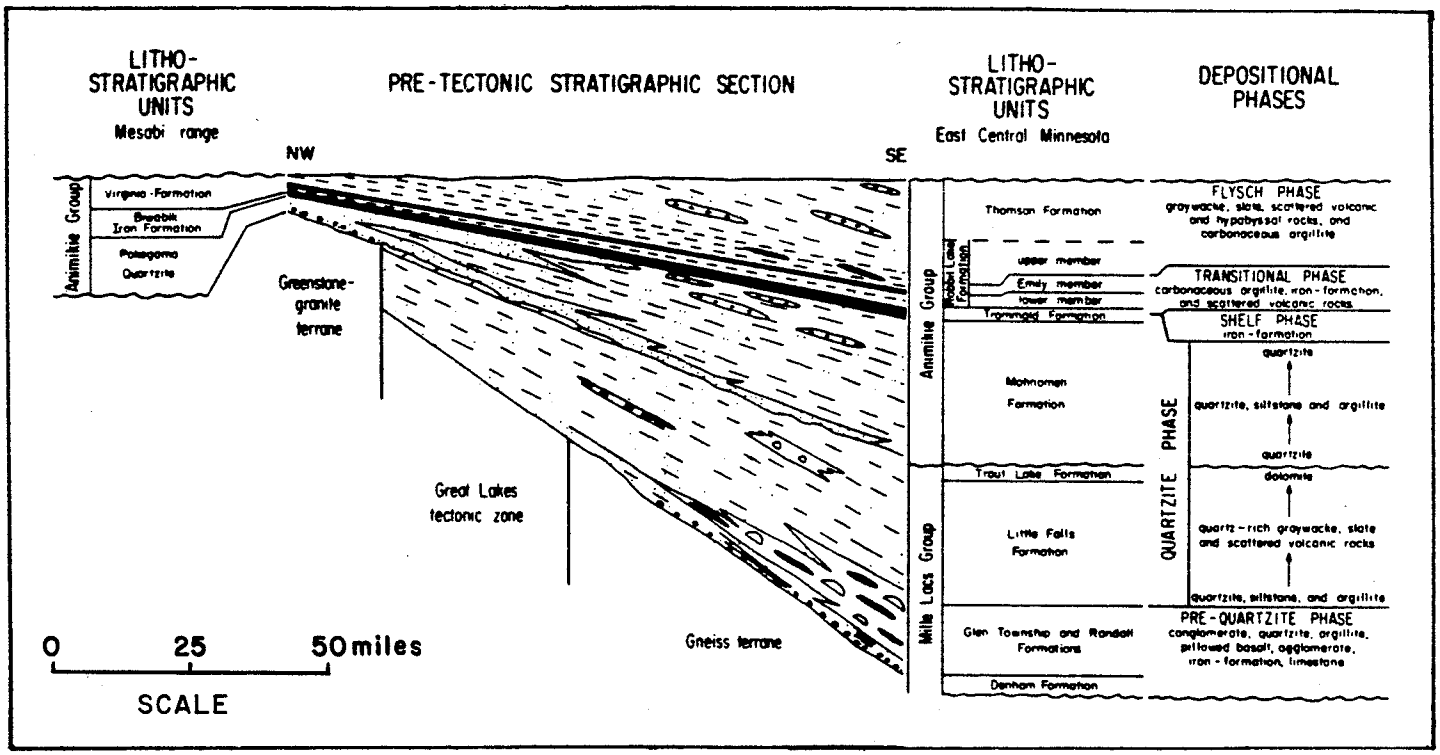


FIGURE 2: Pre-tectonic stratigraphic section through Animikie basin (Morey, 1979).

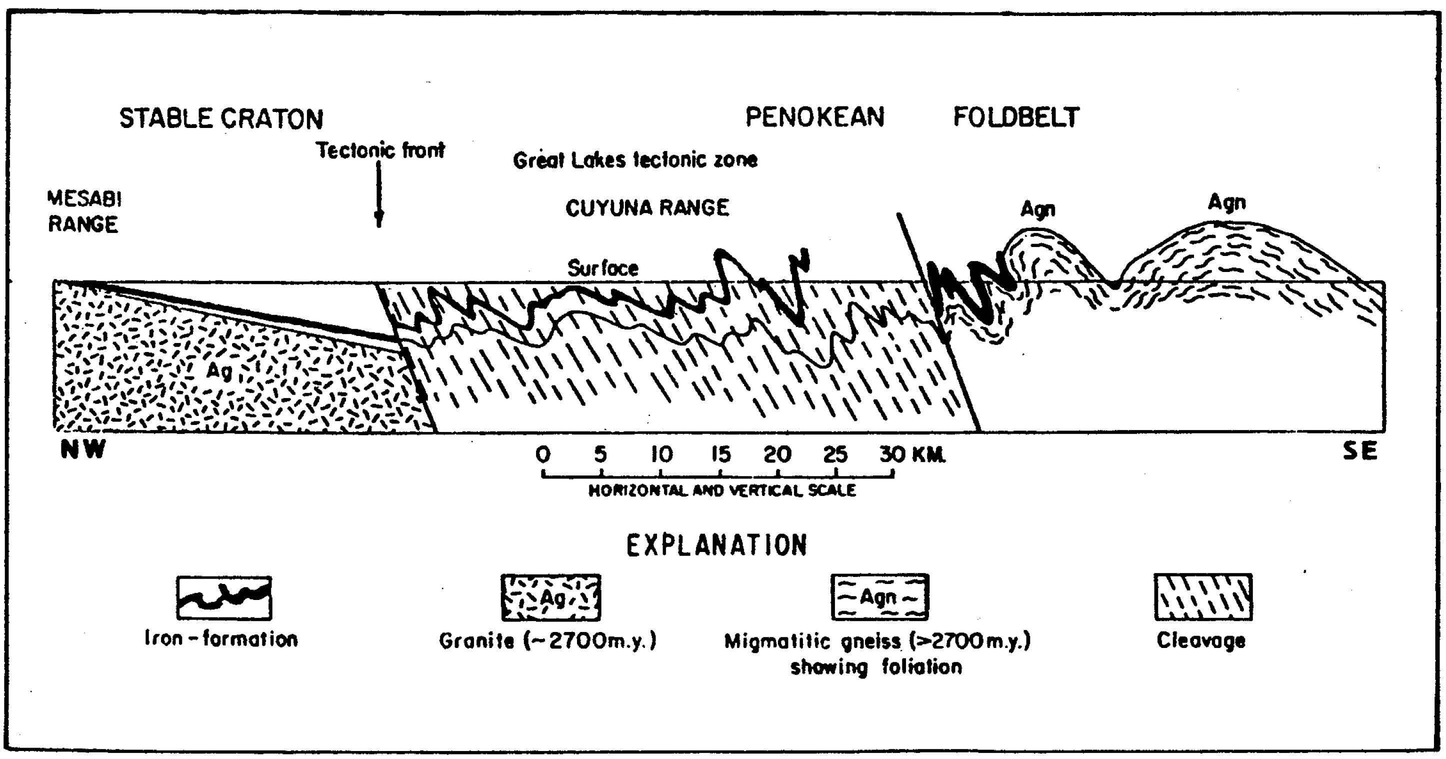


FIGURE 3: Post-tectonic structural section through Animikie basin (Morey, 1983).

The Mille Lacs Group in the study area consists of the Denham Formation (a meta-sedimentary-metavolcanic sequence of coarse to silt-size arenitic quartz-rich rocks), the Glen Township Formation (predominantly sulfide-rich, carbonaceous slate, cherty iron-formation, metabasalt, and argillite), the Randall Formation (dominantly mafic metavolcanics with lesser sedimentary rocks), and the Trout Lake Formation (cherty dolomite).

Similarly, the Animikie Group in the study area is composed of the Mahnomen Formation (argillite and siltstone, with minor quartzite), which is overlain by the Trommald Formation (cherty and slaty iron formation). These, in turn, are overlain by the Rabbit Lake, Thomson (feldspathic graywacke, siltstone, and slate) and the Virginia Formations (argillaceous silstone), which are correlative. The Rabbit Lake Formation is divided into the Lower Member (carbonaceous slate and graywacke), the Emily Member (carbonaceous argillite and calcareous iron-formation), and the Upper Member (argillite, slate, and graywacke).

The stratified rocks in the Mille Lacs and Animikie Groups increase in metamorphic grade from north to south. Iron formations to the north exhibit zeolite facies metamorphism (Morey, 1973), whereas to the south, the argillaceous rocks are metamorphosed to amphibolite facies.

Largely, post-tectonic igneous activity (1.8-1.7 b.y.) resulted in the emplacement of plutons, dikes, and sills throughout east-central Minnesota (Keighen et al., 1972). For example, in the southeast portion of the survey area, the McGrath gneiss has been intruded by numerous augite porphyritic basalt dikes (Morey et al., 1981), whereas, northeasterly trending Keweenawan dikes occur in the eastern portions of the survey area. Mafic dikes and sills are common in the Cuyuna District (Graber, 1985).

Glacial Geology

Glaciers advanced, retreated, and readvanced several times in east-central Minnesota during Pleistocene time. The Wadena lobe, the Rainy lobe, the Superior lobe, and the St. Louis sublobe of the Des Moines lobe converged on east-central Minnesota during their respective ice phases (Fig. 4). Since east-central Minnesota was underlain by complex igneous and metamorphic rocks with apparent similar erosional resistances, there were no prominent lowlands or highlands to channel the ice lobes. Instead, the ice advanced from the east and west out of adjacent shallow basins and converged in east-central Minnesota, resulting in local drift thicknesses in excess of 400 feet (Wright, 1972a, Fig. 5).

Each glacial lobe that invaded east-central Minnesota has an associated ice phase. These phases represent the chronology of glacial advance and retreat and are identified by distinct differences in glacial till lithology. The first glacial advance into east-central Minnesota is represented by the Hewitt phase of the Wadena lobe. The next two glacial advances occurred during the St. Croix and Automba phases representing the respective advances and readvances of both the Superior and Rainy lobes. Finally, the last glacial advance into east-central Minnesota occurred during the Alborn phase of the St. Louis sublobe of the Des Moines lobe.

Drift from all the major ice lobes of Wisconsin glaciation (the Wadena, Rainy, Superior, and Des Moines lobes) is represented in the survey area (Fig. 6, Table 1). Consequently, east-central Minnesota has a complex variety of till with regard to color, composition, and size of fragments.Since the geology is uncertain for much of east-central Minnesota, it is difficult to associate glacial till with local bedrock geology. However, much of the glacial till can be traced to distant source areas.

In general, Wadena drift consists mainly of gray, calcareous till containing limestone clasts indicating a Winnipeg (Manitoba, Canada) source area. Brown to gray noncalcareous drift with pebbles typical of igneous and metamorphic rocks of the Canadian Shield is generally associated with the Rainy lobe. Drift associated with the Superior lobe contains primarily red sandstone clasts as well as basalt and gabbro pebbles derived from the Lake Superior Basin. The drift of the Des Moines lobe is characterized by gray, calcareous till (silt and clay), containing shale and limestone clasts derived from Manitoba and eastern North Dakota (Hobbs and Goebel, 1982).

Lake sediment geochemistry is highly dependent on the depth and the physical characteristics of glacially derived material. Repeated glacial advances and retreats may result in either segregation, mixing or stratification of different till lithologies. Therefore, differences in lake elevations as well as lake sediment sample depths coupled with lateral and vertical changes in till lithology are important interpretational considerations. Furthermore, the chemical composition of the drift will affect the chemistry of the groundwater, its movement, and the migration of metals from bedrock to lake sediments (Vadis and Meineke, 1982). Therefore, the glacial geology of east-central Minnesota is presented here in detail (after Wright, 1972a):

Hewitt Phase—During the Hewitt phase, the Wadena lobe advanced from theWinnipeg lowland southeastwardly into the Red Lakes lowland of northern Minnesota then was diverted towards the southwest by the Rainy lobe which was simultaneously advancing from the northeast. The eastern limit of the Wadena lobe is on the western edge of the geochemical survey area near Jenkins and Pillager, Minnesota. The contact is marked by poorly defined moraines and may extend eastward under the younger Rainy and Superior lobe drift. The Wadena lobe drift west of Pillager is composed of gray to light-brown, sandy calcareous till, but lacks fragments of Cretaceous shale.

St. Croix Phase—Upon retreat of the Wadena lobe, the Rainy lobe advanced from the north-northeast following a path parallel to the Superior lobe which was moving southwestwardly out of the Lake Superior trough. The Rainy lobe terminated and formed the St. Croix moraine on the western edge of the survey area near Pillager, Minnesota. To the east, the St. Croix moraine is buried under younger drift until it resurfaces north of St. Paul, Minnesota. The composition of the St. Croix moraine north and south of the Pillager area consists of brown, sandy till containing basalt, felsite, gabbro, and iron-formation pebbles, indicating a northeastern Minnesota source. Both the Brainerd and Pierz drumlin fields were

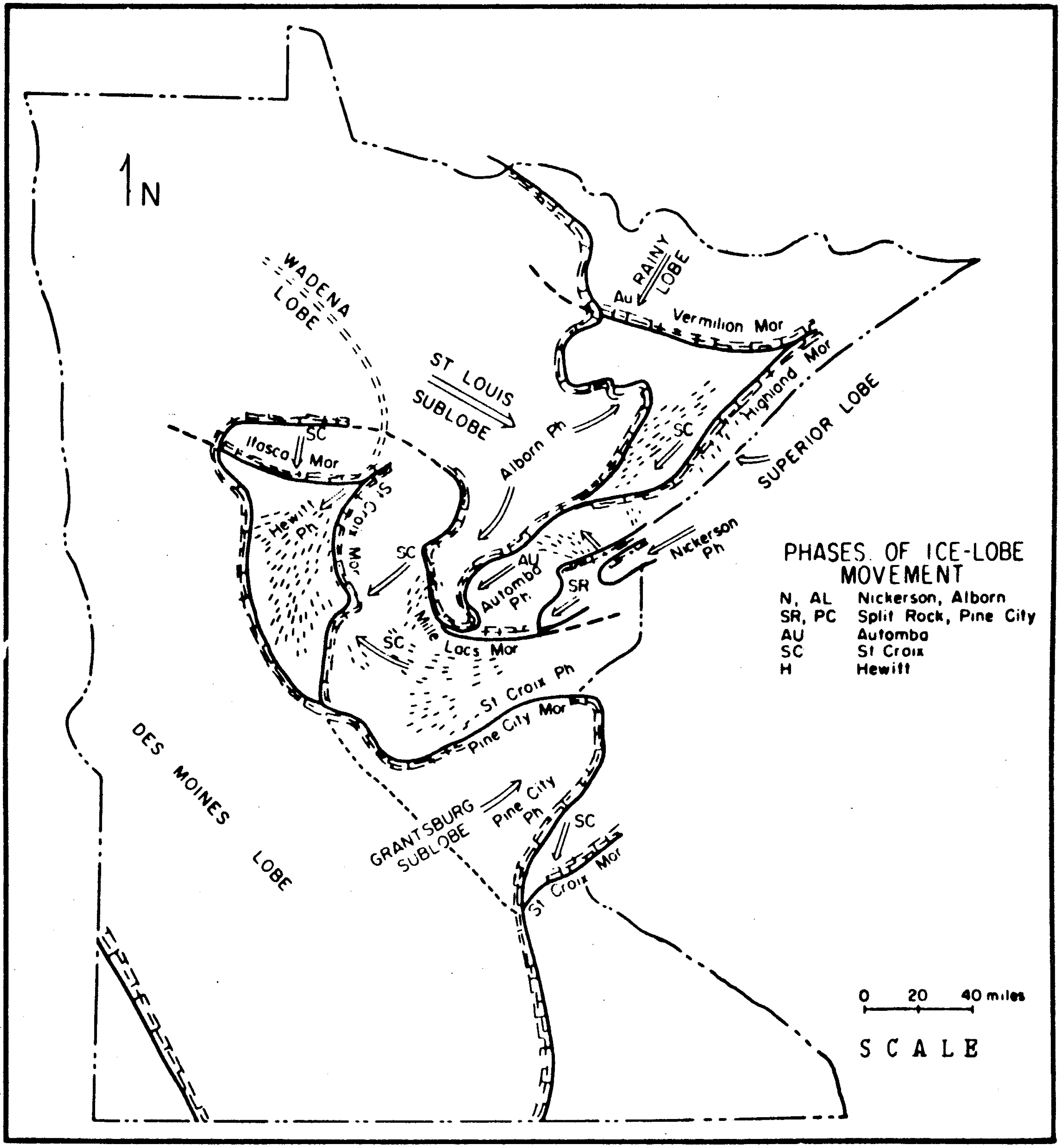


FIGURE 4: Composite map showing main phases of Wisconsin glaciation in Minnesota (From Wright, 1972a).

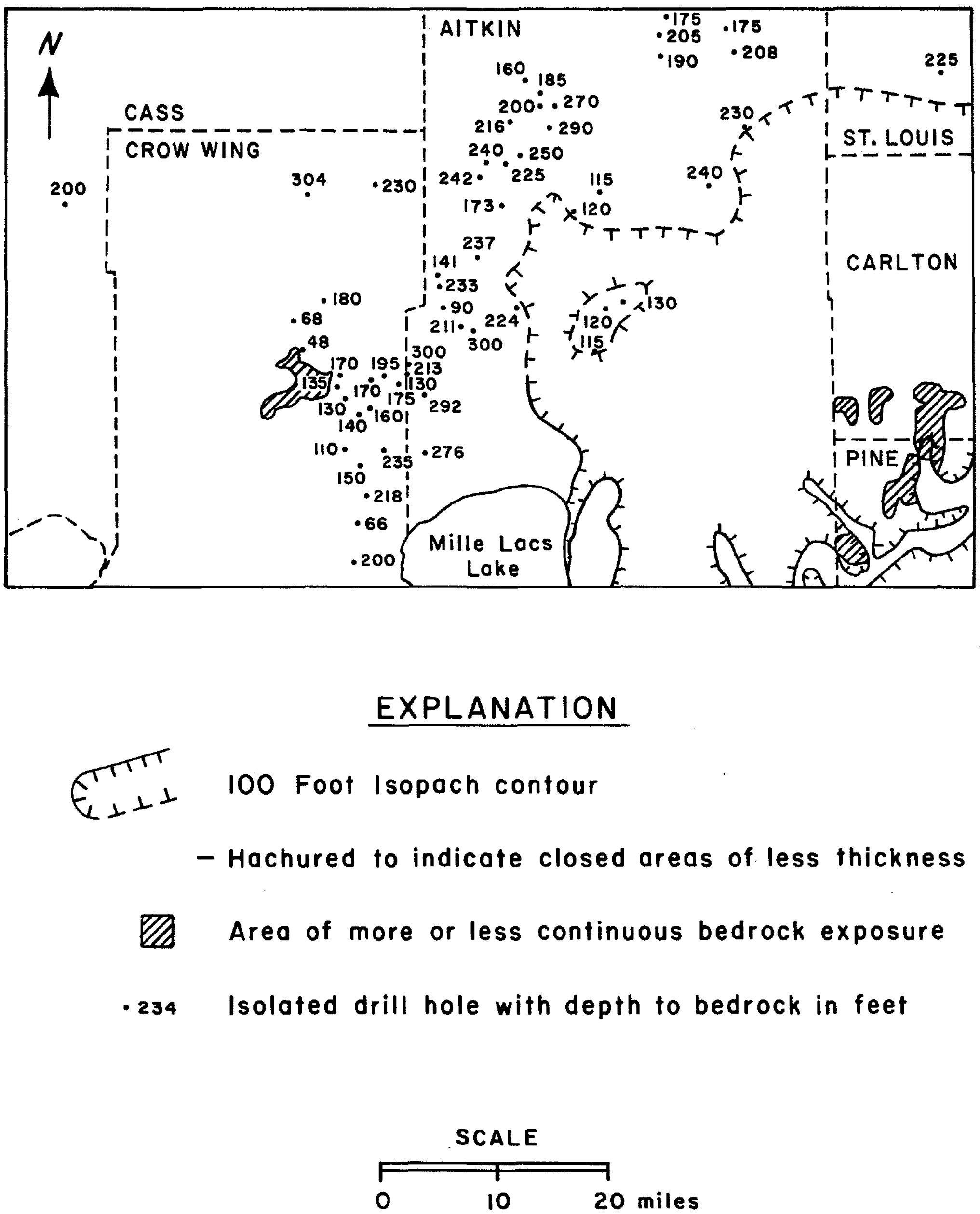


FIGURE 5. Depth to bedrock map of east-central Minnesota (Adapted from Olsen & Mossier, 1982).

formed during the St. Croix phase. The Brainerd drumlins occur near Pine River, Minnesota (northwest of Brainerd), and are composed of sandy till similar to the till of the St. Croix moraine. The Pierz drumlins come into contact with the south side of the Brainerd drumlin field. The northern part of the Pierz field consists of typical brown, sandy Rainy lobe till, whereas the southern part is somewhat contaminated with red sandstone from the Superior lobe. Thus, the St. Croix moraine is formed on the north by the Rainy lobe and to the south by the Superior lobe. At the end of the St. Croix phase, the Superior lobe retreated from the south margin of the St. Croix moraine to a point 120 miles north beyond the southern edge of the Lake Superior basin. Concurrently, the Rainy lobe retreated from the western margin of the St. Croix moraine to the Canadian border.

