THE FINDING OF A MAGNETIC ANOMALY IN COASTAL MAINE

SENIOR THESIS

PRESENTED IN FULFILLMENT OF THE REQUIREMENTS
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BY
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List of Tables And Maps

<u>List of Tables And Maps (Continued)</u>

* (1980, Slack, John F., Tourmaline -- A Prospecting Guide For Massive Base-Metal Sulfide Deposits in the Penobscot Bay Area, Maine)

Abstract

The area of central coastal Maine is rich in sulfide and other valuable minerals. In the Blue Hill and Castine Quadrangles specifically, sulfide minerals occur in relatively small localized concentrations, a fact which has been known for almost 250 years. This paper concerns several local concentrations, their associated rock types, and the methods of a surface magnetic survey.

I. INTRODUCTION

The goals of this paper are to discuss the data obtained in a magnetic survey, to interpret the data, and to find a correlation between magnetic anomalies and bedrock. These correlations should indicate in which rocks the Fe-bearing minerals exist, and the genetic origin of these rocks.

The idea for this thesis was first brought to my attention in Maine, in the Autumn of 1981. Local townspeople spoke of a magnetic body in the area. According to these people, surveyors had not been able to locate a property line because of some local magnetic anomaly. Unfortunately, I was unable to confirm this, but did discover several magnetic anomaly areas.

When I returned to Ohio State I spoke with Dr. Hallan Noltimier about the possibility of doing, as a senior thesis, a magnetic survey of the area. Dr. Noltimier gave me instruction in using a Proton Magnetometer, Susceptibility Bridge, and procedures with which to gather and interpret this data.

II. REGIONAL GEOLOGY

My thesis area is located on the central coast of Maine, in the southwest quarter of the Blue Hill Quadrangle. Most of the magnetic data was gathered near Walker's Pond and Little Deer Isle. The actual coordinates of this magnetic survey are: 68°43' - 68° 39' longitude and 44°23' - 44°16' latitude.

The bedrock of this region is covered by many glacial features. According to several geological histories written on the area, 13,000 years ago a continental glacier covered most of Maine, and had its margins near sea level. This glacier receded rapidly and as a result, south and south-central Maine were ice-free 12,800 years ago.[1] The land was still depressed due to the glacier, thus allowing the sea to cover the coastal lowlands. The glacier moved away from coastal Maine in the south and central portions, allowing the land to uplift and the sea to retreat, which occurred 12,000 years ago. This glaciation caused the entire coastal area to become buried in many areas by tills, clays, gravels, and sands. In some of the higher elevated coastal areas, large glacial boulders still remain, some of which are as large as houses. In the coastal lowland areas, many end moraine deposits, drumlins and depositional glacial features are evident. Till can be as thick as 3-75 feet. In this area these discontinuous till features are 20-1,000 feet thick and several are up to 100 miles long.[2] (surface map) These features all occurred around the Pleistocene Epoch.

The bedrock of the Penobscot Bay area of the central Maine coast is underlain by several types of marine sedimentary and volcanic rocks. Some are varieties of igneous plutons, most of which range in age from early to middle Paleozoic. The plutons, which are mostly granitic, range in age from Upper Silurian to Upper Devonian. These rocks constitute most of the bedrock of my area and were found or inferred in the northern area of my survey (see map, Figure 1).

The Castine Volcanics, which include andesite, rhyolite, quartzite, phyllite, talc and slate, are associated with the Eggemoggin Reach bedrock of Little Deer Isle, and the south Walker's Pond area of the mainland.[3]

These meta-volcanic rocks range from Upper Silurian to Lower Devonian in age. Some parts of the area contain dike swarms in the surrounding bedrock. Many of these rocks suggest the possibility of extreme hydrothermal processes occurring in the area.

III. LOCAL MINES AND MINE HISTORY

Perhaps the most metalliferous source rock is a metasedimentary-metavolcanic rock from the formations of the Ellsworth Schist and North Haven Greenstone. These two formations range in age between Cambrian and Ordovician. They contain some semi-precious minerals such as tourmalines, significant amounts of galena, chalcopyrite, pyrite, sphalerite, and some arsenopyrite. Gold and silver can be found in much smaller amounts.

These metals have been mined since the 1700's at Cape Rosier, and in the Blue Hill area. There seem to be several correlations between these sulfide metals and the associated rocks. All the working mines and abandoned mines seem to be located in either Castine Volcanics or Ellsworth Schist. There are also one or more faults associated with the economic sulfide metal deposits.

According to town records from the past 200 years, small abandoned mines are located between Cape Rosier and the Blue Hill Mine.

Furthermore, a large fault exists bearing approximately N 70 E from Cape Rosier towards the Blue Hill mine. Possibly this linear correlation is not obvious due to Upper Silurian and Upper Devonian rocks intruding older schist, partially destroying a linear arrangement.

According to records of the Black Hawk mine in Blue Hill, and cross sections done in the area, the copper-zinc zones are massive tabular lens-shaped bodies situated on both sides of a fault with quartzite below and biotite schist above. These lenses average 400 meters depth below the surface, 10-60 meters thickness, and the largest are 700-800 meters in length. These sulfide metals are associated within Mg-rich silicate gangue. Many of these lenses have fractionated into their respective components, with zoning of zinc, copper with zinc, and copper, lead and silver.

One geologist, Dr. Wyeth Smith, states that the Black Hawk mine in the Blue Hill, Maine area may be considered to have exhalative syn-sedimentary origins in a proximal environment.[4] The Harborside mine on Cape Rosier is peripheral to a volcanic center. According to the State of Maine Geological Information, Black Hawk and Harborside ore bodies are unrelated in origin.[5] I feel there must be at least some genetic relationship between them according to the localized fault zone evidence which was stated above.

IV. GEOMAGNETIC SURVEY BACKGROUND

There are several instruments used on this thesis. Some of these instruments were used in the field, while others were used in the lab in preparing data and samples.

The most important instrument used in the preparation of this thesis was the Proton Magnetometer model GM-122, which is manufactured by Barringer Research Limited. The specifications are as follows: Range 20,000 to 99,999 Gammas in twelve intervals; Accuracy to within +/- one Gamma from -40°C to 55°C temperature range; Gradient tolerance is within 600 Gammas per foot; Output displayed via L.E.D. read-out in three or six second intervals.

V. PRINCIPLES OF OPERATION AND OTHER INSTRUMENTS USED IN THIS STUDY

The operating precautions of the Proton Magnetometer are as follows: Make sure no ferrous objects are on the body of the reader. If any large metallic objects or line electrical wires are in the area, they should be avoided. The staff and sensing head must be kept vertical.

The principles behind the Proton Magnetometer are that after a sensing head filled with a proton rich fluid is subjected to an orienting magnetic field, the protons precess about the local magnetic field vector, whose strength determines the precession frequency.

