

Uranium-Bearing Minerals in Placer Deposits of the Red River Valley Idaho County, Idaho

GEOLOGICAL SURVEY BULLETIN 1046-C

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By F. C. ARMSTRONG and P. L. WEIS

CONTRIBUTIONS TO THE GEOLOGY OF URANIUM

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UNITED STATES DEPARTMENT OF THE INTERIOR

FRED A. SEATON, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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By F. C. ARMSTRONG and P. L. WEIS

ABSTRACT

In late 1951 or early 1952 uranium-bearing multiple oxide minerals were first recognized in the jig-bed concentrate of the Tyee Mining Company's gold dredge on the Red River about 10 miles south of Elk City, Idaho County, Idaho. The gravels of the placer deposits were derived from the Idaho batholith and a roof pendant of Precambrian rocks in the batholith.

Three samples taken for analysis show that the jig-bed concentrate contains 0.11 percent uranium. The nonmagnetic nonradioactive fractions of the samples assayed 0.2 percent niobium; columbite was not recognized in the samples.

The uranium-bearing placer minerals are brannerite, euxenite, davidite, betafite, and samarskite. Euxenite, samarskite, and betafite, and perhaps ilmenite, also contain niobium. Pegmatites are the probable source of the uranium- and niobium-bearing minerals, but there is only a remote possibility of finding a pegmatite in the area that can be mined economically for uranium or niobium.

INTRODUCTION

The Elk City district is about 40 miles east of Grangeville, Idaho County, Idaho, where the Red and American Rivers join to form the South Fork of the Clearwater River. This district is part of the large central-Idaho gold placer area which has been productive since about 1860. Much of the general and detailed geologic information given here has been taken from reports by Capps (1941), Lorain and Metzger (1938), Reed (1934), Shenon and Reed (1934a, b), and Thompson and Ballard (1924).

In 1951 the Tyee Mining Company¹ of Seattle, Wash., dredged for gold among gravels along the Red River a few miles south of Elk City. In the processing of the gravels, a considerable quantity of coarse heavy black minerals accumulated in the jigs. The Tyee Mining Company gave these heavy minerals to Mullen Mines Company, Inc., of Golden, Idaho, for use as jig-bedding in scheelite concentrating experiments. Mullen Mines encountered unexpected dif-

¹ Tyee Mining Company, published with permission.

difficulty in separating the heavy mineral jig-bed material from the coarse scheelite that accumulated in the jigs and sent samples of the scheelite-bearing jig-bed material to the U. S. Bureau of Mines laboratory at Albany, Oreg., for tungsten analyses and separatory experiments. Uranium-bearing multiple oxide minerals, also referred to as radioactive blacks, were recognized in the samples in late 1951 or early 1952 by Bureau of Mines personnel.

The Tyee Mining Company, although informed of the laboratory findings, continued to discard the uranium-bearing minerals along with the rest of the jig-bed concentrate when the jigs were emptied during each clean up for gold. To determine whether it might be worth while to attempt extraction of the minerals as a byproduct, the writers collected samples of the jig-bed concentrate from the waste piles of the Tyee Mining Company dredge on October 15, 1953. The samples were examined in detail, not only because the minerals are hard to identify, but because the samples represented the first reported discovery of these minerals in an area north of the Salmon River in Idaho that might be an economic source of uranium.

Mr. Kenneth Coates of Elk City, manager of the Tyee Mining Company dredge, provided information about the dredging operation; the U. S. Bureau of Mines and the U. S. Atomic Energy Commission provided analytic and mineralogic information on samples, and similar information was furnished by the Denver and Washington laboratories of the U. S. Geological Survey. The work described here was done for the Division of Raw Materials of the U. S. Atomic Energy Commission.

GENERAL GEOLOGY

The Elk City district is in a roof pendant in the north-central part of the Idaho batholith. The oldest rocks in the area (pl. 1) are intensely folded quartz-mica schists (Shenon and Reed, 1934a) that in a few places grade upward into quartzites. Overlying the quartzites and schists is a thick sequence of gneisses and augen gneisses. All the metamorphic rocks are thought to be of late Precambrian age and are tentatively correlated with the Belt series (Shenon and Reed, 1934a, p. 10). The metamorphic rocks have been intruded, deformed, and recrystallized by granite, quartz monzonite, and quartz diorite of the Idaho batholith. Pegmatite and aplite dikes related to the batholith are abundant. Gold-bearing quartz veins, presumably also related to the batholith, are the source of gold found in the placer deposits near Elk City.

