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A. W. Fahrenwald, Director

Distribution of Heavy Alluvial Minerals in Idaho

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DISTRIBUTION OF HEAVY ALLUVIAL MINERALS IN IDAHO

by W. W. STALEY

INTRODUCTION

Heavy sands or black sands is the term commonly applied to the heavy dark minerals which usually occur with gold in placer deposits. These minerals have a rather high specific gravity (3 to 5+) and are hard and resistant to abrasion and solution. In Table 1 is listed the commonly occurring minerals. All of these are not necessarily present in any given deposit, nor will the amount of many of these minerals be of more than mineralogical interest. In the table is given the usual range of specific gravity and hardness. The harness is based on the following scale:

1—Talc	3—Calcite	5—Apatite	7—Quartz	9—Corundum
2—Gypsum	4—Fluorite	6—Orchoclase	8—Topaz	10—Diamond

The mineral columbite has been found in the Idaho City area[1], and the complex uranium bearing mineral Brannerite[2] at the head of Kelly Gulch in the Stanley Basin area of Custer County.

All of the minerals listed in Table 1, with the exception of amalgam, cassiterite (?), chromite, columbite-tantalite, and Brannerite, have been recognized in recently collected samples. Grains of other substances are found: apatite, quartz, mica, various types of country rock, olivine, etc.

Table 1—Minerals Commonly Occurring in Black Sand

Mineral	Composition	Important Constituent	Sp. Gr.	Hardness
Magnetite	Fe_3O_4	Iron	5.2	5.5-6.5
Gold	Gold. Usually with silver	Gold, Silver	15-19	2.5-3
Ilmenite	Fe TiO_3	Titanium, Iron	4.7-4.8	5-6
Garnet	Various	Abrasive	3.2-4.3	6.5-7.5
Zircon	$ZrSiO_4$	Zirconium & ZrO_2	4.2-4.9	7.5
Chromite	$FeO \cdot Cr_2O_3$	Chromium, Iron	4.5-4.8	5.5
Specular Hematite	Fe_2O_3	Iron	4.8-5.3	5-6
Amalgam	(Au, Ag) Hg	Gold, Silver, Mercury	13-14	3-3.5
Pyrite	FeS_2	Iron, Sulphur	4.8-5	6-6.5
Monazite	(Ce, La, Di) $Po_4 \cdot$ Th and other rare earths	Thorium, Cerium, and rare earths	4.9-5.3	5-5.5
Rutile	TiO_2	Titanium	4.2-4.3	6-6.5
Titanite	$CaTiSiO_5$	Titanium	3.4-3.6	5-5.5
Cinnabar	HgS	Mercury	8	2-2.5
Cassiterite	SnO_2	Tin	7	6-7
Corundum	Al_2O_3	Abrasive	4-4.1	9
Columbite-Tantalite	(Fe, Mn) $(Cb, Ta)_2O_6$	———	5.2-8	6-6.5
Various Uranium Minerals	Various	Uranium, radium	Heavy	Hard

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COMMERCIAL USE OF HEAVY SAND CONSTITUENTS[3]

At the present time there is no established market for the various products as derived from the Idaho black sands. There have been many inquiries regarding some of the constituents, but the main difficulty

[1]Shannon, E. V., The Minerals of Idaho, p. 405, United States National Museum, Bull. 131. (1926).
[2]Shannon, E. V., Ibid, p. 401.
[3]Hammond, R. P., Technology and use of monazite sand, A.I.M.E., Min. Tech., vol. 10, No. 4, July, 1946.
Santmyers, R. M., Monazite, Thorium, and Cerium, U.S.B.M. I.C. 6321, 1930.
Petar, A. V., The Rare Earths, U.S.B.M. I.C. 6847, 1935.
Youngman, Z. P., Zirconium, Parts 1 and 2. U.S.B.M. I.C. 6455 and 6456, 1931.

is an economic one. Transportation to consumers in the east prohibits any attempt at making shipment of such concentrate under present market prices. There is some indication that interest is developing toward establishing a custom concentrating plant. Operators could then stockpile their heavy sands and dispose of them as the demand arose. In fact, it is strongly recommended that those operators using jigs make a policy of stockpiling the jig concentrates. Those who do not have jigs should seriously consider installing them. Hydraulic and other sluice box operators could run their sluice tailings and clean-up sands through trommels and jigs, thus producing a heavy sand concentrate.

Idaho placers are not alone in having monazite and zircon present in alluvial deposits. Any locality which has had extensive placer operations should be investigated for these minerals. A determined effort should be made toward providing for their recovery while mining is in progress. In Idaho and other Western states, Alaska, and Canada, tremendous yardages have been washed in the past. Not all of the gold was saved. Indications are favorable for reworking some old dredge ground, especially when the value of the additional heavy minerals is considered. The recovery of these minerals, as a natural resource, simply must not be ignored.

GOVERNMENT REGULATIONS

Regulations of the Federal Government are too involved to reproduce. Information may be obtained by writing to the U. S. Atomic Energy Commission, P. O. Box 42, Murray Hill Station, New York 16, New York. The pertinent data are: Section 5(b)(7), Atomic Energy Act of 146—(This has to do with locating claims); and Title 11, Atomic Energy, Control of Source, March 31, 1947—(This outlines licensing and possession of uranium-thorium bearing material).

