TIN, QUICKSILVER, PLATINUM, ETC.

TIN IN THE FRANKLIN MOUNTAINS, TEXAS.

By G. B. Richardson.

Introduction.—Since the publication of Mr. W. H. Weed's report on the El Paso tin deposits[a] the geology of the Franklin Range, in which the ore occurs, has been further studied, and some additional prospecting has been done. In view of the scarcity of tin in the United States, it seems desirable to outline the conditions as now known in the western Texas tin field.

Topography.—The Franklin Mountains are the southern extremity of the long, narrow range, known locally by different names, that extends southward from the Rocky Mountains east of the Rio Grande as far as El Paso. The Franklin Mountains are 23 miles in length, 15 of which are in Texas, average 3 miles in width, and rise 3,000 feet above the adjacent lowlands, culminating in North Franklin Peak, whose elevation is 7,140 feet. The western face is relatively little eroded and constitutes a dip slope. The eastern side, on the contrary, is much dissected and exposes cross sections of the rocks. The range is practically bare of vegetation, its lower slopes only being occupied by desert growths, among which greasewood, lechuguilla, sotol, and prickly pear are prominent. The rocks, therefore, are plainly exposed, except where covered by local accumulations of débris.

General geology.—The accompanying geologic map (fig. 7) outlines the distribution of the different formations in the Franklin Mountains. The rocks have been studied in detail only in the eastern part of the range in the area lying within the El Paso quadrangle, west of which only general conditions are shown. For the present purpose it will not be necessary to do more than outline the broader features of the general geology, since details will be published in the forthcoming El Paso folio.

The oldest rocks in the Franklin Mountans are of pre-Cambrian age and include two distinct formations. The lower one consists of about 1,800 feet of light and dark quartzites and subordinate slates, which have been cut by a few thin diabase dikes. These rocks are succeeded by a bed of rhyolitic conglomerate, which attains in places a thickness of 400 feet, above which is a mass of porphyritic red rhyolite over 1,000 feet thick. About 300 feet of indurated, fine-textured sandstones carrying Upper Cambrian fossils overlie the rhyolite and contain rounded pebbles of the latter in the basal bed. The sandstone is succeeded by a considerable thickness, amounting to 5,000 feet or more, of massive gray limestone, which lithologically is difficult to subdivide but paleontologically is separable into four main parts. These are referred to the Lower and Upper Ordovician, Silurian, and Upper Carboniferous, the approximate thickness of limestone assigned to each division being, respectively, 1,000, 400, 1,000, and 3,000+ feet. The Devonian and Mississippian are not represented by sediments. All of these rocks from the pre-Cambrian to the Carboniferous are structurally conformable and dip westward at angles varying in different

[a] Bull. U. S. Geol. Survey No. 178, 1901.

parts of the range from 20° to 45°. No sediments of early Mesozoic age are present, but Cretaceous strata, including the Washita and Benton groups, occur in isolated areas west and south of the range. The adjacent lowlands are underlain by gravel, sand, and clay to a depth of over 2,000 feet.

A considerable amount of granite occurs in the Franklin Mountains along the eastern base, chiefly associated with lines of faulting. The granite is a post-Paleozoic intrusion

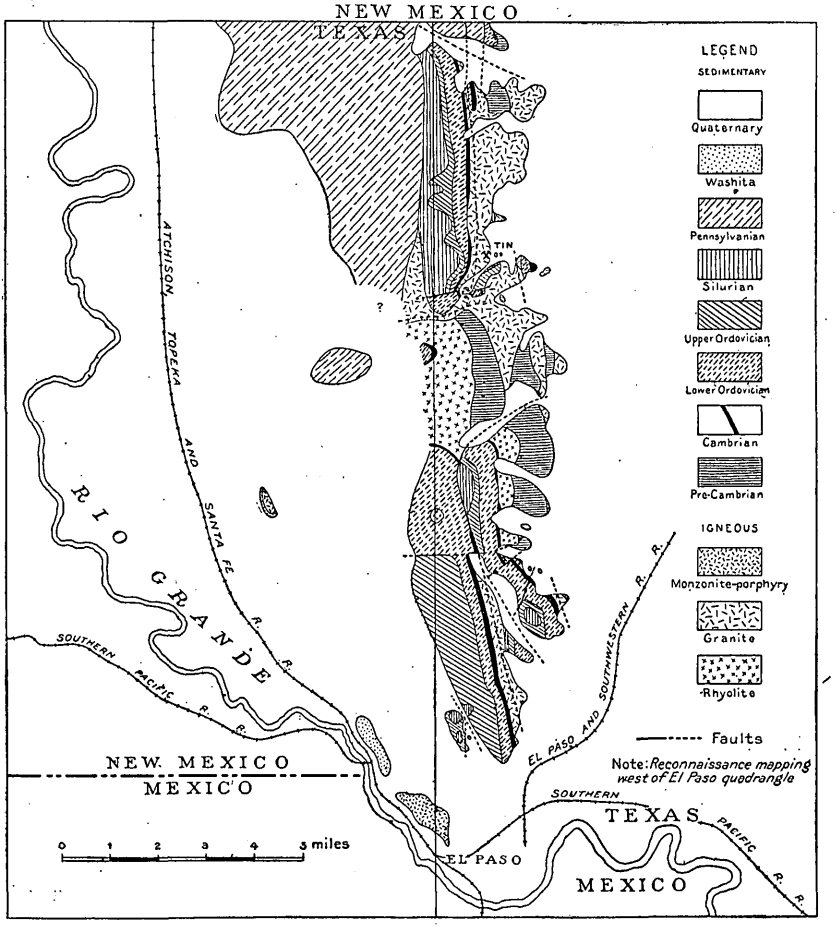

FIG. 7.—Geologic map of the Franklin Mountains, Texas.

and is important as the rock in which the tin ore occurs. It is a medium to coarse textured variety, superficially reddish in color, and weathers readily to a coarse sand. Fresh exposures are rare but from the tin prospects specimens are obtainable, a partial analysis of one of which by E. C. Sullivan, of the United States Geological Survey, gave:

Partial analysis of granite from tin prospect in Franklin Mountains, Texas.

	Per cent.
SiO_2	73.76
CaO	.81
K_2O	5.66
Na_2O	3.64

The alkalies are slightly higher and the lime lower than in normal granite. The rock is composed of preponderating quartz and feldspar, the latter in excess, with subordinate

biotite, rare hornblende, and bits of magnetite. The feldspars are orthoclase and albite, commonly present in the minutely intergrown form known as microperthite. A small area of monzonite-porphyry of post-Comanche age occurs near the Rio Grande.