Automba Phase—After the St. Croix phase, the Rainy and Superior lobes readvanced to new locations. The Vermilion moraine in northeastern Minnesota marks the terminus of the Rainy lobe advance. Concurrently, the Superior lobe readvanced southwestwardly out of the Lake Superior trough to the vicinity of Mille Lacs Lake in east-central Minnesota. The Mille Lacs moraine constitutes the terminus of this advance and is surficially quite distinct on its western flank but fades out on its southern flank. Unfortunately, complex mixing of different glacial till lithologies conceals evidence of the retreat of the Superior lobe in the Automba phase. The compo-

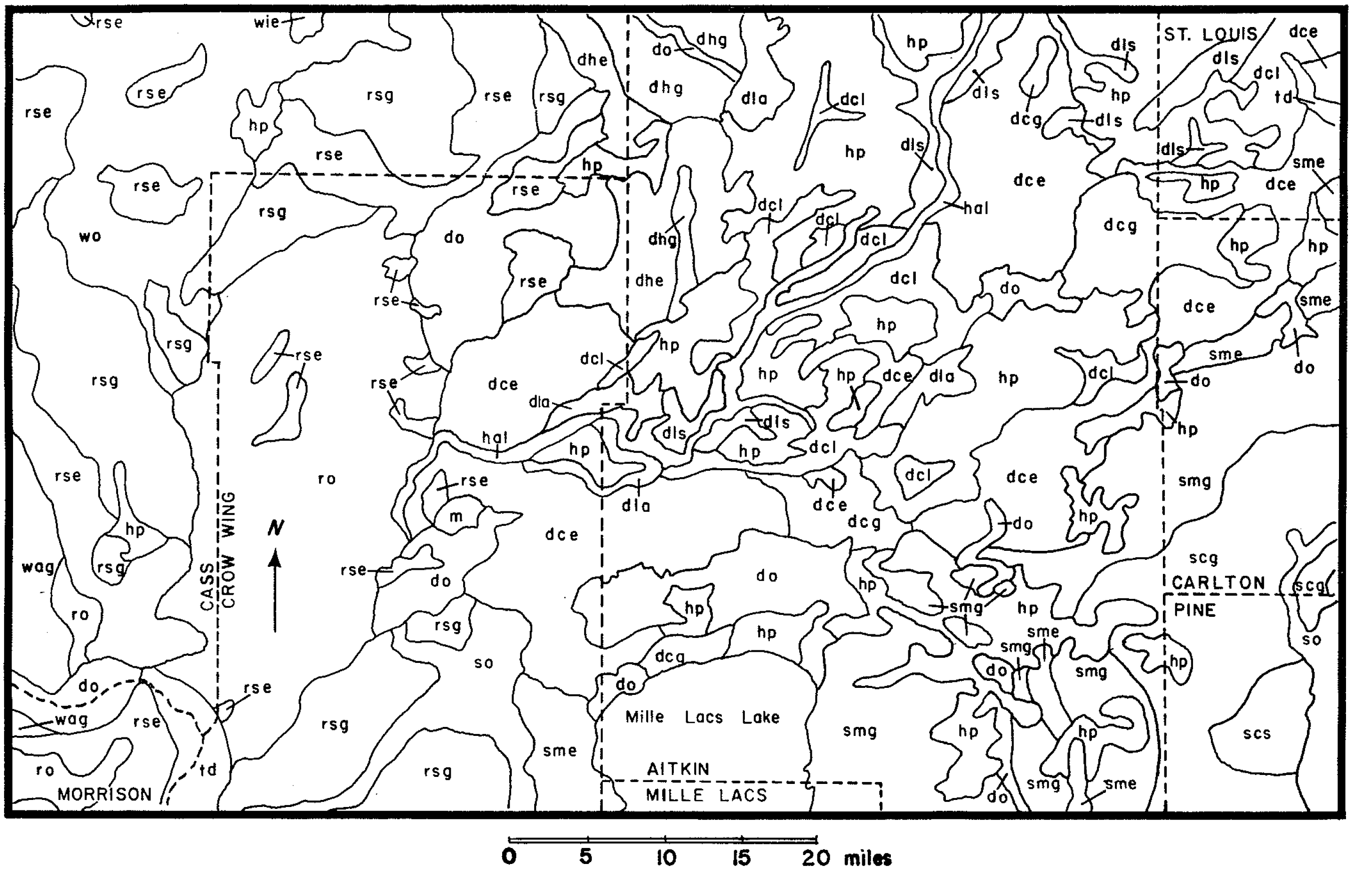


FIGURE 6: Quaternary Geology of east-central Minnesota (Adapted from Hobbs & Goebel, 1982).

sition of drift from the Superior lobe in the Automba phase is similar to that of the St. Croix phase: red sandstone and shale fragments.

Alborn Phase—The Alborn phase represents the advance of the St. Louis sublobe of the Des Moines lobe to the north shore of Mille Lacs Lake (Hobbs, 1984). Large portions of the geochemical survey area include moraines and outwash from the St. Louis sublobe deposited during the Alborn phase. Two major till units were deposited by the St. Louis sublobe; the Culver moraine and the Sugar Hills moraine. Although both moraines were formed from the St. Louis sublobe, they display different till lithologies. The Culver moraine represents the southeastern part of the St. Louis sublobe and contains reddish-brown clayey sediments from earlier glacial lakes. Limestone and shale clasts, as well as leached calcareous till, also occur sporadically in the Culver moraine. The St. Louis sublobe in the northwestern portion of the survey area is represented by the Sugar Hills moraine which contains reddish-brown till derived from glacial lake sediments. However, the Sugar Hills moraine till has a greater percentage of calcareous fragments (limestone and shale clasts) and exhibits less evidence of calcareous leaching than the Culver moraine till. Finally, as the St. Louis sublobe retreated at the end of the Alborn phase, the ice at its furthest advance was buried beneath insulating layers of till forming a stagnation moraine. This moraine blocked drainage to the south allowing Glacial Lake Aitkin-Upham (with its associated clayey lake sediments) to form on the north side of this barrier.

Post-glacial Phase—The topography of the survey area landscape has been locally modified by proglacial terraces, alluvium, and Holocene peat. Terraces representing former floodplains and channels are composed mostly of sand and gravel as well as scoured bedrock surfaces. Alluvium in the form of sand, gravel, silt, and clay was desposited in channels and flood plains of modern streams. Finally, organic deposits of peat were formed in areas of poor drainage, resulting in flat, boggy terranes between wooded, hilly moraines.

PHYSIOGRAPHY

The survey area contains portions of four major physiographic regions (Fig. 7): the Glacial Lake Aitkin-Upham plain, the Sugar Hills-Mille Lacs moraine, the Brainerd-Automba drumlin field, and the St. Croix moraine (western segment). The relief is low to moderate; elevations in the survey area vary from 1179 feet west of Ironton, Minnesota, to 1400 feet north of Mille Lacs Lake. There is little or no influence on surficial topography that can be attributed to bedrock geology, therefore, most of the relief is a result of glacial activity.

EXPLANATION

HOLOCENE DEPOSITS

m	MINE PITS AND DUMPS
hp	PEAT
hal	ALLUVIUM
td	TERRACES

PLEISTOCENE DEPOSITS

LATE WISCONSIN DRIFT

DES MOINES LOBE

dcl	LAKE MODIFIED TILL	CULVER MORAINE
dcg	GROUND MORAINE	CULVER MORAINE
dce	END MORAINE	CULVER MORAINE
dhg	GROUND MORAINE	SUGAR HILLS MORAINE
dhe	END MORAINE	SUGAR HILLS MORAINE
do	OUTWASH	
dla	SAND & GRAVEL	
dls	SILT & FINE SAND	

SUPERIOR LOBE

scg	GROUND MORAINE	CLOQUET MORAINE
scs	STAGNATION MORAINE	CLOQUET MORAINE
sms	GROUND MORAINE	MILLE LACS HIGHLAND MORAINE
sme	END MORAINE	MILLE LACS HIGHLAND MORAINE
so	OUTWASH	

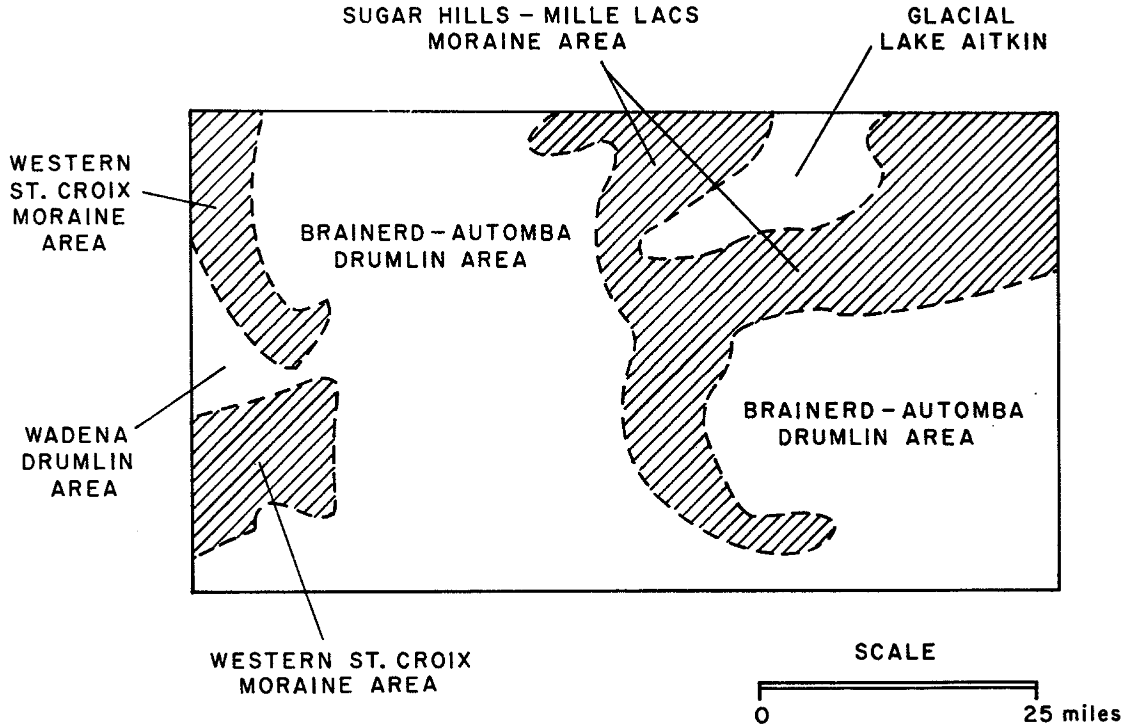
RAINY LOBE

rsg	GROUND MORAINE	ST. CROIX MORAINE
rse	END MORAINE	ST. CROIX MORAINE
ro	OUTWASH	

WADENA LOBE

wie	END MORAINE
wag	GROUND MORAINE
wo	OUTWASH

TABLE 1: Index to Quaternary Geology.



The region is drained by the Mississippi River, which flows through the survey area. Forest vegetation consists of both deciduous and coniferous trees, and a substantial portion of the survey area is under cultivation. The following short review of the physiographic region is summarized from Wright (1972b):

The southwestward extension of the Glacial Lake Aitkin-Upham plain extends across the northern boundary of the survey area. This is a flat area of sand, silt, and clay plains often covered with extensive peat bogs. Lakes in this area are relatively uncommon. Glacial Lake Aitkin-Upham was dammed on the southwest by the Sugar Hills-Mille Lacs moraine complex. This moraine complex extends from the southwest side of Mille Lacs Lake northward to Sugar Hills and eastward along the southeast edge of Glacial Lake Aitkin-Upham to Big Sandy Lake near McGregor, Minnesota.

The Brainerd-Automba drumlin area extends from the southern end of Mille Lacs Lake (Pierz field) northward to Backus, Minnesota, and eastward to Lake Superior. The drumlins are interrupted in numerous places by tunnel valleys and pitted outwash plains, particularly in the vicinity of Brainerd, Minnesota. Consequently, the topography is characterized by numerous deep lakes.

The western part of the survey area is bordered by the St. Croix moraine. This moraine is approximately six miles wide and extends from St. Cloud to Walker, Minnesota; a distance of 100 miles. The St. Croix moraine contains fewer lakes than the Brainerd-Automba drumlin field, although small kettle lakes can be found throughout the St. Croix moraine, especially in Pillsbury State Forest.

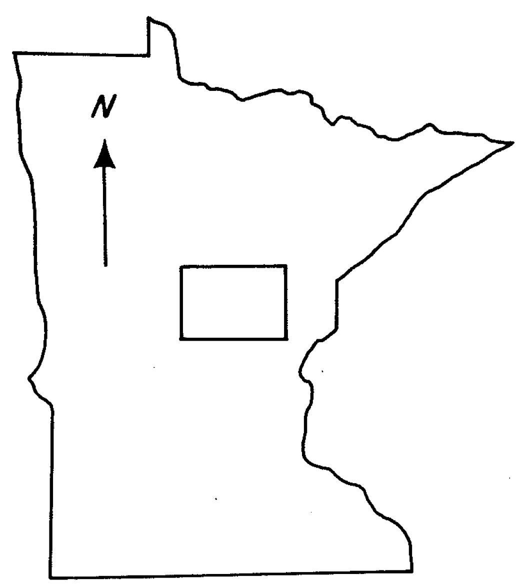


FIGURE 7: Physiographic areas of east-central Minnesota (Adapted from Wright, 1972b).

SAMPLING METHOD

Samples were obtained with a weighted steel core sampler (Fig. 8) weighing 15 pounds (6.8 kg.) which contained a two-inch (5 cm) diameter transparent plastic tube 18 inches long (47 cm). The plastic tube was confined in a steel pipe by a threaded plastic UPC adapter which also served as a cutting edge to burrow into the lake bottom. The plastic tube and adapter protect the sample from contamination. See report 171, p. 7, MN DNR, 1982, by M.K. Vadis and D.G. Meineke for a more detailed description.

Sampling was accomplished with the use of a boat, canoe, or rubber raft, depending upon access to the sample sites. The sampling device was lowered by rope over the side of the boat and allowed to free-fall to the lake bottom to ensure satisfactory penetration into the lake sediments. The sampler was then retrieved and the plastic tube containing a relatively undisturbed vertical section of gyttja was removed (Meineke et al., 1976). To avoid seasonal variations of oxidation and reduction reactions and contamination from recent pollution, the top two inches were discarded for each sample retrieval (Timperly and Allen, 1974; Vadis et al., 1982a).

One to two pounds (0.45-0.90 kg) of gyttja requiring three to eight sampling cycles were taken from each site for analysis. Sample data recorded for each site included texture, color, H_2S scent and sediment/water temperatures. The pH of the sediments and water were measured at selected localities with a Bio-Med. digital pH meter. The sample site description includes topography, drainage, shoreline vegetation, outcrop (if any), and inlets into the lake. Generally, the samples were taken at the greatest depths and selected to include major bays and basins within a lake. (Meineke and Vadis, 1976). A Lowrance electronic depth finder as well as lake bottom contour maps, when available, were used to locate the deeper areas within the lakes. Lake size was used to determine the number of samples taken from each body of water. Sample density was approximately equal to one sample per 5 square miles (13 sq. km.). Sample locations with corresponding sample numbers are shown on Plate 1.

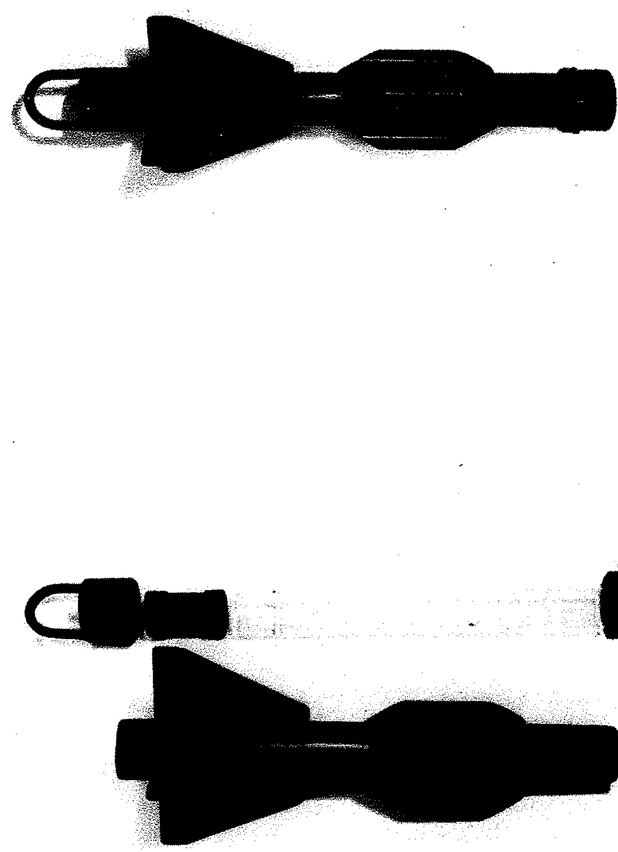


FIGURE 8: Geochemical lake sediment sampler (Designed by Milan Dicklich, MN DNR).

SAMPLE PREPARATION AND CHEMICAL ANALYSIS

Organic-rich lake sediments were freeze dried for 120 hours. The samples were then pulverized with mortar and pestle and sieved with a Rotap using 35 and 80 mesh screens (Tyler series). Any fibric organics or sands not passing 35 mesh were discarded. Gyttja remaining on the 80 mesh screens was reground and the rotapping procedure repeated.

The minus 80 mesh lake sediment samples were leached for analysis of Ag, Co, Cu, Ni, Pb, Zn, Fe, and Mn content by placing one gram samples in a 15 ml solution of 4M HNO_3 and 15 ml of 1M HCL for two hours at 90° C. Next, the solutions were cooled and brought to 50 ml volume by dilution with deionized water. The resulting solutions were analyzed with the aid of a Perkin-Elmer model 603 atomic absorption spectrophotometer (Meineke et al, 1976). Table 2 shows analytical detection limits for trace elements using the atomic absorption spectrophotometer.