Briefly, material which contains less than 0.05 per cent of combined uranium and thorium is not subject to Federal regulation.

MONAZITE

According to Hammond[1], nearly all of the constituents have some important commercial use. True, the consumption is at present limited. However, this is partly due to the scarcity of the raw material and partly to lack of knowledge about the industrial properties of the various rare earths composing monazite and the zirconium in the zircon.

Monazite is usually shown as having the formula (Ce, La, Di)PO_4 with varying amounts of ThO_2 (Thorium oxide).

Didymium (Di) is used to represent the mixture of praseodymium (Pr) and neodymium (Nd). These two elements have very similar properties and are difficult to separate. In addition to the elements given in the formula for monazite, traces of many other members of the rare-earth group are present.

Cerium (Ce) compounds are used as a catalyst; for decolorizing glass; as a drier in paint and printing inks; as a coloring agent for ceramic glazes; as a polishing material for lenses, etc.; gas mantle manufacture; in the tanning industry; in medicine; and pyrophoric alloy. This alloy is also known as Misch metal or sparking alloy. It is an alloy of cerium and iron. As the well-known flint in cigarette lighters and carbide lamps, it is widely used.

Lanthanum (La) is a very important constituent of photographic and optical lenses.

The element neodymium (Nd) is used in the optical industry and for tinting stemware. (Actually, a mixture of neodymium, praseodymium, lanthanum, samarium, and other rare earths is used.)[2]

Thorium (Th) has been used extensively in the manufacture of incandescent mantles. The oxide is used in radio tubes, high temperature refractories (5000°F.), optical glasses, and in the petroleum industry as a catalyst. Mesothorium, the decomposition product of thorium, is present in monazite. The amount depends on the thorium content of the monazite.

Rare-earth oxides and fluorides are used extensively in making electrodes for picture projectors, and other compounds for treating textiles.

Atomic fission gives promise of becoming the important future use of monazite.

ZIRCON

The mineral zircon ($ZrSiO_4$) is valuable as a gem mineral when found in large enough size. The largest application is the use of the oxide (ZrO_2) as a refractory (5400° F.). Lacquers and automobile enamels also contain the oxide. Metallic zirconium has an important use in steel alloys. Many articles of chemical laboratory ware are made from the oxide. High-temperature resistant cements have also been made. The oxide is quite widely used in the ceramic industry and to a limited extent in incandescent mantles.

According to the Minerals Yearbook[3] the use distribution of consumers, by numbers, is as follows:

Electrical and chemical porcelains, 34; metal and alloys, 17; refractories, 17; pottery glazes and vitreous enamels, 12 each; glass, 7; and miscellaneous, 1.

[1]Hammond, R. P., Ibid, p. 31.
[2]Hammond, R. P., Ibid.
[3]Minerals Yearbook, U.S.B.M., p. 831, 1945.

Zirconium metal has some interesting properties. It is resistant to many chemicals. A great deal of research remains to be done on the metallurgy of zirconium.

Actually zirconium is more plentiful than lead or copper. Because of the extremely erratic distribution of zircon and the refractory nature of zirconium, development of uses and metallurgy of the metal have lagged behind other less common substances.

Zirconium is a mixture of zirconium and hafnium. Possibly the presence of hafnium is responsible for the metallurgical difficulties encountered in adapting zirconium to industrial uses.

TITANIUM BEARING MINERALS

(Ilmenite, $FeTiO_3$; Rutile, TiO_2)

Rutile is not of importance in Idaho placers so far as has been determined. There is a considerable quantity of ilmenite.

In 1946, the United States consumption of ilmenite was 404,283 tons[1]. This contained an estimated 202,663 tons of TiO_2 content. The principal uses for titanium were: Pigments (this consumed the bulk of manufactured TiO_2); welding rod coatings; alloys and carbide; ceramics and steel flux; lamp-electrodes; and steel deoxidizer.

Titanium production from placers is nil because the manufacturing and processing market for the oxide is in the east. A recent development is the use of titanium in manufacturing armor plate.

MAGNETITE (Fe_3O_4)

The principal use of magnetite is in the production of iron and steel. Modest amounts are used by cement plants for controlling the iron content of the cement, and a limited tonnage is used for the manufacture of certain refractories. Magnetite occurring in placer sands is usually titaniferous.

CINNABAR (HgS)

Many Idaho placer deposits contain traces of cinnabar. The Ruby placers, in the Secesh Basin near Burgdorf, Idaho County, appear to contain a considerable amount. If jigs were used and the jig concentrate stockpiled for future treatment, the cinnabar content, in some localities, may have economic importance. Cinnabar is the principal ore of mercury.

CASSITERITE (SnO_2)

This ore of tin is rarely found in Idaho placers.

GEOLOGY AND MINEROLOGY

In the Idaho placers, monazite and zircon usually occur together. In the primary state they occur in granites, pegmatites, and gneisses. Much of the geologic literature reports zircon and apatite in the granite and gneiss. But the placer deposits resulting from the erosion and decomposition of these host rocks contains zircon and monazite and very minor apatite. It is possible that apatite has been mistaken for monazite in thin section analysis.

