

MINNESOTA GEOLOGICAL SURVEY

PAUL K. SIMS, *Director*

Information Circular 2

**CHEMICAL ANALYSES
OF
IGNEOUS ROCKS**



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MINNESOTA GEOLOGICAL SURVEY

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CHEMICAL ANALYSES OF IGNEOUS ROCKS

Compiled By

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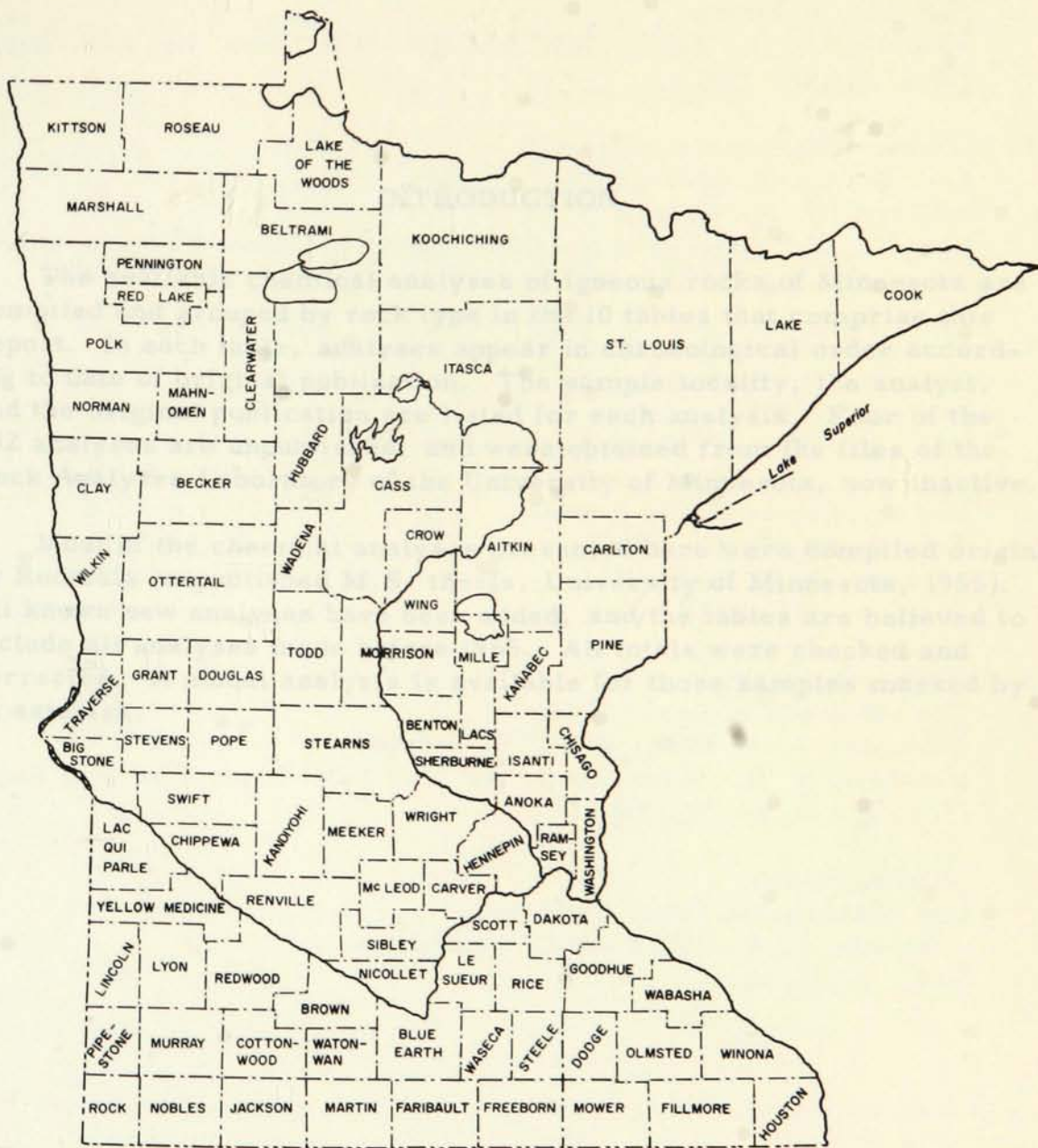


Figure 1. Index to Minnesota counties

INTRODUCTION

The available chemical analyses of igneous rocks of Minnesota are compiled and grouped by rock type in the 10 tables that comprise this report. In each table, analyses appear in chronological order according to date of original publication. The sample locality, the analyst, and the original publication are listed for each analysis. Four of the 232 analyses are unpublished, and were obtained from the files of the Rock Analyses Laboratory of the University of Minnesota, now inactive.

Most of the chemical analyses presented here were compiled originally by Ruotsala (unpublished M.S. thesis, University of Minnesota, 1955). All known new analyses have been added, and the tables are believed to include all analyses made before 1965. All totals were checked and corrected. A modal analysis is available for those samples marked by an asterisk.

MINNESOTA GEOLOGICAL SURVEY

References - Table 1

1. Red granite
Loc. Quarry one mile northwest of Sartell Village, Stearns Co.
Analyst: A. Streng
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 11th Ann. Rept.,
219 p. (p. 81), 1884.
2. Gray hornblende biotite granite
Loc. St. Cloud, Stearns Co.
Analyst: W. H. Willard
Hall, C. W., Sources of the Constituents of Minnesota Soils: Minn.
Acad. Nat. Sci. Bull., v. 3, p. 388-406 (p. 397, no. II), 1891.
3. Medium colored hornblende biotite granite
Loc. St. Cloud, Stearns Co.
Analyst: G. H. Hammond
Ibid., p. 397, no. IV.
4. Red hornblende biotite granite
Loc. St. Cloud, Stearns Co.
Analyst: F. H. Crowell
Ibid., p. 397, no. I.
5. Granite porphyry
Loc. Kekequabic Lake, Cook Co.
Analysts: J. A. Dodge and C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 21st Ann. Rept.,
171 p. (p. 41, no. II), 1893.
6. Normal granite
Loc. Kekequabic Lake, Cook Co.
Analysts: J. A. Dodge and C. F. Sidener
Ibid., p. 41, no. I.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 1. Granitic rocks

Elements	1	2	3	4	5	6
SiO ₂	67.70	71.64	69.47	73.30	67.42	66.84
Al ₂ O ₃	16.11	11.82	14.94	14.20	15.88	18.22
Fe ₂ O ₃	2.47				1.37	2.27
FeO	2.29	3.94	4.07	5.40	1.14	0.20
MgO	1.11	0.32	0.29	0.50	1.43	0.81
CaO	2.89	1.41	1.60	3.00	3.49	3.31
Na ₂ O	3.64	5.22	3.37	2.00	6.42	5.14
K ₂ O	4.47	2.49	4.56	1.40	2.65	2.80
H ₂ O+	0.83	0.88		0.30	0.05	0.46
H ₂ O-						
TiO ₂						
P ₂ O ₅	0.13				0.07	trace
MnO						
ZrO ₂						
CO ₂						
S						
FeS ₂						
Cr ₂ O ₃						
BaO						
Total	101.64	97.72	98.30	100.10	99.92	100.05

MINNESOTA GEOLOGICAL SURVEY

References - Table 1

7. Coarse grained hornblende granite (characteristic Saganaga granite)
Loc. Saganaga Lake, SW1/4 NE1/4 sec. 22, T. 66 N., R. 5 W.,
Cook Co.
Analyst: A. D. Meeds
Ibid., p. 43, no. II.
8. Quartz porphyry
Loc. Kawishiwi River, N1/2 NE1/4 sec. 21, T. 63 N., R. 10 W.,
Lake Co.
Analyst: A. D. Meeds
Ibid., p. 43, no. I.
9. Hornblende porphyrite
Loc. Southwest end of Epsilon Lake, N1/2 sec. 29, T. 65 N.,
R. 6 W., Cook Co.
Analyst: J. A. Dodge
Ibid., p. 58.
10. Greenish gray granite
Loc. Clearwater, 680 paces N and 700 paces W sec. 19, T. 123 N.,
R. 27 W., Stearns Co.
Analyst: F. F. Grout
Grout, F. F., The granites and associated quartz basalts of Stearns
County, Minnesota: Master's thesis (Table III, p. 34-35, no. 8),
1908. (Available at Univ. of Minn. Library, Reference Room.)
11. Fine pink granite
Loc. St. Cloud, 1670 paces N and 385 paces W sec. 29, T. 124 N.,
R. 28 W., Stearns Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 2.
12. Red granite
Loc. St. Cloud, 1670 paces N and 385 paces W sec. 29, T. 124 N.,
R. 28 W., Stearns Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 3.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 1. Granitic rocks

Elements	7	8	9	10	11	12
SiO ₂	69.34	69.70	60.32	62.76	73.80	72.41
Al ₂ O ₃	17.25	18.72	15.80	17.73	14.67	14.33
Fe ₂ O ₃	2.46	0.65	5.42	1.69	0.63	1.09
FeO		0.79	0.89	3.04	1.19	1.47
MgO	1.18	0.45	5.08	2.66	0.32	0.30
CaO	3.43	2.25	4.65	3.94	0.99	1.66
Na ₂ O	4.33	5.01	4.09	3.23	2.46	5.19
K ₂ O	0.71	1.68	1.82	3.72	4.87	3.40
H ₂ O+	1.17	0.71	1.67	0.13	0.39	0.08
H ₂ O-				0.07	0.04	0.02
TiO ₂				0.61	0.19	0.23
P ₂ O ₅			0.12	0.63	0.04	0.23
MnO				0.12		
ZrO ₂						
CO ₂				0.22	0.30	0.21
S						
FeS ₂						
Cr ₂ O ₃						
BaO						
Total	99.87	99.96	99.86	100.55	99.89	100.62

MINNESOTA GEOLOGICAL SURVEY

References - Table 1

13. Granite
Loc. Rockville, 500 paces N and 1500 paces W sec. 9, T. 123 N.,
R. 29 W., Stearns Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 4.
14. Gray granite
Loc. St. Cloud, 1425 paces N and 800 paces W sec. 21, T. 125 N.,
R. 28 W., Stearns Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 5.
15. Gray granite
Loc. St. Cloud, 50 paces from NE cor. sec. 28, T. 124 N.,
R. 28 W., Stearns Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 6.
16. Gray granite
Loc. Main quarry in Sauk Rapids, Benton Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 7.
17. Granite porphyry
Loc. St. Cloud, 300 paces N and 1050 paces W sec. 20, T. 124 N.,
R. 28 W., Stearns Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 1.
18. Greenish gray gneissic granite
Loc. 1300 paces N and 1900 paces W sec. 28, T. 134 N., R. 32 W.,
Cass Co.
Analyst: F. F. Grout
Ibid., p. 34-35, no. 9.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 1. Granitic rocks

Elements	13	14	15	16	17	18
SiO ₂	70.07	65.50	64.40	63.52	76.30	57.12
Al ₂ O ₃	16.79	17.38	14.93	16.71	12.58	18.74
Fe ₂ O ₃	0.64	0.83	1.63	1.58	0.47	2.62
FeO	2.58	2.85	3.13	2.61	1.20	2.42
MgO	0.71	2.28	3.05	2.70	0.02	4.28
CaO	2.27	3.68	4.18	4.54	0.84	7.06
Na ₂ O	2.82	3.36	3.31	3.89	2.70	3.37
K ₂ O	3.82	3.09	3.95	3.96	5.00	1.53
H ₂ O+	0.06	0.16	0.15	0.05	0.27	1.16
H ₂ O-	0.10	0.03	0.07	0.01	0.00	0.08
TiO ₂	0.33	0.42	0.57	0.48	0.15	0.42
P ₂ O ₅	0.34	0.30	0.57	0.44	0.18	0.45
MnO	0.04	0.08	0.09	0.07	0.05	0.06
ZrO ₂			0.07			
CO ₂	0.23	0.31	0.18	0.23	0.35	0.34
S			0.12			
FeS ₂						
Cr ₂ O ₃					0.08	
BaO			0.05			
Total	100.80	100.27	100.45	100.79	100.19	99.65

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References - Table I

19. Typical "St. Cloud gray" granite
Loc. St. Cloud, 1500 paces N and 100 paces W of SE cor. sec. 28,
T. 124 N., R. 28 W., Stearns Co.
Analyst: F. F. Grout
Bowles, Oliver, The structural and ornamental stones of
Minnesota: U. S. Geol. Surv. Bull. 663, 225 p. (p. 52), 1918.
20. Vermilion granite
Loc. SE of Pelican Lake, T. 64 N., R. 19 W., St. Louis Co.
Analyst: F. F. Grout
Grout, F. F., The Vermilion batholith of Minnesota: Jour. Geol.,
v. 33, p. 467-487 (Table VI, p. 483, no. 2), 1925.
21. Vermilion granite
Loc. NW part of Sand Point Lake, sec. 12, T. 68 N., R. 17 W.,
St. Louis Co.
Analyst: F. F. Grout
Ibid., p. 483, no. 1.
22. Biotitic phase of granite
Loc. Gun Lake, sec. 14, T. 65 N., R. 12 W., St. Louis Co.
Analyst: F. F. Grout
Ibid., p. 483, no. 15.
23. Magnetite-rich granitic pegmatite
Loc. sec. 3, T. 66 N., R. 17 W., St. Louis Co.
Analyst: F. F. Grout
Ibid., p. 483, no. 16.
24. Hornblende-granite
Loc. Hinsdale quarry, sec. 17, T. 59 N., R. 17 W., St. Louis Co.
Analyst: R. J. Leonard
Allison, Ira S., The Giants Range batholith of Minnesota: Jour.
Geol., v. 33, p. 488-508 (Table II, p. 505, no. F), 1925.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 1. Granitic rocks

