STATE OF SOUTH DAKOTA
George T. Mickelson, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

REPORT OF INVESTIGATIONS

No. 60

A GEOPHYSICAL STUDY OF THE MILBANK GRANITE AREA

by

Bruno C. Petsch

University of South Dakota
Vermillion, South Dakota
April, 1948

DEPARTMENT OF WATER AND NATURAL RESOURCES
SOUTH DAKOTA GEOLOGICAL SURVEY
Science Center, USD
Vermillion, SD 57069
(605) 624-4471

MEMO

TO: Geological Survey Staff

FROM: Susan Green

SUBJECT: Errata in the Report of Investigations No. 60, A GEOPHYSICAL STUDY OF THE MILBANK AREA, by Bruno Petsch, 1947

DATE: December 14, 1981

An error in the legal description has been found on page 1 of the aforementioned report and the following illustrations:

Figure 4: Table showing value of resistivity soundings.

Figure 5: Table showing value of resistivity soundings. (cont.)

Map showing the relief of the granite surface.

Topographic map of the Milbank Granite area, Grant County.

The legal designations R47W and R46W should be amended to R48W and R47W, respectively.

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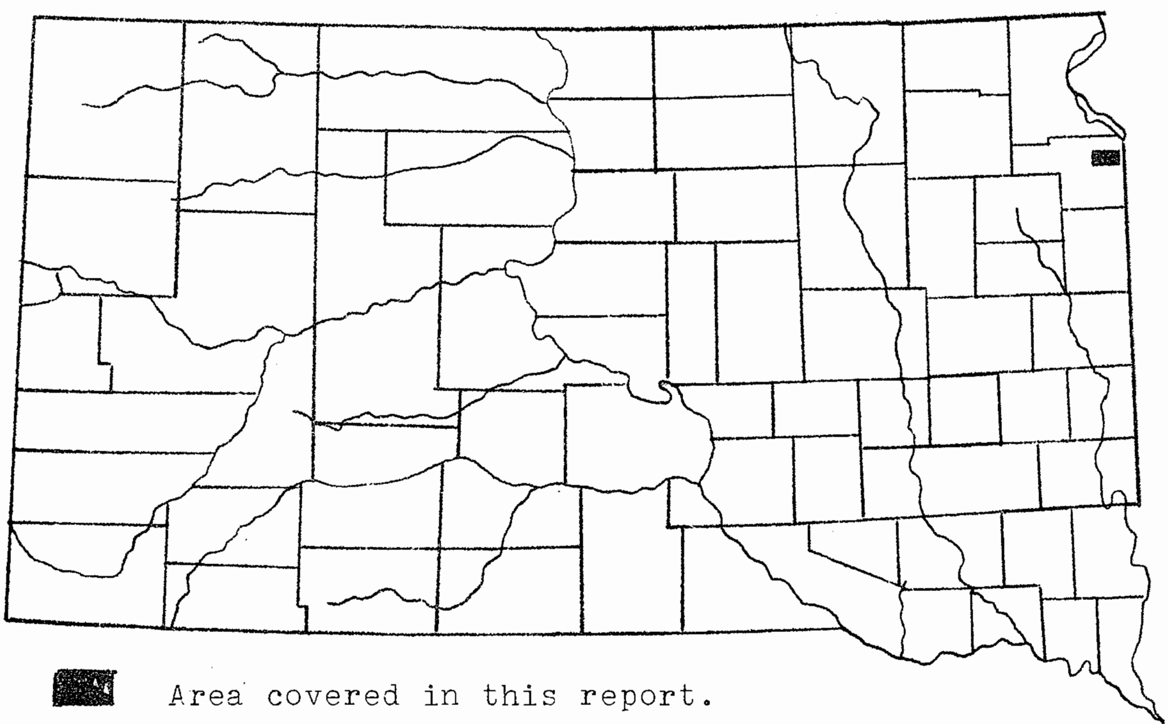
INDEX MAP



Area covered in this report.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION

Purpose of the Report

The purpose of this investigation and survey was to determine the depth to the granite bedrock in order to help operators of the quarrying industry to expand their operations or aid others now interested in new developments.

The original quarries were opened on granite outcrops where a minimum amount of stripping was required. Today, however, stripping methods are well developed; hence quarries can be opened up on places where the granite bedrock is reasonably near the surface. Once an area has been stripped of overburden so that the granite bedrock is exposed, the opening will remain for quarrying operations for many years to come.

In this respect quarry sites are limited by the depth to the granite bedrock; it depends chiefly on how deep an operator can strip economically. Thirty to thirty-five feet is perhaps the practical limit.

Location of the Area

The Milbank granite area, as it is commonly known, is a small area five miles east and one mile south of Milbank, in Grant County. It is located in Sections 12 and 13, T 120 N, R 47 W and in Sections 7, 8, 18, 17, T 120 N, R 46 W. Figure 1. The Minnesota state line is one mile east of the latter section.

The area covered by this investigation is three miles long and one mile wide, and includes all the granite quarries operating at the time of the survey.

Acknowledgements

The writer gratefully acknowledges the assistance given him by Mr. Loyd Carlson and Mr. Ralph Miller for their cooperation throughout the survey.

The State Geological Survey wishes to express appreciation to the citizens of Milbank and of the area over which the

survey was carried, for the many courtesies extended, such as permission to enter fields.

Appreciation is also extended to Mr. E. G. Stengle and members of the Dakota Granite Company for many courtesies, which contributed much to the success of the survey.

Nature and Scope of Work

The survey consisted primarily of taking electric earth resistivity soundings in more or less detail over the strip of land mentioned above.

The equipment used for the sounding was a Resistance Gradiometer, manufactured by the Heiland Research Corporation, Denver, Colorado. It consists of a gas motor-driven AC generator, a direct reading alternating current with amplifier and glavanometer, housed in an instrument box, field wires, iron and copper stakes. Figure 2. The method is an accepted type for geophysical exploration, and it is not deemed necessary to describe the working of the equipment, because it has been described many times in the scientific literature dealing with that phase of geophysics.

The altitude and location of each station was determined with a plane table and alidade, and a topographic map was made of the area.

