Bureau of Mines
Report of Investigations 4593

INVESTIGATION OF MAGNET COVE RUTILE DEPOSIT HOT SPRING COUNTY, ARK.

BY DONALD F. REED

United States Department of the Interior — December 1949

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* * * * * * * * * **Report of Investigations 4593**

A Century of Conservation

1849 1949

UNITED STATES DEPARTMENT OF THE INTERIOR
Oscar L. Chapman, Secretary
BUREAU OF MINES
James Boyd, Director

December 1949

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by

Donald F. Reed 1/

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1/ Mining engineer, Rolla Branch, Mining Division, Bureau of Mines, Rolla, Mo.

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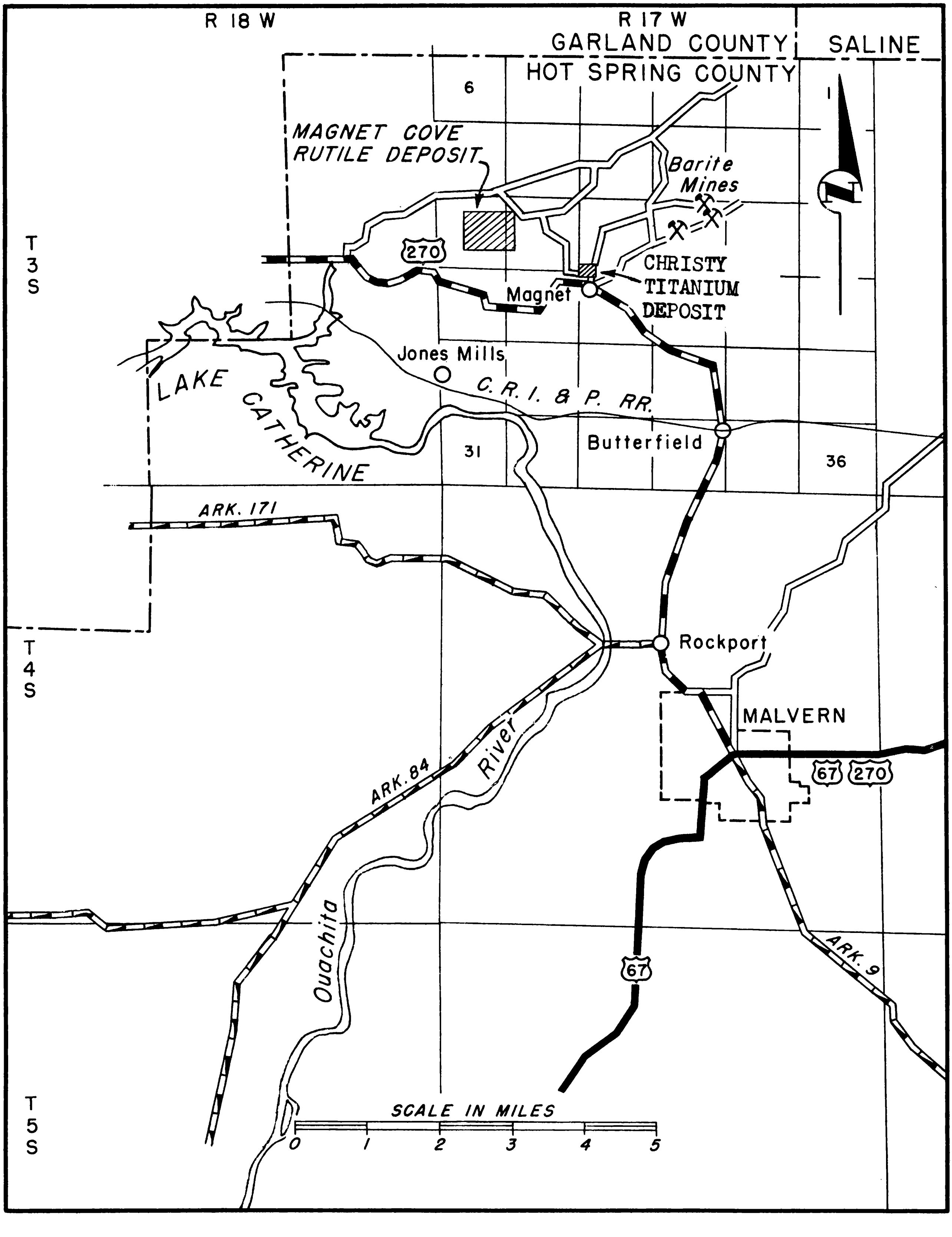


Figure 1. - General location map.

SUMMARY AND INTRODUCTION

In the latter half of 1948 the Bureau of Mines investigated the Magnet Cove Rutile Co.'s property in northern Hot Spring County, Ark. This work was supplemental to the work done by the Bureau on the same property in 1945.2/ It was undertaken for the purpose of investigating the extent of the ore body toward the south and west and at depth and to obtain representative samples of the ore for metallurgical tests. For the latter purpose, the samples were so taken as to minimize alteration of the physical characteristics of the ore, these characteristics being determining factors in working out processes of beneficiation.

During the investigation, 27 holes were drilled, 10 with a diamond-core drill and 17 with churn-drill rigs using a Baker standard cable-tool core barrel. Drilling developed an extension of the ore deposit westward from the previously mined area but did not disclose the full depth of mineralization.

Metallurgical tests to determine methods of beneficiating the ore and utilizing the resultant products are now in progress.

ACKNOWLEDGMENTS

Field work was conducted under the general supervision of Leon W. Dupuy, Chief of the Rolla Branch, Mining Division, and under the immediate supervision of the author of this report. Analyses of samples were made and beneficiation tests are being made by the Rolla Branch, Metallurgical Division, R. G. Knickerbocker, Chief. Samples were analyzed first at the Bureau pilot plant at Bauxite, Ark., W. A. Calhoun, metallurgist in charge, and these were verified at the Rolla laboratory. The metallurgical research was conducted by M. M. Fine at Rolla.

Through the cooperation of Harold B. Foxhall, Director, Division of Geology, Arkansas Resources and Development Commission, geologic maps of the area prepared by Verne C. Fryklund, Jr., were made available to the Bureau, and all drill cores were logged by Drew F. Holbrook.

Percy Upton, principal owner of the Magnet Cove Rutile Co., cooperated with the Bureau in many ways.

LOCATION AND ACCESSIBILITY

The Magnet Cove Rutile Co.'s property embraces 1,450 acres, most of which is in sec. 17, 18, and 19, T. 3 S., R. 17 W., Hot Spring County, Ark. (fig. 1). The rutile deposit is mainly in the SE1/4, sec. 18, about 1 mile north of U. S. Highway 270 and approximately halfway between Hot Springs and Malvern. A graveled road to the deposit takes off from the highway at a point 2 miles west of the hamlet of Magnet.

Malvern and Hot Springs are served by the Missouri Pacific and Chicago, Rock Island & Pacific Railroads, the latter passing about 2 miles south of Magnet Cove. An electric power line and a natural-gas pipe line cross the property.

2/ Spencer, R. V., Exploration of the Magnet Cove Rutile Property, Magnet Cove Area, Hot Spring County, Ark.: Bureau of Mines Rept. of Investigations 3900, 1948.

PHYSICAL FEATURES AND CLIMATE

Magnet Cove is a southeast-trending elliptical basin about 3 miles long and 1-1/2 to 2 miles wide, hemmed by sharp hills. Cove Creek enters it from the northeast and cuts through the southwest bordering ridge to flow into the Ouachita River. Altitudes range from 350 to 400 feet on the floor of the basin to 600 feet on the surrounding hills.

North of the cove is a series of irregular ridges rising to an altitude of 900 feet. Toward the southeast, the terrain gradually flattens to the plains of the Gulf coastal region. The hills are timbered with second-growth pine, hickory, and gum trees. The floor of the cove and of most of the small valleys has been cleared for small farms.

Average annual rainfall in the area is 47 inches. Average temperature is 61 degrees.

HISTORY

The history of the Magnet Cove area was reported by Spencer in his report of the preliminary exploration work done on this same deposit in 1945.3/ He reports that the earliest known geological study of the area was made in 1834 by Featherstonhaugh, an English explorer and geologist. Later studies were made by Williams,4/ who first reported titanium minerals, by Washington,5/ and by Landes.6/

From 1911 to 1913 the Titanium Alloy Manufacturing Co. explored the Magnet Cove Rutile Co.'s property under direction of A. E. Perkins. Auger-drill holes about 15 feet deep were drilled at 200-foot intervals over an area of 40 to 50 acres. Two shafts were sunk, one about 80 feet deep and the other to a lesser depth. Four drifts (directions and lengths not known) are reported to have been driven from the bottom of the deeper shaft.

There is no record of further activity until 1930, when the Titanium Corporation of America started mining operations, which continued until 1942. In that year the property was purchased by the Titanium Alloy Manufacturing Co. Under the name of the Titanium Alloy Co. of Arkansas, they built a new concentrator and continued operations until December 1943, when Percy Upton (Little Rock, Ark.), J. W. Kimsey (Route 5, Malvern, Ark.), and John Ramsey (Malvern, Ark.) formed the Magnet Cove Rutile Co. and operated the property until the fall of 1944. It has not operated since that time.

In 1945 the property was examined by M. L. Malamphy and R. V. Spencer, Bureau of Mines engineers. A geophysical survey was made by the potential drop-ratio method, and 26 holes were drilled, 16 with a churn drill and 10 with a seismograph-type rotary core drill.7/

3/ See footnote 2.
4/ Williams, J. F., The Igneous Rocks of Arkansas: Geological Survey of Arkansas, Annual Report for 1890-91, pp. 163-343.
5/ Washington, H. S., Igneous Complex of Magnet Cove, Ark.: Bull., Geol. Soc. Am., vol. 2, 1900, pp. 389-416.
6/ Landes, K. K., A Paragenetic Classification of the Magnet Cove Minerals: Am. Minerals, vol. 16, 1931, pp. 313-326.
7/ See footnote 2.

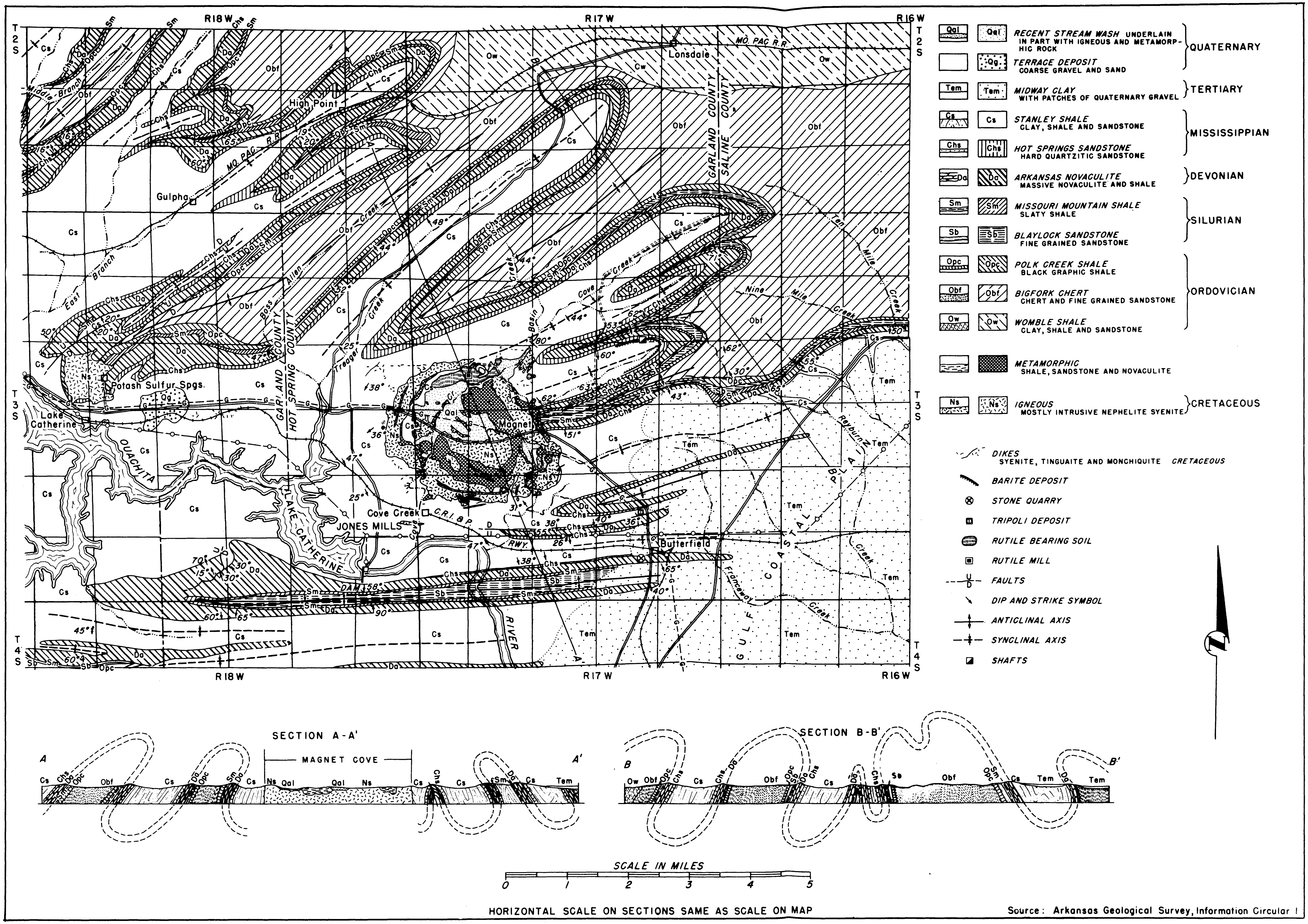


Figure 2. - Geologic map, Magnet Cove area.

No records of production from the property are available, but from the size of the open pits, which cover an area of about 13 acres and range in depth from 3 to 30 feet, it appears that between 450,000 and 500,000 tons of ore has been removed.

The property is now controlled by the Magnet Cove Rutile Co. and the J. H. Rutherford estate.

DESCRIPTION OF THE DEPOSIT

The Magnet Cove igneous complex has been studied by numerous geologists, and many theories have been advanced to explain the modus of its intrusion. Williams 8/ thought that there were three distinct periods of igneous activity. Washington 9/ believed there was a single lacolithic intrusion followed by differentiation into the central basic ijolitic rocks and the peripheral less basic syenites, and Landes 10/ suggested the intrusion of a central and a peripheral magma, the latter being an acid differentiate of the central mass.