Elements	19	20	21	22	23	24
SiO ₂	64.40	72.06	71.73	69.01	58.72	60.42
Al ₂ O ₃	14.93	16.00	14.76	16.92	10.81	12.28
Fe ₂ O ₃	1.63	0.46	0.58	0.55	12.84	5.57
FeO	3.13	0.72	1.35	1.43	6.80	4.32
MgO	3.05	0.97	0.62	1.28	0.94	3.40
CaO	4.18	0.86	1.18	2.67	0.82	4.95
Na ₂ O	3.31	4.56	3.58	4.59	3.59	4.50
K ₂ O	3.95	3.54	4.63	2.55	4.89	2.02
H ₂ O+	0.15	0.39	0.64	0.41	0.34	1.42
H ₂ O-	0.07	0.05	0.20	trace	0.16	0.08
TiO ₂	0.57	0.12	0.53	0.23	0.42	0.74
P ₂ O ₅	0.57	0.09	0.14	0.11	0.20	0.20
MnO	0.09	0.06	0.03	0.03	0.08	0.06
ZrO ₂	0.07	0.03	0.06	0.04	0.02	0.07
CO ₂	0.18	0.10				none
S	0.12			0.04		0.02
FeS ₂		0.09	0.06		trace	
Cr ₂ O ₃		0.02	0.02	0.01		none
BaO	0.05	0.12	0.14	0.03	0.07	0.07
Total	100.45	100.24	100.25	99.90	100.70	100.12

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References - Table 1

25. Hornblende biotite granite
Loc. sec. 28, T. 59 N., R. 17 W., St. Louis Co.
Analyst: I. S. Allison
Ibid., p. 505, no. G.
26. Biotite granite
Loc. sec. 31, T. 59 N., R. 18 W., St. Louis Co.
Analyst: R. J. Leonard
Ibid., p. 505, no. I.
27. Embarrass granite
Loc. Embarrass station, St. Louis Co.
Analyst: R. J. Leonard
Ibid., p. 505, no. J.
28. Burntside granite gneiss
Loc. Portage from Burntside Lake to Little Long Lake,
St. Louis Co.
Analyst: Douglas Manuel
Grout, F. F., The geology and magnetite deposits of northern
St. Louis County, Minnesota: Minn. Geol. Surv. Bull. 21,
220 p. (p. 29), 1926.
29. Granite
Loc. South side of large island in Snowbank Lake, sec. 35,
T. 64 N., R. 9 W., Lake Co.
Analyst: C. W. Sanders, Jr.
Sanders, Clarence W., Jr., A composite stock at Snowbank Lake
in northeastern Minnesota: Jour. Geol., v. 37, p. 135-149 (Table
2, p. 143, no. 9), 1929.
- *30. Saganaga granite
Loc. Island in sec. 22, T. 65 N., R. 5 W., Cook Co.
Analysts: F. F. Grout and A. J. Bauernschmidt
Grout, F. F., The Saganaga granite of Minnesota-Ontario: Jour.
Geol., v. 37, p. 562-591 (Table I, p. 572, no. 1), 1929.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 1. Granitic rocks

Elements	25	26	27	28	29	30
SiO ₂	66.31	71.45	72.39	68.54	69.50	68.81
Al ₂ O ₃	12.70	12.99	13.39	17.89	16.86	16.30
Fe ₂ O ₃	1.98	2.44	0.18	1.77	0.50	1.95
FeO	2.66	1.78	1.44	0.52	0.64	0.75
MgO	3.01	0.84	1.61	1.22	1.45	0.91
CaO	4.77	0.65	0.92	4.02	1.70	2.19
Na ₂ O	5.03	6.96	5.35	5.14	4.58	4.97
K ₂ O	2.33	1.25	2.42	1.05	3.94	2.29
H ₂ O+	0.75	1.24	1.22	0.46	0.42	1.38
H ₂ O-	0.05	0.10	0.02	0.18	0.20	0.12
TiO ₂	0.49	0.13	0.49	0.20	0.53	0.22
P ₂ O ₅	0.13	0.04	0.10	trace		0.07
MnO	0.04	0.04	0.01			0.02
ZrO ₂	0.06	0.10	0.15	none		0.02
CO ₂						0.30
S	trace	trace	none	0.06		0.03
FeS ₂						
Cr ₂ O ₃	0.01	0.02	none	none		0.02
BaO	none	none	none			0.10
Total	100.32	100.03	99.69	101.05	100.32	100.45

MINNESOTA GEOLOGICAL SURVEY

References - Table 1

- *31. Gray granite
Loc. Northernmost U.S. island on Saganaga Lake, sec. 31,
T. 66 N., R. 4 W., Cook Co.
Analyst: G. Ward
Ibid., Table II, p. 575, no. 10.
32. Gradation between granite and granodiorite
Loc. St. Cloud, long outcrop in secs. 21 and 17, T. 125 N.,
R. 28 W., Stearns Co.
Analyst: W. Krum
Krum, William M., A petrographic study of the "gray" St. Cloud
intrusive: Master's thesis (Table 1, p. 41, no. 5), 1935. (Avail-
able at Univ. of Minn. Library and Geology Department.)
33. Warman granite
Loc. Reynold's Granite Co. quarry, Warman, Kanabec Co.
Analyst: F. F. Grout
Thiel, George A. and Dutton, Carl E., The architectural,
structural, and monumental stones of Minnesota: Minn. Geol.
Surv. Bull. 25, 160 p. (p. 105), 1935.
34. Granite
Loc. Small quarry about 7 miles east of Malmo, southern Aitkin
Co.
Analyst: E. B. Sandell
Sandell, E. B. and Goldich, S. S., The rarer metallic constituents
of some American igneous rocks, I: Jour. Geol., v. 51, p. 99-
115 (Table 5, p. 110, no. 3), 1943.
35. Agate granite
Loc. Cold Spring Co. quarry, SW1/4 SE1/4 sec. 22, T. 121 N.,
R. 46 W., Big Stone Co.
Analyst: Eileen S. Oslund
Unpub. analysis by the Rock Analysis Lab., Univ. of Minn., 1959.
36. Rockville granite
Loc. Cold Spring Co. quarry, Rockville, SE1/4 SE1/4 SW1/4 sec. 9,
T. 123 N., R. 29 W., Stearns Co.
Analyst: F. F. Grout
Unpub. analysis by the Rock Analysis Lab., Univ. of Minn., 1959.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 1. Granitic rocks

Elements	31	32	33	34	35	36
SiO ₂	63.47	61.86	69.55	71.19	72.59	69.63
Al ₂ O ₃	17.11	17.22	15.52	15.00	15.10	14.88
Fe ₂ O ₃	0.78	1.26	0.14	0.67	0.71	0.54
FeO	2.36	3.11	3.29	1.49	0.56	3.53
MgO	2.72	1.94	1.61	0.81	0.43	0.83
CaO	6.56	5.15	3.67	1.83	2.06	2.35
Na ₂ O	3.78	4.08	3.79	3.64	4.58	2.32
K ₂ O	2.39	3.35	2.12	4.57	3.20	4.34
H ₂ O+	0.66	0.44	0.40	0.68	0.12	0.23
H ₂ O-	0.18	0.06	0.10	0.03	0.03	0.10
TiO ₂	0.30	0.66	0.44	0.30	0.15	0.37
P ₂ O ₅		0.38	0.07	0.07	0.06	0.28
MnO		0.07		0.01	0.01	0.23
ZrO ₂			0.02			
CO ₂					0.12	0.11
S				0.02	0.00	
FeS ₂						
Cr ₂ O ₃			0.01			
BaO						
Total	100.31	99.58	100.73	100.31	99.72	99.74

MINNESOTA GEOLOGICAL SURVEY

References - Table 2

1. Syenite
Loc. East St. Cloud, Breen and Young's quarry, Sherburne Co.
Analyst: J. A. Dodge
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept.,
v. 1, 697 p. (Table 1, p. 198, no. 1), 1884.
2. Syenite
Loc. Sauk Rapids, Collins, Mitchell & Searle's quarry, Benton Co.
Analyst: J. A. Dodge
Ibid., p. 198, no. 4.
3. Red, quartzose syenite
Loc. East St. Cloud, Breen and Young's quarry, Sherburne Co.
Analyst: J. A. Dodge
Ibid., p. 198, no. 6.
4. Light colored, coarse syenite
Loc. Watab, Saulpaugh Bros. quarry, Benton Co.
Analyst: J. A. Dodge
Ibid., p. 198, no. 9.
5. Red, quartzose syenite
Loc. Watab, Saulpaugh Bros. quarry, Benton Co.
Analyst: W. A. Noyes
Ibid., p. 198, no. 10.
6. Green syenite
Loc. Ashley, 1525 paces N and 2000 W sec. 17, T. 126 N.,
R. 35 W., Stearns Co.
Analyst: F. F. Grout
Grout, F. F., The granites and associated quartz basalts of Stearns
County, Minnesota: Master's thesis (Table III, p. 34-35, no. 10),
1908. (Available at Univ. of Minn. Library, Reference Room.)

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 2. Syenitic rocks (including shonkinites and monzonites)

Elements	1	2	3	4	5	6
SiO ₂	65.12	64.13	74.43	62.66	78.12	56.36
Al ₂ O ₃	16.96	21.01	12.68	19.29	11.14	20.76
Fe ₂ O ₃	4.69		3.82	4.67	2.68	4.48
FeO						0.21
MgO	1.99	1.26	0.25	3.06	trace	1.08
CaO	4.77	6.90	1.28	5.93	0.62	8.76
Na ₂ O	3.07	3.31	1.55	2.45	3.33	5.89
K ₂ O	2.18	1.22	2.33	1.62	4.48	0.45
H ₂ O+						0.60
H ₂ O-					0.43	0.00
TiO ₂						0.57
P ₂ O ₅						0.28
MnO						0.08
ZrO ₂						
CO ₂						0.36
Cl						
S						
FeS ₂						
Cr ₂ O ₃						
BaO						
SrO						
Total	98.78	97.83	96.34	99.68	100.80	99.88

MINNESOTA GEOLOGICAL SURVEY

References - Table 2

7. Syenite
Loc. Basswood Lake, NW cor. Lake Co.
Analyst: F. F. Grout
Grout, F. F., The Vermilion batholith of Minnesota: Jour. Geol.,
v. 33, p. 467-487 (Table VI, p. 483, no. 8), 1925.
8. Syenite
Loc. Linden Twp., sec. 7, T. 62 N., R. 20 W., St. Louis Co.
Analyst: F. F. Grout
Ibid., p. 483, no. 17.
9. Shonkinitic border phase of Vermilion granite
Loc. Near shore of Vermilion Lake, sec. 30, T. 63 N., R. 16 W.,
St. Louis Co.
Analyst: F. F. Grout
Ibid., p. 483, no. 9.
10. Shonkinite
Loc. Idington, [T. 61 N., R. 18 W.], St. Louis Co.
Analyst: I. S. Allison
Allison, Ira S., The Giants Range batholith of Minnesota: Jour.
Geol., v. 33, p. 488-508 (Table II, p. 505, no. A), 1925.
11. Porphyritic shonkinite
Loc. Idington, [T. 61 N., R. 18 W.], St. Louis Co.
Analyst: R. J. Leonard
Ibid., p. 505, no. B.
12. Shonkinite (Basswood type)
Loc. sec. 21, T. 61 N., R. 21 W., St. Louis Co.
Analyst: I. S. Allison
Ibid., p. 505, no. C.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 2. Syenitic rocks (including shonkinites and monzonites)

Elements	7	8	9	10	11	12
SiO ₂	57.12	60.21	58.55	47.27	50.27	49.65
Al ₂ O ₃	16.68	16.28	12.56	6.99	7.61	9.27
Fe ₂ O ₃	1.96	2.49	1.72	3.10	2.86	5.00
FeO	4.60	1.62	5.05	5.44	7.04	6.08
MgO	4.60	2.21	8.63	9.18	7.92	8.89
CaO	8.73	4.76	7.34	20.49	13.87	13.08
Na ₂ O	4.03	3.78	3.09	1.91	2.41	2.38
K ₂ O	1.36	6.32	2.01	0.89	3.63	1.71
H ₂ O+	0.57	0.10	0.50	1.28	0.84	1.71
H ₂ O-	0.01	0.19	0.12	0.04		0.28
TiO ₂	0.29	0.56	0.51	0.67	1.51	0.89
P ₂ O ₅	0.33	0.23	0.14	1.62	1.46	0.06
MnO	0.14	0.08	0.17	0.30	0.20	0.56
ZrO ₂		0.12	0.03	0.01	0.26	0.05
CO ₂	trace	0.47	0.00	trace	none	trace
Cl						
S		0.03		0.01	none	trace
FeS ₂	0.08		0.04			
Cr ₂ O ₃	0.02	0.01	0.09	none	0.03	0.04
BaO	0.02	0.30	0.08	0.08	none	0.16
SrO			0.02			0.12
Total	100.54	99.76	100.65	99.28	99.91	99.93

MINNESOTA GEOLOGICAL SURVEY

References - Table 2

13. Monzonite
Loc. NW1/4, sec. 7, T. 61 N., R. 12 W., St. Louis Co.
Analyst: I. S. Allison
Ibid., p. 505, no. E.
- *14. Shonkinite (Basswood type)
Loc. Saganaga Lake, north of Saganaga Falls, center of north boundary, T. 66 N., R. 4 W., Cook Co.
Analysts: F. F. Grout and A. J. Bauernschmidt
Grout, F. F., The Saganaga granite of Minnesota-Ontario: Jour. Geol., v. 37, p. 562-591 (Table II, p. 575, no. 8), 1929.
- *15. Porphyritic shonkinite
Loc. Island in NE bay of Saganaga Lake, sec. 14, T. 67 N., R. 4 W., Cook Co.
Analyst: G. Ward
Ibid., p. 575, no. 9.
16. Fine syenite
Loc. Between Snowbank Lake and Round Lake, Lake Co.
Analyst: S. W. Sundeen
Sundeen, Stanley W., A petrographic study of the basic dikes of the Saganaga and Snowbank Lake intrusives, and a general review of the literature on lamprophyres: Ph.D. thesis (p. 54, no. I), 1936. (Available at Univ. of Minn. Library and Geology Department.)
17. Aurora sill rock (drill hole)
Loc. Aurora, NW1/4 NE1/4 sec. 2, T. 58 N., R. 15 W., St. Louis Co.
Analyst: Eileen S. Oslund
White, David A., The stratigraphy and structure of the Mesabi Range, Minnesota: Minn. Geol. Surv. Bull. 38, 92 p. (Table 10, p. 65), 1954.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 2. Syenitic rocks (including shonkinites and monzonites)

