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SOME THORIUM DEPOSITS IN WESTERN MONTANA AND EAST-CENTRAL IDAHO

By
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March 1957

Salt Lake Branch Office, AEC
Grand Junction Operations Office
Salt Lake City, Utah

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GRAND JUNCTION OPERATIONS OFFICE
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CONTENTS

	Page
Abstract	5
Introduction	5
Lemhi Pass area	7
Location and surface features	7
General geology	10
Thorium-bearing veins	10
Thorite prospects in the Lemhi Pass area	12
Lone Star No. 2	12
Silver Queen No. 35	14
Silver Queen No. 37	15
Black Bull Fraction	17
Cagoe No. 10	19
Other thorium deposits in the Lemhi Pass area	20
Wonder Lode	20
Thorium Metals Corporation (Last Chance and Shady Tree claims)	22
Duck Creek Area, Broadwater County, Montana	23
Location and surface features	23
Field work and acknowledgments	24
General geology	24
Little Brown Egg thorium deposit	26
Local geology	26
Geology of the thorium-bearing dikes	26
Mineralogy	29
Radioactivity	29
Summary	30
References	31

ILLUSTRATIONS

		Page
Figure 1.	Index map ----------------------------------	6
2.	Index map of the Lemhi Pass area, Idaho -----	8
3.	Index map of the Duck Creek area, Montana ---	9
4.	General geology of the Lemhi Pass area ------	11
5.	Lone Star No. 2 prospect ------------------	13
6.	Silver Queen Nos. 35 and 37 prospects -------	16
7.	Black Bull Fraction and Cagoe No. 10 prospects ---------------------------------	18
8.	General geology of the Duck Creek area, Broadwater County, Montana ---------------	25
9.	Geologic map of the Little Brown Egg claim, Broadwater County, Montana ---------------	27
10.	Geologic sections of the Little Brown Egg claim, Broadwater County, Montana --------	28

SOME THORIUM DEPOSITS IN WESTERN MONTANA AND EAST-CENTRAL IDAHO

ABSTRACT

Significant deposits of thorium occur throughout an area 7 miles long and 4 miles wide in the Lemhi Pass area of southwestern Montana and east-central Idaho. A small deposit of thorium has also been recently exposed in the Duck Creek area of Broadwater County, Montana.

In the Lemhi Pass area, the thorium mineral, thorite, is found in quartz-hematite veins that cut quartzites of the Belt series of Precambrian age. The thorite is fine grained and admixed with iron oxides; it is accompanied by minor amounts of uranium and rare earths.

The Little Brown Egg thorium deposit in the Duck Creek area consists of pods and pockets of massive thorite occurring in aplite dikes which cut limestones of the Belt series.

The average grade of 7 thorium deposits in the Lemhi Pass area and 1 deposit in the Duck Creek area is 0.72 percent thorium oxide. Most deposits are the narrow vein type. One deposit in the Lemhi Pass area contains a significant amount of ore with an average grade of about 1 percent thorium oxide.

INTRODUCTION

The thorium-bearing rare-earth mineral, monazite, was recognized occurring in placers in Idaho and Montana as early as 1897, but it was not until 1949 that thorium in lode deposits was discovered in these states (fig. 1).

Trites and Tooker (1953) conducted reconnaissance investigations for uranium on behalf of the U. S. Atomic Energy Commission (AEC) in east-central Idaho and southwestern Montana. During this examination, 11 mining properties in the Lemhi Pass area of Idaho were found to contain significant amounts of thorium. In 1954, Armstrong (1956) examined and described several thorium prospects east of Lemhi Pass in Montana.

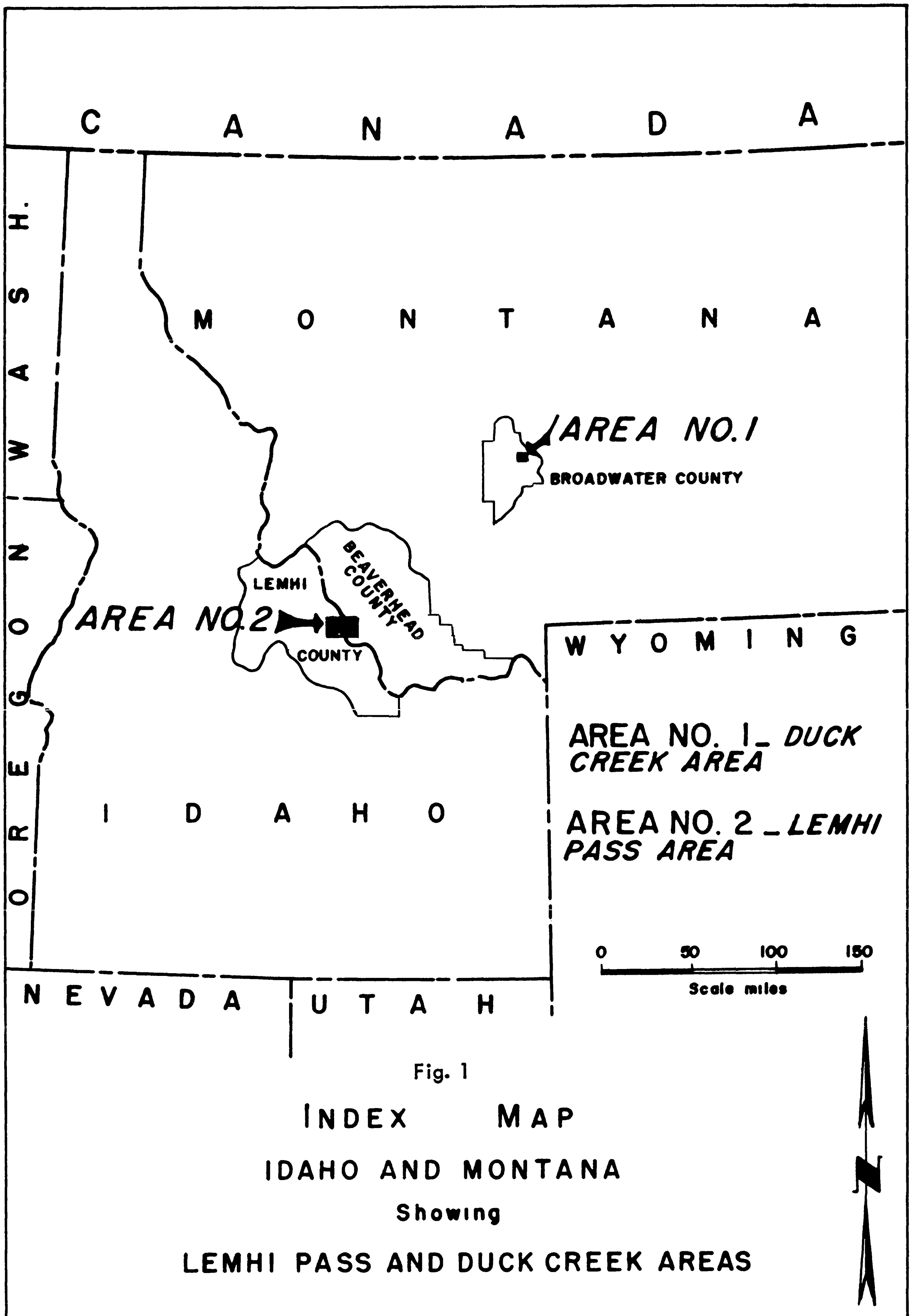


Fig. 1

INDEX MAP

IDAHO AND MONTANA

Showing

LEMHI PASS AND DUCK CREEK AREAS

Reconnaissance examinations were made by AEC in the Lemhi Pass area during parts of September and October 1956 (fig. 2). The purpose of the examinations was to evaluate all new thorium discoveries in the area. Recently exposed thorium veins were examined radiometrically with scintillation counters. Samples were collected and assayed for their thorium content. Deposits that were considered to have significant showings were mapped by Brunton and tape methods at scales of 10 feet to 1 inch and 40 feet to 1 inch. Private exploration was still being conducted and additional thorium discoveries were still being made when AEC field work was terminated.

Thorite was discovered in the Duck Creek area, Broadwater County, Montana, in July 1955 (fig. 3). Intense prospecting continued throughout the summer and fall, but no additional thorium discoveries were made. Field examinations were conducted by AEC in the fall of 1956. An area within a 2-mile radius of the Duck Creek thorium deposit was examined radiometrically. Significant radioactivity was not noted. The investigation of the Duck Creek thorium deposit was undertaken after exploration work by the operators had exposed several thorite-bearing dikes. Only a minor amount of thorium appears to be present in the Duck Creek area, and it is confined to one deposit.

