United States Department of the Interior
Geological Survey
Strategic Minerals Investigations

PRELIMINARY REPORT ON LATERITE DEPOSITS AND OCCURRENCES IN THE PORTLAND REGION, OREGON

P/R 12-10-45

By

Gordon L. Bell

5404

July 1945

45-6

PRELIMINARY REPORT
LATERITE DEPOSITS AND OCCURRENCES IN THE PORTLAND REGION, OREGON

by

Gordon L. Bell

CONTENTS

ILLUSTRATIONS

TABLES

PRELIMINARY REPORT

ON

LATERITE DEPOSITS AND OCCURRENCES

IN THE PORTLAND REGION, OREGON

ABSTRACT

The laterite deposits and occurrences in the Portland region are situated in the northern part of a belt of lateritic weathering that includes parts of Columbia, Washington, and Multnomah Counties, Oregon.

Seven laterite occurrences in Columbia County were explored jointly by the U. S. Geological Survey and the U. S. Bureau of Mines from January to July 1945. A total of 100 hand-auger holes was drilled on the deposits.

The ore occurs as remnants of pisolitic, aluminous laterite on ridges and spurs under a cover of silt. The laterite was derived from basaltic lavas, referred to the Columbia River basalt of Miocene time. The depth of lateritic weathering is great and the zone of pisolitic laterite, commonly 10 feet thick, is underlain by tens of feet of laminated and variegated, lateritic material. Parts of the variegated, lateritic material retain the texture of the original basalt. The basalt unconformably overlies Oligocene sediments.

The region was elevated and considerably dissected in Pliocene time. Much of the laterite was eroded. The remnants of laterite are now protected from erosion by a thick cover of tan, micaceous silt that filled the valleys and covered the ridges. The silt overburden is as much as 80 feet thick on the Yankton area and averages 30 feet thick on the deposits explored. The silt overburden proved an obstacle to exploring the deposits with hand-augers and is an economically undesirable feature of the deposits. There is a marked difference in topography north and south of the Columbia-Washington County line, and the deposits of laterite found in Columbia County are not as extensive as the remnants of laterite in Washington County.

Reserves were calculated for the Yankton area, Alder Creek and Cater Road deposits. No reserves can be calculated for the Lambert Farm, Kramer Farm, Anderson Road, or Rainier prospects. A tonnage factor of 20 cubic feet equals one long dry ton of ore was used. The average moisture content of the ore is 20 percent. There are about 200,000 long dry tons of inferred ore in the Yankton area with 32 percent total Al_2O_3, 20 percent total Fe, 11 percent SiO_2, and 5 percent TiO_2. Preliminary calculations of reserves in the Alder Creek deposit are as follows: 235,000 long dry tons of measured ore, 129,000 long dry tons of indicated ore, and 233,000 long dry tons of inferred ore. The average composition of the three classes of ore in the Alder Creek deposit is 30.4 percent total Al_2O_3, 20.4 percent total Fe, 12.3 percent SiO_2, and 5.3 percent TiO_2. There are about 50,000 long dry tons of

inferred ore in the Cater Road deposit with approximately 30 percent total Al_2O_3, 24 percent total Fe, 11 percent SiO_2, and 5 percent TiO_2.

INTRODUCTION

Deposits of laterite, recently reported from the Portland region, were investigated by the United States Department of the Interior. The Portland region, or the northern part of the belt of lateritic weathering (Fig. 1), includes parts of Columbia, Washington, and Multnomah Counties. The U. S. Bureau of Mines and the U. S. Geological Survey jointly conducted preliminary investigations on seven of the laterite occurrences in Columbia County, between January 1945 and July 1945.

Total reserves for Washington and Columbia Counties are estimated to be a minimum of 10 million tons.