Elements	13	14	15	16	17
SiO ₂	54.57	50.41	58.27	64.10	53.91
Al ₂ O ₃	17.91	15.93	15.31	16.70	17.25
Fe ₂ O ₃	2.68	6.13	1.51	1.54	2.50
FeO	4.80	5.36	3.82	1.81	4.87
MgO	3.86	5.32	6.77	1.86	2.38
CaO	6.01	10.55	8.36	3.25	3.38
Na ₂ O	4.69	2.80	3.26	5.35	6.08
K ₂ O	2.34	1.25	1.61	3.77	3.21
H ₂ O+	1.68	1.38	0.72	0.43	1.93
H ₂ O-	0.06	0.12	0.20	0.08	0.33
TiO ₂	0.20	0.40	0.62	0.46	1.22
P ₂ O ₅	0.11			0.22	0.40
MnO	0.14	0.24		0.05	0.09
ZrO ₂	0.07	0.02			
CO ₂	none	0.10			2.12
Cl					0.03
S	0.04				0.04
FeS ₂					
Cr ₂ O ₃	none	0.12			
BaO	0.11	0.02			0.10
SrO					
Total	99.27	100.15	100.45	99.62	99.84

MINNESOTA GEOLOGICAL SURVEY

References - Table 3

1. Augite diorite
Loc. Richmond, on the Sauk River, Stearns Co.
Analyst: A. Streng
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 11th Ann.
Rept., 219 p. (p. 57), 1884.
2. Augite diorite
Loc. Richmond, Stearns Co.
Analyst: A. Streng
Ibid., p. 60.
3. Augite diorite
Loc. Little Falls, Morrison Co.
Analyst: A. Streng
Ibid., p. 62.
4. Augite diorite
Loc. Little Falls, Morrison Co.
Analyst: A. Streng
Ibid., p. 70.
5. Augite diorite
Loc. Little Falls, Morrison Co.
Analyst: A. Streng
Ibid., p. 64.
6. Augite diorite
Loc. Little Falls, Morrison Co.
Analyst: A. Streng
Ibid., p. 66.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 3. Dioritic and quartz dioritic rocks

Elements	1	2	3	4	5	6
SiO ₂	48.87	52.00	46.52	56.49	52.35	51.27
Al ₂ O ₃	18.72	15.75	13.87	17.49	15.72	23.72
Fe ₂ O ₃	3.28	3.55	3.71	3.51	2.90	1.35
FeO	5.55	12.84	8.79	3.72	7.32	3.81
MgO	9.53	3.42	10.04	4.01	7.36	3.30
CaO	11.93	7.39	11.00	6.64	8.98	10.50
Na ₂ O	2.10	3.37	2.13	4.49	2.81	*3.35
K ₂ O	0.73	1.24	1.01	*3.20	*1.32	0.65
H ₂ O+	0.93	0.35	1.05	1.14	1.35	1.23
H ₂ O-						
TiO ₂						
P ₂ O ₅	0.08	1.06	0.32	0.18	0.30	0.37
MnO						
CO ₂	trace	0.11	0.47	trace	0.23	0.35
S						
BaO						
Total	101.72	101.08	98.91	100.87	100.64	99.90

*with trace Li₂O

MINNESOTA GEOLOGICAL SURVEY

References - Table 3

7. Quartz diorite
Loc. Sauk Centre, Stearns Co.
Analyst: A. Streng
Ibid., p. 73-74.
8. Quartz diorite
Loc. Little Falls, Morrison Co.
Analyst: A. Streng
Streng, A. and Kloos, J. H., Ueber die Krystallinischen Gesteine von Minnesota in Nord-Amerika: Neues Jahr. Min., Geol., Paleo., p. 225-242 (p. 230), 1877.
9. Augite quartz diorite
Loc. Watab, Benton Co.
Analyst: A. Streng
Ibid., p. 232.
10. Diorite
Loc. Little Falls, Williams quarry, Morrison Co.
Analyst: Donald Smith
Sandell, E. B. and Goldich, S. S., The rarer metallic constituents of some American igneous rocks, I: Jour. Geol., v. 51, p. 99-115 (Table 5, p. 110, no. 17), 1943.
11. Diorite flow (M4011B)
Loc. Vermilion Range, NW1/4 SE1/4 sec. 9, T. 61 N., R. 14 W., St. Louis Co.
Analyst: Eileen S. Oslund
Unpub. analysis by Rock Analysis Lab., Univ. of Minn., 1953.
12. Quartz diorite porphyry (tonalite, M4025)
Loc. in greenstone - gradational contact, NE1/4 NW1/4 SE1/4 sec. 9, T. 61 N., R. 14 W., St. Louis Co.
Analyst: Doris Thaemlitz
Unpub. analysis by Rock Analysis Lab., Univ. of Minn., 1955.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 3. Dioritic and quartz dioritic rocks

Elements	7	8	9	10	11	12
SiO ₂	56.59	66.88	65.27	48.14	49.72	62.01
Al ₂ O ₃	12.41	11.69	15.76	17.45	16.76	16.72
Fe ₂ O ₃	5.39	1.68	1.36	3.73	1.92	1.53
FeO	10.28	8.94	3.44	6.72	7.33	1.99
MgO	2.02	3.55	2.14	6.28	7.62	3.70
CaO	6.70	5.45	3.70	9.92	9.35	5.93
Na ₂ O	4.27	1.25	4.57	2.39	3.14	5.20
K ₂ O	1.02	0.20	3.97	1.95	0.71	0.69
H ₂ O ⁺				1.44	1.57	1.08
H ₂ O ⁻	1.45	1.03	0.42	0.12	0.06	0.06
TiO ₂	0.22			0.57	0.89	0.45
P ₂ O ₅	0.44	trace	0.26	0.22	0.09	0.17
MnO				0.17	0.16	0.05
CO ₂	trace	trace			0.10	0.07
S				0.04	0.04	0.28
BaO				0.10	0.06	
Total	100.79	100.67	100.89	99.24	99.52	99.93

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

1. Feldspathic gabbro
Loc. Duluth, NW1/4 sec. 34, T. 50 N., R. 14 W., St. Louis Co.
Analyst: J. A. Dodge
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept.,
v. 5, 1027 p. (p. 85, no. I), 1900.
2. Hornblende gabbro
Loc. St. Louis River near Duluth, St. Louis Co.
Analyst: A. Streng
Ibid., p. 85, no. II.
3. Quartz gabbro
Loc. Portage between L and Wind Lakes, probably in E1/2 sec. 11,
T. 63 N., R. 5 W., Cook Co.
Analysts: J. A. Dodge and C. F. Sidener
Ibid., p. 543.
4. Finely crystalline brown syenite
Loc. Duluth, St. Louis Co.
Analyst: J. A. Dodge
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 13th Ann.
Rept., 196 p. (p. 100, no. 149), 1885.
5. Altered gabbro
Loc. East of Baptism River, (T. 56 N., R. 7 W.), Lake Co.
Analysts: J. A. Dodge and C. F. Sidener
Wadsworth, M. E., Preliminary description of the peridotytes,
gabbros, diabases and andesytes of Minnesota: Minn. Geol. and
Nat. Hist. Surv. Bull. 2, 158 p. (p. 79), 1887.
6. Light portion of gabbro
Loc. 2 1/2 miles SE of St. Cloud, Stearns Co.
Analysts: J. A. Dodge and C. F. Sidener
Ibid., p. 86.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	1	2	3	4	5	6
SiO ₂	50.43	49.15	53.43	53.71	50.86	61.19
Al ₂ O ₃	23.83	21.90	13.81	14.96	15.72	15.22
Fe ₂ O ₃		6.60	5.08	14.45	9.77	3.20
FeO	17.63	4.54	9.86	3.65	2.48	3.55
MgO	2.46	3.03	4.64	4.59	3.55	2.38
CaO	4.79	8.22	8.25	3.35	10.52	7.94
Na ₂ O	2.06	3.83	2.51	1.40	3.89	3.17
K ₂ O	0.34	1.61	1.12	0.56	0.90	2.62
H ₂ O+						
H ₂ O-		1.92	0.27	1.60	2.53	0.40
TiO ₂	trace					
P ₂ O ₅						
MnO			trace			trace
CO ₂						
S						
Cr ₂ O ₃						
NiO						
BaO						
SrO						
Rb ₂ O						
Total	101.54	100.80	98.97	98.27	100.22	99.67

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

7. Dark portion of gabbro
Loc. 2 1/2 miles SE of St. Cloud, Stearns Co.
Analysts: J. A. Dodge and C. F. Sidener
Ibid., p. 86.
8. Olivine gabbro
Loc. Near S1/4 post of sec. 35, T. 61 N., R. 12 W., St. Louis Co.
Analyst: H. N. Stokes
Bayley, W. S., The basic massive rocks of the Lake Superior region, pt. III: Jour. Geol., v. 1, p. 688-716 (p. 712), 1893.
9. Olivine gabbro
Loc. South shore of small lake in SE1/4 SE1/4 sec. 19, T. 63 N., R. 9 W., Lake Co.
Analyst: H. N. Stokes
Ibid., p. 712.
10. Gabbro
Loc. North shore of Bashitanaqueb Lake, Cook Co.
Analyst: A. D. Meeds
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 21st Ann. Rept., 171 p. (p. 151), 1893.
11. Granulitic diallage-hypersthene-gabbro
Loc. NE Minnesota (Akeley Lake vicinity, T. 65 N., R. 4 W.), Cook Co.
Analyst: W. H. Melville
Bayley, W. S., The basic massive rocks of the Lake Superior region, pt. IV: Jour. Geol., v. 3, p. 1-20 (p. 10, no. II), 1895.
12. Granulitic hypersthene-gabbro
Loc. NE Minnesota (Akeley Lake vicinity, T. 65 N., R. 4 W.), Cook Co.
Analyst: H. N. Stokes
Ibid., p. 10, no. I.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	7	8	9	10	11	12
SiO ₂	58.77	46.45	45.66	49.07	49.56	46.96
Al ₂ O ₃	13.12	21.30	16.44	17.21	17.81	14.13
Fe ₂ O ₃	5.45	0.81	0.66	0.46	2.76	0.76
FeO	6.87	9.57	13.90	12.18	9.48	14.95
MgO	4.93	7.90	11.57	3.60	5.93	15.97
CaO	5.99	9.83	7.23	9.66	9.70	2.32
Na ₂ O	1.94	2.14	2.13	2.96	2.87	0.35
K ₂ O	2.83	0.34	0.41	trace		1.68
H ₂ O+		1.02	0.83			1.26
H ₂ O-	0.45	0.14	0.07	1.55	0.50	0.07
TiO ₂		1.19	0.92		0.48	0.62
P ₂ O ₅		0.02	0.05		0.67	0.03
MnO	trace	trace	trace	trace	0.06	0.93
CO ₂				2.70		
S						
Cr ₂ O ₃			trace			trace
NiO		0.04	0.16			0.06
BaO						
SrO						
Rb ₂ O						
Total	100.35	100.75	100.03	99.39	99.82	100.09

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

13. Hard green taconyte banded with magnetite
Loc. SE1/4 NE1/4 sec. 30, T. 58 N., R. 17 W., Cook Co.
Analyst: A. D. Meeds
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 23rd Ann. Rept., 255 p. (p. 212, no. 244), 1895.
14. Another analysis of no. 13 which differs a great deal.
15. Garnetiferous gabbro
Loc. Granite Falls, 1500 paces N of SE cor. sec. 4, T. 115 N., R. 39 W., Yellow Medicine Co.
Analyst: H. N. Stokes
Bayley, W. S., Description no. 109, garnetiferous gabbro: U. S. Geol. Surv. Bull. 150, p. 282-286 (p. 286), 1898.
16. Hornblende gabbro-gneiss
Loc. Minnesota Falls, 600 paces N and 100 paces W of SE cor. sec. 11, T. 115 N., R. 39 W., Chippewa Co.
Analyst: H. N. Stokes
Bayley, W. S., Description no. 144, hornblendic gabbro-gneiss (gabbro-diorite): U. S. Geol. Surv. Bull. 150, p. 369-372 (p. 372), 1898.
17. Olivine gabbro
Loc. Birch Lake, sec. 35 (?), T. 61 N., R. 12 W., St. Louis Co.
Analyst: H. N. Stokes
Winchell, A. N., Mineralogical and petrographic study of the gabbroic rocks of Minnesota, and more particularly, of the plagioclasytes: Am. Geol., v. 26, p. 151-188, 197-245, 261-306, 348-388 (p. 181, no. VI), 1900.
18. Orthoclase gabbro
Loc. Duluth, St. Louis Co.
Analyst: A. N. Winchell
Ibid., p. 374.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	13	14	15	16	17	18
SiO ₂	64.04	58.94	52.31	48.29	47.70	49.06
Al ₂ O ₃	2.11	2.72	18.35	20.87	19.04	15.33
Fe ₂ O ₃	2.81	3.01	5.90	1.13	0.87	5.92
FeO	22.14	22.94	11.06	4.93	8.84	11.53
MgO	4.04	4.74	1.00	7.54	8.65	2.75
CaO	0.60	0.71	7.33	14.32	8.96	6.80
Na ₂ O	0.30	0.24	2.90	1.77	2.53	3.17
K ₂ O	0.11	0.09	0.49	0.38	0.53	1.40
H ₂ O+	0.67		0.35	0.89		
H ₂ O-	3.73	3.35			1.38	1.76
TiO ₂					1.80	1.46
P ₂ O ₅						0.27
MnO					trace	0.61
CO ₂		3.72				trace
S						
Cr ₂ O ₃						
NiO						
BaO						
SrO						
Rb ₂ O						
Total	100.55	100.46	99.69	100.12	100.30	100.06