LEMHI PASS AREA

Location and surface features

The Lemhi Pass area (fig. 2) centers on the Idaho-Montana border, 28 miles southeast of Salmon, Idaho, and 30 miles west of Armstead, Montana. The border is also the Continental Divide and follows the crest of the Beaverhead Range. The area is mountainous, but not rugged, and is characterized by rounded ridges which rise steeply from the valley floors. The altitudes range from 4, 800 feet in the Lemhi Valley to 8, 000 feet at Lemhi Pass. The north-facing slopes in the higher elevations are well timbered with pine, fir, and hemlock. The non-timbered areas are covered by bunchgrass and sagebrush. The climate of the area is semiarid, but snow covers the slopes above

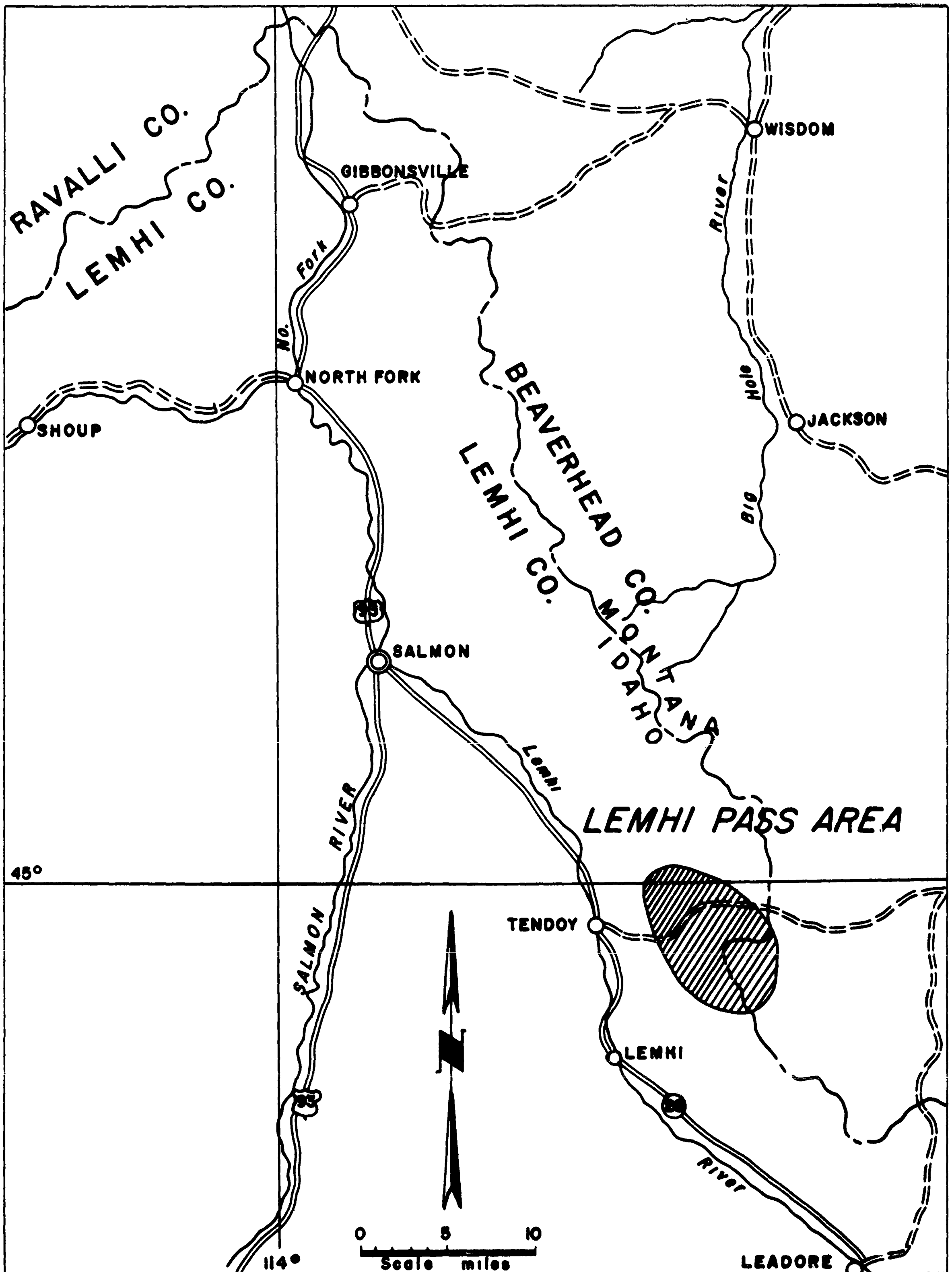


Fig. 2 INDEX MAP
LEMHI PASS AREA

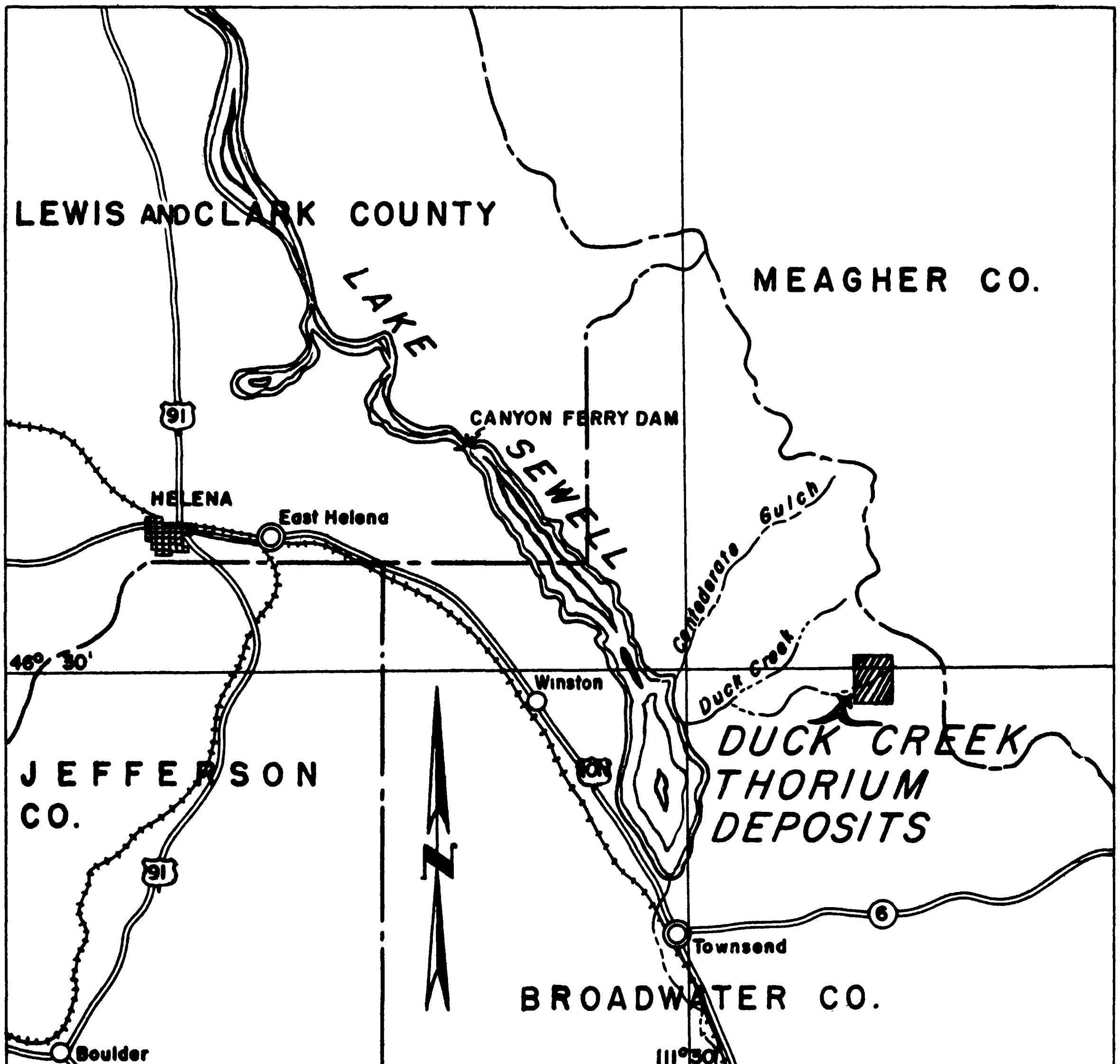


Fig. 3

INDEX MAP

DUCK CREEK AREA

BROADWATER CO., MONTANA

0 5 10
Scale miles

5, 000 feet from December to April. The Lemhi Pass area is readily accessible from Tendoy, Idaho, by a Forest Service road that follows Agency Creek to the Continental Divide.

The area is chiefly within T. 19 N., R. 24 and 25 E., and in the McDevitt and Lemhi Pass mining districts.

General geology

The Beaverhead Mountains in the vicinity of Lemhi Pass consist largely of moderately metamorphosed quartzites, argillites, and phyllites of the Belt series of Precambrian age. The rocks are intensely folded, but a regional attitude of the folding is difficult to determine. Several quartzite beds in the area have a general strike of N. 40°-60° W., with dips from 20° NE. to 50° SW. Jointing is prominent and numerous faults are present. Figure 4 shows the general geology of the Lemhi Pass area.