After intrusion of the Idaho batholith in Cretaceous time, central Idaho was eroded to a surface of low relief. By the beginning of

Miocene time, this surface had been uplifted and deeply dissected. During or perhaps shortly after the extrusion of some of the Columbia River basalt to the west, the area was again deformed by uplift accompanied by faulting and warping which produced large depressions such as the Elk City basin. As the basins formed, clay, sand, and gravel accumulated as deposits of considerable thickness and extent.

An uplift before the Pleistocene epoch rejuvenated the area and marked the beginning of the present cycle of erosion. Large streams, such as the Salmon and the Clearwater, deepened their canyons, and the tributaries, in turn, deepened their valleys and cut into the basin sands and gravels. Most of these sands and gravels were carried out of the watershed by the streams, but during temporary halts in downcutting some of the basin sediments were laid down as small, scattered deposits of reworked material. The reworked gravels were eroded during subsequent downcutting but some were left behind as terraces.

After the present erosion cycle began the higher parts of the area were glaciated. The streams that drained glaciated valleys deposited glacial debris on the two generations of gravels already present. During and after glaciation, a fourth type of deposit, consisting of transported material eroded from exposures of bedrock, was added to the basin gravels, the reworked gravels, and the glacial debris along most of the smaller streams.

Thus, a specific gravel exposure in the Elk City district may be one of four types of deposit or of any combination of types. The geologic history of the gravels is locally complex, and it appears probable that as a result of their geologic histories, each of the four types has certain peculiarities of composition other than those traceable to source rocks nearby.

A study was not made to ascertain the origin of the Red River gravels, but the deposits in that part of the Red River valley covered by this report are believed to be flood-plain gravels of modern streams and to consist dominantly of reworked terrace and postglacial gravels. Any conclusions drawn from this study do not necessarily apply to gravel deposits elsewhere in the district.

SAMPLES

Results of the examination of samples of the Tyee Mining Company's jig-bed concentrate by laboratory technicians of the U. S. Bureau of Mines and the U. S. Atomic Energy Commission are given in table 1.

TABLE 1.—*Jig-bed concentrate samples from Red River placer gravels, Idaho County, Idaho*

[Uranium analyses and radioactive minerals reported by laboratories of the U. S. Bureau of Mines and U. S. Atomic Energy Commission. Published with permission]

Agency	Jig-bed concentrate			Uranium content of radioactive concentrate from jig-bed concentrate ³ (percent)	Radioactive minerals reported ²
	Sample weight (pounds)	Uranium content (percent)			
		eU ¹	U ²		
USBM ⁴	11.5		0.33	10.8	Samarskite, Brannerite, davidite, betafite, euxenite. ⁷
AEC ⁵	5.5	1.0	1.1 ⁶ 1.2		
AEC ⁸1	.055		Monazite, xenotime, radioactive blacks.
USBM ⁹530	None reported.
USBM ¹⁰	10.1	.2		1.66 ¹¹ 5.66 ¹¹ 4.47	Euxenite, davidite, brannerite, thorite, samarskite, xenotime, monazite.

¹ Radiometric analysis.² Chemical analysis.³ Method of identification stated where known.⁴ Memorandum from P. H. Floyd to H. G. Poole, Feb. 2, 1952.⁵ Written communication from M. L. Reyner to James Collard, Golden, Idaho, June 3, 1952.⁶ Duplicate analysis.⁷ X-ray determinations.⁸ Report of analysis from L. D. Jarrard to James Collard, Golden, Idaho, Sept. 29, 1952.⁹ Memorandum from J. A. Bardill to S. M. Shelton, Oct. 13, 1952.¹⁰ Memorandum from J. W. Pressler to G. C. Ware, Feb. 25, 1953.¹¹ Analysis of hand-picked radioactive grains from radioactive concentrate.

The writers collected a 30-pound sample of jig-bed concentrate from each of three waste piles—one at the dredge, one 0.3 mile downstream from the dredge, and one about 0.3 mile below the mouth of Dawson Creek (pl. 1). The piles resulted from operations on the dredge where the river gravels are passed through a trommel with one-half-inch openings. The oversize gravel is returned to the river and the under-size is fed into jigs which are bedded with steel shot and have 10-mesh-screen bottoms. The tailings from the jigs, the light minerals, are carried out the tops of the jigs. The heavy minerals are concentrated in the jigs, the smaller particles pass through the bottom 10-mesh screens to form the hutch product, and the larger heavy minerals accumulate in the jigs above the 10-mesh screens to form the jig-bed concentrate. The size separation is not perfect, however, so the concentrate contains some of the smaller particles. During cleanup for gold, the steel shot are separated magnetically from the jig-bed concentrate which is then discarded in a pile.