GEOLOGIC SETTING

The Portland region is drained by the Columbia and Willamette rivers, and their present courses are partly controlled by structural and topographic features that are important factors in the occurrence of the laterite. There is a notable grouping of the known and reported occurrences in two areas: (1) in Columbia County in an area west of St. Helens, and (2) in Washington County in an area north of North Plains. The absence of deposits in the area between is probably largely the result of dissection and erosion by Scappoose Creek and other streams.

North and south of the Columbia-Washington county line there is a marked difference in the topography, and the drainage divide is the ridge on which Dixie Road has been built. To the northeast of the divide the streams flowing to the east and southeast into the Columbia River have affected marked dissection of the landscape. Southwest of the divide the streams flowing to the south are characterized by a lesser gradient than that of the streams in the St. Helens area; hence there has been less dissection. As a consequence of the differences in physiographic evolution, the deposits of laterite found in Columbia County are not as extensive as the remnants of the laterite layers on the larger, relatively flat spurs in Washington County.

Stratigraphy

Oligocene sediments

The oldest exposed formation in the Portland region is a silty sandstone which, on the basis of fossils, has been assigned to the Oligocene. In a 30-foot section of this formation exposed along Brooks Road in the NE $\frac{1}{4}$ sec. 9, T. 4 N., R. 2 W., there is about 20 feet of yellowish-brown grit and conglomerate interbedded with and overlain by light tan, sandy, micaceous silt. The lenses of grit and conglomerate thicken to the west, and the section has the appearance

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FIG. 1. - INDEX MAP OF NORTHWESTERN OREGON

SHOWING BELT OF LATERITIC WEATHERING

(Base map by Rand McNally)

A. Portland Region
B. Salem Region

of a deltaic deposit. Beds of Oligocene sand and Quaternary (?) micaceous silt crop out along Cater Road in sec. 10, T. 4 N., R. 2 W. The beds strike to the northwest and dip from 5° to 10° to the northeast, and are unconformably overlain by basalt.

Following their deposition, the Oligocene sediments were gently folded, uplifted and eroded. In the Portland region a considerable relief was developed on the surface of the exposed Oligocene beds before the extrusion of the lavas. It is possible that in places "islands" of the sediments were not covered by the fluid lavas.

Columbia River basalt

Basaltic lavas aggregating several hundred feet of thickness were extruded in a succession of flows. These lavas are referred to the Columbia River basalt of Miocene time. The basalt is gray to dark gray, fine-grained and diabasic in texture. It is generally much jointed, and in places columnar jointing is well-developed. In the presence of a well-developed joint system, the basalt typically is weathered into spheroidal structures. Where the jointing is on a small scale and the basalt as a result is blocky, weathering has produced small cobble-like forms which from a distance resemble a sedimentary formation of remarkably well-sorted cobbles. Recent weathering of the basalt appears to result in bleaching of the rock with the formation of kaolin. The lateritic weathering phases of the basalt are considered in the discussion of the laterite deposits.

The period of lateritic weathering following the extrusion of the basalt is believed to have been interrupted by a change in the general environment of northwestern Oregon, probably brought about by physiographic and climatic changes. Uplift of the region, probably representing the early stages of folding that is generally referred to the Pliocene, initiated erosion and caused considerable dissection of the basalt and of the laterite developed on it.

Quaternary (?) silt

Tan micaceous silt is the youngest formation in the region and lies on all the older formations. According to Treasher 1/, the fine-grained silt in the Portland area is composed chiefly of quartz. He describes the structure of the silt as massive and loessal in character, and suggests that the silt was deposited in late Pleistocene or early Recent time.

It is possible that the silt in the Portland area to a large extent is wind-laid, but the presence of well-rounded pebbles of quartzite and of igneous rocks indicates water transportation. Results of the present investigation in Columbia County suggest that the silt may be older than determined by Treasher. The present topography is

---

1/ Treasher, R. C., Geologic Map of the Portland Area, Oregon State Department of Geology and Mineral Industries, 1942.

developed on the silt which shows pronounced weathering effects. These features are suggestive of a considerable time interval since the deposition of the silt.