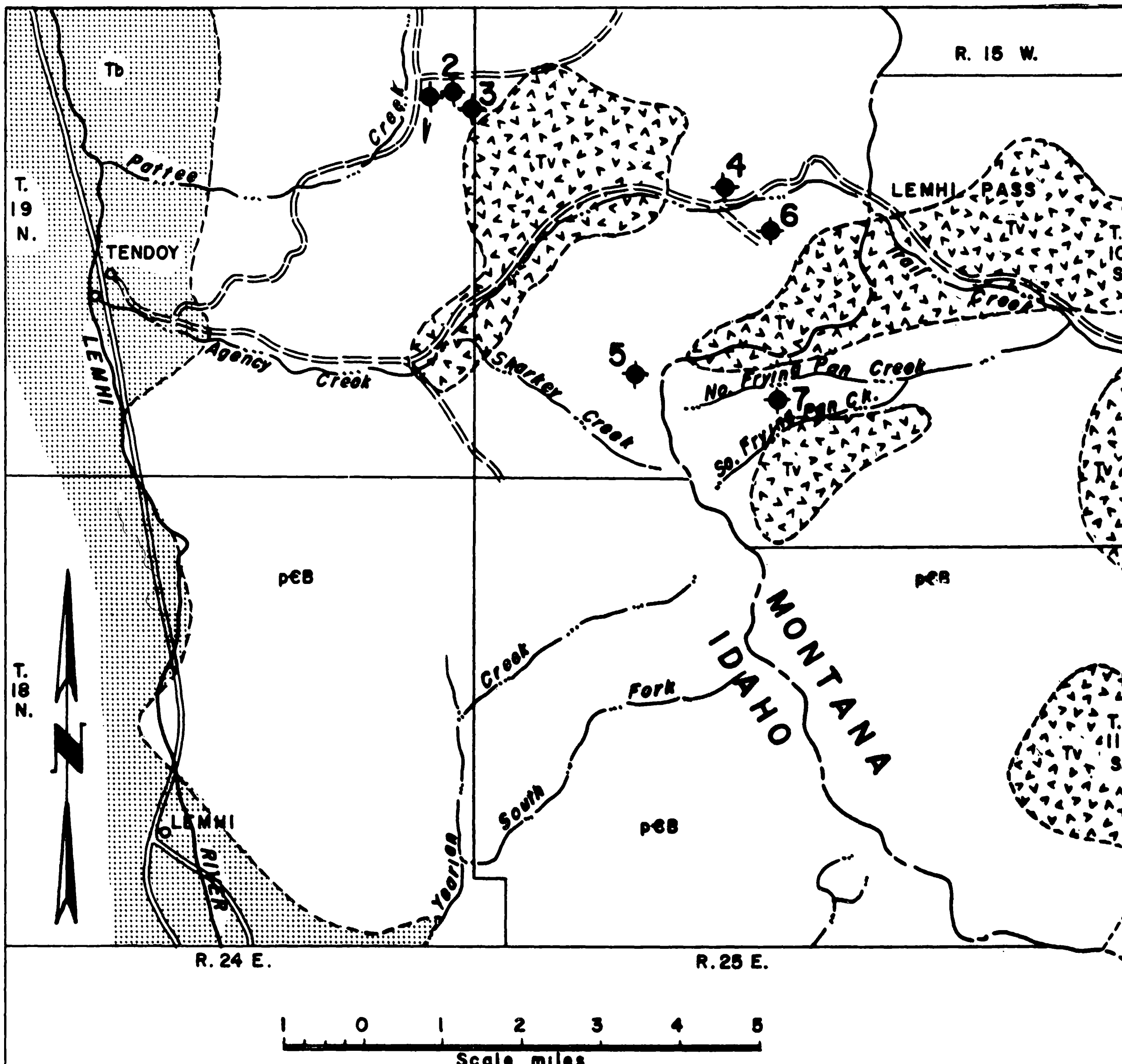
Tertiary lava flows, consisting of basalt and rhyolite, overlie the rocks of the Belt series. Several flows are exposed along Agency Creek on the west side of the divide and on Trail and Frying Pan Creeks on the east side. Tertiary basin deposits of stratified gravels, sands, clays, and tuffs are found in the major valleys. Several small diorite dikes occur in the Lemhi Pass area but generally are not exposed.

Thorium-bearing veins

The thorium mineralization of the Lemhi Pass area is confined chiefly to quartz-hematite veins. The veins range from less than 1 foot to 50 feet wide and are as much as 2, 000 feet long. They occur as fissure fillings and replacements of wall rock along well-developed faults in the Beltian rocks.

The thorium veins generally strike N. 60°-90° W.; the dips are usually vertical. The veins are more resistant than the country rock and form bold outcrops in many places.

The principal minerals of the thorium-bearing veins are quartz, chalcedony, hematite, barite, and thorite. Minor amounts of uranium



EXPLANATION

SEDIMENTARY AND METAMORPHIC ROCKS

Tb — Basin Deposits — TERTIARY

pЄB — Belt Series — PRECAMBRIAN

EXTRUSIVE ROCKS

Tv — Volcanic Rocks — TERTIARY

PROSPECTS EXAMINED

1 — Lone Star No. 2

2 — Silver Queen No. 36

3 — Silver Queen No. 37

4 — Black Bull Fraction

5 — Cagoe No. 10

THORIUM MINES

6 — Wonder Lode

7 — Thorium Metals

Approximate Contact

GENERAL GEOLOGY

LEMHI PASS AREA

Fig. 4

Geology based on geologic maps of Montana and Idaho. (USGS & State) and rare earths accompany the thorium. Hydrous iron oxides give many veins a rusty appearance.

Quartz veins occur throughout the Lemhi Pass area. They range from a few inches to 10 feet wide and fill fissures in the quartzites and phyllites. The quartz veins generally do not form bold outcrops as do the quartz-hematite veins.

The ore minerals of the quartz veins include bornite, chalcopyrite, chalcocite, cuprite, malachite, azurite, gold, and silver. The gangue minerals are quartz, pyrite, hematite, and hydrous iron oxides. Only minor amounts of uranium and thorium are found in the quartz veins.

Anomalous radioactivity is associated with most of the quartz-hematite veins of the area. The radioactivity is due chiefly to thorium and at several deposits exceeds 5 MR/hr. The average background count for the area is 0.08 MR/hr. Uranium is present in trace amounts at several localities but accounts for only a small part of the total radioactivity.

Thorite prospects in the Lemhi Pass area

Lone Star No. 2

The Lone Star No. 2 claim (No. 1, fig. 4) is in sec. 12, T. 19 N., R. 24 E., Boise meridian, on Pattee Creek, a tributary of the Lemhi River. The property is one of a group of contiguous claims held by the Idaho Thorium Company.

A thorite-bearing vein is exposed in bulldozer excavations at the Lone Star No. 2 prospect. The vein is in a highly fractured, light-gray quartzite. The lowermost excavation (fig. 5) has disclosed a horizontal fault which offsets the vein about 5 feet.

The vein, which strikes N. 80° E. and dips about 45° S., is 2 to 3 feet wide and is exposed for 25 feet. It is composed chiefly of quartz, with abundant specular hematite in lenses 2 to 3 feet in diameter. The maximum radioactivity originates from the hematite-rich zones of the vein.