Whatever the mode of occurrence, the tightly folded Paleozoic sediments in the Magnet Cove area were intruded by an elliptical mass of alkalic igneous magma, which enveloped and metamorphosed smaller masses of the sediments (fig. 2). The entire area of the cove is composed of this complex of igneous and metamorphosed rocks.

The rutile deposit is found at the north side of the cove and is bordered on the north by a narrow band of nepheline syenite, which forms the rim of the cove. Its long axis bears about N 75° E. Surface material, consisting of clays and the softer altered portions of the deposit, has been mined in an open pit which has a length of about 3,000 feet, a width of 500 feet, and a maximum depth of 30 feet. Humps or islands of hard, unaltered phonolite were not mined and were left sticking up out of the bottom of the pit. Surrounding these islands of phonolite in the floor of the pit is a metamorphosed but comparatively unweathered mass of feldspar-carbonate minerals and altered phonolite. The extent of the mineralized zone has not been determined. It may extend to the southwest. On the north it is limited by the igneous rim of the cove.

CHARACTER OF THE ORE

Under the topsoil of weathered and alluvial material, the ore body was found to consist of a complex mixture of igneous, sedimentary, and metamorphosed rocks, all of which contained various amounts of pyrite, titanium, and other minerals. An effort has been made to correlate the various minerals between drill holes, but without success. There appears to be no continuity or pattern of sequence of the different formations. Titanium content ranges from less than 1 percent to 4.5 percent, the general average being about 2.5 to 3 percent; an occassional local concentration will run as high as 12.6 percent. Much of the titanium present is in the form of rutile, but other titanium minerals that have been identified are brookite (TiO_2), octahedrite (TiO_2), ilmenite ($FeTiO_2$), perofskite ($CaTiO_2$), titanite ($CaTiSiO_5$), leucoxene (an alteration product similar to titanite in chemical composition), arkansite (TiO_2), ferrotitanite (titanium iron calcium silicate), pseudo brookite (titanic and iron oxide), and schorlomite (calcium iron silicate with some titanium). The rutile appears in the form of crystals ranging in size from 2 inches down to minute needlelike particles too small to be seen with the naked eye.

8/ See footnote 4. 9/ See footnote 5. 10/ See footnote 6.

All of the materials carried titanium. It was found most consistently in the igneous rocks especially in the phonolites (both altered and unaltered), which averaged about 3.5 percent TiO_2. Some rutile was found in tiny cracks and seams in the phonolite.

Although titanium occurs as rutile to some extent in all the rocks, rutile is by far more abundant in the carbonate-feldspar masses, virtually all of which contain visible rutile, and in the surface clay and weathered material lying on them.

The Magnet Cove ore carries only about 0.05 percent V_2O_5. Fryklund[11] discusses the forms in which the titanium minerals occur in the various rocks found on the property. He states:

> The material which contained the highest TiO_2 content was igneous. The feldspar-carbonate veins***averaged the second highest in TiO_2 content. Material logged as clay containing pyrite, rutile, and carbonate varied considerably in TiO_2 content but averaged lower than the other two types***. As the largest volume of rock with high TiO_2 content is igneous, the mineral in which the titanium occurs is of considerable interest. The nepheline syenite (fine-grained type) and the "lucite"-nepheline syenite can be ignored entirely; the small amount of titanium in them can be easily accounted for in the silicate minerals, particularly the garnet, and the small amount of magnetite which probably contains some titanium, as well as the known occurrence of rutile-bearing veinlets.
>
> The large monchiquite mass averages higher in TiO_2 content than the first two rocks, but the TiO_2 content is mainly in titan-augite, which forms more than 50 percent of the rock***.
>
> The TiO_2 of the aegirine phonolite porphory is mainly in the ilmenite,***is uniformly disseminated in hard igneous rock and is of such low concentration that the phonolite cannot be considered as adding to the titanium reserves.
>
> The rutile of the feldspar-carbonate veins and their hydrothermally altered phases occurs as single acicular grains, nests of acicular rutile, and as veins and veinlets***. Leucoxene (actually anatase as determined by Ross (1941) occurs as small, irregular patches and as a coating on the rutile masses***. In even the freshest rocks examined, 15 to 20 percent of the TiO_2 content is in the form of leucoxene.

As titanium occurs in the ore not only as rutile but in other forms, the chemical analyses are not a reliable guide as to what is minable ore and what is not. The determining factor is the amount of recoverable rutile. This can be determined only by petrographic analysis and metallurgical testing, which work is now in progress. As no two samples are likely to be the same, the problem is a difficult one.

11/ Fryklund, Verne C., Jr. The Titanium Ore Deposits of Magnet Cove, Hot Spring County, Ark.; Thesis submitted to the University of Minnesota in partial fulfillment of the requirement for the degree of Doctor of Philosophy, June 1949, pp. 65-67.

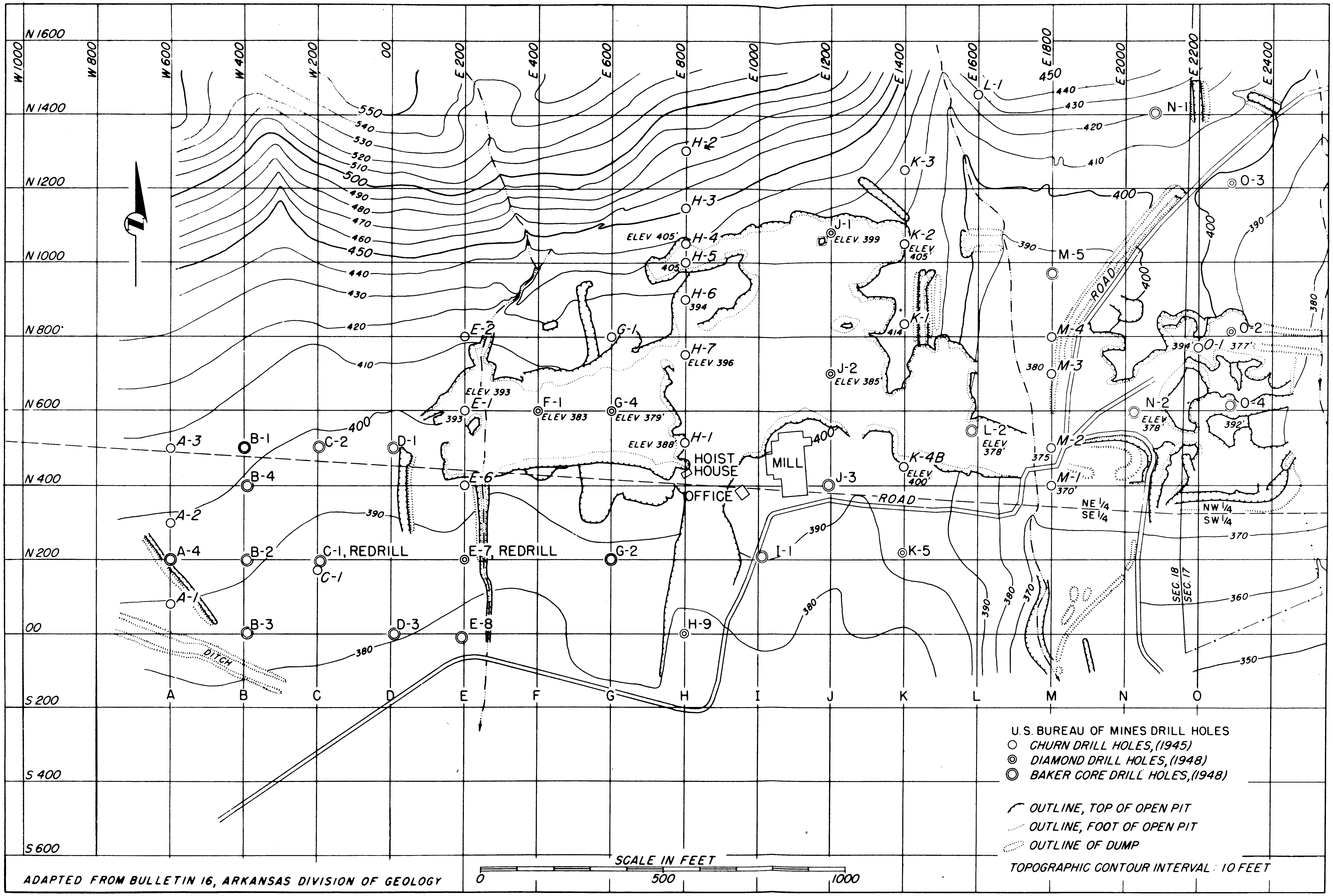


Figure 3. - U. S. Bureau of Mines drilling, Magnet Cove rutile deposit.

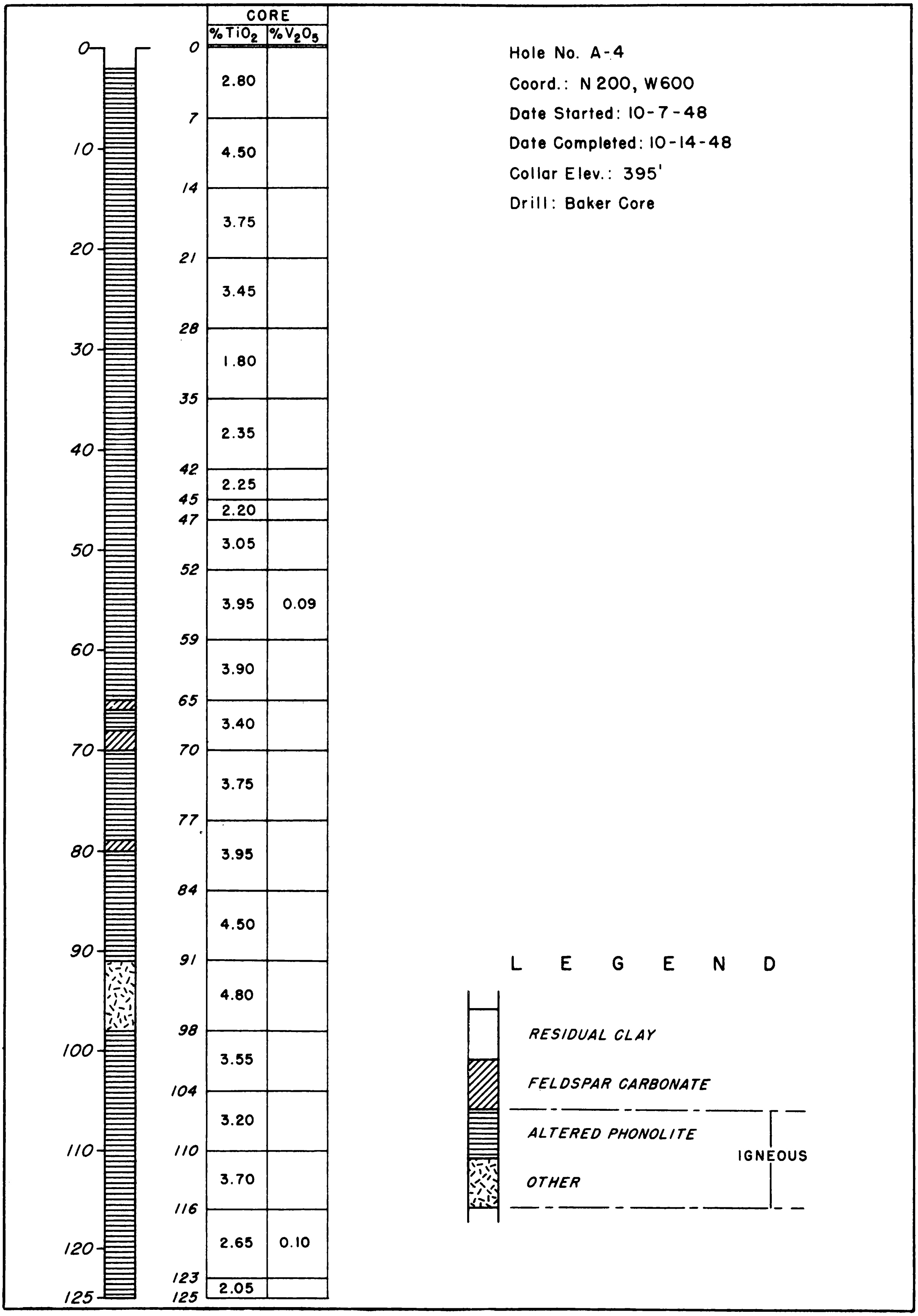


Figure 4. - Graphic log, hole No. A-4.