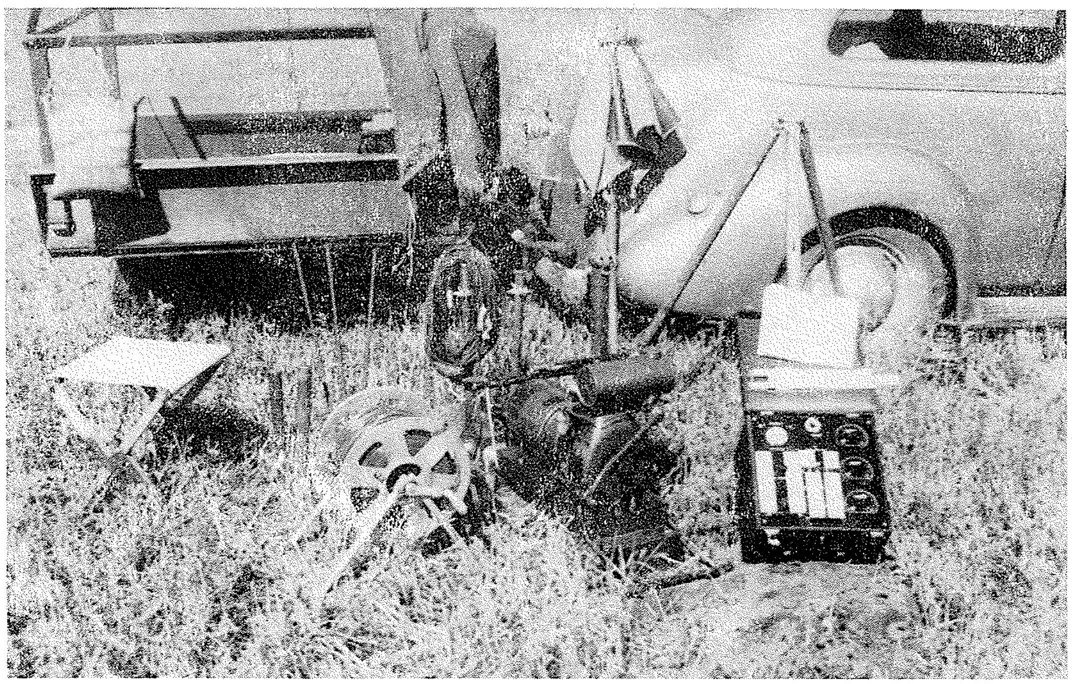
During the first part of the season, the survey was carried on in pastures and cornfields; later, as the harvesting was completed, it was carried on in the stubblefields.

The sounding procedure required an operator, a recorder, and a stake driver; all persons assisted in the assembly, take down, and loading the equipment at the completion of a station.

After several stations were made, the plane table survey was completed for that portion of the work.

There are several places in the area where no resistivity soundings could be taken because the ground was in such a condition that current would not yield a potential sufficient to be measured.

The extremely dry condition of the ground was probably the main reason for weak potentials. In these places soundings could sometimes be taken down to 60 feet if the power probes were watered, or if the generator was speeded up to higher voltages.



Resistance Gradiometer used for sounding.

Figure 2

The high land area in the southeast of the SW of section 12 was such a spot. It is underlain with gravels on which is very thin soil. This was assumed to be the reason that soundings could not be taken in this locality. The hill in the N W of the SW of 18 would not yield potentials sufficient to be measured. An area in the south center of section 7 lacks a few soundings because the ground was extremely dry and hard.

GEOLOGY

The rocks of the Milbank granite area can be divided into three natural divisions with respect to origin and age. First, the granite foundation upon which all subsequent rocks lie; second, the rocks of marine origin, such as shales, limestones, and sandstones, that cover the granite, especially where it is deep beneath the ground; third, a mantle of glacial drift composed of boulder clay, sand and gravel.

In the immediate vicinity of the granite outcrops and quarry sites the granite bedrock is reasonably shallow. It is assumed that the glacial drift forms a mantle cover over it. The marine rocks apparently have been removed.

The granite bedrock outcrops in several places in the north part of section 13, in the south part of section 7, and the northeast ¼ of section 17. Some of the outcrops stand out prominently as bosses; others appear as flat surfaces.

The granite in the outcrops is deeply grooved by glacial action. The surface is deeply weathered and much flaking or spalling occurs from exfoliation.

The granite is hard and highly crystalline. It consists of distinctly visible grains and is composed of approximately 60% dark red feldspar belonging to the orthoclase group, 25% clear quartz and 15% biotite mica. This mineral composition gives the rock a rich, dark color which is well described by its trade name, Mahogany granite. The Mahogany granite is the general type of granite quarried in the area; however, variations in color have given rise to such trade names as American Rose, and Royal Purple. The color of the granite depends largely on the color of the feldspar it contains.

The granite is a deep-seated igneous rock; its depth is unknown and in all probability it can be assumed to be at least hundreds of feet thick, so there is little danger in quarrying operations of running out of rock. Its lateral extent is enormous. The knolls and ridges which appear as outcrops are part of one large body or mass, as it underlies the entire country.

The granite has been struck six miles west of the outcrop at a depth of 456 feet.[1] In Milbank it is below 300 feet. Five miles south of Milbank it is reported 220 feet below the surface. A well nine miles south of Milbank struck it at a depth

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1. Report of Investigations 20, The Geology of Grant County, South Dakota, E. P. Rothrock, 1934, p. 15.

of 240 feet. The southernmost granite is reported one and one half miles east of Albee, ten miles south of the quarries, where it was struck 125 feet underground.

Apparently the granite surface slopes north, west and south of the area. These long, deep slopes are overlain by marine stratified rocks which are shales, limestones and sandstones of the Cretaceous system. The Milbank granite area appears, then, as an island surrounded by these marine rocks. Figure 3. The following log of the Milwaukee Railroad well #1 at Milbank shows the sequence of the formations encountered:

Depth	Log
8- 41	glacial drift and gravel
41- 85	clay, dark slate grey, silty, Carlile?
85-140	sand, fine, angular
140-142	sand, fine, coarser, light grey
142-230	clay, slate grey, some carbonized wood
230-249	marl, dark grey, chalk pellets, Globigerina, Textularia, Greenhorn?
249-256	sand, medium to fine grain, micaceous, angular shark's teeth and spines, fish vertebrae, teeth, Globigerina, Inoceramus, Greenhorn limestone, sandy, some hauerite
256-273	Greenhorn limestone with Inoceramus prisms
273-300	Graneros clay, dark grey, bentonitic, flaky
300-330	sand, fine, angular, considerable selenite
302-304	clay with fossil shells
304-308	clay, dark blue grey, hard, brown ironstone concretions
308-312	arkosic grit and conglomerate of pegmatite, granite, glassy quartz, cemented
315	secondary green copper mineral (malachite or chrysocolla)
	Milwaukee R.R. well No. 2 may have been in arkose to 400 foot depth

Almost the entire area is overlain by a mantle of glacial drift which is composed of boulder clay, sand and gravel. This mantle forms the surface and conceals all the older rocks, except for the small outcrops of the granite bedrock. These deposits are debris left by the melting ice sheet.