TABLE 2: Analytical Detection Limits

Element	Detection Limit
Ag	1 ppm
As	0.1 ppm
Co	1 ppm
Cu	1 ppm
Ni	1 ppm
Pb	10 ppm
Zn	1 ppm
Mn	1 ppm
Fe	0.01%

Arsenic (As) was analyzed by taking 250 mg of sample and adding 1.0 ml of concentrated HNO_3 and 2.0 mls of 30% H_2O_2 (hydrogen peroxide). Samples were digested overnight at room temperature and then heated to 70° C. for six hours. Samples were then allowed to cool to room temperature after which 25 mls of 6N HCl were added to each sample along with enough deionized water to reach 50 ml total volume. An arsine generator was used to analyze these solutions to determine arsenic content.

Loss-on-Ignition (LOI) analyses were performed to measure the amount of organic material present in the lake sediment samples. 1.0 gm samples were placed in porcelain crucibles and heated for 30 minutes at 500° C., then weighed and total ash content recorded.

For uranium trace element analysis, 1.0 gm samples were added to 5 mls of 4N HNO_3 then placed in a heating base for two hours at 70° C. After heating, the solutions were diluted to 50 mls with double distilled and deionized water. Solutions were agitated and allowed to settle, then 0.2 mls of digested sample was placed in a quartz curvette and brought to calibrated volume (7 ml) with deionized water. Fluran was added to activate the solution which was then scanned with a model UA3 Scintrex uranium analyzer. The detection limit for uranium using this method was 5 ppb.

ANALYTIC VARIABILITY

Analytical variability was determined by two methods. The first method was used to analyze a lake sediment precision sample with each batch of 20 samples sent to the chemistry lab. The precision sample is a large homogeneous lake sediment sample prepared identically to the lake sediment samples from this survey. The analytical precision was calculated at the 95% confidence level for the 't' distribution, however, in Table 3 there appears to be a high degree of variability in precision samples (±3% to ±42%). This phenomena may be due to length of storage time for the pre-cision samples and that, over a period of years, oxidizing or reducing conditions could chemically alter the sample.

TABLE 3: Analytical Precision for East-Central Minnesota Lake Sediment Samples

Element	Analytical Precision from Precision Samples*	Analytical Precision from Reanalyzed Samples
As	±34%	±21%
Co	±31%	±14%
Cu	±29%	± 4%
Ni	±24%	± 4%
Pb	±42%	± 0%
Zn	±29%	± 2%
Fe	±12%	±13%
Mn	±14%	± 1%
U	±28%	± 5%
LOI	± 3%	± 2%

*95% Confidence interval.

The second method for determining analytical variability was to reanalyze randomly selected samples from each batch (approx. one duplicate for every twenty samples). The analytical precision was calculated by a method adapted from Garret (1969 and 1973) for geochemical data. The results are shown in the third column in Table 3. Most Ag values were below the detection limit; therefore, analytical precision for Ag was not calculated.

STATISTICAL ANALYSIS

Statistical analyses were performed on the lake sediment data to isolate anomalous relationships and characteristics between individual elements, LOI, and other parameters. Analytically, the raw data varies from approximately linear to near lognormal. Statistical parameters were compared for seven major bedrock units encompassing the survey area. Lake sediment analyses were compared to the general chemistry of the underlying bedrock to investigate possible associations. The complete analytical data set for the 618 lake sediment samples is given in the appendix.

Initially, an analysis of the total data set was computed for the entire survey area. First, a visual analysis of normality versus lognormality was performed using histograms and cumulative frequency distributions. Hence, log transformations could be calculated, when required, so that correlation, regression, and scatter diagrams could be compared consistently.

After reviewing the raw data, it was evident that Ag, As, Cu, Pb, Ni, Zn, Mn, Fe, and U approximate lognormal distributions, whereas temperature, pH, depth, and LOI approximate a normal distribution. Consequently, the metallic elements required log transformation, however, no linearization was needed for the remaining variables.

Statistical Analysis of Total Data Set

Initially statistical analysis was performed using the entire lake sediment data set from east-central Minnesota. Table 4 displays elements by range, mean, standard deviation, coefficient of variation, and median, and indicate significant differences in element concentrations over the seven major bedrock geological subdivisions. The histograms and cumulative frequency distributions for Ag, As, Co, Cu, Ni, Pb, Zn, Fe, Mn, and U are shown on Plates 2-11, and for LOI in Figure 9.

Next, linear correlation analyses were performed on the data set and are listed in Table 5. The linear regression model used is known as the Method of Least Squares (Lindgren et al., 1978). Linear correlation coefficients are used to determine the degree of independence and interdependence between element types. Correlation values may range from −1 to +1. A −1 value indicates a perfect inverse correlation, a 0 value indicates complete independence, whereas a +1 value indicates a total interdependence between correlated elements. For example, a positive correlation (0.45) occurs between Fe and Mn, indicating a moderate interdependent relationship. Similar results are reported by Vadis and Meineke (1982a, b). Although irregular concentrations of Fe

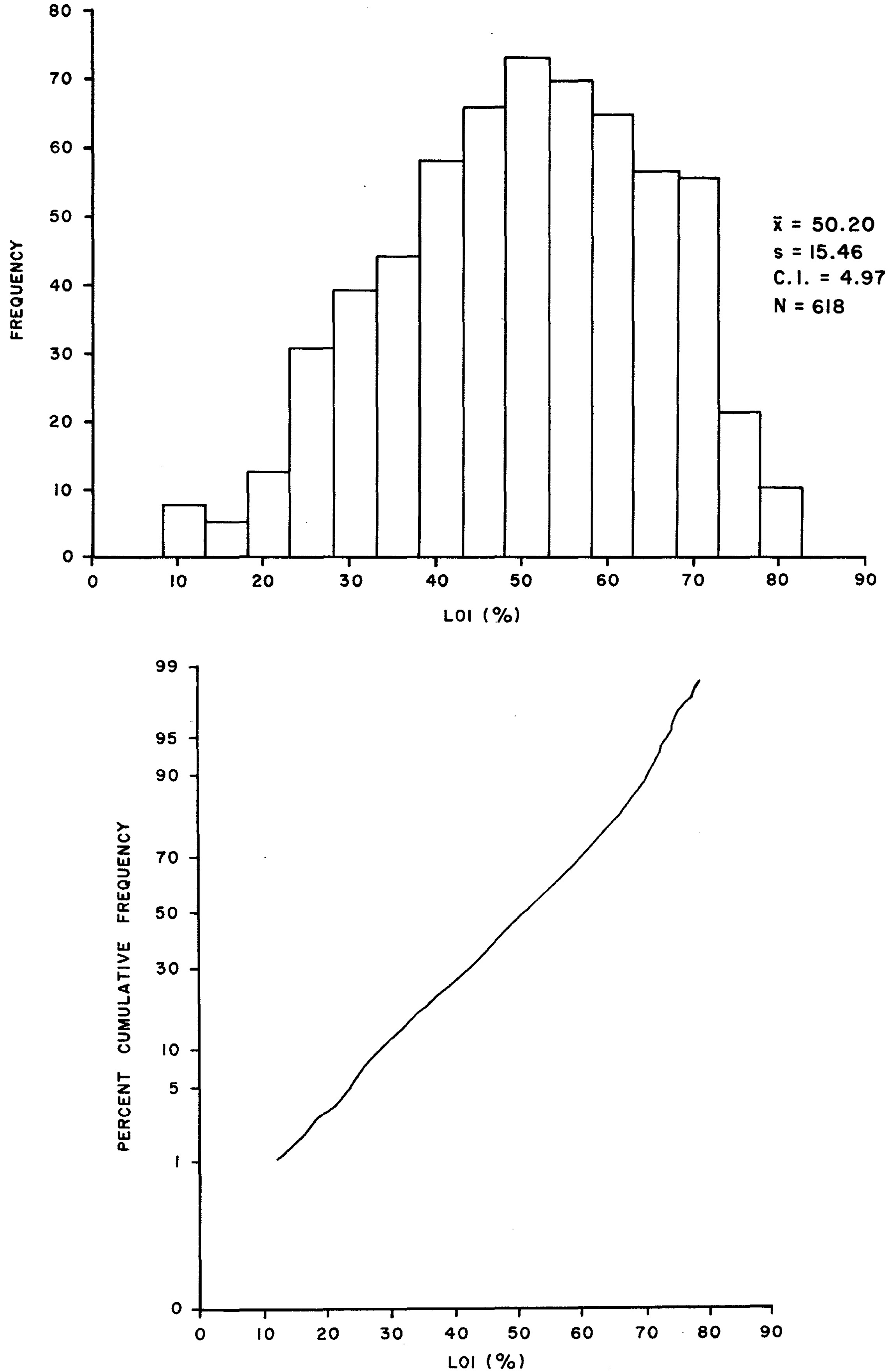


FIGURE 9: Histogram and cumulative frequency distribution of loss-on-ignition (LOI).

TABLE 4: Distribution Statistics for Element Concentrations, LOI, and Water Depth

Element	Range	Arith. $\bar{X}$	$Log_{10}\bar{X}$*	Std. Dev.	C.V.%**	Median
Ag (ppm)	0-9	0.47	1.62	1.29	274	0
As (ppm)	0.6-77.5	8.23	5.45	8.40	102	5.6
Co (ppm)	1-41	9.52	8.39	4.94	52	8
Cu (ppm)	3-78	16.96	14.38	10.49	62	14
Ni (ppm)	2-49	17.83	15.62	9.04	51	16
Pb (ppm)	0-40	10.43	13.79	9.69	93	1
Zn (ppm)	4-356	82.00	64.16	60.33	74	61
Fe (%)	0.13-24.1	4.17	2.25	4.66	112	2
Mn (ppm)	20-34,000	1235.13	440.72	2779.32	225	350
U (ppm)	0.22-42.1	1.63	1.30	2.66	163	1.32
LOI (%)	8.2-82.8	50.20	5.41	15.46	31	42.6
Water Depth (ft)	0-106	25.17	18.37	18.75	74	21.0

Note: N = 618

* Calculated from log_{10} transformed data and antilogged for the arithmetic mean value shown. All other statistical parameters are non-log data.

** Coefficient of Variation, % = $\frac{\text{(Std. Dev.) (100)}}{\text{(Arith. } \bar{X})}$

TABLE 5: Correlation Matrix for East-Central Minnesota Lake Sediment Survey (N = 618)

	Surf. Water Temp.	Surf. Water pH	Sed. Temp.	Sed. pH	LOI	U	Mn	Fe	Zn	Pb	Ni	Cu	Co	As	Ag
Depth	NA	.13	−.43	.06	−.15	.00	.18	.10	.00	.01	.03	.06	.02	.13	.03
Ag	−.03	.01	.00	.00	−.28	−.02	−.02	−.10	−.41	.37	−.05	−.39	−.05	.00	
As	.00	.21	−.04	.20	−.10	.03	.11	.26	−.03	.04	.00	.00	.04		
Co	.03	.00	.00	.08	−.14	.00	.16	.18	.25	.02	.44	.33			
Cu	.00	.00	−.01	.01	−.04	.00	.02	.04	.43	−.01	.64				
Ni	.00	.00	.00	.03	−.12	.00	.04	.05	.31	.00					
Pb	.00	.05	.00	.01	−.16	.00	.02	.00	.01						
Zn	.02	−.06	.00	.00	.01	.00	.01	.00							
Fe	.04	.03	−.06	−.10	.11	.00	.45								
Mn	.00	.11	−.04	.19	−.22	.01									
U	−.01	.01	.00	.01	.00										
LOI	.00	−.11	.02	.00											
Sed. pH	.00	.25	−.02												
Sed.Temp.	.00	−.03													
Water pH	.00														

Note: Mineral element data log_{10} transformed prior to calculation of correlation coefficients. All other data correlated normally.

NA: Not Applicable

and Mn can create false trace element anomalies, there is little evidence of scavenging and coprecipitation from correlated data in Table 5 (Vadis and Meineke, 1982b). However, Fe and Mn scavenging may occur, locally.

Other trace elements exhibit positive correlations from lake sediment data in east-central Minnesota. For example, Zn has an affinity for both Cu (0.43) and Ni (0.31), whereas Ni correlates moderately with Co (0.44) and strong with Cu (0.64). Furthermore, Cu and Co show a positive relation (0.33). Lead (Pb) has a 0.37 relationship with Ag. Loss-on-Ignition (LOI) shows a weak negative relationship with most of the metallic elements, indicating independent relationships. These trace element associations may occur near many types of economic mineral deposits (Rose et al., 1979).

Data for pH and temperature were available for only 50% of the selected sample sites. The correlation coefficients (Table 5) of pH and temperature for both water and lake sediments were inconsistent, specifying a nonexistent to weak relationship. However, there is a negative correlation (−0.43) between lake sediment temperature and water depth confirming that lake sediment temperature decreases with increasing water depth.

Statistical Analysis by Rock Type

Statistical parameters were calculated for each of the seven major geologic bedrock groupings which are based upon inferred geologic contacts (Morey et al., 1981). Since the geology of east-central Minnesota is so complex, it was necessary to generalize and group similar lithological rock units together, so that enough data could be statistically analyzed for each bedrock type (Table 6). The seven major rock types compared are: Archean Gneiss, Mahnomen Formation, Rabbit Lake/Thomson Formation, Iron Formation, Randall Formation, Mille Lacs Group Undivided, and Metavolcanics. Groups not included due to a lack of data points are the Glen Township Formation (N = 3) and the Trout Lake For-

TABLE 6: Legend of Rock Groupings Between Plate Maps and Report Text

Rock Type	No. of Samples	Designation on* Plate Map	Designation on** Computer File
Rabbit Lake/Thomson	172	ru, tgs	RL
Archean Gneiss	149	gs	AG
Mahnomen Formation	125	ma	MA
Mille Lacs Group Undivided	90	mlu	ML
Iron Formation	46	eif, tf, rif	I
Metavolcanics	21	mif, mlb	MV
Randall Formation	10	rfm	R
Glen Township Formation	3	gtc, gtm	G
Trout Lake Formation	2	tld	T

*Refers to geology index on plates inside back cover.
**See appendix column 14 under "Rock Type."

TABLE 7: Distribution Statistics of Lake Sediment Element Data Segrated by Major Geologic Bedrock Subdivisions

Element	Rock Type	Range	Arith. $\overline{X}$	$\text{Log}_{10}\overline{X}$*	Std. Dev.	C.V.%**	Median
Ag(ppm)	Archean Gneiss	0-9	1.06	2.74	2.18	205.66	0
	Mahnomen Form	0-4	0.21	1.13	0.54	257.14	0
	Rabbit Lake/Thomson	0-2	0.31	1.12	0.55	177.42	0
	Iron Form.	0-3	0.23	1.25	0.59	256.52	0
	Randall Form.	0-3	0.30	3.00	0.90	300.00	0
	Mille Lacs Grp. Undvd.	0-8	0.33	1.98	1.11	336.36	0
	Metavolcanics	0-3	0.38	2.62	0.94	247.37	0
As(ppm)	Archean Gneiss	0.6-40	7.10	4.47	7.14	100.56	4.4
	Mahnomen Form.	0.6-62	9.57	5.99	10.28	107.42	5.6
	Rabbit Lake/Thomson	0.8-77.5	8.12	5.59	8.45	104.06	6
	Iron Form.	1.2-27.2	6.75	5.19	5.33	78.96	5
	Randall Form.	1.4-17	7.38	1.40	5.50	74.53	4.3
	Mille Lacs Grp. Undvd.	1-33.2	8.60	6.15	6.83	79.42	7.2
	Metavolcanics	1.7-51	11.89	7.00	13.62	114.55	8
Co(ppm)	Archean Gneiss	1-19	7.91	7.07	3.65	46.14	7
	Mahnomen Form.	2-19	9.02	8.18	3.92	43.46	8
	Rabbit Lake/Thomson	3-41	12.23	10.96	5.63	46.03	11
	Iron Form.	2-35	11.58	9.58	7.01	60.54	11
	Randall Form.	4-8	5.80	5.60	1.53	26.38	5
	Mille Lacs Grp. Undvd.	2-20	7.52	6.95	3.08	40.96	7
	Metavolcanics	4-14	7.85	7.53	2.25	28.66	8
Cu(ppm)	Archean Gneiss	4-78	13.73	12.07	8.43	61.40	12
	Mahnomen Form.	5-76	17.53	14.57	11.72	66.86	15
	Rabbit Lake/Thomson	4-69	21.58	19.00	10.75	49.81	20
	Iron Form.	4-43	18.47	15.47	11.20	60.63	15
	Randall Form.	4-17	9.10	8.58	3.17	34.84	8.5
	Mille Lacs Grp. Undvd.	3-51	12.84	11.19	7.70	59.97	11.5
	Metavolcanics	6-38	16.85	15.13	8.06	47.83	14
Ni(ppm)	Archean Gneiss	4-40	15.57	14.10	7.14	45.86	15
	Mahnomen Form.	5-49	16.40	14.40	8.43	51.40	14
	Rabbit Lake/Thomson	5-47	23.69	21.69	9.02	38.08	24
	Iron Form.	5-46	18.56	15.79	10.44	56.25	15.5
	Randall Form.	6-18	10.50	9.89	3.64	34.67	10
	Mille Lacs Grp. Undvd.	2-36	13.35	11.79	6.84	51.24	12
	Metavolcanics	8-30	15.38	14.18	6.38	41.48	14
Pb(ppm)	Archean Gneiss	0-40	11.40	16.62	12.45	109.21	10
	Mahnomen Form.	0-34	9.44	13.09	8.54	90.47	10
	Rabbit Lake/Thomson	0-40	12.55	13.55	8.56	68.21	10
	Iron Form.	0-30	8.78	13.22	8.77	99.89	10
	Randall Form.	0-17	5.60	13.71	7.07	126.25	0
	Mille Lacs Grp. Undvd.	0-40	8.15	12.43	7.99	98.04	10
	Metavolcanics	0-22	6.80	11.53	6.45	94.85	10
Zn(ppm)	Archean Gneiss	4-263	53.10	43.00	35.52	66.89	45
	Mahnomen Form.	17-300	81.90	67.71	53.52	65.35	61
	Rabbit Lake/Thomson	18-356	119.16	100.66	67.75	56.86	106.5
	Iron Form.	19-334	99.15	76.76	81.25	81.95	67
	Randall Form.	23-99	43.80	40.55	19.96	45.57	38
	Mille Lacs Grp. Undvd.	11-167	58.33	48.58	35.95	61.63	49.5
	Metavolcanics	20-187	68.76	56.42	44.11	64.16	53

TABLE 7: (continued)

Element	Rock Type	Range	Arith. $\bar{X}$	$Log_{10} \bar{X}$*	Std. Dev.	C.V.%**	Median
Fe(%)	Archean Gneiss	0.13-15.9	3.31	1.69	3.50	105.74	1.4
	Mahnomen Form.	0.18-20.8	4.42	2.18	5.44	123.08	1.7
	Rabbit Lake/Thomson	0.25-21.2	4.97	3.22	4.71	94.77	3.15
	Iron Form.	0.3-24.1	4.98	2.78	5.29	106.22	2.91
	Randall Form.	0.22-7.87	1.97	0.90	2.46	124.87	0.54
	Mille Lacs Grp. Undvd.	0.13-18.2	3.49	1.75	4.52	129.51	1.48
	Metavolcanics	0.61-16.6	5.00	3.11	4.77	95.40	2.83
Mn(ppm)	Archean Gneiss	33-8,000	792.22	325.51	1,270.69	160.40	196
	Mahnomen Form.	50-13,920	897.48	393.95	1,711.04	190.65	320
	Rabbit Lake/Thomson	20-34,000	1,778.42	625.41	4,038.95	227.11	520
	Iron Form.	70-8,040	1,141.10	502.79	1,690.80	14.82	443
	Randall Form.	79-700	236.70	175.77	203.05	85.78	144
	Mille Lacs Grp. Undvd.	52-17,200	1,277.60	389.22	2,770.80	21.69	265
	Metavolcanics	135-19,600	2,674.66	981.66	4,282.95	160.13	835
U(ppm)	Archean Gneiss	0.24-42.1	1.82	1.35	3.60	197.80	1.36
	Mahnomen Form.	0.22-17.8	1.48	1.15	2.03	137.16	1.19
	Rabbit Lake/Thomson	0.35-7.29	1.55	1.38	0.82	52.90	1.53
	Iron Form.	0.31-2.77	1.34	1.19	0.61	45.52	1.17
	Randall Form.	0.96-2.29	1.46	1.39	0.46	31.51	1.35
	Mille Lacs Grp. Undvd.	0.31-41.79	1.92	1.30	4.44	231.25	1.28
	Metavolcanics	0.74-2.08	1.33	1.29	0.32	24.06	1.25

Note: Archean Gneiss (N = 149), Mahnomen Formation (N = 125), Rabbit Lake/Thomson Formation (N = 172), Iron Formation (N = 46), Randall Formation (N = 10), Mille Lacs Group Undivided (N = 90), Metavolcanics (N = 21), Not represented are Trout Lake Formation (N = 2) and Glen Township Formation (N = 3)

* Calculated from $\log_{10}$ transformed data and antilogged for the arithmetic mean values shown. All other statistical parameters refer to non-log data.