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

19. Troctolite
Loc. Duluth, St. Louis Co.
Analyst: A. N. Winchell
Ibid., p. 284
20. Orthoclase gabbro
Loc. Duluth, St. Louis Co.
Analyst: A. N. Winchell
Ibid., p. 293, no. I.
21. Orthoclase gabbro, rich in hornblende
Loc. Duluth, St. Louis Co.
Analyst: A. N. Winchell
Ibid., p. 293, no. III.
22. Quartz gabbro
Loc. Near Little Saganaga Lake, SE1/4 SW1/4 sec. 12, T. 64 N.,
R. 6 W., Lake Co.
Analyst: A. N. Winchell
Ibid., p. 352.
23. Gabbro
Loc. Duluth, St. Louis Co.
Analyst: G. H. Stone
Grout, F. F., Contribution to the petrography of the Keweenaw:
Jour. Geol., v. 18, p. 633-657 (p. 656, no. 3), 1900.
24. Gabbro
Loc. Richmond, Stearns Co.
Analyst: E. M. Pennock
Ibid., p. 656, no. 1.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	19	20	21	22	23	24
SiO ₂	35.81	52.48	45.65	56.60	49.42	52.34
Al ₂ O ₃	14.32	15.47	15.20	17.84	24.47	14.17
Fe ₂ O ₃	7.38	5.14	6.71	2.55	3.13	2.40
FeO	15.25	9.25	13.81	4.09	6.13	10.78
MgO	10.49	2.55	2.95	3.16	1.00	3.51
CaO	7.23	7.27	6.33	6.28	8.45	7.25
Na ₂ O	2.06	3.26	3.09	4.45	4.98	3.73
K ₂ O	0.37	1.75	1.05	0.45	1.15	2.37
H ₂ O+					0.55	0.43
H ₂ O-	5.25	1.24	2.29	3.20	0.06	0.18
TiO ₂	2.30	1.26	1.66	1.59	1.87	2.21
P ₂ O ₅		0.29	0.25	0.14	0.04	0.80
MnO	0.18	0.51	0.71	trace	0.11	0.09
CO ₂						
S					0.11	0.14
Cr ₂ O ₃						
NiO						
BaO						
SrO						
Rb ₂ O						
Total	100.64	100.47	99.70	100.35	101.47	100.40

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

25. Gabbro
Loc. Little Falls, Morrison Co.
Analyst: L. Nye
Ibid., p. 656, no. 2.
26. Olivine gabbro
Loc. West Duluth, sec. 23, T. 49 N., R. 15 W., St. Louis Co.
Analyst: F. F. Grout
Grout, F. F., A type of igneous differentiation: Jour. Geol.,
v. 26, p. 626-658 (p. 646, no. 1), 1918.
27. Olivine gabbro
Loc. Short Line Park, Duluth, sec. 33, T. 49 N., R. 15 W.,
St. Louis Co.
Analyst: G. S. Nishihara
Ibid., p. 646, no. 4.
28. Gabbro pegmatite
Loc. Short Line Park, Duluth, sec. 33, T. 49 N., R. 15 W.,
St. Louis Co.
Analyst: G. S. Nishihara
Ibid., p. 646, no. 5.
29. Gabbro
Loc. NE1/4 NW1/4 sec. 5, T. 62 N., R. 10 W., Lake Co.
Analyst: I. S. Allison
Allison, Ira S., The Giants Range batholith of Minnesota:
Jour. Geol., v. 33, p. 488-508 (p. 505, no. D), 1925.
30. Olivine gabbro
Loc. East of Birch Lake (T. 61 N., R. 12 or 13 W.), St. Louis Co.
Analyst: A. N. Winchell
Grout, F. F., Studies for students--origin of the igneous rocks
of Minnesota: Jour. Geol., v. 41, p. 196-218 (p. 209, no. 11), 1933.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	25	26	27	28	29	30
SiO ₂	44.16	48.20	47.10	42.24	52.24	47.90
Al ₂ O ₃	14.89	19.53	12.92	18.50	11.66	19.92
Fe ₂ O ₃	1.19	trace	12.95	4.68	2.33	4.92
FeO	6.83	10.60	9.46	14.50	8.48	9.78
MgO	14.40	9.28	3.08	2.76	9.78	4.55
CaO	13.01	8.51	10.29	10.36	9.41	8.56
Na ₂ O	1.92	2.52	2.61	2.19	1.94	2.75
K ₂ O	0.97	0.32	0.92	0.33	0.87	0.56
H ₂ O+	0.89	0.65	0.71	1.80	1.26	0.76
H ₂ O-	0.05	0.08	0.12	0.25	0.14	
TiO ₂	0.89	0.65	1.38	1.16	1.42	0.57
P ₂ O ₅		0.19	0.01	0.19	trace	
MnO	trace	0.14	0.80	0.13	0.12	
CO ₂		0.02		1.67	none	
S		0.03			0.01	
Cr ₂ O ₃		trace			0.08	
NiO						
BaO					0.08	
SrO						
Rb ₂ O						
Total	99.20	100.72	102.35	100.76	99.82	100.27

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

31. Fine-grained border of Beaver River gabbro
Loc. Reserve Mining Co., Beaver Bay (T. 55 N., R. 8 W.),
Lake Co.
Analyst: Doris Thaemlitz
Gehman, H. M., Jr., The petrology of the Beaver Bay complex,
Lake County, Minnesota: Ph.D. thesis (Table 1, p. 12, no. 1),
1957. (Available at Univ. of Minn. Library and Geology Depart-
ment.)
- *32. Hortonolite-ferrogabbro
Loc. Shore of Lake Superior, SE1/4 NE1/4 sec. 14, T. 55 N.,
R. 8 W., Lake Co.
Analyst: Doris Thaemlitz
Ibid., Table 6, p. 36, no. 9.
- *33. Ferrohortonolite-ferrogabbro
Loc. Shore of Lake Superior, NW1/4 NW1/4 sec. 13, T. 55 N.,
R. 8 W., Lake Co.
Analyst: Doris Thaemlitz
Ibid., p. 36, no. 11.
- *34. Fayalite-ferrogabbro
Loc. Shore of Lake Superior, NW1/4 NW1/4 sec. 13, T. 55 N.,
R. 8 W., Lake Co.
Analyst: C. O. Ingamells
Ibid., p. 36, no. 12.
- *35. Black Bay gabbro from dike marginal to ferrogabbro mass at
Silver Bay
Loc. Fresh cut near diesel repair shop of Reserve Mining Co.,
Lake Co.
Analyst: Doris Thaemlitz
Ibid., Table 11, p. 72.
- *36. Banded troctolite (M4634)
Loc. Bardon Peak, on upper tracks of Canadian National Railroad,
St. Louis Co.
Analyst: Doris Thaemlitz
Taylor, Richard B., Geology of the Duluth gabbro complex: Minn.
Geol. Surv. Bull. 44, 63 p. (Table 8, p. 29, no. VII), 1964.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	31	32	33	34	35	36
SiO ₂	49.16	43.21	47.88	49.83	50.04	47.36
Al ₂ O ₃	17.09	14.22	11.86	11.59	13.00	18.81
Fe ₂ O ₃	2.28	5.11	4.05	4.51	4.20	1.30
FeO	7.99	13.46	15.56	17.19	10.71	10.65
MgO	7.43	4.53	2.47	1.06	3.61	8.59
CaO	10.89	9.31	7.22	7.34	7.59	8.33
Na ₂ O	2.35	2.66	2.89	2.93	2.66	2.94
K ₂ O	0.45	0.67	1.29	1.15	1.17	0.42
H ₂ O+	0.60	0.73	0.92	0.53	1.51	0.24
H ₂ O-	0.39	0.60	0.85	0.48	0.95	0.05
TiO ₂	1.36	4.16	3.00	2.21	3.36	1.10
P ₂ O ₅	0.13	0.78	1.41	0.54	0.69	0.11
MnO	0.19	0.20	0.30	0.37	0.22	0.14
CO ₂	0.02	0.01	0.03	0.01	0.05	0.01
S						
Cr ₂ O ₃						
NiO						
BaO						
SrO						
Rb ₂ O						0.01
Total	100.33	99.65	99.73	99.74	99.76	100.06

MINNESOTA GEOLOGICAL SURVEY

References - Table 4

37. Olivine gabbro (M4633)
Loc. Bardon Peak, on lower tracks of Canadian National Railroad, St. Louis Co.
Analyst: Doris Thaemlitz
Ibid., p. 29, no. XI.
- *38. Ferrogranodiorite (M3781)
Loc. Quarry in Coffee Creek, sec. 20, T. 50 N., R. 14 W., St. Louis Co.
Analyst: Doris Thaemlitz
Ibid., Table 10, p. 32, no. XIII.
39. Ferrogranodiorite (M4624)
Loc. Intrusion in NW1/4 sec. 28, T. 50 N., R. 14 W., St. Louis Co.
Analyst: R. B. Taylor
Ibid., p. 32, no. XIV.
- *40. Ferrogranodiorite intrusion (M4625)
Loc. Outcrop on Skyline Drive south of Twin Lakes and northeast of Enger Tower, St. Louis Co.
Analyst: R. B. Taylor
Ibid., p. 32, no. XV.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 4. Gabbroic rocks (including ferrogabbros)

Elements	37	38	39	40
SiO ₂	46.90	50.13	53.78	50.36
Al ₂ O ₃	15.68	11.72	16.34	14.88
Fe ₂ O ₃	1.23	2.30	4.66	7.19
FeO	10.58	11.99	7.65	8.14
MgO	8.61	3.32	1.31	2.36
CaO	10.11	6.74	7.08	7.06
Na ₂ O	2.32	2.90	4.07	3.74
K ₂ O	0.57	2.16	1.76	1.68
H ₂ O+	0.86	1.09	0.65	0.87
H ₂ O-	0.14	0.36	0.32	0.21
TiO ₂	2.59	2.93	1.55	2.15
P ₂ O ₅	0.10	1.53	0.54	0.83
MnO	0.16	0.24	0.18	0.20
CO ₂	0.03	0.04	0.03	0.01
S		0.07		
Cr ₂ O ₃				
NiO				
BaO		0.02		
SrO		0.03	0.04	0.03
Rb ₂ O		0.01	0.00	0.00
Total	99.88	97.58	99.96	99.71

MINNESOTA GEOLOGICAL SURVEY

References - Table 5

1. Anorthosite
Loc. North shore of Lake Superior, 2 miles below Beaver Bay, NE1/4 sec. 6, T. 55 N., R. 7 W., Lake Co.
Analyst: R. D. Irving
Irving, Roland D., The copper-bearing rocks of Lake Superior: U. S. Geol. Surv. Monograph, v. 5, 464 p. (p. 438), 1883.
2. Anorthosite
Loc. Near Encampment Island (T. 53 N., R. 10 W.), Lake Co.
Analyst: Charles Palache
Lawson, Andrew C., I. The anorthosites of the Minnesota coast of Lake Superior (and) II. The laccolitic sills of the north-west coast of Lake Superior: Minn. Geol. and Nat. Hist. Surv. Bull. 8, 48 p. (p. 6, no. III), 1893.
3. Plagioclasyte
Loc. Carlton Peak (T. 59 N., R. 4 W.), Cook Co.
Analyst: A. N. Winchell
Winchell, A. N., Mineralogical and petrographic study of the gabbroic rocks of Minnesota, and more particularly, of the plagioclasytes: Am. Geol., v. 26, p. 151-188, 197-245, 261-306, 348-388 (p. 281, no. 1), 1900.
4. Anorthosite
Loc. North of Proctor, sec. 19, T. 50 N., R. 14 W., St. Louis Co.
Analyst: F. F. Grout
Grout, F. F., A type of igneous differentiation: Jour. Geol., v. 26, p. 626-658 (p. 646, no. 3), 1918.
5. Anorthosite
Loc. Foot of Caribou Peak, St. Louis Co. (?)
Analyst: C. F. Sidener
Ibid., p. 650, no. 24.
6. Fresh bytownite
Loc. Near Beaver Bay, north shore of Lake Superior, Lake Co.
Analyst: R. J. Leonard
Leonard, R. J., The hydrothermal alteration of certain silicate minerals: Econ. Geol., v. 22, p. 18-43 (p. 26), 1927.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 5. Anorthosites

Elements	1	2	3	4	5	6
SiO ₂	47.25	47.40	49.78	49.39	47.05	47.97
Al ₂ O ₃	31.56	29.74	29.37	29.08	32.03	33.07
Fe ₂ O ₃			0.34	0.34	2.01	
FeO	2.29	1.94	0.60	2.89		
MgO	0.27	0.57	1.01	2.26	0.15	0.16
CaO	15.39	13.30	11.86	13.06	15.85	15.57
Na ₂ O	2.52	4.99	4.39	2.89	1.00	3.00
K ₂ O	0.37	1.56	0.46	0.10	0.05	0.53
H ₂ O+				0.34	1.36	0.38
H ₂ O-	0.40	1.64	1.76	0.09		
TiO ₂			none	trace		
P ₂ O ₅				0.09		
MnO			0.08	0.04		
CO ₂				trace		
Cr ₂ O ₃				trace		
Total	100.05	101.14	99.65	100.57	99.50	100.68