DEPTH TO GRANITE

A general picture of the relief of the granite surface in the Milbank granite area can be observed from the map (in pocket) in the back of this report. The relief is represented by contour lines which show the altitude above sea level. The granite surface lies at various depths below the surface of the ground. The shallow and deep places are about equal in total area.

In many instances the granite surface if probably much more rugged than is illustrated. This condition cannot be shown unless many more soundings could be taken than were made on this survey.

The depth to the granite at the sounding is shown in Figures 4 and 5 as well as on the map.

The trend of the outcrops show the position of the granite as a prominent ridge from the NW$\frac{1}{4}$ of section 13 to the SW$\frac{1}{4}$ of section 7. The outcrops in the NW$\frac{1}{4}$ of section 17 and SE$\frac{1}{4}$ of section 18 are buried hills separate from the prominent ridge designated above. However they are all part of the granite bedrock of the area. (see cross-sections on map in pocket).

A shallow granite ridge is in the eastern portion of the NW$\frac{1}{4}$ of section 18 and in the vicinity of the church in the same quarter section. The areas of deep granite are shown as hatched or depression contours; in these places the granite is sometimes as much as 100 feet beneath the surface of the ground. The contours showing closures or high areas on the granite surface will have depths to the granite generally from 20 to 40 feet.

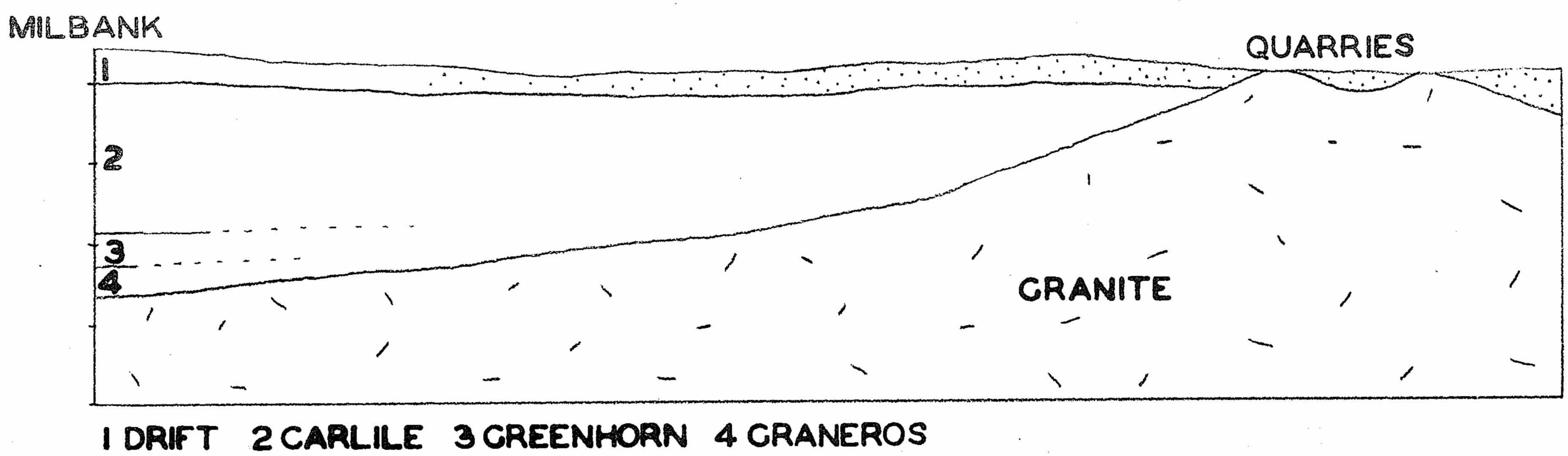
MILBANK
QUARRIES
1
2
3
4
GRANITE
1 DRIFT 2 CARLILE 3 GREENHORN 4 GRANEROS

FIGURE 3

INTERPRETATION OF RESULTS

Various methods have been developed for interpreting resistivity data accumulated from soundings taken in the field, in order to solve a problem pertaining to depths of buried material. They are divided into two groups: first, qualitative methods, whereby the shape or appearance of a depth curve is assumed to show thicknesses of and depths to underlying formations; second, quantitative methods of analysis, whereby formulae or families of calculated master curves are applied to field data.

In the qualitative method abrupt changes in slope of the potential-drop-ratio curves are assumed to indicate changes of material. For quantitative analysis the Wetzel-McMurry Standard Curves were used for three layer cases. The resistivity curve is plotted logarithmically which makes it independent of units of resistivity and electrode separation used. This is matched with a master curve, and if they agree, the resistivities and depth are observed. Roman and Tagg formulae and curves were used for the two-layer cases. The method of interpreting Potential Drop Ratios by correcting for normal ratio, as described in Resistance Gradiometer, Description and Operating Instructions, page 17, Heiland Research corporation, was not used. It was found that the resulting curves were too irregular to permit interpretation by this method. This may have been due to a rough granite surface, lateral anomalies, or lithologic variations in the drift mantle. The tables showing values of resistivity soundings are a detailed summary of the resistivity survey. Figure 4 and 5.

The first column shows the number of resistivity stations; this is followed by the location of the stations, or soundings. They are located with respect to land survey divisions (see index map at base of table). Figure 5. The stations are numbered in the order they were made, but are not listed in order, because during the first part of the survey, it was necessary to work in pastures, hayfields, and corn fields, and later, as the harvesting progressed, the soundings were taken in stubble fields. The column labeled altitude of surface, is the altitude above sea level of each station taken during the topographic survey.

Under the Wetzel-McMurry column are the values taken in the process of fitting the resistivity curve on a standard curve. The thickness of the first layer is represented by h_1, the thickness of the second layers by d, and their combined thicknesses, (the depth to the third layer), by h_2. The columns under P_1, P_2, P_3 are the resistivities of the layers in Ohms per foot as observed. The columns under the Tagg and Roman are analogous to the latter. The diagram at the bottom of table (Figure 4) is an illustration of the thickness, depth, and resistivity of the layers. In the column labeled Qualitative, is the value assumed to be the depth to the granite as that point appears on a plotted potential drop ratio curve as an extreme point of inflection, or at the terminous of a smooth portion in the upper part of the curve. The cumulative column has values showing a change in trend in the resistivity curve, presumed to be the top of the granite according to a method described by John A. Trantina, geologist, Corps of Engineers, Pickstown, South Dakota. The last column shows the altitude above sea level of the top of the granite. This value is obtained by subtracting the depth from the Surface Altitude. These figures are the basis for the contour map (in pocket) showing the relief of the granite surface beneath the ground.