Two prominent sets of joints, striking in general north-south and east-west, traverse the rocks of the Franklin Mountains, and the distribution of the strata reveals several large faults in both of these directions. The main faulting is approximately parallel with the north-south trend of the range, and as the strata dip toward the west the internal structure shows a series of tilted blocks. Whether the whole range is a large block limited on the east by a fault, although suggested by the topography, has not been determined. The fact of recent movements is proved by the presence of minor faults in a sand bank in the northern part of El Paso. These displacements follow the same trend as the principal faults in the mountains.

Occurrence of the ore.—Prospecting has revealed the presence of tin ore in a small area in granite at the eastern base of the Franklin Mountains about 12 miles due north of El Paso, but not enough development has been done to make possible generalizations of much value concerning its occurrence.

Reference to the map brings out the fact that the prospect lies adjacent to one of the main north-south faults. Here the displacement amounts approximately to 3,000 feet, shown by the fact that the Silurian limestone which outcrops on the crest of the range occurs on low hills east of the prospect. The exact position of the fault plane is obscured by the granite, which is intrusive along it. Other near-by faults are also indicated on the map, and there is evidence of minor displacements. The joint planes present in the rocks throughout the range are here characteristically developed, and the tin occurs as cassiterite, associated with quartz veins along the east-west joints in the granite. The joints along which the veins occur strike transversely to the trend of the range, and the veins dip perpendicularly or at high angles either northward or southward. The greatest distance that any of these veins has been traced along the surface is about 1,000 feet, and one has been followed downward to a depth of about 50 feet. The quartz is massive, white, and of variable thickness, varying from a fraction of an inch to 2 feet, irregularly thickening and pinching out. Locally the walls of the vein are plane and the contact with the country rock is smooth. At other places the veins grade off into the granite. The mineralized zone at the greatest width measured is not over 6 feet thick and ranges from this to 0. Sections across the zone show irregular veins of quartz in the granite, which is minutely seamed with joint cracks. Cassiterite occurs in the vein quartz and more abundantly immediately contiguous to it. In the vein quartz the oxide of tin occurs, both in bunches and irregularly disseminated, intergrown with the quartz. More concentrated deposits of cassiterite occur intimately associated with the quartz and feldspar of the granite adjacent to the veins. Mineralization apparently occurs only contiguous to the veins and fades out a few inches from them. The cassiterite is present in crystals less than a tenth of an inch in size, both twinned and in simple tetragonal forms, and it also occurs massive. Specimens of nearly pure cassiterite weighing several pounds are reported to have been obtained from this locality, but the area has been well picked over and at present, without further work, good specimens are difficult to find. The present stage of development, therefore, is unfavorable for detailed study. Minerals usually associated with tin apparently do not occur abundantly here. Weed reports the occurrence of wolframite and of a single grain of tourmaline. Fluorspar is sparingly present, associated with the cassiterite, which occasionally includes it. Some pyrite is present, and limonite occurs superficially through the veins and locally forms a selvage between them and the granite. No dikes have been observed in the granite in the vicinity of the tin prospect, although a specimen in the office of Judge C. R. Morehead, one of the owners of the property, suggests that pegmatite may be present. On the crest of the granite ridge 2½ miles southeast of the main tin prospect there is a vein of common garnet, with no associated vein minerals, parallel to the east-west joints in a coarse-textured phase of the granite. The vein varies from an inch to a foot in width and is at least 200 feet long.

Development and future.—A frame cabin near a feeble seep spring about a quarter of a mile southeast of the main prospect serves as a working base. But for a considerable supply of water, wells must be sunk on the mesa east of the mountains, where an abundant amount is available, reached by wells between 200 and 300 feet deep, in which the water rises to about 180 feet from the surface. The El Paso Southwestern Railroad crosses the mesa 6 miles from the prospect.

The principal development of this property has been recorded by Mr. Weed. The ore was dicovered in 1899 and at the time of his visit, in 1901, the three veins then known had been exposed for several hundred feet along their length and a few pits had been sunk, the deepest being 50 feet. Little work appears to have been done on these veins since then, although they have been much visited. In 1904 two small occurrences of tin ore associated with quartz were found about half a mile apart, the farthest being between 1½ and 2 miles north of the old workings. These new occurrences are similar but smaller than those first found. Development has not gone further than barely scraping the surface along the veins for a few hundred feet and sinking a few shallow pits. The work reveals irregular streaks of quartz, with associated cassiterite, varying up to 2 inches in thickness, in veins parallel to joints transverse to the trend of the range, in much decomposed and broken granite. Locally slickensided surfaces of granite occur. In a pit about 8 feet deep on the northernmost vein the quartz was found to fade away at a depth of 4 feet below the surface.

Present developments do not warrant a prediction of the future of this field; it may or may not prove to be of considerable value. Some of the ore is of excellent quality and the chief question concerns its abundance. This can be determined only by further development and prospecting. In seeking new localities for similar occurrences, the entire granite outcrop might well be examined, and it should be borne in mind that the veins thus far found do not follow the contacts of the granite with the adjacent rocks, but occur along the east-west set of joints.

INVESTIGATION OF BLACK SANDS FROM PLACER MINES.

By DAVID T. DAY and R. H. RICHARDS

INTRODUCTION.

One of the earliest notes concerning the occurrence of gold in California[a] points out the probable occurrence of gold in the black sands of the Pacific seacoast, and also points out the difficulty in the separation of the grains of gold from the accompanying heavy minerals.

Among the early prospectors for gold in California this difficulty of separating gold from black sands was recognized and the black sands were avoided. Some account of the minerals making up these sands was given by B. Silliman,[b] who showed that the black sands of Butte County, Cal., contained platinum and iridosmine, magnetite, zircon, chromite, garnet, rutile, diamond, topaz, epidote, pyrite, and limonite. This is one of the earliest references to the occurrence of platinum on the west coast. Following Silliman, W. P. Blake recognized platinum as of frequent occurrence in the black sands of the California sea beach, between Cape Mendocino and the Oregon line. The attention thus called to the occurrence of platinum resulted in considerable mining designed to extract gold from these sands and frequently a small amount of platinum was saved. The platinum was found to contain also considerable proportions of iridosmium and iridium, for which there was no adequate sale. Only a small amount of iridosmium was bought for the purpose of picking out points for gold pens, the rest having no regular market.