Lindgren[2] states that monazite may be panned from the decomposed granite in most any locality in the Boise Basin.

Anderson[3] reports the presence of zircon and monazite in scattered grains in the granite of the Pierce area. According to Schrader[4], the monazite of the Pierce area is derived from the granite and associated rocks.

In the Elk City area zircon and apatite are reported in the quartzite, gneiss, schist, and granite composing the country rock[5]. Both monazite and zircon are present in the black sands. Strangely enough, monazite was not reported in the country rock.

Day and Richards[6] report a widespread distribution in Idaho.

In his "The Minerals of Idaho," Shannon[7] describes samples from Boise, Clearwater, and Nez Perce Counties. He failed to find monazite in many of the samples from other localities used by Day and Richards and listed as containing the mineral. Shannon's conclusion was confirmed by the field work for the present paper. However, results, in many cases, are inconclusive unless actual operations are in progress during the time of the investigation. It is next to impossible to get good samples unless gravel is actually being dug and concentrated by jigs or riffles. The concentration of monazite in the deposit is quite often spotty. Trying to dig to bedrock with a shovel and panning is just as apt to show negative as positive results. The only satisfactory conclusions come when the property is in operation.

Figure 1 shows typical grains of monazite, zircon, and garnet from the Boise Basin. These drawings were made by the use of a microscope and are very much enlarged. (65 magnifications with further enlargement by means of the camera lucida drawing apparatus). Actually the bulk of the monazite and

[1]Preprint from Minerals Yearbook, "Titanium," 1946. U.S.B.M.
[2]Lindgren, Waldemar, The Mining Districts of the Idaho Basin and Boise Ridge, Idaho., p. 677, U.S.G.S. 18th Annual Report, Part III, 1896-97.
[3]Anderson, A. L., The Geology and Mineral Resources of the Region about Orofino, Idaho, p. 60, Idaho Bur. of Mines and Geol. Pamphlet 34, 1930.
[4]Schrader, F. C., An Occurrence of Monazite in Northern Idaho, p. 189, U.S.G.S. Bull. 430, 1910.
[5]Shenon, P. J. and Reed, J. C., Geology and Ore Deposits of the Elk City, Orogande, Buffalo Hump, and Tenmile Districts, Idaho County, Idaho.
[6]Day, D. T. and Richards, R. H., Useful Minerals in Black Sands of the Pacific Slope, p. 1175, U.S.G.S. Mineral Resources, 1905.
[7]Shannon, E. V., Ibid., p. 411.

zircon will pass a 35-mesh screen and remain on the 100-mesh. This means that one dimension is less than 0.0164 inches. It is interesting to note that, of the three minerals, the zircon retains sharp crystalline edges. The monazite and garnet being somewhat softer are usually rounded and broken on the edges.

The following data will help in recognizing and distinguishing between monazite, zircon, and garnet. It is best to prepare the sample by first carefully panning the material. Then dry and remove the magnetic minerals with a strong magnet. (The best type of magnet is the iron-nickel-aluminum-cobalt. It is exceptionally strong, removing magnetite, ilmenite, garnet, metal particles, and occasionally impure monazite). Then carefully *dry* pan the residue. This final operation separates the bulk of the quartz, leaving a high monazite-zircon concentrate. The ordinary hand lens of 7.5 power is sufficient to recognize the mineral. A 20-power is more satisfactory.

Figure 1a, Monazite:

1. *Crystalline form*: Usually all faces are rounded or broken. Close examination on what appear to be broken or rounded grains, shows remains of crystal faces, intersections, and terminations.
2. *Color*: Consistently some shade of yellow (dirty lemon, orange-yellow, red-yellow, rosin) although impurities may impart reds and blacks. Faded, transluscent yellow is common.
3. *Luster*: Resinous.
4. *Distinguishing properties*: Collects with heavy black sands in panning. Has distinctive yellowish color. Must not be confused with stained quartz particles; the quartz usually lacks uniform coloring and is non-crystalline and angular. Distinguished from zircon by elongated flat particles. Garnet has spherical shape and invariably shows many faces.

Figure 1b, Zircon:

1. *Crystalline form*: Excellent. Consistently stubby or elognated with sharp termination.
2. *Color*: Usually transparent and colorless like clear glass. May occasionally be somewhat milky or yellowish or reddish. The crystalline shape is distinctive.
3. *Luster*: Adamantine or bright. Crystal faces reflect light like a mirror.
4. Zircon usually fluoresces orange to yellow with ultra-violet light.
5. *Distinguishing properties*: Easily told from quartz because of its crystalline form, double ended crystals, transparency, and luster.

Figure 1c, Garnet:

1. *Crystalline form*: Commonly spherical in shape, but still retains crystal faces. Edges are worn and broken.
2. *Color*: Shades of red (light to almost black). Translucent on edges to almost transparent. Many small pink garnets.
3. *Distinguishing properties*: Readily distinguished from monazite by its color and lack of transparency and spherical shape with crystal faces. Monazite is more yellow and rectangular.

