Geology and Thorium-Bearing Deposits of the Lemhi Pass Area Lemhi County, Idaho, and Beaverhead County, Montana

GEOLOGICAL SURVEY BULLETIN 1126

Prepared on behalf of the U.S. Atomic Energy Commission

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By WILLIAM N. SHARP *and* WAYNE S. CAVENDER

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GEOLOGY AND THORIUM-BEARING DEPOSITS OF THE LEMHI PASS AREA, LEMHI COUNTY, IDAHO, AND BEAVERHEAD COUNTY, MONTANA

By William N. Sharp and Wayne S. Cavender

ABSTRACT

The geologic study of the Lemhi Pass area in the Beaverhead Mountains, Lemhi County, Idaho, and Beaverhead County, Mont., was undertaken to evaluate the area as a potential source of thorium. To accomplish this objective some of the geologic relations within the area were determined and the vein deposits were mapped and sampled.

The Beaverhead Mountains in the vicinity of Lemhi Pass are underlain principally by dark-gray to greenish-gray micaceous quartzite and argillite of the Belt series of Precambrian age. Certain quartz veins in these rocks are known to contain thorite as an important constituent.

Tertiary volcanic rocks that range in composition from olivine basalt to rhyolite porphyry overlie the Precambrian rocks on remnants of a well-developed erosional surface. Diorite dikes are the only intrusive rocks in the area. Faults are numerous in the Lemhi Pass area; two major systems bound the district on the north and west.

Quartz veins in the area are grouped into four types: (1) quartz-hematite-thorite veins, (2) quartz-copper-bearing sulfide-thorite veins, (3) quartz-copper-bearing sulfide veins, and (4) quartz-hematite veins. The veins range in size from a few inches wide and 100 feet long to 30 feet wide and several hundred feet long. The ThO_2 content of the veins ranges upward to 2.0 percent in local concentrations. A brief examination of most of the deposits shows that the deposits are small except for three localities.

The three major deposits—the Last Chance, the Wonder Lode, and the Trapper–Lucky Strike claims—have been explored to some extent and may become economic sources of thorium.

INTRODUCTION

This report describes the general geology of an area of about 80 square miles, and the detailed geology of the vein deposits, some of which contain thorite.

The purpose of the study was to establish the extent of the thorite-bearing deposits, to define the geologic associations of the thorite, and to evaluate the district as a potential source of thorium. The study was conducted by the U.S. Geological Survey on behalf of the Division of Raw Materials, U.S. Atomic Energy Commission.

LOCATION AND ACCESSIBILITY

The Lemhi Pass area is in the Beaverhead Mountains, 26 miles southeast of Salmon, Idaho, and lies astride the Continental Divide; part of the area is in Beaverhead County, Mont., and part in Lemhi County, Idaho (fig. 1). An unimproved county road from Tendoy,