Dark reddish-brown, clayey silt commonly containing pisolites occurs in many places on the laterite below the siliceous, tan silty material that makes up the larger part of the overburden. This lower red silt may have been derived in large part from the local products of lateritic weathering. It is also possible that at the time of the laterization, material from outside sources was brought into the region and contaminated the upper surface of lateritic residual materials, resulting in the development of a red, pisolitic, ferruginous silt that may be confused with the primary laterite.

Structure

The Columbia River basalt is gently folded in the Portland region. Treasher mapped the structure of the basalt in the Portland Hills west of Portland as a northerly trending anticline. In Washington and Columbia Counties the main structural feature appears to be a broad anticlinal fold that trends parallel to the drainage divide in a northwest-southeast direction. Along the Dixie-Rocky Point road on the drainage divide, basalt occurs at an altitude of about 1,600 feet. To the south the basalt dips at low angles toward the Tualatin basin. Northeast of the divide, the basalt occurs at the level of the Columbia River in the vicinity of St. Helens. The broad structural features may be complicated by normal faults.

DEPOSITS IN COLUMBIA COUNTY

General Characteristics

The aluminous laterite deposits in Columbia County that have been explored by the Bureau of Mines lie about 4 miles west of St. Helens. This region has been considerably dissected, and as a result, the known deposits are small. They occur near the crests of hills and ridges under a cover of silt. Locally the steep slopes of some of the hills have been modified by landslides which have disturbed the laterite.

Basaltic lava is the parent material from which the laterite was formed. The depth of weathering is great, and in none of the exposures has a complete section showing gradation from laterite to fresh basalt been found. In cuts showing relatively fresh basalt or weathered material in which the texture of the original basalt can be recognized, the upper laterite zones have been removed by erosion. Such an outcrop can be seen in the roadcut near the Lazy "W" Ranch in sec. 30, T. 3 N., R. 2 W. At the Yankton cut in sec. 1, T. 4 N., R. 2 W. the upper part of the lateritic profile is well-exposed. Indurated, pisolitic laterite occurs in a bed from 6 to 9 feet in thickness. This bed is considered to be typical of the pisolitic variety of the laterite in the Portland region.

The pisolitic laterite is underlain by laminated and variegated lateritic material in which there has been a certain amount of segregation of gibbsite and limonite into distinct layers. In outcrops, such as that in the Yankton cut, fragments of gibbsite apparently formed by collapse and breaking up of a thin layer can be found at a definite horizon. The gibbsite is white to cream-colored, dense, and hard in comparison with veinlets of clay minerals that are found in the spheroidally weathered basalt of the region. Nodules, gray to dark gray, occur in the variegated phase of the laterite profile. These are more numerous in the deeper zones. Some appear to have retained the texture of the basalt from which they were formed. Analyses indicate a high alumina content, but a larger relative amount of iron and titania than is characteristic of the gibbsite layer.

The matrix of the nodules is a plastic variegated clay. Chemical and differential thermal analyses of this material indicate a high silica and kaolin content. Analyses of the samples from the Yankton cut representing the pisolitic laterite, the gibbsite layer, the gibbsite nodules, and the variegated lateritic phase are given below:

	Al_2O_3	Fe	SiO_2	TiO_2	Loss on ign.
A. Indurated pisolitic zone; 9-foot channel sample of reddish-brown laterite mottled with gray	35.5	26.5	6.7	5.7	16.8*
B. 1-inch gibbsite layer in laminated laterite below Zone A	61.5	1.9	3.2	0.3	n.d.**
Limonite concretion	20.0	34.7	8.4	3.2	15.6*
C. Variegated nodular zone below laminated Zone B. 3-foot channel sample	33.2	19.5	13.6	5.2	n.d.**
Nodules from Zone C	53.1	5.7	6.9	2.8	n.d.**

* Analysis by the Oregon State Department of Geology & Mineral Industries
** Analysis by the U. S. Bureau of Mines

That there has been segregation and movement of both iron and alumina is clearly indicated in the analyses of the samples from the Yankton cut given above.