Figure 2 shows a tentative distribution of heavy sands in Idaho. The outline of the Idaho Batholith which included islands of metamorphic rocks (gneiss, schist, etc.—the Belt series) and sedimentary rocks (for the most part limestones) is included in the figure.

DISTRIBUTION OF HEAVY SANDS IN IDAHO

About two months were spent in the field during the summer of 1947 visiting and obtaining samples from placer mining areas. Some samples have been sent to the Bureau at Moscow by interested parties. Figure 2 shows the localities from which samples have been obtained.

The results may be roughly grouped in three areas: (1) Those in the western part of the state where the drainage passes essentially through the Idaho batholith (a granitic rock), pegmatite dikes, and metamorphic rocks (quartzites, gneisses, and schists); (2) the eastern part of the state where the drainage passes through the Belt rocks (slates, quartzite, phyllites, etc.), flow rocks (andesites, rhyolite, trachyte, etc.), sedimentary rocks (essentially limestones or dolomitic limestone), and very little granite; and (3) the Snake River deposits (the flour gold in the Snake River gravels apparently comes from the headwaters of the river in Wyoming where a granite has been traversed; magnetite is plentiful but the present investigation found no monazite).

Table 2 provides additional information to accompany Figure 2. Other localities shown in Figure 2 but not listed in Table did not indicate monazite or zircon.

ASSAY RESULTS ON HEAVY SANDS

Table 3 shows the assay of a number of black sand concentrates. It should be understood that by heads is meant jig concentrate, sluice box or riffle cleanup, and panned material. Much foreign material, such as quartz, country rock, and iron particles, is present.

Monazite sand is marketed on the basis of 95 per cent monazite which contains not less than 65 per cent combined rare earth oxides and thorium oxide, and a maximum of 3 per cent titanium oxide (TiO_2). Table 4 shows what may be expected from Idaho monazite.

Table 2—Distribution of Monazite, Zircon, Titanium, and Cinnabar in Idaho Heavy Sands

Sample No.	Location	Minerals				Amount of M and Z		
		Ti	Hg	M	Z	Plentiful	Mod.	Rare
1	Above Asotin, Wash., on Snake River			x	x	—		
2	Head of Gold Creek, near Pierce			x	x			—
3	Tyee Mining Co., American River, Elk City	x		x	x			—
3a	G. S. Slayter, near Elk City			x	x	—		
4	H & H Dredge, Crooked River, Elk City			x	x	—	—	
5	South Fork Placers, So. Fk., Clearwater River			x	x	—	—	
6	Wallberg Dredging Co., near Whitebird			x	x			—
7	Pringle Dredging Co., near Lucile			x	x			—
10	Ruby Placers, near Burgdorf (Dr. Numbers)		x	x	x	Very	High	
11	Secesh Dredging Co., near Warren			x	x	—	—	
12	R. V. Thurston, near Warren			x	x	—		
13	G. M. Loomis, Gold Fk. Cr., near Donnally			x	x	—	—	
14	Frank Tappal, South of Cascade			x	x	—		
15	Idaho-Canadian Dredging Co., below Idaho City			x	x	—	—	
16	Baumhoff and Marshall, Centerville			x	x	—		
17	Snake River, north bank at Grandview			No	ne			
18	South Fk. Boise River, Featherville			x	x			—
20	Idaho Placers—K. Jones, north of Fairfield			?	?			
22	Stanley Cr., Stanley Basin—Henry Middleton		x	x	x			—
22	Stanley Basin, Old Dredge tailings			?	?			
23	Kelly Gulch, Stanley Basin—John Wydman			x	x			—
24	Snake River Mng. Co.—Yankee Fk., N. of Sunbeam			?	x			—
28	Washington Iron Wks., Kirtley Cr., near Salmon	x				High	Ti a	nd Fe
29	Courtis Mining Co., below Gibbonsville	x				High	Ti a	nd Fe
30	Idaho-Warren Dred. Co., Hughes Cr., below Gibbonsville	x				High	Ti a	nd Fe
31	Wallace Cr., east of Leesburg			x	x			—
32	Leesburg, just out of town			?	?			
33	Below Yellowjacket Mill—Yellowjacket			x	?			—
35	Mogul Placer Mine—Bryan Brunzell, DeLamar			x	x		—	

Note: M=Monazite
Z=Zircon
Hg=Cinnabar
Ti=Ilmenite
x=Present

Table 3—Assay of Heavy Sands

Sample No.	Location	Heads[1], percent				Monazite concentrate[2], percent					
		Fe	P_2O_5	TiO_2	Hg	CeO_2	RE[3]	ThO_2	ZrO_2	Hg	P_2O_5
1	Asotin, Washington		4.6	28.0		29.5	63.0	2.0	3.9		24.4
3	Tyee Mining Company	49.1	0.4	18.2							
5	South Fork Placers		1.5	9.1		15.0	37.1	1.6	23.0		15.2
7	Pringle Dredging Company		0.3	4.8							
10	Ruby Placers		6.1	14.8	0.62	22.1	51.5	3.2	10.1	8.5	20.6
11	Secesh Dredging Company		0.8	2.8		12.9	30.6	1.6	20.0		12.7
12	R. V. Thurston		8.4	11.4		17.2	43.7	2.4	5.1		17.5
15	Idaho-Canadian Dredging Company		2.2	8.4		14.2	34.2	1.6	19.0		14.3
16	Baumhoff and Marshall		3.5	28.0		28.7	62.3	1.9	3.8		22.7
24	Snake River Mining Company			4.0							
28	Washington Iron Works (Fine sands)	38.9		2.4							
28	Washington Iron Works (Coarse sand)	46.5		3.8							
29	Courtis Mining Company	51.0		7.4							
30	Idaho-Warren Company			5.5							

[1]By heads is meant the jig, riffle, or pan concentrate.
[2]Most of the magnetic material, garnet, and quartz, was removed by screening, panning and magnet. Contains zircon as major impurity.
[3]RE means rare earth oxides and includes CeO_2 and ThO_2 in addition to La, Di, etc. oxides.