MINNESOTA GEOLOGICAL SURVEY

References - Table 5

7. Brown anorthosite
Loc. Highway No. 61, sec. 1, T. 56 N., R. 7 W., Lake Co.
Analyst: R. B. Ellestad
Grout, F. F. and Schwartz, G. M., The geology of the anorthosites of the Minnesota coast of Lake Superior: Minn. Geol. Surv. Bull. 28, 119 p. (Table 4, p. 55, no. 6), 1939.
8. Split Rock quarry rock (anorthosite)
Loc. sec. 5, T. 54 N., R. 8 W., Lake Co.
Analyst: R. B. Ellestad
Ibid., p. 55, no. 7.
9. Black anorthosite
Loc. Beaver Bay, sec. 12, T. 55 N., R. 8 W., Lake Co.
Analyst: W. T. Kameda
Ibid., p. 55, no. 8.
10. Very coarse anorthosite
Loc. Gove in sec. 5, T. 56 N., R. 7 W., Lake Co.
Analyst: W. T. Kameda
Ibid., p. 55, no. 9.
11. Anorthosite
Loc. Along Highway No. 1, sec. 32, T. 61 N., R. 10 W., Lake Co.
Analyst: R. B. Ellestad
Ibid., Table 6, p. 62, no. 1.
12. Anorthosite
Loc. Island in Rainy Lake, close to Ontario border, St. Louis Co.
Analyst: R. B. Ellestad
Ibid., p. 62, no. 3.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 5. Anorthosites

Elements	7	8	9	10	11	12
SiO ₂	51.54	50.68	51.45	50.59	52.30	45.58
Al ₂ O ₃	28.87	30.67	28.47	29.88	28.79	27.70
Fe ₂ O ₃	1.06	0.21	0.80	0.35	0.49	1.03
FeO	0.22	0.29	1.00	0.49	0.72	2.43
MgO	0.39	0.42	1.07	1.18	1.06	2.75
CaO	12.70	13.79	12.08	13.08	11.93	15.50
Na ₂ O	3.72	3.40	3.90	3.48	3.99	1.64
K ₂ O	0.27	0.09	0.33	0.12	0.30	0.11
H ₂ O+	0.82	0.50	0.63	0.79	0.39	2.20
H ₂ O-	0.08	0.03	0.18	0.22	0.05	0.10
TiO ₂	0.12	0.07	0.15	0.05	0.18	1.00
P ₂ O ₅	0.09	0.16	0.04	0.05		
MnO	0.01	0.01	0.02	0.01	0.02	0.05
CO ₂	0.03	0.03				
Cr ₂ O ₃						
Total	99.92	100.35	100.12	100.29	100.22	100.09

MINNESOTA GEOLOGICAL SURVEY

References - Table 6

1. Rice Point red granite
Loc. Rice's Point, Duluth, St. Louis Co.
Analyst: J. A. Dodge
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 10th Ann. Rept.,
254 p. (p. 204, no. 73), 1882.
2. Red, fine-grained syenite
Loc. Beaver Bay, Wieland Bros. quarry, Lake Co.
Analyst: J. A. Dodge
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept.,
v. 1, 697 p. (Table 1, p. 198, no. 5), 1884.
3. Red rock
Loc. Grand Marais (furnishing pebbles to beach), Cook Co.
Analyst: J. A. Dodge
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 13th Ann.
Rept., 196 p. (p. 100, no. 162), 1885.
4. Brick-red, gritty, subcrystalline (rock)
Loc. Mouth of Passabika River, Lake Co. (?)
Analyst: J. A. Dodge
Ibid., p. 100, no. 153.
5. Purplish-red granite
Loc. West bluff at entrance to Beaver Bay, Lake Co.
Analyst: J. A. Dodge
Ibid., p. 100, no. 155.
6. Red granite
Loc. First island NW from Belle Rose Island, south of Pigeon
Point, Cook Co.
Analyst: J. A. Dodge
Ibid., p. 100, no. 164.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 6. Keweenawan granitic rocks

Elements	1	2	3	4	5	6
SiO ₂	75.78	71.81	73.58	65.56	71.15	73.91
Al ₂ O ₃	11.09	12.82	13.36	10.06	12.40	14.89
Fe ₂ O ₃	2.09	6.02	3.78	14.40	5.21	2.27
FeO			0.69	0.23	0.75	1.70
MgO	0.65	0.56	0.18	0.73	1.13	trace
CaO	0.86	2.26	0.81	0.96	1.90	0.27
Na ₂ O	6.43	2.51	2.42	2.25	1.70	2.64
K ₂ O	1.06	1.92	2.48	2.88	2.40	2.78
H ₂ O+	1.82		1.14	0.86	2.12	1.01
H ₂ O-						
TiO ₂						
P ₂ O ₅						
MnO						
ZrO ₂						
CO ₂						
SO ₃						
Cl						
S						
BaO						
SrO						
Li ₂ O						
Total	99.78	97.90	98.44	97.93	98.76	99.47

MINNESOTA GEOLOGICAL SURVEY

References - Table 6

7. Red granite
Loc. 3rd island below Beaver Bay, Lake Co.
Analyst: J. A. Dodge
Ibid., p. 100, no. 157.
8. Finely crystalline red syenite
Loc. Duluth, St. Louis Co.
Analyst: J. A. Dodge
Ibid., p. 100, no. 148.
9. Red rock (powder of 7 specimens)
Loc. Pigeon Point, Cook Co.
Analyst: W. F. Hillebrand
Bayley, William S., Quartz-keratophyre from Pigeon Point, and Irving's augite-syenites: *Am. Jour. Sci.*, ser. 3, v. 37, p. 54-63 (p. 59, no. 1), 1889.
10. Powder of 3 specimens of the quartz porphyries
Loc. Pigeon Point, Cook Co.
Analyst: W. F. Hillebrand
Ibid., p. 59, no. II.
11. Bright red porphyry
Loc. Little Brick Island off Pigeon Point, Cook Co.
Analyst: L. G. Eakins
Bayley, William S., The eruptive and sedimentary rocks on Pigeon Point, Minn., and their contact phenomena: *U. S. Geol. Surv. Bull.* 109, 121 p. (p. 58), 1893.
12. Intermediate rock, near the red rock
Loc. Pigeon Point, Cook Co.
Analyst: W. F. Hillebrand
Ibid., p. 63.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 6. Keweenawan granitic rocks

Elements	7	8	9	10	11	12
SiO ₂	73.28	66.36	72.42	74.00	73.70	57.98
Al ₂ O ₃	11.83	13.33	13.04	12.04	12.87	13.58
Fe ₂ O ₃	4.61	7.89	0.68	0.78	3.76	3.11
FeO	0.56	2.96	2.49	2.61	0.31	8.68
MgO	0.36	1.20	0.58	0.42	0.11	2.87
CaO	1.04	2.14	0.66	0.85	0.14	2.01
Na ₂ O	1.66	2.63	3.44	3.47	3.63	3.56
K ₂ O	4.50	3.05	4.97	4.33	4.56	3.44
H ₂ O+	1.82	1.21	1.21	0.86	0.57	2.47
H ₂ O-						
TiO ₂			0.40	0.34	0.12	1.75
P ₂ O ₅			0.20	0.06	trace	0.29
MnO			0.09	0.05	0.07	0.13
ZrO ₂						
CO ₂						
SO ₃						
Cl			trace	trace		trace
S						
BaO			0.15	0.12		0.04
SrO						trace
Li ₂ O			trace	trace		trace
Total	99.66	100.77	100.33	99.93	99.84	99.91

MINNESOTA GEOLOGICAL SURVEY

References - Table 6

13. Red rock
Loc. Pigeon Point, Cook Co.
Analyst: J. E. Whitfield
Ibid., p. 90.
14. Red rock
Loc. North side of Pigeon Point, SE1/4 NW1/4 sec. 26, T. 64 N.,
R. 7 E., Cook Co.
Analysts: J. A. Dodge and C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept.,
v. 5, 1027 p. (p. 303), 1900.
15. Red rock
Loc. Duluth, NW cor. sec. 27, T. 50 N., R. 14 W., St. Louis Co.
Analyst: F. F. Grout
Grout, F. F., A type of igneous differentiation: Jour. Geol.,
v. 26, p. 626-658 (p. 650), 1918.
16. Red rock, much contaminated by anorthosite
Loc. Duluth, 13th Ave. W. abd. quarry, St. Louis Co.
Analyst: W. W. Longley
Grout, F. F. and Longley, W. W., Relations of anorthosite to
granite: Jour. Geol., v. 43, p. 133-141 (p. 135, no. 3), 1935.
17. Intermediate rock
Loc. Near Beaver Bay, SE1/4 SE1/4 sec. 8, T. 57 N., R. 7 W.,
Lake Co.
Analyst: R. B. Ellestad
Grout, F. F. and Schwartz, G. M., The geology of the anorthosites
of the Minnesota coast of Lake Superior: Minn. Geol. Surv. Bull.
28, 119 p. (Table 2, p. 35, no. 5), 1939.
18. Intermediate red rock, Endion sill
Loc. Duluth, McLean quarry, between 24th & 25th Aves. E. near
lakeshore, St. Louis Co.
Analyst: R. W. Perlich
Schwartz, G. M. and Sandberg, A. E., Rock series in diabase
sills at Duluth, Minn.: Geol. Soc. Am. Bull. 51, p. 1135-1171
(Table 1, opposite p. 1144, no. 4), 1940.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 6. Keweenawan granitic rocks

Elements	13	14	15	16	17	18
SiO ₂	68.36	61.09	66.92	51.96	63.18	61.46
Al ₂ O ₃	13.76	15.34	12.51	18.97	13.27	13.22
Fe ₂ O ₃	2.65	5.74	4.36	1.98	4.03	3.08
FeO	2.75	3.69	3.93	7.07	4.42	5.42
MgO	0.68	1.33	1.66	2.67	1.62	2.00
CaO	0.70	3.10	1.20	8.60	2.74	2.96
Na ₂ O	3.56	3.41	3.45	3.18	3.47	3.33
K ₂ O	4.48	3.65	3.98	1.43	3.57	4.30
H ₂ O+			1.25	1.31	1.20	1.24
H ₂ O-	0.98	1.80	0.20	0.17	0.40	0.32
TiO ₂	1.57		0.69	1.90	1.51	1.37
P ₂ O ₅	0.33		0.11	0.41	0.31	0.40
MnO	trace		0.16	0.14	0.12	0.18
ZrO ₂			0.22			
CO ₂			0.02			0.53
SO ₃	0.66					
Cl						
S			0.04			
BaO			0.06			
SrO						
Li ₂ O						
Total	100.48	99.15	100.76	99.79	99.84	99.81

MINNESOTA GEOLOGICAL SURVEY

References - Table 6

19. Red rock within a few feet of contact with rhyolite, Endion sill
Loc. Duluth, Tischer's (Congdon) Creek near 2nd St. E.,
St. Louis Co.
Analyst: R. W. Perlich
Ibid., Table 1, no. 6.
20. Red rock, Northland sill
Loc. Duluth, Skyline Blvd. & 41st Ave. projected, St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 10.
21. Red rock, intermediate variety, Northland sill
Loc. 1/4 mile west of center of sec. 33, T. 51 N., R. 15 W.,
St. Louis Co.
Analyst: R. W. Perlich
Ibid., Table 1, no. 11.
22. Red rock, Northland sill
Loc. Lester River above bridge at Maxwell Rd., SW1/4 NE1/4
sec. 32, T. 51 N., R. 13 W., St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 12.
23. Red rock, main facies, Lester River sill
Loc. Shore of Lake Superior, SE1/4 NE1/4 sec. 4, T. 50 N.,
R. 13 W., St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 17.
24. Red rock, along fractures in reddish diabase
Loc. Shore of Lake Superior, NE1/4 NE1/4 sec. 4, T. 50 N.,
R. 13 W., St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 19.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 6. Keweenawan granitic rocks

Elements	19	20	21	22	23	24
SiO ₂	61.07	58.01	62.85	63.33	58.88	61.22
Al ₂ O ₃	13.66	13.63	13.10	12.99	11.84	12.30
Fe ₂ O ₃	3.04	4.59	2.71	2.87	6.82	9.51
FeO	5.54	5.19	5.56	5.12	5.63	2.93
MgO	2.48	3.05	1.40	2.21	2.06	1.36
CaO	2.36	3.63	3.31	2.05	3.63	1.46
Na ₂ O	3.40	4.23	3.51	3.97	2.82	3.24
K ₂ O	4.10	3.30	4.02	3.52	4.07	3.84
H ₂ O+	1.79	1.02	1.08	1.25	1.18	1.05
H ₂ O-	0.45	0.52	0.16	0.58	0.58	0.32
TiO ₂	1.37	2.14	1.59	1.55	1.38	1.62
P ₂ O ₅	0.48	0.41	0.40	0.37	0.41	0.54
MnO	0.15	0.19	0.14	0.16	0.20	0.28
ZrO ₂						
CO ₂	0.20				0.58	0.11
SO ₃						
Cl						
S						
BaO						
SrO						
Li ₂ O						
Total	100.09	99.91	99.83	99.97	100.08	99.78

MINNESOTA GEOLOGICAL SURVEY

References - Table 6

- *25. Granophyre (M4628), irregular mass intruding olivine gabbro
Loc: Bardon Peak, sec. 27 or sec. 33, T. 49 N., R. 15 W.,
St. Louis Co.
Analyst: R. B. Taylor
Taylor, Richard B., Geology of the Duluth gabbro complex:
Minn. Geol. Surv. Bull. 44, 63 p. (Table 13, p. 42, no. XVII),
1964.

- *26. Granophyric aplitic granite (M3787), dike intruding dellenite flow
Loc. Duluth, 8th St. at 3rd Ave. W., sec. 27, T. 50 N., R. 14 W.,
St. Louis Co.
Analyst: R. B. Taylor
Ibid., p. 42, no. XVIII.