While the knowledge of the occurrence of platinum was extended by the placer miners to Del Norte, Humboldt, Trinity, Siskiyou, and other counties in California, and to Coos, Curry, Jackson, and Josephine counties in Oregon, as well as to considerably richer localities in British Columbia, notably in Granite Creek, a tributary of Tulameen River, little interest was taken by them in saving the platinum, on account of its small value. In 1897, however, a demand suddenly arose for osmium from the Welsbach Light Company, which needed a supply for making the filament of the osmium incandescent electric light. In 1897 and 1898 one of the writers examined various placers in Shasta, Tehama, Trinity, Humboldt, Siskiyou, Del Norte, San Luis Obispo, and other counties in California, in Coos, Curry, Jackson, and Josephine counties in Oregon, and at Granite Creek in British Columbia. From these occasional visits it became evident that even with the new market for the osmium found with the platinum, no adequate supply of platinum would be obtained until a system of separating and utilizing the accompanying minerals in the black sand should be developed.

[a] Dr. Edward Everett Hale has furnished this reference from Shellrocke's Voyages to California, published in London in 1742.

[b] Am. Jour. Sci., 3d ser., vol. 6, 1873, p. 132.

In the spring of 1905 Congress directed that the report on the Mineral Resources of the United States should include an investigation into the useful values contained in the black sands of the Pacific slope.

PLAN OF PRESENT INVESTIGATION.

EXAMINATION OF SAMPLES.

As the initial step in this investigation the Geological Survey sent a circular letter to the placer miners of the United States, requesting them to send by mail samples, weighing 4 pounds or less, of the heavy-sand residues left in their sluice boxes in placer mining. This met with hearty response and a large amount of material for a preliminary examination was rapidly accumulated. In all, over 2,000 samples have been sent in from 34 States and Territories, and from British Columbia, Mexico, and South America. The following table shows the chief mineral constituents contained in these sands:

Proportion of various minerals in the black sands of the Pacific slope.

[Pounds per ton, except gold and platinum, dollars per ton.]

No. of sample.	Locality from which sample was obtained.	Magnetite.	Chromite.	Garnet.	Olivine.	Monazite.	Zircon.	Quartz.	Mixed minerals.	Gold and platinum.
	CANADA.									
P21	Toronto	561.00	218.00	818.00	.....	13.00	21.00	.....	.....	$230.78
	ALASKA.									
P65	Cape Nome	137.27	[a] 63.00	755.00	.....	.....	4.00	905.00	[b] 134.10	Trace.
P109	Dominion Creek, Yukon Territory	1,088.00	180.20	632.50	.....	.....	.83	68.82	28.88	411.90
	CALIFORNIA.									
	Del Norte County:									
P99	Crescent City	480.78	209.38	503.13	574.16	56.03	43.55	132.21	.....	.24
P100a	Gilbert Creek, north of Smith River	50.55	48.40	23.86	72.93	.12	.97	1,035.29	768.60	.....
P100b	Smith River	840.57	508.96	83.30	366.92	.....	17.45	237.91	27.50	[c] 2.45
	Humboldt County:									
P89a	Gold Bluff	244.55	75.18	171.57	818.60	.....	16.94	593.60	98.65	6.01
P89b	Do	469.44	103.15	435.26	665.84	.....	16.70	309.84	.....	.....
P89c	Do	103.11	20.77	69.63	836.00	.....	3.65	800.30	166.80	1.19
P130	4 miles north of Upper Gold Bluff	25.01	1.39	8.36	2.58	.....	.18	979.64	982.50	Trace.
	Mendocino County:									
P103a	Fort Bragg	4.61	.....	1,874.00	18.74	.....	34.49	36.14	31.43	[c] .11
P103b	Do	3.60	4.09	1.87	.....	.....	5.77	536.50	1,447.20	[c] .17
P95	Sacramento County: Sacramento Valley	356.00	1,121.00	.....	.....	.....	316.90	93.99	108.40	144.33
P120	San Mateo County: Beach	356.60	1,022.29	14.20	[d] 290.00	.....	110.40	215.70	.....	Trace.
P27	Yuba County: Marysville	562.00	[e] 122.00	10.70	176.00	Trace.	3.00	714.00	.....	.97
	IDAHO.									
	Ada County:									
P36	Boise	26.40	200.80	709.10	.....	219.60	231.40	579.40	.....	1.03
P81a	Do	946.20	51.35	554.20	227.40	.....	.....	220.30	.....	12.50

[a] Ilmenite.
[b] Includes rutile.
[c] No platinum.
[d] Includes other basic igneous minerals.
[e] Includes ilmenite.

Proportion of various minerals in the black sands of the Pacific slope—Continued.

No. of sample.	Locality from which sample was obtained.	Magnetite.	Chromite.	Garnet.	Olivine.	Monazite.	Zircon.	Quartz.	Mixed minerals.	Gold and platinum.
	IDAHO—continued.									
	Ada County—Continued.									
P111a	Boise	[a] 1,092.90	[b] 646.30				100.50	20.38	139.90	173.40
P111b	Do	513.30	[b] 951.00				23.30	281.30	231.20	7.29
P111c	Do	782.70	[b] 746.10				21.13	292.40	157.60	[c] 14.71
P105	Do	3.21	[b] 3.62	10.21			.29	1,606.00	376.50	[c] .78
P113	Do	[f] 7.43		1.19	.96		.10	1,502.55	487.41	
P81b	Bingham County: Snake River	35.80	[b] 8.73	8.23	30.45		1.19	1,185.52	729.21	[c] .40
P74	Custer County: Robinson	886.50	616.70	452.30			[d] 32.87	7.94		7.22
P107	Elmore County: Wood Creek, Pine Grove mining district	1,721.00	[e] 221.71				5.50	51.77		Trace.
	Lemhi County:									
P31a	Arnett Creek, Leesburg Basin	959.60	832.80	116.80		.45	1.55			[c] 86.81
P31b	Camp Creek, Leesburg Basin	1,290.00	474.20	55.99	14.00		.60			Trace.
P31c	Ward's Gulch, Leesburg Basin	747.90	859.00	128.70		5.54	60.89	73.00		[c] 43.54
P31d	Richardson Bros., Leesburg Basin	433.20	477.20			10.89		65.33		[c] 2.69
P31e	Placer diggings, Leesburg Basin	1,939.00	.91	4.20		.50	.86	8.00		
P66	Leesburg	[a] 1,807.20		37.04		20.38		135.18		6.63
P40	Lincoln County: Shoshone	174.80	15.17	80.67		26.34	46.09	1,441.00		[c] 26.33
P93	Nez Perces County: Salmon River	981.10	688.00	113.30	36.89	46.63	122.40	12.03		[c] 234.34
P64	Shoshone County: Dent	28.26	1,336.00	307.60		283.40		45.72		
P25	Washington County: Meadows	629.40	564.10	Trace.		123.80	392.50	232.50		9.64
P85a	Oneida County	9.00	[b] 1.80	8.40	18.00			1,335.30	628.00	Trace.
	MINNESOTA.									
P71	Swift County: Benson	869.00	38.28	717.80	269.80		35.57	70.36		26.22

[a] Includes hematite.
[b] Includes rutile.
[c] No platinum.
[d] Includes trace of cinnabar.
[e] Includes ilmenite and titanite.