The sensor is polarized by depressing the button on the console. This triggers a pulsed one oersted field aligning the protons. The protons behave as elementary gyroscopes, and will start preceding around the external magnetic field of the earth after the polarizing field decays. The magnetometer counts this precession frequency, divides it by the appropriate constant to obtain a reading in Gammas (one Gamma = 10^{-5} gauss) and displays the reading in the form of a five digit number.[6]

A watch or a time piece of some kind is necessary. This is important due to the diurnal variation of the earth's magnetic field during the 24 hour day. There is a maximum and a minimum per 24 hour interval, and repeated reference readings at a fixed location every few hours.

The maximum and minimum are in the form of a crude sine wave. A single base station must be set up and carefully timed readings taken there as many times as possible over the entire day. These readings will show graphically the diurnal variation and are used to correct individual site readings during the day to a standard time of day, where the regional field is known.

Another instrument used for this magnetic survey was a Brunton compass or pocket transit. This tool, along with a topographic map, was used for locating sites for the magnetic survey, or sites for collecting bedrock samples, if possible. The surveyors may use several methods of locating himself. I used any outstanding geologic or topographic features, roads, houses, and water bodies. If the features for locations were in the distance, I used two or three of these as near as possible and took a bearing on each with the compass. The site is located on the map, then numbered and recorded with date and time, and three readings to within one or two Gammas of each other are taken.

The field work is followed by lab work. If any local rock samples were collected, two methods for preparation may be used. The rock may be cored with a diamond tipped drill making sure the diameter and length are held constant. The other method of preparing samples would be to crush equal volumes of the rocks to a sandy texture. The rocks can then be tested for magnetic susceptibility on an instrument called the Magnetic Susceptibility Bridge.

These same rocks may also be cut and polished in thin sections or polished sections in order to determine the rock type and examine for metallic minerals or accessory minerals. These specimens were given an identification number and/or letter.

The Susceptibility Bridge is an instrument used to test the total magnetic susceptibility of crushed or solid cylindrical samples. The objective for using this instrument is to discover which lithologies are more likely to have larger than average magnetic polarizations in the earth's field.[7] For this purpose, samples were prepared in cylinders of constant volume and size, one inch diameter cores, two and one-half inches in length, convenient for the Susceptibility Bridge. The cores were measured to determine the relative bulk iron content since ore bodies generally are rich in iron minerals. Iron minerals are responsible for the magnetic anomalies observed by the Proton Magnetometer, so surface magnetic surveys may locate ore bodies.[8]

The magnetic Susceptibility Bridge measures the ratio of induced magnetic polarization (IP) to a known (one oersted amplitude), alternating magnetic induction field, H, and fixed frequency (400 c.p.s.).[9]

The Susceptibility Bridge determines the total magnetic susceptibility K. Several known numerical factors are used in the calculation to account for any differences in volume and shape between samples. K is given in units of gauss/oersted, gauss for the induced moment per unit volume (Ip), and oersted (Oe), for the induction field amplitude H.

Thus, the expression K = Ip/H is given to express the susceptibility of these cores.

Taking readings of the different core samples gives the field surveyor an idea of what type of magnetic polarization values go along with different lithology. Then, the surveyor may be able to draw a conclusion on which types of rocks contain iron minerals, and predict if these areas are likely to be associated with a magnetic field anomaly. In this case, some of the samples had contained sulfide minerals, and their susceptibilities gave examples of the location and magnitudes which might accompany local ore bodies. The formulas associating the volume and other vital statistics to the susceptibilities are as follows: Anomaly = ^{H}observed-^{H}earth); (^{H}observed-^{H}earth) = KHe* volume of ore, ignoring shape effects.[10]

VI. MAGNETIC RESULTS AND INTERPRETATIONS

Using the magnetic susceptibilities data the highest susceptibilities were associated with the schist and gneiss rocks of the area. These rocks under microscopic examination in some cases, showed sulfide minerals associated with them, especially chalcopyrite, sphalerite, and some galena. The highest susceptibility value obtained was 350 gauss/oersted from a sample of chalcopyrite from Cape Rosier Harborside mine. In terms of enclosing bedrock, the schist-gneiss type of rock had the value of 236 gauss/oersted, while the surrounding bedrock is granite and quartzite have much lower values. The granite has a reading of 96.4 gauss/oersted, while the quartzite has a value of 3.57 to 46.4 gauss/oersted, depending on the purity of the quartzites.

Noting the respective values for each type of rock, the next step involved in interpreting any relationship between bedrock and a magnetic anomaly is to note the rock types and the areas which those samples formed. Using this data, a map can be constructed filling in the corresponding susceptibilities with the rock type of the cores tested. Then the surveyor notes if any correlations exist between the mapped susceptibility values and the contoured map of the magnetic anomalies. If any correlations exist, such as the high susceptibility values associated with the sulfide minerals in the gneiss and schist, these correlations shall be noted.

Once all the magnetic values in Gammas for each site have been recorded, and the time of day corrections made for the diurnal variation curve, the next step is to take all these corrected values and find the average value. When site value is subtracted by this average value, the corresponding value will give a positive or negative number relative to the average Gamma value for the sites. These values will then all be placed on a contour map so that any relatively low or high area of the map is contoured in 25 or 50 Gammas, depending on the amount of change over the area. These anomalies will show up generally as surfaces with a high gradient. In this survey anomalies were found in two small concentric .5 square kilometer areas. Anomalous areas may show values greater or less relative to the surroundings. This is compared with the bedrock map and correlation of ore bodies associated with certain rock types can be interpreted.