- *27. Granophyre (M3764), at contact of anorthositic gabbro with
layered series
Loc. Skyline Drive above ore docks, sec. 32, T. 50 N., R. 14 W.,
St. Louis Co.
Analyst: Doris Thaemlitz
Ibid., p. 42, no. XIX.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 6. Keweenawan granitic rocks

Elements	25	26	27
SiO ₂	64.28	73.55	77.75
Al ₂ O ₃	14.44	12.05	12.71
Fe ₂ O ₃	2.83	2.37	0.39
FeO	3.54	1.09	0.47
MgO	1.76	0.51	0.34
CaO	1.03	0.76	0.68
Na ₂ O	4.03	2.85	6.24
K ₂ O	4.44	5.40	0.40
H ₂ O+	1.21	0.38	0.38
H ₂ O-	0.95	0.09	0.13
TiO ₂	0.71	0.27	0.21
P ₂ O ₅	0.15	0.05	0.01
MnO	0.07	0.05	0.01
ZrO ₂			
CO ₂	0.02	0.16	0.40
SO ₃			
Cl			
S	0.01	0.01	
BaO	0.09	0.07	
SrO	0.02	0.01	
Li ₂ O			
Total	99.58	99.67	100.12

MINNESOTA GEOLOGICAL SURVEY

References - Table 7

1. Olivine gabbro
Loc. Pigeon Point, Cook Co.
Analyst: W. F. Hillebrand
Bayley, William S., The eruptive and sedimentary rocks on Pigeon Point, Minn., and their contact phenomena: U. S. Geol. Surv. Bull. 109, 121 p. (p. 37), 1893.
2. Diabase
Loc. East of Baptism River, Lake Co.
Analyst: J. A. Dodge and C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept., v. 5, 1027 p. (p. 226, no. 156), 1900.
3. Traprock (cupriferous)
Loc. Tischer's Creek quarry near Duluth, St. Louis Co.
Analyst: J. A. Dodge
Ibid., p. 149, no. 57.
4. Olivine diabase
Loc. Pigeon Point, Cook Co.
Analyst: W. F. Hillebrand
Winchell, A. N., Mineralogical and petrographic study of the gabbroic rocks of Minnesota, and more particularly, of the plagioclasytes: Am. Geol., v. 26, p. 151-188, 197-245, 261-306, 348-388 (p. 213, no. 1), 1900.
5. Diabase dike
Loc. Stearns Co.
Analyst: E. B. Noehl
Grout, F. F., Contribution to the petrography of the Keweenawan: Jour. Geol., v. 18, p. 633-657 (Table 8, p. 655, no. 1), 1910.
6. Olivine diabase dike
Loc. Carlton Co.
Analyst: W. H. Truesdale
Ibid., p. 655, no. 2.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 7. Keweenawan basaltic dike and sill rocks

Elements	1	2	3	4	5	6
SiO ₂	49.88	50.86	48.51	49.18	50.51	49.34
Al ₂ O ₃	18.55	15.72	13.79	19.01	15.30	13.03
Fe ₂ O ₃	2.06	9.77		0.89	1.79	2.50
FeO	8.37	2.48	19.34	7.79	8.14	13.74
MgO	5.77	3.55	4.81	6.42	5.94	3.64
CaO	9.70	10.52	8.34	9.12	9.04	7.40
Na ₂ O	2.59	3.89	1.67	3.32	5.18	4.55
K ₂ O	0.68	0.90	0.19	0.82	2.00	1.57
H ₂ O+					1.43	0.69
H ₂ O-	1.04	2.53		2.06	0.00	0.24
TiO ₂	1.19			1.09	2.80	3.16
P ₂ O ₅	0.16					0.15
MnO	0.09			0.51	0.51	0.51
ZrO ₂						0.04
CO ₂						0.96
Cl						
S						0.12
Cr ₂ O ₃						0.02
BaO	0.02					0.03
Total	100.10	100.22	96.65	100.21	102.64	101.69

MINNESOTA GEOLOGICAL SURVEY

References - Table 7

7. Diabase dike (average of 2 analyses)
Loc. Stearns Co.
Analyst: F. F. Grout
Ibid., p. 655, no. 3.
8. Diabase with phenocrysts of quartz and feldspar in a 5-foot dike
Loc. Stearns Co.
Analyst: F. F. Grout
Ibid., p. 655, no. 4.
9. Quartz diabase
Loc. SW1/4 NW1/4 sec. 35, T. 65 N., R. 2 W., Cook Co.
Analyst: H. F. Kendall
Grout, F. F. and Schwartz, G. M., The geology of the Rove formation and associated intrusives in northeastern Minnesota: Minn. Geol. Surv. Bull. 24, 103 p. (Table 8, p. 41, no. 3), 1933.
10. Diabase, chilled phase near top of sill
Loc. sec. 25, T. 65 N., R. 2 W., Cook Co.
Analyst: R. B. Ellestad
Ibid., p. 41, no. 1.
11. Mottled diabase
Loc. Highway No. 61, SW1/4 SW1/4 sec. 28, T. 55 N., R. 8 W., Lake Co.
Analyst: R. B. Ellestad
Grout, F. F. and Schwartz, G. M., The geology of the anorthosites of the Minnesota coast of Lake Superior: Minn. Geol. Surv. Bull. 28, 119 p. (Table 2, p. 35, no. 1), 1939.
12. Diabase gabbro
Loc. Highway No. 61, SW1/4 SW1/4 sec. 14, T. 55 N., R. 8 W., Lake Co.
Analyst: R. B. Ellestad
Ibid., p. 35, no. 2.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 7. Keweenawan basaltic dike and sill rocks

Elements	7	8	9	10	11	12
SiO ₂	48.45	52.91	51.00	50.04	48.77	45.84
Al ₂ O ₃	12.70	17.56	18.93	11.70	18.25	11.19
Fe ₂ O ₃	2.00	0.00	1.19	2.28	2.25	4.02
FeO	13.24	8.61	9.54	13.51	8.44	16.30
MgO	4.39	4.90	4.04	4.20	4.94	3.66
CaO	8.50	7.55	9.46	7.16	10.81	8.39
Na ₂ O	3.94	3.72	1.46	3.47	2.77	2.68
K ₂ O	1.22	1.70	1.20	1.03	0.45	0.83
H ₂ O+	1.58	1.57	1.18	1.28	0.84	0.87
H ₂ O-	0.00	0.00	0.16	0.07	0.45	0.45
TiO ₂	3.17	0.92	1.82	3.76	1.52	3.44
P ₂ O ₅	0.72	0.20		0.47	0.24	1.74
MnO	0.17	0.11		0.15	0.15	0.27
ZrO ₂				none		
CO ₂	0.00			0.25		
Cl				0.10		
S			0.02	0.11		0.04
Cr ₂ O ₃	0.10	0.20		none		
BaO			0.15	0.02		
Total	100.18	99.95	100.15	99.60	99.88	99.72

MINNESOTA GEOLOGICAL SURVEY

References - Table 7

13. Diabase with olivine spots
Loc. Shore of Lake Superior, SE1/4 SW1/4 sec. 6, T. 55 N.,
R. 7 W., Lake Co.
Analyst: T. Kameda
Ibid., p. 35, no. 3.
14. Diabase
Loc. Bluff opposite Encampment Island, sec. 12, T. 53 N., R. 10 W.,
Lake Co.
Analyst: S. S. Goldich
Ibid., p. 35, no. 4.
15. Ophitic diabase, Endion sill
Loc. Duluth, shore of Lake Superior at foot of 18th Ave. E.,
St. Louis Co.
Analyst: S. S. Goldich
Schwartz, G. M. and Sandberg, A. E., Rock series in diabase
sills at Duluth, Minn.: Geol. Soc. Am. Bull. 51, p. 1135-1171
(Table 1, opposite p. 1144, no. 1), 1940.
16. Diabase, Endion sill
Loc. Duluth, shore of Lake Superior at foot of 19th Ave. E.,
St. Louis Co.
Analyst: R. W. Perlich
Ibid., Table 1, no. 2.
17. Diabase, Endion sill
Loc. Duluth, shore of Lake Superior opposite 22nd Ave. E.,
St. Louis Co.
Analyst: R. W. Perlich
Ibid., Table 1, no. 3.
18. Diabase, Northland sill
Loc. Duluth, shore of Lake Superior at foot of 30th Ave. E.,
St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 8.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 7. Keweenawan basaltic dike and sill rocks

Elements	13	14	15	16	17	18
SiO ₂	46.94	46.88	47.25		52.42	47.50
Al ₂ O ₃	11.87	20.98	15.00		12.66	12.94
Fe ₂ O ₃	4.66	3.32	2.64	5.97	3.90	3.94
FeO	11.33	5.56	11.09	9.37	9.55	11.52
MgO	5.99	4.74	6.52		3.74	5.62
CaO	10.88	11.15	8.40		5.16	8.38
Na ₂ O	2.26	2.49	2.52	2.03	3.01	2.39
K ₂ O	0.48	0.29	0.81	1.17	2.44	1.07
H ₂ O+	0.64	1.45	1.63		2.00	1.31
H ₂ O-	0.63	1.59	0.35		0.80	0.68
TiO ₂	3.86	1.11	2.89		2.66	3.74
P ₂ O ₅	0.17	0.15	0.56		1.14	0.69
MnO	0.24	0.12	0.21		0.25	0.22
ZrO ₂						
CO ₂		0.12				
Cl						
S		0.02				
Cr ₂ O ₃						
BaO						
Total	99.95	99.97	99.87		99.73	100.00

MINNESOTA GEOLOGICAL SURVEY

References - Table 7

19. Reddish diabase, Northland sill
Loc. Lester River, NW1/4 SW1/4 sec. 32, T. 51 N., R. 13 W.,
St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 9.
20. Massive, dark, medium-grained diabase, Lester River sill
Loc. Duluth, Highway No. 61 near lakeshore, 1000 feet east of
Lester River bridge, St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 13.
21. Dark, massive diabase, Lester River sill
Loc. Duluth, Highway No. 61, 2000 feet NE of Lester River bridge,
St. Louis Co.
Analyst: L. A. Danielson
Ibid., Table 1, no. 14.
22. Diabase, Lester River sill
Loc. 4600 feet east of Lester River bridge on shore of Lake
Superior, SW1/4 NE1/4 sec. 4, T. 50 N., R. 13 W., St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 15.
23. Reddish diabase, Lester River sill
Loc. Shore of Lake Superior, NE1/4 NE1/4 sec. 4, T. 50 N.,
R. 13 W., St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 18.
24. Diabase, Lester River sill
Loc. Shore of Lake Superior, NE1/4 NE1/4 sec. 4, T. 50 N.,
R. 13 W., St. Louis Co.
Analyst: S. S. Goldich
Ibid., Table 1, no. 20.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 7. Keweenawan basaltic dike and sill rocks

Elements	19	20	21	22	23	24
SiO ₂	58.06	54.86	51.62	50.46	56.76	
Al ₂ O ₃	13.09	11.92	11.39	16.90	12.55	
Fe ₂ O ₃	3.34	5.04	4.94	4.68	4.70	1.96
FeO	7.22	10.32	12.94	6.47	8.04	2.60
MgO	2.05	1.53	3.00	4.01	3.57	
CaO	4.78	5.84	6.36	8.45	1.75	
Na ₂ O	3.48	2.96	2.59	2.82	2.76	2.93
K ₂ O	3.02	2.25	2.03	1.21	3.09	5.75
H ₂ O+	1.48	1.68	1.32	1.63	3.06	
H ₂ O-	0.39	0.53	0.78	1.28	1.16	
TiO ₂	2.16	1.97	2.26	1.64	1.62	
P ₂ O ₅	0.70	0.66	0.54	0.42	0.55	
MnO	0.17	0.26	0.30	0.17	0.33	
ZrO ₂						
CO ₂						
Cl						
S						
Cr ₂ O ₃						
BaO						
Total	99.94	99.82	100.07	100.14	99.94	

MINNESOTA GEOLOGICAL SURVEY

References - Table 7

25. Columnar diabase
Loc. Grand Marais harbor, sec. 14, T. 16 N., R. 1 E., Cook Co.
Analyst: E. D. Burr
Sandell, E. B. and Goldich, S. S., The rarer metallic constituents of some American igneous rocks, I; Jour. Geol., v. 51, p. 99-115 (Table 5, p. 110, no. 9), 1943.
26. Iron-rich diabase (M3174)
Loc. Highway No. 61, 5/8 mile SW of settlement, Beaver Bay (NE1/4 SW1/4 sec. 14, T. 55 N., R. 8 W.), Lake Co.
Analyst: J. W. Scoon
Muir, I. D., Crystallization of pyroxenes in an iron-rich diabase from Minnesota: Mineralog. Mag., v. 30, p. 376-388 (Table 1, p. 377, no. 2), 1954.
27. Basalt (M3744-1), chill zone of microgabbro dike
Loc. Near WFTV tower, sec. 28, T. 50 N., R. 14 W., St. Louis Co.
Analyst: Eileen Oslund
Taylor, Richard B., Geology of the Duluth gabbro complex near Duluth, Minnesota: Minn. Geol. Survey Bull. 44, 63 p. (Table 14, p. 43, no. XXVI), 1964.
28. Microgabbro (M3744-2), chill zone of microgabbro dike about 8 feet from contact
Loc. Near WFTV tower, sec. 28, T. 50 N., R. 14 W., St. Louis Co.
Analyst: Eileen Oslund
Ibid., p. 43, no. XXVII.
29. Basalt (M3762), dike intruding olivine gabbro and anorthositic gabbro
Loc. Just off Haines Road, sec. 36, T. 50 N., R. 14 W., St. Louis Co.
Analyst: Eileen Oslund
Ibid., p. 43, no. XXVIII.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 7. Keweenawan basaltic dike and sill rocks

Elements	25	26	27	28	29
SiO_2	52.70	45.87	49.18	49.21	49.65
Al_2O_3	14.47	10.66	13.82	14.24	13.22
Fe_2O_3	7.44	4.11	2.46	2.36	1.58
FeO	5.55	15.59	10.99	10.59	11.76
MgO	3.70	3.50	5.44	5.73	5.44
CaO	8.01	8.28	9.16	9.14	8.98
Na_2O	3.19	2.84	2.72	2.72	2.71
K_2O	1.14	0.96	0.98	0.97	0.97
H_2O^+	0.68	1.42	1.04	1.00	0.59
H_2O^-	0.48	0.47	0.20	0.19	0.18
TiO_2	1.76	4.65	2.99	2.83	3.93
P_2O_5	0.25	1.70	0.56	0.50	0.53
MnO	0.24	0.29	0.20	0.19	0.21
ZrO_2					
CO_2			0.04	0.02	0.04
Cl					
S	0.02		0.09	0.07	0.08
Cr_2O_3					
BaO	0.05				
Total	99.68	100.34	99.87	99.76	99.87