Table 4—Rare Earth Oxide Content of Idaho Monazite

Sample No.	Impure Monazite, percent						Monazite[1] %	Zircon %	Total RE[2] %	Rare Earth Oxides, basis of 95% monazite, percent			
	RE[3]	P_2O_5	CeO_2	ThO_2	La, Di	ZrO_2				CeO_2	ThO_2	La, Di, etc.	Total RE
1	63.0	24.4	29.5	2.0	31.5	3.9	87.4	5.8	72.2	32.1	2.2	34.2	68.5
5	37.1	15.2	15.0	1.6	20.5	23.0	52.3	34.2	70.8	27.2	2.9	37.2	67.3
10	51.5	20.6	22.1	3.2	26.2	10.1	72.1	15.1	71.5	29.1	4.2	34.5	67.8
11	30.6	12.7	12.9	1.6	16.1	20.0	43.3	29.8	70.5	28.3	3.5	35.3	67.1
12	43.7	17.5	17.2	2.4	24.1	5.1	61.2	7.6	71.5	26.7	3.7	37.4	67.8
15	34.2	14.3	14.2	1.6	18.4	19.0	48.5	28.3	70.5	27.8	3.1	36.1	67.0
16	62.3	22.7	28.7	1.9	31.7	3.8	85.0	5.7	73.4	32.1	2.1	35.4	69.6
Indian*	70.0	26.2	30.6	8.1	31.3	——	96.2		72.8	30.3	8.0	30.9	69.2

*Analysis of Indian monazite included for comparison. (See Hammond, R. P., Ibid. p. 1.)
[1]Monazite % = RE + P_2O_5.
[2]On the basis of pure monazite. $\frac{100 \text{ X } \% \text{ RE}}{\% \text{ monazite}}$. [3]Includes ThO_2.

Table 5—Monazite Content of Idaho Gravels

Sample No.	Locality	Gravel already mined, yards	Heavy Sand, lb. per yard[1]	Heavy Sand, %		Percent Monazite in Gravel[3]
				P_2O_5	Mon.[2]	
1	Asotin, Washington, Snake River Gravel[4]	?	2	4.6	16.1	0.11
3	Tyee Mining Company, near Elk City[5]	?	90	0.4	1.4	0.04
4	H & H Dredging Co., Crooked River, near Elk City[6]	1,300,000	60	1.5	5.3	0.11
5	South Fork Placers, near Elk City[7]	?	90	1.5	5.3	0.16
7	Pringle Dredging Co, near Lucile	?	20[8]	0.3	1.1	0.01
10	Ruby Placers, near Burgdorf[9]	?	100	6.1	21.4	0.71
11	Secesh Dredging Co., near Warren	?	90[10]	0.8	2.8	0.08
12	R. V. Thurston, near Warren	?	3[11]	8.4	29.4	0.03
15	Idaho Canadian Dredging Co., Boise Basin[12]	19,000,000	60	2.2	7.7	0.15
16	Baumhoff and Marshall, Boise Basin[13]	22,000,000	60	3.5	12.3	0.25
24	Snake River Mining Co., Yankee Fork	4,700,000	——	Trace		
A	Warren (Baumhoff's operation)[14]	15,000,000	Said to run higher than Boise Basin			

[1]Assay made on cleanup concentrate (jig, riffles, panning). Usually impure, containing considerable quartz, garnet, magetite, ilmenite, etc. Difficult to estimate proportion of heavy sand to gravel in place.
One yard of gravel taken equal to 3,000 pounds.
[2]Factor to convert P_2O_5 to monazite = ratio of monazite to P_2O_5 from Table 4 and equals 3.50 average. Thus the P_2O_5 content multiplied by 3.50 will give the percent of monazite. This factor closely checks the one obtained from the theoretical formula for monazite. It is assumed that the P_2O_5 resulting from apatite is negligible. So far as Idaho sands go, this assumption appears justified.
[3]Percent of monazite in gravel obtained from (lb. of heavy sand per yd. × percent monazite) ÷ 3,000 lb. per yd. for gravel.
[4]Heavy sand remaining after panning 6 buckets of gravel and sand. Material 1½ tons per cu. yd.
[5]Jig concentrate. Operator estimated 3% heavy sand.
[6]Assay values obtained from Sample No. 5 assigned to this sample.
[7]Estimated 3% heavy sand. Boat has riffles.
[8]Taken same as Sample 1 because of similarity of deposit.
[9]Sluice box concentrate less material over about ¼-in. size. Contained considerable quartz and corundum.
[10]Estimated. Riffles on boat. Operator had no idea on amount of heavy sand.
[11]Estimated from panning 7 pans of gravel. It appears to be considerably underestimated.
[12]From old dredge with riffles. Jigs on new boat.
[13]Jig concentrate from stockpile near office. Operator estimated 2% heavy sand.
[14]Various sources of information indicate higher monazite values here than in Boise Basin. Present investigation indicated this might be so.

