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CHROMITE-BEARING SANDS OF THE SOUTHERN PART OF THE COAST OF OREGON

BY

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CHROMITE-BEARING SANDS OF THE SOUTHERN PART OF THE COAST OF OREGON

By Allan B. Griggs

ABSTRACT

Chromiferous sands, commonly known as "black sands" because of their color, are found both in the present beaches and on raised marine terraces along the southern Oregon coast in Coos and Curry Counties. Most of the deposits are on the lower terraces between Cape Arago and the town of Port Orford, and in the South Slough region. The black sand occurs in layers and lenses that range in thickness from a few inches to 42 feet, in width from a few tens of feet to more than 1,000 feet, and in length from a few hundred feet to a mile or more. The deposits on the terraces are covered with 1 to 75 feet of sand, clay, and gravel. The deposits in the present beaches are transitory, varying from year to year, and were smaller than usual and remained relatively unchanged in 1942 and 1943. Besides chromite, other minerals common in the black sands include quartz, olivine, pyroxene, zircon, ilmenite, rutile, garnet, magnetite and epidote. Zircon constitutes 1 to 2 percent of most of the deposits, and is of definite commercial interest. Gold and platinum are present in minute quantities. The known reserves of measurable and indicated ore, minus what was mined in 1943, are 1,913,000 long tons of sand in deposits averaging more than 5 percent chromic oxide (Cr_2O_3), and 1,212,000 long tons of sand in deposits averaging between 3 and 5 percent chromic oxide. It is estimated that 100,000 long tons of sand in the present beaches contain 5 percent or more Cr_2O_3. The reserves in many of the deposits can be substantially increased with more detailed exploration, and other favorable regions are as yet unexplored. In 1943, two plants (one owned by Humphreys Gold Corporation and the other by Krome Corporation) began making rough chromite concentrations which were treated in a third plant constructed by the Defense Plant Corporation to produce chromite concentrates containing about 40 percent Cr_2O_3.

INTRODUCTION

Location

Concentrations of chromiferous sands are found in the present beaches and on marine terraces along the southern coast of Oregon. These deposits are commonly called "black sands", because of their dark gray and brown to black colors, which are due in part to the predominance of the black minerals chromite ($(Fe,Mg)O.(Cr,Al,Fe)_2O_3$), magnetite ($FeFe_2O_4$), and ilmenite ($FeTiO_3$), and in part to

staining with iron and manganese oxides. The deposits investigated are between Coos Bay on the north and the mouth of Rogue River on the south, which are 75 miles apart (see fig. 11). In most of the black-sand deposits north and south of these points, chromite is a minor constituent, as it is, also, in the deposits at the mouth of Rogue River, and magnetite and ilmenite make up the bulk of the black mineral grains.

Access and transportation

Along much of this part of the southern Oregon coast, a narrow strip of coastal plain, up to 4 miles in width, lies between the coast line and the Coast Range and Klamath Mountains. The greater part of this plain is made up of marine terraces, the only exceptions being the areas at the mouths of the larger streams and a narrow strip about 14 miles long between Bandon and Port Orford, which is covered with wave- and wind-deposited sands.

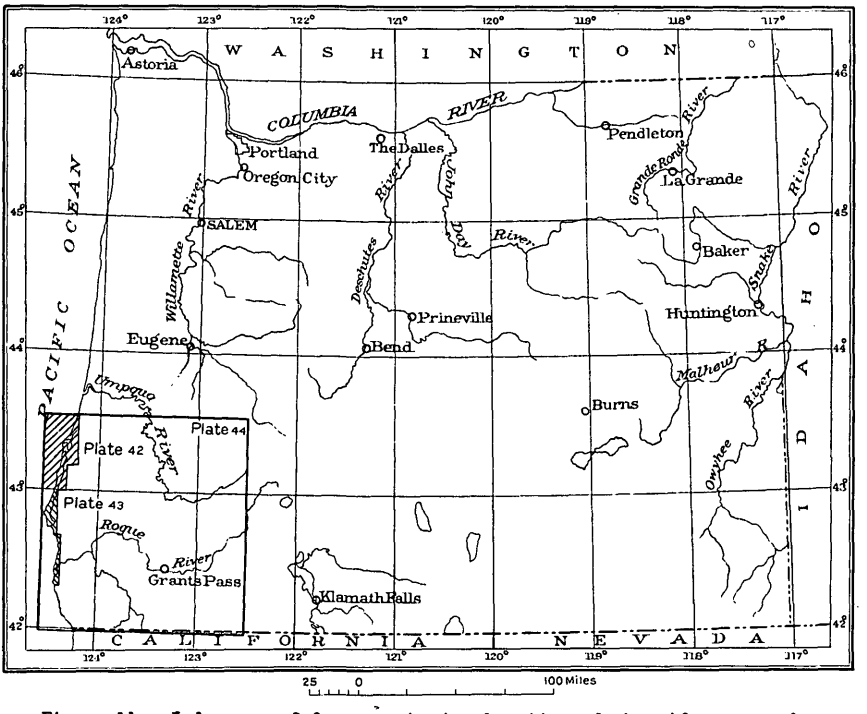

Figure 11.—Index map of Oregon, showing location of chromiferous sand deposits and areas included in plates 41, 42, and 43.

The mountains rise either from the back of the coastal plain or directly from the shore, to summits from 1,750 to 3,600 feet above sea level. In the vicinity of Coos Bay, a flat-topped ridge from 500 to 700 feet in height, trending southeasterly from Cape Arago, separates the coastal plain from the South Slough region (see pl. 42).

Many of the deposits are adjacent to paved or macadam roads, but others can be reached by dirt roads only—some of them as

much as 3 miles in length—which are impassable during the wet season. A branch line of the Southern Pacific Railroad serves the Coos Bay area, and distances from shipping points on the railroad to the deposits range from 10 to 75 miles. Harbor facilities are available at Empire, North Bend, and Marshfield on Coos Bay, at Bandon, and at Port Orford.

History

Gold was discovered in the black sands of the present beaches along the Oregon coast in 1852, and in the elevated marine terraces about 20 years later. According to popular report, these deposits were richly productive for a short time. Soon the richer parts of the terrace deposits were worked out, and since then they have lain idle, except for brief, scattered, and unprofitable ventures. On the beaches small-scale placer operations, known as "sniping," have continued up to the present time, particularly after heavy storms, which tend to reconcentrate the black sands in certain restricted areas. As a result, a small production of gold and platinum is reported annually.

Day and Richards,1/ in a search for sources of platinum, made careful studies of the mineral content of the Oregon black sands and demonstrated a noteworthy content of chromite and zircon, but John D. Mereen was the first to give more than fleeting consideration to the possibility of recovering chromite from these deposits. In 1926 he drilled and sampled the Eagle mine area and concluded that black sands were sufficiently abundant and of high enough grade to be profitably worked. Others have attempted to concentrate various constituents of the sand, but as far as the writer could learn no other exploration of the deposits for these minerals had been carried out prior to 1940.

In February 1940, Earl K. Nixon, Director of the Oregon Department of Geology and Mineral Industries, urged the Geological Survey to drill the terrace deposits as part of the investigation of strategic mineral deposits. J. T. Pardee, who had studied the black sands in 1930 and 1931, also recommended such a project. The funds available for this work were very limited, but the Geological Survey spent a few weeks in the summer of 1940 in drilling at the Pioneer and Seven Devils mines with improvised light hand equipment. After the Survey work demonstrated that heavier equipment would be necessary for adequate prospecting, the Oregon Department of Geology and Mineral Industries obtained a W. P. A. grant for this purpose and the Geological Survey agreed to furnish technical supervision.

The Geological Survey-Oregon State project was started in the spring of 1941, and in July the Krome Corporation started exploratory drilling at the Butler mine. Since then the Humphreys Gold Corporation, Porter Bros. Corporation, and the Pacific Co. also came into the area. E. L. Stephenson of the Geophysical Branch of the Geological Survey made magnetometer surveys of the Butler, Seven Devils, and Geiger mines in the spring of 1942. Reconnaissance magnetometer surveys were also made at the Pioneer, Eagle, Shepard, and Butler mines in 1940 and 1941.

The first mining of the black sands for chromite began in the spring of 1943, when the Humphreys Gold Corporation and the Krome

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1/ Day, D. T., and Richards, R. H., Useful minerals in the black sands of the Pacific slope: U. S. Geol. Survey, Mineral Resources, 1905, pp. 1175-1258, 1906.

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Corporation started their plants at The Lagoons and the Seven Devils mine. Their product, a rough concentrate averaging about 25 percent Cr_2O_3, was delivered to the Defense Plant Corporation's separation plant, where a concentrate containing about 40 percent Cr_2O_3 was produced.

Field work and acknowledgments

This report is based upon the exploratory work done by the various private groups, by the W. P. A. project sponsored by the State Department of Geology and Mineral Industries, by the U. S. Bureau of Mines, and the field work of the writer, during parts of 1941, -42, -43, and -44. F. G. Wells of the Geological Survey and F. W. Libbey of the State Department of Geology and Mineral Industries supervised the W. P. A. project, field supervision of which was taken by A. B. Griggs of the Geological Survey and W. Paulsen of the State Department of Geology and Mineral Industries. Other work done in conjunction with the W. P. A. project included assays by the State employees, check assays and density calculations by Professor G. W. Gleeson of Oregon State College, and a report written by State employees, which was drawn upon freely in preparing this report. Coos County also contributed funds in addition to those furnished by the W. P. A. Exploration data kindly furnished by J. D. Mereen, by W. G. Hellier, O. P. Lance, Edward Thorton, and Stewart Norton of Krome Corporation, by D. G. Brown of Humphreys Gold Corporation, by Robert Porter and L. Vandel of Porter Bros. Corporation and by Albert Burch and R. B. McGinnis of the Pacific Co. have added greatly to the general fund of knowledge on the black sands. R. J. Hundhausen was in charge of the exploration work of the U. S. Bureau of Mines and made all of the data from this work available. Much credit is due to F. G. Wells because of the time and thought he gave to the work. R. W. Lemke and J. J. Glass made most of the mineral determinations; R. E. Stevens made the analyses; and F. C. Calkins, J. W. Peoples, and P. J. Shenon reviewed the report and made many helpful suggestions. Local residents gave information and acted as guides on many occasions, and their voluntary assistance is gratefully acknowledged.

GEOLOGY

General features

The geologic formations occurring along the southern Oregon coast range from probably Paleozoic metamorphic rocks to Recent wind- and wave-formed shore deposits. Most of the coastal area is underlain by sediments, but inland, especially in the old Klamath land mass, igneous rocks are predominant (see pl. 41). The area between Coos Bay and the Coquille River is underlain by Tertiary sandstone and shale, but from the Coquille River south the rocks are largely older. They include schists, and Mesozoic sandstones, conglomerates, shales, and small lentils of chert which Diller 2/ grouped together in the Myrtle formation, partially altered periodotite and serpentine, and other intrusive and extrusive rocks, mostly of basaltic composition. The Myrtle formation is locally metamorphosed where intruded by igneous bodies and is much more folded and faulted than the Tertiary sediments. On most of the coastal plain, and on parts of higher

2/ Diller, J. S., U. S. Geol. Survey Geol. Atlas, Port Orford folio (no. 89), pp. 2-3, 1903.

terraces, Pleistocene beach and offshore deposits cap all other rocks. The wave-cut terraces, on which the beach and offshore deposits lie, were formed as the sea periodically retreated from a height of 1,500 feet to its present position; some advances during this period of general recession are indicated by buried sea cliffs. Recent alluvium covers the flood plains of the larger streams. A strip of the coast between Bandon and Cape Blanco, 14 miles long and up to a mile or more wide, has been built out from the former shoreline by wind- and wave-deposited material, and bay bars have been formed on the northern sides of the mouths of Coos Bay and the Coquille River.

Geology of terraces

A series of Pleistocene marine terraces occurs at intervals along the southern Oregon coast, and remnants of them are found at altitudes of as much as 1,500 feet.3/ All of the known black-sand deposits, however, with the exception of an occurrence in a terrace at an altitude of 800 feet, are restricted to the terraces less than 400 feet above sea level. For this reason these lower terraces only are considered in this report (see pls. 42 and 43).

South Slough, a southward-extending inlet of Coos Bay, is surrounded by an irregular terrace plain about 8 miles long, from 2 to 3 miles wide, and from 50 to 300 feet in altitude. This plain has been largely destroyed by erosion along the western side of the slough, but on the eastern side it rises irregularly for 1 to 2 miles to the old sea cliff. This same plain is also continuous from Coos Bay south to Cape Arago, extending along the western side of the ridge between South Slough and the ocean.

The lower terraces are best developed on a coastal plain, 38 miles long, that extends from the Seven Devils area, just south of Coos Bay, to the town of Port Orford. This plain is from 2 to 5 miles wide, and ranges in altitude from sea level up to 400 feet. On it are three distinct terraces which have been named, beginning with the highest, the Seven Devils, Pioneer, and Whisky Run terraces (pl. 42). They are traceable south of the Seven Devils area to the Coquille River, but from there to Port Orford they are usually ill-defined, and at many places the plain slopes gently down to the coast line or ends in a cliff from a few feet to 100 feet in height. The only exception is at Cape Blanco, where an upwarp has altered the slope and the sea cliff reaches a maximum height of 225 feet.

A narrow fringe of a terrace plain still remains along the coast from Euchre Creek to a point 2 miles south of the mouth of Rogue River, a distance of 12 miles. It ranges in width from a few hundred feet to about half a mile, and in altitude from near sea level at either end to about 200 feet at the center. Other remnants occur along the coast southward to the California boundary.