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

1. Melaphyr
Loc. Sauk Rapids on the Mississippi River, Benton Co.
Analyst: A. Streng
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 11th Ann. Rept., 219 p. (p. 49), 1884.
2. Melaphyr-porphyr
Loc. Duluth, St. Louis Co.
Analyst: A. Streng
Ibid., p. 44.
3. Fine, dark rock, thickly porphyritic with red feldspar
Loc. Duluth, Brewery Creek, St. Louis Co.
Analyst: C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 13th Ann. Rept., 196 p. (p. 100, no. 151), 1885.
4. Red, laminated or "streamed" rhyolite
Loc. at base of Great Palisades, Lake Co.
Analyst: C. F. Sidener
Ibid., p. 100, no. 159.
5. Flow
Loc. Duluth, St. Louis Co.
Analyst: C. F. Sidener
Ibid., p. 100, no. 150.
6. Gray quartzite
Loc. Mouth of Beaver Creek, Beaver Bay, Lake Co.
Analyst: C. F. Sidener
Ibid., p. 100, no. 156.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	1	2	3	4	5	6
SiO ₂	48.97	50.03	48.81	69.66	57.50	71.99
Al ₂ O ₃	16.50	15.38	23.27	11.49	13.29	12.36
Fe ₂ O ₃	4.14	11.78	11.80	3.95	11.62	4.99
FeO	6.58	3.90	3.66	0.60	4.54	0.56
MgO	9.85	3.60	1.72	0.71	1.63	0.72
CaO	10.93	5.39	5.15	2.64	6.12	0.85
Na ₂ O	*2.69	5.01	2.38	1.15	1.85	0.99
K ₂ O	0.69	1.14	0.75	1.08	0.80	2.45
H ₂ O+	1.14	2.73	2.53	8.55	1.48	2.92
H ₂ O-						
TiO ₂						
P ₂ O ₅	1.18	0.33				
MnO						
CO ₂		0.98				
S						
FeS ₂						
Cr ₂ O ₃						
BaO						
SrO						
CuO						
Total	102.67	100.27	100.07	99.83	98.83	97.83

*with trace Li₂O

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

7. "Streamed," light red (rock), with translucent laminations and specks
Loc. London (near Duluth), St. Louis Co.
Analyst: J. A. Dodge
Ibid., p. 100, no. 152
(See also Lawson, A. C., The anorthosites and laccolitic sills of Lake Superior coast lines, with a prefatory note on the Norian of the northwest: Minn. Geol. Survey. Bull. 8, 82 p. (p. XXXIII, no. VI), 1893.)
8. Red quartz porphyry
Loc. Bulk of Great Palisades, Lake Co.
Analyst: J. A. Dodge
Ibid., p. 100, no. 158.
9. Brown conchoidal basalt
Loc. Little Two Harbors, Lake Co.
Analyst: C. F. Sidener
Ibid., p. 100, no. 154.
(See also Grout, F. F. and Schwartz, G. M., The geology of the anorthosites of the Minnesota coast of Lake Superior: Minn. Geol. Surv. Bull. 28, 119 p. (p. 32, no. 154), 1939.)
10. Green rock enclosing Keewatin ore
Loc. SW1/4 NW1/4 sec. 4, T. 63 N., R. 9 W., Lake Co.
Analyst: C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 17th Ann. Rept., 273 p. (p. 126-127), 1889.
(See also Winchell, N. H. and Winchell, H. V., The iron ores of Minnesota, their geology, discovery, development, qualities and origin, and comparison with those of other iron districts: Minn. Geol. and Nat. Hist. Surv. Bull. 6, 430 p. (p. 38), 1891.)
11. Kawashachong rock (green)
Loc. Kawashachong falls, forming brink and bluffs below falls, south side sec. 17, T. 63 N., R. 11 W., Lake Co.
Analyst: C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 19th Ann. Rept., 255 p. (p. 126, no. 214), 1892.
(See also Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept., v. 5, 1027 p. (p. 332, no. 365), 1900.)

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	7	8	9	10	11	12
SiO ₂	73.72	76.68	52.54	50.47	43.96	60.61
Al ₂ O ₃	12.82	12.14	13.50	18.45	16.03	16.61
Fe ₂ O ₃	2.51	3.16	3.60	2.13	10.50	1.97
FeO	0.22	0.52	15.35	7.74	8.74	5.09
MgO	0.35	0.26	3.73	6.90	6.56	3.10
CaO	1.70	0.25	6.51	6.61	9.54	4.46
Na ₂ O	2.70	1.06	1.10	2.58	1.62	3.11
K ₂ O	2.40	3.53	0.37	0.30	0.27	0.25
H ₂ O+			3.34			
H ₂ O-	0.94	1.66	0.00	2.34	1.84	2.45
TiO ₂						
P ₂ O ₅				trace		
MnO						
CO ₂						1.57
S						
FeS ₂						
Cr ₂ O ₃						
BaO						
SrO						
CuO						
Total	97.36	99.26	100.04	97.52	99.06	99.22

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

12. Greenish felsite from interior of rounded mass in agglomerate
Loc. Railway cut at Ely, St. Louis Co.
Analyst: C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 23rd Ann. Rept., 255 p. (p. 204, no. 222), 1895.
13. Greenish felsite
Loc. Country rock at Ely, St. Louis Co.
Analyst: C. F. Sidener
Ibid., p. 204, no. 221.
14. Amygdaloidal diabase
Loc. Grand Marais, Cook Co.
Analyst: C. P. Berkey
Ibid., p. 195.
15. Andesite
Loc. Island in Frog Lake, about 1/2 mile south of its outlet, NW1/4 SW1/4 sec. 17, T. 65 N., R. 5 W., Cook Co.
Analysts: J. A. Dodge and C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. Final Rept., v. 5, 1027 p. (p. 519), 1900.
16. Diabase
Loc. Along railway track at Taylor's Falls, Chisago Co.
Analyst: F. F. Grout
Grout, F. F., Contribution to the petrography of the Keweenawan: Jour. Geol., v. 18, p. 633-657 (Table 1, p. 644, no. 2), 1910.
17. Diabase
Loc. Tamarack Falls on Tamarack Creek, Pine Co.
Analyst: F. F. Grout
Ibid., p. 644, no. 3.
18. Diabase (weathered red)
Loc. Upper Tamarack Creek, Pine Co.
Analyst: A. W. Johnston
Ibid., p. 644, no. 4.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	13	14	15	16	17	18
SiO ₂	52.94	55.40	49.65	48.88	47.82	48.07
Al ₂ O ₃	14.70	22.55	16.36	16.39	18.52	19.02
Fe ₂ O ₃	2.52	14.67	4.39	5.51	6.39	7.65
FeO	7.80	3.75	7.19	7.21	3.15	4.83
MgO	4.49	0.74	8.00	5.80	8.20	3.30
CaO	6.56	1.41	9.18	9.11	11.09	9.84
Na ₂ O	3.09		2.49	2.08	1.67	2.84
K ₂ O	0.04		1.17	0.47	0.17	0.63
H ₂ O+				2.15	1.53	1.69
H ₂ O-	2.04	0.97	2.39	0.19	0.66	0.43
TiO ₂				1.84	0.78	1.72
P ₂ O ₅				0.10	0.05	none
MnO				0.15	0.12	0.21
CO ₂	4.86			0.09	0.17	none
S				0.05	0.04	0.11
FeS ₂						
Cr ₂ O ₃				none	0.03	0.18
BaO				0.02	0.02	0.02
SrO				none	none	0.02
CuO				0.02	trace	
Total	99.04	99.49	100.82	100.06	100.41	100.56

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

19. Diabase (weathered green)
Loc. Upper Tamarack Creek, Pine Co.
Analyst: A. W. Johnston
Ibid., p. 644, no. 5.
20. Rather fine-grained diabase
Loc. Taylor's Falls, Chisago Co.
Analyst: C. A. Taylor
Ibid., Table II, p. 647, no. 1.
21. Diabase
Loc. Crooked Creek, Pine Co.
Analyst: C. A. Tronson
Ibid., p. 647, no. 2.
22. Diabase, coarse and fresh
Loc. Pine City, Pine Co.
Analyst: F. F. Grout
Ibid., p. 647, no. 3.
23. Altered, hackly diabase forming belt of laumontite pseudo-amygdaloidal outcrops across the area of Keweenawan
Loc. Probably Pine Co.
Analyst: F. F. Grout
Ibid., p. 647, no. 4.
24. Altered, hackly diabase as in 23.
Loc. Probably Pine Co.
Analyst: F. F. Grout
Ibid., p. 647, no. 5.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	19	20	21	22	23	24
SiO ₂	46.99	48.68	53.20	48.27	42.35	47.22
Al ₂ O ₃	21.15	19.29	15.83	16.29	17.24	17.17
Fe ₂ O ₃	7.14	4.07	3.39	4.55	9.90	10.21
FeO	3.94	8.31	6.79	10.09	2.69	2.47
MgO	2.73	5.52	5.44	4.94	7.01	5.00
CaO	2.17	7.78	6.95	8.42	7.47	6.58
Na ₂ O	0.80	3.49	3.73	2.14	0.93	2.70
K ₂ O	6.12	1.16	1.34	0.77	1.48	2.15
H ₂ O+	6.32	0.16	1.44	1.67	7.13	3.73
H ₂ O-	1.30	0.10	0.63	0.64	1.57	0.54
TiO ₂	0.92	1.70	1.35	2.46	1.84	1.96
P ₂ O ₅	0.56	0.05		0.14	0.14	0.15
MnO	0.12		0.15	0.17	0.15	0.12
CO ₂	none			0.05	0.10	none
S	0.14			0.04	none	none
FeS ₂						
Cr ₂ O ₃	0.06			none	0.01	0.02
BaO	none			0.04	0.01	0.03
SrO	0.03					
CuO				0.03		
Total	100.49	100.31	100.24	100.71	100.02	100.05

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

25. Altered, hackly diabase as in 23.
Loc. Probably Pine Co.
Analyst: F. F. Grout
Ibid., p. 647, no. 6.
26. Conchoidally fracturing diabase (average material)
Loc. Crooked Creek, Pine Co.
Analyst: F. F. Grout
Ibid., Table III, p. 648, no. 2.
27. Conchoidal diabase, altered but hard
Loc. Tamarack Creek, Pine Co.
Analyst: F. F. Grout
Ibid., p. 648, no. 3.
28. Porphyritic diabase (average of 2 samples some miles distant)
Loc. Kettle River, east of Hinckley, Pine Co.
Analyst: F. F. Grout
Ibid., Table IV, p. 650, no. 1.
29. Thompsonite-bearing rock
Loc. Good Harbor bay, Lake Superior (sec. 34, T. 61 N., R. 1 W.),
Cook Co.
Analyst: C. F. Sidener
Ibid., p. 650, no. 2.
30. Altered diabase
Loc. Grand Marais, Cook Co.
Analyst: C. F. Sidener
Ibid., p. 650, no. 3.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	25	26	27	28	29	30
SiO ₂	47.54	53.16	65.00	50.48	46.80	45.37
Al ₂ O ₃	17.40	15.12	14.01	16.33	15.21	18.21
Fe ₂ O ₃	9.21	5.95	6.42	5.99	13.13	1.22
FeO	2.71	6.75	0.44	7.10		
MgO	5.14	4.76	2.83	4.08	8.13	6.98
CaO	6.40	5.74	0.85	6.47	11.11	11.49
Na ₂ O	2.61	2.38	1.82	2.44	1.95	0.84
K ₂ O	1.80	1.54	5.42	1.39	0.01	0.02
H ₂ O+	4.38	1.92	1.93	2.70	2.79	4.66
H ₂ O-	0.73	0.38	0.26	0.46		
TiO ₂	1.79	1.68	0.69	2.15		
P ₂ O ₅	0.06	0.09	0.07	0.21		
MnO	0.11	0.17	0.10	0.16		
CO ₂	0.15	0.05	0.07	0.01		
S	0.04	0.04	none	0.01		
FeS ₂						
Cr ₂ O ₃	0.02					
BaO	0.02	0.02	0.06	0.04		
SrO						
CuO		0.02		0.02		
Total	100.11	99.77	99.97	100.04	99.13	88.79