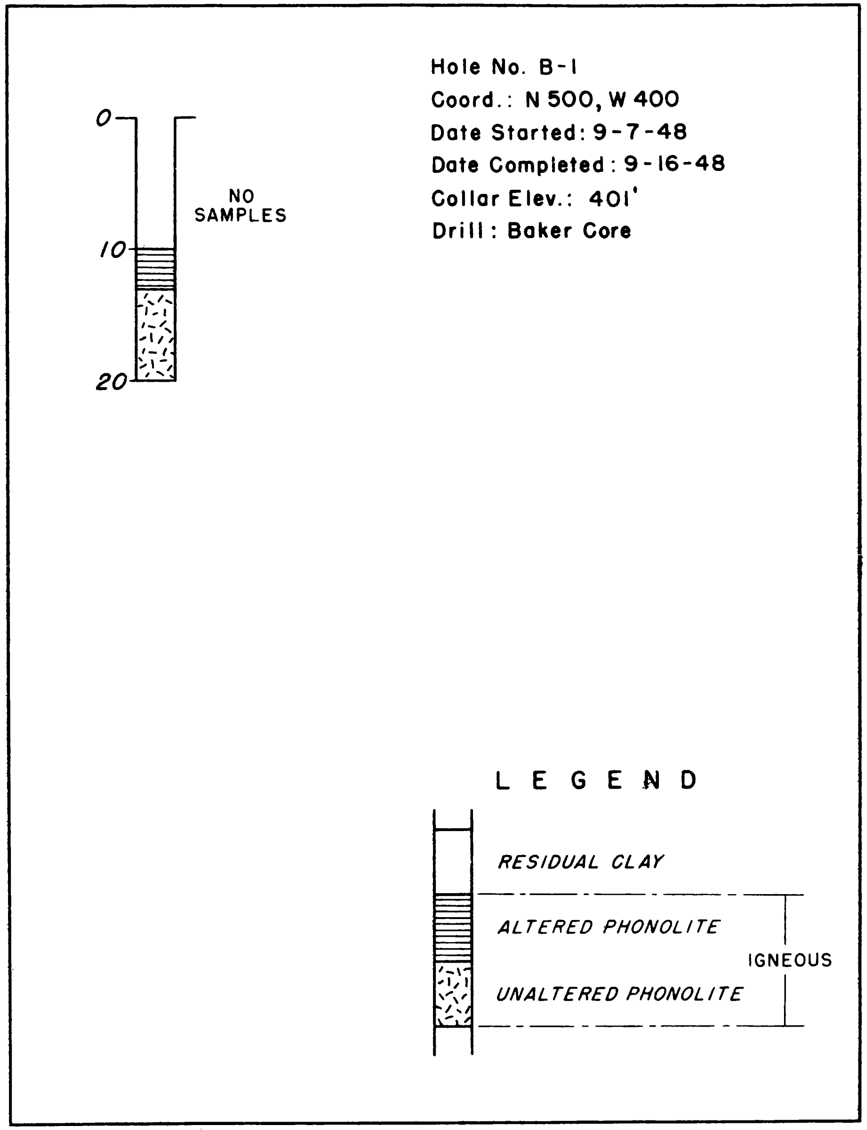
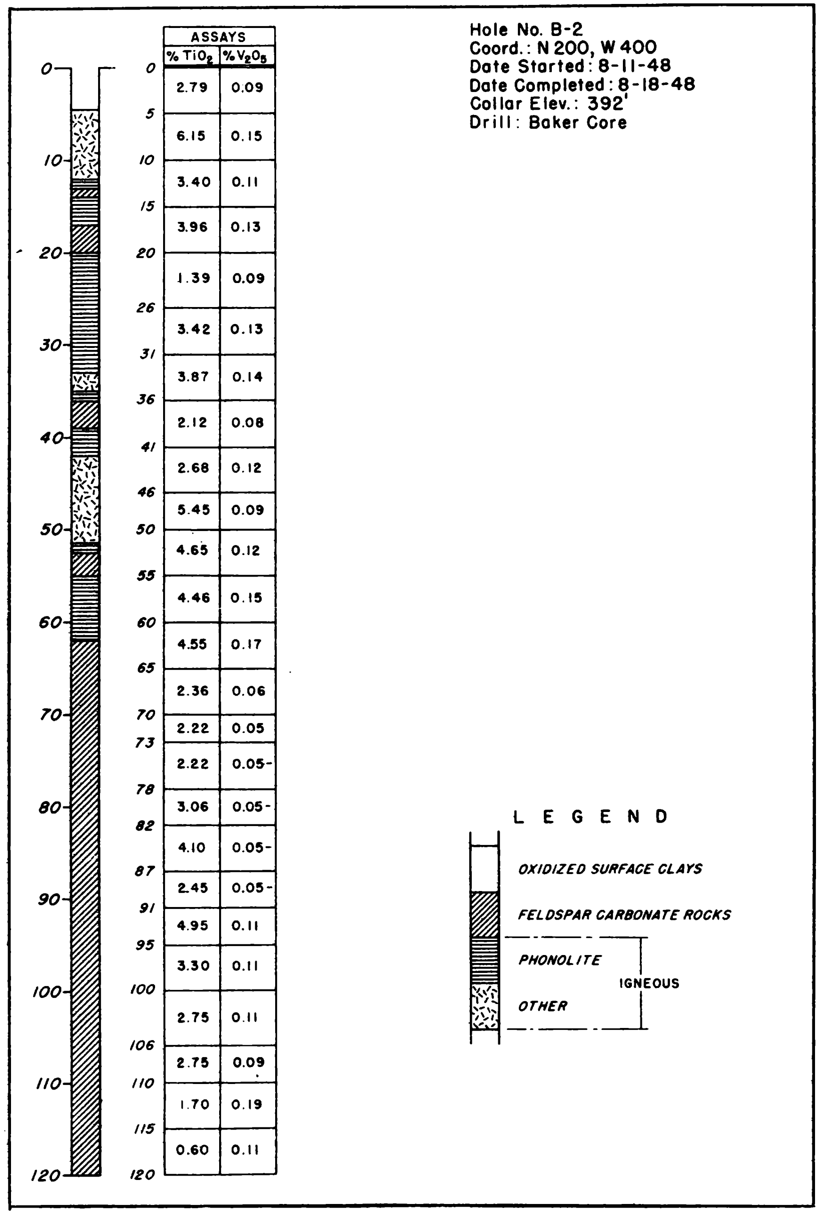
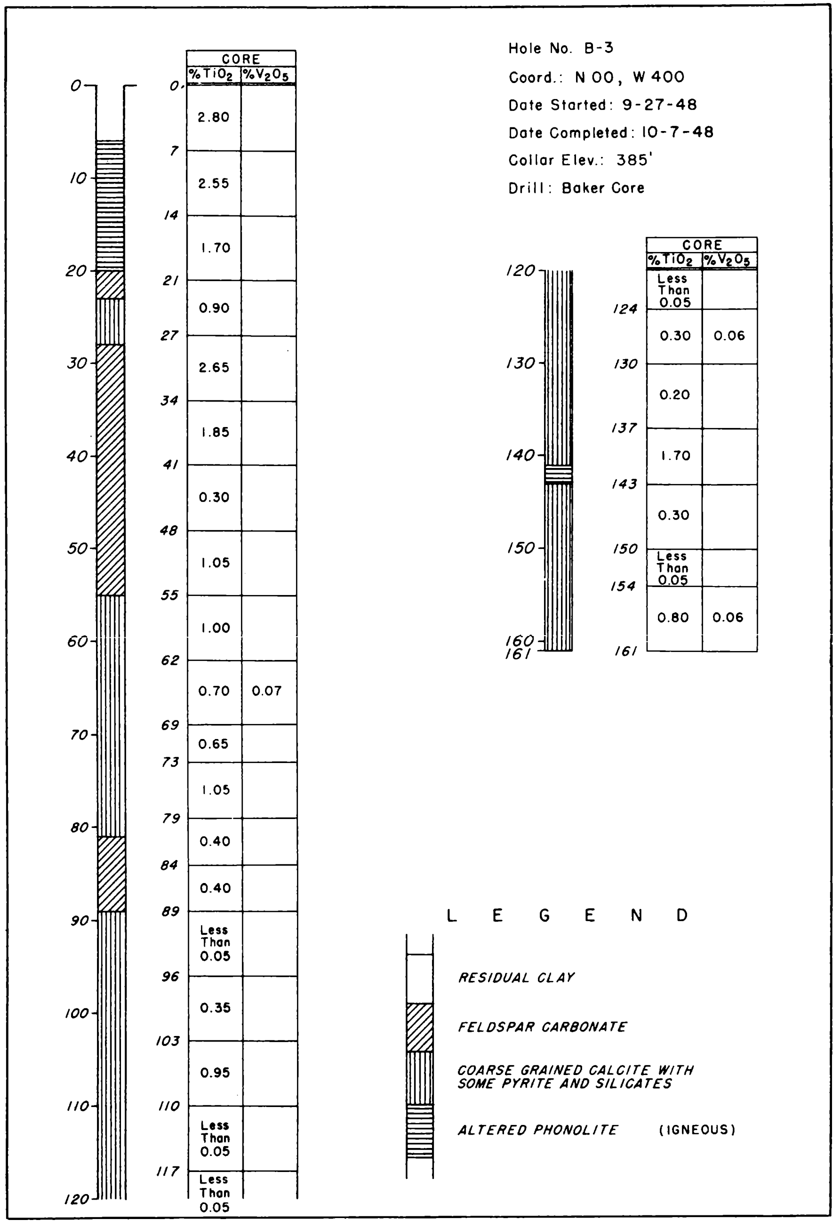


Figure 5. - Graphic log, hole No. B-1.



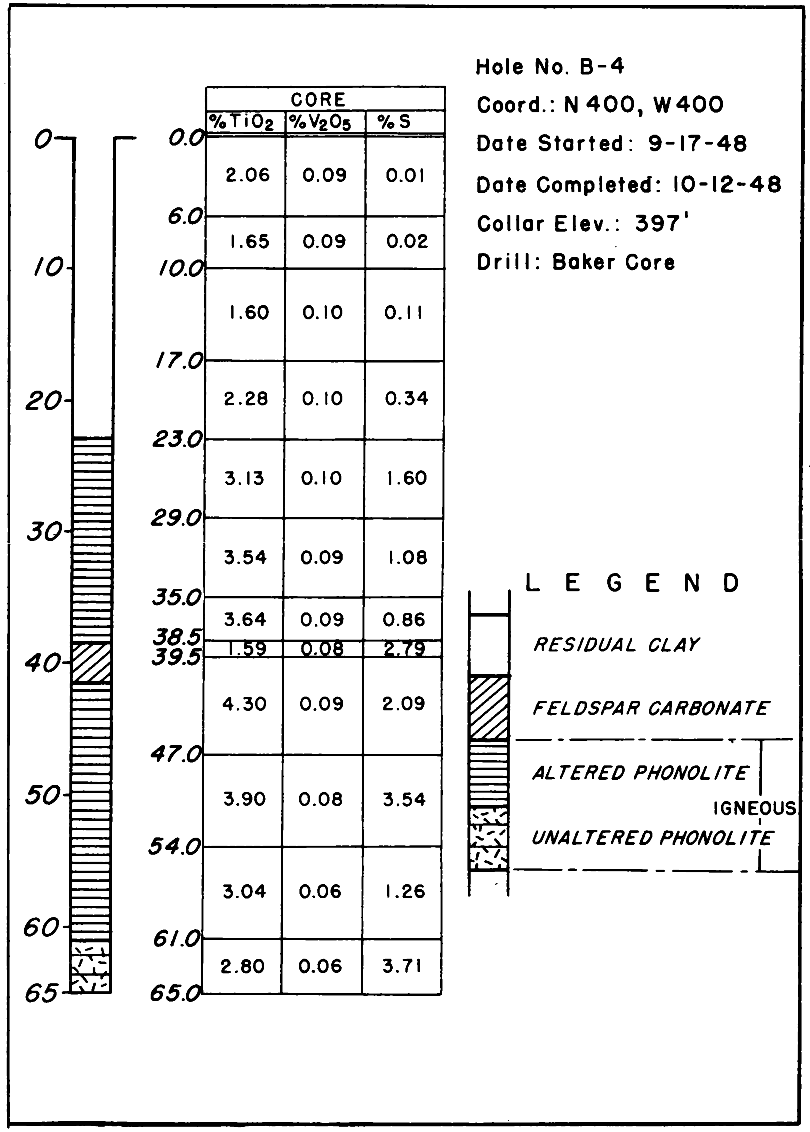
Depth	ASSAYS % TiO_2	ASSAYS % V_2O_5
0–5	2.79	0.09
5–10	6.15	0.15
10–15	3.40	0.11
15–20	3.96	0.13
20–26	1.39	0.09
26–31	3.42	0.13
31–36	3.87	0.14
36–41	2.12	0.08
41–46	2.68	0.12
46–50	5.45	0.09
50–55	4.65	0.12
55–60	4.46	0.15
60–65	4.55	0.17
65–70	2.36	0.06
70–73	2.22	0.05
73–78	2.22	0.05-
78–82	3.06	0.05-
82–87	4.10	0.05-
87–91	2.45	0.05-
91–95	4.95	0.11
95–100	3.30	0.11
100–106	2.75	0.11
106–110	2.75	0.09
110–115	1.70	0.19
115–120	0.60	0.11

Figure 6. - Graphic log, hole No. B-2.



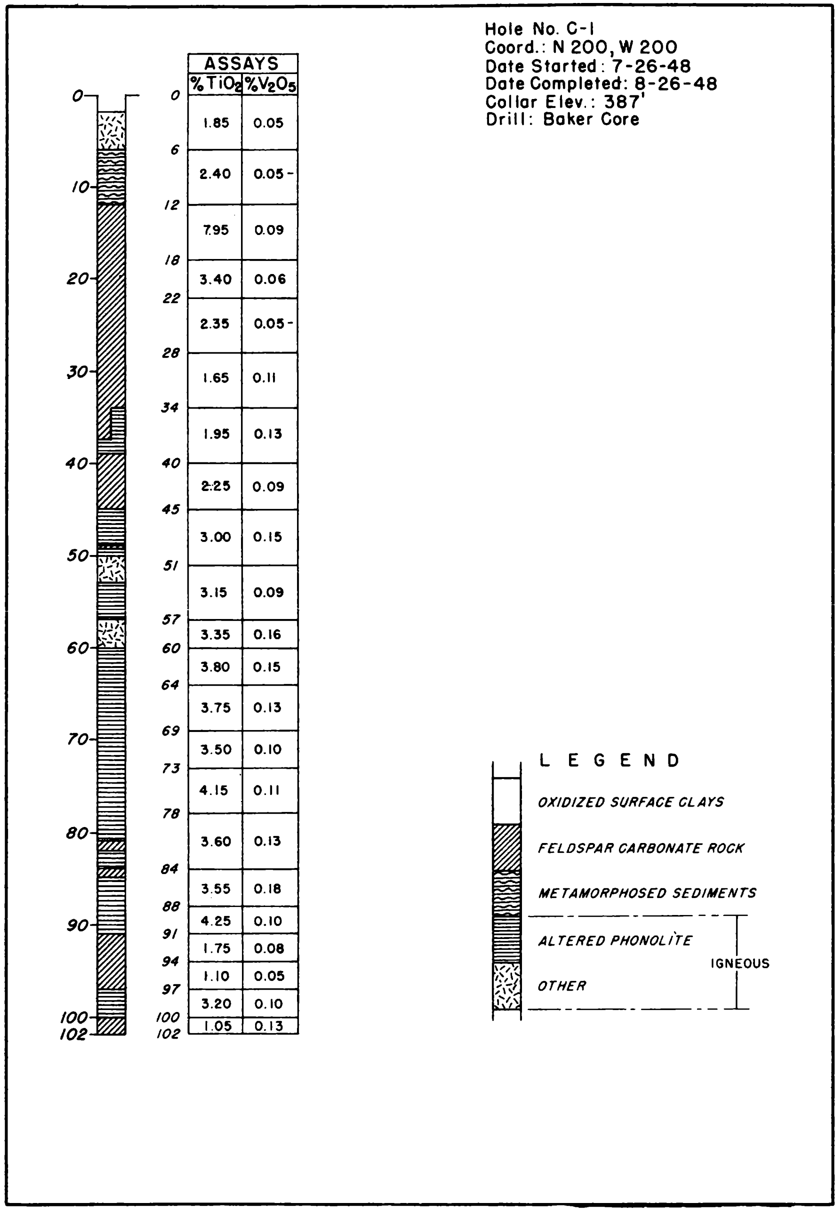
Depth	CORE %TiO_2	CORE %V_2O_5
0–7	2.80	
7–14	2.55	
14–21	1.70	
21–27	0.90	
27–34	2.65	
34–41	1.85	
41–48	0.30	
48–55	1.05	
55–62	1.00	
62–69	0.70	0.07
69–73	0.65	
73–79	1.05	
79–84	0.40	
84–89	0.40	
89–96	Less Than 0.05	
96–103	0.35	
103–110	0.95	
110–117	Less Than 0.05	
117–120	Less Than 0.05	
120–124	Less Than 0.05	
124–130	0.30	0.06
130–137	0.20	
137–143	1.70	
143–150	0.30	
150–154	Less Than 0.05	
154–161	0.80	0.06

Figure 7. - Graphic log, hole No. B-3.