Proportion of various minerals in the black sands of the Pacific slope—Continued.

No. of sample.	Locality from which sample was obtained.	Magnetite.	Chromite.	Garnet.	Olivine.	Monazite.	Zircon.	Quartz.	Mixed minerals.	Gold and platinum.
	MONTANA.									
	Custer County:									
P147a	Miles City	11.29	74.00	21.60	119.00	.....	2.40	1,266.00	578.00	[a].11
P147b	Do	7.26	.....	2.00	122.00	.....	8.00	.....	1,868.00	Trace.
P91	Powell County	1,779.00	17.00	128.00	.....	16.33	.80	.....	.....	[a]10.31
	NEVADA.									
	Ormsby County:									
P35	Carson City	1,387.00	485.60	41.90	.....	29.47	21.32	9.08	.....	[a]7.44
P75	Do	1,190.00	168.70	353.60	.....	5.35	80.76	5.00	.....	8.78
	OREGON.									
	Baker County:									
P98	Durkee	486.40	868.60	308.70	119.80	.....	62.38	155.00	.....	[a]139.40
P84	Do	435.89	126.00	1,000.00	250.70	.....	.....	187.40	.....	[a]2,325.00
P26	Sumpter	1.21	.56	29.75	11.70	1.05	.01	1,672.31	285.50	.43
P32	Clatsop County: Clatsop Beach	537.50	43.50	137.00	.....	.43	.61	54.80	.....	.....
	Coos County:									
P92	Johnson Gulch	656.70	261.70	842.10	2.60	.....	1.10	209.70	25.61	[a]704.67
P443	Marshfield	23.00	[b]467.70	29.39	.....	.....	36.52	1,200.00	243.48	2.21
P102a	Beach, Randolph district	11.35	45.58	2.61	.05	.98	6.94	.15	1,909.00	8.78
P102c	Do	22.63	216.71	698.22	219.56	.15	46.86	794.95	1.87	[a]1.46
P102d	Do	20.59	583.24	741.93	.....	.02	45.46	240.29	368.65	.....
P102e	Do	11.80	202.57	168.22	221.84	.03	16.44	1,378.43	.03	.....
P102f	Do	29.75	893.89	382.29	171.31	.....	51.80	413.54	57.34	[a].56
P102g	Do	15.60	235.66	164.32	.....	.....	22.61	1,295.40	265.00	28.70
P101	Whiskey Run, 7 miles north of Bandon	4.55	5.02	2.22	71.23	.....	.39	1,609.07	227.30	.17
	Curry County:									
P46	Gold Beach	584.60	82.21	205.90	67.50	.54	5.33	524.30	529.70	.78
P86	Chetco	1,520.38	285.51	.....	110.26	.....	4.96	54.32	24.04	[a].30

[a] No platinum.

[b] Includes ilmenite.

Proportion of various minerals in the black sands of the Pacific slope—Continued.

No. of sample.	Locality from which sample was obtained.	Magnetite.	Chromite.	Garnet.	Olivine.	Monazite.	Zircon.	Quartz.	Mixed minerals.	Gold and platinum.
	OREGON—continued.									
	Curry County—Continued.									
P87a	Port Orford	26.37	24.59	197.03	217.87			1,299.99	304.77	.30
P87b	Do	259.08	66.80	1,104.50	276.50	.07	2.99	289.84		.18
P88	Port Orford Beach	31.62	71.79	54.56	919.53		2.91	914.97		1.04
P97	Rogue River Beach	865.70	106.43	61.88	781.76		2.25	181.95		
P86		1,520.38	285.51		110.26		4.96	54.32	24.04	[a].30
	Jackson County:									
P13	Ashland	1,181.00	2.00	370.00		34.00	66.00	344.00		.15
P62	Gold Hill	183.20	1,691.00		[b]31.24		2.40	91.79		[a]82.68
P19	Jacksonville	1,463.00	[c]296.60	Trace.			4.14			74.00
P106	Medford	408.30	1,159.00					63.14	373.50	117.00
	Josephine County:									
P92	Holland	656.60	261.70	842.10	2.60		1.10	209.70	25.61	704.67
P34	Suttler Creek	1,146.00	[c]673.00				24.69	11.50		275.91
P67a	Waldo	27.37	8.75	73.98				1,890.00		25.73
P67d	Do	26.61	124.13	32.64			5.88	521.59	1,289.96	.25
P68a	Do	77.60	641.77	719.37			.45	223.00	337.40	[a]18.99
P68b	Do		22.34				28.00	371.44	1,596.00	[a].19
P95	Do	359.00	1,121.00				316.90	93.99	108.40	144.33
P18	Wolf Creek	392.60	90.60	690.20	31.70	.06	15.34	245.60	533.60	192.33
P73	Linn County: Foster	1,238.00	600.80	71.25		.10	.73	10.52		Trace.
	Multnomah County:									
P61a	Portland	10.95	50.78	15.43		.43	12.42	1,757.00		
P61b	Do	3.89	31.46					1,864.00		.11
P63a	Do	823.10	351.60	178.30	1.08	.59	133.10	429.50	82.17	15.86
P63c	Do	119.20	670.20	494.20	11.52	1.79	14.50	688.00	.40	17.78
P70	Polk County: Falls City	217.74	612.60	739.54	285.71	.35	101.96	40.59	1.68	.34
P37	Wallowa County: Wallowa	59.00	9.30	175.00		.67		630.50	[d]610.60	[a]2.25

[a] No platinum. [b] Serpentine. [c] Includes ilmenite. [d] Pyrite. [e] Includes hematite.