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

31. Greenstone, average of three phases at Ely
Loc. Ely, St. Louis Co.
Analyst: S. Darling
Grout, F. F., The geology and magnetite deposits of northern St. Louis Co., Minnesota: Minn. Geol. Surv. Bull. 21, 220 p. (Table 1, p. 12, no. 1), 1926.
32. Greenstone
Loc. Pine Island, Lake Vermilion, St. Louis Co.
Analyst: S. Darling
Ibid., p. 12, no. II.
33. Greenstone, altered by granite, nearly all hornblende
Loc. Near 1/4 cor. between sec. 20 and 21, T. 65 N., R. 4 W., Cook Co.
Analysts: R. W. Gannett and F. F. Grout
Ibid., p. 12, no. IX.
34. Rhyolite
Loc. Duluth, Tischer's (Congdon) Creek near 2nd St. E., St. Louis Co.
Analyst: S. S. Goldich
Schwartz, G. M. and Sandberg, A. E., Rock series in diabase sills at Duluth, Minn.: Geol. Soc. Am. Bull. 51, p. 1135-1171 (Table 1, opposite p. 1144, no. 7), 1940.
35. Rhyolite, above Lester River sill
Loc. Mouth of creek on shore of Lake Superior, NE1/4 NE1/4 sec. 34, T. 50 N., R. 13 W., St. Louis Co.
Analyst: R. W. Perlich
Ibid., Table 1, no. 22.
36. Basalt hornfels (M3763)
Loc. Duluth, NW of 57th Ave. W. quarry, St. Louis Co.
Analyst: Eileen H. Oslund
Taylor, Richard B., Geology of the Duluth gabbro complex near Duluth, Minnesota: Minn. Geol. Surv. Bull. 44, 62 p. (Table 3, p. 13, no. I), 1964.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	31	32	33	34	35	36
SiO ₂	51.73	51.95	48.01	75.48	71.12	41.31
Al ₂ O ₃	15.28	12.58	8.34	12.30	12.58	12.12
Fe ₂ O ₃	3.41	0.90	2.29	2.54	5.20	3.52
FeO	7.30	8.77	10.85	0.36	0.15	14.57
MgO	6.72	8.90	16.84	trace	0.08	6.58
CaO	9.40	7.00	9.86	0.14	0.58	11.07
Na ₂ O	3.83	2.79	0.98	3.43	2.85	2.06
K ₂ O	0.76	1.38	0.37	5.17	6.19	0.16
H ₂ O+	2.86	2.67	0.40	0.24	0.22	0.44
H ₂ O-	0.00	0.14	0.10	0.04	0.05	0.06
TiO ₂	0.78	1.03	0.46	0.21	0.45	7.04
P ₂ O ₅			0.12	0.02	0.03	0.63
MnO	0.15	0.15	0.25	0.02	0.06	0.21
CO ₂		1.02	none		0.18	0.05
S		0.11				0.10
FeS ₂			0.02			
Cr ₂ O ₃		0.17	0.22			
BaO						
SrO						
CuO						
Total	102.22	99.56	99.11	99.95	99.74	99.92

MINNESOTA GEOLOGICAL SURVEY

References - Table 8

37. Dellenite (M4600), flow above anorthositic gabbro (average of two closely agreeing analyses)
Loc. Duluth, 8th St. & 3rd Ave. W., St. Louis Co.
Analysts: S. S. Goldich and Deane K. Smith
Ibid., Table 17, p. 54, no. XXXV.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 8. Lava flows

Elements	37
SiO ₂	64.95
Al ₂ O ₃	12.58
Fe ₂ O ₃	4.70
FeO	4.83
MgO	0.93
CaO	2.07
Na ₂ O	3.46
K ₂ O	4.21
H ₂ O+	0.54
H ₂ O-	0.32
TiO ₂	0.82
P ₂ O ₅	0.15
MnO	0.16
CO ₂	0.03
S	0.03
FeS ₂	
Cr ₂ O ₃	
BaO	0.12
SrO	
CuO	
Total	99.90

MINNESOTA GEOLOGICAL SURVEY

References - Table 9

1. Peridotite, var. saxonite
Loc. sec. 4, T. 112 N., R. 34 W., Renville Co.
Analyst: A. D. Meeds
Hall, C. W., The gneisses, gabbro-schists, and associated rocks of southwestern Minnesota: U. S. Geol. Surv. Bull. 157, 160 p. (p. 113), 1899.
2. Peridotite
Loc. Short Line Park, sec. 34, T. 49 N., R. 15 W., St. Louis Co.
Analyst: F. F. Grout
Grout, F. F., A type of igneous differentiation: Jour. Geol., v. 26, p. 626-658 (Table I, p. 646, no. 2), 1918.
3. Hornblendite
Loc. North of High Lake (T. 63 N., R. 12 W.), St. Louis Co.
Analyst: F. F. Grout
Grout, F. F., The Vermilion batholith of Minnesota: Jour. Geol., v. 33, p. 467-487 (Table VI, p. 483, no. 13), 1925.
- *4. Hornblendite
Loc. North of Saganaga Falls, SE1/4 sec. 33, T. 66 N., R. 4 W., Cook Co.
Analyst: G. W. Ward
Grout, F. F., The Saganaga granite of Minnesota-Ontario: Jour. Geol., v. 37, p. 562-591 (Table II, p. 575, no. 7), 1929.
5. Lamprophyre
Loc. Saganaga Lake, Cook Co.
Analyst: S. W. Sundeen
Sundeen, Stanley W., A petrographic study of the basic dikes of the Saganaga and Snowbank Lake intrusives, and a general review of the literature on lamprophyres: Ph.D. thesis (p. 22, no. I), 1936. (Available at Univ. of Minn. Library and Geology Department.)

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 9. Miscellaneous igneous rocks

Elements	1	2	3	4	5
SiO_2	43.65	32.90	38.13	49.81	57.95
Al_2O_3	6.81	1.59	12.26	11.43	13.98
Fe_2O_3	15.94	13.25	8.86	2.77	2.49
FeO	5.14	21.06	11.68	7.22	3.62
MgO	12.91	20.14	11.55	12.18	6.61
CaO	4.86	0.50	10.35	13.14	6.85
Na_2O	0.43	trace	1.39	1.10	3.93
K_2O	0.52	trace	0.43	0.91	2.31
H_2O^+	7.46	4.56	2.36	1.58	0.97
H_2O^-		0.55	trace	0.14	0.02
TiO_2		5.36	2.49	0.35	0.62
P_2O_5		trace	0.19		0.27
MnO		0.40	0.30		0.10
CO_2	1.12	0.10	trace		trace
S		0.05			
FeS_2			0.33		
Cr_2O_3		0.04	0.02		
BaO			0.05		
CuO		0.15			
Total	98.84	*100.71	100.39	100.63	99.72

*includes 0.06 "rarer elements"

MINNESOTA GEOLOGICAL SURVEY

References - Table 10

1. Iron ore
Loc. West of Gunflint Lake, NE1/4 sec. 23, T. 60 N., R. 13 W.,
St. Louis Co.
Analyst: C. F. Sidener
Winchell, N. H., Minn. Geol. and Nat. Hist. Surv. 17th Ann. Rept.,
273 p. (p. 80), 1889.
2. Iron ore
Loc. sec. 36, T. 63 N., R. 10 W., Lake Co.
Analyst: C. F. Sidener
Ibid., p. 81.
3. Iron ore
Loc. sec. 30, T. 62 N., R. 10 W., Lake Co.
Analyst: C. F. Sidener
Ibid., p. 97.
4. Iron ore
Loc. Iron Lake, sec. 36, T. 63 N., R. 3 W., Cook Co.
Analyst: J. A. Dodge
Winchell, N. H. and Winchell, H. V., The iron ores of Minnesota,
their geology, discovery, development, qualities, and origin, and
comparison with those of other iron districts: Minn. Geol. Surv.
Bull. 6, 430 p. (p. 141), 1891.
5. Magnetite ore
Loc. North side of Long Lake, north line of T. 63 N., R. 12 W.,
St. Louis Co.
Analyst: J. A. Dodge
Ibid., p. 11.
6. Magnetite ore
Loc. Iron Lake, SE1/4 sec. 36, T. 65 N., R. 3 W., Cook Co.
Analyst: R. S. Robertson
Ibid., p. 141.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 10. Iron ores associated with igneous rocks

Elements	1	2	3	4	5	6
SiO ₂	11.89	11.37	11.39	20.90	10.90	2.02
Al ₂ O ₃	0.34	1.32	trace	1.75	5.83	2.68
Fe ₂ O ₃	87.00	53.33	85.55	70.29	70.39	80.78
FeO		14.42		2.01	8.75	
MgO	0.80	2.73	3.44	2.63	1.50	
CaO	0.20	0.10	0.22	trace	1.20	trace
Na ₂ O						
K ₂ O						
H ₂ O+						
H ₂ O-						
TiO ₂		16.03	none	2.23		12.09
P ₂ O ₅						0.03
MnO						
CO ₂						
S	trace	trace	trace		0.47	
Cr ₂ O ₃						2.40
V ₂ O ₃						
NiO						
CoO						
Mn					none	
P	0.06	0.01	0.02	none	0.02	
Ti	none				none	
Total	100.29	99.31	100.62	99.81	99.06	100.00
Metallic iron	63.07	49.40	61.95	52.46	56.08	58.48

MINNESOTA GEOLOGICAL SURVEY

References - Table 10

7. Silicoferrolite
Loc. Birch Lake (T. 61 N., R. 12 or 13 W.), St. Louis Co.
Analyst: A. N. Winchell
Winchell, A. N., Mineralogical and petrographic study of the gabbroic rocks of Minnesota, and more particularly, of the plagioclasytes: *Am. Geol.*, v. 26, p. 151-188, 197-245, 261-306, 348-388 (p. 357, no. 1), 1900.
8. Magnetite ore (core at 100' depth)
Loc. Tucker Lake, NE1/4 NE1/4 sec. 2, T. 64 N., R. 3 W., Cook Co.
Analyst: J. T. Singewald
Singewald, Joseph T., Jr., Titaniferous iron ores in the U.S., their composition and economic value: *U. S. Bur. Mines Bull.* 64, 145 p. (p. 105), 1913.
9. Magnetite ore (same core as no. 8, 30' depth)
Loc. Tucker Lake, NE1/4 NE1/4 sec. 2, T. 64 N., R. 3 W., Cook Co.
Analyst: J. T. Singewald
Ibid., p. 105.
10. Magnetite ore (same core as no. 8, 150' depth)
Loc. Tucker Lake, NE1/4 NE1/4 sec. 2, T. 64 N., R. 3 W., Cook Co.
Analyst: J. T. Singewald
Ibid., p. 105.
11. Magnetite ore (same core as no. 8, 60' depth)
Loc. Tucker Lake, NE1/4 NE1/4 sec. 2, T. 64 N., R. 3 W., Cook Co.
Analyst: J. T. Singewald
Ibid., p. 105.
12. Magnetite ore (core at 75' depth)
Loc. Iron Lake, NE1/4 NE1/4 sec. 1, T. 64 N., R. 3 W., Cook Co.
Analyst: J. T. Singewald
Ibid., p. 106.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 10. Iron ores associated with igneous rocks

Elements	7	8	9	10	11	12
SiO ₂	21.50	26.00	24.00	26.00	24.50	13.81
Al ₂ O ₃	8.02	0.40	0.51	0.26	0.48	4.00
Fe ₂ O ₃	30.54	35.00	35.00	33.71	35.14	35.14
FeO	33.53	32.28	32.92	33.41	32.28	32.40
MgO	1.95	1.82	1.20	1.16	1.25	0.06
CaO	1.55	2.24	2.16	1.14	2.07	0.04
Na ₂ O	0.42					
K ₂ O	0.10					
H ₂ O+	2.77					
H ₂ O-						
TiO ₂	trace	0.62	1.25	0.17	1.28	8.25
P ₂ O ₅		0.01	0.01	none	0.01	trace
MnO	0.32	2.26	2.86	2.12	2.89	3.20
CO ₂						
S		none	0.01	none	0.01	none
Cr ₂ O ₃		0.01	0.06	0.01	0.08	2.05
V ₂ O ₃		trace	trace	trace	trace	1.03
NiO						
CoO						
Mn						
P						
Ti						
Total	100.70	100.64	99.98	97.98	99.99	99.98
Metallic iron		50.00	50.50	50.00	50.00	48.40

MINNESOTA GEOLOGICAL SURVEY

References - Table 10

13. Magnetite ore (same core as no. 12, 85' depth)
Loc. Iron Lake, NE1/4 NE1/4 sec. 1, T. 64 N., R. 3 W.,
Cook Co.
Analyst: J. T. Singewald
Ibid., p. 106.
14. Magnetite ore (same core as no. 12, 65' depth)
Loc. Iron Lake, NE1/4 NE1/4 sec. 1, T. 64 N., R. 3 W.,
Cook Co.
Analyst: J. T. Singewald
Ibid., p. 106.
15. Iron ore (same core as no. 12, 55' depth)
Loc. Iron Lake, NE1/4 NE1/4 sec. 1, T. 64 N., R. 3 W.,
Cook Co.
Analyst: J. T. Singewald
Ibid., p. 106.
16. Magnetite band
Loc. sec. 4, T. 63 N., R. 12 W., St. Louis Co.
Analyst: J. H. McCarthy
Grout, F. F., The geology and magnetite deposits of northern
St. Louis County, Minnesota: Minn. Geol. Surv. Bull. 21, 220 p.
(Table X, p. 74, no. 1), 1926.
17. Magnetite-ilmenite
Loc. East of Benning Lake, sec. 1, T. 64 N., R. 2 W.,
Cook Co.
Analyst: L. C. Peck
Grout, F. F., The titaniferous magnetites of Minnesota:
St. Paul, Office of the Commissioner of the Iron Range
Resources and Rehabilitation, 117 p. (p. 28), 1949-50.

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

Table 10. Iron ores associated with igneous rocks

Elements	13	14	15	16	17
SiO ₂	20.67	21.65	17.11	5.69	8.86
Al ₂ O ₃	2.20	4.89	2.70	7.23	5.51
Fe ₂ O ₃	41.43	46.14	35.61	46.92	22.50
FeO	24.05	21.53	30.00	27.87	35.68
MgO	1.54	1.20	1.70	3.70	4.23
CaO	0.05	0.06	2.50	1.03	0.99
Na ₂ O				0.28	0.62
K ₂ O				0.24	0.20
H ₂ O+				1.17	0.26
H ₂ O-					0.11
TiO ₂	5.75	none	6.50	5.97	20.27
P ₂ O ₅	trace	0.01	trace	0.02	0.02
MnO	0.20	2.60	1.75	0.26	0.31
CO ₂				0.26	
S	trace	none	0.01	0.12	
Cr ₂ O ₃	1.50	1.01	1.11	0.03	0.19
V ₂ O ₃	2.60	0.91	1.01	0.49	0.30
NiO				0.09	
CoO				0.07	
Mn					
P					
Ti					
Total	99.99	100.00	100.00	101.44	100.05
Metallic iron	48.20	49.30	49.20		43.47

CHEMICAL ANALYSES OF IGNEOUS ROCKS OF MINNESOTA

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