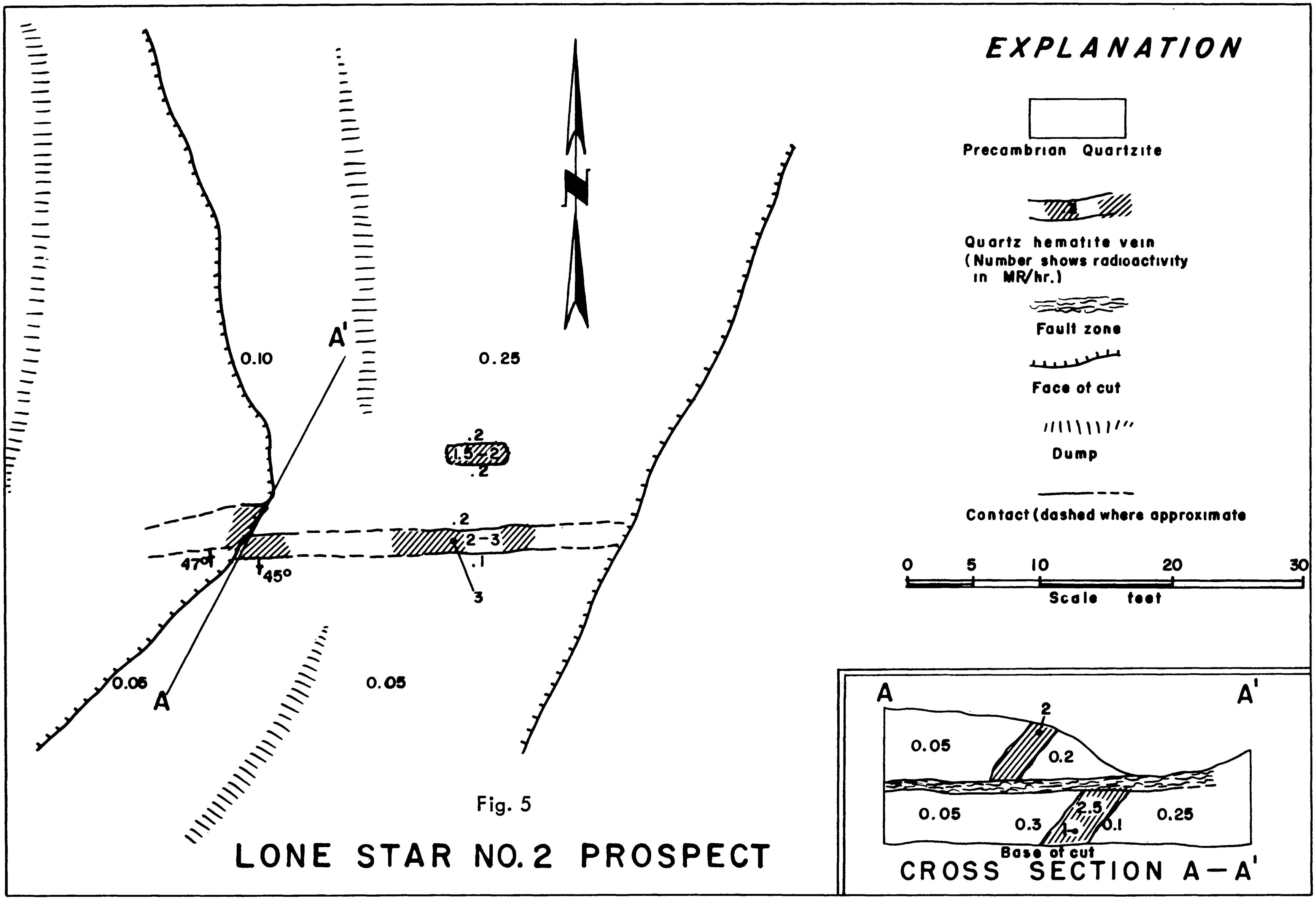


Fig. 5

LONE STAR NO. 2 PROSPECT

The background count in the area of the Lone Star No. 2 claim is 0.025 MR/hr. The significant radioactivity is confined to the quartz-hematite vein, and readings along the vein range from 1.5 to 3 MR/hr. The abnormal radioactivity of the vein is due chiefly to thorium.

Table 1 shows the equivalent thorium-oxide* content of the samples from the vein of the Lone Star No. 2 claim (see fig. 5 for sample locations).

Table 1

Sample location number	Sample number	Description (width)	Equivalent thorium oxide % ThO_2
1	103162	3' vein below fault	0.45
2	103162A	2' vein above fault	0.50
3	103162B	2' vein above fault	1.75

Silver Queen No. 35

The Silver Queen No. 35 prospect (No. 2, fig. 4) is on the south side of Poison Gulch, about one-fourth mile above its junction with Pattee Creek. The prospect is one-fourth mile east of Lone Star No. 2 claim and in sec. 12, T. 18 N., R. 24 E., Boise meridian. The property is one of a group of nearly 200 claims controlled by the Idaho Thorium Company. Several hundred feet of bulldozer cuts are present and, in one cut, two thorium-bearing veins are exposed.

*Equivalent thorium oxide is that quantity of thorium oxide (in equilibrium) which will produce the same amount of radioactivity.

The two veins (fig. 6) cut light-gray quartzite of the Belt series and strike N. 70° E. with near vertical dips. The larger of the veins is 10 feet wide where exposed at the north end of a north-trending bulldozer cut. The vein is composed mainly of black and white quartz with distinct banding and minor amounts of goethite. Brecciation of the white quartz and recementation by black quartz indicate that there has been at least two stages of silicification. This structure is only weakly radioactive with readings ranging from 0.25 to 0.35 MR/hr. The background count of the quartzite adjacent to the vein is around 0.12 MR/hr. The radioactivity is probably due to fine-grained thorite disseminated in the quartz.

The smaller vein averages about 2 feet in width and is 75 feet south of the quartz vein. The vein consists chiefly of hematite and goethite. Some quartz and calcite are present. The structure is poorly exposed in the bottom of the cut but can be traced with a geiger counter over a distance of 50 feet. The vein is moderately radioactive with readings from 0.6 to 1.6 MR/hr. The radioactivity is due almost entirely to thorium although no thorium minerals were identified.

A sample across 1.5 feet of the quartz vein assayed 0.25 percent equivalent thorium oxide, while the full width, 2.8 feet, of the hematite vein contained 0.70 percent.

Silver Queen No. 37

The Silver Queen No. 37 claim (No. 3, fig. 4) is in a gully, tributary to Poison Gulch, in sec. 12, T. 19 N., R. 24 E., Boise meridian. The property is three-fourths mile east of Pattee Creek and accessible by a jeep road from Poison Gulch. Idaho Thorium Company is the present owner of the claim. Workings consist of a bulldozer cut 150 feet long.

The excavation on the Silver Queen No. 37 claim cuts a 12-foot wide quartz vein. The vein (fig. 6) strikes east and dips steeply north, cutting a gray quartzite of the Belt series. The quartz vein crops out in only one small area near the discovery cut. Black and white quartz, which gives the vein a banded appearance, is the chief constituent of the vein. The banding is parallel to the sides of the vein and probably represents several stages of vein filling of a fissure. Hematite, goethite, and calcite are also present in the vein, though in minor amounts. The quartzite wall rock is intensely fractured and

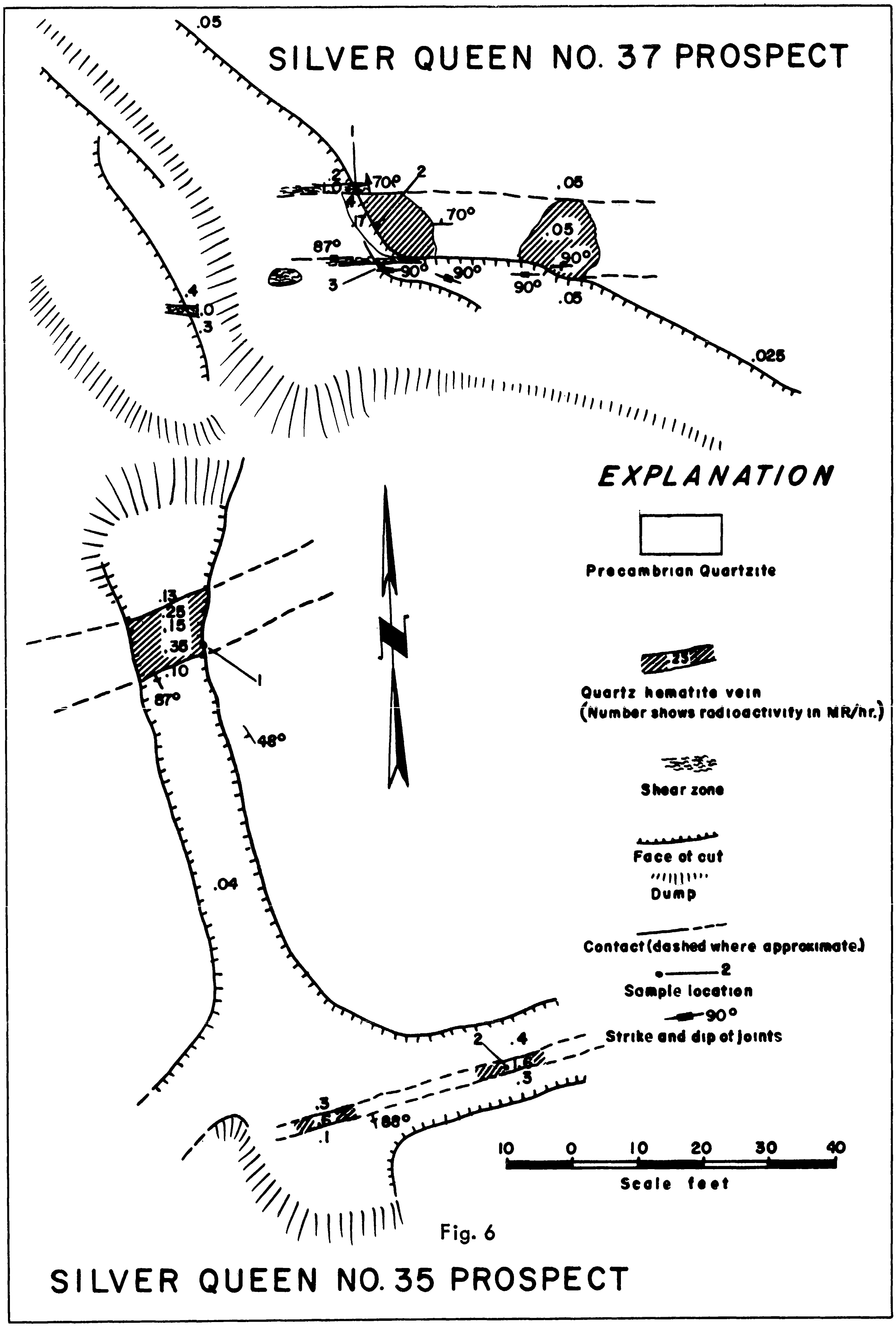

SILVER QUEEN NO. 37 PROSPECT
EXPLANATION
Precambrian Quartzite
Quartz hematite vein
(Number shows radioactivity in MR/hr.)
Shear zone
Face of cut
Dump
Contact (dashed where approximate)
Sample location
Strike and dip of joints
Scale feet
SILVER QUEEN NO. 35 PROSPECT

Fig. 6

sheared for about 2 feet on both sides of the vein. Abundant goethite is present in the sheared zones and exhibits anomalous radioactivity. Several seams from 1 to 3 inches wide along the south wall of the vein contain as much as 2.95 percent equivalent thorium oxide.