When the jig-bed material on the dredge was tested with scintillation counters, radioactivity of sufficient intensity to affect the instruments through the layer of water and light minerals was noted. The hutch product and tailings from the jigs did not show enough radioactivity to warrant taking samples.

ANALYSIS OF SAMPLES

Ten-pound splits of each of the three samples were examined in detail. The splits were sieved² first and plus 3-mesh, minus 3- plus 6-mesh, minus 6- plus 8-mesh, minus 8- plus 14-mesh, and minus 14-mesh fractions were separated and weighed.

A hand magnet was used to separate the magnetic material from the sieved fractions coarser than 14-mesh of samples FCA-16A and FCA-17A. Only the plus 8-mesh fractions of sample FCA-18A were separated magnetically. A Geiger counter was used to select the radioactive grains from the nonmagnetic fractions; radioactive grains were not found in the magnetic fractions. The radioactive grains from the plus 8-mesh fractions were weighed and their uranium content determined chemically. Because the radioactive grains in the minus 8-mesh fractions were too small to handpick, the minus 8-mesh fractions were chemically analyzed in bulk for uranium. The percentage distribution of total uranium and the average uranium content in each sized fraction were calculated for each sample. Results of these separations, analyses, and calculations are given in table 2. Table 2 also shows a weighted compilation of the three samples, their weighted uranium content, and the weighted distribution of uranium in the different sized fractions.

Because the average uranium content in the small amount of minus 14-mesh material was much lower than the average of the coarser fractions, the uranium in the minus 14-mesh material was not included in the totals shown on the table or considered in computing percentages and grades.

Analysis of the samples shows:

1. About half of the jig-bed concentrate is magnetic. It probably consists mainly of magnetite, but some ilmenite may be present. The other half of the jig-bed concentrate is nonmagnetic and consists of several minerals including the radioactive ones.
2. Radioactive minerals make up 1.0 percent of the jig-bed concentrate and 2.1 percent of the nonmagnetic fraction.
3. The average uranium content of the radioactive minerals is 11.0 percent.
4. The average uranium content of the jig-bed concentrate is 0.11 percent.
5. About 97 percent of the total uranium in the jig-bed concentrate is in the plus 8-mesh-sized fraction.

The possibility that the jig-bed concentrate might also contain columbite that could be obtained as a byproduct of the gold dredging was checked by sending one 10-pound split from each of the three

² American Society for Testing Materials, Tyler U. S. Standard Sieve Series.

TABLE 2.—Uranium content and distribution in three samples of jig-bed concentrate from Red River placer gravels, Idaho County, Idaho

Sample	Size, magnetic, and radioactivity separates										Uranium content of the various separates				Distrib- tion of uranium in sample, according to sieve size (weight percent)
	Sieved fractions					Nonmagnetic parts of sieved fractions					Radioactive grains from nonmag- netic parts of sieved fractions				
	Sieve size (ASTM)	Weight (ounces)	Weight per- cent of sample	Weight (ounces)	Weight per- cent of frac- tions	Weight per- cent of sample	Weight (ounces)	Num- ber of grains	Weight per- cent of magnetic parts of sieved frac- tions	Weight per cent of sample	Uranium in radio- active grains (weight percent)	Uranium in nonmag- netic parts of sieved fractions (weight percent)	Uranium in sieved fractions (weight percent)		
FCA-16A	10	+3	42.3	98.6	18.2	43.0	11.4	11	2.7	0.3	0.947	0.11	0.11	23.6	
		+6	103.8	65.2	47.2	45.5	29.6	72	2.5	8.8	1.120	0.24	0.14	72.4	
		+8	8.9	5.6	2.7	32.6	1.8	10	1.7	<.05	13.1	0.07	0.20	3.5	
		+10 to +14	4.1	2.6	1.7	41.5	1.1	(¹)				0.01	1.06	0.2	
Totals or averages ¹			159.2	100.1	70.0	43.9		93	2.6	1.1	1.199	.28	.13	100.0	
FCA-17A	10	+3	15.0	9.4	9.7	64.6	6.1	7	3.1	0.2	0.023	0.24	0.15	9.7	
		+6	102.2	63.9	59.5	58.3	37.2	110	2.6	1.0	1.7.7	0.23	0.15	73.0	
		+8	21.0	13.1	9.1	43.3	5.7	41	2.7	.2	14.6	.73	.40	17.2	
		+10 to +14	16.9	10.6	6.8	40.2	4.2	(²)				.086	1.07	2.1	
Totals or averages ¹			160.3	100.2	85.2	53.2		158	2.5	1.3	1.237	.28	.15	100.0	
FCA-18A	10	+3	29.8	18.6	19.9	66.7	12.4	2	0.5	0.1	0.11	0.05	0.04	10.1	
		+6	85.0	53.1	38.2	44.9	23.9	60	1.7	.4	1.9.3	0.16	0.07	55.9	
		+8	30.0	18.7	13.1	50.3	9.4	51	1.3	.1	12.8	.026	.17	23.9	
		+10 to +14	14.2	8.9	(¹)			(²)				.011	1.08	10.1	
Totals or averages ¹			159.9	99.9	73.2	45.7		113	1.3	.6	1.109	.15	.07	100.0	
Weighted composite FCA-16A, FCA-17A, FCA-18A	30	+3	87.1	18.2	47.8	54.8	10.0	20	1.9	0.2	0.081	0.17	0.09	14.9	
		+6	291.0	60.8	145.0	49.8	30.2	242	2.3	0.7	11.1	0.23	0.13	69.3	
		+8	59.9	12.5	27.1	45.3	5.7	102	1.8	.1	13.7	.069	.25	12.7	
		+10 to +14	35.2	7.3	6.5	40.5	6.7	(¹)				.017	0.07	3.1	
Totals or averages ¹			479.4	100.1	228.4	47.7		364	2.1	1.0	0.545	0.23	0.11	100.0	