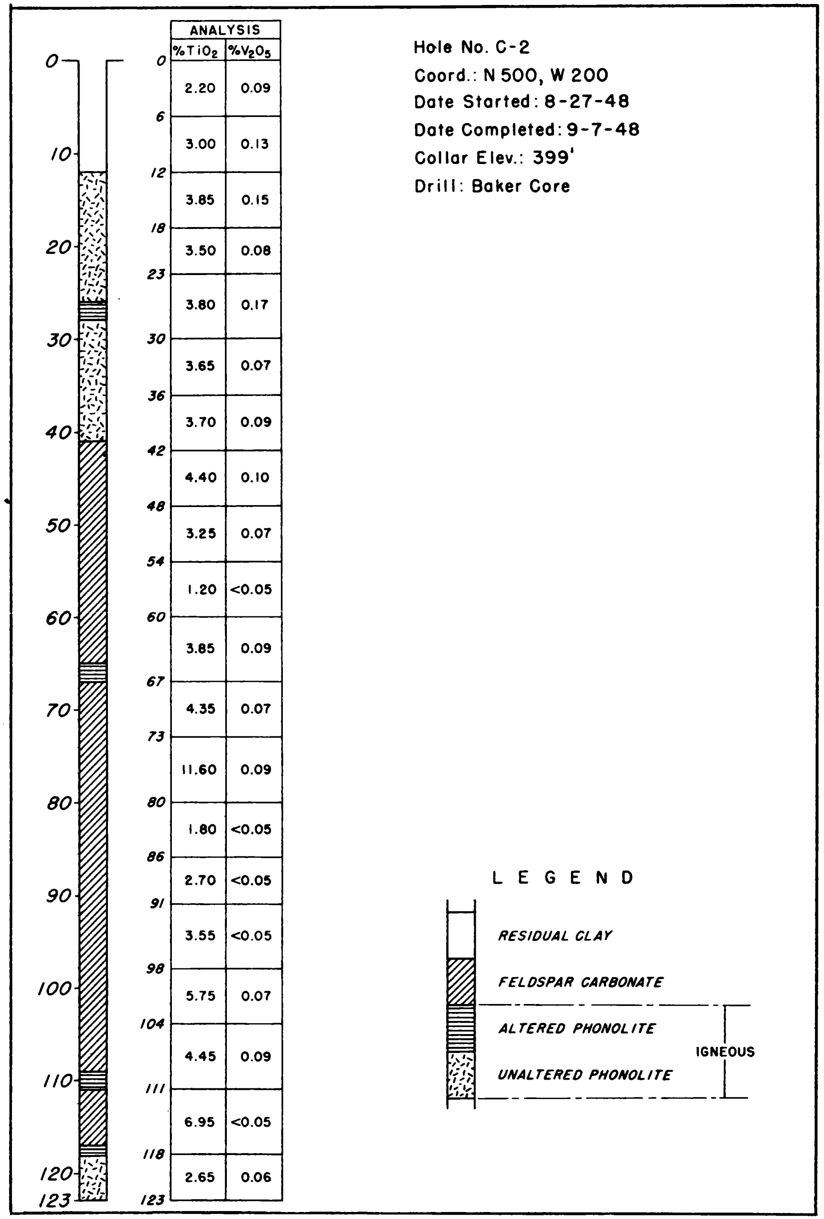
Depth	CORE %TiO_2	CORE %V_2O_5	CORE %S
0.0–6.0	2.06	0.09	0.01
6.0–10.0	1.65	0.09	0.02
10.0–17.0	1.60	0.10	0.11
17.0–23.0	2.28	0.10	0.34
23.0–29.0	3.13	0.10	1.60
29.0–35.0	3.54	0.09	1.08
35.0–38.5	3.64	0.09	0.86
38.5–39.5	1.59	0.08	2.79
39.5–47.0	4.30	0.09	2.09
47.0–54.0	3.90	0.08	3.54
54.0–61.0	3.04	0.06	1.26
61.0–65.0	2.80	0.06	3.71

Figure 8. - Graphic log, hole No. B-4.



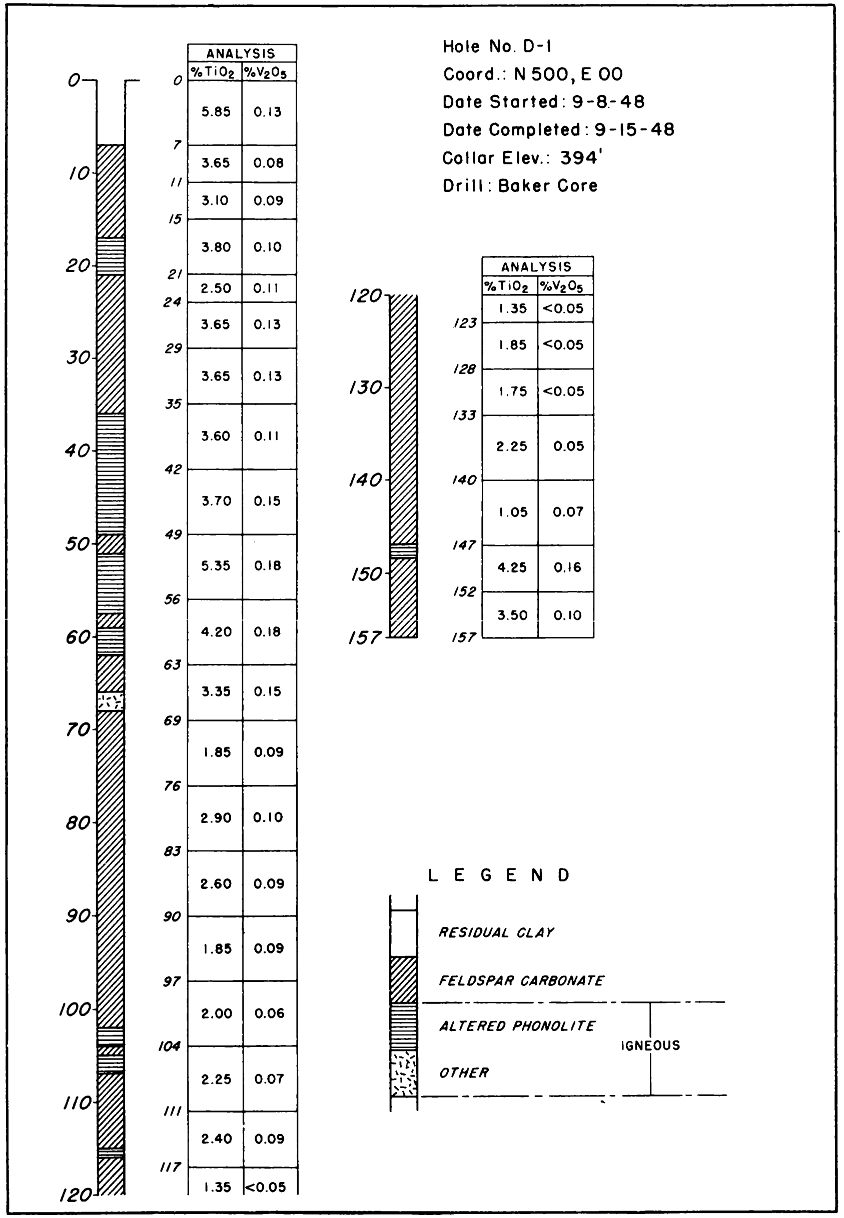
Depth	ASSAYS % TiO_2	ASSAYS % V_2O_5
0–6	1.85	0.05
6–12	2.40	0.05-
12–18	7.95	0.09
18–22	3.40	0.06
22–28	2.35	0.05-
28–34	1.65	0.11
34–40	1.95	0.13
40–45	2.25	0.09
45–51	3.00	0.15
51–57	3.15	0.09
57–60	3.35	0.16
60–64	3.80	0.15
64–69	3.75	0.13
69–73	3.50	0.10
73–78	4.15	0.11
78–84	3.60	0.13
84–88	3.55	0.18
88–91	4.25	0.10
91–94	1.75	0.08
94–97	1.10	0.05
97–100	3.20	0.10
100–102	1.05	0.13

Figure 9. - Graphic log, hole No. C-1.



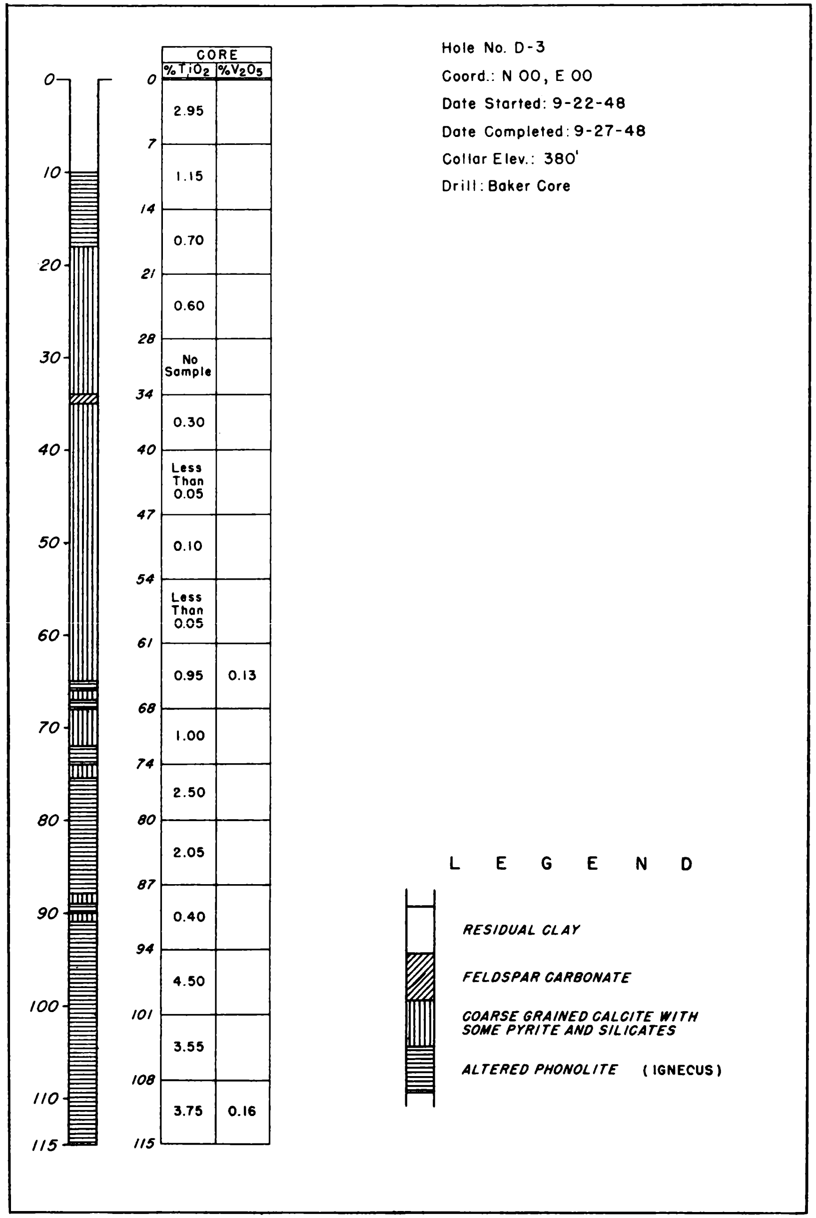
Depth	ANALYSIS % TiO_2	ANALYSIS % V_2O_5
0–6	2.20	0.09
6–12	3.00	0.13
12–18	3.85	0.15
18–23	3.50	0.08
23–30	3.80	0.17
30–36	3.65	0.07
36–42	3.70	0.09
42–48	4.40	0.10
48–54	3.25	0.07
54–60	1.20	<0.05
60–67	3.85	0.09
67–73	4.35	0.07
73–80	11.60	0.09
80–86	1.80	<0.05
86–91	2.70	<0.05
91–98	3.55	<0.05
98–104	5.75	0.07
104–111	4.45	0.09
111–118	6.95	<0.05
118–123	2.65	0.06

Figure 10. - Graphic log, hole No. C-2.



Depth (ft)	ANALYSIS %TiO_2	ANALYSIS %V_2O_5
0–7	5.85	0.13
7–11	3.65	0.08
11–15	3.10	0.09
15–21	3.80	0.10
21–24	2.50	0.11
24–29	3.65	0.13
29–35	3.65	0.13
35–42	3.60	0.11
42–49	3.70	0.15
49–56	5.35	0.18
56–63	4.20	0.18
63–69	3.35	0.15
69–76	1.85	0.09
76–83	2.90	0.10
83–90	2.60	0.09
90–97	1.85	0.09
97–104	2.00	0.06
104–111	2.25	0.07
111–117	2.40	0.09
117–120	1.35	<0.05
120–123	1.35	<0.05
123–128	1.85	<0.05
128–133	1.75	<0.05
133–140	2.25	0.05
140–147	1.05	0.07
147–152	4.25	0.16
152–157	3.50	0.10

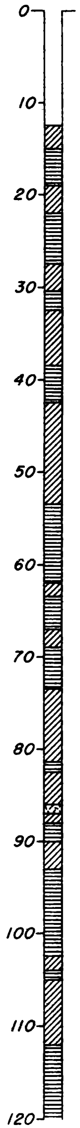
Figure 11. - Graphic log, hole No. D-1.