** Coefficient of Variation, % = $\frac{\text{Std. Dev. (100)}}{\text{Arith. } \bar{X}}$

mation (N = 2).

Statistics were computed identically to that of the entire data set, except, in this case, statistics were performed for each rock type. In this way, it was easier to see irregularities, anomalies, relationships, and contrasts between individual rock types. Figure 10 shows a frequency distribution for Cu as an example to illustrate subtle differences in concen-tration levels between five of the seven major geologic units. Table 7 depicts elements by rock type, mean, standard deviation, coefficient of variation, and median.

Anomalous amounts of Ag over Archean Gneiss terrane are shown in Table 7 and on Plate 2. Other Ag anomalies scattered throughout the east-central Minnesota survey area are illustrated on Plate 12. Metavolcanics immediately west of Mille Lacs Lake exhibit high background values of As (11.89 ppm). Also, above average concentrations of Co, Cu, Ni, and Zn are found over slate and shale bedrock including Mahnomen Formation, Rabbit Lake/Thomson Formation, and various Iron Formations. These results are supported by investigations of similar rock types by Rose et al (1979). On the other hand, Pb is relatively uniform throughout the seven major bedrock units, except for slightly higher concentrations above Archean Gneiss and Rabbit Lake/Thomson Formation. As expected, Fe shows higher average values (arith. $\bar{X}$ = 5%) above Rabbit Lake/Thomson Formation, Iron Formation, and Metavolcanics. Similarily, Mn displays high uniform values over Rabbit Lake/Thomson Formation as well as metavolcanic units. In contrast, U shows little geochemical response, with the exception of slightly higher values above Mille Lacs Group Undivided (Plate 11).

Correlation Analysis by Rock Type

Correlation matrices for the five major rock types are shown in Tables 8-12. Unfortunately, Metavolcanics (N = 21), Randall Formation (N = 10), Glen Township Formation (N = 3), and Trout Lake Formation (N = 2) could not be realistically analyzed due to a lack of sufficient data points.

Gneissic rocks in Table 8 depict moderate correlations of Ni to Co (0.39) and Ni to Cu (0.37). Also, Mn and As display a correlation coefficient of 0.58. A marked difference was revealed when Ag was correlated with Zn and Pb, that is, Zn demonstrates a strong negative relation (-0.75), whereas Pb demonstrates a strong positive relation (0.70).

Table 9 illustrates correlation values for samples taken above Rabbit Lake/Thomson Formation. Arsenic (As) is moderately associated with Mn (0.40) and Fe (0.39), which may indicate scavenging by Mn and Fe hydroxides. Copper (Cu) and Ni share a strong association (0.71), but a somewhat weaker relation is exhibited by Co with Cu (0.34) and Ni (0.43). Manganese (Mn) and Fe show a typical positive relationship (0.50).

The Mahnomen Formation (Table 10) correlates similarily with the Rabbit Lake/Thomson Formation as indicated above. However, there are some additional associations present. For example, Zn shows a moderate to strong positive relationship with Ni (0.42) and Cu (0.52). In contast, LOI relates somewhat negatively with Mn (-0.42). This inverse coefficient suggests that Mn is concentrated in the inorganic fraction of the lake sediment.

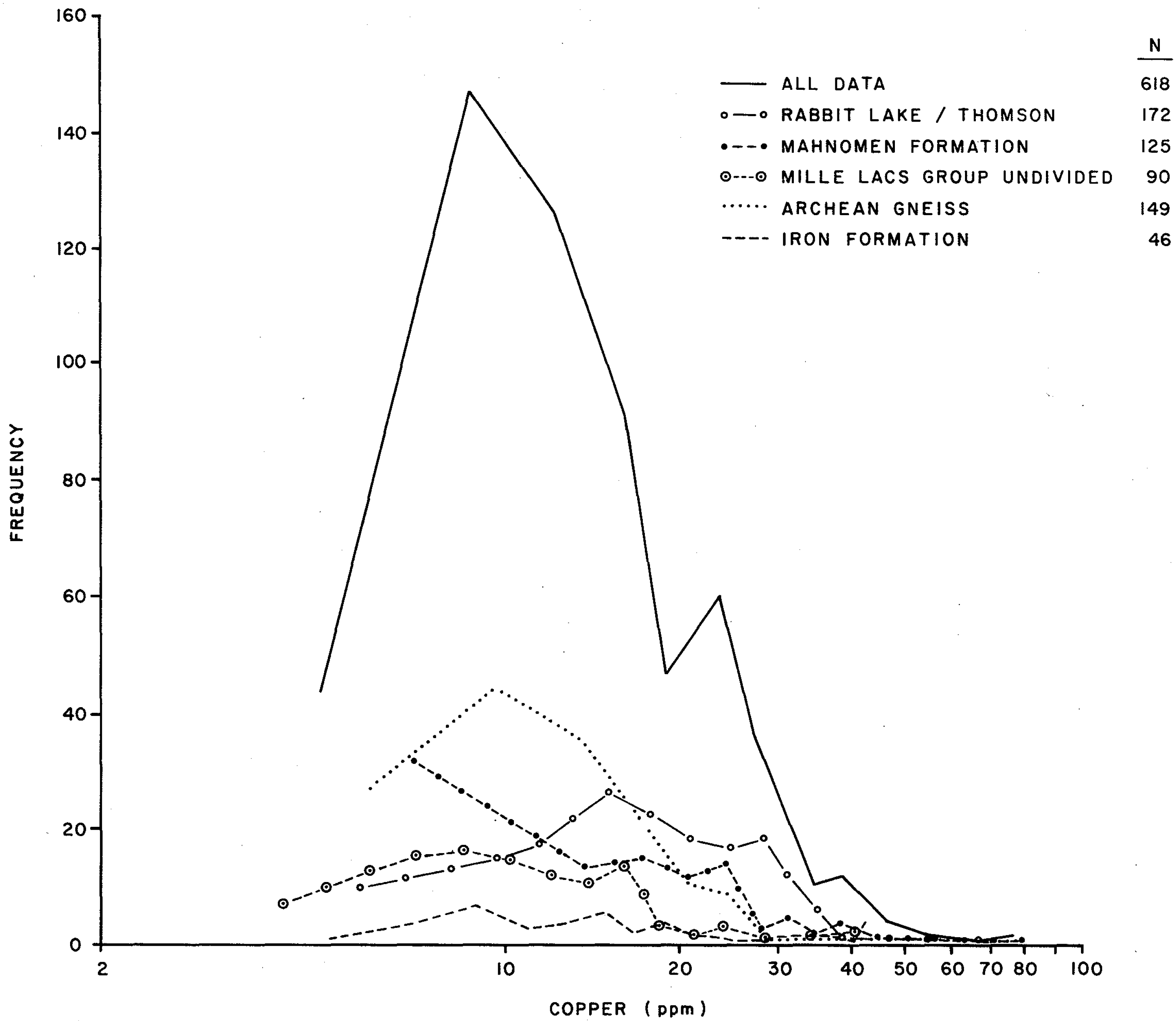


FIGURE 10: Frequency distribution of copper in lake sediment data from major bedrock geologic subdivision in east-central Minnesota.

TABLE 8: Correlation Matrix for Archean Gneiss in East-Central Minnesota (N = 149)

	LOI	U	Mn	Fe	Zn	Pb	Ni	Cu	Co	As	Ag
Depth	−.09	.07	.16	.04	.00	.01	.00	.01	.00	.21	.00
Ag*	−.49	−.04	−.03	−.09	−.75	.70	.00	−.58	.03	.00	
As	−.13	.10	.58	.14	−.07	.05	.02	.00	.03		
Co	−.09	.00	.10	.11	.02	.10	.39	.09			
Cu	.00	.01	.00	.06	.31	−.23	.37				
Ni	−.14	.00	.08	.09	.01	.02					
Pb	−.33	−.02	.06	.00	−.35						
Zn	.15	.00	−.01	.00							
Fe	−.01	.00	.27								
Mn	−.21	.06									
U	.00										

Note: Mineral element data $\log_{10}$ transformed prior to calculation of correlation coefficients. All other data correlated normally.
* Only 40 samples exceed the detection limit.

TABLE 9: Correlation Matrix for Rabbit Lake/Thomson Formation in East-Central Minnesota (N = 172)

	LOI	U	Mn	Fe	Zn	Pb	Ni	Cu	Co	As	Ag
Depth	−.10	.01	.10	.10	.00	.01	.11	.19	.12	.03	.00
Ag*	.00	.02	.00	.06	.00	−.05	−.01	−.02	.00	.02	
As	−.06	.11	.40	.39	−.06	.04	.00	−.01	.07		
Co	−.32	.04	.29	.23	.20	.06	.43	.34			
Cu	.20	.00	.04	.00	.26	.02	.71				
Ni	−.26	.00	.04	.01	.26	.04					
Pb	−.06	.00	.05	.00	.02						
Zn	.00	.00	.00	.00							
Fe	−.12	.07	.50								
Mn	−.16	.06									
U	.00										

NOTE: Mineral element data $\log_{10}$ transformed prior to calculation of correlation coefficients. All other data correlated normally

* Only 42 samples exceed the detection limit.

TABLE 10: Correlation Matrix for Mahnomen Formation in East-Central Minnesota (N = 125)

	LOI	U	Mn	Fe	Zn	Pb	Ni	Cu	Co	As	Ag
Depth	−.21	.00	.17	.10	.01	.06	.09	.12	.03	.17	−.08
Ag*	.00	.05	−.01	−.01	−.01	.00	−.23	−.22	−.18	.01	
As	−.31	.00	.48	.38	−.04	.05	.00	.00	.02		
Co	−.24	.00	.17	.23	.29	.00	.54	.37			
Cu	−.05	.00	.02	.04	.52	.00	.75				
Ni	−.12	.00	.06	.07	.42	.00					
Pb	−.16	.00	.00	.01	.00						
Zn	.00	.00	.00	.01							
Fe	−.29	.00	.50								
Mn	−.42	.00									
U	.04										

NOTE: Mineral element data $\log_{10}$ transformed prior to calculation of correlation coefficients. All other data correlated normally.

* Only 22 samples exceed the detection limit.

TABLE 11: Correlation Matrix for Iron Formation in East-Central Minnesota (N = 46)

	LOI	U	Mn	Fe	Zn	Pb	Ni	Cu	Co	As	Ag
Depth	−.29	−.02	.06	.13	.00	.07	.01	.03	.03	.15	.08
Ag*	−.04	.04	.00	−.01	−.34	.45	−.15	−.47	−.64	.36	
As	−.16	.00	.50	.54	−.02	.06	.02	.00	.06		
Co	−.13	−.04	.15	.13	.43	.00	.53	.52			
Cu	−.27	.00	.04	.04	.33	.00	.78				
Ni	.00	.06	.06	.33	.03						
Pb	−.12	.01	.07	.02	.00						
Zn	.00	−.05	.00	.00							
Fe	−.20	.00	.52								
Mn	−.15	.05									
U	.00										

Note: Mineral element data $\log_{10}$ transformed prior to calculation of correlation coefficients. All other data correlated normally.

* Only 10 samples exceed the detection limit.

Table 11 represents correlation data analyzed from samples collected over Iron Formation. These results are similar to correlation analyses of Mahnomen Formation, with the exception of little association between Mn and LOI. Ag correlates negatively with Zn (-0.34), Cu (-0.47), and Co (-0.64), however, Pb and As are positively associated to Ag with coefficients of 0.45 and 0.36, respectively.

Finally, Table 12 delineates correlation coefficients over Mille Lacs Group Undivided lithology. These correlations illustrate a familiar positive relationship between Mn and Fe (0.49), Cu and Ni (0.55), and Co and Ni (0.35). Also, Zn is moderately associated with Cu (0.45). However, Ag displays a mixed association with Fe (-0.34), Zn (-0.46), and Pb (0.82). These trace element correlations mark familiar associations with their respective bedrock types (Rose et al., 1979).

TABLE 12: Correlation Matrix for Mille Lacs Group Undivided in East-Central Minnesota (N = 90)

	LOI	U	Mn	Fe	Zn	Pb	Ni	Cu	Co	As	Ag
Depth	−.27	−.01	.36	.16	.00	.00	.00	.01	.01	.16	.32
Ag*	−.07	−.02	−.19	−.34	−.46	.82	−.01	−.16	−.07	−.08	
As	−.04	.00	.26	.18	−.03	.03	.00	−.01	.07		
Co	−.04	.00	.13	.09	.16	.00	.35	.24			
Cu	.00	.05	.00	.00	.45	−.07	.55				
Ni	−.01	−.06	−.01	.00	.27	−.03					
Pb	−.11	.00	.00	−.07	−.13						
Zn	.03	.00	.00	.02							
Fe	−.08	.00	.49								
Mn	−.25	.00									
U	−.25										

Note: Mineral element data log_{10} transformed prior to calculation of correlation coefficients. All other data correlated normally.
* Only 20 samples exceed the detection limit.

SURVEY RESULTS AND DISCUSSION

Plates 1-12 (inside back cover) were produced in cooperation with Land Management Information Center (LMIC). The introduction of computer graphics by the Division of Minerals for illustrating geochemical maps was initiated in this report. In addition, the most current bedrock geology is superimposed on each trace element map. As a result, trace element concentrations can be coupled with each bedrock unit for convenient visual comparison.

The shaded circles represent ranges of concentration determined from cumulative frequency distributions for each element. To better depict anomalies, the circular polygons are shaded darker with increasing trace element concentration. In this way, anomalies are more directly located, as compared to grade contouring (isopach maps), which may lead to false anomalies when data points are sparse and scattered over relatively great distances. To avoid overlap, twenty percent ranges were selected, except for Pb and Ag. Accordingly, Pb is shown with a skewed percentile range, whereas Ag is shown in ppm. Lead (Pb) has an irregular percentile range because 60% of the data points fall below the 10 ppm detection limit (Table 2). Silver (Ag) is shown in ppm since most of the data is below the detection limit (Table 2). At concentrations above the 80th percentile, ranges were reduced to illustrate anomalous samples (i.e. percentiles 80-90%, 90-95%, 95-99% and 99-100%). The appendix lists sample numbers and concentration values for each element. Plate 1 illustrates sample location sites along with corresponding sample numbers.

The percentile maps (Plates 2-11) illustrate at least six unique anomalous areas. These local areas, along with anomalous elements, are as follows: West of Pelican Lake(Ag, As, Cu, Pb, Mn, U); Pillager Lake (Ag, As, Zn, Pb, U); east of Serpent Lake (As, Fe, Cu, Zn, Ni, Co, Mn, U); west of Mille Lacs Lake (Ag, As, Fe, Cu, Mn); Big Sandy Lake (Ag, As, Co, Zn, Ni); and Tamarack-Wright, MN (Fe, Cu, Zn, Co, Ni, Pb). These six areas are shown on Plate 12 which illustrates more than one element concentration that is greater than or equal to 90% cumulative frequency.

The Pelican Lake/Pillager Lake anomalies lie over Archean gneissic terrane (Morey et al., 1981). However, recent drilling results indicate that these geochemical anomalies possibly lie over volcanic rocks (Southwick, 1984). The large anomaly east of Serpent Lake lies over proposed Rabbit Lake Formation, but this geology is also unknown and may be volcanic terrane (Southwick, 1984). West of Mille Lacs Lake is an anomalous area of metavolcanics and iron-formation. Here, there is some drilling information, but the geology is based primarily on geophysics. The Big Sandy Lake anomaly lies over Rabbit Lake Formation, and the adjacent Tamarack-Wright anomaly is located on the inferred fault contact between the Rabbit Lake and Thomson formation.

As indicated in Table 7, distinct differences in trace element concentration exist between the various bedrock types in the survey area. Therefore, when viewing the anomaly maps, care must be taken to ensure that anomalous trace element concentrations over some rock types are not mistaken for background values. In other words, an apparent anomaly may only represent a rock unit with a high background. The geology must also be considered recognizing that it is not well known in many instances.

SUMMARY AND CONCLUSIONS

An organic-rich lake sediment survey was undertaken in east-central Minnesota to try to determine if the lake bottom media would reflect the bedrock in an area of complicated, thick glacial overburden. Six hundred eighteen samples were collected from 463 lakes, ponds, and marshes encompassing an area of 3150 mi^2 (8160 km^2). The samples were prepared by freeze drying and then ground to −80 mesh. Next, the samples were chemically digested and analyzed for Ag, As, Co, Cu, Pb, Ni, Zn, Fe, and Mn with the aid of atomic absorption spectrophotometry. Uranium was analyzed with a Scintrex uranium analyzer and organic content was estimated by ashing (LOI).

Computer-aided statistical analyses were performed on the entire data set in an attempt to identify, as well as distinguish, the correlations, associations and relationships between bedrock and individual elements. Statistical analysis showed little positive correlation of Fe and Mn with the other trace elements. Therefore, on a regional scale, scavenging and coprecipitation by Fe and Mn hydroxides apparently had no significant adverse effects such as creating false anomalies in the survey area. However, scavenging and coprecipitation by Fe and Mn hydroxides may occur on a local scale. Also, slight negative correlations between LOI and metallic elements suggest an absence of organic complexing known to create false anomalies.

Caution is necessary to properly digest and interpret the raw data due to intricate, thick glacial overburden. In addition, variable glacial till chemistry may result in fluctuating background values, which should be noted prior to final mineral potential evaluations. In general, however, the element concentrations do reflect the bedrock chemistry, suggesting that lake sediment geochemistry can be a useful tool in locating halos of economic mineralization. The success of lake sediment geochemistry is strongly dependent upon favorable geologic, hydrologic, and chemical conditions. Furthermore, local Pleistocene glacial geology must be thoroughly understood along with ice flow patterns to determine the sources of geochemical anomalies in east-central Minnesota.