In Table 5 is given the estimated monazite content of various Idaho gravels. This is an approximation. It is based on the estimate shown in the column "Heavy Sand per Yard", and on the analyses shown in Table 3. There is no positive proof that the gravel already mined would average the figure shown in the last column; nor that future gravel excavated will average this amount.

An *approximation* of the percentage of the important constituents in Idaho placer gravels is shown in Table 6.

SPECTROGRAPHIC ANALYSIS*

Numerous spectrographic analyses were made on Sample 16 from the Boise Basin. Table 7 shows a few of the results.

*Through the courtesy of Mr. A. Y. Bethune, Sullivan Mining Co., Electrolytic Zinc Plant, Kellogg, Idaho.

MARKET VALUE OF PRODUCTS

Monazite

In December, 1947, the market price of monazite ranged from $130 to $170 per metric ton. (A metric ton is equal to 1.1023 English short tones.) The minimum specifications were:

Monazite	95%
Rare earth oxides plus thorium oxide	65%
Titanium oxide, maximum	3%

Zircon

For December, 1947, crude zircon was worth about $40 per metric ton f.o.b. Eastern seaboard. The specifications were not given. Probably not less than 60-70% zircon is meant by crude ore.

Ilmenite

Price quoted in December, 1946, was about $20 per long ton, f.o.b. Atlantic seaboard for ore running 57 to 60 per cent.

RESOURCES AVAILABLE IN IDAHO

Any attempt to estimate the quantity of monazite, zircon, and ilmenite in Idaho gravels approaches pure speculation. Figures thus obtained must certainly be taken with the proverbial "grain of salt."

Table 6—Approximate Constituent Content of Idaho Placer Gravels

Sample No.	Location	Heavy Sand				Gravel, percent					
		Fe, %	P_2O_5, %	TiO_2, %	Lb. per yard	Fe	TiO_2	Monazite	RE	ThO_2	Zircon[1]
1	Asotin, Washington		4.6	28.0	20		0.186	0.11	0.077	0.00245	0.01
3	Tyee Mining Company	49.1	0.4	18.2	90	1.47	0.546	0.04			
5	South Fork Placers		1.5	9.1	90		0.273	0.16	0.113	0.00486	0.1
7	Pringle Dredging Company		0.3	4.8	20		0.032	0.01			
10	Ruby Placers		6.1	14.8	100		0.493	0.71	0.507	0.0315	0.15
11	Secesh Dredging Company		0.8	2.8	90		0.084	0.08	0.059	0.0031	0.06
12	R. V. Thurston		8.4	11.4	3		0.011	0.03	0.021	0.00114	0.004
15	Idaho Canadian		2.2	8.4	60		0.168	0.15	0.109	0.00508	0.09
16	Baumhoff and Marshall		3.5	28.0	60		0.560	0.25	0.181	0.00551	0.02
24	Snake River Mining Company			4.0	60		0.080	Trace			Trace
28	Washington Iron Works (Fines)	38.9		2.4	60	0.78	0.048				
28	Washington Iron Works (Coarse)	46.5		3.8	30	0.47	0.038				
28a	Average for No. 28	41.4		7.4	90	1.24	0.081				
29	Courtis Mining Company	51.0		7.4	90	1.53	0.222				
30	Idaho-Warren			5.5	60		0.110				

[1]Rough estimate. Difficult to determine ZrO_2 on heavy sand concentrate. The values shown may be very much in error.

Table 7—Spectrographic Analysis of Boise Basin Heavy Sands

Sample 16	Mg	Ca	Al	Si	Mn	Fe	Ni	Au	Cu	Cd	Zn	Pb	P	As	Ge	Sn	Ti	Zr	Ce	V	Cr	W	Z	Th	La	Di	Ga	In	Cb
Heavy Sand	x	x	x	x	x	x		x	x		x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x
Strongly Magnetic	x	x	x	x	x	x										x	x			x	x	x			x				
Zircon	x	x		x			x				x			x				x											
Monazite	x		x	x	x					x	x	x	x	x			x	x	x					x	x	x			
Weakly Magnetic	x	x	x	x	x	x										x	x			x		x			x				
Garnet	x	x	x	x	x	x									x		x												

From the area, in which monazite occurs in the gravel, there has been produced about 5,000,000 ounces of placer gold since 1863. Just what the average value per yard for this production was, no one can say. From the period 1863 to about 1873, the values were high. As time passed the grade has dropped until in recent years probably 20 to 25 cents per yard has been reached. If we assume an average of 50 cents per yard, then there has been dug, in Boise and Idaho counties, (approximately $92,000,000 at $20 gold and $14,000,000 at $35 gold) about 210,000,000 yards of gravel. To add additional uncertainty to this figure, much of the gravel has been reworked several times since the early days. On the other hand, to lend some weight to this astronomical sum, there has in recent years been dredged 41,000,000 yards in the Boise Basin and 15,000,000 yards at Warren, giving a total of 56,000,000 yards for three dredges.