The writer concludes that the pisolites were formed in place. Further petrographic study will be needed to elucidate the details of formation. In this regard the magnetic properties of the pisolites present an interesting problem. One analysis of laterite float quotes ferrous as well as ferric iron. This sample represents the ferruginous rather than the aluminous phase of the laterite and the content of Fe_2O_3 is 44.0 percent; the FeO, 1.6 percent. Analyses show a larger relative amount of iron in the pisolites than in the laterite as a whole. Ferrous iron, however, has not been determined. The magnetic property of the pisolites is thought to be developed in their formation.

The general features of the laterite described above from outcrops can be recognized in the samples taken from hand-auger holes. A typical section is shown in the log of auger hole No. 1 from the Alder Creek deposit (Table 1). In drilling the auger holes a chopping bit was used to penetrate the hard pisolitic laterite. Soft, mealy pisolitic zones also were encountered. The pisolitic laterite invariably grades downward to variegated, plastic, aluminous clay in which the holes were bottomed.

TABLE 1 LOG AND CHEMICAL ANAYLSES OF AUGER HOLE NO. 1, ALDER CREEK DEPOSIT

Depth in Feet	Fe_2O_3 %	Al_2O_3 %	SiO_2 %	TiO_2 %	Description
0 - 4	(Not sampled)				Silty top soil
4 - 9	23.1	35.1	16.3	5.02	Lateritic material, red-brown, few magnetic pisolites
9 - 12	18.3	37.2	16.7	6.16	Lateritic material, as above
12 - 14	14.2	42.3	13.8	4.79	Lateritic material, as above
14 - 18	34.2	33.6	5.6	6.68	Laterite, red, abundant magnetic pisolites
18 - 21	42.2	27.8	4.6	7.26	Laterite, as above
21 - 25	31.4	30.2	11.2	6.79	Laterite, grading to variegated clay. Rare pisolites
25 - 30	31.7	30.7	11.9	6.26	As above, except no pisolites
30 - 34	14.3	24.0	46.7	2.36	Variegated clay, red, yellow and gray. No pisolites
34 - 36	27.7	30.4	18.4	5.24	Variegated clay, with fragments of red weathered basalt

Analyses by U. S. Bureau of Mines

Yankton Area

General Description

The Yankton area (Plate 2) is approximately 3 miles west of St. Helens and includes the Marshall and Howard farms in sec. 6, T. 4 N., R. 1 W., and the Gaman, the Brown, and the Workman properties in sec. 1, T. 4 N., R. 2 W. The laterite is at an altitude of 300 feet in a westerly trending ridge. The area has a relief of 200 feet.

Thirty-two holes were drilled in the area, and brief logs of the holes are contained in Table 2. A maximum depth of 62.5 feet reached in the auger holes was not sufficient to penetrate the silt overburden on the main ridge.

The pisolitic, aluminous laterite crops out at the east end of the ridge on the Marshall Farm, and similar material is exposed in the adits and test pit near the western end of the ridge. The bed of laterite averages 10 feet in thickness, as indicated in the outcrops and by the drilling. It is not continuous throughout the area, and locally appears to have been removed by erosion.

Detailed sampling of the exposures and adits on the Gaman property was done by the U. S. Bureau of Mines. Adit No. 1 (Plate 2) is 50 feet long. An aggregate thickness of 18 feet of lateritic material was sampled at the portal by combining channel samples with a 2.7-foot auger hole. The most notable chemical difference in the samples taken was in the silica content. The average silica content of the upper 13 feet of material sampled is 9.5 percent, compared with an average of 17 percent for the 6 feet below the level of the adit.