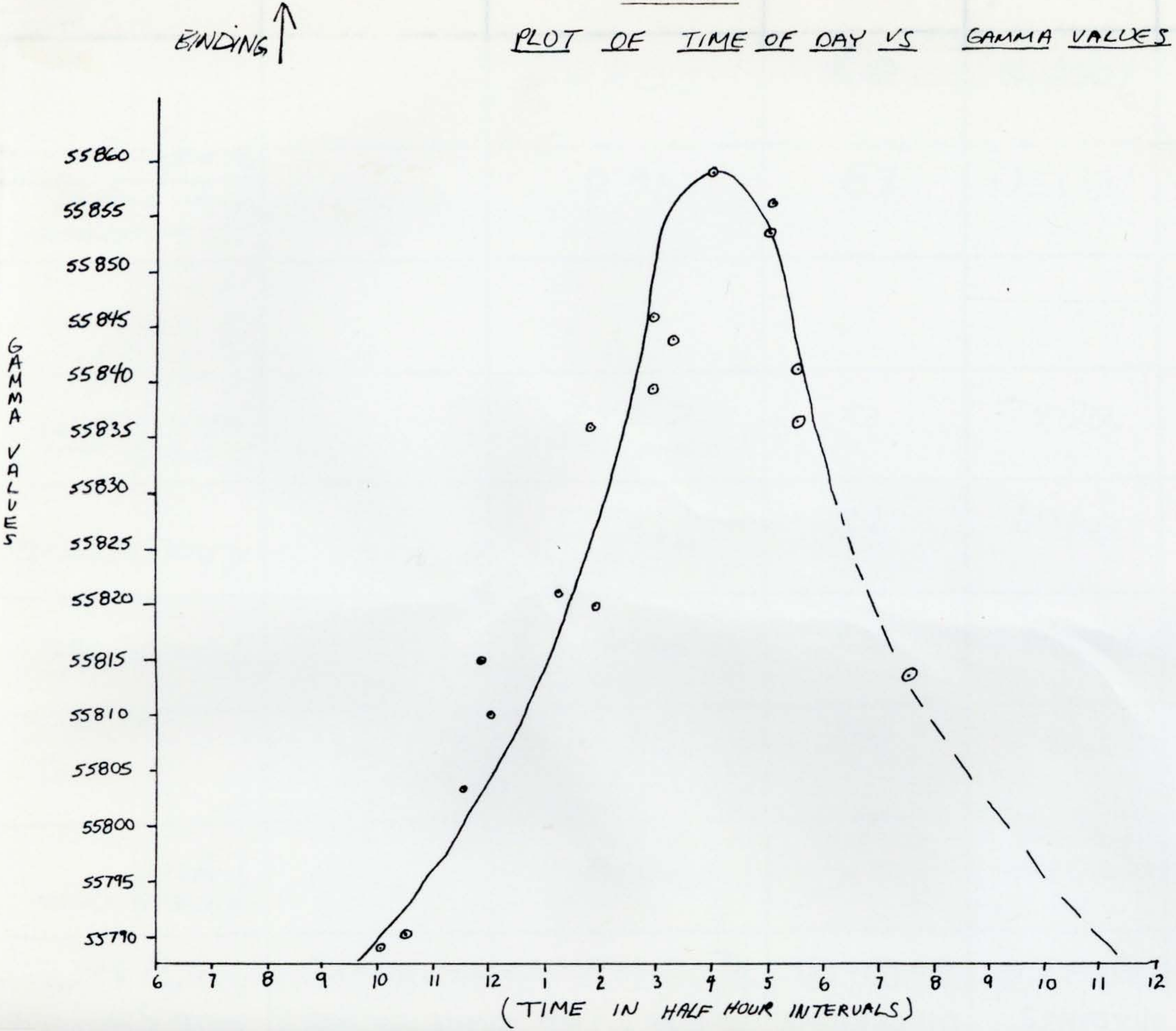
In the case of this survey area, the two areas of interest with the greatest negative Gamma gradient were located adjacent to the toll bridge crossing Eggemoggin Reach in sector 196. One anomaly is found just north of the toll bridge in metavolcanic type bedrocks. The area has an abandoned silver mine shaft which is on the cliffs above Eggemoggin Reach. There is much injected quartz and many micro dikes associated with these rocks. These rocks have been in several cases highly altered. Further to the north, the bedrock in some places even shows signs of oxidation of the Fe minerals.

The southern negative anomaly is located on Little Deer Isle approximately next to site 225. This Island has a nearly east-west fault which runs somewhere near the area of the southern anomaly. The rocks associated with the fault have been highly altered and a slickenside of serpentine is observable on the cliffs of the nearby quarry located in sector 224. This fault, like the faults associated with the Harborside mine and Blackhawk mines, may be part of the genetic origin of these anomalies. Once again, metavolcanic rocks and quartzites are associated with these areas.

The metavolcanics and schist and gneisses seem to be the rock types associated with the sulfide minerals and magnetic anomalies, while the granite and quartz rich rocks seem to be lacking either iron bearing minerals or anomaly occurrences.

In conclusion, I believe that the most recent granite pluton may have intruded a fairly rich sulfide bearing rock like those associated with both mines. Maps of these areas, the main bedrock lithology, susceptibilities, and magnetic anomalies are documented and labeled in this thesis.

APPENDIX A


BINDING
PLOT OF TIME OF DAY VS GAMMA VALUES
GAMMA VALUES
55860
55855
55850
55845
55840
55835
55830
55825
55820
55815
55810
55805
55800
55795
55790
6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12
(TIME IN HALF HOUR INTERVALS)

TOTAL MAGNETIC SUSCEPTIBILITY MEASUREMENTS

CORE NUMBER	BALANCE B READINGS ① EMPTY	② CORE	DIFFERENCE $\Delta = ① - ②$	K FOR 1 INCH DIAMETER CORES $K_a = 3.57 \times \Delta \times 10^{-6}$	$K = 1.413 \times K_a$	DATE & COMMENT 1/7/82
P2-1	~~10068~~ 10065	~~10041~~ 10064	~~27~~ 1	~~96.4~~ 3.57		~~granite core~~ Pyrite
P2-2	10065	9999	66	236		
P2-3	10068	10041	27	96.4		granite core
P2-4	10067	9969	98	350.0		Chalcopyrite
P2-5	10062	10062	0	< 3.57		Pyrite in quartzite (?)
P2-6	10061	10060	1	3.57		quartzite
P2-7	10063	10050	13	46.4		Metamorphosed thin bedded sediment rich in quartz
P2-8	10062	10005	57	203.5		
P2-9	10061	10044	17	61.0		