Proportion of various minerals in the black sands of the Pacific slope—Continued.

No. of sample.	Locality from which sample was obtained.	Magnetite.	Chromite.	Garnet.	Olivine.	Monazite.	Zircon.	Quartz.	Mixed minerals.	Gold and platinum.
	OREGON—continued.									
P28	Wasco County: Hood River Beach	995.00	[a] 174.50	221.00	287.00	5.00	16.50			
P82b	Washington County: Hillsboro	[b] 42.38						1,096.00	861.08	[c] 3.40
P93	Umatilla County: Weston	981.10	688.00	113.30	36.89	46.63	122.40	12.03		204.34
	UTAH.									
	Salt Lake County:									
P72a	Salt Lake City	848.70	677.90	300.10		25.35	120.70	22.35		100.33
P72b	Do	1,532.00	321.80	78.45		1.97	43.76	16.39		[c] 339.98
	WASHINGTON.									
	King County:									
P60	Seattle	10.82	.28	9.26		1.18	1.48	1,635.00		[c] .31
P91	Do	1,779.00	17.23	128.00		16.33	.80	59.02		10.31
P83	Kittitas County	1,643.00	188.00	118.70				5.50	45.00	[c] 315.00
	Whatcom County:									
P78	Bellingham	[b] 1,978.60		2.57				18.26		Trace.
P79	Do	[d] 1,427.00							[e] 573.22	Trace.
P113	Do	[f] 7.43		1.19	.96		.10	1,502.55	487.41	Trace.

[a] Includes ilmenite.
[b] Includes hematite.
[c] No platinum.
[d] Limonite.
[e] Pyrite and iron phosphate or durfrenite.

In undertaking an examination of these specimens it was evidently necessary to define more or less generally what minerals should be considered "valuable." More than forty distinct mineral species were likely to be encountered in one or another of these sands, and of these there are very few which are not used industrially under some conditions in some part of the United States. The first essential condition determining the usefulness of any of the minerals is its purity. Therefore the ease with which the various minerals could be separated became an important feature to be determined by the investigation.

It was important to determine the most efficient means of separating the various minerals, as an aid in identifying them, in determining the proportion of each in a given sample, and, finally, in forming a satisfactory conclusion as to whether the conditions involved in separation would admit of classifying certain minerals as useful.

Prof. Robert H. Richards, dean of the mining school of the Massachusetts Institute of Technology, was promptly retained to carry out experiments in mineral separation, assisted by Mr. F. W. Horton. As many of the specimens received contained noteworthy quantities of gold and platinum, they were first assayed by Mr. Charles E. Locke, assistant to Professor Richards. These assays showed the following proportions of gold to platinum, where the latter element was detected:

Gold and platinum contained in black-sand concentrates from various placer-mining districts, by States and counties.

Number of sample.	State and county.	District.	Ounces per ton of concentrate.	
			Gold.	Platinum.
	ARIZONA.			
D 5007 No. 2	Yavapai	Columbia	0.79	0.06
D 5010	do	Granite Creek	Trace.	Trace.
D 5008	do	Walnut Grove	Trace.	Trace.
	CALIFORNIA.			
D	Butte	Oroville	19.94	27.45
D 8	do	Alvarado placer mine, Butte Creek	5.22	.17
D 26	do	Buchanan Hill	1.09	.08
D 29	do	Peavine Creek	7.03	.83
D 30	do	Empire	.08	Trace.
D 16	Calaveras	Wild Goose mine	39.08	.35
D 34	Humboldt	Orleans	19.00	4.00
D 9	Mendocino	Sec. 7, T. 16 N., R. 12 W	Trace.	Trace.
D 19	Nevada	Rough and Ready Township	5.60	.52
D 2	Placer	Taylor mine, North Fork American River, Colfax.	29.26	1.27
D 1	do	Southwest of Auburn	24.14	1.48
D 6	do	Gold Run	37.61	8.78
D 11	do	Gold Blossom mine, Butcher Ranch mining district.	191.60	3.36
D 23	do	American River	126.9	9.67
D 15	Plumas	Nelson Creek	1.45	.12
D 21	do	Bowlder Nest mine on Grizzly Creek, Genesee district.	1.44	.66
D 32	do	Rock Island Hill mine	10.80	.16
D 40	do	Little Grizzly mine	Trace.	Trace.
D 47 No. 1	do	La Porte	2.98	.21
D 38	San Bernardino	Van Dusan Ca yon, Holcomb	.12	.06
D 5	Shasta	Sacramento River, North of Redding, Gem mine.	.64	.28
D 14	do	Gypsy mine, Shasta district	8.29	.25
D 18	Siskiyou	Fox Creek	.72	Trace.

Gold and platinum contained in black-sand concentrates from various placer-mining districts, by States and counties—Continued.

Number of sample.	State and county.	District.	Ounces per ton of concentrate.	
			Gold.	Platinum.
	CALIFORNIA—con.			
D 22	Siskiyou	Grouse Creek	10.31	0.18
D 36	do	Happy Camp district	None.	.82
D 20	Trinity	Junction City mining district	28.43	25.80
D 33	do	South Fork and Trinity River	9.02	1.28
D 35	do	T. 5 N., R. 7 E	4.90	4.61
	COLORADO.			
D 6037	Chaffee	Buena Vista	1.99	.43
D 6033	Costilla	San Luis Valley	None.	Trace.
D 6043	Pitkin	Junction of Gunnison, Chaffee, and Pitkin counties.	.05	.05
D 6029	Saguache	Pole Creek, Cretone	.34	.06
D 6006	San Miguel	West of Telluride	.37	.09
D 6016	do	Saw Pit	Trace.	Trace.
	IDAHO.			
D 4012	Bingham	West of Blackfoot	19.62	.18
D 4021	do	West bank Snake River	1.60	.70
D 4009	Boise	Oxbow tunnel, Payette River	.52	.28
D 4014	do	Gold Fork, North Payette River	2.02	.08
D 4010	Elmore	Bear Creek mining district, Rocky Bar	1.10	.11
D 4029	do	Baker Gulch, Crooked River	Trace.	Trace.
D 4017	Fremont	Gem Placer mine, Menan	Trace.	Trace.
D 4034	Idaho	Elk City district	1.06	.05
D 4023	Shoshone	Pierce City	.16	.04
D 4030	do	Big Island, North Fork Clearwater River	.16	.08
D 4031	do	Beaver Butte mining district, Trail Creek	6.40	Trace.
	MONTANA.			
D 1004	Granite	Princeton	1.67	.05
	NEW MEXICO.			
D 9006	Santa Fe	Los Cerrillos	Trace.	Trace.
D 9008	Lincoln	Tecolote Mountains	Trace.	Trace.
	OREGON.			
D 2002	Baker	South of Durkee	9.90	.22
D 2009, No. 1	Coos	Old Ocean Beach, Randolph mining district.	1.8	2.10
D 2009, No. 2	do	do	None.	.91
D 2009, No. 3	do	do	.02	.10
D 2045	do	Ocean Beach, Whiskey River	None.	.20
D 2010	do	Ocean Beach	1.25	6.23
D 2003	Douglas	East of Riddle	4.71	8.59
D 2006	do	Cow Creek mining district, Glendale	.50	2.25
D 2023	do	Riddle	19.27	128.73
D 2028	do	North Fork Steamboat River	.18	.02
D 2028, No. 2	do	Bohemian mining district	Trace.	Trace.
D 2014a	Josephine	Fry Gulch mine	1.88	4.53
D 2021	do	Galice Creek	None.	.26
D 2029	do	Sucker Creek	6.53	.67