Other terrace levels are indicated by the buried sea cliffs at the Eagle and Pioneer mines, which are on the Pioneer terrace, and at the Geiger mine east of Bandon. Here the sea cliff at the back of one terrace has been buried and masked by later deposition due to submergence, and another terrace has been superimposed upon the earlier buried one. It is reasonable to deduce

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3/ Diller, J. S., Topographic development of the Klamath Mountains: U. S. Geol. Survey Bull. 196, pp. 26-28, 1902.

from this relation that some of the deposits are older than the terraces near whose surfaces they lie, and although this is apparently true of all the known deposits on the Pioneer and Whisky Run terraces, whether it is true of all the deposits, as Twenhofel 4/ believes, is doubtful. The relations of all the deposits in the South Slough region and on the Seven Devils terrace indicate that they are contemporaneous with the plain and terrace on which they lie.

A marine terrace is usually regarded as a nearly plane surface with a gentle seaward slope, formed by wave erosion and deposition while the land remained relatively static, and afterward raised. In this area, however, the relief of the former land surface was not entirely obliterated by wave erosion, for the bedrock floors or abrasion platforms of the terraces are quite irregular in some places. These irregularities are reflected on the terrace surfaces and some have been proved by exploration. Good examples are to be found in the South Slough region in the W½ sec. 36, T. 26 S., R. 14 W., at the Seven Devils mine on the Seven Devils terrace, and on the ridge rising from the Pioneer terrace east of the Pioneer and Eagle mines; in the two first instances the irregularities have probably controlled the deposition of the associated black sands. Such irregularities have partly controlled the present drainage. The ridge slope west of South Slough and the region just south of Port Orford show little or no effect of wave erosion, being capped by beach and offshore deposits from near sea level to an altitude of 600 feet.

Slight slumping and faulting have been noted at the Seven Devils and Shepard mines; a vertical displacement of 10 or more feet is indicated along the fault at the Seven Devils mine. Other such post-depositional structures might be found at other deposits.

The beach and offshore deposits on the terraces consist principally of sand, which in some places is mixed with clay and interstratified with layers of gravel. The gravel is mostly confined to the basal parts of deposits near the mouths of the present larger streams, indicating that these streams have maintained essentially the same courses since the formation of the lower terraces. The sand and clay covering parts of some of the beach sand deposits that lie next to the sea cliffs has probably reached that position mainly as a result of creep. Discontinuous peaty layers were cut in many drill holes. A number of holes were drilled through well-preserved logs and stumps, which were also exposed in banks at some places. The proportion of wind-deposited sand on the terraces is probably small, although sand dunes, some of them 50 feet or more in height, are distinguishable, especially on the lower terraces. These offshore and beach deposits, which cap the wave-cut benches, range in thickness from a thin veneer to a probable maximum of 200 feet.

CHROMIFEROUS SAND DEPOSITS

General character

The black-sand deposits on the terraces are divisible into two general types, depending upon where they were laid down. Those formed on the beaches lie next to old sea cliffs and are

4/ Twenhofel, W. H., Origin of the black sands of the coast of southwest Oregon: Oregon Dept. Geol. and Min. Ind., Bull. 24, pp. 22-24, 1943.

elongated parallel to the former coast line. These beach deposits are roughly lenticular in shape, thinning out rapidly on the landward side, but usually having ill-defined boundaries on the seaward side. Those deposited further seaward in the offshore zone do not necessarily lie parallel to the coast line, for they were formed in depressions or in the lee of rises of the sea floor. They occur in the form of a layer, which may terminate sharply where the irregularities are abrupt, but in most places have ill-defined boundaries. The offshore deposits are usually more irregular in outline than the beach deposits. In the beach deposits the best concentrations of heavy minerals are on the landward side, while in the offshore deposits they are not restricted to any one place. Only the seaward boundaries of beach deposits need be determined by assays, while almost all of the boundaries of offshore deposits must be determined in this manner. Of the deposits explored, the Shepard, Rose, Eagle and Pioneer, and Butler are thought to be ancient beach deposits, and the Seven Devils, Section 4, Section 33, and the deposit in the N½ SW¼ sec. 36, T. 26 S., R. 14 W. are believed to have been deposited in the offshore zone.

The black-sand bodies range from less than a foot to 42 feet in thickness, usually averaging between 5 and 10 feet. The width ranges from several tens of feet to more than 1,000 feet, and the length from several hundred feet to over a mile.

Pinching and swelling, both vertically and laterally, are controlled by the irregularities of the bedrock or shore against which the heavy-mineral deposits were formed. All are covered with a foot to 75 feet of relatively barren sand, mixed in many places with clay, and at the Butler mine with gravel also. In some places the deposits lie directly on the bedrock, but they are commonly separated from it by a layer of sand, sand and gravel, or sand, clay, and gravel, usually only a few feet thick, although in some places exceeding 50 feet. As a rule the deposits are cemented with oxides of iron and manganese where they have been exposed by erosion or wherever they have been above the water table for a long interval. This feature is especially noticeable in the South Slough region and on the Seven Devils terrace.

In their internal structures the beach and offshore deposits are similar. Both are made up of many discontinuous layers containing quartz and heavy mineral grains in various proportions (see fig. 12); some layers consist of almost pure quartz sand, while others consist almost entirely of heavy minerals. They range in thickness from a fraction of an inch to a foot or more, but most of them are not more than a few inches thick. Cross-bedding and truncated layers are not uncommon. A peat layer, lying directly above the black sand, was cut in many holes at the Eagle and Pioneer deposit and at the Geiger mine, and at the Seven Devils mine a sandy clay parting containing many pieces of wood was struck in a number of holes. Logs apparently are common in the deposits at the Eagle and Pioneer mines, and were found in the deposits at the Seven Devils, Shepard, and Butler mines.

Mineralogy

The chromite in the black-sand deposits consists of grains from many sources, and for this reason it probably has a wide range of composition. The chromic oxide (Cr_2O_3) content of the chromite, however, is fairly uniform in samples collected from the terrace area north of the Coquille River (see table 7), but

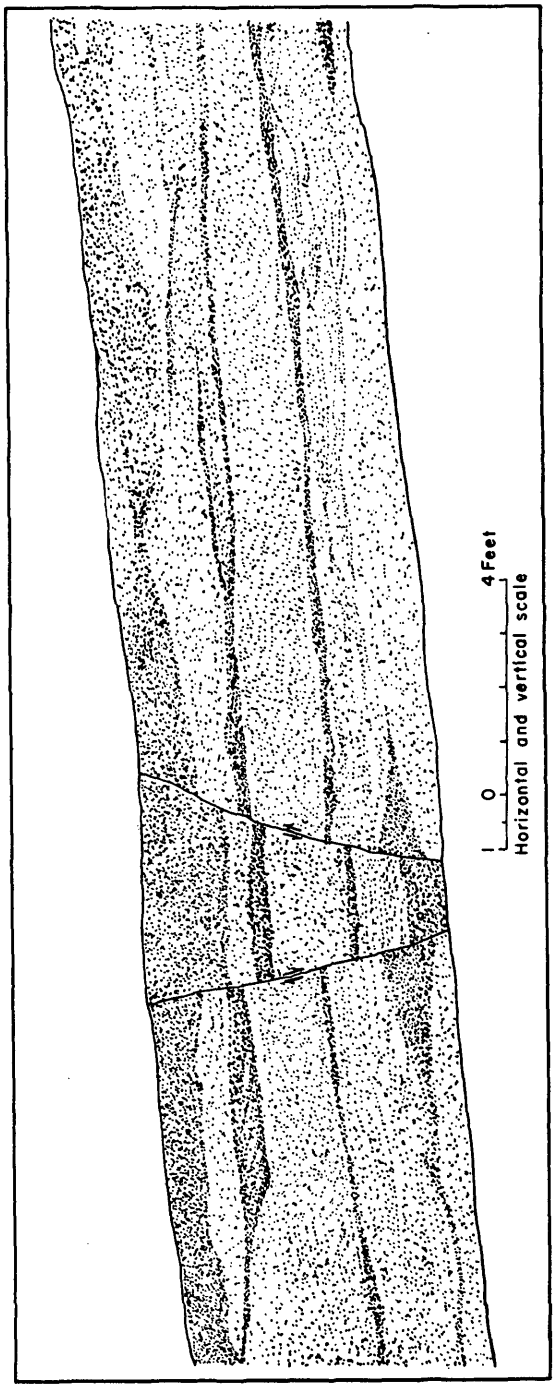

Figure 12.—Diagrammatic sketch of layering in sand in tunnel at the Shepard mine. Section at slight angle to strike of beds.

as the samples are a composite (originally from many sources), they do not indicate this wide range. The iron content, however, is also high, giving the concentrates an undesirably low chrome-iron ratio.

Table 7.—Partial analyses of black sands from the terrace area north of the Coquille River, Coos County, Oregon
[R. E. Stevens, U. S. Geol. Survey, analyst]

Sample	Concentrate				Crude ore	
	Cr	Fe	Ratio Cr/Fe	Cr_2O_3	Cr_2O_3	Percent chromite
BS-1-G	33.79	21.40	1.58	49.37	26.11	53
BS-2-G	34.91	19.76	1.77	51.01	15.23	30
BS-3-G	33.22	21.61	1.54	48.53	14.15	29
BS-4-G	33.80	20.32	1.66	49.40	24.27	49
BS-41-G	35.00	19.16	1.83	51.15	8.20	16

BS-1-G Grab sample from black sand exposed in northwest side of the pit at the Pioneer mine.
BS-2-G Grab sample of higher-grade sand from test pit No. 3 at the Shepard mine.
BS-3-G Channel sample 3.5 feet in length from test pit No. 18 at the Shepard mine.
BS-4-G Channel sample 4 feet in length taken across upper part of black sand layer exposed in ditch at the Eagle mine.
BS-41-G Channel sample taken across 32 feet of brown and black cemented sand at the Seven Devils mine.

The grains of chromite are small; most of them range from 0.1 to 0.25 millimeter in diameter, although a few are as much as 1.5 millimeters in diameter. In most of the deposits the grains are noticeably well rounded, the only exceptions being the deposits in the vicinity of Rogue River, in which almost all of the grains are angular. Some of the angular fragments in the Rogue River deposits are rock particles, consisting of chromite and olivine or serpentine, whereas each grain in the other deposits generally consists of a single mineral. Many of the chromite grains in the deposits in the vicinity of the Coquille River are crystals, but those in the deposits to the south are mostly angular to rounded fragments.

The first four samples listed in table 7 were studied in detail by R. W. Lemke and J. J. Glass of the Geological Survey to determine what minerals were common in the black sands. Those found to be present, including their chemical formulae and specific gravities, are listed in the table on the next page.

As shown by table 8, the mineral associations in deposits of the same general area are similar, even though there are wide local variations within individual deposits. This fact is further illustrated by table 9, in which the relative numbers of grains of minerals or mineral groups are tabulated. Quartz was removed from the sample before the count was made. The same similarity of ratios is also evident in table 10.

Although the present interest in the black-sand deposits is centered in the chromite content, it should be pointed out that several other minerals have economic possibilities. Zircon, for example, which constitutes from 1 to 2 percent of most of the black sand, may well be marketable and has been separated from the other heavy minerals. A clean garnet product also has been

Table 8.—Minerals in black-sand deposits in the terrace area north of the Coquille River

Mineral	Chemical Composition	Specific gravity	Percent by weight in samples			
			BS-1-G	BS-2-G	BS-3-G	BS-4-G
Quartz.....	SiO_2	2.55-2.66	3.0	5.1	10.6	4.3
Olivine.....	$(Mg,Fe)_2.SiO_4$	3.18-3.57	6.0	21.6	20.1	5.6
Pyroxene....	Ca,Mg,Al,Fe, silicate	2.8 -3.7	2.8	23.0	13.6	5.3
Ilmenite....	$FeTiO_3$	4.44-4.90	2.8	8.3	6.4	6.4
Rutile.....	TiO_2	4.18-5.13	.3	.5	.2	.1
Zircon.....	$ZrSiO_4$	4.02-4.86	2.5	1.9	1.5	3.0
Garnet:						
Almandite..	$Fe_3Al_2Si_3O_{12}$	3.69-4.33	28.8	10.2	25.7	27.6
Spessartite	$Mn_3Al_2Si_3O_{12}$	3.8 -4.3				
Chromite....	$(Mg,Fe)O.(Fe,Al,Cr)_2O_3$	4.32-4.57	48.8	20.8	18.4	43.1
Magnetite...	$FeFe_2O_4$	4.97-5.18	4.7	7.0	2.7	4.4
Epidote.....	$Ca(Al,Fe)_3(OH)(SiO_4)_3$	3.07-3.50	...	.2	...	...
All others..	.....	.....	.4	1.4	.4	.3
Total.....	.....	.....	100.1	99.9	99.6	100.1

separated, but as most of the grains, which range from 0.5 to 2.0 millimeters in diameter, are well rounded, it is doubtful whether this garnet could be marketed as an abrasive. Rutile, if it could be separated, would also be of value. Gold and platinum are present in the black sands in very small quantities. According to Hornor 5/ the black sands in some small isolated areas have a good precious-metal content, but in most places they contain only a few cents worth of gold and platinum.