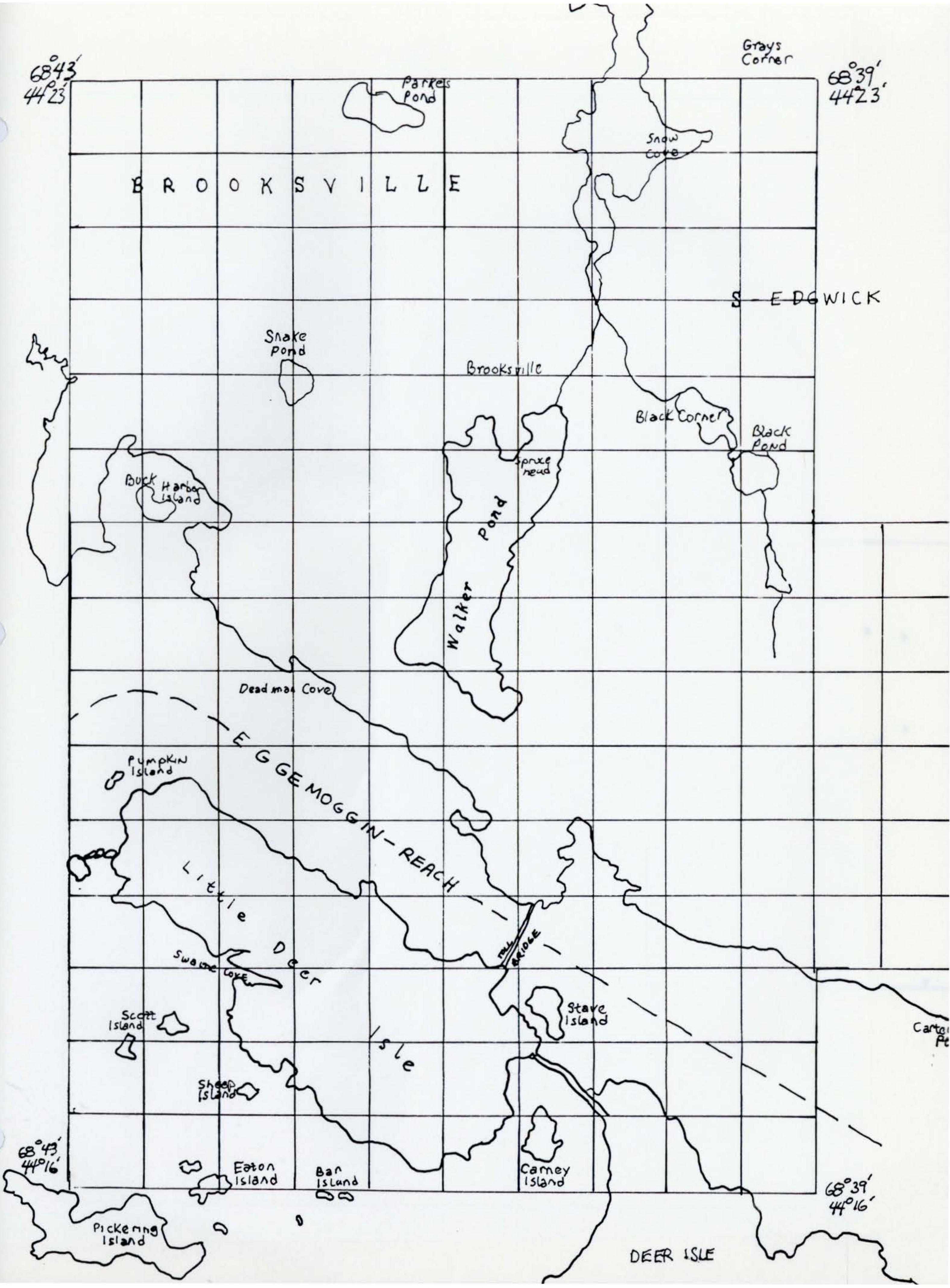
TABLE OF SITE NUMBERS, TIMES AND VALUES

Site Number	Time	Reading 1	Reading 2	Reading 3	Average Reading	Correction #	New Value	$\Delta\gamma$
106	10:17	56125	56125	56125	56125	2	56123	- 34
109	1:42	55918	55918	55918	55918	41	55877	-101
116	10:07	55885	55885	55885	55885	1	55884	-108
118	1:52	55901	55901	55901	55901	45	55856	- 80
119	1:47	55903	55903	55903	55903	42	55861	- 85
126	10:00	55853	55853	55853	55853	0	55853	- 77
128	1:35	55895	55895	55895	55895	42	55853	- 77
130	12:03	55821	55821	55821	55821	17	55804	- 28
136	9:50	55862	55862	55862	55862	1	55861	- 85
137	1:28	55858	55858	55858	55858	41	55817	- 41
138	1:30	55871	55871	55871	55871	40	55831	- 55
140	12:15	56165	56165	56165	56165	21	56144	-368
141	12:24	55757	55757	55757	55757	23	55734	42
142	12:55	55828	55828	55828	55828	31	55797	- 21
143	1:03	56124	56124	56124	56124	33	56091	-315
144	1:13	55877	55877	55877	55877	37	55840	- 64
145	1:20	55816	55816	55816	55816	38	55778	- 2
146	9:40	55855	55855	55855	55855	3	55852	- 76
147	7:57	55831	55831	55831	55831	31	55800	- 24
154	3:04	55856	55856	55856	55856	57	55799	- 23
157	2:51	55839	55839	55839	55839	30	55793	- 17
158	8:02	55850	55850	55850	55850	27	55823	- 47
164	3:08	55861	55861	55861	55861	58	55803	- 37
168	8:16	55782	55782	55782	55782	22	55850	- 74
167	7:35	55896	55896	55896	55896	33	55863	- 87
169	8:24	55801	55801	55801	55801	19	55782	- 6
169	8:33	55835	55835	55835	55835	17	55818	- 42
174	3:15	55803	55803	55803	55803	59	55744	32
177	Base Station ---							
179	8:42	55773	55773	55773	55773	19	55759	17
179	8:48	55828	55828	55828	55828	14	55814	- 38
184	3:20	55793	55793	55793	55793	63	55730	46
185	3:25	55777	55777	55777	55777	62	55715	61
187	10:48	55851	55851	55851	55851	4	55847	- 71
189	9:00	55817	55817	55817	55817	11	55806	- 30
189	9:05	55820	55820	55820	55820	9	55811	- 35
190	2:25	55791	55791	55791	55791	52	55739	37
191	2:53	55748	55748	55748	55748	47	55701	75
196	9:58	55750	55750	55750	55750	3	55749	27
196	10:40	55998	55998	55998	55998	4	55994	-218
197	10:16	55733	55733	55733	55733	2	55740	35
200	2:15	55730	55730	55730	55730	55	55730	46
201	3:00	55772	55772	55772	55772	58	55714	62
202	2:17	55789	55789	55789	55789	49	55740	36
203	2:10	55821	55821	55821	55821	57	55764	12
206	10:54	55703	55703	55703	55703	6	55697	79
207	11:37	55747	55747	55747	55747	13	55734	42
208	None ---							
210	3:11	55742	55742	55742	55742	60	55682	94

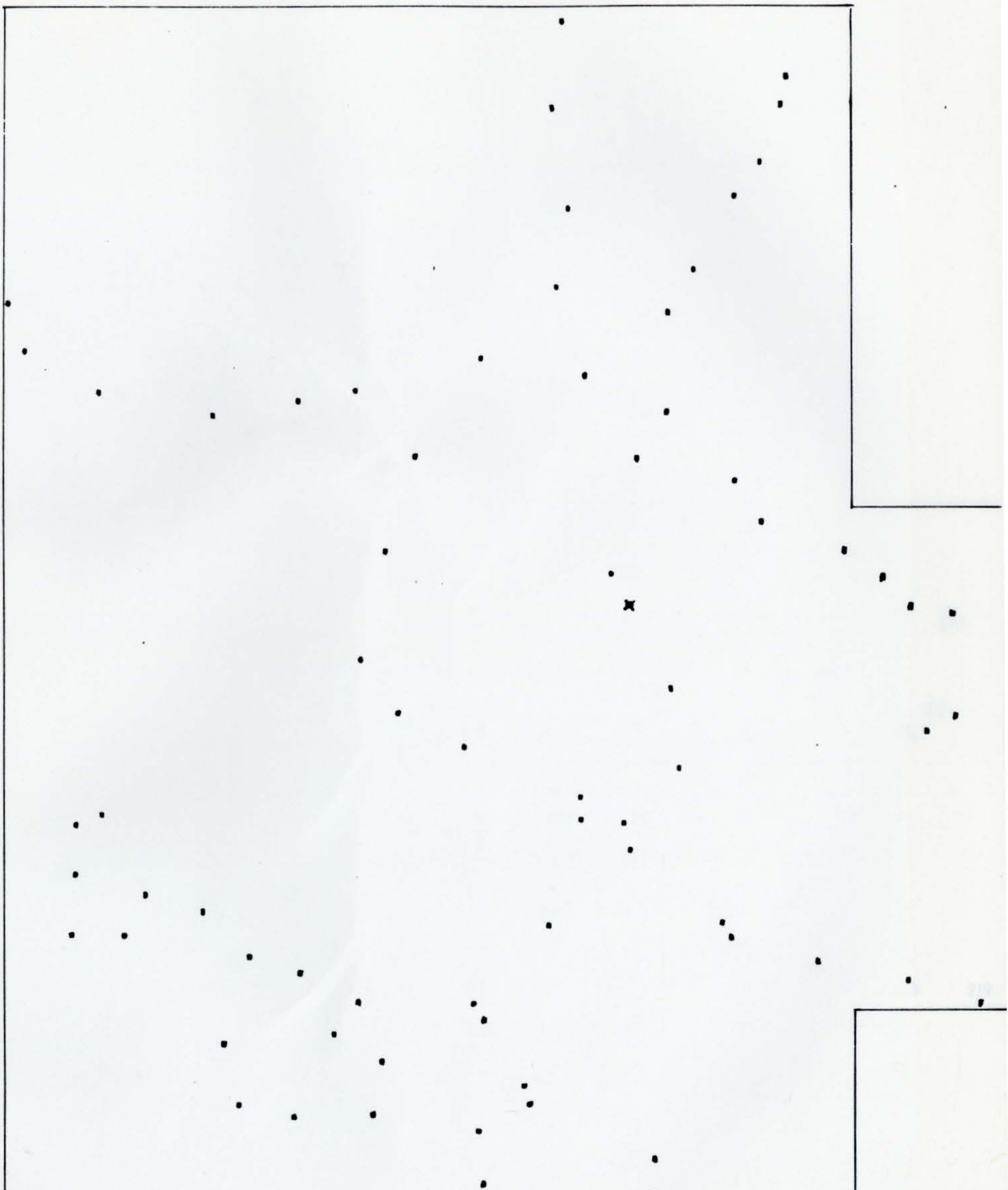
CONTINUED TABLE OF SITE NUMBERS, TIMES AND VALUES