TABLE 2 AUGER HOLES, YANKTON AREA

Hole No.	Total depth Feet	Depth in Feet Silt	Laterite	Aluminous Clay
1	39		0-26	26-39
2	39		0-13.5	13.5-39
3	43		0-15	15-43
4	45	0-45		
5	31		0-18	18-31
6	46		0-16	16-46
7	33	0-18		18-33
8	33	0-33		
9	39			0-39
10	33		0-10.5	10.5-33
11	24	0-15		15-24
12	53.5	0-15		15-53.5
13	47	0-34		34-47
14	40	0-40		
15	49.5	0-36.5		36.5-49.5
16	43	0-39		39-43
17	31	0-7		7-31
18	39.5	0-22.5		22.5-39.5
19	45	0-45		
20	41	0-41		
21	40	0-40		
22	61.5	0-51		51-61.5
23	62.5	0-62.5		
24	38	0-38		
25	49	0-49		
26	46.5	0-46.5		
27	41	0-41		
28	46	0-46		
29	44	0-44		
30	30	0-25	25-28	28-30
31	36	0-22		22-36
32	42.5	0-32		32-42.5

Eleven channel samples were taken in adit No. 1. In adit No. 2, 250 feet west of adit No. 1, 9 channel samples were taken. The arithmetic averages for these samples are given below:

	Adit No. 1	Adit No. 2	Average Grade (Arithmetic)
Al_2O_3	33.0	32.6	32.8
Fe	22.6	18.9	20.7
SiO_2	7.3	14.8	11.05
TiO_2	6.4	3.7	5.05

The percentages indicate that horizontal variations in composition may be expected.

Reserves

The limited exploration does not permit determination of measured or indicated reserves. However, on the assumption that the bed of laterite, which is exposed for a distance of 800 feet, extends under the ridge for half of this distance with an average thickness of 10 feet, a reserve of 160,000 long dry tons may be inferred, averaging 32.8 percent total Al_2O_3, 20.7 percent total Fe, 11.05 percent SiO_2, and 5.05 percent TiO_2. In this calculation a tonnage factor of 20 cubic feet is taken as equivalent to one long dry ton of ore. This factor is approximately the same as that used by the Bureau of Mines of 15 cubic feet per short, wet ton, because a moisture content of about 20 percent can be expected.

Additional ore on the Marshall farm near the eastern end of the Yankton area would increase the inferred reserves to about 200,000 long dry tons, averaging 32 percent total Al_2O_3, 20 percent total Fe, 11 percent SiO_2, and 5 percent TiO_2. Assay data from the Marshall farm, in addition to the data from the adits, were used in the calculation of this grade.

The thickness of the silt overburden in the Yankton area is an undesirable feature and proved an obstacle to exploring the area with hand-augers. The ratio of the thickness of the overburden to that of the inferred ore is in the order of 5:1 and precludes economical mining methods.

Alder Creek Deposit

General Description

The Alder Creek deposit (Plate 3) is situated one-half mile north of Spitzenberg in the NW $\frac{1}{4}$ sec. 16, T. 4 N., R. 2 W. at an altitude of 900 feet. The area has a relief of 300 feet.

Because of the relatively thin overburden, the Alder Creek deposit is one of the most promising in Columbia County. The silt ranges from 2 to 40 feet in thickness, and averages 13 feet. As indicated in the auger holes, the laterite ranges from 2 to 32.5 feet in thickness, averaging about 14 feet. Forty-four hand-auger holes spaced 100 to 200 feet apart were drilled. A log of the holes is given in Table 3. Many of the holes penetrated a section of silt and laterite and were bottomed in variegated, aluminous clay. Some of the holes, because of difficulties encountered in drilling, were stopped in the silt or in the upper part of the hard laterite.