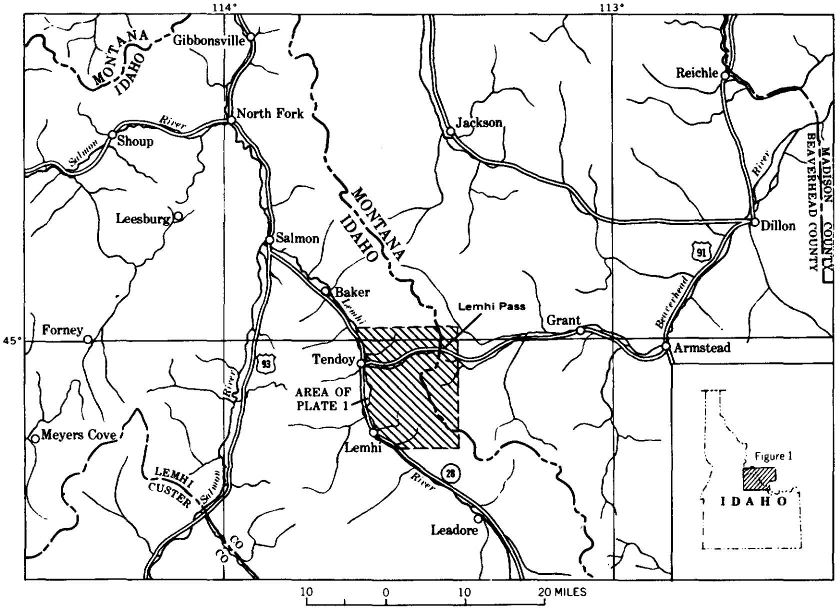

FIGURE 1.—Index map showing location of Lemhi Pass area, Idaho and Montana.

Idaho, to Armstead, Mont., crosses the range at Lemhi Pass. Roads and trails lead off from this county road and give access to most of the properties and mine sites in the area.

SURFACE FEATURES

The Beaverhead Mountains in this area are a generally rugged, single-crest divide that trends southeast, separating the valley of the Lemhi River on the west from the Horse Prairie of the Beaverhead valley on the east. The range rises steeply from the flanking valleys to altitudes of 7,300 to 9,000 feet at the crest and is asymmetrical in cross section. The eastward slope is more irregular and at places more abrupt than the generally unbroken front of the western slope. Glacial cirques are prominent on the east side of the divide. The crest of the divide is broadly rounded and is almost parklike for several miles in the area of the broad shallow saddle of Lemhi Pass, but becomes more rugged as well as higher in altitude both southward and northward. Drainage has dissected the slopes of the range into a series of deep gorges and steep ridges that are heavily timbered on the north-facing slopes and also in shaded canyons. Yellow pine, lodgepole pine, Douglas-fir, and aspen are the principal trees of the area; limber pines grow at places on the highest crest. South-facing slopes and ridge crests generally are devoid of timber but are heavily covered with grasses and sparse amounts of sagebrush.

Snow is abundant from mid-October to mid-May. The summers are mild, and occasional showers and thunderstorms provide sufficient moisture to maintain the flow of all the creeks and numerous springs.

FIELDWORK AND ACKNOWLEDGMENTS

Fieldwork on which the report is based was done in July to October 1952. Areal mapping was done on Geological Survey aerial photographs at scales of 1:20,000 and 1:15,000 and compiled on a planimetric base map constructed by the Geological Survey. Detailed maps of some of the veins and deposits, as well as basic control for the base map, were made by planetable methods. Mine mapping was done using a Brunton compass and tape. G. E. Shoup of Salmon, Idaho, R. A. Wellborn of Medicine Lodge, Mont., and Walt G. Armeson of Dillon, Mont., were particularly helpful in offering much information about mining history in the district and extending many courtesies to the authors. Thanks are also due the Elkhorn Mining Co. of Boulder, Mont., Defense Metals, Inc., of Kellogg, Idaho, and Mr. Charles Kapp of Salmon, Idaho, representative for the owner of the Copper Queen mine, for complete freedom to work on their properties and permission to publish mine maps and sections.

PREVIOUS INVESTIGATION

The earliest description of the Lemhi Pass area is contained in the report of the Lewis and Clark expedition of 1804–06. The route of this expedition crossed the Beaverhead Mountains into Idaho at Lemhi Pass (Lewis, 1903). A spring near the crest above Agency Creek in Idaho, which has been named Lewis and Clark Spring, is supposed to have been mentioned in the original notes.

Early geologic work in the Lemhi Pass district was brief. In 1901 Robert Bell (1901) presented an outline of Idaho geology and of the principal ore deposits of Lemhi and Custer counties. In 1910, J. B. Umpleby (1913) worked in Lemhi County and reported briefly on parts of the area. The next geologic studies were reconnaissance examinations by F. J. Anderson in August 1949 and by J. S. Vhay (1951) in October and November 1949. In 1950, with the renewed search for radioactive minerals, the region again became active. Several of the quartz veins were explored for thorium and rare earths under contracts of the Defense Minerals Administration and of its successor agency, the Defense Minerals Exploration Administration. A reconnaissance of the major vein deposits was made in 1950 by A. F. Trites, Jr., and E. W. Tooker.