Site Number	Time	Reading 1	Reading 2	Reading 3	Average Reading	Correction #	New Value	$\Delta\gamma$
211	3:10	55752	55752	55752	55752	58	55694	82
212	2:07	55730	55730	55730	55730	49	55681	95
213	2:03	55851	55851	55851	55851	48	55803	- 27
214	1:56	55676	55676	55676	55676	47	55629	147
215	3:40	55750	55750	55750	55750	64	55693	83
218	9:43	55709	55709	55709	55709	1	55708	68
218	9:37	55674	55674	55674	55674	2	55672	104
219	9:15	55717	55717	55717	55717	5	55611	165
219	9:27	55616	55616	55616	55616	8	55709	67
222	4:07	55819	55819	55819	55819	69	55750	26
223	3:35	55730	55730	55730	55730	63	55667	109
224	4:30	55677	55677	55677	55677	70	55607	169
225	3:01	55886	55886	55886	55886	57	55829	- 53
226	11:51	55739	55739	55739	55739	17	55722	54
232	4:00	55793	55793	55793	55793	67	55726	50
233	3:51	55725	55725	55725	55725	66	55659	117
234	3:13	55829	55829	55829	55829	61	55768	8
235	11:56	55694	55694	55694	55694	18	55668	108
237	12:40	55698	55698	55698	55698	26	55672	104
244	3:37	55802	55802	55802	55802	64	55738	38
245	12:01	55686	55686	55686	55686	18	55668	108
247	12:26	55670	55670	55670	55670	23	55647	129
248	12:49	55686	55686	55686	55686	30	55656	120

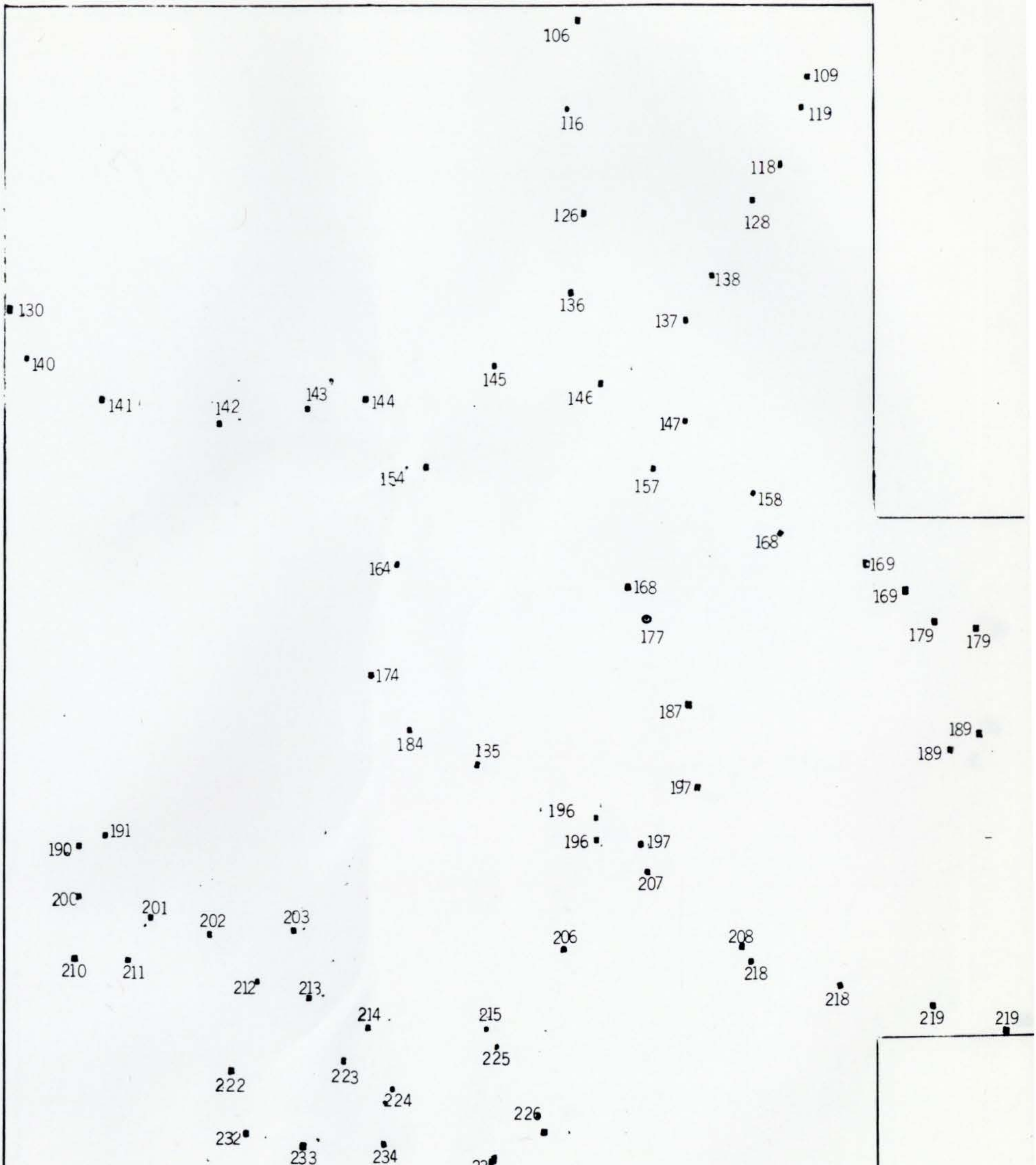
Base Station	Time	Reading 1	Reading 2	Reading 3	Average Reading			
177	10:23	55790	55791	55791	55791	-	-	- 20
177	9:30	55791	55791	55791	55791	-	-	- 19
177	11:57	55810	55810	55810	55810	-	-	0
177	5:20	55837	55837	55837	55837	-	-	27
177	10:00	55789	55789	55789	55789	-	-	- 22
177	1:44	55836	55836	55836	55836	-	-	+ 27
177	2:50	55846	55846	55846	55846	-	-	36
177	5:33	55843	55843	55843	55843	-	-	33
177	11:23	55803	55803	55803	55803	-	-	- 7
177	1:15	55821	55821	55821	55821	-	-	11
177	1:50	55819	55819	55819	55819	-	-	9
177	2:51	55839	55839	55839	55839	-	-	29
177	4:00	55858	55858	55858	55858	-	-	48
177	5:00	55853	55853	55853	55853	-	-	43
177	9:00	55814	55814	55814	55814	-	-	4
177	11:55	55815	55815	55815	55816	-	-	6
177	3:15	55843	55843	55843	55843	-	-	33
177	4:26	55831	55831	55831	55831	-	-	21
177	7:27	55812	55812	55812	55812	-	-	2