The entire area is covered by a mantle of glacial drift which is composed of clays, sands, and gravel. In it at varying depth is the water table. These materials have various thicknesses and positions beneath the surface. They become two, three, or multiple layer cases with the granite.

Predictions resulting from the quantitative analysis will show thicknesses and depths to the layers in the drift mantle, which are true but will not yield the depth to the top of the granite unless it is a near surface layer. The granite must be the second or third layer of a two or three layer case. If this is the condition, the top of the granite can be predicted with reasonable accuracy. When the drift mantle is composed of clay lying directly on the granite it is a two layer case, when the mantle is composed of a layer of sand and gravel lying on the granite, and clay being the surface layer, it becomes a three layer case.

The map showing the position of the granite beneath the ground as shown by contour lines is derived from the interpretation of resistivity soundings. Several determinations were proved by the drill and found to be reasonably accurate.

The following table is a list of resistivity stations which were drilled; Column I gives the values for h_2, the depth as determined by the Wetzel-McMurry master curves; Column II gives the drilled depth:

	I	II
Station	h_2	drilled
13	13	14
72	16	18
97	20	27
107	30	29.6
Test Well	36	33
Test Well	15	20

The main point brought out by the analysis is that when the granite is predicted to be shallow (within reasonable stripping depth) or deeper, it can be counted on as the position of the granite surface.

In obtaining the figure which represents the altitude of the top of the granite, both quantitative and qualitative analyses were used. Where a depth value was shown by quantitative and it agreed closely with the qualitative, the former was used for the depth desired. However, the statement by Wetzel and McMurry, "......it is not claimed that this interpretation method may be used automatically to grind out answers..."[1] may be applied to any method of interpreting resistivity data.

It stands to reason that of all the curves produced, some will not yield to any methods of interpretation, the greater portion of the curves yield the points in question. When quantitative methods could not be applied, a point was taken by direct observation by the qualitative method.

Some field curves could be fitted with several standard curves which yielded depths in close agreement to one another. The following table shows a list of stations:

Station	Depth			
5	53	56	58	60
6	20	22		
8	55	56	58	60
10	50	50		
19	94	98	103	
63	25	27		

1. Howard V. McMurry, W.W. Wetzel, "A Set of Curves to Assist in the Interpretation of the Three Layer Resistivity Problem," Geophysics, Vol. II (October, 1937), 341.

TABLE SHOWING VALUES OF RESISTIVITY SOUNDINGS

MILBANK GRANITE AREA

STA	LOCATION ¼	¼	Sec	T	R	ALTITUDE OF SURFACE	WETZEL-MC MURRY h_1	d	h_2	ρ_1	ρ_2	ρ_3	TAGG h	ρ_1	ρ_2	ROMAN h	ρ_1	ρ_2	QUALITATIVE	CUMULATIVE	ALTITUDE TOP OF GRANITE	
40	SW	NE	13	120	47	1090	40	0	40.	800	2400	80							50		1050	
30	SE					1083	6	18	24.	140	14000	1400							55		1059	
31						1089	16	49	65.	500	165	50							60		1024	
32						1108													60.		1048	
33						1089	36	64	100.	310	103	31000							90	100-110	989	
141	NE	SW				1069	11	34	45.	400	1200	400							30		1024	CORRELATES WITH STA. 97
142	NW	SE				1072	75	22.5	30.	260	26000	260	13.9	561	4188				30		1042	
143						1067	7	23	30.	240	720	24000	18						40		1037	
37						1069													55.		1014	
34	NE					1094	7	22	29.	250	25	2500							45		1065	
35						1089	9	27	36.	170	17	1700							40		1053	
36						1089													65.		1024	
28	NW	NW	18	120	46	1094	22	68	90.	200	66	20000							75		1004	
29						1087													70.		1017	GRAVEL SURFACE MATERIAL
135						1076	68	22	90	600	200	60000							60		1006	ACCORDING TO DAKOTA GRANITE CO. 70 FT.
136						1071	8	24	32.	150	450	15000							40		1039	
8	NE					1084	15	45	60.	500	50	50000							63		1024	FITTED WITH CURVES H_2 55, 56, 58, 60
9						1084	10	10	20.	220	2200	73							25		1064	
10						1086	18	32	50.	240	24	24000							60		1036	FITTED WITH 2 CURVE H_2 50, 50
11						1077	8	22	30.	210	630	70							30		1047	
12						1084	5	15	20.	120	1200	120							30		1064	
46						1074	26	64	90.	180	1800	18000							90		984	
26	SW	NW				1088	6	20	26.	180	1800	540							65		1062	
27						1088	27	80	35.	400	4	4000							50		1053	
22						1094	5	17	22.	260	2600	86							25		1072	
23						1088	9	27	36.	300	3000	300							40		1052	
24						1085	15	45	60.	520	1560	520							55		1025	
25						1087	25	9	34.	500	5	1500							85		1053	
74	SE	NW				1075													25.		1050	
72						1075	12	4	16	130	1300	390									1057	AUGER HOLE DRILLED TO GRANITE 18 FT.
73						1082	10	10	20.	160	1600	16							35		1062	
75						1078													50.		1028	
18	NW	NE				1084	55	55	110	450	150	45000							55.		1029	
20						1086	27	8	35.	200	66	600							35		1051	
21						1082	16	50	66.	220	22	2200							55		1016	
45						1086	12	38	50.	280	93	28000							55		1036	
70						1066													50.		1016	
13	NE					1082	9	4	13.	235	23500	235							30		1069	SEVERAL AUGER HOLES TO GRANITE 14 FT.
14						1082	22	68	90.	700	233	2100							75		992	
15						1084	15	45	60.	330	110	900							65		1024	
16						1079			70	230	2300	23000	19.3	454					45.		1034	