Subsequent to the field investigations made for this report, other groups have done work in the Lemhi Pass area. Investigations for radioactive mineral deposits by the U.S. Geological Survey included reconnaissance studies of a part of the Lemhi Pass area (Weis and others, 1958). The Idaho Bureau of Mines and Geology conducted a study of deposits of thorium and related metals in the region of Salmon, Idaho, including the Lemhi Pass area (Anderson, 1958).

REGIONAL GEOLOGIC SETTING

The Lemhi Pass area of the Beaverhead Mountains is underlain by low-grade metamorphic rocks of Precambrian age, igneous dikes, quartz veins, and Tertiary volcanic rocks of several types. Plate 1 shows the general geology of the area and the vein deposits.

The Beaverhead Mountains are underlain by metamorphic rocks of the Precambrian Belt series from a point about 20 miles south of Lemhi Pass northward to the end of the range, a total distance of more than 60 miles. Most of this unit in the vicinity of Lemhi Pass is light- to dark-gray and greenish-gray micaceous quartzite, and dark-gray argillite. An alternation of thin light and dark beds in the quartzite is discernible at most outcrops, and commonly flow cleavage or shear cleavage is present. Outcrops are not sufficiently abundant to delineate the intricate pattern of folding that is believed to be present.

West of the Beaverhead Mountains, the Belt series forms the bulk of the Lemhi Range in Idaho; to the east, rocks of the Belt series occur in many of the ranges of western Montana; to the north, they crop out over much of northern Idaho, western Montana, and southwestern Canada. The type locality of the Belt series is in the Big Belt Mountains of western Montana, where the rocks were first described by Walcott (1899). Regional geologic features are shown on the State geologic maps of Montana (Ross, Andrews, and Witkind, 1955) and Idaho (Ross and Forrester, 1947).

Dikes of dark-green to gray-green, medium-grained porphyritic diorite intrude the Precambrian metamorphic rocks. The dikes range in width from a few feet to 30 feet. Quartz veins, parallel to the general trend of the dikes, cut the rocks and in places have a close spatial relation to the dikes.

Overlying the Belt series, on an erosional surface that appears similar to the present surface, is a series of flows and pyroclastic rocks. These rocks have a great diversity in composition, ranging from olivine-bearing basalt to rhyolite. From older to younger, the sequence is olivine basalt to rhyolite porphyry to pyroclastic rocks. Nowhere are these younger rocks of great thickness, and at many places, particularly at high altitudes, the underlying Precambrian rocks are exposed through the thin volcanic veneer. Umpleby (1913, p. 48) states that volcanic rocks similar to those at Lemhi Pass are interlayered in the Miocene lake beds of Lemhi Valley, to the west. He thus dates all the volcanic rocks as Oligocene to Pliocene.

Several major faults in the Lemhi Pass area cause distinct topographic features, among which are saddles and landslides that aline with elongate depressions, and give rise to many springs. Although direction of movement along these major faults cannot definitely be determined, most of the movement appears to have been nearly parallel to the dip. The largest and most extensive of these faults bounds the district on the north and crosses the divide at Lemhi Pass. Other lesser faults trend parallel to this major structure and some trend almost normal to it.

Many quartz veins [1] cut the micaceous quartzite of the Belt series in an area of about 10 square miles at Lemhi Pass. These veins, some containing copper minerals and some containing thorium minerals, constitute the mineral deposits of the district.

ROCKS OF THE DISTRICT

The consolidated rocks of the district are Precambrian, late Mesozoic or early Tertiary, and middle Tertiary in age; however, metasedimentary rocks of the Precambrian Belt series are by far the most common. Diorite of probable late Mesozoic or early Tertiary age is intruded into the Precambrian metamorphic rocks as dikes; the much younger middle Tertiary volcanic sequence of basaltic and rhyolitic materials is deposited on rocks of the Belt series over a well-developed erosion surface. Lake beds of the intermountain valleys overlap the flanks of the range, directly on the Belt rocks and on Tertiary volcanic rocks alike, where present.