¹ Chemical analysis.
² The magnetic part of this sieved fraction assayed 0.001 percent uranium.
³ Not handpicked.
⁴ Not separated magnetically.
⁵ Does not include -14 fractions.
⁶ Does not include FCA-18A.

samples to E. P. Kaiser of the U. S. Geological Survey who reported (written communication, 1954):

Several hundred grains of the nonmagnetic and nonradioactive fraction of the material in the bags were ground and analyzed for Nb; it contained 0.2 Nb. I have not been able to find anything that looks like columbite, and it is probable that the Nb is in ilmenite. * * * This is not an unusual concentration of Nb in accessory or pegmatite ilmenite, * * *.

If it is in the ilmenite, the niobium may not be marketable.

Euxenite, samarskite, and betafite, listed in table 1, are uranium-bearing multiple oxides of niobium, tantalum, and titanium; the combined niobium-tantalum oxide content of these minerals can range from 27.60 percent in euxenite to 60.68 percent in samarskite (Palache and others, 1946, p. 789, 798). Niobium and tantalum are in critically short supply; so their separation should be considered in any contemplated production of uranium. Because the writers do not know of a regular market at present for niobium and tantalum in such minerals, the amount of each in the radioactive minerals was not determined.

MINERALOGY

Specific identification of uranium-bearing multiple oxides is at best difficult and is complicated by their lack of homogeneity (Hutton, 1953) and by the fact that they are usually metamict. All the radioactive blacks examined by the writers were metamict and had to be heated before X-ray identification could be made. In samples of the jig-bed concentrate Pressler³ recognized intergrowths of euxenite and ilmenite, euxenite and xenotime, bannerbite and rutile, and samarskite and columbite.

The U. S. Bureau of Mines and the U. S. Atomic Energy Commission reported the following radioactive and nonradioactive minerals in the jig-bed concentrate samples listed in table 1 (see footnotes 1-5, table 1). Minerals in a sample of the undersize material (hutch product) from the jigs, collected by the U. S. Bureau of Mines, were identified by D. L. Schmidt (written communication, 1954) of the Geological Survey. Schmidt did not recognize any radioactive black minerals in the samples.

The method used in the identification of samarskite was not given; the other minerals in group 2 were identified by X-ray. These group 2 radioactive minerals, uranium-bearing multiple oxides of titanium, niobium, tantalum, iron, and rare earths, are the minerals of principal concern in this report.

³ Memorandum from J. W. Pressler to G. O. Ware, Feb. 25, 1953. Published with permission of the U. S. Bureau of Mines.