Table 8 gives an approximation of what might have been recovered from several operations. As shown in Table 6, a fair tonnage of ilmenite could have been saved from operations in Eastern Idaho.

SEPARATION OF MINERALS IN HEAVY SANDS

It is not the purpose of this paper to discuss methods of separating the heavy sand into its various constituents. This interesting and successful operation will be made available in a forthcoming publication of the Idaho Bureau of Mines and Geology. Screening, jigging, flotation, and magnetic separation have been successfully applied. Commercial grades of the valuable products have been obtained.

CONCLUSIONS

Idaho has available a large *prospective* tonnage of monazite, zircon, and ilmenite, particularly the monazite. The establishment of a plant to treat heavy sand stockpiles is worth investigating. Placer deposits already dredged may well be investigated for reworking. The combined values of gold, monazite, zircon, and ilmenite should make redredging profitable.

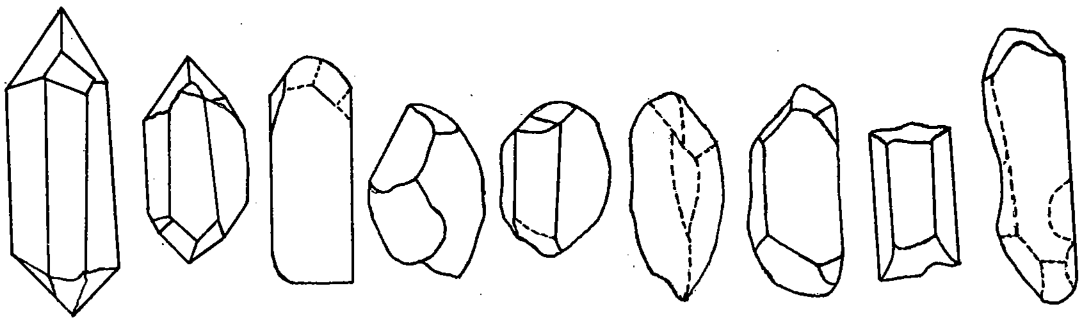
While no particular emphasis has been placed on the titaniferous magnetite that can be recovered, this mineral should not be overlooked. There is a considerable tonnage in placer deposits. Like the other minerals the market for magnetite is, at present, too far removed for economic use.

Table 8—Tonnage of Monazite, Zircon, and Ilmenite in Recently Dredged Gravels

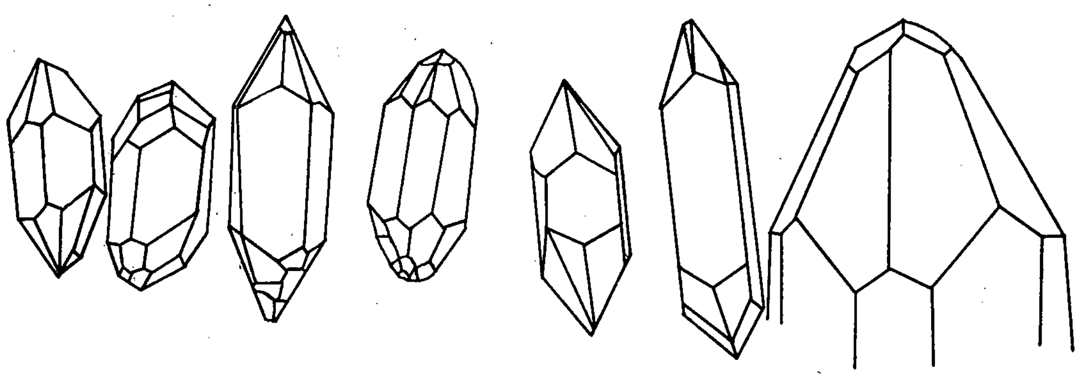
Location	Assay, %			Total Tons of Gravel	Tons of Mineral		
	Mon.	Zircon	Ilmenite		Monazite	Zircon	Ilmenite
Idaho-Canadian Company, Boise Basin	0.15	0.09	0.32	28,500,000	42,700	25,600	91,300
Baumhoff & Marshall, Boise Basin	0.25	0.02	1.1	33,000,000	82,500	6,500	362,500
Baumhoff, at Warren*	0.25	0.06	0.16	22,500,000	56,300	13,500	36,000

*Boise Basin assay assigned to Warren operation for monazite. For zircon and ilmenite, assay of Sample 11 used.