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Appendix

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11248	45.00	.0	6.80	7.00	18.00	14.00	.0	56.00	5.50	106.00	1.85	61.20	MA
11249	72.00	.0	13.00	5.00	23.00	13.00	.0	53.00	.6	1583.00	1.06	54.60	MA
11250	55.00	.0	9.40	4.00	14.00	10.00	.0	54.00	.18	317.00	1.57	62.40	MA
11251	30.00	.0	21.20	7.00	20.00	13.00	.0	50.00	3.85	514.00	1.60	56.60	MA
11252	42.00	.0	27.60	7.00	12.00	10.00	.0	37.00	7.00	5000.00	1.25	40.00	MA
11253	35.00	.0	14.60	9.00	26.00	19.00	.0	45.00	5.00	1278.00	1.60	44.60	MA
11254	45.00	.0	15.00	5.00	11.00	12.00	14.00	34.00	3.88	3900.00	1.65	36.80	RL
11255	22.00	.0	12.80	7.00	16.00	13.00	17.00	37.00	3.03	2020.00	1.02	32.80	I
11256	37.00	4.00	11.40	10.00	5.00	8.00	22.00	8.00	.49	842.00	2.15	10.20	AG
11257	35.00	4.00	11.40	8.00	6.00	10.00	27.00	8.00	.3	1145.00	2.08	8.60	AG
11258	4.00	4.00	21.40	8.00	6.00	11.00	21.00	4.00	.22	338.00	1.04	14.00	AG
11259	25.00	.0	2.60	8.00	78.00	29.00	.0	78.00	1.97	137.00	2.36	65.00	AG
11260	5.00	.0	3.40	6.00	15.00	13.00	15.00	61.00	.62	2430.00	1.57	25.40	AG
11261	5.00	.0	.6	4.00	9.00	8.00	.0	18.00	.14	48.00	.96	19.40	AG
11262	5.00	.0	1.40	6.00	12.00	12.00	.0	35.00	.26	193.00	1.34	64.80	AG
11263	10.00	.0	1.80	5.00	5.00	7.00	.0	41.00	1.86	60.00	1.06	59.60	AG
11264	35.00	.0	6.80	12.00	17.00	18.00	.0	83.00	3.43	666.00	1.95	31.20	AG
11265	6.00	.0	5.40	10.00	19.00	36.00	.0	69.00	1.06	352.00	2.06	77.60	ML
11266	3.00	.0	3.60	4.00	8.00	8.00	17.00	50.00	.22	79.00	2.29	73.00	R
11267	14.00	.0	13.80	8.00	10.00	14.00	13.00	37.00	1.13	419.00	3.00	59.00	ML
11268	15.00	.0	17.00	8.00	10.00	14.00	.0	47.00	2.13	527.00	2.21	58.00	R
11269	58.00	.0	6.20	3.00	12.00	10.00	15.00	41.00	.64	161.00	1.72	51.00	AG
11270	45.00	.0	5.00	4.00	10.00	9.00	.0	30.00	.53	113.00	1.69	39.00	AG
11271	12.00	.0	5.60	1.00	8.00	4.00	.0	33.00	.56	94.00	1.34	76.00	AG
11272	12.00	3.00	2.60	6.00	5.00	8.00	23.00	10.00	.18	447.00	1.17	12.00	AG
11273	45.00	.0	7.60	6.00	11.00	11.00	10.00	37.00	2.53	447.00	1.52	51.00	AG
11274	20.00	.0	ND	6.00	7.00	8.00	.0	37.00	.41	110.00	1.53	61.00	AG
11275	11.00	.0	1.80	5.00	16.00	18.00	.0	49.00	.51	78.00	1.10	27.00	ML
11276	6.00	.0	2.80	4.00	15.00	9.00	11.00	45.00	2.82	92.00	1.18	45.00	ML
11277	5.00	.0	2.60	5.00	6.00	8.00	20.00	37.00	.22	112.00	1.04	78.00	AG
11279	12.00	.0	4.20	5.00	9.00	13.00	.0	40.00	.28	94.00	1.69	72.00	R
11280	7.00	.0	1.60	6.00	6.00	10.00	14.00	23.00	.16	75.00	1.96	57.00	ML
11281	8.00	.0	3.00	5.00	17.00	18.00	10.00	34.00	.49	139.00	1.63	40.00	R
11282	4.00	.0	5.80	4.00	5.00	10.00	.0	34.00	.49	139.00	1.38	66.00	MA
11283	23.00	.0	19.20	5.00	6.00	5.00	.0	25.00	2.16	447.00	1.94	61.00	MA
11284	28.00	.0	19.40	4.00	8.00	5.00	34.00	54.00	2.94	1285.00	1.31	44.00	MA
11285	6.00	.0	9.40	2.00	6.00	2.00	.0	46.00	.13	52.00	1.25	69.60	ML
11286	7.00	3.00	10.40	9.00	5.00	8.00	26.00	14.00	.33	133.00	1.25	32.80	ML
11287	10.00	.0	9.20	4.00	5.00	3.00	.0	31.00	.38	60.00	1.32	69.40	ML
11288	4.00	.0	2.40	15.00	14.00	38.00	.0	11.00	.29	165.00	13.73	59.40	AG
11289	5.00	.0	1.40	3.00	4.00	7.00	.0	9.00	.13	179.00	1.63	82.00	AG
11290	4.00	.0	6.00	8.00	14.00	35.00	.0	8.00	.48	62.00	12.16	68.80	AG
11291	27.00	2.00	12.80	8.00	7.00	8.00	20.00	23.00	.42	415.00	1.07	37.20	ML
11292	10.00	.0	2.60	5.00	7.00	6.00	.0	73.00	.19	124.00	1.14	65.00	AG
11293	5.00	.0	4.40	4.00	7.00	9.00	13.00	99.00	.23	149.00	1.06	67.60	R
11294	8.00	.0	3.60	8.00	5.00	8.00	12.00	48.00	.33	187.00	1.08	72.80	AG
11295	6.00	.0	3.20	9.00	10.00	11.00	.0	48.00	3.20	112.00	1.14	67.60	AG
11296	8.00	.0	3.20	7.00	7.00	9.00	.0	29.00	.27	87.00	1.20	73.60	AG
11297	9.00	.0	2.20	5.00	4.00	6.00	.0	40.00	.19	58.00	1.10	70.40	AG
11298	5.00	.0	3.00	5.00	14.00	10.00	.0	52.00	.29	49.00	2.24	60.80	AG
11299	4.00	.0	1.40	4.00	11.00	9.00	.0	26.00	.26	92.00	.93	23.40	AG
11300	4.00	.0	4.00	10.00	14.00	17.00	.0	90.00	.61	113.00	1.72	69.40	AG
11301	12.00	.0	1.40	6.00	12.00	12.00	.0	71.00	.18	129.00	1.16	72.60	AG
11302	3.00	.0	1.60	2.00	15.00	13.00	13.00	55.00	.26	140.00	1.07	61.80	AG
11303	6.00	.0	6.40	8.00	19.00	20.00	12.00	117.00	.76	115.00	1.64	69.00	AG
11304	30.00	.0	5.40	4.00	15.00	15.00	25.00	82.00	.83	123.00	1.02	52.20	AG
11305	5.00	.0	1.00	3.00	15.00	16.00	.0	39.00	.46	154.00	1.37	42.20	AG
11306	7.00	.0	1.00	5.00	17.00	20.00	.0	52.00	.72	120.00	1.30	27.80	AG
11307	11.00	.0	1.60	8.00	19.00	16.00	.0	126.00	.67	175.00	1.54	57.60	AG

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11308	22.00	.0	1.20	8.00	18.00	21.00	10.00	65.00	.87	108.00	1.61	27.20	AG
11309	16.00	.0	2.00	11.00	23.00	25.00	10.00	88.00	1.10	130.00	1.61	31.80	AG
11310	40.00	.0	2.60	7.00	23.00	21.00	10.00	62.00	1.28	124.00	1.72	35.20	AG
11311	6.00	.0	4.40	8.00	9.00	13.00	11.00	57.00	.72	137.00	1.75	71.80	AG
11312	19.00	.0	5.20	9.00	9.00	13.00	.0	66.00	1.21	196.00	1.20	66.40	AG
11313	26.00	.0	5.20	6.00	7.00	10.00	.0	58.00	.8	176.00	.79	68.40	AG
11314	9.00	.0	2.20	10.00	17.00	17.00	.0	99.00	.54	84.00	1.49	58.20	AG
11315	6.00	.0	2.40	8.00	14.00	14.00	.0	77.00	.55	107.00	1.20	55.00	AG
11316	23.00	.0	5.20	10.00	21.00	19.00	.0	58.00	1.27	143.00	1.67	35.20	AG
11317	10.00	.0	2.20	6.00	15.00	11.00	.0	46.00	1.40	135.00	1.06	72.40	AG
11318	5.00	.0	1.20	4.00	12.00	12.00	11.00	39.00	.3	121.00	1.28	22.00	AG
11319	19.00	.0	1.60	10.00	16.00	20.00	.0	52.00	.86	127.00	1.19	21.00	AG
11320	6.00	.0	40.40	14.00	38.00	33.00	.0	22.00	3.20	241.00	42.10	59.20	AG
11321	10.00	.0	2.60	6.00	11.00	8.00	.0	42.00	.33	58.00	1.92	70.20	AG
11322	9.00	.0	2.80	7.00	20.00	18.00	10.00	33.00	.66	87.00	.92	53.60	AG
11323	48.00	.0	1.60	7.00	21.00	21.00	.0	90.00	.8	129.00	.92	49.40	AG
11324	45.00	.0	1.80	8.00	22.00	17.00	.0	93.00	1.02	173.00	1.42	46.40	AG
11325	62.00	.0	1.80	7.00	19.00	18.00	11.00	78.00	.75	109.00	1.02	45.80	AG
11326	8.00	.0	2.40	7.00	12.00	10.00	.0	66.00	1.05	106.00	1.06	69.80	AG
11327	5.00	.0	1.40	8.00	8.00	11.00	.0	34.00	.59	86.00	.96	65.60	R
11328	23.00	.0	1.00	5.00	7.00	8.00	.0	39.00	.63	74.00	.85	64.00	AG
11329	6.00	.0	2.80	6.00	8.00	10.00	.0	25.00	.53	81.00	1.17	65.00	MA
11330	5.00	.0	1.60	6.00	7.00	7.00	.0	42.00	.41	161.00	1.44	69.80	MA
11331	5.00	.0	2.40	8.00	11.00	12.00	.0	30.00	.46	112.00	1.49	72.60	R
11332	11.00	.0	2.20	2.00	10.00	6.00	.0	38.00	.3	33.00	1.22	68.60	AG
11333	10.00	.0	2.00	4.00	12.00	12.00	.0	48.00	.61	66.00	1.47	61.60	AG
11334	ND	.0	2.00	3.00	6.00	5.00	.0	27.00	.25	58.00	.83	76.80	MA
11335	25.00	.0	2.40	5.00	10.00	9.00	21.00	88.00	.63	97.00	1.52	56.60	MA
11336	38.00	.0	3.40	2.00	7.00	7.00	15.00	36.00	.74	127.00	.96	58.00	MA
11337	6.00	.0	2.20	5.00	7.00	8.00	.0	38.00	.46	140.00	1.21	70.80	MA
11338	5.00	.0	2.20	3.00	6.00	3.00	.0	19.00	.32	77.00	1.28	82.80	ML
11339	10.00	2.00	4.80	4.00	7.00	10.00	10.00	22.00	.5	141.00	1.14	56.80	ML
11340	15.00	.0	1.80	4.00	10.00	7.00	.0	105.00	.7	98.00	1.09	66.00	AG
11341	7.00	.0	12.60	11.00	7.00	12.00	.0	55.00	5.80	293.00	.86	64.40	ML
11342	20.00	2.00	10.60	10.00	10.00	13.00	17.00	23.00	.7	280.00	1.47	47.80	ML
11343	10.00	.0	3.40	5.00	13.00	6.00	.0	44.00	.27	73.00	1.56	74.80	ML
11344	27.00	.0	13.00	11.00	19.00	17.00	.0	55.00	2.09	213.00	2.29	52.00	ML
11345	28.00	.0	11.20	9.00	18.00	13.00	.0	46.00	1.46	148.00	2.32	59.40	ML
11346	10.00	.0	1.80	3.00	11.00	7.00	.0	37.00	.37	194.00	1.47	74.20	ML
11347	ND	5.00	9.20	8.00	6.00	12.00	25.00	11.00	.92	211.00	1.02	27.20	ML
11348	9.00	3.00	11.00	6.00	4.00	8.00	16.00	23.00	7.87	700.00	.98	47.00	R
11349	7.00	.0	1.80	3.00	3.00	5.00	.0	11.00	1.56	142.00	.53	8.20	ML
11350	20.00	2.00	8.60	8.00	7.00	8.00	14.00	21.00	6.65	2400.00	1.25	27.00	MA
11351	20.00	.0	11.40	5.00	7.00	8.00	15.00	36.00	2.25	512.00	1.12	56.60	MA
11353	28.00	.0	15.80	5.00	8.00	6.00	.0	45.00	2.26	320.00	1.12	55.60	R
11354	26.00	.0	15.80	6.00	8.00	7.00	.0	37.00	2.77	335.00	.93	48.60	ML
11355	18.00	.0	11.00	5.00	9.00	6.00	.0	36.00	5.21	161.00	1.22	69.60	R
11356	4.00	.0	2.80	4.00	7.00	5.00	16.00	35.00	.35	59.00	1.20	69.00	ML
11357	40.00	.0	33.20	6.00	7.00	6.00	.0	32.00	2.33	215.00	1.83	70.20	ML
11358	35.00	.0	33.00	5.00	7.00	12.00	13.00	29.00	1.26	161.00	2.32	68.00	ML
11359	13.00	.0	13.20	6.00	9.00	8.00	.0	25.00	3.23	186.00	2.68	64.20	MA
11360	5.00	.0	2.00	5.00	7.00	10.00	13.00	39.00	.27	131.00	.88	79.00	RL
11361	3.00	.0	1.60	5.00	11.00	14.00	12.00	59.00	.47	145.00	1.43	36.00	RL
11363	18.00	.0	6.20	9.00	13.00	16.00	22.00	42.00	2.76	2100.00	1.00	41.00	I
11364	45.00	.0	8.20	7.00	15.00	18.00	11.00	45.00	6.58	3100.00	1.76	49.60	I
11365	35.00	.0	7.20	11.00	19.00	23.00	14.00	55.00	5.90	1400.00	2.08	54.20	I
11366	5.00	.0	2.20	5.00	9.00	13.00	.0	75.00	.35	162.00	1.52	65.80	I
11367	12.00	.0	11.40	9.00	6.00	13.00	.0	37.00	7.84	436.00	1.35	66.20	RL
11368	4.00	.0	2.00	5.00	8.00	9.00	10.00	47.00	.25	257.00	2.32	72.60	RL
11369	5.00	.0	2.20	7.00	12.00	19.00	.0	28.00	.68	233.00	1.14	78.60	RL
11370	10.00	.0	3.40	8.00	26.00	19.00	15.00	117.00	.79	135.00	1.10	40.80	MV
11371	15.00	.0	2.40	8.00	17.00	15.00	.0	140.00	.61	145.00	1.19	63.80	MV

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11372	7.00	.0	1.80	9.00	23.00	21.00	.0	137.00	.97	147.00	1.09	46.60	ML
11373	15.00	.0	8.60	10.00	12.00	11.00	11.00	60.00	8.81	700.00	1.32	47.20	ML
11374	35.00	.0	3.60	6.00	15.00	9.00	.0	47.00	7.38	156.00	1.60	56.80	I
11375	55.00	3.00	49.00	8.00	11.00	9.00	14.00	20.00	7.90	4500.00	1.25	37.00	MV
11376	45.00	2.00	51.00	9.00	12.00	12.00	10.00	21.00	10.49	19600.00	1.45	37.40	MV
11377	20.00	.0	1.80	6.00	16.00	12.00	.0	55.00	.8	188.00	1.41	65.60	MV
11378	25.00	.0	1.40	7.00	12.00	9.00	.0	37.00	.8	94.00	1.01	66.80	ML
11379	5.00	.0	3.60	6.00	9.00	8.00	11.00	67.00	.7	162.00	1.22	66.00	ML
11380	5.00	.0	2.40	7.00	11.00	10.00	.0	28.00	.34	82.00	1.12	72.60	ML
11381	8.00	.0	2.40	6.00	8.00	8.00	12.00	44.00	2.40	53.00	1.14	71.80	MA
11382	8.00	.0	1.20	6.00	8.00	8.00	.0	37.00	.47	50.00	1.10	69.80	MA
11383	47.00	.0	5.20	10.00	27.00	28.00	22.00	86.00	1.70	152.00	1.14	37.80	MV
11384	40.00	.0	3.40	10.00	29.00	30.00	12.00	88.00	1.68	154.00	1.10	38.60	MV
11385	10.00	.0	2.60	6.00	7.00	8.00	.0	38.00	.85	214.00	1.20	79.00	MA
11386	23.00	.0	49.50	9.00	8.00	11.00	.0	45.00	17.90	1100.00	1.10	43.60	MA
11387	8.00	.0	4.40	5.00	13.00	12.00	.0	54.00	.73	143.00	1.19	71.80	MA
11388	30.00	.0	4.40	5.00	13.00	9.00	.0	66.00	1.23	1290.00	1.26	60.60	I
11389	13.00	.0	12.80	7.00	15.00	12.00	.0	48.00	9.27	7160.00	1.47	42.00	I
11390	11.00	.0	13.20	7.00	13.00	13.00	.0	53.00	8.52	749.00	1.42	33.00	MA
11391	8.00	.0	6.00	4.00	6.00	8.00	.0	40.00	1.91	195.00	.88	72.80	RL
11392	15.00	.0	19.00	4.00	7.00	7.00	.0	30.00	6.56	1386.00	1.58	52.00	RL
11393	24.00	.0	12.40	5.00	13.00	11.00	.0	52.00	9.85	504.00	1.50	55.90	ML
11394	15.00	.0	10.20	6.00	15.00	14.00	.0	52.00	2.06	600.00	2.80	57.70	ML
11395	52.00	3.00	22.40	6.00	6.00	9.00	.0	20.00	2.83	4500.00	1.55	33.60	MV
11396	45.00	.0	14.40	4.00	11.00	8.00	.0	41.00	2.89	780.00	2.08	55.20	MV
11397	40.00	.0	10.40	9.00	10.00	14.00	.0	27.00	1.94	1225.00	1.09	20.00	MV
11398	60.00	.0	13.60	7.00	16.00	15.00	.0	54.00	14.37	2990.00	13.60	34.30	ML
11399	23.00	.0	11.20	6.00	13.00	8.00	.0	53.00	2.95	835.00	1.26	50.90	MV
11400	78.00	.0	1.31	7.00	15.00	12.00	.0	54.00	10.58	17200.00	1.41	32.30	ML
11401	6.00	.0	1.60	5.00	7.00	9.00	.0	25.00	.51	70.00	.94	63.40	AG
11402	60.00	.0	11.80	8.00	15.00	18.00	11.00	29.00	1.23	1000.00	2.17	39.60	ML
11403	60.00	.0	12.20	6.00	16.00	20.00	12.00	33.00	1.05	630.00	2.04	42.60	AG
11404	48.00	.0	7.80	10.00	16.00	20.00	.0	36.00	6.39	1100.00	2.22	50.00	AG
11405	44.00	.0	10.80	7.00	15.00	17.00	20.00	45.00	2.85	482.00	1.58	44.20	AG
11406	70.00	.0	9.20	7.00	12.00	14.00	26.00	43.00	2.26	2800.00	1.52	29.20	ML
11407	60.00	.0	10.70	8.00	15.00	18.00	.0	35.00	2.23	3700.00	1.85	35.40	AG
11408	23.00	.0	21.00	5.00	5.00	7.00	.0	26.00	8.40	1621.00	1.78	57.20	AG
11409	65.00	.0	12.00	5.00	12.00	12.00	.0	30.00	2.10	349.00	1.70	30.90	ML
11410	60.00	.0	12.40	4.00	11.00	11.00	.0	33.00	2.50	6010.00	1.62	31.30	AG
11411	46.00	.0	12.50	6.00	13.00	15.00	.0	41.00	1.91	1705.00	1.50	33.00	AG
11412	45.00	.0	15.00	6.00	9.00	13.00	.0	32.00	1.32	882.00	1.47	35.20	AG
11413	77.00	.0	29.00	5.00	7.00	10.00	.0	29.00	2.12	3460.00	1.43	28.00	AG
11414	28.00	.0	20.20	5.00	10.00	14.00	.0	34.00	1.30	774.00	2.60	46.00	AG
11415	43.00	.0	17.40	4.00	13.00	16.00	.0	36.00	1.75	1047.00	2.03	43.50	AG
11416	42.00	.0	17.20	4.00	13.00	15.00	.0	33.00	1.36	704.00	1.36	41.80	AG
11417	43.00	.0	12.80	6.00	14.00	16.00	.0	41.00	1.71	648.00	2.03	45.20	AG
11418	48.00	.0	14.00	7.00	16.00	20.00	.0	41.00	2.11	1095.00	2.19	45.80	AG
11419	48.00	.0	17.40	5.00	11.00	11.00	.0	36.00	1.17	190.00	1.26	55.80	MA
11420	77.00	.0	23.60	5.00	8.00	8.00	.0	34.00	3.31	2560.00	1.06	44.60	ML
11421	42.00	.0	22.40	8.00	9.00	11.00	.0	30.00	2.70	1847.00	1.43	40.30	ML
11422	53.00	.0	16.20	7.00	4.00	9.00	.0	21.00	6.50	4610.00	.8	11.80	ML
11423	45.00	.0	17.00	8.00	12.00	16.00	.0	36.00	2.70	1164.00	1.72	38.60	MA
11424	35.00	.0	20.40	7.00	9.00	13.00	.0	31.00	1.78	1256.00	1.32	36.30	MA
11425	21.00	.0	8.80	5.00	10.00	15.00	10.00	44.00	1.20	290.00	2.39	39.10	AG
11426	17.00	3.00	10.80	5.00	8.00	12.00	10.00	28.00	1.00	680.00	1.40	31.90	AG
11427	56.00	3.00	9.60	10.00	12.00	15.00	30.00	41.00	2.00	980.00	1.72	36.80	AG
11428	63.00	2.00	9.00	8.00	13.00	17.00	30.00	42.00	2.00	1140.00	2.11	39.60	AG
11429	36.00	1.00	4.40	5.00	7.00	10.00	10.00	25.00	1.50	810.00	1.28	13.20	ML
11430	25.00	1.00	6.60	11.00	21.00	22.00	20.00	91.00	5.40	1280.00	1.00	26.30	AG
11431	25.00	1.00	12.00	15.00	30.00	32.00	20.00	102.00	9.50	1340.00	.61	37.80	AG
11432	14.00	1.00	5.00	7.00	13.00	17.00	10.00	51.00	1.00	120.00	.58	66.60	AG
11433	8.00	.0	14.00	8.00	7.00	12.00	.0	12.00	1.75	282.00	.39	32.10	ML
11434	17.00	.0	15.00	3.00	7.00	8.00	.0	30.00	1.09	169.00	1.79	70.90	MA