Gold and platinum contained in black-sand concentrates from various placer-mining districts, by States and counties—Continued.

Number of sample.	State and county.	District.	Ounces per ton of concentrate.	
			Gold.	Platinum.
	OREGON—cont'd.			
D 2030	Josephine	Allen Gulch mine, Waldo	37.30	0.58
D 2013	do	Coyote Creek	None.	Trace.
D 2025	Linn	South Santiam River	2.60	3.52
D 2001	Union	Camp Carson district, Grande Ronde River	2.40	.12
	SOUTH DAKOTA.			
D 9504	Custer	French Creek	Trace.	Trace.
	UTAH.			
D 15516	Garfield	Colorado River	6.36	.15
D 15511	Morgan	North of Morgan	Trace.	Trace.

FIELD WORK.

Economy of time required that the examination of the conditions of occurrence of the heavy minerals in placer gravels should be undertaken long before the laboratory specimens had been completed. Therefore a corps directed at first by Prof. J. F. Kemp, of Columbia University, New York, proceeded to the well-known localities on the Pacific slope where previous examinations had shown the gravels to contain considerable percentages of minerals heavier than quartz.

Investigation of sands at the mouth of Columbia River.—On account of the accessibility and the slight cost of transporting the sands to the concentrating headquarters at Portland, an investigation was promptly undertaken of the seashore sands at the mouth of Columbia River. Mr. A. H. Gale, field assistant, visited Astoria and examined the coast sands from that point on the river beach to the mouth of the river at Fort Stevens and southward on the Pacific beach to Tillamook Head, a total distance of about 15 miles. The beach sands of this region are limited by a clay ridge extending from Tongue Point about 6 miles inland from the mouth of Columbia River southwest to the ocean beach at Tillamook Head. The triangle formed by this ridge and the ocean and river contains a great variety of sands which can be roughly grouped as follows:

Beginning at Tillamook Head the beach is made of heavy bowlders diminishing in size to the north until within less than a mile they change into heavy dark-green sands containing a small proportion of magnetite and other heavy minerals and a little quartz. Farther up the beach the sands are gradually lighter in color, with a much larger proportion of quartz, until the mouth of the river is reached. The jetty extending from Fort Stevens northwest to the deep channel has caused light-gray sands to fill in, building out the shore from the original beach about one-half mile and doubtless burying deposits of much heavier sand such as those immediately adjacent on the river beach. These sands on the south side of the mouth of the river are exceptionally black and contain a large proportion of magnetic iron ore and other heavy minerals. To the east from the ocean beach the usual sand dunes are encountered, consisting largely of quartz sand with very little magnetite or other heavy minerals. Still farther east, up to the clay ridge which limits the beach sands, the sands show an increasing percentage of clay, but only exceptionally carry any interesting proportion of heavy minerals. This region, bounded on the east by the clay ridge extending from Tongue Point to Tillamook Head, is known as Clatsop Plains.

Mr. Gale selected five carloads of the sand from this region, one of which represented the green sand on the beach in the neighborhood of Tillamook Head; another the heavy black

sand on the river beach near Fort Stevens; a third represented the material directly east of the sand dunes and characteristic of the interior plain between the sand dunes and the clay ridge; a fourth was taken at Warrenton, also in the Clatsop Plains region toward the northeast; and the fifth was taken from the dredge *William H. Ladd,* which is excavating the river channel in Columbia River at Pillar Rock, about 12 miles from the mouth. In addition to these, many small samples were taken over this entire area wherever variations promised to give interesting results. Finally, by means of driving pipes to a depth of 100 feet, it was found that the surface conditions extended certainly that far, and well records at Hammond station show varying layers of sands and clay to a distance of 400 feet. The specimens were separated at the concentrating pavilion in Portland.

Examination was also made of the sands in the large sand bar of Columbia River opposite Hood River, Oregon. Twenty tons collected at this point were separated at the concentrating pavilion in Portland.

Field work in southern Oregon and in California.—After the investigation of the sands at the mouth of Columbia River, Mr. Gale joined Prof. J. F. Kemp at Grants Pass and aided him in the examination of the heavy sands found in the placer mines at Leland, Wolf Creek, Grants Pass, at the Champlin dredge south of Grants Pass, at Kirby, and at Waldo; proceeding southward they crossed the Oregon line at Crescent City, Cal., and turned north along the beach, collecting samples at Smith River, the mouth of Pistol River, the mouth of Rogue River, Gold Beach, Bandon, Marshfield, and Ophir, Oreg. Professor Kemp then examined similar placer deposits on Snake River in Idaho, while Mr. Gale turned to the south and examined the ocean beach from Crescent City to Eureka, Cal., and then went eastward to Weitchpec, on Trinity and Klamath rivers, California, and finally secured many valuable samples of black sands from Siskiyou, Sierra, and Butte counties, Cal.

Other beach sands were examined by Mr. W. T. Schaller at San Diego, Lompoc, Aptos, San Luis Obispo, and in the neighborhood of San Francisco, Cal.

Mr. H. E. Crain, of Cheyenne, Wyo., collected several tons of ore from the Rambler copper mine, Wyoming, for examination for platinum. He also visited the Bighorn Mountains of Wyoming and collected samples of black sands in that region.

Dr. Joseph Hyde Pratt investigated the placers of Yellowstone River near Miles City and Helena, Mont.

