been able to match its x-ray pattern with that of any other species available to us.

Other minerals commonly associated with the fluocerite are small grains of altered gadolinite, small grains and crystals of metamict thorite, and a rare unidentified colorless species of moderate birefringence, biaxial character, with a mean index of refraction near 1.54. Relict in sections rich in fluocerite are corroded grains of quartz, plagioclase, and microcline-perthite.

The identity of the fluocerite was checked by means of an x-ray powder photograph (Table 2); its composition is given in Table 3, Column B.

Most of the rare-earth pegmatites of the South Platte–Lake George area are enriched in Y-group rare earths. The nearest neighbor to the Black Cloud, the Teller pegmatite near Lake George (Glass *et al.*, 1958), as well as most of the other pegmatities of the district, are characterized by Y-earth accessory mineral assemblages. The Black Cloud deposit appears to be unique for the area in having an accessory mineral group of both Y- and Ce-group elements.

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THE AMERICAN MINERALOGIST, VOL. 45, MARCH-APRIL, 1960

DETRITAL EUXENITE AND ASSOCIATED MINERALS, SAND BASIN, GRANITE COUNTY, MONTANA*

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The presence of metamict multiple oxide and silicate minerals ("radioactive blacks") in many stream placers in west-central Idaho has long been established (e.g. Shannon, 1922), and in 1952–1954 the geology of these deposits was studied in detail (Mackin and Schmidt, 1956; summarized in Heinrich, 1958). The radioactive placer minerals have been derived chiefly from the quartz monzonitic facies of the Idaho batholith, in which they occur locally as accessory species. "Segregations" of quartz

* Contribution No. 236 from the Department of Mineralogy, The University of Michigan, Ann Arbor.

Table 1. Minerals of the Heavy Fraction of the Black Sands of Sand Basin, Montana

A. Non-radioactive species (in approximate order of abundance)

Major	1. Magnetite, usually in lustrous euhedral octahedra with common re-entrant angles parallel to (101). Up to 90% of some samples
	2. Ilmenite, somewhat rounded
	3. Garnet, red, translucent, euhedral, trapezohedra
	5. Epidote
Minor	5. Leucoxene, well rounded grains
	6. Hornblende
	7. Biotite, in part chloritized
Trace	8. Kyanite
	9. Rutile
	10. Tourmaline
	11. Limonite, pseudomorphous after pyrite cubes

B. Radioactive species (in order of abundance)

1. Sphene. Yellow-brown translucent euhedra of the "envelope" type, flattened parallel to (001) and bounded by {100}, {112}, and {001}; some crystals of prismatic habit also present, 0.5–2 mm. in size (Fig. 1, B). Minute black opaque inclusions common; fractures abundant. Fluoresces olive green under unfiltered ultraviolet from high pressure mercury arc. Very weakly radioactive.
2. Monazite. Reddish-yellow tabular euhedra flattened parallel with (100), with a general rhombic outline. Usually smaller than sphene, 0.25–1 mm. in size (Fig. 1, C). Fluoresces emerald green. Radioactivity moderate, stronger than euxenite.
3. Euxenite. Submetallic. Broken prismatic crystals. Common forms {110}, {010}, and {111}. 0.5–2 mm. in size. Two types of alteration, 1) (more common) a tan powdery fracture filling, and 2) milky to bluish white coating on unabraided surfaces (Fig. 1, A). Radioactivity weak.
4. Allanite. Dull black irregular grains and prismatic crystals, 0.5 mm. in size. Subangular to subrounded with tan alteration films. Strongly radioactive.
5. Zircon. Very slender elongate prismatic euhedra, colorless and free of inclusions; 0.25 mm. or less in length. Feebly radioactive.
6. Thorianite. Translucent deep emerald green grains of irregular outline. 0.25–0.5 mm. in size. Very strongly radioactive. *X*-ray powder pattern of unignited grains showed two pronounced diffuse bands from 7.5–2.6 and from 2.2–1.8 Å.

monzonite containing marked concentrations of these minerals range in size from a few inches to a few tens of feet and are megascopically identical with enveloping quartz monzonite that has a much lower content of these species.

In some areas deep pre-Wisconsin regoliths provided initial concentrations, and subsequent placer accumulations have resulted from late Pleistocene glacial derangements of the drainage or drainage blocking by Pleistocene lava flows (Mackin and Schmidt, 1956). The percentages of metamict species decrease very rapidly downstream.