The laterite in the Alder Creek deposit appears to conform with the present surface (cross-sections, Plate 3). Landslides are well-developed on the southwestern slope of the hill, and undoubtedly these slides have disturbed the laterite bed. The laterite bed was thinned by erosion before deposition of the silt, and lateritic material was incorporated in the lower part of the silt. Recent erosion has exposed a part of the laterite to renewed attack.

The average composition of the pisolitic laterite in the Alder Creek deposit as indicated by chemical analyses made by the Bureau of Mines follows: total Al_2O_3, 30.4; total Fe, 20.4; SiO_2, 12.3; and TiO_2, 5.3 percent. A log of hole No. 1 with chemical analyses is given in Table 1. A $1\frac{1}{2}$ ton sample of the laterite was collected for experimental study in the Bureau of Mines laboratories.

<u>Reserves</u>

Preliminary calculations of reserves in the Alder Creek deposit are as follows:

Measured ore	235,000 long dry tons
Indicated ore	129,000 long dry tons
Inferred ore	233,000 long dry tons
Total	597,000 long dry tons

These calculations, made before all the chemical data were available, are subject to revision. The estimated average grade is 30.4 percent total Al_2O_3, 20.4 percent total Fe, 12.3 percent SiO_2, and 5.3 percent TiO_2. The ratio of the thickness of the overburden to that of the three classes of ore is 1:1.

TABLE 3 AUGER HOLES, ALDER CREEK DEPOSIT

Hole No.	Total depth Feet	Depth in Feet Silt	Laterite	Aluminous Clay
1	36	0-4	4-30	30-36
2	32		0-18	18-32
3	29	0-12		12-29
4	12	0-4.5	4.5-7	7-12
5	24	0-9	9-12	12-24
6	25		0-16.5	16.5-25
7	28	0-26	26-28	
8	32		0-30	30-32
9	27		0-22	22-27
10	19	0-8.5	8.5-17.5	17.5-19
11	31	0-27	27-31	
12	36	0-21	21-36	
13	38	0-19	19-38	
14	28		0-28	
15	29	0-17	17-29	
16	27			0-27
17	35	0-23		23-35
18	52.5	0-40	40-52.5	
19	20	0-20		
20	39	0-34	34-39	
21	27	0-27		
22	30	0-30		
23	36	0-9	9-36	
24	24	0-14		14-24
25	24		0-24	
26	21	0-10	10-15	15-21
27	41.5	0-17	17-41.5	
28	8	0-2.5	2.5-8	
29	37		0-34	34-37
30	24	0-8	8-24	
31	32	0-28	28-32	
32	46	0-46		
33	29	0-19		19-29
34	36	0-30		30-36
35	36	0-36		
36	23	0-23		
37	24	0-18		18-24
38	35	0-25	25-35	
39	40	0-40		
40	40	0-7		7-40
41	40	0-29		29-40
42	21	0-6		6-21
43	25.5	0-19		19-25.5
44	24	0-15.5		15.5-24

Lambert Farm Prospect

The Lambert Farm prospect (Plate 4) is 5 miles southwest of St. Helens in the SE $\frac{1}{4}$ sec. 11, T. 3 N., R. 2 W., at an altitude of 470 feet. There is a relief of about 200 feet in this area.

Ten hand-auger holes were drilled on the prospect. A brief log of these holes is given in Table 4. The drilling shows a few inches to a few feet of pisolitic laterite near the surface. It is inferred that the bed of laterite once present has been almost completely removed by erosion. The thinness of the silt cover suggests considerable recent erosion.

No reserves can be computed for the Lambert Farm prospect.