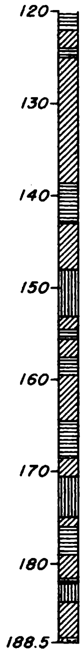
Depth (ft)	CORE %TiO_2	CORE %V_2O_5
0–7	2.95	
7–14	1.15	
14–21	0.70	
21–28	0.60	
28–34	No Sample	
34–40	0.30	
40–47	Less Than 0.05	
47–54	0.10	
54–61	Less Than 0.05	
61–68	0.95	0.13
68–74	1.00	
74–80	2.50	
80–87	2.05	
87–94	0.40	
94–101	4.50	
101–108	3.55	
108–115	3.75	0.16

Figure 12. - Graphic log, hole No. D-3.

Hole No. E-7
Coord.: N 200, E 200
Date Started: 7-21-48
Date Completed: 8-17-48
Collar Elev.: 387'
Drill: Diamond Drill



Depth	Core %TiO_2	Core %V_2O_5	Sludge %TiO_2	Sludge %V_2O_5
0–7	3.80	0.13		
7–10	2.20	0.13		
10–12.5	2.85	0.14		
12.5–15	4.40	0.13		
15–20	3.10	0.16		
20–23.3	3.15	0.15	3.45	0.18
23.3–27	3.90	0.23		
27–30.5	3.60	0.18	3.15	0.20
30.5–32.5	4.30	0.23	3.50	0.16
32.5–34	4.20	0.11	2.75	0.20
34–36	4.25	0.19		
36–38	4.20	0.18	3.90	0.23
38–40	3.50	0.17		
40–43	3.90	0.16		
43–48	1.80	0.10	1.15	0.05-
48–49.8	3.20	0.05-	2.60	0.14
49.8–52	2.70	0.10		
52–53.5	1.65	0.11	3.05	0.13
53.5–57.5	3.10	0.18		
57.5–62	2.40	0.09	1.25	0.13
62–63.5	2.55	0.13	2.80	0.11
63.5–67	3.25	0.15		
67–69	2.35	0.14	2.55	0.14
69–73	4.45	0.16	4.75	0.17
73–76.5	1.35	0.18	2.15	0.10
76.5–81.5	2.00	0.10	3.20	0.08
81.5–84.2	2.00	0.13		
84.2–85.2	1.25	0.11		
85.2–87.2	3.75	0.13		
87.2–89.2	3.05	0.18		
89.2–93	2.40	0.10	2.55	0.05-
93–98	3.85	0.15		
98–100	3.55	0.11		
100–102.2	3.85	0.10		
102.2–104	3.00	0.14		
104–106.2	3.50	0.06		
106.2–108.2	3.50	0.10		
108.2–111.4	2.30	0.08	2.25	0.05-
111.4–113.4	2.25	0.10		
113.4–117	2.90	0.10		
117–119.2	4.25	0.22		
119.2–120	2.90	0.17		



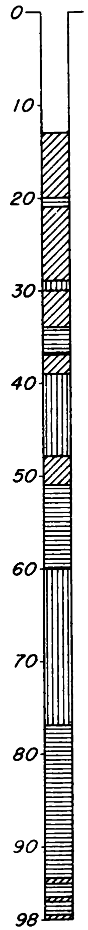
Depth	Core %TiO_2	Core %V_2O_5	Sludge %TiO_2	Sludge %V_2O_5
120–122.2	2.90	0.17		
122.2–125	2.15	0.13		
125–130	2.95	0.13	2.25	0.09
130–133	4.35	0.16	3.00	0.08
133–134	2.40	0.09		
134–138	1.05	0.13	1.40	0.14
138–141	2.90	0.18		
141–144	2.00	0.13		
144–145.5	1.40	0.09	2.35	0.10
145.5–152	1.20	0.07		
152–154.8	0.55	0.05		
154.8–159.6	1.35	0.10		
159.6–162.6	3.20	0.10		
162.6–167	3.95	0.22		
167–168	5.30	0.22		
168–170.5	3.40	0.13		
170.5–177.5	1.40	0.06		
177.5–178.9	4.00	0.17		
178.9–182	2.50	0.17		
182–188.5	1.50	0.09		

L E G E N D

OXIDIZED SURFACE CLAYS
FELDSPAR CARBONATE ROCK
COARSE GRAINED CALCITE
PHONOLITE, UNUSUALLY ALTERED — IGNEOUS
OTHER — IGNEOUS

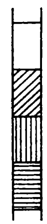
Figure 13. - Graphic log, hole No. E-7.

Hole No. E-8
Coord.: N 00, E 200
Date Started: 9-15-48
Date Completed: 9-22-48
Collar Elev.: 379'
Drill: Baker Core



Depth	Analysis %TiO	Analysis %V O
0–7	2.00	0.11
7–14	0.95	0.11
14–21	2.10	0.09
21–27	0.60	0.07
27–34	0.75	0.08
34–39	1.35	0.11
39–46	0.80	0.07
46–53	1.25	0.10
53–60	2.60	0.20
60–66	0.45	0.06
66–72	0.50	0.05
72–78	1.55	0.07
78–85	4.80	0.21
85–92	3.50	0.18
92–98	3.10	0.09

L E G E N D



RESIDUAL CLAY
FELDSPAR CARBONATE
COARSE GRAINED CALCITE
ALTERED PHONOLITE (IGNEOUS)

Figure 14. - Graphic log, hole No. E-8.

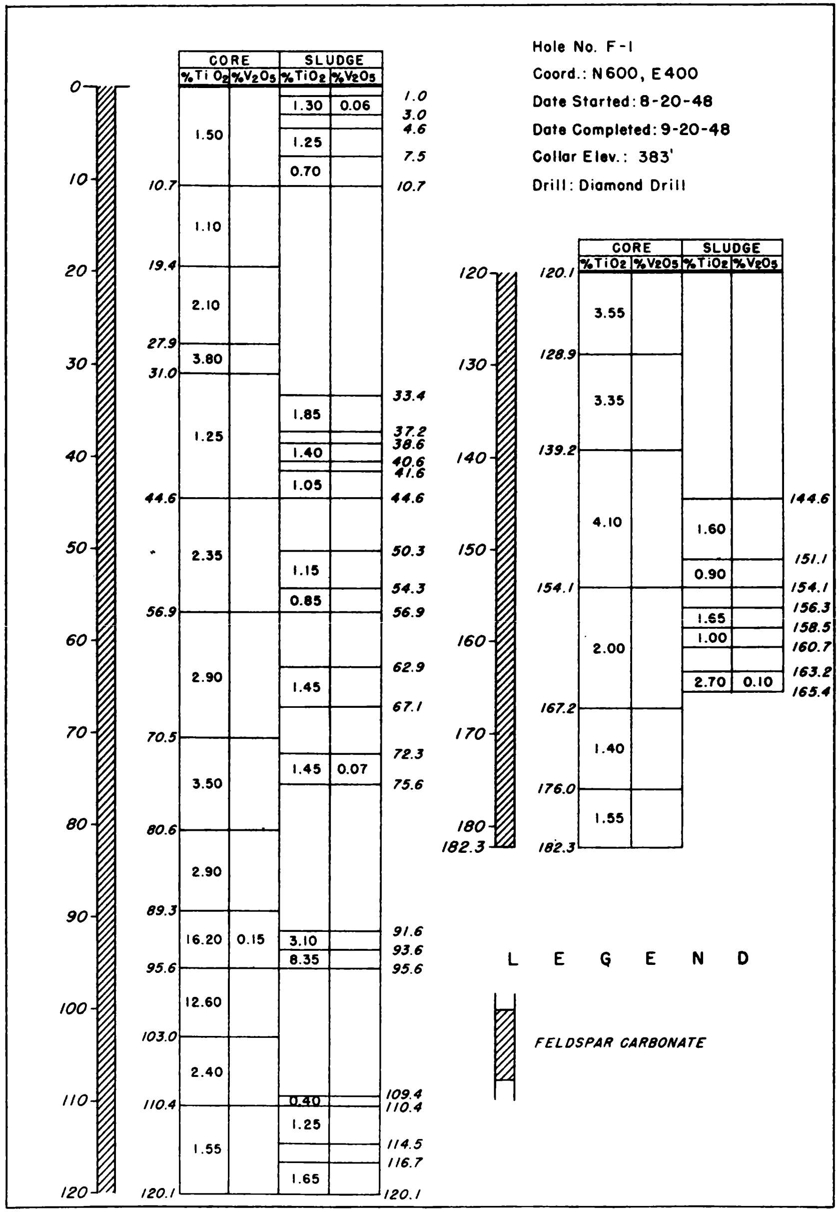


Figure 15. - Graphic log, hole No. F-1.

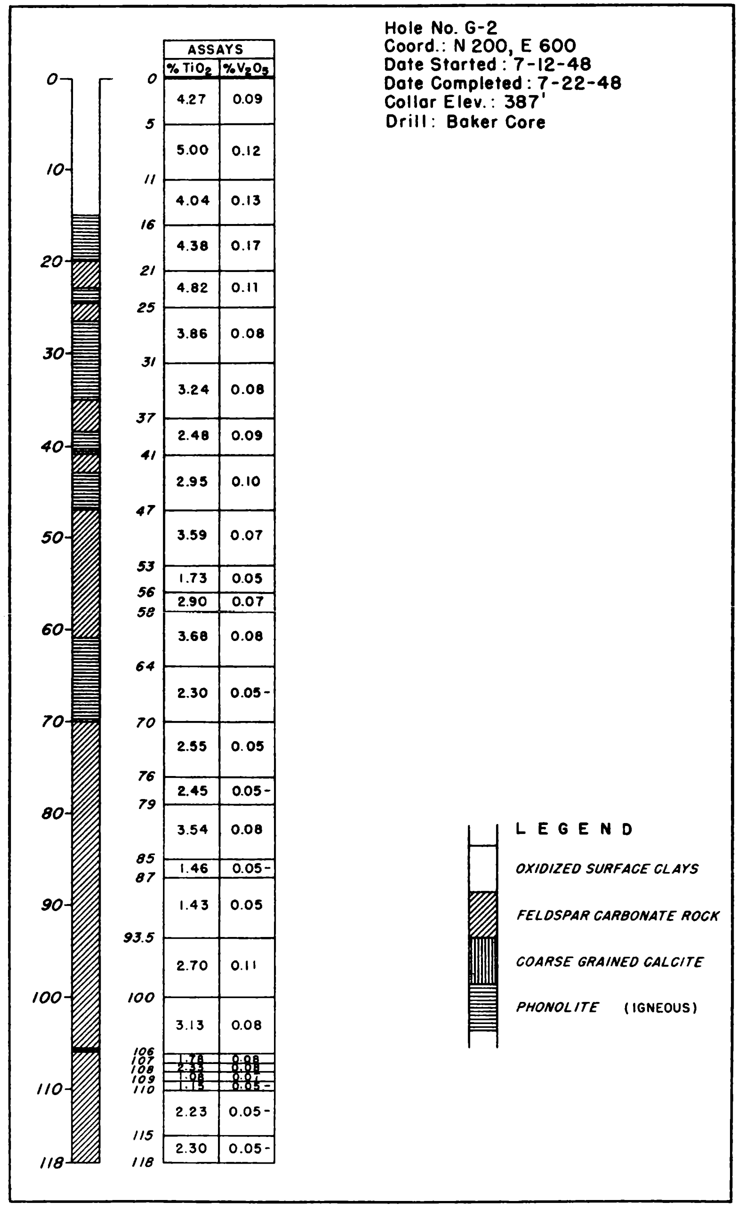
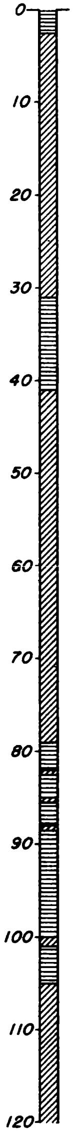
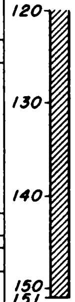


Figure 16. - Graphic log, hole No. G-2.





Hole No. G-4
Coord.: N 600, E 600
Date Started: 10-14-48
Date Completed: 10-21-48
Collar Elev.: 379'
Drill: Diamond Drill

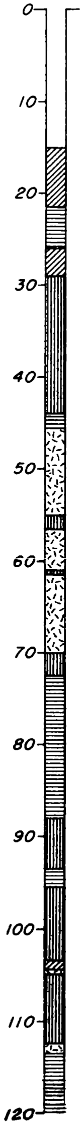
Depth (ft)	Core %TiO_2	Core %V_2O_5	Core % S	Sludge %TiO_2	Sludge %V_2O_5
0.0–11.8	2.44	0.08	4.56	1.91; 1.82	0.07; 0.09
11.8–25.7	3.36	0.06	5.63	1.91; 2.40	0.09; 0.09
25.7–30.4	2.45	0.07	4.59		
30.4–34.5	3.45	0.09	1.50		
34.5–45.7	2.97	0.10	2.68	1.45; 2.64	0.07; 0.09
45.7–58.9	2.16	0.10	3.83	2.09; 2.02; 1.78	0.09; 0.09; 0.08
58.9–68.1	2.74	0.10	3.95		
68.1–75.7	1.56	0.06	3.34		
75.7–81.1	2.12	0.07	4.21		
81.1–90.3	2.36	0.07	2.69		
90.3–101.7	1.82	0.07	2.54		
101.7–110.5	2.80	0.07	2.20		
110.5–117.9	2.44	0.07	2.71		
117.9–	2.93	0.06	2.33		
120–123.5	2.93	0.06	2.33		
123.5–127.9	2.93	0.06	3.44		
127.9–135.8	2.37	0.07	2.41		
135.8–145.0	3.78	0.08	3.21		
145.0–146.6	3.60	0.09	6.63		
146.6–151.0	1.85	0.08	1.48	2.06	0.09

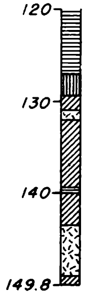
L E G E N D

FELDSPAR CARBONATE

ALTERED PHONOLITE (IGNEOUS)

Figure 17. - Graphic log, hole No. G-4.