In 1954 Mr. Joseph Abbey discovered "radioactive blacks" in stream sands in Sand Basin, a small park-like area in Granite County, Montana, embracing parts of the drainages of Sand Basin, Bowles and West Fork Rock Creeks, all tributaries of North Fork Rock Creek. The deposits lie at an elevation of about 6400 feet, on the east side of the Sapphire Mountains, about 5 miles southeast of Skalkaho Pass. The U. S. Bureau of Mines sampled the deposits in 1954 by means of about 40 shallow pits. The senior writer studied the deposits in July 1957, and laboratory

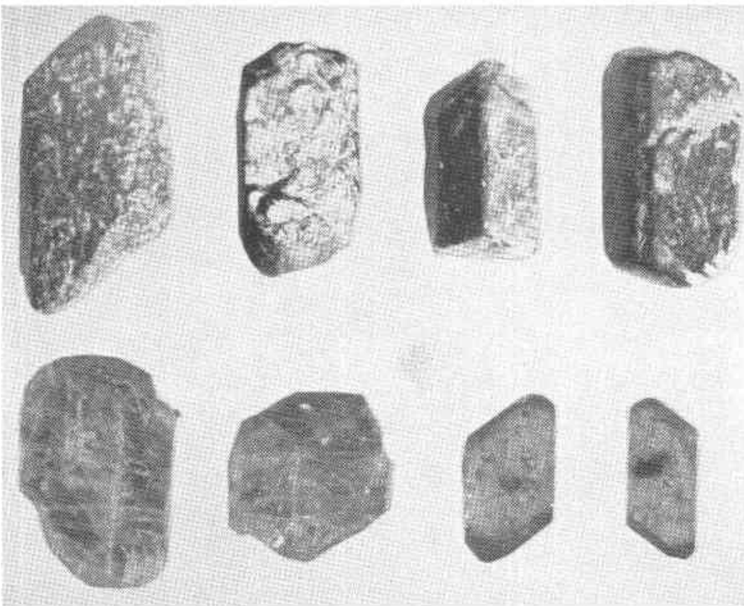

FIG. 1. Chief radioactive detrital minerals of Sand Basin placer deposits, Granite County, Montana. A. (top row) Euxenite; note zoning in second from left (×15). B. (lower left) Sphene (×15). C. (lower right) Monazite (×30).

studies, supported by a grant from Michigan Memorial-Phoenix Project No. 150, were completed in June 1959. The deposits are of interest not only because of their unusual mineralogy but also because they are the first major find of "radioactive blacks" in Montana placers, thus representing the easternmost known occurrences of such deposits associated with rocks of the Idaho batholith.

The area is underlain by a coarse-grained granodiorite assigned to the Idaho batholith, which just to the north intrudes rocks of the Newland formation of the Precambrian Belt Series. The granodiorite crops out as low rounded ridges that separate the sand-filled basins ("flats"). Where the ridges slope down to constrictions or terminations of the flats, a jumble of granite boulders is a characteristic feature. The area does not appear to have been glaciated (Alden, 1953) but is periglacial. The streams of the "flats" are irregular in direction, meandering, and incised as much as 7 feet. In contrast, the upper part of West Fork Rock Creek, whose course is not marked by flats, is straight and its tributaries appear to have been controlled partly by jointing in the granodiorite.

The valley fill of the "flats" consists of a locally developed veneer of subangular rock pieces, 8 inches or less in size, mainly of quartzites, nodular muscovite schist, and other low-grade metamorphic rocks that are

TABLE 2. MINERALS OF IDAHO-MONTANA "RADIOACTIVE BLACKS"