TABLE 3.—*Radioactive and nonradioactive minerals in the jig-bed concentrate and hutch product from the Tyee Mining Company's gold dredge on the Red River, Idaho County, Idaho*

Radioactive minerals		Nonradioactive minerals		
Jig-bed concentrate	Hutch product	Jig-bed concentrate		Hutch product
Group 1: Monazite Thorite Xenotime Zircon	} Allanite } Monazite } Xenotime } Zircon	Barite	Limonite	Apatite
Group 2: Betafite Brannerite Davidite Euxenite Samarskite		} None identified	Biotite	Magnetite
			Chlorite	Muscovite
		Columbite	Pyrite	Gold
		Corundum	Quartz	Ilmenite
		Epidote	Rutile	Magnetite
		Feldspar	Sericite	Pyrite
		Garnet	Sillimanite	Rutile
		Goethite	Titaniferous magnetite	Spene
		Hematite	Tourmaline	Tourmaline
		Hornblende		
		Ilmenite		

The radioactive minerals in the samples collected by the writers were seen under a binocular microscope as slightly rounded hard heavy grains that break with a conchoidal fracture. Many are incompletely coated with a buckskin-brown alteration product; fresh surfaces are lustrous black to dark brown. None of the grains show recognizable crystal faces, but few have undergone enough abrasion to more than slightly round and polish the sharper edges and corners. A few reddish grains with nonmetallic luster, probably monazite or thorite, were studied under the microscope.

X-ray identifications and semiquantitative spectrographic analyses were made of the samples sent to E. P. Kaiser of the U. S. Geological Survey who reported (written communication, 1954):

From one of the Elk City placer samples, I picked 10 radioactive grains, of which 8 were black and 2 were brownish red. One of the black grains gave an X-ray pattern, after heating, of brannerite; its analysis was $0.0X + Ce$; $X. Y$; $0.X + Nb$; $0.0X + Ta$; $X. Ti$; and $X. + U$. This fits generally with the name brannerite. The reddish material gave $0.X - Ce$; $0.X Y$; $0.0X - Nb$; $0 Ta$; $0.000X + Ti$; $0 U$; and high thorium; it is probably thorite.

Because brannerite and euxenite are the minerals that have been identified most frequently in the jig-bed concentrate, it is believed that they are the most abundant uranium-bearing minerals there.

Specimens FCA-3091 and FCA-1743 are two strongly radioactive grains from the jig-bed concentrate (not from the 30-pound samples mentioned previously) that were chosen for more detailed work. Their specific gravities, as determined with a Berman balance, are 5.225 and 5.178, respectively.

Powders of the two specimens appear to be the same under a petrographic microscope. The transparent thin edges, yellowish brown with a slight greenish tinge, are crowded with inclusions. The rest of the mineral is opaque and is dark brown in reflected light. Neither

specimen is pleochroic. The refractive index of both specimens before heating was considerably above 2.008, the highest index oil available for use by the writers. The unheated minerals were isotropic; they became anisotropic after heating in a differential thermal analysis machine, but the powders were so finely crystalline that it was impossible to obtain any optical data. In an attempt to make the specimens more coarsely crystalline, they were heated in an electric furnace at atmospheric pressure and at 1000°F for 21 hours; this treatment did not noticeably coarsen the crystallinity of the specimens.

The powders were sent for X-ray identification to E. P. Kaiser (written communication, 1954) of the U. S. Geological Survey who reported:

Sample FCA-3091: X-ray pattern similar to that of brannerite; may be considered as brannerite or a very similar mineral.

Sample FCA-1743: pattern indeterminate, but generally similar to columbite, samarskite, euxenite.

Because metamict uranium-bearing multiple oxide minerals are hard to identify, a relatively simple, reliable field identification method is needed. One possible method is differential thermal analysis. A few attempts to identify these minerals by the use of differential thermal analysis curves have been made (Kerr and Holland, 1951; Puig⁴), but basic data are still being compiled (Hutton, 1953). Because this method may become useful for differentiating among the uranium-bearing multiple oxide minerals, DTA curves (analyses made by F. C. Armstrong) for samples FCA-3091 and FCA-1743 are given in figure 11. The samples were run in a portable, three-unit, 115-volt, AC-DC, 450-watt differential thermal analysis apparatus with an upper temperature limit of 1000°C, similar to that described by Hendricks and others (1946). Both of the samples were run on the lowest of the three sensitivity settings on the machine.

DISTRIBUTION OF THE URANIUM-BEARING MINERALS

There is little variation in the amounts of heavy minerals concentrated in the jig-bed throughout the area covered by the sampling, nor are there many significant differences in the percentages of the different sized fractions or in the proportions of magnetic to nonmagnetic minerals. The uranium content, however, varies considerably; sample FCA-17A has more than twice as much uranium as sample FCA-18A.