Hole No. H-9
Coord.: N 00, E 800
Date Started: 6-25-48
Date Completed: 7-20-48
Collar Elev.: 378' Diamond Drill

Depth (ft)	Core TiO_2	Core V_2O_5	Sludge TiO_2	Sludge V_2O_5
0–4	3.05	0.05-		
4–10	6.05	0.09		
10–13	4.55	0.08		
13–15.5	4.35	0.13		
15.5–17.5	1.95	0.05-		
17.5–19.5	2.70	0.05		
19.5–21.5	4.33	0.08		
21.5–23.5	4.20	0.11		
23.5–25.5	4.90	0.14		
25.5–27.5	4.10	0.09	4.54	0.12
27.5–29.5	0.83	0.05-		
29.5–31.5	0.75	0.05-	1.91	0.05-
31.5–33.5	0.30	0.05-	0.52	0.05-
33.5–35.5	0.54	0.05-	0.60	0.05-
35.5–37.5	0.17	0.07		
37.5–39.5	0.25	0.05-	0.93	0.05-
39.5–41.5	0.23	0.05-		
41.5–43.5	0.30	0.05-		
43.5–45.5	1.13	0.05-		
45.5–47.5	1.75	0.06		
47.5–49.5	1.97	0.13		
49.5–51.5	1.16	0.05-		
51.5–53.5	2.00	0.07		
53.5–55.5	1.58	0.05	2.28	0.05-
55.5–61	2.04	0.07		
61–65	1.71	0.05		
65–70	1.93	0.05-		
70–75	1.00	0.09		
75–80	2.77	0.11		
80–85	3.43	0.05		
85–90	2.05	0.09		
90–94	0.65	0.05-		
94–99	1.20	0.05-		
99–103.8	0.34	0.05-		
103.8–108.5	0.53	0.05-		
108.5–113.3	0.53	0.05-		
113.3–118.1	3.08	0.08		
118.1–	4.01	0.09		
120–123	4.01	0.09		
123–128	2.33	0.05		
128–132.8	2.93	0.05		
132.8–136.8	3.38	0.07		
136.8–139.8	5.23	0.05		
139.8–143.8	3.44	0.07	3.52	0.05-
143.8–147	2.71	0.08		
147–149.8	2.14	0.05		

L E G E N D

OXIDIZED SURFACE CLAYS

FELDSPAR CARBONATE ROCK

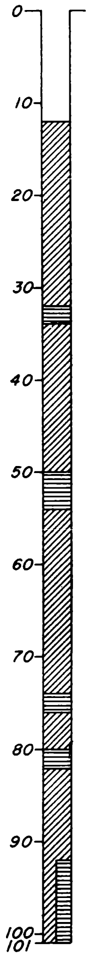
COARSE GRAINED CALCITE

ALTERED PHONOLITE — IGNEOUS

OTHER — IGNEOUS

Figure 18. - Graphic log, hole No. H-9.

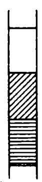
Hole No. I-1
Coord.: N 200, E 1000
Date Started: 6-24-48
Date Completed: 7-2-48
Collar Elev.: 390'
Drill: Baker Core



ASSAYS

Depth	% TiO_2	% V_2O_5
0–6	1.10	0.05-
6–12	0.98	0.05-
12–20	0.80	0.05-
20–26	0.88	0.07-
26–32	0.95	0.05-
32–36	3.50	0.08
36–40	2.35	0.05-
40–44	2.90	0.05-
44–50	3.73	0.05-
50–55	3.48	0.05-
55–57	2.90	0.05-
57–60	0.85	0.05-
60–65	0.95	0.05-
65–67	0.65	0.05-
67–72	1.15	0.05-
72–76	2.74	0.10
76–78	2.33	0.05
78–81.1	4.37	0.12
81.1–86	2.64	0.07
86–91	1.13	0.07
91–96	3.23	0.08
96–101	3.84	0.09

LEGEND



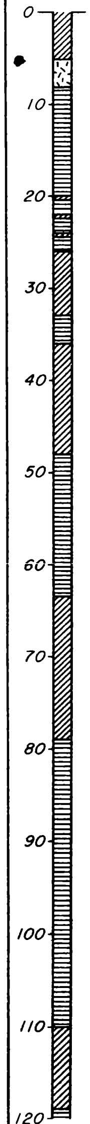
OXIDIZED SURFACE CLAYS

FELDSPAR CARBONATE ROCK

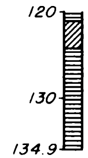
PHONOLITE (IGNEOUS)

Figure 19. - Graphic log, hole No. I-1.

Hole No. J-1
Coord.: N 1085, E 1200
Date Started: 10-27-48
Date Completed: 11-8-48
Collar Elev.: 399'
Drill: Diamond Drill



Depth	CORE			SLUDGE		
	%TiO	%V O	% S	%TiO	%V O	% S
0–4.7	3.80	0.08	2.47	4.06	0.08	0.71
4.7–6.9	3.14	0.08	1.34	5.56	0.09	2.43
6.9–11.9	2.58	0.09	1.62	3.40	0.07	0.85
11.9–16.3				2.92	0.07	1.79
16.3–19.3	3.82	0.09	3.21			
19.3–22.7	2.83	0.08	2.55	3.30	0.09	2.02
22.7–27.2	3.11	0.08	0.76	2.15	0.09	4.70
27.2–30.7	2.43	0.09	3.39	4.14	0.09	4.94
30.7–32.5				4.38	0.09	3.47
32.5–35.9	3.14	0.09	1.72			
35.9–37.9	2.02	0.08	2.34			
37.9–40.5	2.90	0.09	4.59	3.25	0.09	2.48
40.5–45.7	3.45	0.08	3.62			
45.7–49.6	3.28	0.08	2.85	4.35	0.09	2.66
49.6–53.0	3.50	0.08	1.80			
53.0–57.0	3.50	0.09	2.49			
57.0–63.4	3.76	0.09	1.91			
63.4–66.4	2.82	0.09	2.88			
66.4–67.5	2.55	0.09	2.73			
67.5–69.5	2.12	0.08	3.92	3.89	0.09	3.67
69.5–73.9	3.30	0.09	2.08	3.30	0.07	1.95
73.9–75.0	3.02	0.10	3.54			
75.0–80.3	3.72	0.10	3.08			
80.3–83.8	4.60	0.09	1.93			
83.8–91.5	4.50	0.09	2.97			
91.5–94.5	4.30	0.07	5.23			
94.5–100.4	4.10	0.10	3.38			
100.4–104.6	4.26	0.10	2.09			
104.6–108.6	4.61	0.12	2.91			
108.6–112.2	4.19	0.13	4.39			
112.2–114.2	3.28	0.12	7.86			
114.2–115.6	2.04	0.12	9.39			
115.6–117.2	3.33	0.11	7.87	2.50	0.08	3.05
117.2–	2.97	0.12	5.55			



Depth	CORE		
	% TiO_2	% V_2O_5	% S
–121.0	2.97	0.12	5.55
121.0–122.5	4.00	0.10	5.91
122.5–123.8	2.44	0.10	5.29
123.8–126.0	4.08	0.15	3.42
126.0–129.4	3.92	0.11	3.33
129.4–131.7	2.67	0.09	7.73
131.7–134.9	4.18	0.09	2.70

LEGEND

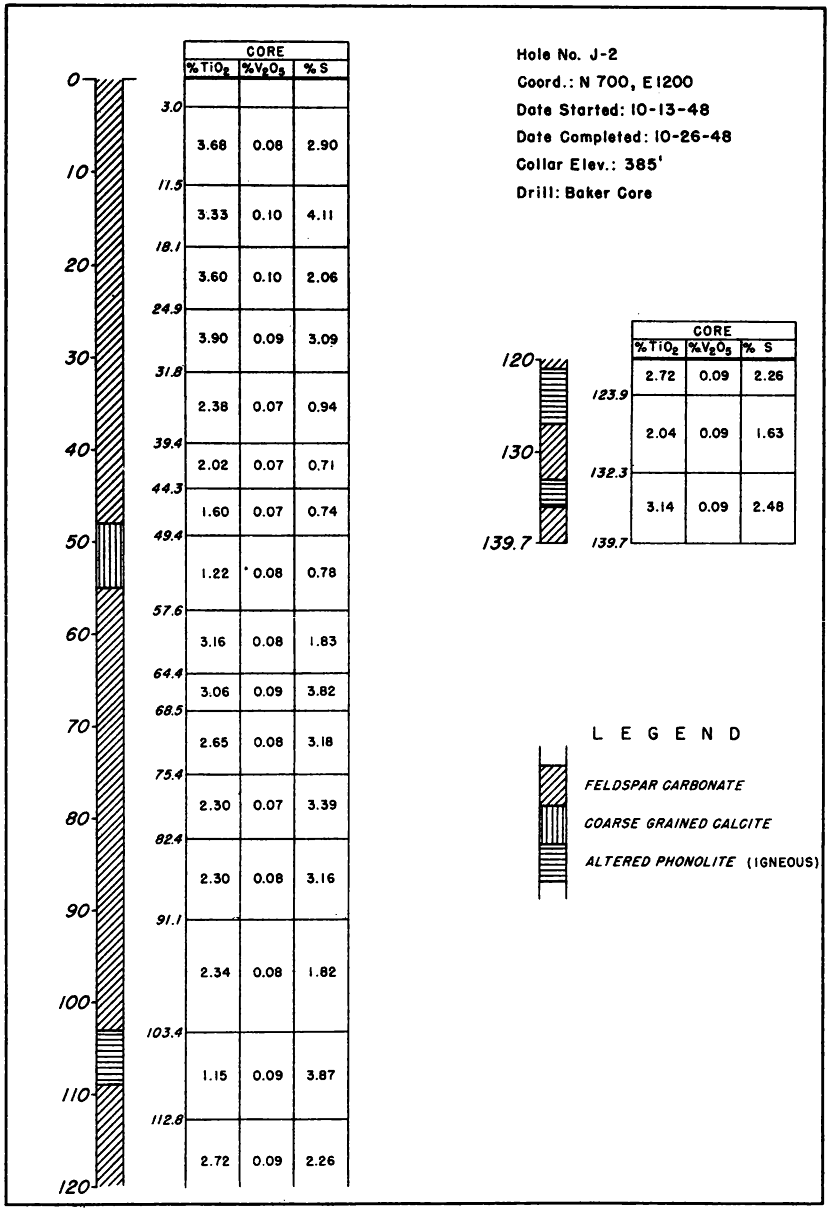
FELDSPAR CARBONATE

ALTERED PHONOLITE

IGNEOUS

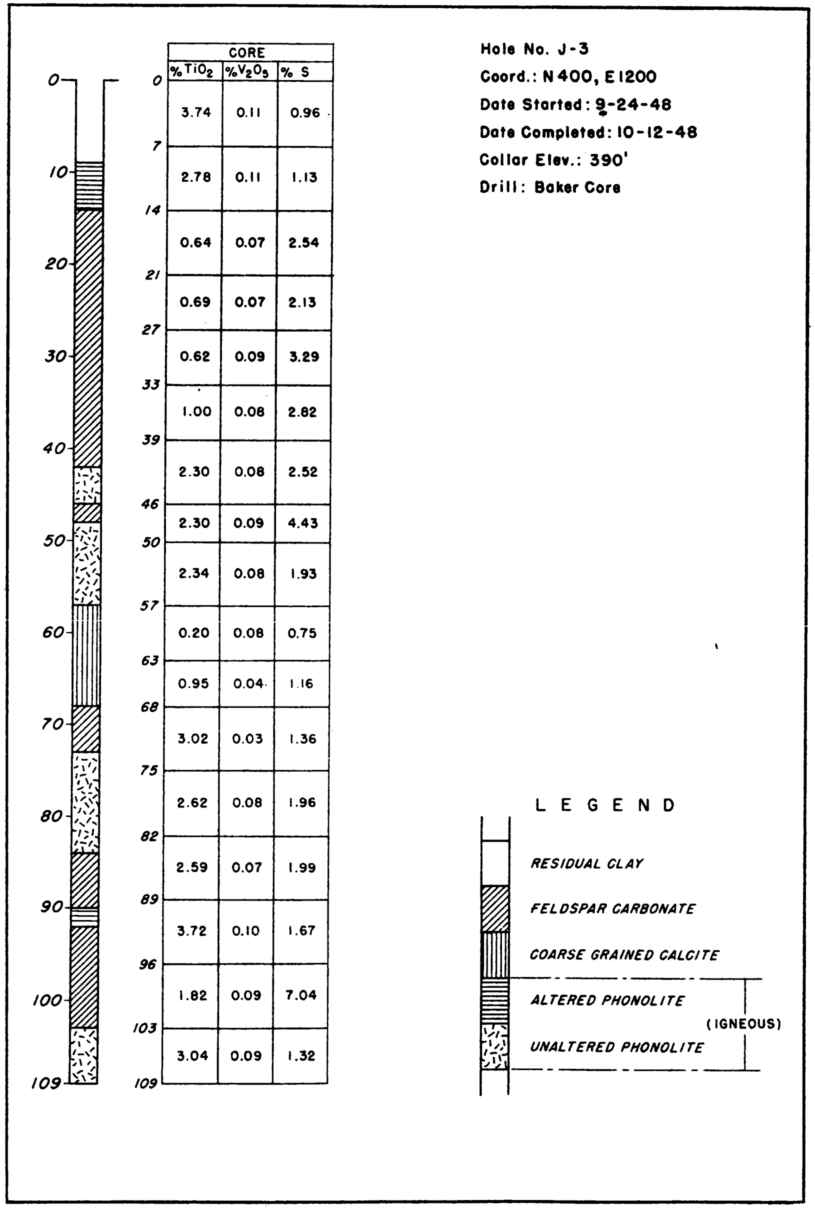
OTHER

Figure 20. - Graphic log, hole No. J-1.