PRECAMBRIAN ROCKS

Precambrian rocks, of the Belt series, are exposed throughout the Lemhi Pass area, from the lake beds of the Lemhi Valley on the west to the lake beds of the Horse Prairie on the east, except where covered

[1] Some irregular-shaped bodies formed largely by replacement of the host rock occur in the area. Although these bodies do not have the generally tabular shape of typical veins, for convenience they are included in the term vein in this report.

by volcanic rocks. Lemhi Pass lies near the southern limit of the exposures of the Belt series in the Beaverhead Mountains.

The large areal extent of clastic and nonclastic rocks, in which changes in lithologic composition and sequence and thickness are gradational, led the Fentons (1937) to classify the Belt series in the northern basin—Montana, Idaho, Alberta, and British Columbia—into a number of facies. The Beaverhead Mountains have not been mapped sufficiently for the Belt series to be given this specific classification; however, the Belt rocks in this range might be expected, because of proximity, to tie more closely to the Coeur d'Alene or Blackfoot Canyon facies. It might be pointed out also that a very close similarity exists between the Belt rocks of the Lemhi Pass area and rocks of the Ravalli group of the Belt series in the Philipsburg quadrangle as described by Calkins (Emmons and Calkins, 1913, p. 40). Scholten and others (1955) have described Belt graywacke in the Lima region of the Beaverhead Mountains, 30 to 35 miles southeast of Lemhi Pass, as apparently similar in appearance to Belt rocks in Lemhi Pass but strikingly different in feldspar content. They suggest, with some reservation, that the Lima rocks may correlate with the Spokane formation of the series.

MICACEOUS QUARTZITE

Rocks of the Belt series in the Lemhi Pass area appear to be predominantly micaceous quartzite with local thin interbeds of argillite. Several thousand feet of Belt strata can reasonably be assumed to be present in the Lemhi Pass area, although the actual thickness is not known. The general dip of the beds in the area is northward, at angles that range from about 20° to 50°. At this dip, a section of more than 10,000 feet could be exposed in a distance of 10 miles north to south across the area. This is at best an approximation of thickness, because the rock almost certainly has been folded as well as faulted.

The micaceous quartzite is generally a fine-grained dark- and light-gray to greenish-gray rock, locally pink-hued. Generally the argillite interbeds are darker than the quartzite but have the same general hue. The rock is thin bedded in most outcrops, but at other places it is fairly massive. Bedding is marked by 1/16- to 1/8-inch dark-gray to black and evenly to irregularly spaced layers, which impart a banding to the rock. The Belt series along the western edge of the area is characterized by beds of micaceous quartzite, 1 to 2 feet thick, separated by thin seams of argillite. One lithologic change is recognizable in the Belt series in the extreme southeastern part of the mapped area, where a grayish-green argillite is the dominant rock.

The character of the zone of change from micaceous quartzite to predominantly greenish argillite containing thin micaceous quartzite interbeds is not apparent. However, rock attitudes taken in this argillite zone show a consistent eastward dip, whereas dips in the predominantly quartzite zone are northward. This change in attitude combined with the change in composition may indicate a fault contact between the two rock types.

The micaceous quartzite is composed predominantly of quartz grains in a fine-grained groundmass of white mica—an alteration product of the original clay matrix—and, at places, of biotite. The quartz grains are poorly sorted and predominantly angular; they range in size from 0.007 mm to 0.210 mm, averaging about 0.09 mm. The grains are separated by interstitial masses and oriented wisps of the small white mica laminae. (See fig. 2.)