TABLE 4 AUGER HOLES, LAMBERT FARM PROSPECT

Hole No.	Total depth Feet	Depth in Feet		
		Silt	Laterite	Aluminous Clay
1	33	0-5		5-33
2	40	0-40		
3	40	0-3.5		3.5-40
4	39	0-4		4-39
5	40	0-32		32-40
6	35	0-25		25-35
7	40	0-5	5-10	10-40
8	30	0-3.5		3.5-30
9	40	0-4		4-40
10	38			0-38

Kramer Farm Prospect

The Kramer Farm prospect (Plate 5) is 3 miles west of St. Helens in the SW $\frac{1}{4}$ sec. 1, T. 4 N., R. 2 W., at an altitude of 420 feet. Approximately 1,500 feet north of the Kramer property a bed of massive, pisolitic, aluminous laterite is exposed in the Yankton cut at an altitude of 300 feet. Two holes drilled on the Kramer property failed to reach the laterite. Hole No. 1 was drilled to a depth of 47.5 feet, and hole No. 2, to 34.5 feet.

Cater Road Deposit

General Description

The Cater Road deposit (Plate 6) is situated about 1 mile northwest of the Lambert Farm prospect in the E $\frac{1}{2}$ sec. 10, T. 4 N., R. 2 W. at an altitude of 425 feet. The deposit is on a ridge in an area with a relief of about 300 feet.

Six hand-auger holes, the logs of which appear in Table 5, were drilled on the Cater Road deposit, but only one penetrated the laterite. In hole No. 4, 20 feet of lateritic material is overlain by 23 feet of silt. A log with chemical analyses for this hole is given in Table 6. An important feature of the composition of the laterite is the variation in silica content. The average silica content of the intervals from 25 to 31 feet is 10.5 percent; from 31 to 36 feet, 12.4 percent; and from 36 to 43 feet, 7.8 percent. Below a depth of 43 feet, the silica content increases rapidly.

In addition to the auger holes, 10 channel samples were taken from a roadcut below auger hole No. 4. Chemical analyses of these samples are not yet available.

The silt overburden ranges from a few feet at the roadcut to more than 40 feet in thickness on the main ridge, and was an obstacle to exploring the deposit with hand augers.

Reserves

The limited exploration data do not permit the determination of measured or indicated reserves in the Cater Road deposit. However, on the assumption that the bed of laterite exposed in the roadcut and cut in auger hole No. 4, extends over an area 200 by 500 feet under the ridge, with an average thickness of 10 feet, a reserve of about 50,000 long dry tons may be inferred, averaging 30 percent total Al_2O_3, 24 percent total Fe, 11 percent SiO_2, and 5 percent TiO_2.

The ratio of the thickness of the overburden to that of the inferred ore in the Cater Road deposit is 2:1.

TABLE 5 AUGER HOLES, CATER ROAD DEPOSIT

Hole No.	Total depth Feet	Depth in Feet		
		Silt	Laterite	Aluminous Clay
1	33.5	0-30		30-33.5
2	40	0-35		35-40
3	40	0-40		
4	50	0-23	23-43	43-50
5	40	0-40		
6	33	0-30		30-33

TABLE 6 LOG AND CHEMICAL ANALYSES OF AUGER HOLE NO. 4, CATER ROAD DEPOSIT

Depth Feet	Fe %	Al_2O_3 %	SiO_2 %	TiO_2 %	Description
0-5					Silty top soil
5-9	5.9	16.7	60.1	1.4	Silt, micaceous, red and yellow clay streaks
9-13	5.9	19.4	61.2	1.5	Silt, micaceous, as above
13-16	6.7	22.8	54.4	1.6	Silt, as above
16-20	7.5	24.3	51.3	1.6	Silt, as above, mealy
20-21	10.6	32.3	32.8	2.3	Silt, micaceous, gray to red, brown, scattered pisolites
21-23	12.7	39.3	20.4	3.0	Silt, contains considerable lateritic material
23-25	13.5	41.6	15.2	3.3	Lateritic material, red-brown, pisolitic
25-28	17.1	38.3	11.1	3.5	Lateritic material, as above
28-31	22.2	33.4	9.8	4.2	Laterite, pisolitic
31-32.5	14.3	38.6	13.7	5.7	Lateritic material, pisolitic
32.5-36	24.3	30.3	11.1	5.1	Lateritic material, yellowish-brown, hard, pisolitic
36-39.5	22.0	34.3	7.5	4.1	Laterite, brown, hard, pisolitic
39.5-43	15.4	39.4	8.0	3.3	Laterite, as above
43-46	15.0	35.6	18.8	3.5	Aluminous clay, yellowish-brown
46-47	7.9	39.0	26.5	3.9	Aluminous clay, with brown relict basalt
47-50	4.3	35.3	38.1	5.6	Aluminous clay, variegated, gray, red, and yellow