68°43'
44°23'
Parkes Pond
Grays Corner
68°39'
44°23'
Snow Cove
BROOKSVILLE
SEDGWICK
Snake Pond
Brooksville
Black Corner
Black Pond
Spruce head
Buck Harbor Island
Walker Pond
Deadman Cove
EGGEMOGGIN-REACH
Pumpkin Island
Little Deer Isle
TOLL BRIDGE
Scott Island
Stave Island
Sheep Island
68°43'
44°16'
Eaton Island
Bar Island
Carney Island
68°39'
44°16'
Pickering Island
DEER ISLE

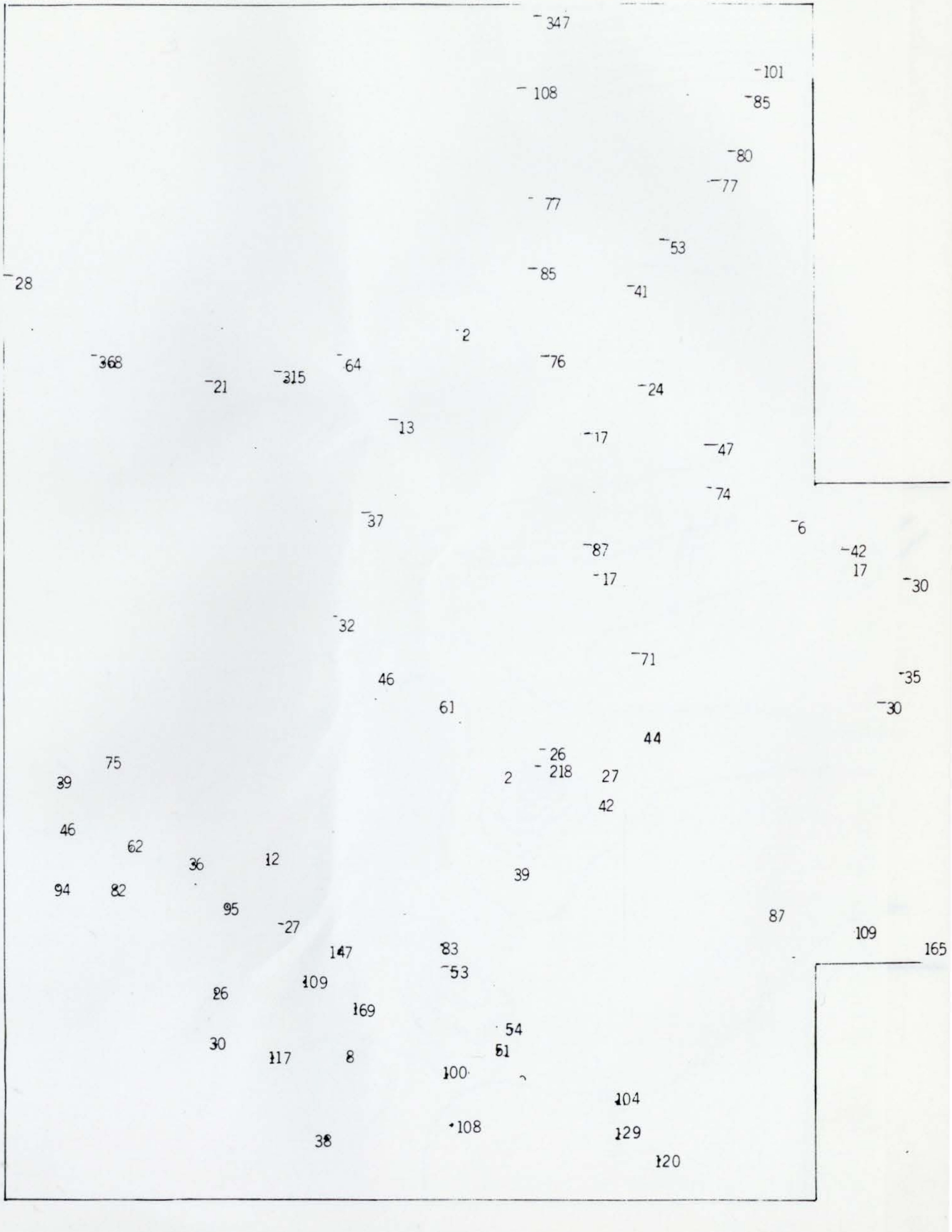
LOCATED POINTS



SITES AND LOCATIONS WITH NUMBERS



LOCATED AND CORRECTED ΔY VALUES

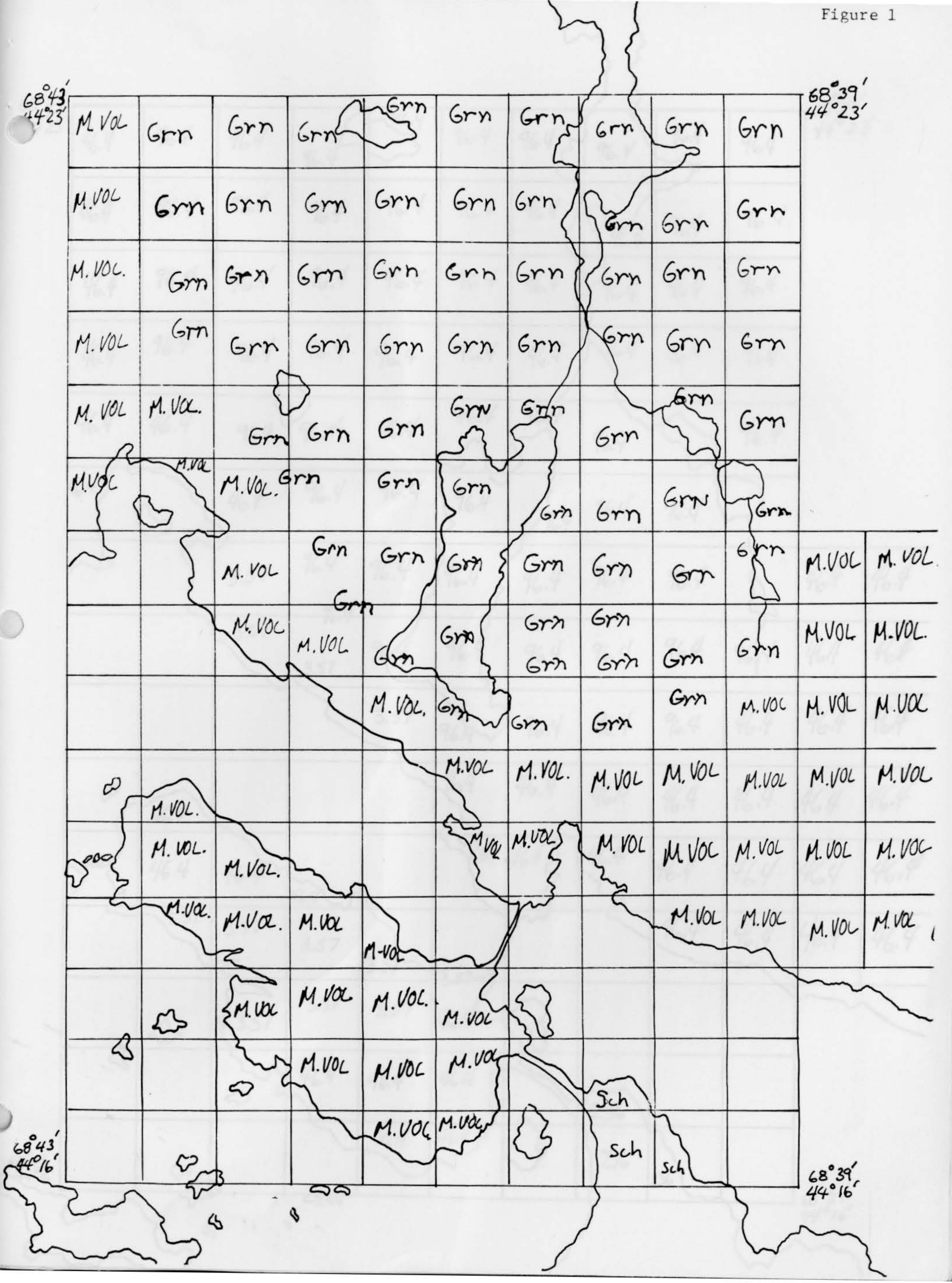


REGIONAL MAGNETIC VARIATIONS

LEGEND FOR

MAP VI AND ASSOCIATED ROCK TYPES