17						1083	36	54	90.	175	1750	17 000									993	
59						1079													55.		1024	
60						1079	37	48	80	130	1300	13 000							55.		1024	
61						1084	16	48	64.	270	27	27 000							60		1020	
69	SW	NE				1076	8	26	34.	235	2350	23 500							40		1042	
71						1074	6	42	48.	80	800	8000				27.4	655		55		1026	
19						1085			103.	500	166	50 000							45		982	*FITTED WITH CURVES H_2 94, 98, 103*
63						1093	7	20	27.	270	2700	27							25		1066	
62	SE					1085	33	12	45.	290	29	29000							55		1040	
64						1080	19.5	58.5	78.	170	56	17 000							75		1002	
47	NW	NW	17	120	46	1082	37	0	37.	400	133	40000							50		1045	
49						1087	9	27	36.	210	2100	210							40		1051	
48						1081	20	62	82.	1550	516	15500							70		999	
50						1081													45.		1036	
140						1080	17	13	30.	115	11	1150							40		1050	
53						1078	16	6	22.	570	5700	190							55		1056	
139	SW					1082	8	23	31.	300	3000	100							45		1051	
55						1049	27	8	35.	900	90	9000							35		1014	
52	NE					1092							15-16						30.		1062	
57						1087	9	27	36.	180	18000	180	18.4	365	6940	23.9	398		30	95-100	1051	
51						1093													50.		1043	
58						1075													55.		1020	
54						1060	22	0	22.	100	10	10000							25		1038	
56	SE					1044	8	8	16.	140	14000	420							20		1028	
66	NW	NE				1049	5	35	40.	135	1350	13500							45		1009	
65	NE					1039	30	44	74.	82	820	8200	25.5						75		965	
68						1040	10.5	31.5	42.	180	1800	540							55		998	
67						1043	5	40	45.	135	1330	13500							30		998	
77	SW					1052							14.3	608	∞				35.		1017	
76						1057	50	0	50.	340	113	34000							65		1007	
78	SE					1040	9	27	36.	125	1250	12500							40		1004	
	SW	SW	18	120	46	1067															1047	*TEST WELL DRILLED TO GRANITE 20 FT.*
82	NW	SE	12	120	47	1080	13	13	26.	350	1050	350							25		1054	

W.W. WETZEL & H.V. MC MURRY, *INTERPRETATION OF THE THREE LAYER RESISTIVITY PROBLEM,* GEOPHYSICS VOL. II, NO. 4, OCT. 1937.

G.F. TAGG, *INTERPRETATION OF RESISTIVITY MEASUREMENTS,* A.I.M.M.E., TRANSACTIONS VOL. 110, 1934.

IRWIN ROMAN, *SUPERPOSITION IN THE INTERPRETATION OF TWO-LAYER EARTH-RESISTIVITY CURVES,* U.S.G.S. BUL. 927-A, 1941.

DIAGRAM SHOWING THE LAYER THICKNESSES AND RESISTIVITIES.

ρ = RESISTIVITY ∞ = INFINITY h & d = THICKNESS

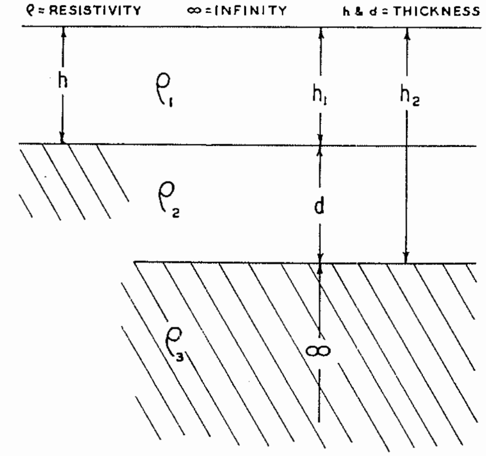

FIGURE 4

SHEET 1 OF 2 SHEETS

TABLE SHOWING VALUES OF RESISTIVITY SOUNDINGS

(CONTINUED)

	LOCATION					ALTITUDE OF SURFACE	WETZEL-MC MURRY						TAGG			ROMAN			QUALI-TATIVE	CUMU-LATIVE	ALTITUDE TOP OF GRANITE	
STA	$\frac{1}{4}$	$\frac{1}{4}$	Sec	T	R		h_1	d	h_2	ρ_1	ρ_2	ρ_3	h	ρ_1	ρ_2	h	ρ_1	ρ_2				
102	SW	NW	12	120	47	1073	36	54	90.	165	1650	16500	21.8	515	2920	26.3	562	2650	80	25	983	
101	SE					1073	7	21	28.	110	11000	37							35		1045	*CORRELATES WITH STA. 97*
145	SW	NE				1072	6	17	23.	115	11500	11.5							35		1049	*CORRELATES WITH STA. 97*
97	NW	SW				1073	10	10	20	235	23500	78							30		1046	*DRILLED TO GRANITE 27 FT.*
95	SW					1076	22	23	45.	840	2520	270							50		1031	
96						1073	12	8	20.	420	42000	140							35		1053	*CORRELATES WITH STA. 97*
98	NE					1074	75	225	30.	265	2650	795							65		1044	
99						1072	8	22	30.	160	16000	63							30		1042	*CORRELATES WITH STA. 97*
100						1073	9	15	24.	165	16500	495							40		1049	
144	NW	SE				1072	10	30	40.	310	3100	930				28.8	331	615	65		1032	
87						1080	10	30	40.	250	615	2050							40		1040	
83						1063	21	63	84.	170	1700	17000	17.3	410	2320	30.2	596	2810	70		979	
80						1076	51	17	68.	80	8	800							60		1008	*FITTED 2 CURVES H_2 62, 68*
85	NE					1064	5	35	40.	120	1200	12000				31	407	7740	40		1024	
84						1063	6	20	26.	150	15000	1500	13-17	460	3680	16-20	316	12300	30		1037	*CORRELATES WITH STA. 97*
81						1068	5	14	19.	155	1500	1550	19	603	11457				45		1049	
86						1065	7	20	27.	165	16500	1650							35		1038	*CORRELATES WITH STA. 97*
104	SW					1083													30.		1053	
103						1096													40.		1056	
137	SE					1088													40.		1048	
138						1081	21	32	53.	50	500	5000							60		1028	
90	NW	SW	7	120	46	1075	10	30	40.	580	193	5800							55		1035	
87	NE					1079	10	30	40.	205	615	2050	28.9	302	1715	29.5	490	3430	45		1039	
91						1075	7	20	27.	160	480	160							40		1048	
88	SW					1061	7	23	30.	200	20000	2000	20	441	∞	12.6	441	∞	40		1031	*CORRELATES WITH STA 97*
89	SE					1071	18	54	72.	540	54	54000							65		999	
110	NW	SE				1086	27	27	54	450	45	45000							45		1032	
111						1094	7	22	29.	150	15000	50							25		1065	*CORRELATES WITH STA. 107*
93	SW					1085	28	18	46.	410	41	4100							55		1039	
109	NE					1090	6	20	26.	145	1450	48							20		1064	
112						1084	26	79	105.	490	163	1470							95		979	
113						1085	9	27	36.	75	750	225							40		1049	
92	SE					1088													55.		1033	
114						1087													65.		1022	
115	NW	SW	8	120	46	1046	11	44	55.	120	1200	12000							45		991	
116						1059	17	16	34.	150	450	1500				28.8			30		1025	
117						1047			30.	210	21000	70							40		1017	
118	SW					1084	7	53	60.	175	1750	17500							40		1024	
119						1083	9	27	36.	360	36	36000							45		1047	
120	SE					1090	10	10	20.	155	15500	1550							20		1070	*CORRELATES WITH STA. 107*
123						1046	9	29	38.	260	2600	26000							50		1008	