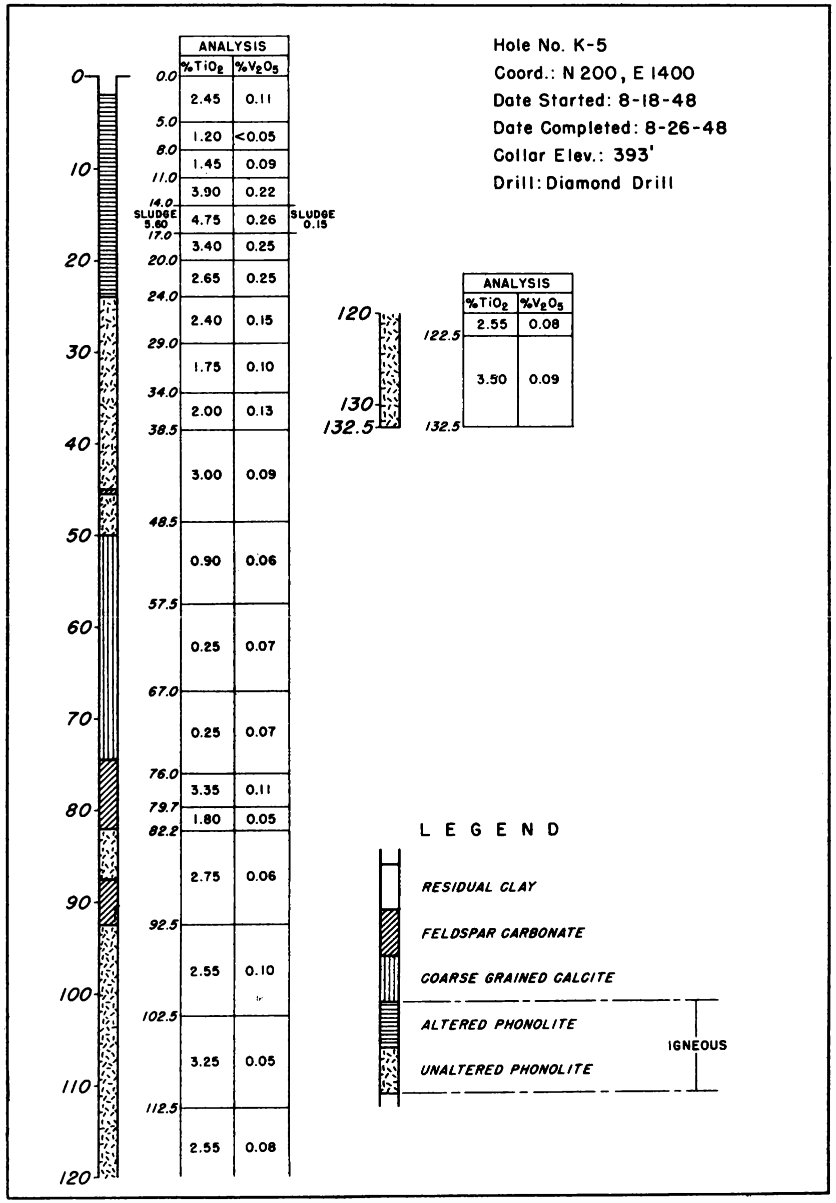
Depth (ft)	CORE %TiO_2	CORE %V_2O_5	CORE %S
0–3.0			
3.0–11.5	3.68	0.08	2.90
11.5–18.1	3.33	0.10	4.11
18.1–24.9	3.60	0.10	2.06
24.9–31.8	3.90	0.09	3.09
31.8–39.4	2.38	0.07	0.94
39.4–44.3	2.02	0.07	0.71
44.3–49.4	1.60	0.07	0.74
49.4–57.6	1.22	0.08	0.78
57.6–64.4	3.16	0.08	1.83
64.4–68.5	3.06	0.09	3.82
68.5–75.4	2.65	0.08	3.18
75.4–82.4	2.30	0.07	3.39
82.4–91.1	2.30	0.08	3.16
91.1–103.4	2.34	0.08	1.82
103.4–112.8	1.15	0.09	3.87
112.8–120	2.72	0.09	2.26
120–123.9	2.72	0.09	2.26
123.9–132.3	2.04	0.09	1.63
132.3–139.7	3.14	0.09	2.48

Figure 21. - Graphic log, hole No. J-2.



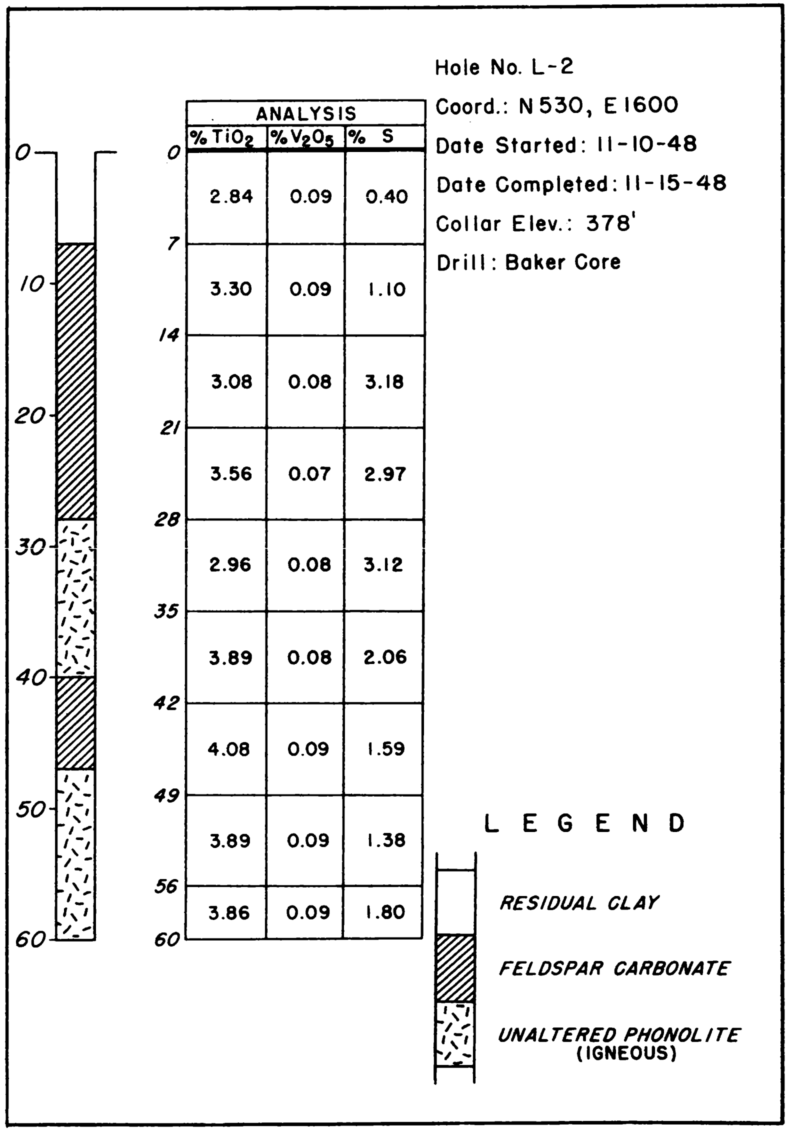
Depth (ft)	CORE %TiO_2	CORE %V_2O_5	CORE %S
0–7	3.74	0.11	0.96
7–14	2.78	0.11	1.13
14–21	0.64	0.07	2.54
21–27	0.69	0.07	2.13
27–33	0.62	0.09	3.29
33–39	1.00	0.08	2.82
39–46	2.30	0.08	2.52
46–50	2.30	0.09	4.43
50–57	2.34	0.08	1.93
57–63	0.20	0.08	0.75
63–68	0.95	0.04	1.16
68–75	3.02	0.03	1.36
75–82	2.62	0.08	1.96
82–89	2.59	0.07	1.99
89–96	3.72	0.10	1.67
96–103	1.82	0.09	7.04
103–109	3.04	0.09	1.32

Figure 22. - Graphic log, hole No. J-3.



Depth	ANALYSIS %TiO_2	ANALYSIS %V_2O_5
0.0–5.0	2.45	0.11
5.0–8.0	1.20	<0.05
8.0–11.0	1.45	0.09
11.0–14.0	3.90	0.22
14.0–17.0	4.75	0.26
17.0–20.0	3.40	0.25
20.0–24.0	2.65	0.25
24.0–29.0	2.40	0.15
29.0–34.0	1.75	0.10
34.0–38.5	2.00	0.13
38.5–48.5	3.00	0.09
48.5–57.5	0.90	0.06
57.5–67.0	0.25	0.07
67.0–76.0	0.25	0.07
76.0–79.7	3.35	0.11
79.7–82.2	1.80	0.05
82.2–92.5	2.75	0.06
92.5–102.5	2.55	0.10
102.5–112.5	3.25	0.05
112.5–	2.55	0.08
–122.5	2.55	0.08
122.5–132.5	3.50	0.09

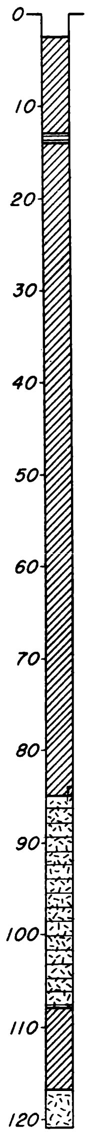
Figure 23. - Graphic log, hole No. K-5.



Depth	ANALYSIS % TiO_2	ANALYSIS % V_2O_5	ANALYSIS % S
0–7	2.84	0.09	0.40
7–14	3.30	0.09	1.10
14–21	3.08	0.08	3.18
21–28	3.56	0.07	2.97
28–35	2.96	0.08	3.12
35–42	3.89	0.08	2.06
42–49	4.08	0.09	1.59
49–56	3.89	0.09	1.38
56–60	3.86	0.09	1.80

Figure 24. - Graphic log, hole No. L-2.

Hole No. M-5
Coord.: N 1000, E 1800
Date Started: 10-22-48
Date Completed: 10-28-48
Collar Elev.: 391'
Drill: Baker Core



Depth (ft)	Core % TiO_2	Core % V_2O_5	Core % S
0–7	0.73	0.08	0.55
7–14	0.34	0.07	4.33
14–21	1.12	0.08	7.46
21–28	1.46	0.08	10.43
28–34	1.78	0.08	6.44
34–41	1.37	0.08	6.18
41–48	1.38	0.08	12.53
48–54	0.87	0.09	10.77
54–61	0.49	0.08	11.59
61–68	0.66	0.08	5.96
68–75	1.80	0.07	6.13
75–82	0.56	0.07	6.68
82–86	1.65	0.07	9.20
86–93	1.97	0.09	6.07
93–98	1.68	0.08	8.51
98–104	1.39	0.08	4.09
104–111	0.86	0.09	2.04
111–118	0.58	0.08	3.02
118–121	1.05	0.09	0.53

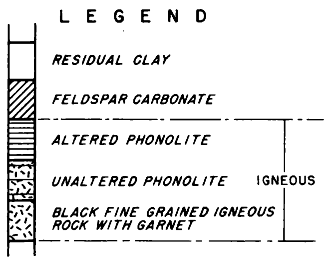
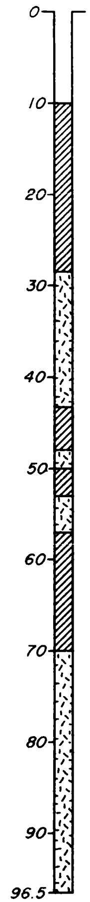


Figure 25. - Graphic log, hole No. M-5.

Hole No. No. N-1
Coord.: N 1400, E 2100
Date Started: 8-16-48
Date Completed: 8-20-48
Collar Elev.: 418'
Drill: Diamond Drill



Depth (ft)	Core % TiO_2	% V_2O_5
0.0–2.2	0.70	
2.2–10.5	0.60	
10.5–15.5	3.35	
15.5–20.5	4.80	
20.5–25.0	4.10	
25.0–28.6	4.25	
28.6–33.6	1.70	
33.6–38.6	1.00	
38.6–43.6	1.85	
43.6–47.2	0.75	CORE 0.07
47.2–50.2	0.70	
50.2–53.3	1.50	
53.3–57.4	2.05	SLUDGE 0.08
57.4–60.2	0.90	
60.2–88.1	1.45	
88.1–96.5	1.65	

Depth (ft)	Sludge % TiO_2
43.6–47.2	1.65
47.2–50.2	2.10
50.2–53.3	1.45
53.3–57.4	0.95
57.4–60.2	0.90
60.2–65.2	1.00
65.2–69.7	1.90
69.7–74.7	0.90
74.7–78.0	1.20
78.0–79.7	0.80
79.7–82.9	1.05
82.9–85.1	
85.1–88.1	1.20

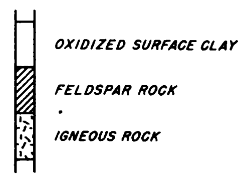
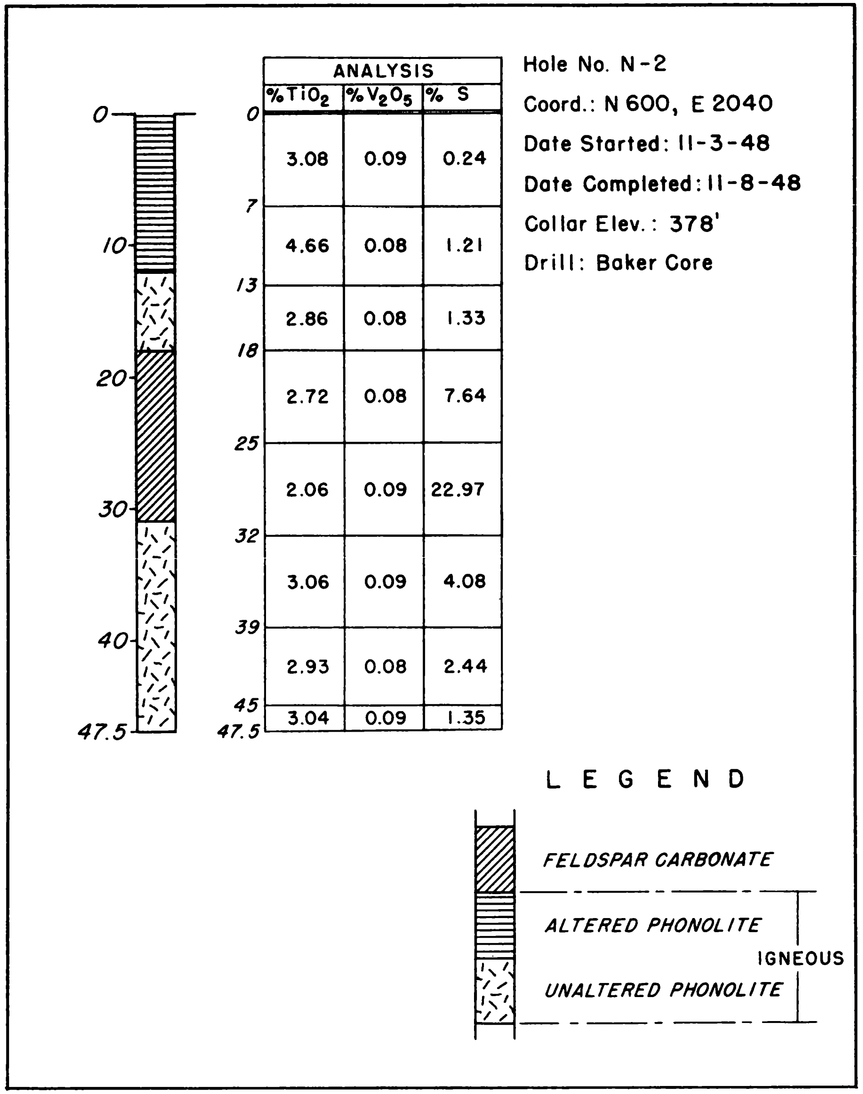