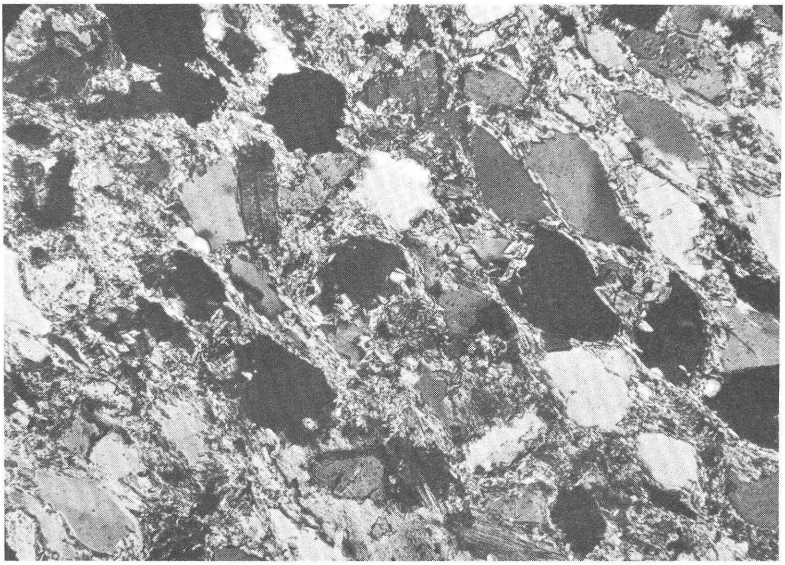

FIGURE 2.—Photomicrograph of a micaceous quartzite of the Belt series, Lemhi Pass area. Chief constituents are quartz, in irregular grains, and white mica that separates the quartz grains. One grain of twinned feldspar and a large biotite grain are present. Schistosity trends diagonally across field of picture. Crossed nicols. × 100

In several sections studied, quartz constitutes 80 to 90 percent (by volume) of the rock, and feldspar, predominantly plagioclase, about 2 percent; the micas form the matrix and range in volume from 15 to 20 percent of the rock. Other constituents, such as magnetite, tourmaline, zircon, and chlorite, make up less than 1 percent of the rock.

The dark minerals, mostly biotite and magnetite, are concentrated in the dark bands of the bedding, but these minerals also are disseminated throughout the rock. The biotite has a distinct greenish hue in thin section. The magnetite grains are generally irregular in outline, but crystal faces are evident on many grains. The interstitial mica is oriented in some rocks, and in thin sections it can be seen to constitute a schistosity that is almost normal to the bedding. This schistosity was not noticeable in all outcrops.

INTRUSIVE ROCKS OF LATE MESOZOIC OR EARLY TERTIARY AGE

Intrusive rocks in the Lemhi Pass area are small masses and dikes of dark-green diorite. They intrude the Belt series and together with this series are truncated by an early Tertiary erosion surface. The dikes are not restricted to the Lemhi Pass area but occur also in mine areas north of Lemhi Pass, in the Beaverhead Mountains (Umpleby, 1913, p. 122). Umpleby states that diorite "bands" (dikes) cut the layered "quartzite" in the Goldstone mine, 10 miles north of Lemhi Pass. The age of the dikes is somewhat in question, because Paleozoic and Mesozoic units are missing in the vicinity of the Lemhi Pass district. Umpleby considered all dikes in the region of east-central Idaho—including other types along with the diorite—to be a "later phase of the late Mesozoic or early Tertiary volcanic epoch" (Umpleby, 1913, p. 46). Diorite in the Philipsburg quadrangle, northeast of Lemhi Pass, intrudes rocks of Mississippian age and appears to be post-Paleozoic, thus correlating moderately well with Umpleby's age designation. It seems most probable that the intrusive rocks of the Lemhi Pass area are also of this general age. The purpose in defining an age for the dikes in the district evolves from an effort to date the quartz veins of the district that cut the diorite at one locality.

The diorite dikes probably are more abundant than indicated on plate 1, for they weather to a soft greenish material that commonly is covered by soil and grasses. The dikes appear to be more numerous near the crest of the mountains south of the pass. The largest dikes trend northwest—for example, the dike on Agency Creek about 3½ miles east of Tendoy, Idaho, and also the several dikes that cross the divide 6 miles south of the pass. Small dikes appear to trend mostly north and east of north.