ROCK TYPE	DESCRIPTIONS AND LITHOLOGIES
Grn.	PLUTONS - MOSTLY GRANITE SEDGWICK PLUTON UPPER SILURIAN TO UPPER DEVONIAN INTRUSIVE ROCKS
M. VOL.	CASTINE VOLCANICS, THOROFARE ANDESITE, AND VINAL HAVEN RHYOLITE UPPER SILURIAN TO LOWER DEVONIAN METAVOLCANIC ROCKS
Sch.	ELLSWORTH SCHIST AND NORTH HAVEN GREENSTONE PALEOZOIC METASEDIMENTARY AND META VOLCANIC ROCKS


68°43'
44°23'
68°39'
44°23'
M.VOL Grn Grn Grn Grn Grn Grn Grn Grn Grn
M.VOL Grn Grn Grn Grn Grn Grn Grn Grn Grn
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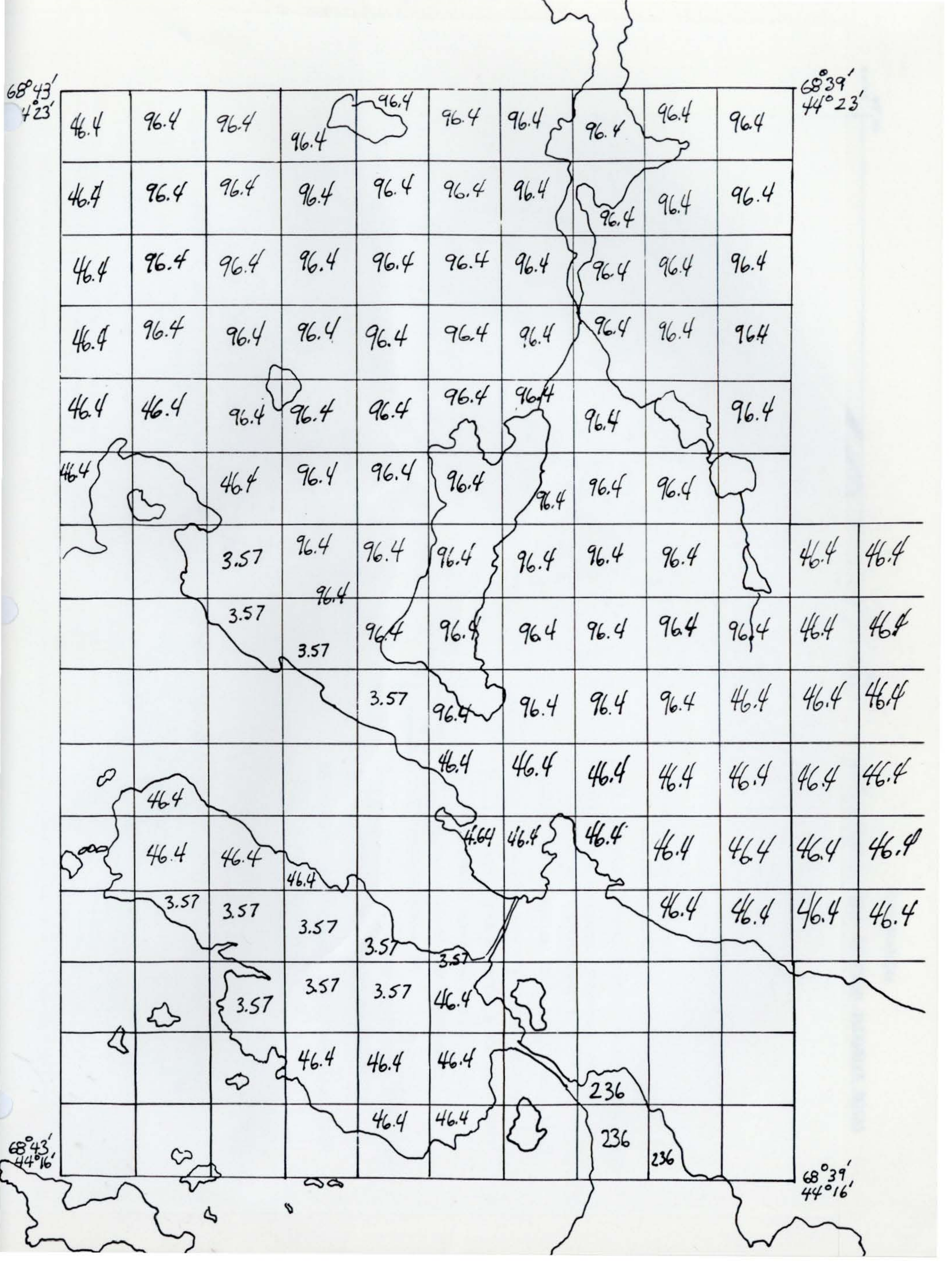
68°43'
44°16'
68°39'
44°16'