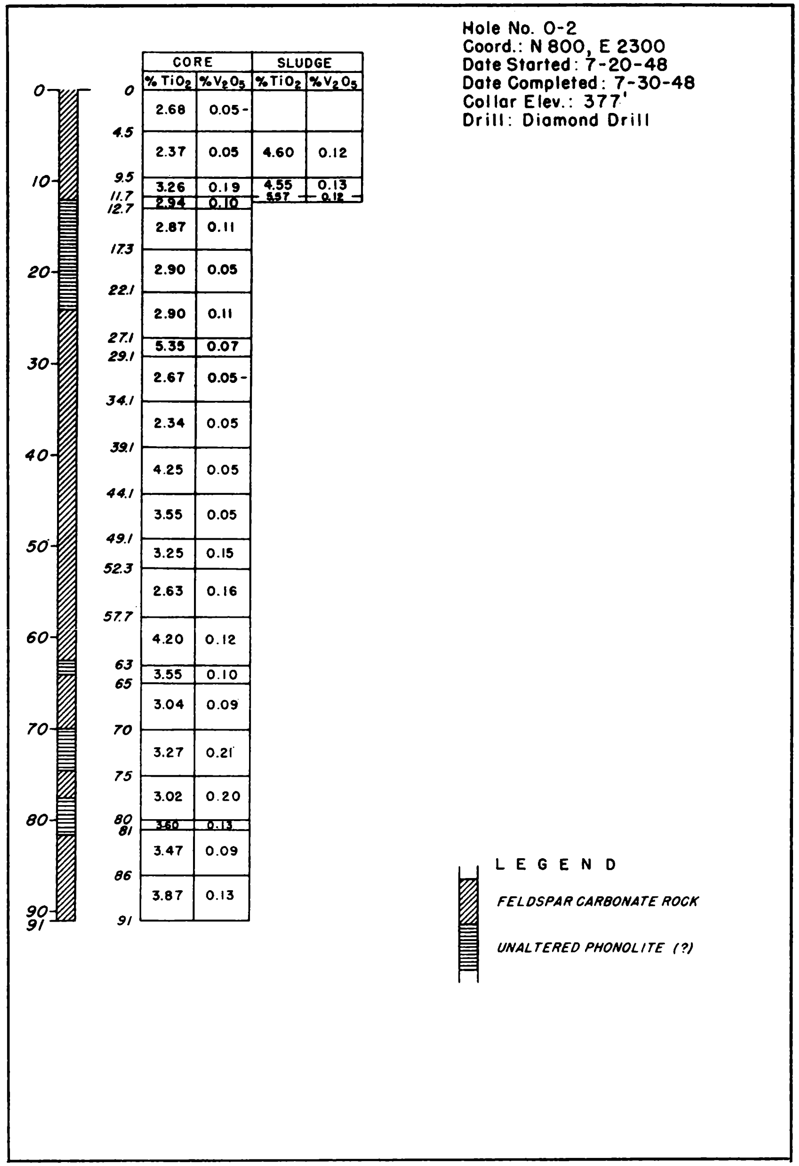
Figure 26. - Graphic log, hole No. N-1.



Hole No. N-2
Coord.: N 600, E 2040
Date Started: 11-3-48
Date Completed: 11-8-48
Collar Elev.: 378'
Drill: Baker Core

Depth	ANALYSIS $\%TiO_2$	$\%V_2O_5$	% S
0–7	3.08	0.09	0.24
7–13	4.66	0.08	1.21
13–18	2.86	0.08	1.33
18–25	2.72	0.08	7.64
25–32	2.06	0.09	22.97
32–39	3.06	0.09	4.08
39–45	2.93	0.08	2.44
45–47.5	3.04	0.09	1.35

Figure 27. - Graphic log, hole No. N-2.

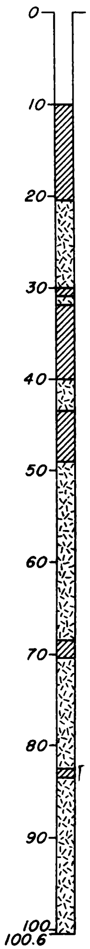


Hole No. 0-2
Coord.: N 800, E 2300
Date Started: 7-20-48
Date Completed: 7-30-48
Collar Elev.: 377'
Drill: Diamond Drill

Depth	CORE $\%TiO_2$	CORE $\%V_2O_5$	SLUDGE $\%TiO_2$	SLUDGE $\%V_2O_5$
0–4.5	2.68	0.05-		
4.5–9.5	2.37	0.05	4.60	0.12
9.5–11.7	3.26	0.19	4.55	0.13
11.7–12.7	2.94	0.10	5.57	0.12
12.7–17.3	2.87	0.11		
17.3–22.1	2.90	0.05		
22.1–27.1	2.90	0.11		
27.1–29.1	5.35	0.07		
29.1–34.1	2.67	0.05-		
34.1–39.1	2.34	0.05		
39.1–44.1	4.25	0.05		
44.1–49.1	3.55	0.05		
49.1–52.3	3.25	0.15		
52.3–57.7	2.63	0.16		
57.7–63	4.20	0.12		
63–65	3.55	0.10		
65–70	3.04	0.09		
70–75	3.27	0.21		
75–80	3.02	0.20		
80–81	3.60	0.13		
81–86	3.47	0.09		
86–91	3.87	0.13		

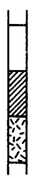
Figure 28. - Graphic log, hole No. 0-2.

Hole No. O-3
Coord.: N 1200, E 2300
Date Started: 8-2-48
Date Completed: 8-13-48
Collar Elev.: 395'
Drill: Diamond Drill



Depth (ft)	Core %TiO2	Core %V2O5	Sludge %TiO2	Sludge %V2O5
0–2	1.90	0.10		
2–6.5	1.40	0.15		
6.5–8.7	0.65	0.09		
8.7–9.7	0.70	0.05-		
9.7–14	0.55	0.12	0.35	0.05
14–18.6	0.55	0.09	0.60	0.06
18.6–20.2	0.50	0.11		
20.2–23	0.70	0.11		
23–26.5	0.70	0.11	0.55	0.08
26.5–28.5	0.85	0.10		
28.5–31.8	0.75	0.10		
31.8–33.3	0.70	0.09		
33.3–34.3	0.70	0.09		
34.3–35.2	0.95	0.09	0.55	0.08
35.2–36.6	0.80	0.09		
36.6–37.7	1.90	0.09		
37.7–39.8	1.90	0.09	1.25	0.07
39.8–41.8	1.00	0.09		
41.8–43.3	0.80	0.09		
43.3–43.7	0.90	0.09		
43.7–46.9	0.85	0.09	0.50	0.07
46.9–48.7	1.25	0.05-		
48.7–49.9	1.10	0.05-		
49.9–51.9	0.65	0.05-		
51.9–54.8	0.65	0.05-		
54.8–59.5	0.70	0.05-		
59.5–64.5	1.15	0.05-		
64.5–69.5	1.55	0.05-		
69.5–74.5	2.85	0.05-		
74.5–79.5	0.85	0.05-		
79.5–84.5	1.40	0.05-		
84.5–88.3	0.65	0.05-	0.80	0.05
88.3–90.6	0.55	0.05-		
90.6–95.6	0.65	0.05		
95.6–100.6	0.75	0.06		

L E G E N D



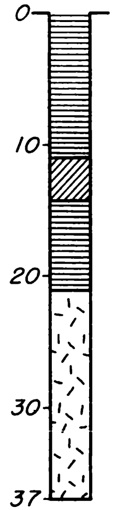
OXIDIZED SURFACE CLAYS

FELDSPAR ROCK

ALTERED NEPHELINE SYENITE (IGNEOUS)

Figure 29. - Graphic log, hole No. O-3.

Hole No. O-4
Coord.: N600, E 2300
Date Started: 10-29-48
Date Completed: 11-3-48
Collar Elev.: 392'
Drill: Baker Core



Depth (ft)	Analysis %TiO2	Analysis %V2O5	Analysis %S
0–7	4.64	0.07	0.27
7–14	4.42	0.08	0.30
14–21	4.38	0.09	0.25
21–28	3.37	0.08	1.94
28–32	3.01	0.08	2.24
32–37	3.11	0.09	1.57

L E G E N D

FELDSPAR CARBONATE

ALTERED PHONOLITE

UNALTERED PHONOLITE

Figure 30. - Graphic log, hole No. O-4.

WORK DONE BY THE BUREAU OF MINES

The drilling done by the Bureau of Mines in 1945 12/ did not establish the southern or western limits of the deposit or provide a suitable representative sample for metallurgical testing. For these purposes a supplemental program of drilling was started in June 1948. In view of the experience gained in drilling the Christy brookite deposit, 13/ the four-wheel-drive combination rig using the Baker standard cable-tool core barrel (2-13/16-inch I. D. core tube) was chosen to do most of the drilling. For drilling deeper holes, a Longyear Straitline diamond drill was employed. Later, the F.W.D. combination rig was replaced by a Star 71 churn drill rig, which proved to be more efficient in handling the Baker tool. Still later, the Bureau of Mines moved a Keystone churn-drill rig onto the project, and the owner of the property drilled three holes with a privately owned Sullivan diamond drill (fig. 3). A summary of holes drilled is as follows:

Rig	Type	Owned by	Holes drilled	Footage drilled
F.W.D. ...	Churn (Baker)	U.S.B.M.	2.6	279.0
Star	do.	do.	12.4	1,313.0
Keystone .	do.	do.	2	85.0
Longyear .	Diamond	do.	7	1,078.7
Sullivan .	do.	Upton	3	288.1
		5 rigs	27	3,043.8

A very excellent description of the equipment and discussion of drilling methods employed has been given by Dupuy. 14/ Five holes were drilled in the east pit to investigate the vertical extent of the ore. Four of these were diamond-drill holes; one was a Baker core hole.

Three diamond-drill holes and five Baker holes along the south side of the old pit, eight Baker holes on its westerly extension, and one Baker hole on its easterly extension were drilled to investigate the extent of the ore in those directions. Two Baker holes were drilled in the east pit. All of the above drilling was done with Bureau of Mines equipment. In addition, the privately owned diamond drill belonging to the owner of the property drilled one hole in the east pit and two holes north of it. Locations of holes are shown on figure 3. Graphic logs and sample analyses are given in figures 4 to 30, inclusive.

SAMPLING

All core samples, both diamond and Baker, were split, and half was retained for the core library. The other half of the core was sacked at proper intervals and sent to the Bureau of Mines laboratory at Bauxite, Ark., for analysis. Diamond-drill sludges, which were retained only for the intervals in which core recovery was less than 75 percent, were sacked and sent to the same laboratory. Diamond-drill core recovery averaged 82.1 percent.

12/ See footnote 2.

13/ Reed, D. F., Christy Titanium Deposit, Hot Spring County, Ark.: U. S. Bureau of Mines R. I. 4592, December 1949.

14/ Dupuy, Leon W., Drilling and Sampling Unconsolidated Materials: Min. Eng., A.I.M.E., May 1949.

The other half of the Baker cores was split, and one-quarter was made into samples and sent in for analysis. The remaining quarter was sacked on the same intervals as the laboratory sample and placed in airtight cans for future use in metallurgical testing. The metallurgical samples were taken to the Mississippi Valley Experiment Station at Rolla, Mo.

The Metallurgical Division is now engaged in research, endeavoring to work out methods of recovering the rutile from the Magnet Cove ores by flotation and of utilizing the resultant product.

Concerning the results of the work done to date, the Metallurgical Division reports as follows.15/

> Metallurgical samples taken from the surface in the old pit at the Magnet Cove rutile property were an exceedingly complex mixture of rutile, leucoxene, albite, quartz, pyrite, apatite, iron oxides, clay, mica, ankerite, and other carbonates containing 3.4 percent titanium dioxide. Much of the rutile was free of gangue at minus 20-mesh, but a considerable amount was still locked in sizes finer than 200-mesh. Many tiny rutile needles less than 1 micron in width were noted in the petrographic examination.
>
> The beneficiation process utilized tumbling in a cylindrical mill to disintegrate the ore and sedimentation and classification to remove clay slimes. Gravity methods, jigging, and tabling removed most of the gangue and some pyrite. The remainder of the pyrite was removed from the coarse sizes by agglomerate tabling and from the fine sizes by flotation. The final rutile concentrate was then recovered by sizing, classification, tabling, and magnetic separation. This treatment gave a recovery of 46.35 percent of the titania in the sample. The rutile concentrate contained 92.2 percent titania, 1.4 percent iron, 0.63 percent silica, 0.52 percent lime, 0.09 percent sulfur, and 0.60 percent vanadium pentoxide.

15/ Fine, M. M., Kenworthy, H., Fisher, R. B., and Knickerbocker, R. G., Titanium Investigations: The Laboratory Development of Mineral-Dressing Methods for Arkansas Rutile: Paper presented at St. Louis, Mo., meeting of A.I.M.E., October 1948.

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Fryklund, V. C. Jr., and Holbrook, Drew F. Titanium Ore Deposits of the Magnet Cove Area, Hot Spring County, Ark. Bull. 16, Arkansas Resources and Development Commission. (In process of publication.)