The dioritic dikes vary greatly in thickness. One large dike, exposed in a bank of Agency Creek and striking about N. 20° W., is about 70 feet thick. Another large diorite dike, which crosses the divide in a northwesterly direction about 6 to 7 miles south of the pass, is about 40 feet wide and crops out as a massive reef. Other smaller dikes range in width from 2 to 20 feet and are 100 to several hundred feet in outcrop length.

The dike rocks differ only slightly in appearance throughout the area. They are generally medium fine grained to medium grained, and dark greenish gray. The diorite in several dikes contains phenocrysts of clinopyroxene and plagioclase as large as 5 mm. This porphyritic texture is most prominent in the dikes at the head of South Frying Pan Creek and at the shaft of the Copper Queen mine. Several inclusions of the quartzose country rock, seemingly unaltered, are enclosed within one dike. Fine-grained border zones are not apparent.

The dikes consist of plagioclase, clinopyroxene, biotite, hornblende, quartz, magnetite, chlorite, and calcite. Plagioclase (oligoclase to andesine) is generally the most abundant constituent. It forms a groundmass of laths and irregular masses, twinned and untwinned; at some places it is mottled and altered. Augite commonly is the most abundant mafic mineral. Biotite, however, is the principal mafic mineral in the dike at the Silver Queen group of claims on Pattee Creek, and hornblende is most abundant in a dike on the Wonder Lode claims.

Accessory minerals conspicuous in some dikes include magnetite, quartz, calcite, and some alteration minerals. Magnetite is finely disseminated as crystals and crystal aggregates in most dikes, and a small amount of quartz occurs in several dikes at the head of North Frying Pan Creek and at the Uranium Queen claims. Calcite occurs in small amounts in the dike at the Copper Queen shaft and is abundant as small patches evenly disseminated in the small dike at the head of North Frying Pan Creek. Chlorite and other alteration minerals are abundant. Antigorite is present in the small dike at the head of North Frying Pan Creek, and epidote is abundant in the dike that crosses the head of South Frying Pan Creek.

TERTIARY ROCKS

Tertiary rocks are widespread in the Lemhi Pass area, where they include a sequence of volcanic rocks that range in composition from olivine-bearing basalt to rhyolite porphyry flows and tuffaceous rocks, including welded ash flows and bedded tuffs. Basalt flows of at least two ages lie on both sides of the divide; rhyolitic material, mostly in the form of tuff or ash flows, is widespread.

The cover of volcanic rocks is thin, and in many places at higher elevations the Belt rocks are exposed locally through it. The projection of the exposed surfaces of underlying rocks does not easily allow for thicknesses of volcanic material greater than a few feet and rarely greater than 50 feet.

The relations between the various volcanic rocks at several localities indicate the following sequence of deposition. Basalt, from at least one period of extrusion, is followed by a rhyolite flow and this by pyroclastic material. The series is not complete at any one locality; however, contacts between rhyolite flows and ash flows are fairly common. Contacts between rhyolite and basalt are evident in at least two places, one north and one south of Agency Creek, and fragments of both olivine-bearing basalt and rhyolite flows are found in the welded tuffaceous material, which is considered to be the youngest rock.

BASALT FLOWS

Basalt is present as separated patches in every part of the mapped area except along the crest of the mountains. Basalt at least 100 feet thick is exposed east of Lemhi Pass, where the flows are most extensive. At most other places the basalt appears to be much thinner, at most only a few tens of feet thick.

The rock is dark gray and very fine grained to porphyritic. Most commonly it consists of a very dense groundmass containing small phenocrysts of olivine, plagioclase, and at places pigeonite. The amounts of these minerals vary from place to place. The basalt body east of the divide and south of the county road along Trail Creek contains about 20 percent olivine crystals, some larger than 1 cm across. On the west side of the divide, along Agency Creek, pigeonite occurs as small phenocrysts, and olivine appears to be absent or sparse. Plagioclase laths are locally abundant in the groundmass and may reach 1 mm in size.