68°43'
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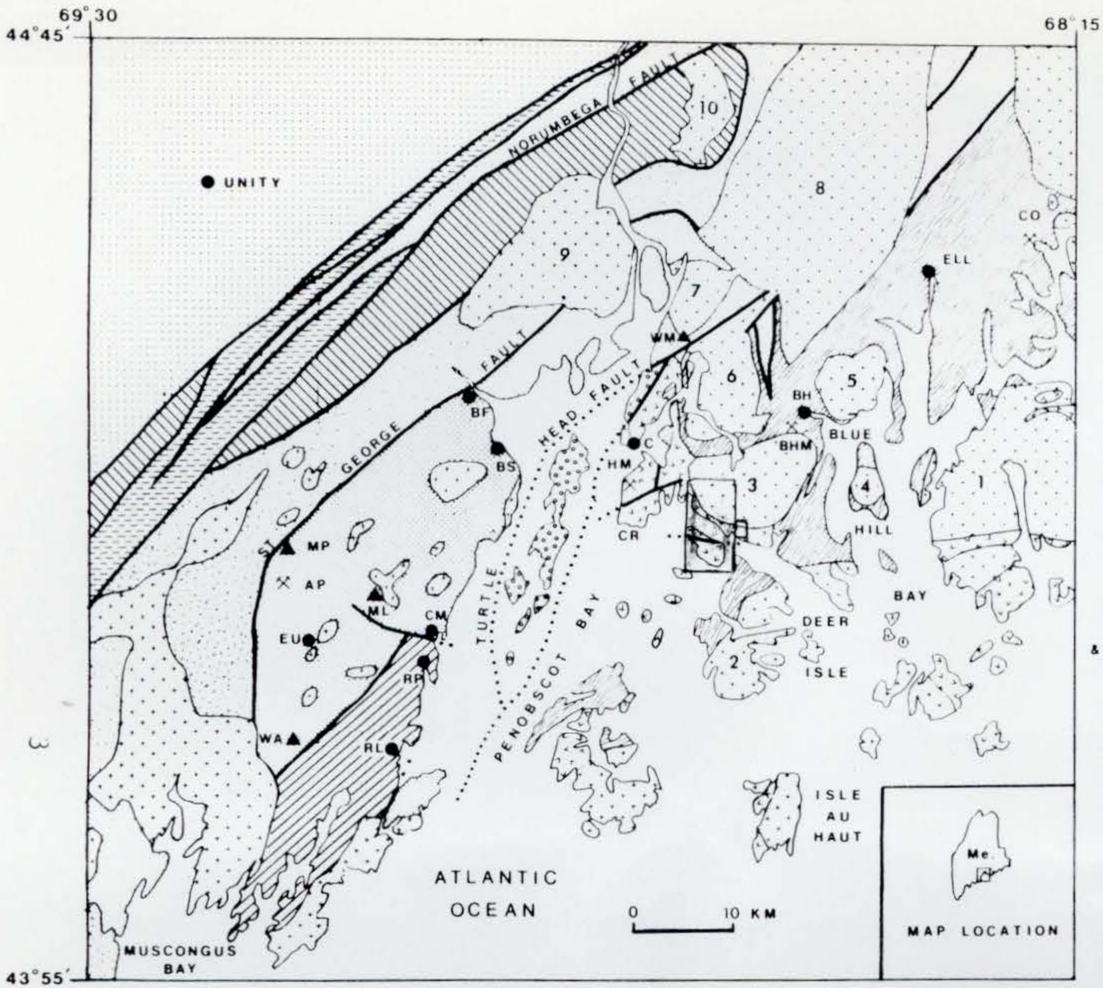

EXPLANATION

UPPER SILURIAN TO UPPER DEVONIAN INTRUSIVE ROCKS

PLUTONS—MOSTLY GRANITE

1. MOUNT DESERT
2. DEER ISLE
* 3. SEDGWICK
* 4. LONG ISLAND
* 5. EAST BLUE HILL
6. SOUTH PENOBSCOT
* 7. WALLAMATOGUS
* 8. LUCERNE
9. MOUNT WALDO
10. STRICKLEN RIDGE

UPPER SILURIAN TO LOWER DEVONIAN METAVOLCANIC ROCKS

CASTINE VOLCANICS, THOROFARE ANDESITE AND VINALHAVEN RHYOLITE

PALEOZOIC METASEDIMENTARY AND METAVOLCANIC ROCKS

SILURIAN & DEVONIAN

VASSALBORO AND WATERVILLE FORMATIONS

CAMBRIAN AND/OR ORDOVICIAN

BUCKSPORT AND APPLETON RIDGE FORMATIONS

PENOBSCOT FORMATION AND EQUIVALENTS

HOGBACK SCHIST AND EQUIVALENTS

ISLESBORO FORMATION

ELLSWORTH SCHIST AND NORTH HAVEN GREENSTONE

ROCKPORT AND BENNER HILL SEQUENCES

PROTEROZOIC OR PALEOZOIC METASEDIMENTARY ROCKS

PASSAGASSAWAKEAG GNEISS AND CUSHING FORMATION

Figure 1.--Geologic map of the Penobscot Bay area, Maine, showing the location of tourmaline-bearing rocks. Granitic plutons containing tourmaline are marked by an asterisk (*) in the explanation. Non-plutonic tourmaline occurrences and other localities mentioned in the text are identified on the map by letter symbols: AP = Appleton prospect, BF = city of Belfast, BH = village of Blue Hill, BHM = Black Hawk (Blue Hill) mine (includes nearby Douglas mine and Stober prospect), BS = Bayside village, C = Castine village, CM = city of Camden, CO = Copperopolis (Custer) mine, CR = Cape Rosier, ELL = city of Ellsworth, EU = village of East Union, HM = Harborside (Penobscot) mine, ML = Megunticook Lake locality, MP = Mill Pond locality, RL = city of Rockland, RP = village of Rockport, WA = Warren locality, WM = Wallamatogus Mountain locality. Geology compiled from Bastin (1908), Bickel (1976), Chapman (1974), Hussey and others (1967), Osberg and Guidotti (1974), Smith and others (1907), and Stewart and Wones (1974). Areas containing Precambrian rocks on small islands within the Islesboro fault block (Stewart, 1974) are not shown. All faults shown are of high-angle type.

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