126						1055	9	27	36.	180	1800	18000	19			15	195	∞	40		1019	*CORRELATES WITH STA. 107*
124	NW	SE				1061	25	37	62.	56	560	5600							40		999	
121	SW					1043							21	585	∞				30.		1013	
122						1043	480	0	40.	420	1260	42000							50		1003	
125						1054													45.		1009	
128						1054	4	28	32.	98	980	9800	20	314		25	295	∞	25		1022	
127						1054	19	28	47.	41	410	4100							50		1007	
130						1061	8	23	31.	115	1150	335	18			31			35		1030	
134	NE					1061	6	19	25.	300	30000	300							25		1036	
129	SE					1050													45.		1005	
131						1072	9	27	36.	300	3000	9000							30		1036	
132						1057	6	39	45.	190	1900	19000									1012	
133						1059													25.		1034	
1	NW	NW	13	120	47	1078	6	11	17.	90	9000	9							21		1061	
2						1074	7	23	30.	270	2700	810							24		1044	
107						1075	7.5	27.5	30.	150	15000	1500	20	314	3620	16.6	2850	11100	40	15–20	1045	*DRILLED TO GRANITE 29.6 FT.*
108						1072	18	27	45.	100	1000	10000							40		1027	
94	SW					1077	10	30	40.	200	2000	20000				27.2	407	∞	45		1037	*CORRELATES WITH STA. 97*
3						1080	2	7	9.	60	6000	600									1071	
106						1078	12	36	48.	245	24500	2450							50		1030	
105						1074	9	26	35.	180	18000	60	14.7	375	2400	324	661	3740	40		1039	
43	SE					1069							13.3	687	∞				25.	15–20	1044	
44						1065										19	631	∞	35.		1030	
42						1065	36	52	88.	210	2100	21000							95		977	
41						1072	14	56	70.	135	405	1350				53	202	2490	65		1002	
4	NE					1074	22	0	22.	300		900							24		1052	
5						1095	14	44	58.	350	35	3500							55		1037	*FITTED WITH 4 CURVES H_2 53, 56, 58, 60*
6	NW	NE				1091	8	14	22.	200	20000	2000							15		1069	*FITTED WITH 2 CURVES H_2 20, 22*
7						1099	8	24	32.	150	15000	15							30		1067	
38	SW					1089													75.		1014	
39						1089	28	42	70.	125	1250	12500							70		1019	

INDEX MAP

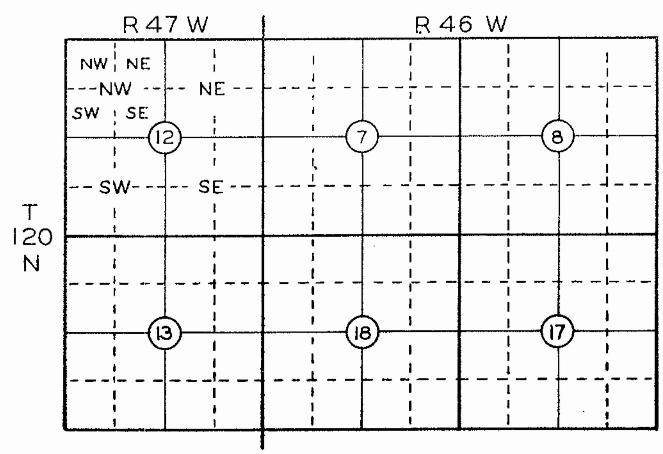

FIGURE 5

SHEET 2 OF 2 SHEETS

It is the opinion of the writer that the above determinations are in accord with the true depth to the granite.

The following table is a list of resistivity stations showing the agreement between determinations of two layer cases where the Tagg and Roman methods were used:

	Tagg	Roman
Station	h_1	h_1
84	13-17	16-20
87	28	29
88	20	12
57	18	23
102	21	26
107	19-20	17
126	19	15
128	20	25

These values are not necessarily the top of the granite surface but the depth to a second layer in the drift mantle which is probably the water table or a bed of sand and gravel. In station 107, a bed of gravel was encountered by the drill from 18 to 23 feet, which agrees with the prediction of a two-layer curve.

The resistivity of granite as determined from the Wetzel-McMurry master curves, is in the region of 104 Ohm ft. or more, whereas the resistivity of drift material is much less; however, the resistivity of granite for many stations is very low. For example at Station 97, the resistivity of the third layer (granite) determined from the master curve is 78 Ohm ft. It may be assumed that this is caused by the ground water.

GRANITE PRODUCERS

The quarries in the Milbank granite area are working to full capacity. A total of nine companies are located in the area, as follows:

Hunter	Figure 6
Dakota	Figure 6 and 7
Delano	Figure 6
Cold Springs	Figure 7
North Star	Figure 8
Columbia	Figure 8
Melrose	Figure 8
Kaddez and Company	Figure 8
B.F. Coggins	

The production is primarily monumental and dimension stone of quarried granite. The Hunter and Dakota Companies are South Dakota firms, the B.F. Coggins Company is located in Elberton, Georgia; this firm has recently purchased granite rights in this area in preparation to opening a quarry and erecting a fabrication plant. The remainder of the companies operating in the area are Minnesota firms.

The Hunter Granite Company maintains a fabricating plant in Milbank and all of their stone is hauled by truck from the quarry to the plant. They have a sawing unit at the quarry. Recently, a new stiff leg derrick has been put into operation at the quarry. It is probably the largest capacity derrick in South Dakota of that type. Their product is known as Hunter's Royal Purple and Hunter's Variegated Mahogany.

The Dakota Granite Company has its entire works in the granite area. It consists of the quarry and sawing units and fabrication plant.

The Dakota operates two quarries; one produces a granite known as the Dakota Mahogany and the other produces a granite known as American Rose.

The Cold Springs, North Star, Melrose, and Columbia Granite Companies are Minnesota operators; all their stone is trucked to points in Minnesota. The Delano and Kaddez quarries are the most recently opened, having been in operation only a short time.

All quarries in this area are from 60 to 140 feet deep, except those of Kaddez and Delano, and have been operating for many years. The distribution of the quarries is shown on the Topographic Map (in pocket).