In most places weathering has altered the rocks and the formation of iron oxides has stained the rock surfaces a red brown. At some outcrops the removal of olivine phenocrysts has left pock-marked surfaces that at first glance suggest a porous rock. Elsewhere, the rock is completely converted to a soft brown mass.

RHYOLITE FLOWS

Rhyolite flows, although less abundant than basalt, are distributed over the Lemhi Pass area in patches as much as a mile across. Generally these patches are higher on the slopes of the mountains than the basalt flows.

The thickness of any rhyolite flow probably does not exceed several tens of feet at any place. Generally, the material appears to form a relatively thin mantle over the country rock. Outcrops conform to the contour of the land surface and do not form prominences or sudden breaks in slope.

The rhyolite is generally light gray to greenish gray and weathers to white, purple white, red brown, or light green. Characteristically, it has a fine-grained groundmass that contains phenocrysts of quartz and potassic feldspar, principally sanidine, 1 to 2 mm across. Thinly disseminated biotite as well as sparse hornblende and plagioclase may be present. The rock south of the county road at the Ghoul Basin turnoff is 30 percent rounded to angular crystals of sanidine and quartz. Rhyolite, on a nose west of Lewis and Clark Spring, consists of a typically fine-grained groundmass containing sparsely disseminated phenocrysts of quartz and sanidine that range in size from 1 to 4 mm. The large rhyolite flow southeast of the pass is mostly porous, semiscoriaceous material containing small amygdules filled with greenish silica. Near the junction of the North and South Frying Pan Creeks the rhyolite is light gray, very fine grained and dense and has a conchoidal fracture. Rhyolite in Ghoul Basin has been silicified, perhaps because of the activity of springs, to a dense white to buff-colored rock in which quartz phenocrysts are still prominent.

PYROCLASTIC ROCKS

Pyroclastic rocks that appear to be of rhyolitic composition are conspicuous in the area. They range from finely textured welded tuff or ashflow to lapilli-tuff to a composite rock composed of conglomerate indurated by intercalated volcanic ejecta and mud.

RHYOLITIC WELDED TUFFS AND TUFFACEOUS MATERIAL

Welded tuff and tuffaceous material of rhyolitic composition mantle large areas on both sides of the divide near Lemhi Pass and are the only volcanic rocks to cover parts of the divide crest. The largest area of pyroclastic rocks is northwest of Pattee Creek; this material extends beyond the mapped area along the western slope of the Beaverhead Range and apparently continues under the sedimentary units of Lemhi Valley. The thickness of these rocks within the mapped area is at most a few tens of feet. However, northwest of Pattee Creek this mantle may be considerably thicker, for it covers an area of great relief. Elsewhere in the area the tuffaceous mantle thins and the underlying micaceous quartzite is exposed locally. Irregular patches of the rock in several places cover steep slopes from the ridge crest to the valley bottom; thus, it would appear that at one time the whole area was covered fairly uniformly by these rocks, and subsequent differential erosion produced the present exposure pattern.

The welded tuff is similar in appearance throughout its extent. Over most of the area it has a fine-grained groundmass that supports small crystal fragments of quartz, biotite, and sanidine; it is characterized by evenly distributed fragments of the dark-gray Belt country rock. The tuff is gray to pink to green on fresh surfaces and weathers to a white color. Bedding is not apparent in most of the rock unit, but a wavy flow or eutaxitic structure is discernible in a few places; this results from the elongation of small pores and the differential alteration and weathering of the flattened shards and glassy matrix that make up the groundmass.

Just east of Lemhi Pass a small mass of welded tuff, greenish tan on the weathered surface, has a granular texture in hand specimen and contains almost no fragments of country rock.