Origin and distribution

Although the ultimate source of the chromite in the black sands is the more or less serpentinized ultramafic rock in the nearby Coast Range and Klamath Mountains, much of the chromite probably has been reworked from the Tertiary sedimentary rocks. Tertiary sediments at the northern end of the area are known to contain chromite, which must have been eroded out of the peridotites and serpentines. After being released from the original source, some of the chromite was deposited in the Tertiary sediments, and then released again, and concentrated in the present terraces. This appears to have been the history of the chromiferous sand deposits at the northern end of the area, where they are largest, richest, and more completely sized. Here, as elsewhere, heavy mineral deposits of sufficient size and grade to be noteworthy appear to have been formed by sizing and concentration effected by several cycles of erosion.6/ Further to the south, where there are no Tertiary sediments, the chromite has been

5/ Hornor, R. R., Notes on black sand deposits of southern Oregon and northern California: U. S. Bur. Mines Tech. Paper 196, p. 10, 1918.

6/ Wells, F. G., The origin of economically significant sedimentary deposits of heavy minerals: In preparation.

taken, by means of either stream or wave erosion, either directly from peridotite and serpentine bodies or from higher terraces. The black-sand deposits in the terraces near the Rogue River were for the most part derived from material brought to the sea by this stream. Most of the chromite along the present beaches has come from material eroded from the adjacent terrace deposits.

Table 9.—Proportions of minerals in black sands from several localities, determined by count of 200 grains from each sample

Location	Heavy fraction			
	Black 1/ opaques	Garnet	Zircon	Others 2/
South Slough region:				
NE¼ sec. 13, T. 26 S., R. 14 W...	127	54	10	9
NE¼ sec. 36, T. 26 S., R. 14 W...	172	3	22	3
Terrace area north of Coquille River and adjacent beaches:				
Seven Devils mine.....	128	14	15	43
Near center sec. 15, T. 27 S., R. 14 W.....	105	13	13	69
Shepard.....	117	54	19	11
Shepard (3).....	54	15	4	28
Eagle.....	99	51	5	45
Pioneer.....	120	58	11	11
Pioneer (3).....	64	22	7	7
Fivemile Beach.....	100	18	6	26
Threemile Beach.....	74	30	10	86
Twomile Beach.....	86	36	12	66
Area east and south of Bandon and adjacent beach:				
North of Geiger mine.....	90	13	11	86
Johnson Creek beach.....	130	21	17	32
Denmark area and adjacent beach:				
Butler mine.....	110	9	9	72
Butler mine 3/.....	62	6	3	29
Cape Blanco beach.....	111	4	3	82
Rogue River area and adjacent beach:				
Terrace north of Rogue River.....	151	2	3	44
Rogue River beach.....	85	1	0	114

1/ Includes chromite, magnetite, and ilmenite.
2/ Includes olivine, pyroxene, epidote, and all others.
3/ Reprinted from U. S. Bur. Mines Rept. Inv. 3668. Mineral count 100 instead of 200.

It seems unlikely that shore currents have carried the chrome sands for long distances. Local origin seems, on the contrary, to be indicated by the fact that neighboring deposits are generally similar in mineral composition, in grain size, in degree of roundness of grains, and in percentage of faceted crystals, while deposits that are far apart generally differ in these respects. The South Slough deposits are characterized by uniformly small well-rounded black mineral grains and by relative abundance of ilmenite, magnetite, and zircon; in some places ilmenite and magnetite together are more abundant than chromite. The deposits on the terraces and in the present beaches just north and south of the Coquille River have a high ratio of chromite and usually garnet, and many of the black mineral grains have partly rounded crystal outlines. The black sand on the Whisky Run terrace at Fivemile Point is an exception, however, for although it is immediately below the Pioneer and Seven Devils terraces in which

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Table 10.—Percentages of magnetite, ilmenite, chromite, and zircon in samples from the black sands
[Determined by R. W. Lemke, U. S. Geol. Survey]

	1	2	3	4	5	6	7	8	9	10	11	12
Weight of sample in grams.....	67.9	67.1	65.1	65.2	65.9	62.2	51.9	61.4	63.8	66.2	61.3	57.5
Weight of portion with sp. gr. 3.3..	21.7	35.6	31.4	10.3	26.0	13.8	25.4	25.6	42.3	15.7	26.2	8.6
Weight of portion with sp. gr. 4.0..	14.5	30.2	23.9	5.9	16.9	9.8	19.2	21.9	37.1	7.0	24.4	5.1
Weight of magnetite portion in grams.....	1.7	2.9	.7	1.2	.7	.5	1.0	2.6	4.5	1.3	18.8	3.6
Percentage of magnetite.....	2.5	4.3	1.1	1.8	1.1	.8	1.9	4.2	7.1	2.0	30.7	6.3
Weight of ilmenite and chromite portion in grams.....	9.88	20.20	18.80	3.74	6.38	7.47	14.70	16.25	28.61	5.4	4.15	.43
Weight of ilmenite portion in grams.	4.25	2.52	3.13	1.68	1.91	2.53	3.69	1.63	3.58	1.08	2.26	Trace
Percentage of ilmenite.....	6.3	3.8	4.8	2.6	2.9	4.1	7.1	2.7	5.6	1.6	3.7	...
Weight of chromite portion in grams.	5.63	17.68	15.67	2.06	4.47	4.94	11.01	14.62	25.03	4.32	1.89	.40
Percentage of chromite	8.3	26.3	24.1	3.2	6.8	7.9	21.2	23.8	39.2	6.5	3.1	.7
Weight of zircon portion in grams...	.95	1.10	1.13	.25	.95	.80	1.0	.55	1.15	.05	.10	Trace
Percentage of zircon.....	1.4	1.6	1.7	.4	1.4	1.3	1.9	.9	1.8	.07	.2	...

South Slough region:
1. Composite of 5 samples from N½, SW¼ sec. 36, T. 26 S., R. 14 W.

Terrace area north of Coquille River and adjacent beaches:
2. Sec. 33 deposit.
3. Composite of 4 samples from Seven Devils mine.
4. Composite of 4 samples from Fivemile Point deposit.
5. Composite of 5 samples from Fivemile, Threemile, and Twomile Creeks' beaches.

Terrace area east and south of Bandon and adjacent beaches:
6. North of Geiger mine.
7. Composite of 4 samples from Johnson and China Creek's beaches.

Denmark area and adjacent beach:
8. Butler mine.
9. Cape Blanco beach.
10. Ophir beach.

Rogue River area and adjacent beach:
11. Composite of 3 samples from terrace deposits north of Rogue River.
12. Composite of 11 samples from Rogue River beach.

chromite is the predominant black mineral, it contains more ilmenite and magnetite, in the aggregate, than it does chromite. In accordance with the concept of local origin, this may be explained by the fact that ilmenite and magnetite are the predominant black minerals in the underlying sandstone, which differs lithologically from the bedrock underlying the deposits on the adjacent Seven Devils and Pioneer terraces. In the deposits in the Denmark region and at Cape Blanco the olivine and pyroxene content is high and there is a wide range in the size of the black mineral grains. The Ophir beach deposit is similar to that at Cape Blanco, except that it contains only a little zircon. In the deposits near the Rogue River, magnetite and ilmenite together outweigh chromite 10 to 1; garnet and zircon are almost absent and most of the black mineral grains are angular.

The well-rounded character of the monomineralic grains in the deposits at the north show that they have been acted upon by erosive agents a great deal more than those further south, especially those in the vicinity of the Rogue River, where there are many granular rock fragments mixed with angular black mineral grains. The Rogue River could have furnished all the black mineral grains in the deposits near its mouth, since its drainage system is large and contains many large bodies of igneous rocks, including peridotite and serpentine (see pl. 41). The small amount of chromite-bearing igneous rocks in the drainage basins of the Coos and Coquille Rivers precludes the possibility that these streams could have furnished much chromite from such sources to the deposits in the northern end of the area, although most of the chromite deposits are adjacent to their mouths. The drainage patterns of all of the present streams appear to be essentially the same now as during the time the deposits were being formed. All these facts combine to support the view that the deposits are local in origin.

Reserves

Methods of concentrating the run-of-mine ore, from 5 to 10 percent Cr_2O_3 (plus 20 percent chromite), were in operation and the beneficiation of this concentrate on full mill scale to yield a usable product (40 percent Cr_2O_3) appeared to have been perfected. The low grade of the concentrates obtainable (40 percent Cr_2O_3 with a chrome-iron ratio of less than 2 to 1) and the cost of mining, processing, and transportation make it unlikely that these black sands could produce chromite in competition with ore from foreign sources in normal times. If, however, other valuable minerals, such as zircon, are also recoverable from the black sands, and if further metallurgical treatment can raise the grade of the chromite concentrates at a reasonable cost, the chromiferous sand deposits might be able to compete in the open market even under normal conditions.

Black sand containing an average of 5 percent Cr_2O_3 was believed to be the lowest grade which could be economically mined and concentrated, but sand averaging as low as 3 percent Cr_2O_3 may possibly be utilized where it contains enough of the other minerals to share the burden of cost and where the cost of mining and beneficiation would be low. Too great a thickness of overlying barren sand and clay may make the working of some of the black sand impracticable even under emergency conditions. A heavy litter of dead fallen timber and brush would raise the cost of mining of many of the deposits.

A cut-off of from 2 to 3 percent Cr_2O_3 has been used to delimit the boundaries of the deposits, and the higher figure was

used in all cases in determining the assay boundaries on the seaward side of ancient beach deposits. In calculating tonnages the weight of a cubic foot was assumed to be 110 pounds for unconsolidated sand, 115 pounds for consolidated sand averaging 3 to 5 percent Cr_2O_3, and 130 pounds for consolidated sand averaging more than 5 percent Cr_2O_3. These figures are considered conservative, for the dry weight of samples collected during the exploration in 1941 at The Lagoons averaged 114 pounds per cubic foot, and 29 samples of dried, consolidated sand collected from the Shepard and Seven Devils deposits had an average specific gravity of 2.38 (147 lbs. per cubic foot). As the consolidated samples came from exposed areas and hence contained more iron oxide than the average of the deposits, a greater reduction was made in the weight for the consolidated sand than for the unconsolidated sand. Estimated reserves of the explored deposits with an average Cr_2O_3 content of more than 5 percent, calculated on the above volume figures, less what has been mined and processed, are: measured ore, 1,445,000 long tons, and indicated ore, 468,000 long tons. Estimated reserves of the explored deposits with an average Cr_2O_3 content between 3 and 5 percent are: measured ore, 872,000 long tons, and indicated ore, 340,000 long tons. The total estimated reserves would yield 456,000 long tons of concentrates containing 40 percent Cr_2O_3, the most probable grade of a commercially obtainable product.

The exploration of several of the deposits has been of a reconnaissance nature only, and parts of most of the other deposits are unexplored. Reserves are therefore likely to be increased in the more promising deposits, particularly in those on the Seven Devils terrace, which include the Section 33 deposit; extension of the Section 4 deposit into the SE¼ sec. 4, NE¼ sec. 9, and NW¼ sec. 10; the Seven Devils mine; and the deposit in the SW¼ sec. 10 and NW¼ sec. 15. Furthermore, the northern portion of the Seven Devils terrace as far south as sec. 22, T. 27 S., R. 14 W. contains other favorable areas as yet unexplored.

In the South Slough region only a very small part of the area that may be underlain by black sand has been explored; but, on the basis of evidence gained from the exploration done thus far, it seems improbable that undiscovered deposits in this area could constitute important sources of chromite. A strip of ground between the Eagle and Rose mines may be underlain by black sand, at least for part of the distance, but the overburden probably is too thick to make mining profitable. Black sand might be found on the eastern side of the north-south-trending rise immediately east of the Pioneer and Eagle mines. In the terrace area east and south of Bandon, none of the known black-sand deposits is large enough to be of economic interest, though it is possible that larger ones may be found. Between South Twomile Creek and Denmark, no deposits of black sand are known to occur, and it is not likely that there are any, for early-day miners prospected the many gullies that cut this area. A strip near the back of the terrace between Stone and Madden Buttes in secs. 27 and 34, T. 31 S., R. 15 W., in which the Butler mine lies about midway, may be underlain by black sand; the results, however, from seven drill holes in the region south of the Butler mine are not encouraging. The terraces above an altitute of 400 feet are believed to be less favorable ground for future exploration than the lower terraces in which, thus far, all the black-sand deposits with enough chromite to be of economic interest have been found.

Wildcat exploration remote from known exposures and away from areas of favorable topography might locate new deposits, but

except on the Seven Devils terrace the results of such exploration have not been encouraging.

Magnetometer surveys made at the Butler mine and in conjunction with drilling at the Geiger and Seven Devils mines by E. L. Stephenson showed small anomalies that corresponded closely to the heavy mineral concentrates. Similar work south of the Butler mine was not conclusive, however, and earlier surveys at the Eagle and Shepard mines were negative. Magnetometer surveys, or dip needle surveys in close conjunction with drilling, might be useful in guiding exploration on favorable ground.

MINING AREAS

The black sand deposits between Coos Bay and Rogue River lie in five separate geographic units, which are, from north to south: the South Slough region, the terrace area north of the Coquille River, the terrace area east and south of Bandon, the Denmark area, and the Rogue River area (see pls. 42 and 43). The explored deposits in these areas will be described in north-south order, after which an account will be given of other occurrences and of the results of random exploration.

South Slough region

South Slough is a north-south trending tidal estuary of Coos Bay about 5 miles long, from which the land rises rapidly to the rugged Seven Devils Ridge on the west and more gently across the terrace plain to the ridge on the east (see pl. 42). The region is difficult of access, as the roads leading into it are for some stretches dirt and for this reason impassable during wet weather.