Analyses by U. S. Bureau of Mines

Anderson Road Prospect

The Anderson Road prospect (Plate 7) is situated about 1 mile northwest of Yankton in the W $\frac{1}{2}$ sec. 35, T. 5 N., R. 2 W., at an altitude of 450 feet. The southwest-trending ridge is covered by red-brown, silty soil containing abundant pisolites. Two holes on the property penetrated Oligocene sediments beneath a thin cover of the pisolitic silt. Hole No. 1 encountered a hard layer of dark, reddish-brown, pisolitic material 2 inches thick at a depth of 3.5 feet, and struck the Oligocene sediments at a depth of 13 feet. Oligocene sediments were found in hole No. 2 at a depth of 13.5 feet.

Rainier Prospect

The Rainier prospect (Plate 8) is about 2 miles west of the town of Rainier on U. S. Highway 30 in sec. 18, T. 7 N., R. 2 W., in Kalama quadrangle, at an altitude of 680 feet. Cuts along the road from Rainier to the prospect show a good section of the basalt on the south bank of the Columbia River. Some of the lowermost flows may possibly be of Eocene age. The lavas have been severely altered by weathering. In the cuts on the highway near the crest of the hill, lateritic materials are exposed.

Study of the cuts indicates that the Rainier prospect is composed of materials that have been transported, rather than of laterite developed in situ. Pisolitic, lateritic material lies unconformably on weathered basalt. This material was channel sampled at a point shown as locality No. 1 on Plate 8. The upper 4 feet of pisolitic material gave the following analysis: Al_2O_3, 34.4; Fe, 19.4; SiO_2, 12.0; TiO_2, 3.8 percent. The material is poorly bedded and is composed of hard, dark red-brown pisolites and rounded pebbles of basalt in a silt matrix. A second channel was sampled at a point 250 feet southwest of locality No. 1. The material obtained from the upper 6 feet in this channel was analyzed with the following results: Al_2O_3, 30.0; Fe, 15.5; SiO_2, 22.5; and TiO_2, 3.3 percent. An analysis of the lower 6 feet of the section gave Al_2O_3, 30.3; Fe, 15.2; SiO_2, 24.1; and TiO_2, 4.3 percent. The upper 6 feet, on casual inspection, appears to be massive, pisolitic laterite grading down to aluminous lateritic clay; at a point 25 feet east of the channel, however, the massive, pisolitic material grades down into tan, micaceous silt that contains an abundance of pisolites and wood fragments. These features clearly indicate that the materials have been moved and are not truly residual. It is likely, however, that they have been in large part locally derived.

Three hand-auger holes drilled on the Rainier prospect were located to test the possible extension of the lateritic material exposed in the roadcuts. A log of holes is given in Table 7. The holes penetrated silt and aluminous clay, and the absence of laterite confirms the idea suggested by the outcrops that the lateritic material in the Rainier area is channel fill.

The high silica content of the lateritic material and the limited extent of the deposit make it unlikely that a commercial ore could be developed in the Rainier area.

TABLE 7 AUGER HOLES, RAINIER PROSPECT

Hole No.	Total depth Feet	Depth in Feet		
		Silt	Laterite	Aluminous Clay
1	40	0-15		15-40
2	40	0-26.5		26.5-40
3	40	0-6		6-40