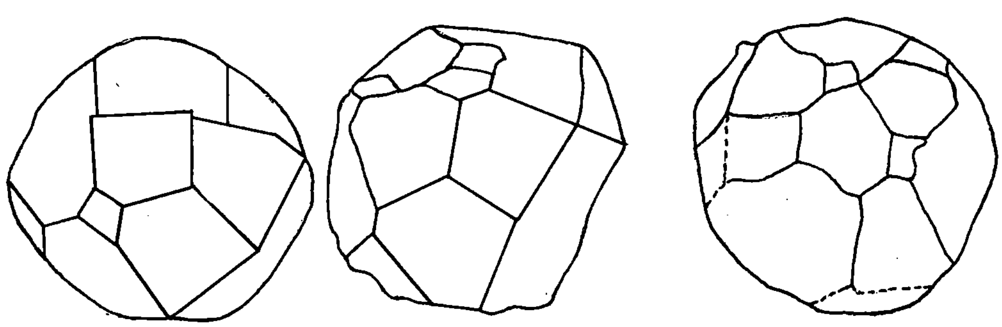
When sampling material (virgin gravel or concentrates) for monazite content, a very close estimate of the monazite content may be had by analyzing the same for P_2O_5 content. The determination of phosphorus pentoxide is relatively easy; and small amounts may be determined. By multiplying the percentage of P_2O_5 by the factor 3.50, the per cent of monazite is given. This factor will vary slightly depending on the composition of the monazite. With Idaho monazite, where the thorium oxide is low, it gives good results. When the ThO_2 content approaches about 8 per cent, 3.60 should probably be used.



(a) – Monazite



(b) – Zircon



(c) – Garnet

Figure 1 – Typical Particle Shape

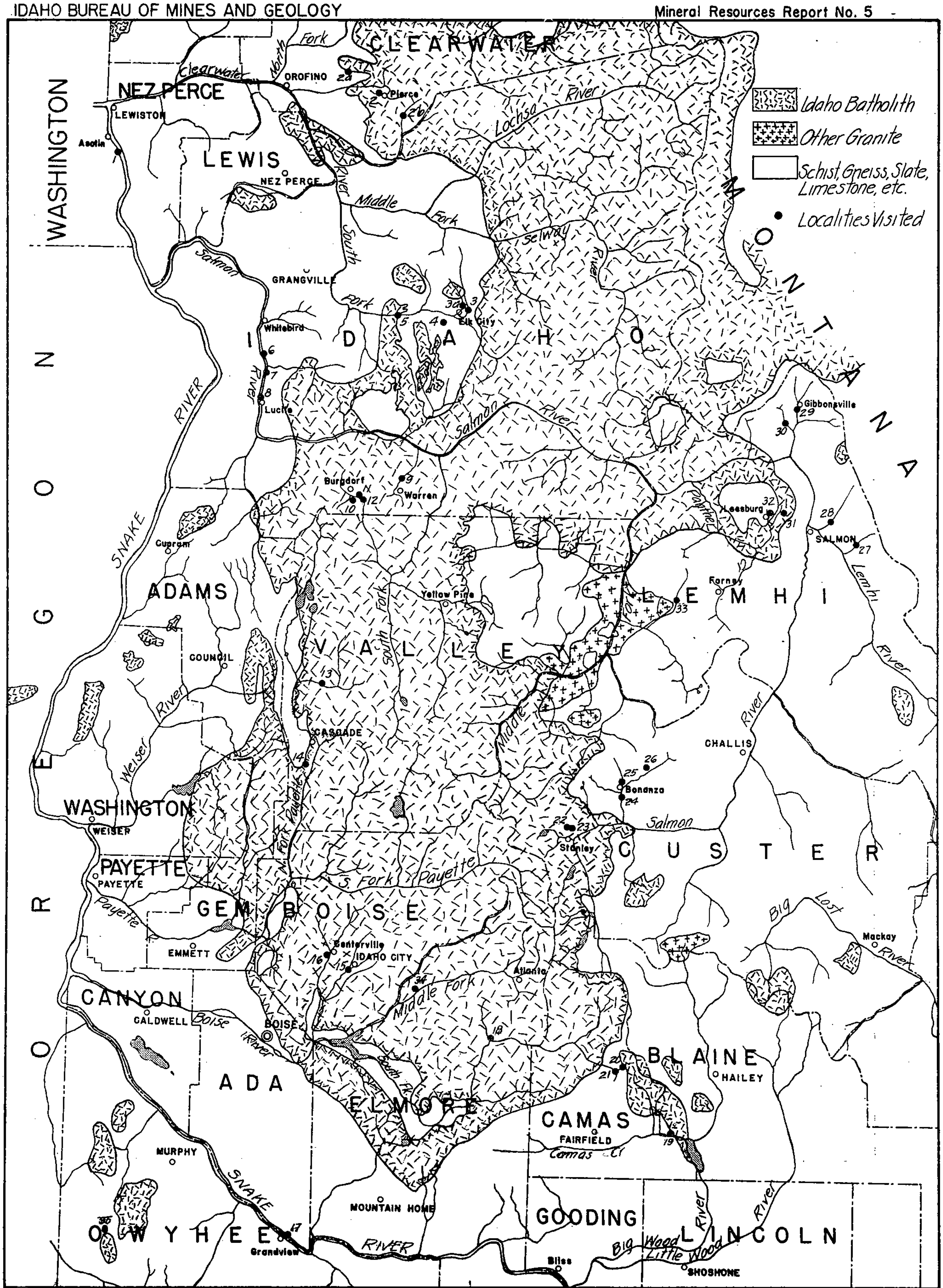


Figure 2— Distribution of Heavy Sands in Idaho