The known occurrences in the South Slough region lie on the east side of the slough, within an area about 1 mile wide and 6 miles long, trending northward from sec. 12, T. 27 S., R. 14 W., to sec. 13, T. 26 S., R. 14 W., at altitudes ranging from 50 to 275 feet. Most of the black-sand bodies are 2 to 5 feet thick; one, however, has a maximum thickness of 24 feet. Depending upon their topographic position these bodies are overlain by sand and clay a few feet to 75 feet thick, and except for the northernmost occurrence, which overlies sandy shale, are separated from bedrock by as much as 40 feet of sand or sand and gravel. The true color and content of the deposits are commonly masked by black- to rust-colored stains.

Little is known of the size of the South Slough deposits for only one has been systematically explored and outcrops are few, but the available information indicates that most of the deposits are smaller than those on the terraces north of the Coquille River. Furthermore, many of the deposits are of doubtful economic interest because ilmenite and magnetite make up so large a portion of the black mineral grains (see table 10).

Explored deposit

N½SW¼ sec. 36, T. 26 S., R. 14 W. (6) 7/.—The chromiferous sand deposit in the N½SW¼ sec. 36, T. 26 S., R. 14 W., is about 7 miles by road south of Charleston and just east of the south end of South Slough. The Pacific Co., which had leased the deposit from Coos County, explored a part of it in the summer of 1942. They hand-drilled 110 holes in testing the southern portion of the deposit; over half of these holes, however, were put down merely to determine the limits of the deposit and were not sampled.

The exploration outlined a roughly triangular deposit of stained and cemented sand trending northeastward at altitudes ranging from 50 to 75 feet. The deposit varies in width from 600 feet at the southwestern end to 100 feet at the northeastern end and has been explored for a length of 650 feet. Its thickness varies from 1.5 to 24.0 feet and averages 9.7 feet. The thickness of the overlying barren sand ranges from 1 to 5 feet on the southeast side to a maximum of 24.4 feet on the northwest side, and averages 6.1 feet. Similar barren sand also underlies the deposit, and a hole drilled 20 feet deeper than the base of the black sand near the southwestern end of the deposit did not reach bedrock. About 20 percent of the chrome sand within the limits of the explored ground has been eroded away.

The deposit apparently grades into barren sand on the southwest and northwest, but on the thicker eastern side it thins out rapidly, thus having a modified lenticular-shape. A ridge trending north to northeast, 50 to 75 feet higher than the deposit and lying just to the northwest of it, probably was one of the controlling factors in the concentration of the black sand, for other nearby bodies to the north and south are similarly located with respect to ridges.

The explored portion of the deposit averages 3.6 percent Cr_2O_3, with a 2.5 percent cut-off. Separation tests were unsuccessful, and nothing more has been done with the deposit.

Other occurrences

NE¼NE¼ sec. 13, T. 26 S., R. 14 W. (1).—A layer of well consolidated and stained black sand, 1.7 feet thick, is exposed in a pit near the old Marshfield-Bandon road, in the NE¼NE¼ sec. 13, T. 26 S., R. 14 W., at an altitude of 275 feet. A channel sample taken across the layer assayed 7.8 percent Cr_2O_3. The black sand is covered by 3 feet of soil and underlain by sandy shale.

SW¼NE¼ sec. 36, T. 26 S., R. 14 W. (4).—A layer of black and gray sand, 3.2 feet thick, is exposed below about 50 feet of gray sand in a ravine on the west side and near the mouth of John B Creek (at the head of Brown Slough), in the SW¼NE¼ sec. 36, T. 26 S., R. 14 W. A channel sample taken across the layer assayed 1.4 percent Cr_2O_3.

Chickamin mine (2).—The Chickamin mine is on the east side of John B Creek, in the SE¼ sec. 25, T. 26 S., R. 14 W. A 6-inch to 3-foot layer of brown sand with black laminae, the basal part of which is mostly gravel, is exposed in the pit at an altitude

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7/ Numbers in parentheses are those used on the maps (pls. 42 and 43) to show locations of deposits.

of 65 feet. This rather lean material is covered by about 10 feet of barren sand and underlain by at least 40 feet of similar sand.

S½ sec. 25, T. 26 S., R. 14 W. (3).—A 14-foot bed of cemented brown- and black-stained sand is exposed at the portal of a short tunnel on the west side of John B Creek, just across from the Chickamin mine and at about the same elevation, in the S½ sec. 25, T. 26 S., R. 14 W. Black mineral grains are concentrated only in the lower 6 feet of the layer. A sample taken across this part assayed 6.53 percent Cr_2O_3.

NW¼ sec. 36, T. 26 S., R. 14 W. (5).—Well cemented brown- and black-stained sand containing a good percentage of black mineral grains, is exposed in one fork, and similar float was found in the other fork, of a small stream that flows northwestward through the NW¼ sec. 36, T. 26 S., R. 14 W. These occurrences are about 1,500 feet north of the deposit explored in the N½SW¼ sec. 36(6), and may be part of the same ore body. The layer is at least 5 feet thick at one exposure; the overburden is estimated to be 35 to 50 feet thick.

S½SW¼ sec. 36, T. 26 S., R. 14 W. (7).—By test pitting and hand augering, the Krome Corporation delimited a body of firmly cemented black- and brown-stained sand about 500 feet long and 250 feet wide, in the S½SW¼ sec. 36, T. 26 S., R. 14 W. The deposit lies on the point of a flat-topped north-trending ridge at an altitude of slightly over 100 feet and is bounded by erosional edges on the west, north, and east. It probably grades out to an assay boundary on the south. The deposit is from 3.5 to 6.0 feet thick, is covered by as much as 10 feet of barren sand, and is partly underlain by similar sand, although just across the gully to the west the shale bedrock surface rises 50 or more feet above the level of the black sand. The average Cr_2O_3 content of this deposit is estimated to be about 5 percent.

NE¼ sec. 1, T. 27 S., R. 14 W. (8, 9).—The Krome Corporation explored two occurrences of black sand along the tributary of Cox Creek that runs along the western side of the NE¼ sec. 1, T. 27 S., R. 14 W. The black-mineral content of both deposits is moderately high, but consists mostly of ilmenite and magnetite. Two to 7 feet of sand is exposed in two log skidways on the west side of the gully, near the center of the section. A sample taken across 7 feet of brown- and black-stained sand was assayed by the Krome Corporation and found to contain 1.5 percent Cr_2O_3, 12.0 percent TiO_2, and 26.0 percent iron oxide (taken to be FeO and Fe_2O_3). The other occurrence is about 800 feet south of the mouth of the tributary on the east side of the gully, about 50 feet above the stream and 20 feet below the top of the bank. A sample taken across 4 feet of brown- and black-stained sand assayed less than 2 percent Cr_2O_3. Several auger holes were put down in the vicinity of these two occurrences, but no other black sand was found.

Terrace area north of Coquille River

The terraces north of the Coquille River occupy an area 2.5 to 4 miles wide and about 7 miles long. On the north and east this area is bounded by a flat-topped ridge 500 to 700 feet in altitude, which is capped by remnants of a higher terrace, and extends southeastward from Cape Arago to the Coquille River. This area includes the more important chrome-bearing sands on the

Seven Devils and Pioneer terraces and most of the exploration work has been done here. Mining of the sand for chromite began here in the spring of 1943 at The Lagoons and Seven Devils deposits. The Whisky Run terrace, which is also in this area, contains no black sand deposit of any importance. The terraces, especially the Seven Devils terrace, are considerably dissected by the streams draining the area.

The Seven Devils terrace, at its northern end, extends east from the seacoast for 2 miles, and it then extends south for 6 miles, varying from about ½ to 1½ miles in width (see pl. 42). The surface of the terrace deposits is from 275 to 375 feet in altitude. The gullies of a former land surface which cause the terrace floor to be uneven and which have partly controlled the present drainage are still evident. The ancient sea cliff bounding the terrace on the north and east is from 100 to 250 feet high.

The Pioneer terrace is represented only by narrow remnants along the seacoast from the Seven Devils area south to Threemile Creek. There the width of the terrace abruptly increases to about half a mile, and reaches a maximum of 2 miles at the south end, 6 miles away. The terrace surface ranges in altitude from 125 feet along the seacoast to 250 feet on the ridge east of the Eagle and Pioneer mines. The larger irregularities of the surface are due to the unevenness of the rock floor rather than to sand dunes. The Pioneer terrace is from 100 to 150 feet lower than the Seven Devils terrace.

The Whisky Run terrace, which is the lowest, lies next to the seacoast between Twomile and Cut Creeks. It is about 3 miles long and almost a mile across at the widest place. The top of it varies in altitude from about 50 feet at Cut Creek to 100 feet at the northern end. The ancient sea cliff behind it, which is from 20 to 50 feet in height, fades out opposite the Eagle and Pioneer mines, and there the Whisky Run and Pioneer terraces grade into one another.

Explored deposits on the Seven Devils terrace

Section 33 deposit (10).—The Section 33 chromiferous sand deposit is at the back of the Seven Devils terrace in the S½ sec. 33, T. 26 S., R. 14 W. It lies on both sides of the Seven Devils road, 13.5 miles north of Bandon. Prior to 1942 the only prospect in the deposit had been a pit 5.5 feet deep, 250 feet north of a logging road junction and 50 feet west of the Seven Devils road, near the back of the terrace.

In 1942, the Humphreys Gold Corporation leased the property and put down 53 hand-auger holes and 7 test pits, but as no samples were collected from many of the holes and as very few of the holes were taken to bedrock, the work was considered only as a reconnaissance. In the winter of 1943-44, the U. S. Bureau of Mines explored the western and middle segments more fully, drilling 86 holes and digging 7 bulldozer trenches and cuts (pl. 44).

The deposit lies next to the east-west portion of the sea cliff behind the Seven Devils terrace, and although once continuous for a length of at least 2,900 feet, has been divided into three separate segments and 30 to 40 percent eroded away by three south-flowing tributaries of Fivemile Creek. The probable maximum width of the deposit is 2,100 feet. It may extend farther

east and west but no chromite sand was found by reconnaissance on remnants of the terrace on either side of the explored ground, and exploration work indicates that it terminates abruptly at both ends.

The deposit is lenticular in cross section, ranging from a probable thin edge on the northern side to a known maximum of 26.5 feet near the center, to 2 or 3 feet on the southern side, the average thickness being 12.5 feet over the area explored. An overburden of barren clay and sand covers all but the central part of the deposit, where chromiferous sand is found from the surface down. Away from the central part, the overburden thickens to a usual 2 to 8 feet, except on the northwestern corner of the deposit, where it is as much as 21 feet thick. The overall average thickness of the overburden is 5.5 feet. The top of the deposit ranges from 325 to 355 feet above sea level along the northern side, from which altidude it slopes at angles of 2° to 5° towards the south to about the middle of the deposit, and then flattens out southward between altitudes of 260 and 270 feet.

The chromiferous sand in the deposit was concentrated during two different intervals. Along the northern side of the deposit a sandy clay parting, from 4 to 8 feet thick, separates the sand deposited during the two periods. This parting thins out and grades into chromiferous sand near the middle of the deposit, where the slope toward the south begins to flatten out, and the only evidence of the two periods of deposition in the southern part of the deposit is a peaty parting a foot or so thick, encountered in several of the holes drilled in the southern part of the middle segment. From the outcrop in the road cut along the northeastern side of the western segment and from drilling in the northern part of the deposit, it is evident that only thin eroded remnants of the sand laid down during the earlier period remain under the northern part of the deposit, and because these remnants are so small, they are considered as part of the sandy clay separating the upper layer of the chromiferous sand in the northern part of the deposit from bedrock. The chromiferous sand body lies directly on bedrock in the middle part of the deposit, but under the southern part a barren sandy layer, which thickens to 5 feet or more and which is intermixed with gravel under the southwest corner, separates the deposit from bedrock.

The top few feet of the chromiferous sand commonly contains some clay; however, in several holes in the central part of the middle segment clay was found intermixed with the sand throughout the deposit. The sand immediately below the clayey layer is stained, usually highly so, and is cemented. It in turn grades into several feet of relatively unstained and unconsolidated sand, which makes up the bottom layer of the deposit and which is usually also clayey.

Although this deposit lies next to an old sea cliff and slopes seaward, the greatest concentration of chromite is not on the landward side, as in beach deposits. Good concentrations occur at several places and are apparently controlled by the surface on which they were laid down. For this reason, and because of the great width of the ore body and the relatively large amount of clay mixed with the sand, the deposit is believed to have been formed under water rather than on a beach.

The average grade of the explored ground is 4.2 percent Cr_2O_3. A cut-off of 1.5 percent Cr_2O_3 was used to limit the top and bottom of the chromiferous sand, as there was usually a definite break near this figure. Almost 40 percent of the

ground underlain by the deposit is not as yet fully explored, but because much of it is along the southern side of the deposit, the average thickness for this unexplored portion will be less than for that now explored.

Section 4 deposit (14).—The explored portion of the Section 4 chromiferous sand deposit is mostly in the SW¼ sec. 4, T. 27 S., R. 14 W., but extends into the adjoining NW¼ of the section. It is on the Seven Devils terrace, 12 miles north of Bandon, and lies just east of the Seven Devils road, along the dirt road to the Seven Devils mine. The Humphreys Gold Corporation, which had leased the W½ sec. 4, discovered the deposit during reconnaissance exploration in the summer of 1942, and later in the year explored it more fully.