Mr. Walter Harvey Weed collected samples of chrome iron ore sand in the neighborhood of Soldiers Delight, Baltimore County, Md., and Mr. D. B. Sterrett collected a number of black-sand samples from the Balsam Forest region of North Carolina. Mr. F. C. Hess collected and shipped to Portland several tons of black sands from the beach at Cape Nome, Alaska. Mr. H. C. Landes, State geologist of Washington, and Mr. Earl W. Bachert collected several tons of black sands from the Pacific beach from Cape Flattery south to Ozette.

One of the writers collected a ton of black sand from Grays Harbor at Hoquiam, Wash.; another ton of sand, unusually rich in magnetite, from Damons Point, Grays Harbor; and several sacks of sand representing the Pacific beach at Moclips, Wash., as well as two carloads of tailings from the dredges at Oroville and Marysville, Cal.

CONCENTRATION EXPERIMENTS.

By the courtesy of the Lewis & Clarke Exposition Company, a pavilion, 100 feet long by 50 feet wide, adjoining the Mines Building on the exposition grounds was provided for the installation of concentrating machinery, thus enabling the Survey to carry on large-scale experiments to find the best methods of separating the useful minerals in the black sands collected. This concentrating plant was under the supervision of Prof. Robert H. Richards, of the Massachusetts Institute of Technology. The invitation to various manufacturers of concentrating machinery to cooperate in this work by sending full-sized machines resulted in the following equipment:

Wilfley concentrator, erected by the Mine and Smelter Supply Company, of Denver, Colo., and operated by Mr. A. W. Park.

Laboratory Wilfley concentrator, built for the United States Geological Survey.

Pinder concentrator, installed by the Joshua Hendy Machine Works, of San Francisco, and operated by the inventor, Capt. J. W. Pinder.

Woodbury concentrating table, installed and operated by the inventor, Mr. George E. Woodbury, of San Francisco, Cal.

Christensen concentrator, installed and operated by the inventor, Mr. C. Christensen, of Oretown, Oreg.

Wetherill magnetic separator, type E, full size, loaned by the Wetherill Magnetic Separator Company of New York. This machine has been arranged to be operated with a current varying from 0.015 ampere to 3.5 amperes. It was operated by Mr. Harmon V. Morse, of Johns Hopkins University, and by Mr. Hermann Gray.

Knowles magnetic separator, furnished by the American Contractor Company, of Joplin Mo., and operated by Mr. Thomas W. Johnson.

Three forms of hydraulic classifiers, devised by Prof. Robert H. Richards.

Amalgamating table, devised by Prof. Robert H. Richards.

Glass table with greased surface for the separation of special minerals after the South African diamond method.

Hendy Challenge ore feeder, loaned by the Joshua Hendy Machine Works.

Set of Imperial ore screens, loaned by Mr. John Traylor, of Denver, Colo., and operated by Mr. Clifford L. Gardiner.

Merrill ore muller, invented and operated by Mr. I. J. Merrill.

Laboratory rock crusher and laboratory ore pulverizer.

The capacity of this equipment is a carload of sand in eight hours. The plant is also provided with mechanical agitating apparatus for bottle amalgamation with sodium amalgam.

Assay laboratory.—An assay laboratory, 20 by 20 feet, has been established. Here the following apparatus, partly lent and partly purchased of the F. W. Braun Company, of San Francisco, Cal., and of Messrs. Eimer & Amend, of New York City, has been installed: No. 40 Braun's combination crucible and cupelling furnace, with complete blowpipe apparatus and Cary hydrocarbon burner; the necessary crucibles, cupels, scorifiers, fluxes, etc., and weighing devices, supplied by Eimer & Amend, including very fine pulp and button balances. The last-named firm has also supplied a small electric furnace and electric hot plate. All the necessary chemicals and apparatus for making simple mineralogic determinations are found here.

Method of treatment.—Obviously the course of treatment used has varied greatly with the kind of sand. These sands are grouped in two classes: (1) Sea sands, river sands, and sand-dune material; and (2) low-grade gravels, tailings from dredges and placer workings, and richer heavy tailings from the clean-up of dredges, etc.

The method of treatment of class 1 consists of sampling and feeding to a Hendy automatic feeder, from which it is elevated to the roof of the building, where the sand passes over the Traylor screen, with holes 1 mm. in diameter. The oversize is examined and the undersize is delivered to an automatic distributor which divides it evenly to the four tables through four iron pipes. Each of these machines separates the sands into three portions—concentrates, middlings, and tailings. All of the concentrates and middlings are collected, and samples of the tailings are taken every five minutes. Samples of these concentrates, middlings, and tailings are dried and then treated by the system devised by Mr. Henry E. Wood, of Denver, Colo., by which the sands are first separated on the Wetherill magnetic separator into six portions by five successively increasing strengths of current. The strengths of current used in this machine are such as to group together in separate portions (1) magnetite, (2) chromite and ilmenite, (3) garnet; (4) olivine, hypersthene, and similar heavy silicates; (5) monazite, and (6) a nonmagnetic residue containing zircon, quartz, iridium, iridosmium, gold, and some of the platinum.[a] These separations are the result of many experiments in regard to the magnetic permeability of these minerals, carried out on specimens obtained from mineral dealers in the East.

Each portion is then carefully examined by mineralogists, and where complete separation is not already effected the proportion of different minerals unseparated is ascertained as carefully as possible under the microscope.

[a] Much of the crude platinum found, occasionally 60 per cent, is removable by a magnet.

In the examination for precious metals a separate kilogram sample of each product of the concentrating tables is mixed with water in a 2-gallon bottle. To this is added a small quantity of sodium amalgam, and after mechanical agitation for about thirty minutes it is found possible to extract practically all the free gold, platinum, and iridosmium, It has been found that the platinum and iridosmium will stick to the sodium amalgam as long as the sodium is not all converted by water into sodium hydroxide. As in some instances the gold has been found to be so coated with martite and other oxides of iron as to defeat amalgamation, each product is also examined by fire assay to determine the total gold and platinum.

In the treatment of class 2 the sands are sized through an 8-mm. screen. What remains on this screen is hand picked, and the screenings are passed over a 2-mm. screen. What remains on this screen is jigged for the separation of heavy minerals. The concentrates of the hand jig are hand picked. The material going through the 2-mm. screen is again sieved through a half-millimeter screen, and the coarse and fine materials are run separately after appropriate sampling on one of the tables. All the above concentrates are subjected to the same final examination as the sands of class 1.