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11435	44.00	.0	11.20	4.00	8.00	8.00	.0	35.00	2.40	620.00	.77	48.60	MA
11436	10.00	.0	2.00	2.00	7.00	7.00	.0	52.00	.51	124.00	.3	66.80	AG
11437	38.00	.0	7.60	4.00	8.00	9.00	.0	42.00	1.63	101.00	.35	56.70	AG
11438	37.00	.0	8.00	5.00	9.00	9.00	.0	42.00	2.25	137.00	.24	49.80	AG
11439	4.00	.0	3.20	5.00	4.00	5.00	.0	68.00	10.69	620.00	.33	61.80	ML
11440	36.00	.0	10.40	4.00	6.00	7.00	.0	24.00	13.58	609.00	.53	53.20	I
11441	24.00	.0	9.40	6.00	9.00	9.00	.0	34.00	10.25	396.00	1.04	48.30	I
11442	2.00	.0	4.40	3.00	5.00	5.00	.0	17.00	.44	85.00	.91	74.60	MA
11443	5.00	.0	2.00	4.00	6.00	7.00	.0	37.00	.83	101.00	.54	62.90	MA
11444	15.00	.0	3.60	3.00	7.00	6.00	.0	38.00	.79	63.00	1.02	73.70	RL
11445	3.00	.0	1.60	4.00	8.00	7.00	.0	39.00	.3	94.00	1.59	72.30	I
11446	8.00	.0	5.20	5.00	8.00	8.00	.0	31.00	.71	94.00	1.63	56.40	RL
11447	3.00	.0	2.00	5.00	6.00	5.00	.0	40.00	.4	128.00	.96	75.00	I
11448	11.00	.0	2.60	6.00	7.00	9.00	.0	20.00	.9	119.00	1.00	14.00	RL
11449	36.00	.0	5.00	4.00	7.00	7.00	.0	40.00	.85	81.00	.93	50.00	I
11450	62.00	.0	21.20	7.00	6.00	9.00	.0	20.00	1.53	800.00	.77	24.60	MA
11451	43.00	.0	18.60	6.00	10.00	10.00	.0	36.00	2.16	514.00	41.79	43.80	ML
11452	85.00	.0	9.00	6.00	5.00	9.00	.0	22.00	1.23	4400.00	.96	14.40	ML
11453	94.00	.0	8.00	7.00	7.00	10.00	.0	27.00	1.70	9400.00	.83	28.60	ML
11454	24.00	.0	7.20	8.00	5.00	9.00	.0	18.00	.76	599.00	.62	15.10	MA
11455	11.00	.0	4.00	6.00	8.00	6.00	.0	80.00	4.01	121.00	1.38	73.30	RL
11456	6.00	.0	2.20	6.00	7.00	8.00	.0	59.00	.58	134.00	1.31	58.00	MA
11457	41.00	.0	2.40	5.00	6.00	6.00	.0	51.00	.72	66.00	.82	46.70	MA
11458	37.00	.0	1.40	5.00	8.00	8.00	.0	57.00	.75	76.00	.91	51.50	I
11459	22.00	.0	1.20	4.00	4.00	8.00	.0	68.00	.73	131.00	.85	58.30	I
11460	7.00	.0	13.60	4.00	7.00	7.00	.0	37.00	2.69	264.00	.46	63.90	RL
11461	32.00	.0	3.20	5.00	16.00	15.00	.0	46.00	1.95	525.00	1.38	53.10	MV
11462	50.00	.0	11.00	14.00	14.00	15.00	.0	80.00	12.79	7970.00	.74	39.80	MV
11463	60.00	.0	21.20	5.00	14.00	11.00	.0	41.00	10.50	4380.00	1.11	43.50	ML
11464	80.00	.0	18.60	6.00	14.00	12.00	.0	51.00	14.29	11400.00	.96	31.80	ML
11465	52.00	.0	1.90	5.00	13.00	10.00	.0	49.00	2.56	1954.00	.98	34.80	ML
11466	106.00	.0	18.80	7.00	9.00	8.00	.0	39.00	17.87	12600.00	.46	36.00	ML
11467	78.00	.0	12.60	8.00	17.00	21.00	10.00	94.00	1.58	348.00	1.33	48.20	ML
11468	38.00	.0	8.60	9.00	24.00	21.00	20.00	114.00	1.10	109.00	.99	47.80	ML
11469	30.00	.0	2.80	9.00	23.00	25.00	10.00	128.00	.89	128.00	.98	49.20	ML
11470	12.00	.0	2.40	12.00	40.00	29.00	10.00	122.00	.99	121.00	1.24	41.60	ML
11471	43.00	.0	3.60	10.00	38.00	27.00	10.00	187.00	1.52	304.00	1.07	44.50	MV
11472	27.00	.0	16.20	6.00	12.00	14.00	10.00	71.00	6.00	2640.00	1.61	47.80	MV
11473	37.00	.0	16.20	5.00	10.00	8.00	10.00	43.00	6.80	2920.00	2.04	51.30	MV
11474	40.00	.0	1.70	7.00	9.00	14.00	.0	43.00	16.60	2760.00	1.25	42.60	MV
11475	45.00	.0	8.00	9.00	9.00	10.00	10.00	37.00	14.20	4060.00	1.37	38.80	MV
11476	30.00	.0	10.80	10.00	21.00	18.00	10.00	47.00	8.00	2000.00	1.72	27.40	MV
11477	35.00	.0	2.00	7.00	25.00	19.00	10.00	81.00	1.27	195.00	.98	41.30	MV
11478	32.00	.0	2.40	8.00	22.00	19.00	10.00	141.00	1.48	580.00	1.23	61.30	MV
11479	43.00	.0	3.40	7.00	22.00	21.00	10.00	114.00	1.11	125.00	1.35	45.50	ML
11480	45.00	.0	4.60	7.00	20.00	18.00	20.00	101.00	.95	120.00	1.57	45.00	ML
11481	12.00	.0	6.00	8.00	14.00	15.00	20.00	167.00	.6	169.00	.7	61.50	ML
11482	15.00	.0	17.20	11.00	15.00	20.00	10.00	137.00	5.80	520.00	1.02	56.40	ML
11483	8.00	.0	3.20	15.00	51.00	34.00	10.00	116.00	1.64	243.00	1.26	37.60	ML
11484	4.00	.0	3.60	5.00	13.00	14.00	20.00	82.00	.52	117.00	1.52	62.30	ML
11485	6.00	.0	1.40	6.00	11.00	11.00	10.00	70.00	.8	200.00	.86	69.20	MA
11486	6.00	.0	1.60	6.00	9.00	10.00	10.00	76.00	.85	183.00	.79	67.80	ML
11487	57.00	.0	5.80	20.00	40.00	24.00	10.00	130.00	9.00	1720.00	1.18	45.80	ML
11488	3.00	.0	2.20	8.00	26.00	16.00	10.00	100.00	.79	246.00	1.04	51.70	MA
11489	13.00	.0	5.60	7.00	21.00	15.00	20.00	134.00	.8	195.00	.75	58.90	MA
11490	5.00	.0	2.80	9.00	15.00	14.00	10.00	121.00	.6	160.00	.85	62.80	MA
11491	2.00	.0	3.20	8.00	11.00	8.00	10.00	73.00	.55	165.00	1.79	58.80	MA
11492	22.00	.0	77.50	9.00	8.00	8.00	10.00	65.00	14.60	1020.00	1.02	50.90	RL
11493	4.00	.0	3.80	6.00	8.00	9.00	10.00	50.00	.64	115.00	.96	69.60	MA
11494	22.00	.0	14.20	13.00	16.00	13.00	10.00	80.00	7.60	1160.00	1.28	49.70	MA
11495	41.00	.0	3.80	10.00	13.00	12.00	10.00	48.00	1.28	194.00	1.08	32.00	I
11496	73.00	.0	6.60	8.00	11.00	11.00	20.00	53.00	1.37	348.00	1.23	35.40	MA
11497	42.00	.0	12.40	10.00	15.00	14.00	10.00	53.00	1.40	580.00	1.72	51.30	ML

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11498	27.00	.0	21.60	15.00	12.00	13.00	10.00	60.00	13.00	4800.00	1.51	45.10	ML
11499	11.00	.0	6.00	12.00	10.00	12.00	20.00	39.00	1.95	620.00	.74	32.30	MA
11500	8.00	.0	14.40	13.00	7.00	7.00	10.00	34.00	13.40	1040.00	.46	36.30	MA
11501	5.00	.0	1.80	6.00	10.00	11.00	10.00	33.00	.49	136.00	1.00	65.10	ML
11502	7.00	.0	3.60	8.00	6.00	10.00	10.00	89.00	2.00	164.00	.67	75.80	ML
11503	7.00	.0	1.80	8.00	10.00	10.00	.0	61.00	2.00	282.00	1.11	68.50	MA
11504	24.00	.0	5.80	9.00	15.00	15.00	10.00	76.00	1.40	186.00	1.82	62.80	RL
11505	7.00	.0	2.00	9.00	13.00	15.00	10.00	77.00	.74	93.00	.7	65.50	RL
11506	8.00	1.00	7.00	19.00	45.00	32.00	20.00	180.00	1.88	474.00	15.91	29.70	MA
11507	5.00	.0	4.60	5.00	10.00	10.00	10.00	31.00	15.00	89.00	.4	72.00	MA
11508	24.00	.0	7.00	8.00	12.00	14.00	20.00	87.00	1.25	156.00	.69	55.00	MA
11509	11.00	.0	12.60	7.00	8.00	11.00	10.00	80.00	1.07	349.00	.55	71.90	ML
11510	12.00	.0	3.80	9.00	12.00	16.00	10.00	56.00	5.50	820.00	1.47	60.00	MA
11511	4.00	.0	.6	7.00	8.00	11.00	10.00	40.00	.37	162.00	.79	79.00	MA
11512	23.00	1.00	4.40	11.00	18.00	17.00	10.00	46.00	7.40	3850.00	2.77	48.70	I
11513	5.00	.0	3.80	15.00	20.00	21.00	10.00	80.00	1.00	310.00	1.04	67.90	I
11514	34.00	.0	2.20	13.00	25.00	24.00	10.00	155.00	1.63	142.00	1.36	51.30	MA
11515	25.00	.0	2.80	12.00	15.00	14.00	10.00	184.00	6.90	295.00	.44	62.50	I
11516	9.00	.0	2.40	16.00	32.00	25.00	10.00	156.00	1.32	189.00	.87	49.30	RL
11517	23.00	.0	12.80	12.00	11.00	14.00	10.00	58.00	14.70	685.00	1.32	42.30	I
11518	18.00	.0	10.80	17.00	27.00	27.00	20.00	66.00	9.20	2530.00	2.23	35.40	I
11519	26.00	1.00	11.60	13.00	25.00	23.00	20.00	56.00	11.10	2890.00	1.67	35.50	MA
11520	13.00	1.00	18.80	9.00	10.00	14.00	10.00	35.00	20.50	1580.00	.98	38.10	MA
11521	60.00	1.00	16.60	10.00	18.00	15.00	20.00	58.00	6.50	1290.00	.98	42.90	RL
11522	24.00	.0	25.00	12.00	14.00	13.00	10.00	44.00	15.40	3950.00	1.06	45.00	I
11523	12.00	1.00	21.80	10.00	12.00	18.00	.0	40.00	12.40	2850.00	1.25	47.20	RL
11524	15.00	.0	24.00	7.00	13.00	12.00	.0	49.00	3.70	780.00	1.72	68.20	RL
11525	7.00	.0	2.20	5.00	10.00	8.00	10.00	46.00	.7	190.00	1.00	67.70	ML
11526	7.00	.0	5.40	9.00	10.00	9.00	.0	80.00	3.30	244.00	1.28	73.10	ML
11527	17.00	.0	2.00	5.00	13.00	8.00	10.00	56.00	.71	348.00	2.08	69.00	MA
11528	22.00	.0	3.40	5.00	11.00	8.00	10.00	64.00	.68	287.00	1.42	69.80	MA
11529	9.00	.0	3.80	7.00	12.00	12.00	.0	74.00	.68	185.00	1.34	72.00	ML
11530	7.00	1.00	15.00	12.00	5.00	11.00	10.00	87.00	9.80	1380.00	.87	62.30	MA
11531	7.00	1.00	6.00	12.00	11.00	16.00	.0	107.00	3.50	545.00	1.61	69.60	I
11532	13.00	1.00	5.00	12.00	9.00	11.00	.0	298.00	8.00	1080.00	.87	65.90	RL
11533	11.00	4.00	14.20	11.00	8.00	12.00	20.00	77.00	2.84	384.00	1.66	48.40	MA
11534	7.00	.0	9.80	6.00	8.00	8.00	10.00	38.00	.83	297.00	.98	73.20	MA
11535	6.00	2.00	16.40	9.00	7.00	9.00	20.00	43.00	11.90	3080.00	.91	54.20	ML
11536	26.00	.0	3.40	11.00	22.00	21.00	.0	60.00	1.23	107.00	.88	57.10	MA
11537	43.00	.0	12.60	14.00	27.00	24.00	10.00	194.00	7.20	1480.00	1.12	48.00	MA
11538	33.00	.0	5.00	15.00	37.00	33.00	10.00	181.00	1.60	224.00	.76	48.90	I
11539	7.00	.0	3.00	12.00	36.00	32.00	10.00	171.00	1.10	126.00	.82	47.50	I
11540	7.00	1.00	3.00	10.00	15.00	13.00	10.00	66.00	.9	263.00	.85	45.70	RL
11541	6.00	.0	5.80	19.00	12.00	9.00	10.00	313.00	3.10	548.00	.94	72.40	I
11542	9.00	.0	6.60	20.00	11.00	13.00	.0	181.00	1.60	535.00	.79	80.00	I
11543	64.00	1.00	43.00	14.00	16.00	14.00	20.00	55.00	16.20	8060.00	.74	38.90	MA
11544	50.00	.0	27.60	12.00	24.00	23.00	10.00	68.00	9.60	1240.00	.71	44.20	MA
11545	53.00	.0	27.80	14.00	20.00	19.00	10.00	61.00	13.50	1830.00	1.37	41.10	MA
11546	42.00	1.00	22.80	12.00	19.00	21.00	10.00	61.00	13.70	1390.00	1.17	38.30	MA
11547	10.00	.0	8.80	7.00	13.00	16.00	10.00	115.00	1.00	226.00	.61	66.20	MA
11548	8.00	.0	18.60	9.00	6.00	7.00	10.00	37.00	17.50	940.00	.47	51.60	MA
11549	9.00	1.00	36.50	10.00	7.00	8.00	20.00	53.00	16.60	1220.00	.27	51.60	MA
11550	8.00	.0	3.20	12.00	18.00	14.00	20.00	172.00	.8	178.00	1.08	60.10	MA
11551	25.00	.0	62.00	15.00	13.00	13.00	.0	105.00	16.00	2200.00	.69	49.80	MA
11552	70.00	1.00	42.50	11.00	20.00	20.00	30.00	80.00	12.60	13920.00	.4	37.20	MA
11553	63.00	.0	27.20	12.00	21.00	22.00	20.00	66.00	5.60	3250.00	.78	38.30	MA
11554	60.00	1.00	27.60	11.00	24.00	24.00	10.00	59.00	9.70	4100.00	1.60	42.90	MA
11555	36.00	1.00	13.00	10.00	22.00	23.00	30.00	78.00	7.20	770.00	1.38	37.20	MA
11556	59.00	.0	14.40	9.00	22.00	24.00	20.00	63.00	3.70	1610.00	.78	34.50	MA
11557	35.00	1.00	8.40	13.00	22.00	22.00	10.00	71.00	7.20	1840.00	1.64	28.90	MA
11558	25.00	.0	10.40	9.00	31.00	30.00	10.00	57.00	2.00	650.00	1.36	48.90	MA
11559	45.00	.0	12.60	12.00	19.00	23.00	10.00	68.00	14.00	4600.00	.75	43.40	MA