Monazite, sphene, euxenite, allanite, zircon, thorianite	Sand Basin, Mont.	This paper
Monazite, xenotime, thorite, samarskite, betafite, brannerite, davidite, euxenite	Red River Valley, Elk City, Idaho	Armstrong and Weis (1957)
Monazite, sphene, zircon, samarskite, columbite, polycrase	Idaho City and Centerville, Idaho	Shannon (1922)
Monazite, xenotime, columbite, samarskite, fergusonite, zircon	Dismal Swamp, Elmore Co., Idaho	Shelton and Stickney (1955)
Monazite, xenotime, columbite, euxenite, allanite, sphene, zircon	Bear Valley, Valley Co., Idaho	Mackin and Schmidt (1956)
Thorite, sphene, allanite, zircon	Hailey, Blaine Co., Idaho	Mackin and Schmidt (1956)

foreign to the immediate area of the deposits. Many of the finer-grained accompanying particles of this surficial layer are of weathered granodiorite or its constituents. In stream banks and pits the bulk of the valley fill can be seen to consist of coarse sand that locally contains layers and lenses of black minerals, usually one inch or less thick. Diamond drilling has shown that this sand continues to a depth of at least 35 feet in the central part of Sand Basin, but grades downward into a silt locally as much as 55 feet thick, which is much poorer in heavy (and radioactive) detritals.

The minerals of the black sands are listed in Table 1. The concentrates, panned in the field, were studied as follows: 1) Separation of the heavy minerals in methylene iodide. 2) Removal of the magnetite. 3) Fixing the remaining optically unidentifiable grains on glass plates with diluted Duco cement, and laying over these mounts x-ray film to produce autoradiographs. 4) Removal of individual radioactive grains for powder x-ray study (following ignition, if necessary). The euxenite, allanite and thorianite identities were checked via x-rays.

A specimen of granodiorite from the north side of Sand Basin was crushed and the concentrated heavy mineral fraction was found to contain magnetite, ilmenite, sphene, monazite, euxenite, allanite, thorianite, and zircon. The size, habit, color, fluorescence, and radioactivity of these minerals are essentially identical to these properties as exhibited by the same species in detrital form. Thus of the abundant heavy species in the sands, only garnet and epidote have come from outside of area underlain by granodiorite.

Table 2 compares "radioactive black" suites from some of the Idaho

Table 3. Accessory Minerals of Rocks of Idaho Batholith

Sphene, monazite, euxenite, allanite, thorianite, zircon	Sand Basin, Mont.	This paper
Monazite, zircon, sphene, allanite, xenotime, thorite	Idaho batholith in general	Larsen and Schmidt (1958)
Euxenite, monazite	Bear Valley, Idaho	Mackin and Schmidt (1956)
Thorite, sphene	Hailey, Idaho	Mackin and Schmidt (1956); Robertson and Storch (1955A, B)

and Montana placers, and in Table 3 are listed similar suites that have been identified *with certainty*, as occurring as accessory minerals in nonpegmatitic rocks of the Idaho batholith. Armstrong and Weis (1957, p. 35) state, with respect to deposits of the Red River Valley, Idaho, that "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." Certainly some pegmatites of Idaho batholith affinity which are known to contain some of these "radioactive blacks" may well be an additional source for them in some areas, but the evidence is now preponderant that many of these deposits are of nonpegmatitic derivation.

The Idaho batholith has several outliers that extend eastward into Montana, just as the Boulder batholith has outliers to the west of its main mass. The assignment of outliers in this "intermediate zone" to one or the other of these intrusive units has been fraught with considerable uncertainty. Since it is now known that units of the Idaho batholith contain a widespread varied assemblage of U-Th-Nb-Ta species as accessory constituents and since no similar assemblages, either in igneous rocks or derived placers, are reported for the Boulder batholith, this relationship might offer an additional characteristic for correlating these intrusive units.

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THE AMERICAN MINERALOGIST, VOL. 45, MARCH–APRIL, 1960

HYDROXYL ION CATALYSIS OF THE HYDROTHERMAL CRYSTALLIZATION OF AMORPHOUS SILICA; A POSSIBLE HIGH TEMPERATURE pH INDICATOR

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Introduction

A study has been made of the effect of hydroxyl ion concentration on the time for the formation of quartz from silicic acid at 245° C. The time appears to be almost a linear function of reciprocal hydroxyl ion concentration. It is considered that all observations on this crystallization can be explained by a mechanism involving the concentration of a singly charged silicate anion as the rate controlling species. The effect of other mineral substances, in particular silicates, on this reaction may provide a method of determining the extent of hydrolysis of these minerals at moderate temperatures.

Previously a number of workers have found that when amorphous silica is crystallized under hydrothermal conditions, a number of intermediate phases tend to develop before the stable phase quartz is formed. Corwin et al. (1953) have shown that in a fixed time either cristobalite or quartz is produced, quartz being favored by high pH. Carr and Fyfe