Aside from the dimension stone produced, there are numerous piles of waste rock in the area. Some of these grout piles, as they are known, are as much as 60 feet high and 400 feet long. They contain rock of all sizes and dimensions, plus the smaller chips from fabrication. All the stone in the grout piles is considered waste, but in the future, the use of this stone will be in demand.

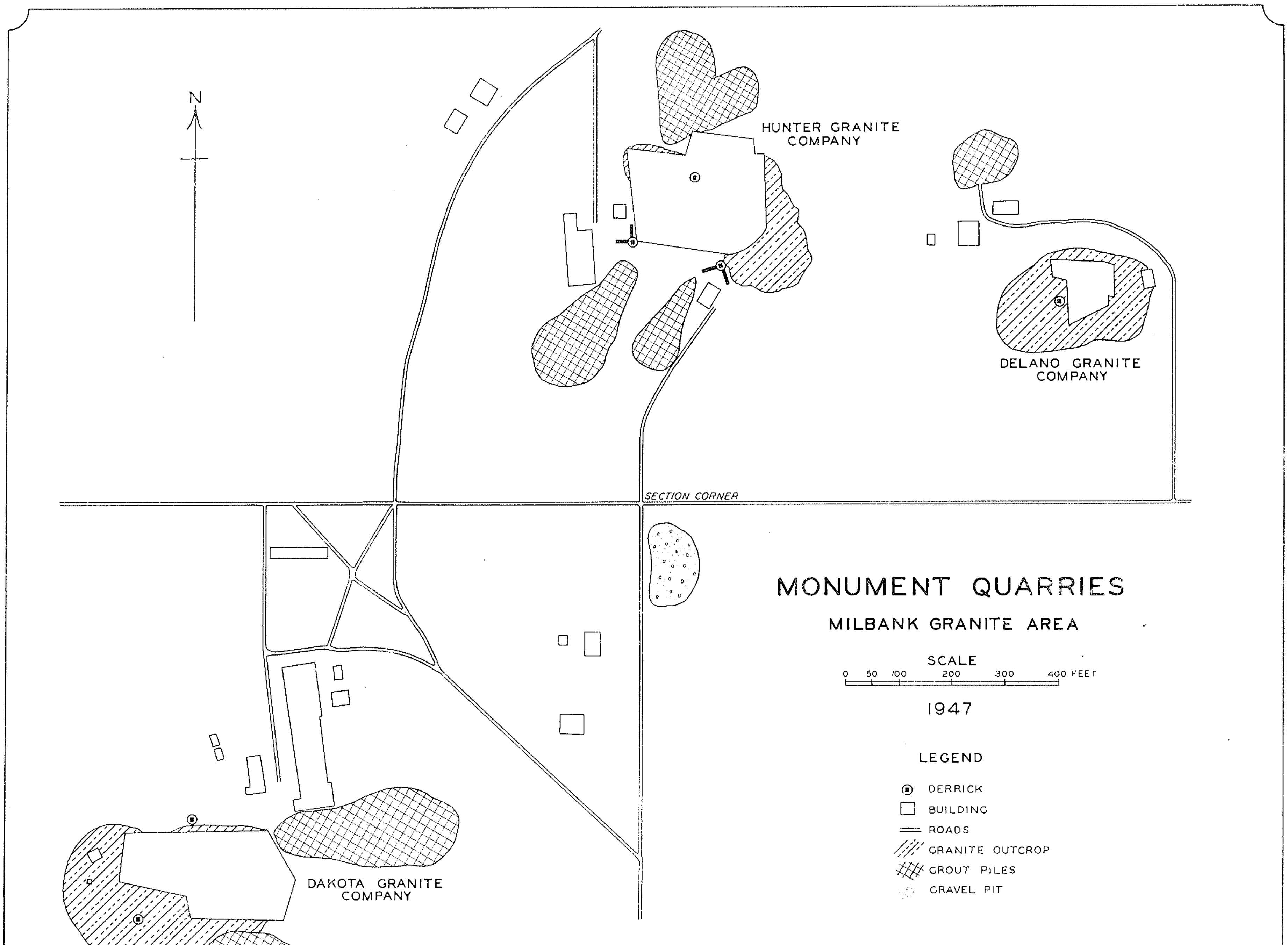
N
HUNTER GRANITE COMPANY
DELANO GRANITE COMPANY
SECTION CORNER
DAKOTA GRANITE COMPANY
MONUMENT QUARRIES
MILBANK GRANITE AREA
SCALE
0 50 100 200 300 400 FEET
1947
LEGEND
DERRICK
BUILDING
ROADS
GRANITE OUTCROP
GROUT PILES
GRAVEL PIT