The significant radioactivity is confined to the wall rock of the vein. The radioactivity of the quartz vein ranges from 0.05 to 0.40 MR/hr., and the background count for the area is 0.025 MR/hr. The wall rock averages 1 MR/hr. for 2 feet on both sides of the vein. The maximum radioactivity in the area is in excess of 5 MR/hr. and is confined to a small pocket of hydrous iron oxide about 3 feet in diameter. The pocket is on the bottom of the cut and along the south wall of the vein.

Samples from the Silver Queen No. 37 claim with the equivalent thorium oxide are given in table 2 (see fig. 6 for sample locations).

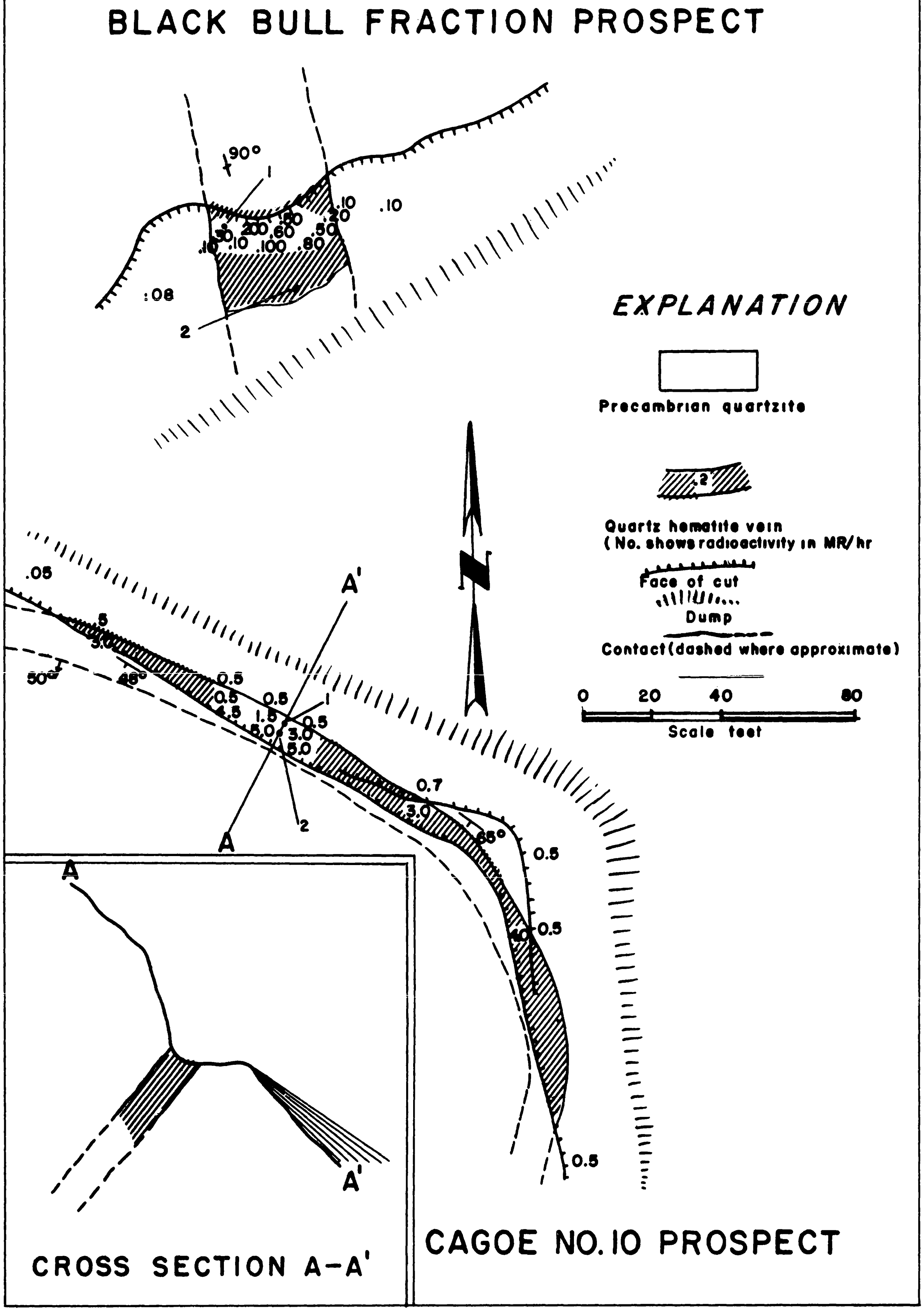
Table 2

Sample location number	Sample number	Description (width)	Equivalent thorium oxide % ThO_2
1	103161	2', north wall rock	0.40
2	103161A	6', quartz vein	0.50
3	103161B	0.2', goethite seam	2.95

Black Bull Fraction

The Black Bull Fraction (No. 4, fig. 4), in sec. 15, T. 19 N., R. 25 E., Boise meridian, is 11 miles east of Tendoy, Idaho, on the Agency Creek road. The workings consist of one bulldozer cut which is to the north and 30 feet above the road. The prospect is about one-eighth mile east of the Copper Queen mine turnoff. The property is one of a group of unpatented claims owned by the Idaho Thorium Company.

Fig. 7


BLACK BULL FRACTION PROSPECT
90°
1
2
.10
.20
.10
.80
.60
.50
.80
.100
.200
.30
.10
:08
EXPLANATION
Precambrian quartzite
Quartz hematite vein
(No. shows radioactivity in MR/hr
Face of cut
Dump
Contact (dashed where approximate)
0
20
40
80
Scale feet
.05
5
3.0
50°
48°
A'
A
0.5
0.5
4.5
1.5
5.0
3.0
5.0
0.5
1
2
0.7
3.0
65°
0.5
40
0.5
0.5
CROSS SECTION A-A'
CAGOE NO. 10 PROSPECT

The Black Bull Fraction has been staked on a north-trending quartz-hematite vein that cuts a gray quartzite of the Belt series (fig. 7). The vein appears to have a nearly vertical dip. The vein, as exposed in the cut, is 40 feet wide and consists of gray and pink quartz with many intersecting specular-hematite veinlets which form up to 60 percent of the rock in several places. Magnetite and hydrous iron oxides are also present.

The anomalous radioactivity is confined to that part of the vein which contains the hematite veinlets. The width of this section averages 16 feet. The radioactivity is probably from thorite which accompanies the hematite.

The radiometric readings across the vein range from 0.20 to 2.00 MR/hr.; the background count for the area is 0.05 MR/hr. The highest readings are found on the west half of the vein. Samples of the hematite-rich part of the vein, 10 feet wide, contained 0.15 percent equivalent thorium oxide (No. 2, fig. 7). A 6-foot sample across the section of the vein exhibiting the maximum radioactivity contained 1.22 percent equivalent thorium oxide (No. 1, fig. 7).

Cagoe No. 10

The Cagoe No. 10 claim (No. 5, fig. 4) is 4 miles southwest of Lemhi Pass and one-fourth mile north of the Continental Divide. The prospect is in the NE$\frac{1}{4}$ sec. 28, T. 19 N., R. 25 E., Boise meridian, and is reached by a jeep trail that follows the Montana-Idaho border. The property is an unpatented claim owned by Messrs. Groggins, McConnell, Moore, Ellis, Bell, and Kattecenes of Tendoy and Salmon, Idaho. A bulldozer cut, which exposes a thorite-bearing quartz vein for nearly 200 feet, is the only working on the property. The vein cannot be traced beyond the cut because of thick overburden.

Light-gray argillaceous quartzite of the Belt series is the country rock of the area (fig. 7). Locally the quartzite strikes N. 70°-76° W. and dips 50°-60° SW.

The thorite-bearing vein occupies a fracture zone in quartzite, and strikes N. 70° W. with a dip of 50° SW. The vein, which is poorly exposed in the bulldozer cut, appears to be about 10 feet wide. Quartz, chalcedony, and hematite are the major constituents of the vein. Minor amounts of barite and magnetite are also present. The quartz is white to pink and has been intensely fractured, and medium- to very fine-grained specular hematite deposited in the fractures. The hematite veinlets range from less than 1 inch to several feet wide and are parallel to the walls of the quartz vein. Iron oxides coat most of the fracture surfaces of the vein giving it a rusty appearance.