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SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11560	17.00	.0	11.20	7.00	19.00	18.00	.0	61.00	20.80	1390.00	.75	42.60	MA
11561	50.00	.0	4.00	10.00	31.00	24.00	.0	157.00	2.00	380.00	.64	56.90	MA
11562	35.00	1.00	10.20	12.00	17.00	20.00	.0	110.00	18.30	1790.00	.97	40.40	MA
11563	12.00	.0	3.20	13.00	38.00	33.00	10.00	126.00	1.20	130.00	1.38	52.10	MA
11564	10.00	.0	5.40	11.00	40.00	33.00	.0	210.00	14.40	160.00	1.36	57.60	MA
11565	40.00	.0	3.60	6.00	22.00	21.00	10.00	89.00	1.40	170.00	.77	53.00	MA
11566	13.00	.0	2.80	13.00	46.00	36.00	.0	107.00	1.50	170.00	1.17	44.70	RL
11567	30.00	1.00	4.40	13.00	19.00	23.00	.0	328.00	7.30	490.00	.72	55.30	I
11568	25.00	.0	3.80	14.00	22.00	25.00	.0	334.00	5.00	350.00	1.36	55.70	I
11569	5.00	.0	3.40	6.00	39.00	28.00	10.00	88.00	21.20	170.00	.58	22.30	RL
11570	ND	1.00	8.20	16.00	69.00	40.00	.0	192.00	5.90	990.00	1.05	47.80	RL
11571	20.00	.0	10.60	18.00	16.00	23.00	.0	105.00	20.20	1400.00	.3	40.90	MA
11572	14.00	2.00	12.00	6.00	10.00	11.00	10.00	143.00	18.80	870.00	.22	47.80	MA
11573	45.00	1.00	9.80	19.00	18.00	11.00	20.00	88.00	24.10	1950.00	.31	44.90	I
11574	27.00	.0	5.20	16.00	26.00	19.00	20.00	142.00	3.50	230.00	1.40	56.20	MA
11575	43.00	.0	3.00	11.00	25.00	25.00	10.00	132.00	1.60	110.00	.82	53.30	MA
11576	10.00	.0	2.00	15.00	41.00	38.00	10.00	110.00	1.10	120.00	.77	39.80	I
11577	43.00	.0	6.00	15.00	55.00	47.00	20.00	112.00	3.20	308.00	.87	33.30	RL
11578	50.00	1.00	9.00	13.00	17.00	23.00	.0	77.00	18.10	5120.00	2.04	44.10	RL
11579	28.00	1.00	5.20	15.00	50.00	27.00	10.00	320.00	2.90	280.00	.79	69.90	RL
11580	45.00	.0	2.00	9.00	30.00	25.00	10.00	130.00	1.50	163.00	.79	47.30	MA
11581	7.00	.0	2.40	8.00	25.00	20.00	10.00	61.00	.7	135.00	.69	67.30	MA
11582	4.00	.0	1.00	11.00	33.00	23.00	10.00	114.00	.9	165.00	.66	47.70	MA
11583	33.00	1.00	6.60	17.00	64.00	38.00	20.00	150.00	2.40	213.00	17.80	34.70	MA
11584	90.00	.0	9.00	10.00	27.00	22.00	10.00	102.00	5.90	1000.00	1.38	48.60	RL
11585	50.00	.0	7.80	9.00	23.00	26.00	20.00	88.00	1.60	200.00	.83	49.20	RL
11586	70.00	.0	27.20	24.00	21.00	25.00	10.00	71.00	19.20	8040.00	.78	37.50	I
11587	30.00	.0	10.60	14.00	35.00	30.00	10.00	134.00	4.40	1140.00	.69	50.90	RL
11588	ND	1.00	4.80	15.00	43.00	32.00	20.00	134.00	2.80	303.00	.43	36.20	I
11589	65.00	.0	7.60	15.00	42.00	30.00	30.00	149.00	2.40	315.00	.83	38.10	I
11590	20.00	1.00	4.80	16.00	40.00	32.00	30.00	139.00	1.70	175.00	.71	36.00	MA
11591	30.00	1.00	6.60	19.00	48.00	39.00	10.00	112.00	4.90	880.00	1.79	46.00	RL
11592	17.00	.0	7.00	26.00	47.00	42.00	20.00	118.00	4.80	640.00	2.08	31.70	RL
11593	20.00	1.00	13.60	11.00	24.00	20.00	20.00	47.00	10.40	4000.00	.68	40.10	RL
11594	25.00	1.00	13.80	12.00	23.00	29.00	10.00	65.00	11.50	4600.00	1.39	41.40	RL
11595	45.00	.0	4.40	10.00	34.00	24.00	.0	300.00	3.20	530.00	.97	40.60	MA
11596	33.00	1.00	11.60	18.00	76.00	49.00	10.00	176.00	3.40	610.00	1.49	42.40	MA
11597	38.00	.0	5.40	17.00	55.00	37.00	10.00	163.00	4.80	610.00	.99	49.50	MA
11598	24.00	1.00	4.60	11.00	22.00	24.00	10.00	86.00	1.90	870.00	1.59	62.30	MA
11599	25.00	.0	14.00	18.00	28.00	24.00	.0	73.00	9.20	2480.00	1.28	35.70	RL
11600	8.00	.0	1.00	17.00	27.00	28.00	10.00	77.00	.9	180.00	.98	71.60	MA
11601	7.00	.0	5.20	19.00	38.00	27.00	10.00	245.00	1.20	230.00	1.61	54.50	MA
11602	65.00	.0	4.20	12.00	31.00	26.00	.0	181.00	4.50	1170.00	1.69	59.30	MA
11603	45.00	2.00	13.40	27.00	38.00	43.00	10.00	90.00	8.60	3400.00	2.21	27.00	RL
11604	20.00	1.00	9.00	28.00	31.00	35.00	.0	93.00	7.40	1830.00	1.70	46.40	I
11605	20.00	1.00	7.20	19.00	33.00	32.00	10.00	73.00	2.30	680.00	1.58	27.10	RL
11606	36.00	.0	5.60	35.00	42.00	46.00	.0	123.00	6.80	1770.00	2.63	26.20	I
11607	48.00	1.00	10.60	11.00	17.00	20.00	.0	48.00	7.90	8400.00	2.04	48.70	RL
11608	45.00	1.00	5.00	19.00	32.00	33.00	.0	74.00	6.90	2350.00	.83	25.90	RL
11609	28.00	.0	10.20	20.00	22.00	20.00	.0	61.00	13.30	3320.00	1.11	33.50	RL
11610	10.00	.0	2.00	21.00	31.00	35.00	.0	320.00	1.50	520.00	.91	63.90	I
11611	10.00	.0	12.00	15.00	7.00	15.00	10.00	90.00	20.10	5400.00	5.29	47.00	RL
11612	7.00	.0	7.60	11.00	12.00	20.00	10.00	280.00	4.40	660.00	2.86	68.10	RL
11613	55.00	1.00	13.40	11.00	9.00	13.00	.0	26.00	19.40	12300.00	7.29	33.50	RL
11614	53.00	2.00	13.20	12.00	11.00	21.00	30.00	31.00	14.30	16500.00	2.50	38.00	RL
11615	38.00	.0	3.60	10.00	23.00	25.00	10.00	96.00	1.10	150.00	4.32	56.00	RL
11616	34.00	.0	1.80	10.00	22.00	24.00	10.00	84.00	1.00	160.00	2.15	53.80	RL
11617	9.00	.0	2.60	11.00	12.00	16.00	10.00	49.00	1.20	370.00	3.13	65.40	MA
11618	13.00	.0	1.20	6.00	15.00	10.00	.0	64.00	.6	110.00	2.20	70.50	MA
11619	14.00	.0	3.60	15.00	20.00	25.00	10.00	76.00	.8	280.00	1.40	72.20	RL
11620	21.00	.0	1.80	10.00	22.00	18.00	10.00	89.00	.9	150.00	2.38	56.40	I
11621	39.00	2.00	12.80	12.00	14.00	12.00	10.00	48.00	14.80	7100.00	2.43	39.70	RL

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11622	10.00	1.00	8.40	12.00	11.00	9.00	.0	167.00	11.90	1570.00	2.44	64.40	RL
11623	26.00	.0	5.40	12.00	40.00	17.00	20.00	356.00	1.53	470.00	.95	60.00	RL
11624	16.00	.0	1.80	6.00	18.00	8.00	10.00	170.00	2.30	80.00	1.06	63.80	MA
11625	26.00	.0	4.80	6.00	24.00	17.00	.0	128.00	1.00	150.00	2.31	55.50	RL
11626	37.00	.0	5.40	6.00	17.00	9.00	30.00	101.00	.8	120.00	2.37	63.40	MA
11627	32.00	.0	5.60	7.00	17.00	13.00	10.00	87.00	1.00	140.00	1.92	65.30	MA
11628	21.00	.0	6.20	6.00	18.00	11.00	.0	68.00	1.00	140.00	1.51	64.80	MA
11629	5.00	.0	1.60	2.00	7.00	5.00	10.00	19.00	.3	70.00	2.34	76.80	I
11630	51.00	.0	11.00	10.00	15.00	15.00	10.00	60.00	9.20	3400.00	2.20	47.00	RL
11631	17.00	.0	5.40	16.00	27.00	33.00	20.00	93.00	4.60	530.00	1.95	53.00	RL
11632	60.00	.0	8.40	22.00	24.00	25.00	10.00	72.00	16.00	14100.00	1.22	37.00	RL
11633	75.00	1.00	12.80	16.00	26.00	26.00	10.00	50.00	9.00	34000.00	2.13	32.70	RL
11634	55.00	.0	12.80	19.00	28.00	30.00	10.00	67.00	10.10	21800.00	2.56	31.90	RL
11635	45.00	.0	9.20	17.00	32.00	37.00	20.00	87.00	5.30	2250.00	1.18	29.40	RL
11636	67.00	.0	12.00	13.00	30.00	28.00	10.00	52.00	6.20	14800.00	1.88	31.00	RL
11637	75.00	.0	11.60	16.00	32.00	34.00	10.00	65.00	8.80	13700.00	1.95	29.20	RL
11638	54.00	.0	11.60	14.00	28.00	32.00	10.00	68.00	4.90	6200.00	2.23	33.60	RL
11639	33.00	.0	3.20	41.00	24.00	22.00	20.00	305.00	4.40	1390.00	.59	57.00	RL
11640	26.00	.0	3.80	19.00	51.00	43.00	20.00	212.00	3.10	390.00	.86	31.60	RL
11641	40.00	1.00	13.40	16.00	20.00	24.00	.0	77.00	18.20	7700.00	1.51	40.00	RL
11642	25.00	1.00	10.40	17.00	32.00	31.00	20.00	104.00	5.30	1530.00	.91	23.50	RL
11643	25.00	.0	3.40	26.00	35.00	36.00	20.00	120.00	4.90	830.00	.46	32.40	RL
11644	45.00	.0	6.60	23.00	27.00	34.00	20.00	125.00	13.00	2600.00	.4	44.00	RL
11645	23.00	.0	4.40	23.00	42.00	41.00	10.00	123.00	3.30	560.00	1.69	29.20	I
11647	41.00	1.00	11.20	12.00	17.00	22.00	30.00	49.00	9.50	7700.00	.88	28.20	MA
11648	34.00	1.00	13.40	13.00	10.00	20.00	20.00	44.00	19.40	8800.00	.85	36.40	RL
11649	7.00	.0	6.20	5.00	11.00	12.00	10.00	71.00	1.20	220.00	.8	74.50	RL
11650	24.00	.0	10.60	9.00	14.00	24.00	20.00	53.00	1.30	100.00	1.51	65.10	MA
11651	47.00	.0	10.80	8.00	15.00	21.00	10.00	62.00	9.80	1540.00	2.10	47.40	RL
11652	37.00	1.00	10.60	8.00	16.00	15.00	10.00	50.00	2.40	750.00	1.79	57.30	RL
11653	9.00	7.00	9.00	13.00	7.00	16.00	40.00	13.00	2.30	190.00	.72	28.10	AG
11654	10.00	.0	1.20	10.00	13.00	11.00	.0	108.00	9.00	110.00	.8	65.40	AG
11655	26.00	.0	3.40	8.00	11.00	13.00	.0	51.00	9.00	130.00	.81	56.90	AG
11656	6.00	.0	.8	10.00	9.00	6.00	20.00	44.00	5.00	120.00	.26	79.20	AG
11657	17.00	.0	2.20	15.00	18.00	7.00	10.00	263.00	1.20	280.00	.64	74.80	AG
11658	10.00	.0	1.00	9.00	10.00	8.00	10.00	87.00	1.40	250.00	1.72	75.40	AG
11659	45.00	2.00	2.40	11.00	17.00	15.00	20.00	68.00	1.00	110.00	1.79	48.90	AG
11660	46.00	.0	3.00	7.00	13.00	9.00	20.00	58.00	8.00	140.00	1.60	69.00	AG
11661	5.00	.0	1.60	6.00	11.00	11.00	10.00	44.00	5.00	106.00	1.80	69.10	AG
11662	28.00	1.00	10.20	19.00	28.00	32.00	20.00	100.00	14.10	1640.00	2.04	38.20	AG
11663	29.00	1.00	9.80	18.00	24.00	28.00	10.00	98.00	14.00	1980.00	1.20	33.70	AG
11664	21.00	1.00	7.80	17.00	24.00	29.00	10.00	104.00	12.00	1400.00	1.06	35.40	AG
11665	11.00	.0	10.60	19.00	34.00	40.00	10.00	79.00	10.20	720.00	1.79	51.30	AG
11666	18.00	.0	9.20	9.00	27.00	29.00	10.00	69.00	5.10	500.00	1.52	50.20	AG
11667	58.00	.0	4.40	3.00	10.00	10.00	10.00	53.00	1.00	236.00	.86	57.00	AG
11668	38.00	.0	9.00	5.00	9.00	8.00	30.00	59.00	5.60	770.00	.85	58.30	AG
11669	47.00	.0	2.40	5.00	14.00	11.00	10.00	60.00	8.00	100.00	.85	65.30	AG
11670	29.00	.0	11.40	6.00	12.00	19.00	10.00	45.00	7.80	1680.00	1.90	60.00	AG
11771	16.00	.0	1.80	9.00	24.00	25.00	10.00	178.00	8.00	130.00	1.28	59.00	RL
11772	31.00	.0	1.40	10.00	28.00	33.00	10.00	124.00	1.20	180.00	1.61	42.50	RL
11773	24.00	.0	1.40	5.00	23.00	25.00	10.00	190.00	1.30	200.00	1.32	53.30	RL
11774	19.00	.0	6.00	7.00	11.00	17.00	20.00	137.00	1.10	200.00	.99	65.90	RL
11775	12.00	.0	9.40	10.00	14.00	25.00	30.00	131.00	3.50	480.00	2.54	47.30	RL
11776	5.00	.0	8.40	6.00	9.00	16.00	10.00	91.00	1.70	290.00	.35	47.00	RL
11777	15.00	.0	1.40	10.00	17.00	23.00	10.00	308.00	1.70	670.00	.89	61.00	RL
11778	50.00	.0	32.40	16.00	15.00	21.00	20.00	119.00	14.00	12000.00	1.37	33.90	RL
11779	5.00	.0	.8	3.00	4.00	5.00	.0	28.00	7.00	140.00	.43	78.80	RL
11780	20.00	.0	9.80	11.00	19.00	23.00	30.00	113.00	3.80	710.00	1.79	44.00	RL
11826	24.00	.0	1.60	7.00	18.00	17.00	10.00	124.00	1.10	254.00	.92	63.80	RL
11827	23.00	1.00	3.40	13.00	17.00	18.00	20.00	157.00	1.60	416.00	.48	35.60	RL
11828	58.00	1.00	6.20	20.00	30.00	34.00	40.00	163.00	2.60	1050.00	1.79	48.30	RL
11829	53.00	.0	4.40	18.00	33.00	32.00	20.00	160.00	2.40	710.00	.85	46.50	RL

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11830	38.00	1.00	10.00	17.00	33.00	36.00	30.00	103.00	3.20	1640.00	1.60	30.10	RL
11831	35.00	1.00	10.40	15.00	29.00	36.00	20.00	92.00	2.70	720.00	1.89	31.90	RL
11832	32.00	.0	4.40	21.00	28.00	35.00	40.00	170.00	2.70	940.00	1.54	50.30	RL
11833	ND	.0	3.80	19.00	35.00	38.00	20.00	173.00	2.40	870.00	1.76	57.60	RL
11834	25.00	.0	1.20	10.00	24.00	26.00	10.00	83.00	3.20	270.00	1.75	42.70	RL
11835	11.00	.0	6.40	15.00	20.00	35.00	10.00	224.00	3.80	426.00	1.85	39.70	RL
11836	25.00	.0	1.80	10.00	20.00	31.00	10.00	106.00	1.80	292.00	1.76	42.60	RL
11837	40.00	.0	2.20	4.00	20.00	19.00	10.00	172.00	1.20	320.00	1.66	60.80	RL
11838	3.00	.0	1.40	10.00	14.00	26.00	.0	145.00	.9	260.00	1.14	41.90	RL
11839	20.00	.0	4.80	15.00	20.00	32.00	20.00	186.00	1.80	490.00	1.63	41.80	RL
11840	49.00	.0	5.80	15.00	23.00	34.00	20.00	202.00	2.20	700.00	1.04	41.90	RL
11841	10.00	.0	.8	5.00	18.00	32.00	.0	95.00	.7	140.00	.58	56.40	RL
11842	25.00	.0	2.20	5.00	21.00	26.00	30.00	146.00	.7	90.00	.89	56.20	RL
11843	20.00	.0	1.80	12.00	35.00	45.00	20.00	96.00	2.40	260.00	.79	26.80	RL
11852	45.00	.0	3.40	11.00	17.00	21.00	10.00	50.00	1.30	1700.00	1.76	27.50	ML
11853	50.00	.0	5.40	13.00	19.00	21.00	.0	57.00	1.90	370.00	2.13	28.40	AG
11854	40.00	1.00	9.40	13.00	14.00	16.00	20.00	50.00	7.20	1450.00	2.70	46.60	RL
11855	30.00	.0	9.80	15.00	15.00	20.00	10.00	48.00	7.30	1250.00	3.35	51.40	RL
11856	23.00	1.00	10.00	15.00	14.00	16.00	10.00	54.00	8.10	2020.00	2.70	49.20	RL
11857	27.00	2.00	12.00	8.00	8.00	15.00	20.00	37.00	7.20	1360.00	2.04	51.50	I
11858	15.00	2.00	12.20	7.00	10.00	15.00	10.00	37.00	6.50	1140.00	2.10	51.80	RL
11859	35.00	3.00	9.80	8.00	9.00	14.00	30.00	48.00	3.70	1060.00	1.76	42.60	I
11860	30.00	1.00	10.80	7.00	10.00	13.00	10.00	45.00	3.70	690.00	2.22	58.50	RL
11861	35.00	.0	8.60	5.00	11.00	10.00	20.00	53.00	1.20	154.00	1.69	47.00	ML
11862	27.00	.0	11.60	7.00	15.00	20.00	10.00	53.00	2.80	237.00	1.85	53.40	ML
11863	8.00	.0	5.60	7.00	10.00	6.00	10.00	56.00	1.90	190.00	1.76	63.20	ML
11864	33.00	.0	5.00	9.00	9.00	13.00	10.00	45.00	1.00	186.00	1.82	63.70	ML
11865	6.00	.0	3.80	6.00	14.00	18.00	10.00	70.00	2.10	380.00	1.79	60.90	ML
11866	15.00	.0	2.00	7.00	11.00	12.00	10.00	96.00	.9	151.00	1.66	64.20	ML
11867	8.00	.0	11.20	12.00	9.00	15.00	20.00	44.00	9.30	540.00	2.13	54.70	AG
11868	35.00	.0	3.40	7.00	9.00	13.00	20.00	49.00	.8	115.00	1.92	68.00	MA
11869	20.00	.0	5.40	4.00	12.00	16.00	40.00	83.00	1.10	163.00	1.79	57.20	RL
11870	10.00	.0	11.00	2.00	8.00	8.00	10.00	64.00	1.20	175.00	2.24	74.60	I
11871	6.00	1.00	8.00	4.00	7.00	9.00	10.00	18.00	.7	310.00	1.90	64.30	T
11872	5.00	.0	1.40	9.00	14.00	19.00	10.00	32.00	.4	69.00	2.01	71.00	MA
11873	9.00	1.00	11.40	14.00	26.00	30.00	20.00	66.00	8.60	850.00	1.62	43.20	MA
11874	25.00	.0	3.20	8.00	13.00	9.00	10.00	65.00	.8	110.00	2.02	61.70	T
11875	9.00	.0	5.00	7.00	10.00	10.00	10.00	109.00	1.50	272.00	1.84	73.40	MA
11876	17.00	.0	4.40	8.00	25.00	27.00	30.00	88.00	1.40	195.00	2.25	47.50	I
11877	12.00	.0	5.60	7.00	10.00	11.00	10.00	53.00	1.90	213.00	2.58	71.00	RL
11878	9.00	.0	1.80	5.00	8.00	13.00	10.00	38.00	.9	390.00	2.25	55.00	MA
11879	6.00	.0	.6	3.00	7.00	12.00	10.00	60.00	.5	150.00	2.38	73.70	MA
11880	14.00	1.00	4.40	10.00	14.00	15.00	10.00	66.00	8.50	1030.00	1.51	55.50	MA
11881	3.00	3.00	14.60	6.00	6.00	14.00	20.00	23.00	15.90	1210.00	.78	39.60	AG
11882	21.00	.0	9.20	7.00	12.00	13.00	10.00	56.00	4.20	385.00	1.57	46.60	ML
11883	70.00	1.00	8.80	12.00	15.00	12.00	10.00	74.00	16.40	2540.00	1.46	45.00	ML
11884	29.00	1.00	6.80	12.00	10.00	12.00	10.00	50.00	18.20	630.00	.49	42.60	ML
11885	12.00	.0	2.20	8.00	15.00	11.00	10.00	107.00	1.10	229.00	.31	59.60	ML
11886	35.00	.0	7.00	7.00	11.00	15.00	10.00	52.00	1.30	167.00	.8	58.00	ML
11887	25.00	.0	9.20	9.00	13.00	20.00	10.00	44.00	4.60	540.00	.75	26.80	ML
11888	6.00	8.00	2.80	8.00	11.00	17.00	40.00	17.00	.5	308.00	.96	23.40	ML
11889	38.00	.0	3.40	6.00	16.00	15.00	10.00	159.00	6.80	1140.00	1.52	56.10	ML
11890	7.00	.0	3.20	6.00	12.00	14.00	10.00	53.00	.8	107.00	1.92	60.90	MA
11891	31.00	.0	4.00	6.00	14.00	16.00	10.00	60.00	1.10	148.00	1.28	58.90	I
11892	16.00	.0	2.20	11.00	15.00	18.00	10.00	112.00	1.10	425.00	.56	65.30	MA
11893	7.00	.0	3.60	14.00	20.00	26.00	20.00	150.00	1.20	482.00	1.91	49.00	MA
11894	4.00	.0	1.60	4.00	16.00	21.00	10.00	42.00	.7	242.00	1.04	59.00	RL
11895	45.00	1.00	4.00	17.00	31.00	21.00	30.00	182.00	1.90	660.00	2.08	56.30	RL
11896	17.00	2.00	14.00	8.00	8.00	10.00	20.00	31.00	17.00	4500.00	1.92	41.50	ML
11897	7.00	.0	2.20	7.00	14.00	10.00	10.00	49.00	.9	131.00	1.72	61.50	ML
11898	16.00	.0	.6	10.00	15.00	9.00	10.00	83.00	.6	125.00	1.18	63.00	AG
11899	21.00	1.00	7.80	12.00	26.00	21.00	20.00	73.00	3.90	1170.00	1.76	42.00	AG