The deposit is an irregular layer lying on the northeast side of a low northwest-trending ridge of the terrace floor (see pl. 45). From its northwest end, which is near the western boundary of section 4, the layer has been proved to extend continuously at least 2,600 feet to the southeast, and reconnaissance exploration by the Krome Corporation indicates that it continues about 3,500 feet farther. The width of the deposit varies from about 100 feet at the west end to more than 1,800 feet at the east side of the explored ground, and averages about 700 feet. The thickness of the chromiferous sand ranges between 1 and 10 feet, apparently in relation to local irregularities of the terrace floor, but in over two-thirds of the holes the layer is 2 to 4 feet thick, averaging 3.1 feet. The thickness of the overlying sand and clay varies from 1.5 to 5.0 feet and averages 3.8 feet. The top of the black sand ranges in altitude from 300 to 315 feet. Except where it is mixed with clay, the chromiferous sand is stained brown or black, and where heavily stained the sand is cemented. In some places a foot or more of sand or sand and gravel separates the chromiferous sand from the shale and sandstone bedrock. The ore has assay boundaries, as the Cr_2O_3 content of the sand within the deposit falls below the 3 percent cut-off on all sides. On the southwest side the assay boundary is regular and conforms closely to the break in slope of the rise, but on the northeast side it is irregular, probably because of minor irregularities of the bedrock surface.

The deposit is almost a mile seaward of the sea cliff back of the terrace, and is considered to be of offshore origin. Other evidence supporting this assumption is the gradational nature of the boundaries and shape and position of the deposit. The northwest-trending ridge under the southwest side of the deposit rises only 15 to 30 feet, forming a slope of only 1° or 2 ° to the northeast, but this slope was apparently enough to cause the concentration of heavy minerals by currents and wave action. The indicated sudden drop in the terrace floor just north of the deposit probably also had some effect on the deposition.

The western part of the deposit is generally thicker and of higher grade than the eastern part, and for this reason the data for the two parts were calculated separately, using the fourth line of north-south holes from the east side as the dividing line. The chromiferous sand in the western part averages 3.6 feet in thickness and 6.6 percent in Cr_2O_3 content; that in the eastern part averages 2.6 feet in thickness and 4.3 percent in Cr_2O_3 content.

Seven Devils (Last Chance) mine (19).—The Seven Devils mine, formerly known as the Last Chance mine, is in sec. 10, T. 27 S., R. 14 W., 14 miles by road north of Bandon. The

mine, owned by the Krome Corporation, is now connected with the Coos Bay Branch Line of the Southern Pacific Railroad at Beaverhill, 9.3 miles distant, by a graded gravel road built in the fall of 1942.

In July 1940, when the Geological Survey drilled 16 hand-auger holes in the area, the only evidence of any former mining activity was a small prospect pit at the bottom of one of the gullies, in which was exposed 2 feet of black sand. The Krome Corporation acquired the property in early 1942 and during that year carried on a comprehensive exploration program, drilling 96 holes and digging 17 pits. In 1943, they drilled 16 more holes in and along the South ore body. Magnetometer surveys also were made by the Geological Survey.8/ A gravity type primary concentrating plant of 2,000 tons daily capacity was built at the mine by the Krome Corporation in the summer and fall of 1942 and winter of 1942-43.9/ Mining and stockpiling of the chromiferous sand began in February 1943, and delivery of rough concentrates began in May 1943 under a contract with Metals Reserve Co., which was terminated in December 1943.

The chromiferous sand deposit at the Seven Devils mine is at the foot of the ancient sea cliff of the Seven Devils terrace (see pl. 46). The cliff is arcuate and swings from a southeasterly trend at the northern end of the deposit to a southerly trend back of most of the deposit. It is a distinct topographic feature which rises steeply from the top of the old terrace deposits between altitudes of 350 and 380 feet. Here the terrace surface has been largely dissected by the headwaters of Threemile Creek, which have cut steep-walled 200-foot ravines in the terrace plain and removed a large part of the chromiferous sand.

The terrace floor on the Tertiary sandstone and shale is irregular along the base of the sea cliff. Drilling has disclosed a troughlike depression, which at its deepest is 80 feet below the general level of the erosion platform. This trough was probably cut by an ancient northward-flowing stream, as the northern end of the deposit is 100 feet lower than the southern end.

The black sand deposit which occupies this depression was at least 5,100 feet long before much of the middle part was eroded away. Now the southern portion, the South ore body, is 2,200 feet long, and the northern portion, the North ore body, 1,900 feet long over-all. The North ore body has itself been eroded into two segments. The width of the South ore body ranges from 200 to 500 feet and averages 350 feet; that of the North ore body ranges from 150 to 1,200 feet and averages about 600 feet. This deposit is by far the thickest of any that have been explored; the South ore body reaches a maximum of 42 feet and averages 20.3 feet thick, and the North ore body reaches 22 feet and averages 14.3 feet thick. The overburden of sand and clay on the South ore body thickens from 2 to 8 feet on the west side to a maximum of 35 feet on the east side and averages 16.0 feet; that on the North ore body ranges in thickness from about 12 feet on the west side to 72 feet at the north end and averages 35 feet.

The deposit is roughly lenticular. On the gentle slope to the west it thins out gradually, but on the east, where it is bordered by a steep slope, it terminates abruptly against and

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8/ Stephenson, E. H., report in preparation.

9/ Huttl, J. B., Oregon chrome sand yields to magnetic separation: Eng. and Min. Jour., vol. 144, no. 9, pp. 62-65, 1943.

interfingers with a mass of angular fragments of sandstones and shale at or near the bottom of the depression. This pile of rubble apparently was built up at the base of the sea cliff while the black-sand deposit was being formed, for it broadens upward and many of the interstices between the fragments are filled with concentrations of black sand (see fig. 13). The deposit slopes gently to the north, thus conforming with the bottom of the depression, which is 100 feet lower at the north end of the explored ground. The altitude of the top of the black sand ranges from 265 to 375 feet.

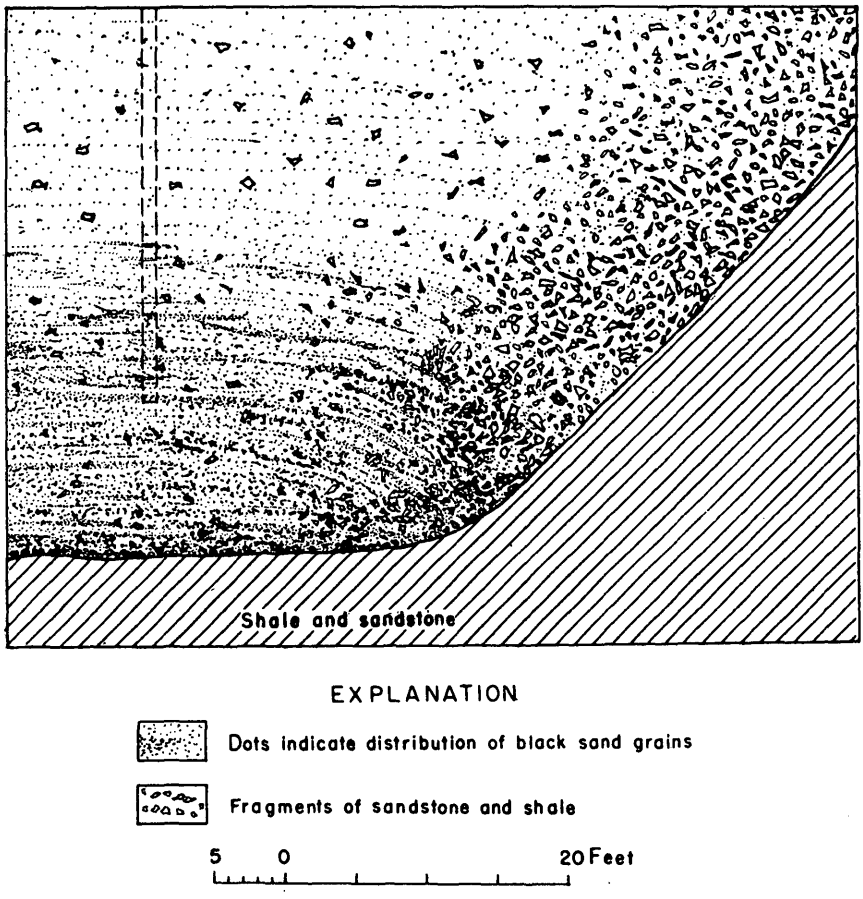

Figure 13.—Diagrammatic sketch of the eastern edge of the black sand deposit at the Seven Devils mine, showing dilution by fragments of sandstone and shale.

A probable postdepositional fault, along which the vertical displacement was more than 10 feet, is indicated by both the drilling records and the sudden cut-off of the erosional remnant of the deposit on the small 300-foot ridge west of the main part of the South ore body.

Rich concentrations of black sand in this deposit are not restricted to any particular depth or place. In some places the better concentrations were found near the top, in others at the bottom, and in still others in intermediate layers within the lens. Good concentrations may be found almost anywhere in the deposit except at the north and northeast end of the North ore body, where a cut-off has been made because of the low grade of the sand and the great thickness of overburden. A lenticular parting of nearly barren sand and clay at least 27 feet thick, probably a remnant of a landslide block, was encountered in several holes in the mideastern part of the South ore body. One hole in it encountered a log and other fragments of well preserved wood, and small pyrite crystals also were found in it. The basal part of the black-sand lens contains pebbles and gravel in some places, and it is commonly separated from bedrock by a foot or more of low-grade or barren sand or of mixed sand and gravel. Rounded fragments of the underlying sandstone and shale make up much of the gravel. All of the chromiferous sand, with the exception of the bottom few feet in the relatively thicker parts of the deposit, far from the surrounding gullies, is stained, and much of the stained sand is cemented. The cementation is especially pronounced in certain layers and in places where the black sand has been exposed.

Although the deposit was laid down next to the sea cliff, it was undoubtedly formed under water, for the bedrock surface on the western side is as much as 65 feet above the top of the deposit, which precludes the possibility of its being a beach deposit. The location and shape of the deposit, the wide range in the depth of overburden, and the haphazard pattern of concentration all conform to this view.

The average Cr_2O_3 content of the South ore body, calculated from the results of the exploration, is 5.8 percent; that of the North ore body is 6.7 percent.

Exploration both to the north and south has eliminated the possibility of any extension of this particular deposit in either of these directions; further exploration, however, on the western side of the North ore body will probably increase the known reserves. About one-third of the South ore body was mined out during 1943.

Other occurrences on the Seven Devils terrace

NE¼ sec. 5, T. 27 S., R. 14 W. (13).—The Humphreys Gold Corporation has drilled 12 holes in the NE¼ sec. 5, T. 27 S., R. 14 W., on a bench that is 25 to 75 feet lower than the Seven Devils terrace, which bounds it on the east and south sides, and 75 to 125 feet higher than the Pioneer terrace, which bounds it on the west. All of these holes were drilled to depths of from 18 to 20 feet. Minor concentrations of heavy minerals were cut in several of the holes, and a sample taken from the most favorable looking sand assayed 3.33 percent Cr_2O_3. This is too low to be of economic interest, but better concentrations might be found to the south of the rim of the Seven Devils terrace that bounds this bench on the south.

W½ sec. 3 and NE¼ sec. 4, T. 27 S., R. 14 W. (12).—The Krome Corporation drilled 12 holes near the back of the terrace north of the Seven Devils mine, in the W½ sec. 3 and NE¼ sec. 4, T. 27 S., R. 14 W. Four of these holes struck black sand in which the

chromite content was relatively low, ranging from 3.3 to 4.9 percent Cr_2O_3, but this sand may nevertheless be of economic interest, as it is relatively thick. The overburden is 7 to 37 feet thick, and the thickness of the sand ranges from 3 to 27 feet. As the deposit lies in a cove in the former coast line and in a depression in the bedrock surface, it probably was deposited under about the same conditions as the sand at the Seven Devils mine.

SE¼ sec. 4, NE¼ sec. 9, NW¼ sec. 10, T. 27 S., R. 14 W. (16). —Reconnaissance exploration by the Krome Corporation showed that the Section 4 chromiferous sand deposit, explored by Humphreys Gold Corporation in the W½ sec. 4 (14), extended more than 3,000 feet southeast of the Humphreys ground into the SE¼ sec. 4, NE¼ sec. 9, and NW¼ sec. 10. This ground lies in the strip of the Seven Devils terrace that is bounded by Fivemile Creek on the northeast and Threemile Creek on the southwest, and which is traversed by a dirt road going from the Seven Devils road to the Seven Devils mine. Although slightly uneven, the average altitude of the area is about 300 feet. Six holes out of 18 drilled in the course of exploration struck sand with a high enough percentage of Cr_2O_3, and great enough thickness, to be considered part of the deposit. The Krome Corporation's results indicate a probable average width of 750 feet. The chromiferous sand in their six good holes is from 3.5 to 11.0 feet thick, the Cr_2O_3 content varies from 2.7 to 7.8 percent, and the overburden is 3.0 to 10.5 feet thick. The chromiferous sand is stained and slightly cemented, as in the ground explored by Humphreys Gold Corporation. The layer of sand and gravel between the deposit and bedrock varies from 2 feet to a probable maximum of 10 feet. Slightly higher ground on both the east and west sides has probably been an important controlling factor in the formation of the deposit.

SW¼ sec. 10 and NW¼ sec. 15, T. 27 S., R. 14 W. (20).—In 1942 the Krome Corporation discovered a deposit of chromiferous sand one remnant of which lies in the SW¼ sec. 10 and the other in the NW¼ sec. 15, T. 27 S., R. 14 W. The northern part lies just west of the low ridge that forms the western boundary of the Seven Devils deposit; the remainder lies about 1,000 feet to the south across the ravine occupied by the south fork of Threemile Creek. Reconnaissance work in 1942 and more detailed exploration of the northern remnant in 1943 indicated that the original deposit may have been about 2,000 feet long and 600 feet wide; more than two-thirds of it, however, has been eroded away.