Megascopic subhedral and anhedral thorite crystals occur throughout the hematite. The thorite is transparent, reddish-colored, and has a distinct cleavage. Some specimens of the hematite contain as much as 20 percent thorite. Mineralogical studies of the thorite-rich hematite performed by W. L. Gnagy of the U. S. Bureau of Mines indicate that the principal thorium mineral is huttonite, a thorite silicate ($ThSiO_4$). Chemical analyses of selected samples of the thorite-rich hematite disclosed 6.85 percent ThO_2, 0.147 percent U_3O_8, 44.4 percent Fe, and small amounts of SiO_2 as quartz.

The Cagoe No. 10 vein is strongly radioactive, and readings range from 1 to 5+ MR/hr. The quartz vein material exhibits radioactivity from 1 to 4.5 MR/hr., whereas the readings of the hematite veinlets are from 4 to 5+ MR/hr. The background count of the quartzite is 0.05 MR/hr.

A 2.5-foot section across the main hematite vein contains 6.65 percent equivalent thorium oxide (No. 1, fig. 7). Three feet of quartz and hematite adjacent to the vein assayed 0.45 percent equivalent thorium oxide (No. 2, fig. 7).

Other thorium deposits in the Lemhi Pass area

There are two thorium mines in the Lemhi Pass area of Montana and Idaho. Although the mines are not producing thorium, sufficient exploration work has been undertaken at these properties to justify a brief discussion in this report. The mines were not examined during the course of the examination of the newly discovered thorite occurrences.

Wonder Lode

The Wonder Lode mining claims (No. 6, fig. 4) are in secs. 22 and 23, T. 19 N., R. 25 E., Boise meridian, 11 miles east of Tendoy, Idaho. The claims are accessible by a Forest Service road which follows Agency and Camp Creeks. The Idaho Thorium Company is the present owner of the property.

Impure quartzites of the Belt series underlie the Wonder Lode claims. The quartzites are predominantly gray; however, adjacent to the thorite-bearing veins the quartzites are reddish. A diorite dike, about 20 feet wide, cuts the quartzites. The dike strikes eastward and dips from near vertical to 58° S.

The Wonder Lode thorite vein strikes about N. 85° E., dips 42°-80° S., and occupies a shear zone in the quartzites. The vein ranges from less than 1 foot to approximately 10 feet wide. Service and Weis (1955) describe the vein material as being tan to nearly black, soft, friable to pulverulent, and amorphous. Minerals which have been recognized include siderite, quartz, calcite, sphalerite, chalcopyrite, and malachite. Iron and manganese oxides are abundant; barite, thorite, and gypsum have been tentatively identified. Several north-trending cross faults displace the vein 10 to 20 feet horizontally. Surface trenches expose parts of the vein for more than 500 feet.

The underground workings at the Wonder Lode mine consist of four accessible adits with a total length of 950 feet. The two short adits, 50 and 75 feet, were undertaken prior to 1951 in search for copper, lead, zinc, and silver. In 1954, two drifts were advanced on the Wonder Lode vein to evaluate the vein for thorium and uranium. The exploration work was under a Defense Minerals Exploration Administration contract.

In the upper adit, which is about 160 feet above the creek, 280 feet of drifts and 56 feet of crosscuts are present. The Wonder Lode vein is exposed for 150 feet, between 35 and 185 feet from the portal. Radiometric readings along the vein range from 0.09 to 6 MR/hr. The vein contains 0.05 to 2.66 percent thorium oxide and 0.002 to 0.02 percent uranium oxide.

The lower adit is 40 feet above the creek and consists of 436 feet of drifts and 51 feet of crosscuts. The vein in the lower adit is exposed from 85 to 235 feet from the portal. The radioactivity of the vein ranges from 0.05 to 0.44 MR/hr. The vein, as exposed in the lower adit, contains 0.02 to 0.502 percent thorium oxide and 0.006 to 0.148 percent uranium oxide. Spectrographic analysis of samples from the lower workings indicated as much as 0.50 percent rare earths.

Thorium Metals Corporation

The mining claims (No. 7, fig. 4) of the Thorium Metals Corporation of Dillon, Montana, are in secs. 19, 20, 21, 28, 29, and 30, T. 10 S., R. 15 W., Principal meridian, Montana. The group of claims is on the Montana side of the Continental Divide, near the headwaters of Frying Pan Creek. Access to the property is by way of graveled and dirt roads from Armstead, Montana, on U. S. Highway 91 or from Tendoy, Idaho, on Idaho State Highway 28. The group consists of 51 unpatented claims, and the main workings are confined to the Last Chance and Shady Tree claims.

The area is underlain by quartzites of the Belt series which strike generally northwest and dip gently to the northeast. The main mineralized structure is the Last Chance-Shady Tree vein. The vein is 12 to 40 feet wide and surface trenches indicate a length of about 2,000 feet. The vein strikes from N. 45°-60° W. and dips from 45°-60° SW. The vein occupies a fault along which recurrent movement has occurred, intensely fracturing parts of the vein.

The Last Chance-Shady Tree vein is composed of gray to pinkish quartz with barite. Hematite and goethite are present and impart a reddish color to most of the vein. The only economic mineral in the vein is fine-grained thorite which occurs along fractures in the quartz and appears to be associated with the hematite. Uranium and rare earths are present but in minor quantities.

The principal working on the Last Chance-Shady Tree vein is a 500-foot crosscut which cuts the vein 240 feet vertically below the surface. The vein at this point is 16 feet wide. A 50-foot drift driven southeast along the vein indicates that the vein is persistent at this depth. Samples of the vein along the surface outcrop contain from 0.60 to 3.34 percent thorium oxide. At a depth of 240 feet, the average thorium content of the vein is 0.52 percent (Jarrard, 1956).

Thorium also occurs in lenticular pods along a well-developed shear zone 2,600 feet northeast of the Last Chance-Shady Tree vein. The shear zone has the same strike and dip as the Last Chance-Shady Tree vein. The zone has a strike length of about 3,500 feet, as determined from surface excavations. The pods are usually not more than 1 to 2 feet in width in the shear zone which in places is 40 feet wide. The individual pods pinch to narrow stringers both horizontally and vertically. The highest-grade ore occurs along the center of the shear zone without definite confining walls. The gangue minerals of the shear-zone structure consist of gray to reddish quartz, barite, hematite, and goethite. Thorite, the only ore mineral, is accompanied by minor amounts of xenotime and uranium. The thorite occurs disseminated in the hematite and cannot be megascopically recognized.

The only workings on the shear-zone structure are the surface cuts. Sampling of the vein along the surface exposures disclosed from 0.20 to 4.30 percent thorium oxide.

DUCK CREEK AREA, BROADWATER COUNTY, MONTANA

Location and surface features

The Little Brown Egg thorium deposit (fig. 3 and fig. 8) is on the Wayne Plymale homestead of which the mineral rights belong to Mr. Plymale. The location is further described as being on the Duck Creek drainage in the SE$\frac{1}{4}$ sec. 35, T. 9 N., R. 3 E., Principal meridian, Montana. The prospect is readily accessible from Montana State Highway 6 by graveled and dirt roads. Townsend, Montana, a station on the Northern Pacific Railway and the county seat for Broadwater County, is 15 miles to the southeast.

The deposit is on the southwest slope of the Big Belt Mountains, 3 miles from the crest of the range. Although the area is mountainous, the relief is moderate and is characterized by smoothly rounded ridges. The deposit is at an altitude of 6,000 feet. The surface southwest of the deposit slopes to within 3 miles of the Townsend Valley, a broad basin with an altitude of 3,500 feet. Because of heavy overburden and alluvium, rock exposures in the vicinity of the Little Brown Egg thorium occurrence are poor. The area is covered by pine and aspen trees, with open parks of sagebrush and bunchgrass. The climate is semiarid. Permanent and intermittent streams provide drainage. Snow generally covers the higher mountains from December through March.

Field work and acknowledgments

The Little Brown Egg thorium deposit was discovered by Theodore A. Zimple of Seeley Lake, Montana, in the summer of 1955. In late September 1956, AEC mapped the geology of the deposit at a scale of 60 feet equals 1 inch. During parts of October and November of the same year the writer added details to this map and conducted a radiometric scintillation survey over an area of about 2 square miles in the vicinity of the deposit.