FIGURE 6

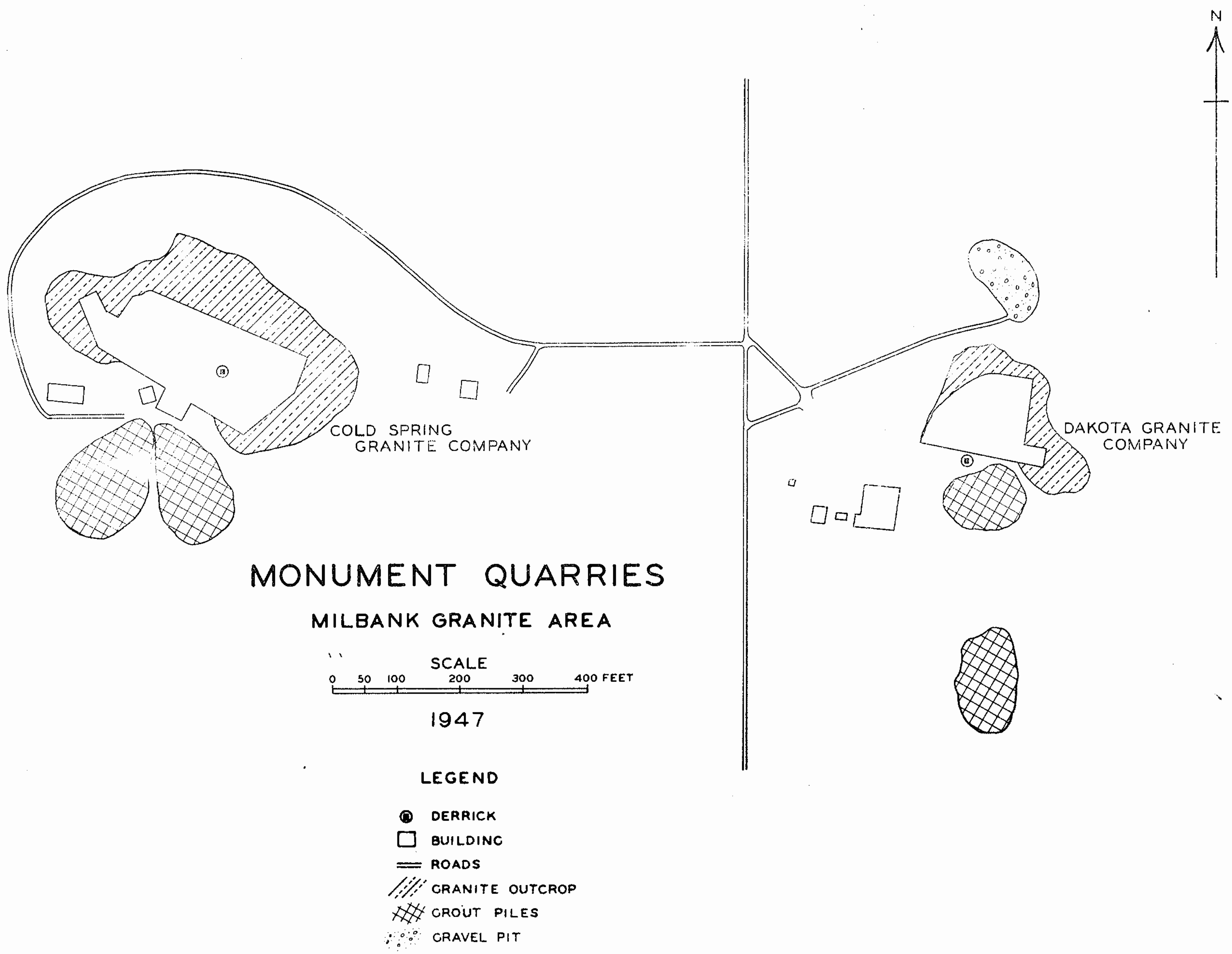
N
COLD SPRING
GRANITE COMPANY
DAKOTA GRANITE
COMPANY
MONUMENT QUARRIES
MILBANK GRANITE AREA
SCALE
0 50 100 200 300 400 FEET
1947
LEGEND
DERRICK
BUILDING
ROADS
GRANITE OUTCROP
GROUT PILES
GRAVEL PIT

FIGURE 7

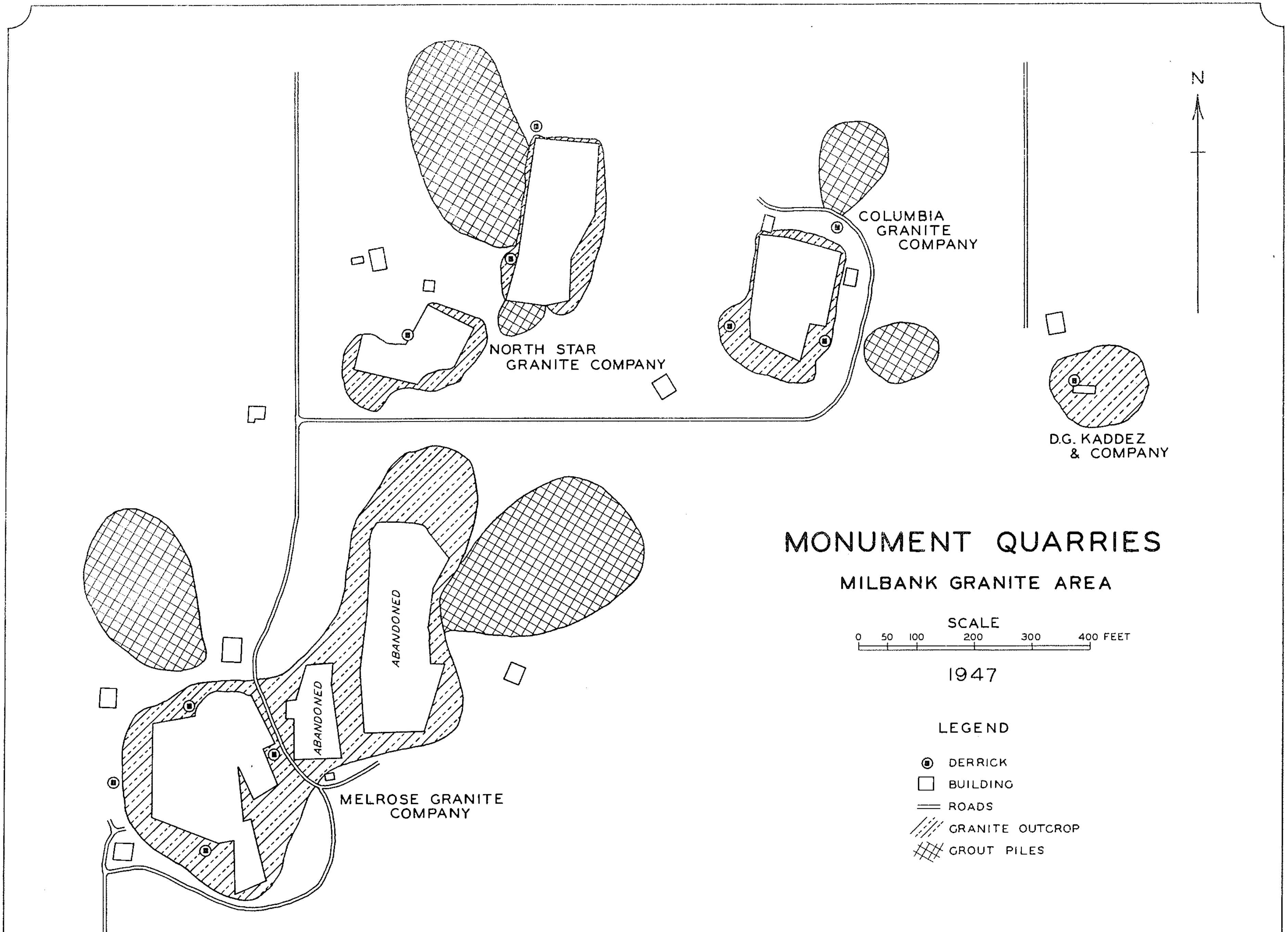
N
COLUMBIA GRANITE COMPANY
NORTH STAR GRANITE COMPANY
D.G. KADDEZ & COMPANY
ABANDONED
ABANDONED
MELROSE GRANITE COMPANY
MONUMENT QUARRIES
MILBANK GRANITE AREA
SCALE
0 50 100 200 300 400 FEET
1947
LEGEND
DERRICK
BUILDING
ROADS
GRANITE OUTCROP
GROUT PILES

FIGURE 8