The northern remnant, trending northeast along the rim of the ravine, is about 900 feet long and averages 145 feet in width. The chromiferous sand in this part averages 3.7 feet in thickness, is covered by an average of 14 feet of overburden, and has an average Cr_2O_3 content of 5.3 percent.

The reconnaissance work on the southern remnant indicates that it is equal in area, thickness, and grade to the northern part, but that the overburden probably is a few feet thicker on the average.

The parts of this deposit appear to be remnants of a once continuous heavy mineral concentration of variable chromite content that extended northwestward from the NW¼ sec. 15 to NW¼ sec. 4, including the Section 4 deposit and its extension to the southeast. Approximately 20 percent of this concentration has been eroded away, and of the remainder, 65 percent or more has a sufficiently high chromite content, sufficient thickness, and a sufficiently favorable ratio of overburden to chromiferous sand to be of economic interest.

Near center sec. 15, T. 27 S., R. 14 W. (21).—Brown- and black-stained sand containing appreciable amounts of black mineral grains crops out along the branches of the north fork of Twomile Creek near the center of sec. 15, T. 27 S., R. 14 W. It is overlain by 20 to 35 feet of brown and gray sand and is underlain by similar material. Two channel samples, 5 and 8 feet in length, taken across the dark sand assayed 4.04 and 6.14 percent Cr_2O_3.

Explored deposits on the Pioneer terrace

Shepard mine (22).—The chromiferous sand deposit at the Shepard mine is in the W½ sec. 16, T. 27 S., R. 14 W., a quarter of a mile east of the Seven Devils road and 8.5 miles north of Bandon. Two pits, one 140 feet long, 60 feet wide, and 20 to 35 feet deep, and the other about half as large, have been sluiced out at a fork of a small tributary of Twomile Creek and a tunnel 1,300 feet south of the pits has been driven east-northeastward for at least 100 feet. Only the first 85 feet of the tunnel is still open. During former mining operations about one-half of the uncovered black sand was removed from the pits in attempts to recover the contained gold and platinum. The mine is now leased to the Humphreys Gold Corporation.

In 1941, a crew of W. P. A. workers under the supervision of the Geological Survey explored part of the deposit, and in 1942, Humphreys Gold Corporation check-drilled the same area with paralleling results. In 1943, the U. S. Bureau of Mines explored most of the remainder of the northern end of the deposit.

The black sand deposit is at the foot of an ancient sea cliff which marks the landward edge of the Pioneer terrace. Although the sea cliff is not high, it is clearly defined, being arcuate in form with a sharp westward turn at the probable northern end of the deposit. The terrace area in which the deposit lies, between Twomile Creek and the sea cliff, is much dissected. At the foot of the cliff the surface of the terrace is 160 to 180 feet above sea level.

The deposit has been proved by drilling for a length of 2,400 feet northward from the point where it is exposed in the northeast bank of the ravine of Twomile Creek, and it probably continues northward another 200 to 400 feet to the westward bend of the sea cliff (see pl. 47). The southern end of the deposit was determined by the Humphreys Gold Corporation, who found a small remnant of the deposit on the southwestern side of the ravine. The explored ore body ranges from 250 to 425 feet in width, averaging slightly more than 300 feet, and its average thickness is 7 feet. The top of the black sand ranges in altitude from 100 to 127 feet. The thickness of the sand and clay overburden varies from 13 to 48 feet and averages about 30 feet.

Beach deposits such as this are usually lenticular in shape and slope gently seaward, but only the northern few hundred feet of this one is normal, and has such a shape and position. The southern part, because of a depression along the eastern side, is convex in cross section with ill-defined boundaries on both the west and east sides. The low area near the southern end can be best explained by slumping and faulting subsequent to deposition, as several minor faults are to be seen in the test pits and tunnel at the southern end of the deposit.

A layer of gravel containing some black sand usually separates the deposit from the sandstone and shale bedrock, and in the bottom part of the western half of the deposit gravel is intermixed with sand to a thickness of as much as 4 feet. No driftwood was uncovered in the pits and only one log was struck in the drill holes, such material being apparently scarce in this deposit. The black sand is stained and cemented in many exposures, but in a few places the sand is unconsolidated and unstained, and it will probably prove to be so wherever the sand has been continuously below the water table. Because of the irregularities in the bedrock, the proportion of heavy mineral grains varies from place to place, but the richer sand is generally found in the east-central part of the deposit. The average Cr_2O_3 content of the explored body of black sand is 6.8 percent.

Rose mine (24).—The Rose mine lies near the eastern edge of the NW¼ sec. 21, T. 27 S., R. 14 W., 8 miles north of Bandon, and a little over a quarter of a mile east of the Seven Devils road. It is about half a mile south of the Shepard mine on the west side of the ravine of Twomile Creek. According to Hornor,10/ Abraham Rose, who located and worked the mine, was reported to have recovered a considerable amount of gold and platinum by ground sluicing.

The mine consists of a north-south pit 800 feet long, 150 to 350 feet wide, and 30 to 50 feet deep, most of the bottom of which is on sandy shale bedrock (see pl. 48). Black sand was found in only one of five holes drilled by the W. P. A. crew and Humphreys Gold Corporation at the south end of the pit; in this hole the sand was 4.5 feet thick and assayed 9.6 percent Cr_2O_3. This exploration indicates that a small remnant of the deposit still remains at the southern end. Another remnant of brown and black cemented sand, about 100 feet wide and 150 feet long is exposed along the western edge of the pit. Similar sand, 4 feet thick and covered by 30 feet of barren sand, is exposed at the foot of the western bank of the pit, 100 feet further north; it assayed 9.1 percent Cr_2O_3. A hole another 100 feet north cut 2.5 feet of black sand, but several other holes along the western edge of the pit were barren. Any former extension of the deposit to the north or east has been eroded away by Twomile Creek. It is concluded from this exploration that two small patches, one along the northwest edge of the pit and the other at the south end, are all that remain of the deposit worked in the pit; the rest has been eroded or sluiced away.

Another body of black sand extending parallel to the pit deposit but separated from it by 150 to 300 feet of barren or low-grade sand, was also explored by the Humphreys Gold Corporation. The top of this deposit ranges between 125 and 130 feet in altitude, which is from 5 to 10 feet higher than the remnants of the pit deposit. The Humphreys Gold Corporation cut this black sand body in 8 holes, which indicate that the sand averages 7.1 percent Cr_2O_3 over an average thickness of 3 feet and width of 50 to 200 feet. The relatively small size of the deposit and the disproportionate thickness of overburden, which averages 40 feet, make the deposit of scientific interest only.

Eagle and Pioneer mines (27).—The Eagle claim lies mostly in the W½SE¼ sec. 28, but a small portion extends into the NW¼NE¼ sec. 33, T. 27 S., R. 14 W. The Pioneer claim, which adjoins the Eagle claim on the south and continues for 1,500 feet in that direction, is in the W½NE¼ sec. 33, T. 27 S., R. 14 W. (see pl. 49).

10/ Hornor, R. R., op. cit., p. 24.

The workings of both mines are on Cut Creek 6.5 miles north of Bandon and just east of the Seven Devils road. Hornor 11/ reports that the Pioneer claim was located in 1866 by A. H. Hinch and John Dame and later sold to Simon Lane, who worked the mine actively until the middle seventies when it was shut down. It probably has produced more gold than any other of the black sand deposits. The claim was patented in 1872. The Eagle mine was likewise actively worked from the late sixties to 1873. During the past seventy years many attempts have been made to operate these properties, but all proved unprofitable. The extent of mining is indicated by the large amount of black sand tailings which were sluiced from these operations into The Lagoons. The first person to explore the deposit for its chromite content was J. D. Mereen, who put down a north-south line and an east-west line of churn drill holes in 1926. Porter Bros. Corporation now controls the Eagle and Pioneer mines, and explored them in 1942 and 1943.

The workings at the Pioneer, where most of the mining was done, consist of a pit 450 feet long, 250 feet wide, and 50 feet deep, and a reported 2,000 feet of tunnels. One of the tunnels is said to have been dug just inside the eastern edge of the deposit for the entire length of the claim. At the Eagle only a small portion of the black sand body was removed from a narrow pit 750 feet long, 120 feet wide, and 55 feet deep, which cuts across the deposit, and from a 35-foot tunnel running south from the pit. Another tunnel was driven 400 feet northward from the pit in 1931-32, above the deposit and along its western edge.

Exploration by J. D. Mereen in 1926, by the Geological Survey in 1940, by the W. P. A. in 1941, and by Porter Bros. Corporation in 1942-43 has shown that the Eagle and Pioneer claims are underlain by a continuous black-sand deposit at least 4,650 feet long, that extends 1,250 feet south of the Pioneer pit and 2,400 feet north of the Eagle pit. As neither end of it has been located by exploration, the deposit probably extends even farther, both to the north and to the south. Black sand said to have been struck in several holes dug in the NW¼NE¼ sec. 28, T. 27 S., R. 14 W., near the Coquille mine, may be part of the same body. Three holes drilled by Porter Bros. on the Lane Extension claim on an east-west line, 3,000 feet south of the Pioneer pit, struck no black sand, but they may have been west of the deposit. The width of the black sand deposit, which is lenticular in shape, is mostly between 300 and 400 feet, but it attains a maximum of 700 feet near the center, and is only about 150 feet wide for the southern 1,100 feet; its thickness ranges from 0 to 14 feet and averages 7.8 feet. The black sand body ranges in altitude from 145 to 175 feet. The overlying sand, clay, and peat ranges from 45 to 75 feet in thickness and averages 57 feet.

The better concentrations of heavy minerals are in the central part and the eastern or landward side. Gravel occurs in the basal part of the deposit in many places. The black sand exposed in the Eagle pit is stained and cemented, but that in the Pioneer pit is unconsolidated and unstained. Most of the deposit is probably similar to that exposed in the Pioneer pit, as the lens is from 10 to 30 feet below the water table. The northern half of the explored part of the deposit lies directly on shale bedrock, but the southern half is underlain by sand, clay, and gravel that is at least 50 feet thick at the Pioneer pit.

11/ Hornor, R. R., op. cit., pp. 18-21.

Logs and stumps are exposed in the Pioneer pit and were found in the black sand in several of the drill holes, and a layer of peat and clay lying just above the deposit was struck in many of the drill holes. A buried sea cliff indicated by the sudden rise of 30 to 40 feet in the shale bedrock along the east edge of the deposit north from the Eagle pit, together with the logs and the layer of peat (later deposited under lagoon conditions), are indicative of a beach deposit.

The average Cr_2O_3 content of the explored ground, with a 3 percent cut-off on the western side, is 8.0 percent. The economic limit of the deposit, even under the most favorable conditions, is probably somewhat south of the northernmost line of drill holes, for there the average depth of overburden is 72 feet and the average thickness of the black sand is 6 feet.

The Lagoons (28).—The Lagoons tailings deposit was near the center of sec. 32, T. 27 S., R. 14 W., 6 miles north of Bandon by road, three-fourths of a mile of which is a dirt road running west from the Seven Devils road. Several unsuccessful attempts had been made to mine the tailings for gold and platinum. The Humphreys Gold Corporation leased the deposit and built a gravity type concentrating plant there in the spring of 1943.12/ Mining and processing of the black sand, and delivery of the rough concentrates under a contract with Metals Reserve Co. began in May 1943. By the time the contract was canceled in December 1943 all but a very small portion of the deposit at the eastern end of The Lagoons had been mined and processed.

The filled-in lagoons for which the deposit was named had been a narrow lake, about 2,500 feet long and averaging slightly over 200 feet in width. Exploration by the W. P. A. crew in 1941 and by the Humphreys Gold Corporation in 1942-43 showed that a layer of peat had accumulated on the bottom and that all but the lower or western 500 feet of the lake had been partly filled with barren sand. The black-sand tailings from the Pioneer and Eagle mines were then sluiced down, completely filling the lake, so that the water table stood at or near the ground surface. The thickness of the black sand deposited in the lake varied from a few feet at the eastern end, where it averaged 5.8 feet, to a maximum of 32 feet at the western end, where it averaged 14.0 feet.

The tailings were made up of irregular and discontinuous layers of sand, in which the chromite content varied widely, especially in the explored area near the east end, where some layers were barren and others were almost 50 percent chromite. The averaged assays of the drill-hole samples collected from the eastern and western areas do not indicate this fact; the western area averages 10.6 percent and the eastern area 11.1 percent Cr_2O_3. The sand is unconsolidated and free from any stain or adherent material.

It is doubtful whether the central unexplored part of The Lagoons deposit, about 100,000 square feet in extent, contained as much chromite to the square foot as the areas explored. The black sand just west of this central area was lower than average in grade, and just east of it the chromite-bearing layer was only from 2 to 5 feet thick.

12/ Huttl, J. B., New type concentration cuts chromite dressing costs: Eng. and Min. Jour., vol. 144, no. 10, pp. 68-70, 1943.