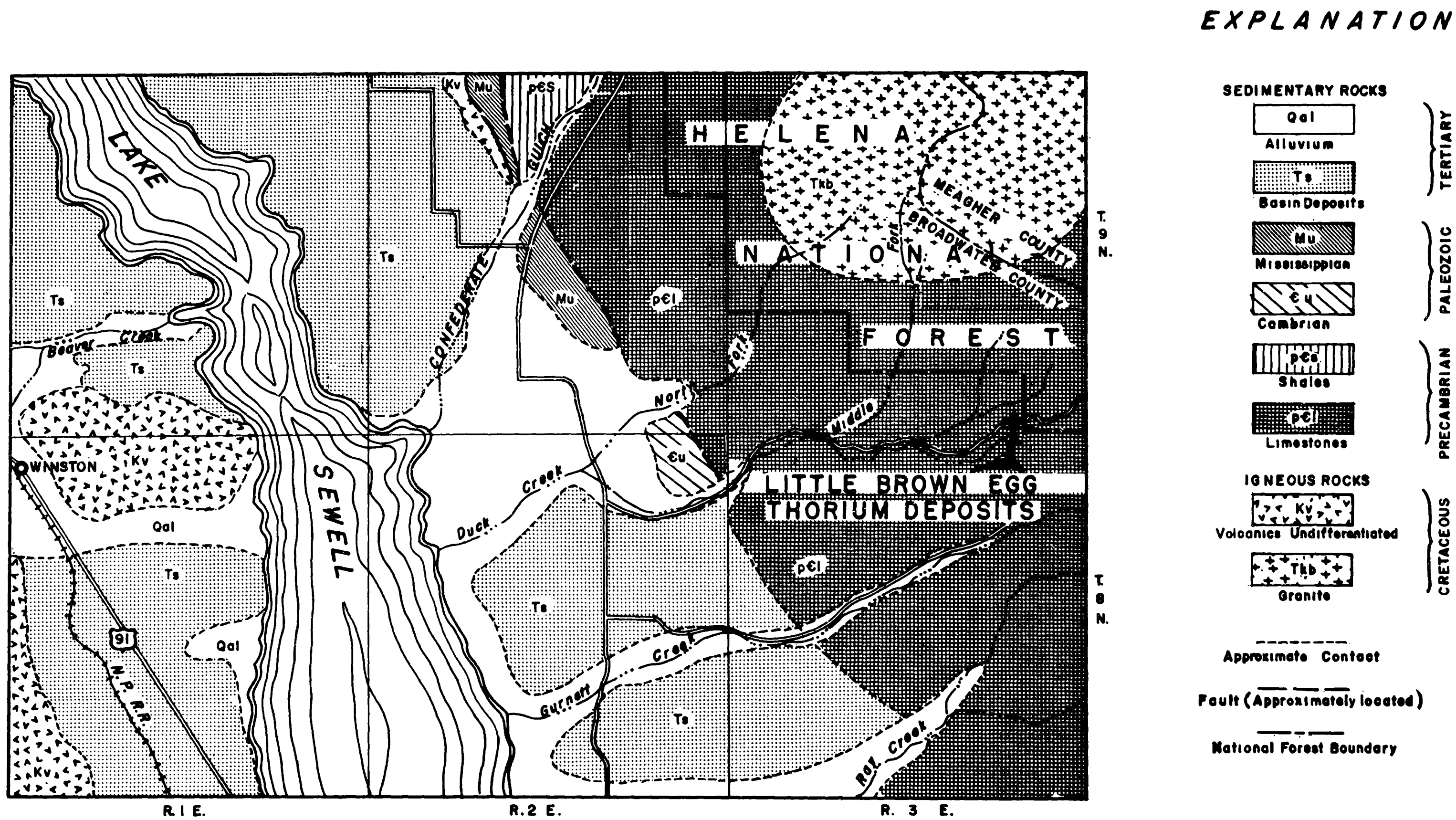
The general geology of the Duck Creek area is shown on the Montana stage geologic map at a scale of 1:500,000. Detail geologic maps of the area are not available; however, some adjacent quadrangles have been mapped. Assaying and mineralogical work was done during the course of the investigation by the Salt Lake City laboratories of the U. S. Bureau of Mines and the AEC.

General geology

Precambrian rocks of the Belt series are the oldest and most predominant rocks of the Big Belt Mountains. They constitute the basal unit of the range and consist of great thicknesses of shales and limestones. The major units of the Belt series in the Big Belt Mountains are the Newland limestone and the Greyson and Spokane shales. Cambrian through Permian rocks are found in a narrow belt on the west flank of the range, about 18 miles northwest of the Duck Creek thorium deposit. These rocks lie unconformably and in fault contact against the Belt series. Thick Tertiary basin deposits occupy the larger valleys of the area. The general geology of the area is shown in figure 8.

The Paleozoic rocks include quartzites and shales of Cambrian age; limestones and shales of Devonian age; limestones and quartzites of Carboniferous age; and shales, sandstones, and limestones of Permian age. Mesozoic sedimentary rocks are absent in the Big Belt Mountains. The Tertiary sediments, which are chiefly basin deposits, consist of thick sequences of clay, sand, and gravel with some interbedded tuffs.

Stocks, dikes, sills, and flows of late Mesozoic and Tertiary age occur in the Canyon Ferry region of the Big Belt Mountains. The dikes



Geology based on Geologic Map of Montana. (USGS & State)

Fig. 8

GENERAL GEOLOGY

DUCK CREEK AREA

BROADWATER COUNTY, MONTANA

1 0 1 2 3 4 5
Scale miles

and sills are composed chiefly of diorite. The larger dikes are as much as 6 miles long and 200 to 300 feet thick. Several stocks of quartz monzonite and quartz diorite occur in the area. The largest stock is 20 square miles in area and lies 3 miles north of the Duck Creek thorium deposit. Latite, andesite, and basalt flows are exposed in scattered localities north of the Duck Creek area. The flows are not extensive but occur as isolated outcrops usually not more than 1 square mile in area.

The geology of the area has been described by Knopf (1913) in his report of the Helena mining district; by Pardee (1925) in a report on the geology and ground water of the Townsend Valley; and by Mertie, Fischer, and Hobbs (1951) in their report on the geology of the Canyon Ferry quadrangle.

Little Brown Egg thorium deposit

Local geology

The predominant rock unit in the area of the Little Brown Egg thorium deposit in the Newland limestone, a hard dolomitic limestone which is dark bluish gray on fresh fractures and is buff to straw colored on weathered surfaces. The limestone in the immediate vicinity of the thorium deposit is distinctly platy with one-fourth inch to 3-inch parting planes. Locally the limestone strikes N. 80°-90° E. and dips 8°-30° N. Well-developed fractures at nearly right angles to the bedding are present. Pronounced shearing and contortion of the limestone occurs adjacent to the thorium-bearing structure.

Geology of the thorium-bearing dikes

Aplite dikes, which are the thorium-bearing structures of the Little Brown Egg deposit, strike about N. 60° E. and are vertical (figs. 9 and 10). Stripping operations have exposed the dikes for nearly 300 feet. Beyond the stripped areas the dikes cannot be traced because of a thick cover of overburden. Several open cuts on the property expose a series of aplite dikes, along fractures in the limestone. The individual dikes are from 1 to 5 feet wide and merge into a single structure about 15 feet wide. Several of the dikes exhibit small apophyses which are conformable to the bedding planes of the limestone.