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11900	53.00	1.00	13.20	10.00	22.00	16.00	20.00	58.00	6.70	5500.00	1.14	33.00	AG
11901	43.00	1.00	10.20	7.00	23.00	20.00	20.00	58.00	6.50	4000.00	1.99	46.20	AG
11902	17.00	.0	14.20	5.00	11.00	9.00	10.00	48.00	6.60	1110.00	2.45	61.00	AG
11903	19.00	.0	12.00	6.00	12.00	8.00	10.00	38.00	1.20	710.00	2.08	59.80	AG
11904	26.00	1.00	12.20	5.00	10.00	10.00	10.00	40.00	9.00	2260.00	1.92	50.90	AG
11905	25.00	1.00	12.00	4.00	12.00	10.00	10.00	36.00	8.80	3000.00	2.16	54.30	AG
11906	18.00	.0	13.00	6.00	17.00	13.00	10.00	49.00	3.40	840.00	2.63	62.60	AG
11907	22.00	1.00	12.00	10.00	15.00	12.00	10.00	47.00	8.90	1880.00	2.38	52.90	AG
11908	39.00	4.00	4.00	9.00	9.00	17.00	30.00	27.00	7.60	5500.00	1.43	37.20	AG
11909	25.00	2.00	18.20	10.00	11.00	15.00	20.00	36.00	8.00	1800.00	2.78	53.10	AG
11910	41.00	7.00	17.80	12.00	10.00	18.00	40.00	18.00	5.30	2300.00	.89	25.30	AG
11911	46.00	6.00	31.50	12.00	10.00	21.00	40.00	20.00	7.70	5500.00	1.68	24.80	AG
11912	43.00	6.00	38.50	13.00	7.00	21.00	40.00	18.00	8.80	8000.00	1.28	23.60	AG
11913	40.00	6.00	15.20	11.00	11.00	22.00	40.00	24.00	4.20	1660.00	2.98	30.80	AG
11914	20.00	2.00	24.40	8.00	15.00	13.00	20.00	26.00	9.90	2350.00	1.36	43.60	AG
11915	26.00	.0	2.40	10.00	11.00	13.00	10.00	145.00	6.20	930.00	.8	64.20	AG
11916	14.00	1.00	2.00	9.00	9.00	11.00	20.00	58.00	1.30	137.00	1.72	67.60	AG
11917	5.00	7.00	2.80	14.00	10.00	24.00	40.00	19.00	1.00	461.00	.64	21.10	AG
11918	5.00	6.00	1.00	13.00	8.00	23.00	40.00	21.00	.5	240.00	.45	21.70	AG
11919	8.00	3.00	24.00	12.00	10.00	22.00	20.00	35.00	9.10	2370.00	.49	37.50	AG
11920	4.00	7.00	1.40	13.00	6.00	23.00	40.00	14.00	1.30	392.00	.85	31.50	AG
11921	7.00	7.00	1.80	12.00	7.00	23.00	40.00	16.00	.3	137.00	.91	25.50	AG
11922	37.00	8.00	10.80	14.00	8.00	22.00	40.00	18.00	3.70	2330.00	1.17	19.00	AG
11923	28.00	.0	1.80	6.00	13.00	16.00	.0	65.00	.7	70.00	1.76	70.30	AG
11924	30.00	.0	1.20	4.00	9.00	13.00	10.00	50.00	.7	80.00	.77	66.60	AG
11925	5.00	8.00	9.80	8.00	5.00	24.00	40.00	10.00	1.50	548.00	.8	22.50	AG
11926	5.00	3.00	10.20	9.00	7.00	15.00	20.00	19.00	1.00	500.00	.96	31.50	AG
11927	7.00	.0	6.00	3.00	9.00	9.00	.0	56.00	8.00	110.00	1.59	63.30	AG
11928	5.00	3.00	2.40	6.00	11.00	12.00	20.00	57.00	7.00	140.00	1.00	52.40	AG
11929	14.00	.0	2.00	6.00	23.00	20.00	10.00	137.00	8.00	140.00	.85	62.20	AG
11930	6.00	.0	1.60	9.00	10.00	14.00	10.00	35.00	6.00	100.00	.7	71.90	AG
11931	ND	.0	12.40	25.00	25.00	30.00	30.00	202.00	8.90	1830.00	2.15	27.60	RL
11932	35.00	.0	8.40	20.00	25.00	38.00	20.00	180.00	7.30	1130.00	1.80	27.60	RL
11933	36.00	1.00	10.00	24.00	26.00	30.00	30.00	180.00	7.70	1580.00	1.84	24.30	RL
11934	22.00	.0	9.40	22.00	18.00	28.00	10.00	127.00	5.90	1040.00	1.88	15.50	RL
11935	22.00	.0	7.40	16.00	14.00	23.00	10.00	108.00	4.00	750.00	1.04	10.40	RL
11936	8.00	.0	7.60	16.00	21.00	18.00	10.00	306.00	1.50	620.00	2.26	57.50	RL
11937	77.00	.0	6.00	19.00	36.00	36.00	10.00	166.00	2.40	740.00	2.06	43.80	MA
11938	75.00	1.00	6.00	18.00	36.00	33.00	30.00	139.00	2.20	680.00	2.18	48.80	RL
11939	35.00	.0	2.40	12.00	29.00	25.00	10.00	157.00	1.90	470.00	1.76	60.70	MA
11940	25.00	1.00	9.00	16.00	22.00	24.00	20.00	196.00	3.20	770.00	1.92	40.00	RL
11941	27.00	.0	3.20	11.00	25.00	23.00	20.00	114.00	1.40	200.00	.91	49.10	RL
11942	55.00	.0	2.40	6.00	30.00	18.00	10.00	138.00	1.10	110.00	1.16	58.40	RL
11943	7.00	.0	3.80	9.00	13.00	18.00	10.00	143.00	1.20	310.00	.96	42.20	RL
11944	7.00	.0	6.60	8.00	14.00	18.00	20.00	171.00	1.60	360.00	1.00	46.90	RL
11945	26.00	.0	5.40	21.00	26.00	41.00	30.00	180.00	7.00	900.00	1.64	21.30	RL
11946	23.00	.0	23.20	11.00	20.00	30.00	20.00	86.00	5.50	580.00	2.14	57.60	RL
11947	12.00	.0	18.80	15.00	21.00	31.00	10.00	87.00	8.00	550.00	1.85	48.70	RL
11948	22.00	.0	5.20	21.00	24.00	39.00	20.00	168.00	7.10	960.00	1.48	20.20	RL
11949	10.00	.0	6.40	14.00	33.00	33.00	20.00	125.00	2.50	440.00	1.54	39.40	RL
11950	23.00	.0	10.00	15.00	19.00	25.00	20.00	167.00	2.50	560.00	1.72	28.90	RL
11951	11.00	.0	8.00	17.00	17.00	29.00	10.00	190.00	2.40	550.00	1.72	31.10	RL
11952	46.00	1.00	1.60	10.00	34.00	30.00	10.00	127.00	1.40	310.00	1.63	45.80	RL
11953	14.00	2.00	36.50	13.00	9.00	16.00	10.00	167.00	19.40	1220.00	1.69	47.00	RL
11954	48.00	1.00	1.60	12.00	27.00	34.00	10.00	137.00	1.50	310.00	.96	44.30	RL
11955	64.00	2.00	1.60	13.00	29.00	33.00	10.00	140.00	1.70	410.00	.85	48.30	RL
11956	46.00	.0	1.40	9.00	29.00	26.00	10.00	310.00	1.50	320.00	1.09	56.60	RL
11957	20.00	1.00	9.60	11.00	11.00	17.00	10.00	78.00	14.70	1530.00	1.81	49.70	RL
11958	19.00	.0	1.00	11.00	21.00	20.00	10.00	114.00	7.00	100.00	.96	54.70	RL
11959	9.00	2.00	41.50	17.00	12.00	22.00	10.00	240.00	14.00	810.00	1.14	51.20	RL
11960	14.00	2.00	27.40	17.00	23.00	29.00	10.00	167.00	8.30	750.00	1.82	48.70	RL
11961	12.00	.0	23.20	15.00	19.00	27.00	10.00	129.00	3.50	350.00	1.98	48.90	RL

Note: ND = No Data

SAMPLE NUMBER	SAMPLE DEPTH	AG (PPM)	AS (PPM)	CO (PPM)	CU (PPM)	NI (PPM)	PB (PPM)	ZN (PPM)	FE (%)	MN (PPM)	U (PPM)	LOI (%)	ROCK TYPE
11962	36.00	.0	2.20	10.00	21.00	28.00	10.00	205.00	1.30	370.00	1.28	55.60	RL
11963	14.00	1.00	9.40	11.00	19.00	24.00	10.00	126.00	1.40	300.00	2.54	60.40	RL
11964	26.00	.0	1.20	9.00	13.00	20.00	10.00	184.00	8.00	140.00	1.05	62.30	RL
11965	35.00	.0	.8	9.00	14.00	22.00	10.00	135.00	1.00	260.00	.85	51.10	RL
11966	16.00	.0	3.00	9.00	19.00	21.00	10.00	83.00	1.60	400.00	2.05	56.00	RL
11967	13.00	1.00	1.20	10.00	11.00	18.00	10.00	109.00	9.00	290.00	1.61	58.30	RL
11968	17.00	.0	2.00	10.00	14.00	18.00	10.00	100.00	1.00	180.00	.72	58.50	RL
11969	20.00	.0	1.80	14.00	34.00	26.00	10.00	181.00	1.40	260.00	1.28	52.60	RL
11970	36.00	.0	1.80	11.00	19.00	22.00	10.00	128.00	1.40	260.00	1.28	53.40	RL
11971	50.00	.0	4.20	10.00	19.00	21.00	10.00	161.00	3.10	430.00	1.02	50.90	RL
11972	ND	.0	5.60	18.00	26.00	32.00	20.00	145.00	5.10	840.00	1.64	25.00	RL
11973	30.00	.0	5.00	8.00	14.00	12.00	30.00	86.00	1.50	950.00	1.07	64.50	RL
11974	25.00	.0	3.00	8.00	23.00	21.00	10.00	87.00	6.00	110.00	.68	65.20	RL
11975	10.00	.0	3.20	12.00	18.00	22.00	10.00	87.00	1.20	310.00	.96	51.40	RL
11976	19.00	.0	4.80	14.00	27.00	33.00	20.00	113.00	2.90	470.00	1.28	22.20	RL
11977	12.00	.0	1.80	12.00	33.00	33.00	10.00	133.00	1.60	270.00	1.72	27.30	RL
11978	20.00	.0	2.40	16.00	29.00	31.00	10.00	220.00	2.10	540.00	1.67	51.40	RL
11979	28.00	.0	5.60	13.00	23.00	29.00	30.00	165.00	1.50	260.00	2.30	48.40	MA
11980	19.00	.0	2.60	5.00	23.00	19.00	10.00	117.00	.8	140.00	.38	58.00	MA
11981	10.00	1.00	15.20	19.00	30.00	35.00	10.00	151.00	7.80	730.00	2.13	42.30	ML
11982	52.00	.0	1.80	7.00	23.00	25.00	.0	152.00	1.20	630.00	.44	64.90	MA
11983	3.00	.0	3.80	10.00	12.00	26.00	10.00	64.00	1.10	220.00	1.69	22.80	G
11984	53.00	.0	9.00	10.00	29.00	28.00	10.00	205.00	3.90	1290.00	1.88	49.30	RL
11985	23.00	.0	4.60	10.00	17.00	25.00	20.00	214.00	5.00	510.00	1.79	47.60	RL
11986	8.00	.0	9.40	8.00	16.00	23.00	.0	87.00	1.50	350.00	1.76	49.30	RL
11987	13.00	.0	9.60	11.00	23.00	32.00	20.00	119.00	2.40	290.00	1.72	53.10	RL
11988	15.00	.0	11.60	10.00	42.00	34.00	10.00	88.00	4.20	420.00	1.82	51.20	RL
11989	4.00	.0	6.20	4.00	9.00	15.00	10.00	48.00	1.10	450.00	.7	62.60	RL
11990	15.00	1.00	10.40	11.00	23.00	27.00	10.00	77.00	4.60	480.00	1.85	47.60	RL
11991	23.00	.0	13.00	21.00	20.00	17.00	10.00	254.00	8.70	1940.00	2.76	55.40	RL
11992	16.00	.0	5.40	8.00	18.00	23.00	10.00	84.00	1.60	320.00	2.08	52.40	MA
11993	14.00	.0	7.20	11.00	17.00	25.00	10.00	87.00	2.40	390.00	1.90	48.40	I
11994	20.00	.0	1.60	6.00	15.00	16.00	10.00	237.00	7.00	220.00	1.16	63.50	MA
11995	6.00	.0	4.00	3.00	5.00	7.00	10.00	18.00	2.00	20.00	1.72	77.40	RL
11996	6.00	.0	1.00	2.00	5.00	10.00	10.00	23.00	3.00	60.00	2.49	80.70	ML
11997	15.00	.0	26.40	13.00	9.00	11.00	20.00	170.00	10.80	670.00	2.43	56.60	RL
11998	20.00	.0	7.40	11.00	23.00	32.00	10.00	77.00	2.20	520.00	2.50	41.90	ML
11999	43.00	.0	9.80	8.00	25.00	28.00	30.00	89.00	2.40	380.00	2.26	37.90	G
12000	21.00	.0	4.40	11.00	23.00	23.00	10.00	99.00	1.10	170.00	2.06	47.30	G
12001	10.00	.0	2.40	8.00	14.00	25.00	10.00	107.00	1.20	250.00	1.22	56.60	ML
12002	14.00	.0	12.40	13.00	26.00	33.00	10.00	166.00	3.00	470.00	1.53	48.70	RL
12003	37.00	1.00	15.20	11.00	21.00	26.00	10.00	103.00	5.70	1350.00	.87	44.50	RL
12004	25.00	.0	4.80	9.00	16.00	25.00	20.00	145.00	1.60	420.00	1.16	48.80	RL
12005	14.00	.0	2.60	5.00	16.00	17.00	10.00	100.00	.6	150.00	2.51	62.80	RL
12006	20.00	.0	3.00	8.00	44.00	24.00	20.00	209.00	1.90	480.00	1.21	58.10	RL
12007	26.00	.0	2.80	13.00	28.00	22.00	10.00	157.00	2.80	690.00	2.39	59.90	RL
12008	30.00	.0	1.40	8.00	24.00	27.00	10.00	91.00	1.20	150.00	1.43	51.60	RL
12009	33.00	.0	1.40	8.00	25.00	24.00	10.00	185.00	1.00	180.00	.8	54.10	RL
12194	38.00	8.00	8.40	12.00	7.00	18.00	40.00	11.00	8.00	1540.00	1.40	9.20	AG
12195	40.00	9.00	9.60	11.00	8.00	18.00	40.00	11.00	9.00	1290.00	1.28	9.80	AG
12196	5.00	8.00	6.40	13.00	7.00	19.00	40.00	9.00	8.00	570.00	1.61	23.60	AG
12197	7.00	.0	1.80	4.00	9.00	12.00	.0	62.00	5.00	90.00	1.16	60.50	AG
12198	ND	.0	2.00	5.00	13.00	15.00	10.00	83.00	6.00	90.00	1.43	64.40	AG
12199	6.00	.0	9.60	16.00	19.00	34.00	10.00	187.00	3.90	1630.00	1.22	54.50	AG
12200	3.00	.0	1.20	5.00	16.00	14.00	20.00	53.00	6.00	200.00	1.35	31.40	AG
12201	3.00	.0	1.60	5.00	18.00	17.00	20.00	75.00	5.00	230.00	1.09	68.90	AG
12202	6.00	1.00	1.40	9.00	26.00	20.00	10.00	49.00	6.00	280.00	1.00	59.60	AG
12203	34.00	.0	4.40	14.00	42.00	37.00	10.00	113.00	2.00	240.00	1.00	24.50	AG
12204	10.00	.0	1.60	13.00	26.00	25.00	10.00	151.00	8.00	270.00	1.28	53.40	AG
12205	3.00	.0	1.60	7.00	18.00	16.00	20.00	59.00	6.00	160.00	1.61	53.10	AG
12206	8.00	.0	1.20	5.00	16.00	12.00	10.00	56.00	4.00	70.00	2.35	68.10	AG

Note: ND = No Data