Not enough information is available to explain the differences in the uranium content of the samples. However, Mr. Coates, superintendent of the dredge, suggested a possible explanation based on his

⁴ Puig, J. A., 1954, Thermal analyses of brannerite: Unpublished thesis, New York Univ., 10 p.

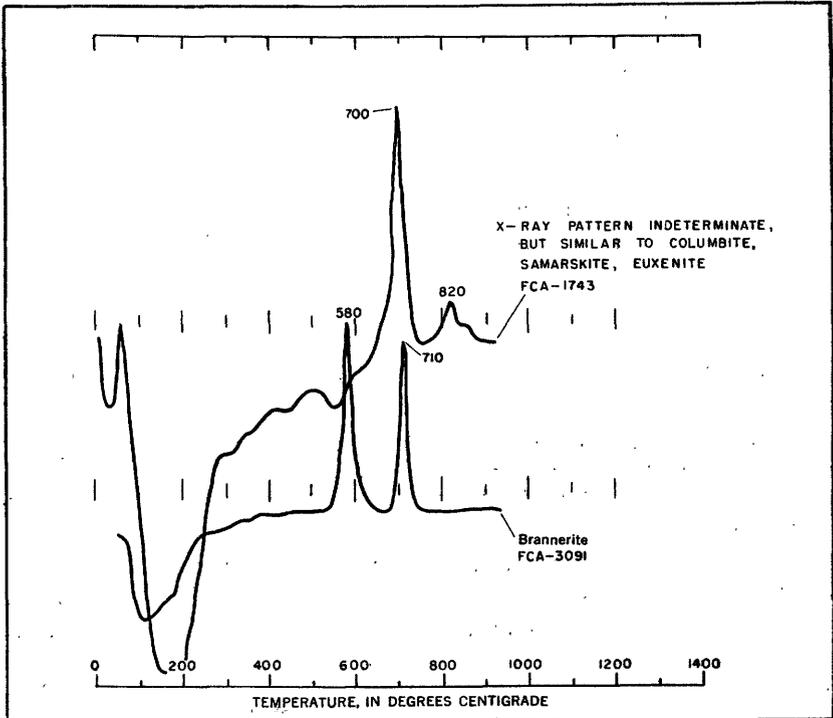


FIGURE 11.—Differential thermal analysis curves of two uranium-bearing multiple oxide minerals from placer gravels in the Red River, Elk City district, Idaho County, Idaho.

operating experience in the area. The concentrates from which samples FCA-16A and FCA-17A were taken had accumulated on the jig-beds between cleanups separated by several days of dredging and separating, but that from which sample FCA-18A was taken had accumulated during a run of only 8 hours since the last cleanup. Mr. Coates suggested that the greater uranium content in the FCA-16A and FCA-17A concentrates is the result of more material having passed through the jigs between cleanups. He believes that as gravel passes through the jigs the radioactive blacks are preferentially caught and retained in the jigs by displacing other minerals, and that this process with continued dredging progressively enriches the jig-bed concentrate in uranium.

The average of the analyses (table 2) is believed to be a correct representation of the uranium content in the gravels dredged by the Tyee Mining Company.

SOURCE OF THE URANIUM-BEARING MINERALS

The source of the uranium-bearing minerals is not known, but because they characteristically occur widely disseminated in pegmatites, it is assumed that pegmatites related to the Idaho batholith are the source of the radioactive blacks in the placer gravels. This assumption is in part supported by the coarseness of most of the radioactive grains (about 97 percent of the uranium in the samples is contained in the plus 8-mesh-sized fraction), and, although earlier workers made no mention of radioactive blacks in the pegmatites of the area, in part by the fact that similar suites of minerals occur in other Idaho pegmatites—in Bear Valley, Valley County (Mackin and Schmidt, 1956, p. 377); in Kelly Gulch, Custer County (V. C. Fryklund, oral communication, 1954); and in the Garden Valley district, Boise County (Fryklund, 1951).

CONCLUSIONS

The uranium- and niobium-bearing minerals are not economically recoverable under present market conditions from Red River placer gravels. If economic conditions change enough to warrant recovering these minerals as byproducts, the minerals, although hard to identify, may not be too difficult to separate from the gangue minerals because of their high specific gravities, different electromagnetic susceptibilities, and intense radioactivity.

Mining the pegmatites is not considered economically feasible because the minerals characteristically are widely disseminated; there is not at present any reason to believe the pegmatites contain concentrations of the minerals that could be mined profitably.

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