Results.—The following table gives a synopsis of the results obtained by the concentration of various sands:

Results of concentration of black sands.

a. Lots in which a high per cent of the gold and platinum were concentrated into a small bulk.

Record number.	Locality from which sample was obtained.	Material.	Amount.	Actual value of gold and platinum in product.	
	OREGON.				
	Coos County:		*Pounds.*	*Dollars.*	*Per cent.*
P102a	Randolph district, beach.	Concentrates	20	1.819	93.37
		Tailings, including No. 2 concentrates.	423.5	.129	6.63
P101	Whiskey Run, 7 miles north of Bandon.	Through 2 mm. on ½ mm.:			
		Concentrates Nos. 1 and 2.	1.497	.0022	73.11
		Tailings	22.5	.0008	26.83
	Josephine County:				
P68a	Waldo	Through ½ mm.:			
		Concentrates	19	2.015	87.87
		Tailings and No. 2 concentrates.	222.5	.277	12.11
P68a	Do	Through 2 mm. on ½ mm.:			
		Concentrates	37	.940	90.77
		Tailings and No. 2 concentrates.	393.5	.028	2.67
P67a	Do	Through 2 mm. on ½ mm.:			
		Concentrates No. 1	16.5	6.713	99.93
		Tailings	73.5	.004	.07
P67a	Do	Through ½ mm.:			
		Concentrates	11	.623	99.82
		Tailings	37.5	.001	.18

Results of concentration of black sands—Continued.

b. Lots in which a high per cent of gold and platinum was saved, but the concentrates are too large in quantity or there is some imperfection in the assays not yet located, or both.

Record number.	Locality from which sample was obtained.	Material.	Amount.	Actual value of gold and platinum in product.	
	CALIFORNIA.		*Pounds.*	*Dollars.*	*Per cent.*
P100b	Del Norte County: Smith River.	Concentrates Nos. 1 and 2	90	0.012	11.35
		Tailings	50	.000	.00
	OREGON.				
P102c	Coos County: Randolph district, beach.	Concentrates Nos. 1 and 2	165	.075	18.03
		Tailings, including No. 3 concentrates.	402	.026	6.29
	Curry County:				
P87b	Port Orford	Concentrates No. 1	18	.018	60.75
		Tailings, including No. 2 concentrates.	312	.000	.00
P88	Port Orford, beach	Concentrates Nos. 1 and 2	37	.033	40.61
		Tailings	121.25	.00	.....

c. Lots in which the concentrates show values, while the original samples failed by assay to show any. The per cent can not be computed, therefore.

	ALASKA.				
P65	Cape Nome	Concentrates No. 1	147.25	0.047	.....
		Tailings and No. 2 concentrates	1,941.75	(a)	.....
	CALIFORNIA.				
P89b	Humboldt County: Gold Bluff.	Concentrates No. 1	24.5	.038	.....
		Tailings, including No. 2 concentrates.	167	.000	.....
	IDAHO.				
P113	Ada County: Boise	Concentrates No. 1	.25	.004	.....
		Tailings, including No. 2 concentrates.	57.75	.000	.....
	OREGON.				
P102d	Coos County: Randolph district, beach.	Concentrates No. 1	4.5	.013	.....
		Tailings, including No. 2 concentrates.	123.5	.000	.....
P97	Curry County: Rogue River, beach.	Concentrates No. 1	21	.003	.....
		Tailings, including No. 2 concentrates.	44.5	.000	.....
P70	Polk County: Falls City	Concentrates No. 1	9.5	.036	.....
		Tailings	124.5	(a)	.....

a Trace.

Results of concentration of black sands—Continued.

d. Lots in which the reduction of values in the tailings is complete, but the weight of the concentrates is much too large.

Record number.	Locality from which sample was obtained.	Material.	Amount.	Actual value of gold and platinum in produet.	
	CALIFORNIA.		*Pounds.*	*Dollars.*	*Per cent.*
P99	Del Norte County: Crescent City.	Concentrates Nos. 1, 2, and 3	837	0.120	78.49
		Tailings	459	.0	.00
P89a	Humboldt County: Gold Bluff.	Concentrates No. 1	41.5	.647	99.17
		Tailings	175.5	.000	.....
	OREGON.				
P102f	Coos County: Randolph district, beach.	Concentrates Nos. 1, 2, and 3	385	.142	98.27
		Tailings	171	.00	.....
	Curry County:				
P46	Gold Beach	Concentrates Nos. 1 and 2	49	.041	99.81
		Tailings	58.25	.001	2.56
P86	Chetco	Concentrates Nos. 1 and 2	429.2	.050	73.09
		Tailings	36.8	.0004	.66
P67b	Josephine County	Concentrates Nos. 1 and 2	157.5	.153	100.80
		Tailings	565.5	.00	.....

e. Lots in which the values are so minute that concentration has failed to reduce the values in the tailings and the assays fail to check up.

	CALIFORNIA.				
P89c	Humboldt County: Gold Bluff.	Concentrates Nos. 1 and 2	96.5	0.061	9.50
		Tailings	986	.291	45.25
	IDAHO.				
P105	Ada County: Boise	Concentrates Nos. 1 and 2	7	.017	15.04
		Tailings	289	.080	69.76
P81b	Bingham County: Quaker River.	Concentrates Nos. 1 and 2	3	.001	35.16
		Tailings	12	.002	75.25
	OREGON.				
P26	Baker County: Sumpter	Concentrates Nos. 1 and 2	5.5	.004	17.08
		Tailings	96.5	.018	83.32
P101	Coos County: Whiskey Run, 7 miles north of Bandon.	Through ½ mm.:			
		Concentrates Nos. 1 and 2	1.93	.0008	39.07
		Tailings	23.07	.0013	60.77
P87a	Curry County: Port Orford	Concentrates Nos. 1 and 2	82	.026	31.46
		Tailings	476	.047	56.30

It is evident from the above results that a great majority of the black sands are sufficiently valuable to justify separation into their various mineral constituents by concentrating tables of the Wilfley, Pinder, Woodbury, and Christensen types; and it is evident also that the effective operation of these tables is comparatively independent of the fineness of the gold, since in many sands gold as fine as 200-mesh is readily saved on the tables—frequently from 95 to 98 per cent of the total assay value.

Further examination of black-sand localities and of concentrating methods during the remainder of the fiscal year 1906 has been recommended by the Secretary of the Interior.

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