Other occurrences on the Pioneer terrace

Kendall mine (17).—The Kendall mine, which contains the northernmost occurrences of black sand on the Pioneer terrace, is on the line between the NE¼ sec. 8 and the NW¼ sec. 9, T. 27 S., R. 14 W., 10.5 miles north of Bandon and just east of the Seven Devils road on the southern bank of Threemile Creek. Black sand is exposed at several places in a sluiced-out pit 100 feet long from east to west, 30 feet wide, and 20 feet deep. This body of sand, lying against the sea cliff on the east, is at least as wide as the pit is long, and as much as 3 feet thick. The deposit is relatively small, as any former continuation of it to the north has been eroded away by Threemile Creek, and as two east-west lines of holes which were drilled by the Humphreys Gold Corporation in 1942, next to the sea cliff 800 and 2,600 feet, respectively, south of the pit, penetrated only barren sand. A sample taken across 3 feet of consolidated brown- and black-stained sand exposed in the north side of the pit, assayed 8.1 percent Cr_2O_3.

Coquille (Norman) mine (25).—The Coquille mine is on the Pioneer terrace in the NW¼NE¼ sec. 28, T. 27 S., R. 14 W., 7.5 miles north of Bandon and about a quarter of a mile east of the Seven Devils road. A pit 100 feet in diameter and 50 feet deep has been sluiced out on the west side of a gully draining into Sevenmile Creek. Trenches which were dug at the bottom of the pit, but which did not bottom the sand, uncovered clayey sand containing only a small amount of chromite. It is reported that several holes which were drilled just west of the pit struck black sand.

SE¼ sec. 27, T. 27 S., R. 14 W. (26).—Blocks of cemented black-sand float as much as a foot in diameter are scattered for a distance of 200 feet along the west side and near the head of a gully made by a tributary of Sevenmile Creek in the SE¼ sec. 27, T. 27 S., R. 14 W. A sample taken from one of these blocks assayed 7.7 percent Cr_2O_3. The Krome Corporation drilled several hand-auger holes and sank several test pits in this vicinity, but did not find any black sand of sufficient thickness and grade to be of economic interest.

Random exploration on the Pioneer terrace

Shale bedrock was struck at depths varying from 41.0 to 46.5 feet in six holes drilled by Humphreys Gold Corporation at intervals of 300 to 600 feet along a line extending westward from the common corner of sections 16, 17, 20, and 21, T. 27 S., R. 14 W. No black sand was found in any of these holes.

The hole drilled by Humphreys Gold Corporation in the SW¼ sec. 33, T. 27 S., R. 14 W. struck shale bedrock at a depth of 33.5 feet. No black sand was found. The terrace sand is about 50 feet thick at this place, as the collar of the hole on the side of a gully is more than 15 feet below the surface of the terrace.

Occurrence on Whisky Run terrace

Fivemile Point (23).—An unconsolidated layer of black and gray sand crops out along the present sea cliff for a distance of

over 2,000 feet northward from Fivemile Point, which is near the common corner of secs. 17, 18, 19, and 20, T. 27 S., R. 14 W. It varies in thickness from 5 to 9 feet, is covered by 25 to 50 feet of buff and iron-stained barren sand, and is usually separated by several feet of sand and gravel from the underlying uneven shale and sandstone bedrock surface. The top of the gray and black sand layer is about 50 feet above sea level. It contains a relatively high proportion of black mineral grains in some places, but a large percentage of these are ilmenite and magnetite, and none of the 11 samples collected from 6 test pits dug into the layer assayed more than 2.5 percent Cr_2O_3.

Terrace area east and south of Bandon

Black-sand deposits have been mined or prospected in all of the main stream gullies in the terrace area east and south of Bandon from Ferry Creek southward to South Twomile Creek. These deposits are embraced in an area 5½ miles long, 3 to 4 miles wide, and ranging in altitude from about 50 feet at the sea cliff to almost 400 feet at the back. The three easternmost occurrences, at the Iowa mine (29), at the prospect 2,000 feet south of the Iowa (30), and on Johnson Creek (34), are 75 to 150 feet higher than those to the west, and undoubtedly differ somewhat in age from the lower ones. All the known deposits in this area are too thin or too low in grade to be considered as economic sources of chromite.

Explored deposit

Geiger (Little) mine (32).—The Geiger mine is in the SE¼ sec. 32, T. 28 S., R. 14 W., on the south fork of Ferry Creek, 3.2 miles southeast of Bandon. During former placer operations a pit 700 feet long, 200 feet wide, and 20 to 40 feet deep was sluiced out along the creek. In the spring of 1942 the Pacific Co. drilled 19 holes south and east of the pit and along its western edge. Although concentrations of heavy minerals were found in several of the holes, the Cr_2O_3 content was too low to be of economic interest, and the Pacific Co. abandoned all interest in the deposit.

The exploration showed a sharp north-south break in the shale bedrock surface, indicating a buried sea cliff. Holes 1 to 9 inclusive, which are west of the break, reached the shale at altitudes ranging from 142 to 150 feet, whereas holes 10 to 19, which are east of the break, reached bedrock at altitudes ranging from 160 to 185 feet. Brown and gray sand, containing minor concentrations of heavy minerals, were penetrated in holes 1, 2, 3, 7, and 8 just above the bedrock and immediately under a layer of peat. Samples were collected from the last three holes, in which the brown and black sand is 4.3 feet in average thickness, is overlain by 45 feet of overburden, and averages 3.1 percent Cr_2O_3. All of the samples collected from the holes east of the buried sea cliff assayed less than 1 percent Cr_2O_3.

Other occurrences

Iowa mine (29).—The Iowa mine is near the head of a small tributary of the north fork of Ferry Creek, in the S½ sec. 28,

T. 28 S., R. 14 W. During former placer gold-mining operations, a pit 250 feet long and 150 feet wide was sluiced out. A 12-inch layer of chromiferous sand made up of alternating thin sheets of black and gray sand assaying 2.5 percent Cr_2O_3 is exposed in a 45-foot tunnel in the northern end of the pit. The layer is interbedded with buff to gray sand under about 30 feet of overburden.

Prospect 2,000 feet south of the Iowa mine (30).—At a prospect in the N½ sec. 33, T. 28 S., R. 14 W., on the south bank of the north fork of Ferry Creek, 2,000 feet south of the Iowa mine, two short tunnels, now caved, were dug into the side of the gully about 20 feet below the top of the terrace. A layer of black and gray sand interbedded in gray to buff sands, at about 230 feet altitude, or the same as the Iowa mine, and about 1 foot thick, is exposed at the entrance to one of the tunnels. A channel sample taken across this layer assayed 3.0 percent Cr_2O_3.

NW¼ sec. 9, T. 29 S., R. 14 W. (34).—A layer of buff sand, 6 feet thick, containing numerous laminae of gray and black sand, is exposed in a gully running northeast from Johnson Creek, in the NW¼ sec. 9, T. 29 S., R. 14 W. This layer is overlain by about 40 feet of similar sand without laminae, and it is underlain by barren buff sand. A channel sample taken across the laminated gray and black layer assayed 2.3 percent Cr_2O_3. The general appearance and manner of concentration are similar to those at the Iowa mine and the prospect just south of it.

N½SE¼ sec. 32, T. 28 S., R. 14 W. (31).—Black- and brown-stained sand containing a fair percentage of black mineral grains crops out for 100 feet along an old road cut on the east bank of the south fork of Ferry Creek, 1,200 feet north of the Geiger mine pit, in the N½SE¼ sec. 32, T. 28 S., R. 14 W. A 3-foot sample taken from an auger hole 75 feet east of the road cut assayed 4.7 percent Cr_2O_3. Gray shale lies immediately beneath the chromiferous layer and about 20 feet of barren buff to gray sand overlies it.

Pits on Crooked Creek (37).—Two pits were sluiced out, one on each side of Crooked Creek, in the NW¼NW¼ sec. 17, T. 29 S., R. 14 W. Several laminae of black sand are exposed in the pit in the north bank, 30 feet below the top of the terrace. A layer of black sand, 3 feet thick, is said to occur at this locality, but it was not seen.

Black sand deposits, along China and South Twomile Creeks, said to be 1 or 2 feet thick, were worked for gold in the latter part of the nineteenth century.

Denmark area

The Denmark area is about 4 miles long and extends southward from Stone Butte to Crystal Creek. Although the terraces are continuous from the Seven Devils area to Port Orford, the only known occurrences of black sand between the Bandon area and the southern end of the terraces are in the Denmark area, which lies near the back of the lower terraces, 6 to 10 miles north of Port Orford.

Explored deposit

Butler (Baker) mine (38).—The Butler mine is 9 miles north of Port Orford and just east of U. S. Highway 101, in the SW¼SW¼ sec. 27, T. 31 S., R. 15 W. A pit extending 700 feet in a north-south direction and having a width of 100 to 200 feet was sluiced out during former mining operations. The property is owned by the Krome Corporation.

Exploration by the Krome Corporation in the summer of 1941 proved that the deposit of chromiferous sand exposed in the pit extends at least 500 feet north and 200 feet south from the ends of the pit (see pl. 50). No black sand was found in trenches dug along a stream gully 800 feet north of the pit, and a magnetometer survey, made by the geophysical branch of the Geological Survey in the spring of 1942, indicated that the lens pinched out a short distance south of the explored ground. It is concluded from this evidence that the deposit is between 1,600 and 1,800 feet long. The width of the explored part of the deposit ranges from 90 to 300 feet and averages 220 feet, and the average thickness is 5.9 feet. Approximately 30 percent of the deposit has been removed by ground sluicing in the pit. The top of the black sand ranges from 143 to 162 feet in altitude. The overlying material, which is mostly clay on the east side and sand and gravel on the west side, varies from 5 to 20 feet in thickness and averages 15 feet.

The deposit has a rudely lenticular shape; it thins to a knife edge on the east or landward side, is thickest in the center, where it has a maximum known thickness of 14.8 feet, and grades into low-grade sand of medium thickness on the west side. Although the surface of the shale bedrock is irregular, the deposit has a general average slope of about 5° W. Although the chromiferous sand exposed in the pit is coated with brown and black stain and is poorly cemented, some of the sand taken from the drill holes was free from any adherent material. The explored part of the chromiferous sand averages 8.5 percent Cr_2O_3. Wood was struck in only one of the 37 holes and pits. The basal part of the deposit for the most part consists of a foot or more of black sand and gravel. Large boulders of pre-Tertiary rocks found in the coarse gravel indicate that the Sixes River formerly emptied into the sea nearby.

Other occurrences

NW¼ sec. 34, and SW¼ sec. 27, T. 31 S., R. 15 W. (39).—The State Department of Geology and Mineral Industries, in the spring of 1942, drilled seven holes south of the Butler mine, two of them in the SW¼ sec. 27, T. 31 S., R. 15 W., and the other five in the NW¼ sec. 34. Two of these holes were on an east-west line about 250 feet south of the Butler mine pit, two more were on an east-west line 1,500 feet south of the pit, and the other three were on an east-west line about 1,000 feet farther south. Although all of these holes were drilled in ground outlined by a magnetic anomaly, only 2 to 3 feet of black sand covered by 30 to 50 feet of overburden and containing 5 percent Cr_2O_3 was found in the two holes on the middle line. None of the other five holes, however, were taken to bedrock, and they might have struck black sand if continued.

Madden mine (40).—The Madden mine is about 7.5 miles north of Port Orford and a quarter of a mile east of U. S. Highway 101, in the SE¼SE¼ sec. 4, T. 32 S., R. 15 W. The material constituting the terrace deposits exposed in the mine pit ranges from coarse sand to gravel; black sand occurs only in scattered thin layers a fraction of an inch thick.

Rogue River area

Sand layers made up of alternating brown and gray and black laminae crop out in several places at the base of the terrace deposits along the sea cliff 2 to 5 miles north of the Rogue River. They are 4 to 10 feet thick and are overlain by 30 to 60 feet of barren sand and clay. Black sand is concentrated most in depressions in the wave-cut bench. The average Cr_2O_3 content of the sand layers is probably less than 3 percent, for 90 percent of the black mineral grains in the observed concentrations are magnetite and ilmenite. Since the present sea cliff is as much as a quarter of a mile west of the back of the terrace at some places, the deposits farther inland may contain greater concentrations of heavy minerals, but it is doubtful whether even they would contain enough chromite to be considered economic. The following two samples are from localities that showed the best concentrations.

E½ sec. 12, T. 36 S., R. 15 W. (43).—A channel sample taken across 6 feet of alternating layers of black and brown sand, lying at the base of the terrace deposit 1,000 feet south of Hubbard Mound, in the E½ sec. 12, T. 36 S., R. 15 W., assayed 6.53 percent Cr_2O_3. One layer of almost jet-black sand is 2.5 feet thick. The overlying barren sand is about 60 feet thick.

NW¼ sec. 13, T. 36 S., R. 15 W. (44).—A channel sample taken across 6 feet of alternating layers of black and brown sand at the base of the terrace deposit just north of Otter Point, in the NW¼ sec. 13, T. 36 S., R. 15 W., assayed 3.6 percent Cr_2O_3. The overburden at this place is 35 feet thick.

PRESENT BEACHES

General character of beaches

Promontories and rock headlands divide the 60 miles of beaches between Coos Bay and Gold Beach into many segments. Most of these are less than a mile in length and roughly crescentic in plan, though some are 2 to 14 miles in length and are uninterrupted for many miles. Stacks and small islands, which lie off many of the beaches, tend to deflect and complicate shore currents. The backshore, that portion of the beach between high-tide shoreline and the sea cliff, is well developed only near the mouths of the larger streams, where bay bars have been formed. The foreshore, the portion of the beach between high-tide shoreline and low-tide shoreline, varies from 25 to 750 feet in width. The beach deposits probably increase in thickness from a few inches or feet at the back, at the base of the sea cliff, to 5 to 20 feet in the lower foreshore.

Fine- to coarse-grained sand makes up most of the visible beach, though gravel and some cobbles crop out at short intervals along the back of the beach and such material may extend

seaward under the beach sand. Driftwood and logs, many of which are several feet in diameter and as much as 40 feet long, litter the landward part of some of the beaches.