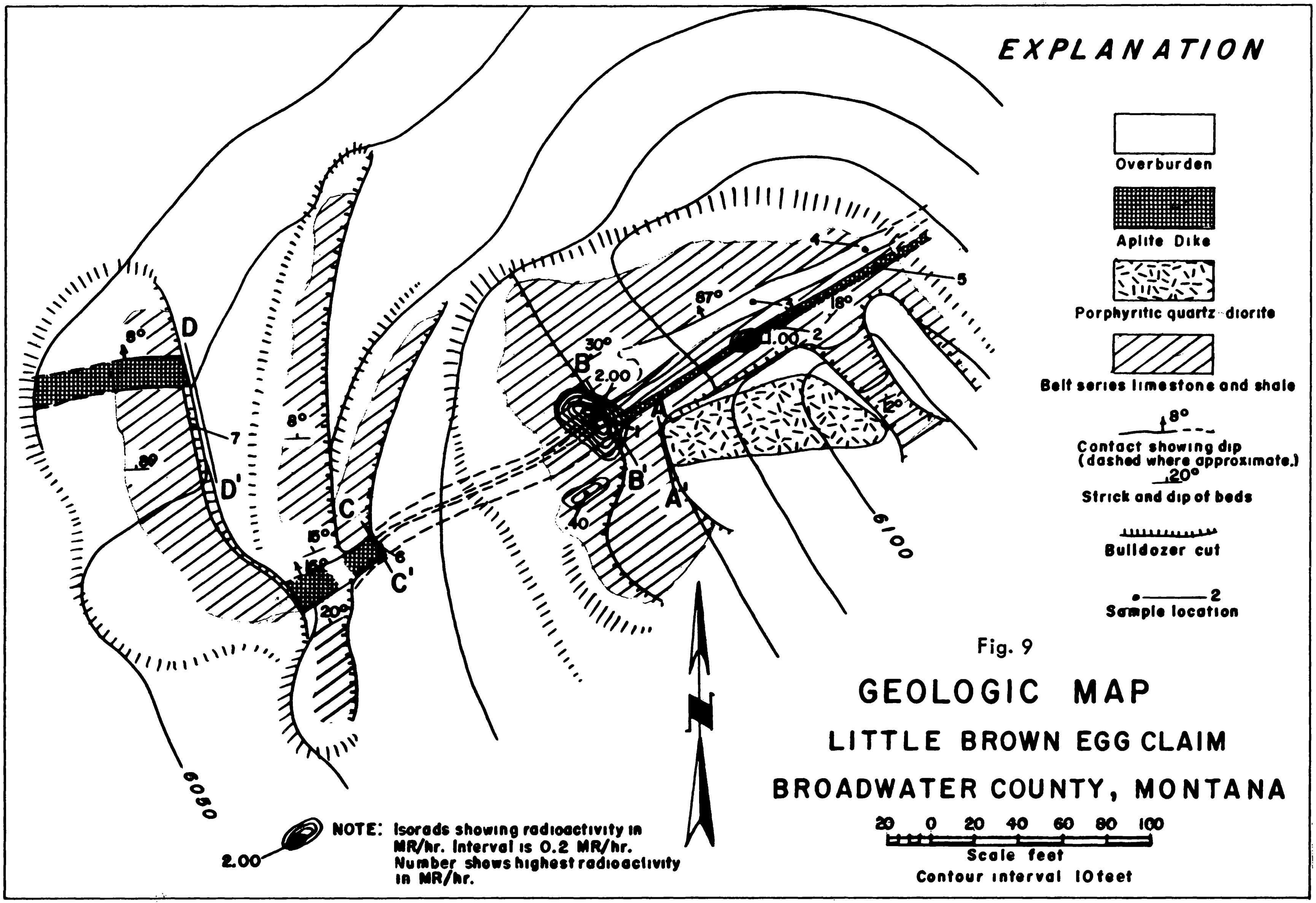


Fig. 9

GEOLOGIC MAP

LITTLE BROWN EGG CLAIM

BROADWATER COUNTY, MONTANA

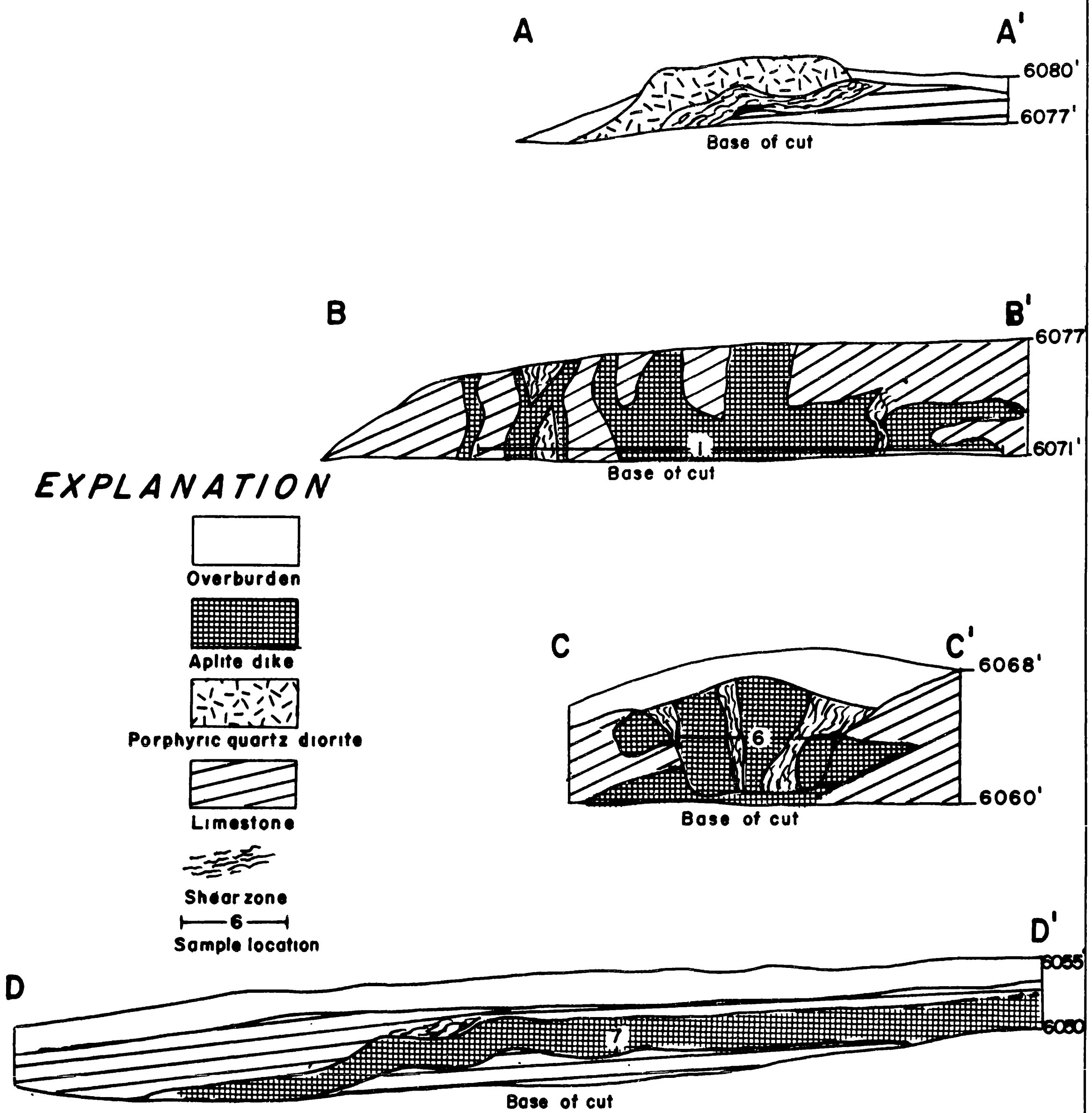
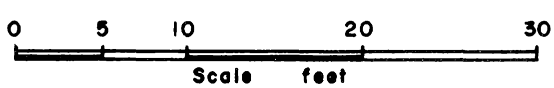


Fig. 10

GEOLOGIC SECTIONS

LITTLE BROWN EGG CLAIMS

BROADWATER CO. MONTANA



The aplite dikes consist of approximately 95 percent albite, 2 percent muscovite, and small amounts of iron oxide and manganese dioxide. This rock type is classified by Johannsen (1939) as albitite. The dike is very fine grained near its contact with the limestone, in places resembling a felsite, and pegmatitic within portions of the larger dikes. Alteration of the dike is distinct, with the formation of sericite and clay minerals from the feldspar.

A small elongated mass of porphyritic quartz diorite (leuco-sodaclase-tonolite-porphyry, after Johannsen), an apparent remnant of one of the Cretaceous sills of the area, crops out near the thorite-bearing structure of the Little Brown Egg claim. No relationship has been established between the quartz diorite and the aplite dikes.

Mineralogy

Thorite, an anhydrous thorium orthosilicate ($ThSiO_4$), is the only thorium mineral that has been identified in this deposit. The mineral is dark brown to black, vitreous to glossy when fresh, but becomes dull to greasy by alteration. Chemical analyses indicate that calcium, uranium, and phosphate are intimately mixed with the thorite, possibly as the mineral autunite. However, autunite could not be identified petrographically or by X-ray patterns. Analyzed samples of thorite showed a U_3O_8-ThO_2 ratio of approximately 1:700. No detectable rare-earth elements are present. Minute quantities of very fine-grained galena occur as disseminations in the aplite and accompany the thorite. It is possible that the galena is of radiogenic origin.

The thorite of the Little Brown Egg thorium occurrence is disseminated in the aplite and is epigenetic in origin. The particles of thorite range from small irregular blebs, indistinguishable to the naked eye, to one mass nearly 4 feet in diameter. The larger masses of thorite are irregularly distributed in the dikes, with no apparent structural control.

Radioactivity

The anomalous radioactivity of the Little Brown Egg thorium deposit is confined to the aplite dikes. Scintillation-counter readings of the area range from 0.008 MR/hr. to 2 MR/hr. The average reading for the dikes is 0.035 MR/hr. The highest reading is 2 MR/hr. which is confined to a pocket of thorite about 4 feet in diameter. The radioactivity of the limestone host rock and the diorite sill is 0.008 MR/hr. which is also the background court for the area.

The thorium content of samples taken from the radioactive dikes is shown in table 3 (see fig. 9 for sample locations).

Table 3

Sample location number	Sample number	Description	Equivalent thorium oxide $\%ThO_2$
1	A-0818	8 feet of north wall rock	0.03
	A-0819- A-0821	19-foot vein (aplite)	0.33
	A-0822	6 feet of south wall rock	0.04
2	A-0823	2.5-foot vein (aplite)	1.20
3	A-0824	8-foot vein (aplite)	0.02
4	A-0825	5-foot vein (aplite)	0.007
5	A-0826	3-foot vein (aplite)	0.005
6	A-0827	9-foot vein (aplite)	0.03
7	A-0828	2-foot vein (aplite)	0.39

SUMMARY

The known thorium deposits of Lemhi Pass and the Duck Creek areas constitute a raw-material source of thorium. The economics of these deposits are dependent on the marketability of thorium or thorium oxide which at present is practically wholly confined to several chemical companies representing a limited demand.

The geologic probability of discovering additional thorium occurrences in Lemhi Pass is excellent. However, the rate of discovery probably will also depend on the marketability of the product.

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