Concentrations of heavy minerals occur near the backs of some beaches. These concentrations are made up of irregular layers of buff, gray, green, and black sand, usually overlain by a thin layer of white or buff-colored sand which thickens seaward. In general, from what is known, these concentrations are relatively long, narrow, and thin, so that they might be called "stringers." Where they have been formed in a well developed back beach, as Ophir Beach and Gold Beach, they may be as much as 10 to 20 feet thick, although most of the stringers range from a few inches to several feet in thickness, averaging 2 to 3 feet. Most stringers are 1,000 to 2,000 feet in length, and a few have been traced for distances of almost a mile. The widths of the stringers, as determined by shoveling, are commonly between 30 and 100 feet, and range up to 200 to 400 feet. It is possible, however, that some of these concentrations may be still wider, being concealed on the seaward side under barren sand. Chromiferous sand bodies may also occur offshore within the range of wave action, where the shape of the shoreline and sea bottom are favorable.

All the concentrations of heavy minerals are found in beaches that contain sand reworked from terraces by waves or streams, or both, and the concentrates in the present beaches are mineralogically similar to those in the black-sand deposits in the terraces immediately behind. These two facts prove conclusively the local origin of the deposits in the present beaches. Chromite is predominant over magnetite and ilmenite in all the beach deposits between Coos Bay and Gold Beach except those close to Gold Beach.

During violent storms, wave action changes the forms of beaches and the distribution of material in them. Concentrations may be built up in a storm, only to be carried away during the next storm or dissipated by wind during the dry season. The following descriptions apply to those beaches which contained the larger concentrations during 1942 and 1943, when the concentrations were relatively static. It is estimated that the beaches described contain 100,000 to 150,000 long tons of chromiferous sand averaging at least 5 percent of Cr_2O_3. Most of the sand in these beaches contains less than 1 percent Cr_2O_3 and may be regarded as barren.

Beach deposits

Beach at mouth of Fivemile Creek (11).—The beach at the mouth of Fivemile Creek is in the $S\frac{1}{2}$ sec. 32, T. 26 S., R. 14 W. It is 4,000 feet long and 100 to 500 feet wide, including a poorly defined backshore up to 200 feet wide, in which a strip 50 to 75 feet wide, 2 to 3 feet thick, and 1,200 feet long, lying just west of the sea cliff, is made up of alternating thin layers of gray and black sand (see pl. 51). A 3-foot vertical channel sample, collected 500 feet north of the mouth of Fivemile Creek and 50 feet west of the sea cliff, assayed 7.8 percent Cr_2O_3.

Beach at mouth of Threemile Creek (15).—The beach at the mouth of Threemile Creek, in sec. 5, T. 27 S., R. 14 W., is about 2,500 to 3,000 feet long. A deposit 50 to 75 feet wide and 2 to 3 feet thick, next to the sea cliff, extending 400 feet north and 1,200 feet south of the mouth of the stream, is made up of alternating thin layers of black and gray sand (see pl. 51). A

2.5-foot vertical channel sample, collected 1,000 feet south of the mouth of the stream and 20 feet west of the sea cliff, assayed 7.7 percent Cr_2O_3.

Beach at mouth of Twomile Creek (18).—The beach at the mouth of Twomile Creek, in secs. 8 and 17, T. 27 S., R. 14 W., is 2 miles long. A strip 800 feet long and 50 to 75 feet wide, lying next to the sea cliff near the north end of the beach, is underlain by alternating thin layers of black and gray sand (see pl. 51). A 2.5-foot vertical channel sample, collected 500 feet south of the north end of the beach and 20 feet west of the sea cliff, assayed 6.7 percent Cr_2O_3.

Beach at mouth of Johnson Creek (33).—The beach at the mouth of Johnson Creek, in sec. 36, T. 28 S., R. 15 W., and sec. 1, T. 29 S., R. 15 W., is about 1 mile long. For almost 2,500 feet north from the mouth of the creek, a layer of black sand about a foot thick and 100 feet or more in width, lying next to the sea cliff, is covered with 1 to 3 feet of buff to gray sand. Of 11 samples collected from this beach, 5 came from the part underlain by the chromiferous sand, or from holes deep enough to have cut that sand if it were present. These 5 samples, which were channeled from the surface down, represented an average thickness of 2.8 feet and averaged 7.6 percent Cr_2O_3.

Black sand occurrences in the beach near the mouth of China Creek (35, 36).—A layer of black sand about a foot thick, lying near the back of the beach, occurs 2,500 feet north of the mouth of China Creek, in sec. 11, T. 29 S., R. 15 W. No continuation was struck to the north or south. A 3.5-foot channel sample taken from the top of the beach to the bottom of the layer of black sand assayed 9.6 percent Cr_2O_3(see pl. 51).

Gray sand, ranging in thickness from 3.5 to 7.5 feet and containing many thin layers of black sand, is exposed for a width of 250 feet where China Creek has cut through the backshore in sec. 11, T. 27 S., R. 15 W. A 7.5-foot channel sample, taken where the thickness was greatest, assayed 4.7 percent Cr_2O_3.

Cape Blanco beach (41).—Cape Blanco beach, which lies between Cape Blanco and The Heads, is $6\frac{1}{2}$ miles long. It crosses secs. 1, 2, and 12, T. 32 S., R. 16 W., and secs. 18, 19, 30, and 31, T. 32 S., R. 15 W. (see pl. 51). A strip of the beach midway between the promontories, 4,000 feet long, 30 to 60 feet wide, and lying just west of the sea cliff, is covered with a veneer of alternating layers of black and gray sand averaging half a foot in thickness. A 2.5-foot channel sample taken at one of the indentations where the black sand concentration was thicker, assayed 12.18 percent Cr_2O_3.

Ophir beach (42).—Ophir beach is in sec. 8, T. 35 S., R. 14 W., at the mouth of Euchre Creek. The back portion of the beach, about a mile long and as much as 1,200 feet wide, contains a concentration of black sand in a triangular area, approximately 500 feet on a side, in the northeastern part of the beach. Two channel samples, one across 12 feet and the other across 8.5 feet, assayed 9.3 and 8.1 percent Cr_2O_3 respectively.

Rogue River beach (45).—The backshore part of the Rogue River beach, which crosses secs. 24 and 25, T. 36 S., R. 15 W., and secs. 1, 12, and 13, T. 37 S., R. 15 W., averages about 20 feet in thickness and 400 to 500 feet in width over a length of 4 miles. It is grown over with grass and brush and littered in places with drift logs, and seems to be stable, although it is

reported to have been part of the active beach in the late part of the nineteenth century. Black opaque mineral grains make up 10 to 25 percent of the sand in the backshore beach, but a large proportion of them are magnetite, and 11 channel samples, representing thicknesses of 4 to 9 feet, averaged only 1.12 percent Cr_2O_3.

ANNOTATED BIBLIOGRAPHY

Blake, W. P., Gold and platinum of Cape Blanco: Am. Jour. Sci., 2d ser., vol. 18, p. 156, 1854.

Author reports upon sample of gold and platinum washed from beach sands at Point Oxnard (Cape Blanco).

Diller, J. S., U. S. Geol. Survey Geol. Atlas, Coos Bay folio (no. 73), 1901.

Coos Bay quadrangle is on southwest coast of Oregon, and is bounded by parallels 43° and 43°30', the coast on the west, and meridian 124° on the east. The formations in this area are mostly Tertiary sedimentary rocks, with some Mesozoic sedimentary rocks at the southern end, some basaltic intrusives, and marine sand and gravel capping the terraces along the coast. Mineral resources are mainly coal; some sandstone and amphibole schist have been quarried for jetties, and a small amount of gold has come from black sand deposits in present and ancient beaches.

Diller, J. S., Topographic development of the Klamath Mountains: U. S. Geol. Survey Bull. 196, 66 pp., 13 pls., 7 figs., 1902.

Physiographic history of the Klamath Mountains area of southern Oregon and northern California is discussed, beginning with formation of Klamath peneplain in Miocene time and ending with Recent local subsidence in the Coos Bay area of Oregon. Describes development of marine terraces, which are found from sea level to an altitude of 1,500 feet.

Diller, J. S., U. S. Geol. Survey Geol. Atlas, Port Orford folio (no. 89), 1903.

Port Orford quadrangle is on southwest coast of Oregon, bounded by parallels 42°30' and 43°, the coast on the west, and meridian 124° on the east. Rocks in this area include schists, Mesozoic and Tertiary sedimentary rocks, intrusive igneous rocks, and Pleistocene marine sand and gravel capping the terraces along the coast. The mineral resources consist principally of coal, and stream and beach placer deposits of gold and platinum.

Day, D. T., and Richards, R. H., Useful minerals in the black sands of the Pacific slope: Mineral Resources U. S., 1905, pp. 1175-1258, 1906.

Mineral determinations were made of 862 samples of black sand, most of which were concentrates from placer operations. Special emphasis, however, was placed upon the beach sands of Oregon, which were found to contain the following minerals: quartz, magnetite, ilmenite, chromite, garnet, hypersthene, olivine, monazite, zircon, gold, the platinum metals (the main reason for the study), and other minerals in greater or less quantity.

Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, 143 pp., 9 pls., 16 figs., 1914.

Bulletin discusses geology of southwestern Oregon, and then describes gold-quartz and copper lodes, and stream and beach placer mines and prospects. Platinum, quicksilver, and nickel are briefly considered. Coal, especially in Coos Bay field, is also discussed. Production figures for mineral resources are given.

Butler, G. M., and Mitchell, G. J., Preliminary survey of the geology and mineral resources of Curry County: Mineral resources of Oregon, vol. 2, 136 pp., 1916.

A report on a reconnaissance survey of Curry County in which the geology is briefly summarized and brief descriptions of the mineral deposits are given. The statements about the beach deposits are largely quoted from Diller.

Hornor, R. R., Notes on the black sand deposits of southern Oregon and northern California: U. S. Bur. Mines Tech. Paper 196, 39 pp., 8 illus., 1918.

Author investigated and described 18 black sand mines and prospects on the terraces and 4 in the present beaches, and 3 stream placer mines. Concluded that black sand deposits were disappointing in both quality and quantity, gold and platinum rarely occurring in quantities sufficient to be exploited at a profit.

Pardee, J. T., Beach placers of the Oregon coast: U. S. Geol. Survey Circular 8, 41 pp., 16 figs., 1934.

About half of Oregon coast bordered by coastal plains; most of these south of Coos Bay are moderately elevated marine terraces, which are a part of a terrace series appearing at intervals along Oregon and California coast between sea level and height of 1,500 feet. Submature shore is about half prograded and other half along terrace plains is retrograded. Terraces are capped by Pleistocene beach and offshore sediments, containing black sand placer deposits from which gold and platinum have been extracted, as well as from concentrations in present beaches. Source of beach minerals is the Klamath Mountains from which they have been eroded ever since middle Tertiary time. Present beach placers are suitable for small-scale operations, and black sand beds on the terraces contain a little gold and platinum and might be a future reserve of chromite.

Twenhofel, W. H., Origin of the black sands of the coast of southwest Oregon: Oregon State Dept. Geol. and Min. Ind., Bull. 24, 25 pp., 6 figs., 1943.

Interest in the black sands, which occur in present beaches and beneath surfaces of marine terraces, is renewed because of the chromite in them. Sources of black sands are basic and ultrabasic rocks in Klamath Mountains, especially that part drained by Rogue, Illinois, Smith, and Klamath Rivers. Discusses theory of beach and offshore sedimentation in relation to: strength of waves and currents and their impingements on a coast, shoreline configuration, changes of sea level relative to land, and specific gravity and dimensions of sedimentary particles. On basis of distribution of deposits and theoretical considerations, author concludes that the black sand deposits on the terraces must have been laid down during submergence

of coastline, and for this reason most of them have no relation to present terraces which were cut by retreating sea. Some black sand deposits may still remain deeply buried.

Dasher, J., Frass, F., and Gabriel, A., Mineral dressing of Oregon beach sands: U. S. Bur. Mines Rept. Inv. 3668, 19 pp., Nov. 1942.

Authors concluded that a chromite concentrate containing more than 40 percent Cr_2O_3 may be produced from samples from Pioneer, Shepard, and Butler mines, The Lagoons, and Ophir beach. The proposed milling steps are cleaning, classification, hydraulic tabling, drying, and electrostatic and, in some instances, magnetic separation. A salable zircon concentrate and a garnet concentrate that may be salable may also be produced.

Griggs, A. B., and Wells, F. G., Origin of some chromiferous sands along the southwestern Oregon coast (abstract): Econ. Geology, vol. 38, no. 1, p. 38, 1943.

Paper reports on exploration, description, and origin of chromiferous sand deposits that occur on marine terraces and in present beaches along southwestern coast of Oregon.

Huttl, J. B., Oregon chrome sands yield to magnetic separation: Eng. and Min. Jour., vol. 144, no. 9, pp. 62-65, Sept. 1943.

Author describes flow sheets for the Krome Corporation's concentrating plant at the Seven Devils mine and Defense Plant Corporation's separation plant near Coquille, Oreg. Also briefly describes chrome-sand deposit at Seven Devils mine.

Huttl, J. B., New type concentrator cuts chromite dressing costs: Eng. and Min. Jour., vol. 144, no. 10, pp. 68-70, Oct. 1943.

Author gives detailed description of Humphreys Gold Corporation's spiral concentrator and describes flow sheet of their plant at The Lagoons chrome-sand deposit.