Near Eskersell Spring on Agency Creek a thin unit of tuff that does not contain fragments of country rock appears to lie between the breccia-bearing welded tuff and the Belt series. The shard and pumice components of this unit are not distorted and appear to be the result of an ash shower rather than a dense ash cloud or flow.

Nests and pockets of well-bedded clastic material, 5 to 20 feet long and 2 to 4 feet thick, are found at places in the massive rhyolite welded tuff. These units are thinly layered beds of a coarse- to fine-grained, well-sorted material that probably could be called crystal and crystalithic tuff. The rock is composed principally of fragments and crystals of minerals found in the enclosing welded rhyolite tuff. Good examples of this bedded tuff are seen along the Agency Creek road at Agency Creek gap and on the high point a short distance southwest of Eskersell Spring (pl. 1). The bedding at the locality southwest of Eskersell Spring dips 31° SE.

In thin section the welded rhyolite tuff consists of fragments and crystals of quartz, sanidine, and less abundant plagioclase and biotite in a groundmass of glassy, partly devitrified and compressed shards, which form a streaky lamination or eutaxitic microstructure (fig. 3). The crystals and fragments are as much as 4 mm across. Accidental breccia fragments are evenly distributed throughout most of the rock and range in diameter from 1 mm to 5 cm, although most are within the range 5 to 10 mm. The breccia fragments are predominantly micaceous quartzite from the Belt series, but a few are basalt or rhyolite.

The thin-bedded clastic material consists of fragments of the same minerals that are found in the welded rhyolite tuff—sanidine, plagioclase, quartz, and biotite, as well as glassy fragments and clay.

MUDFLOW

Mudflow deposits, with unsorted stream gravel, rhyolite breccia, and pyroclastic material in a mud and clay matrix, form a large surficial body perhaps as much as 50 feet thick along Agency Creek at the Flume Creek reentrant, as well as several small elongate bodies located on basin divides and slopes near Lemhi Pass (pl. 1).

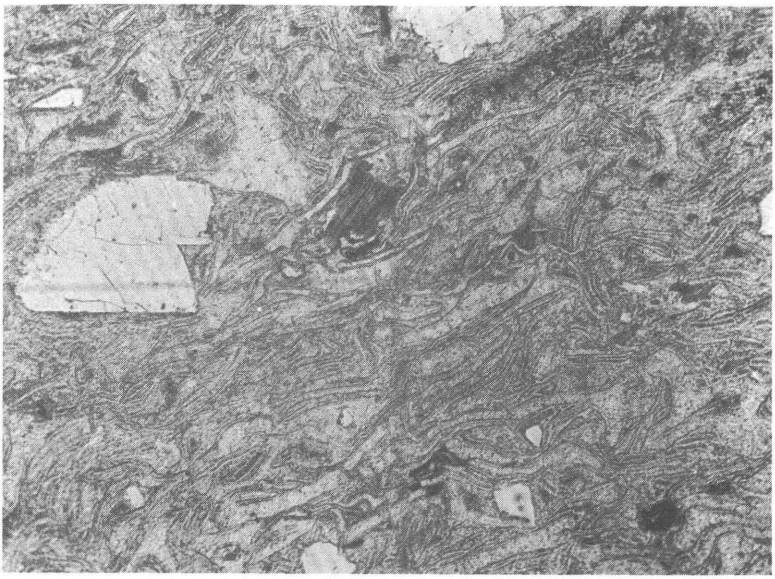

FIGURE 3.—Photomicrograph of rhyolitic welded tuff showing compressed shards and phenocrysts of feldspar and biotite. Ordinary light. × 100.

The mudflow deposits consist largely of well-rounded particles that range in size from sand to boulders as much as 6 feet across, cemented together by dark chloritic clay and silica. In some of the small elongate units, the matrix appears to be mostly silica and white clay, probably representing altered tuffaceous material. Most of the rounded particles are dark-gray micaceous quartzite, but boulders of white to pink vitreous quartzite, coarse-grained porphyritic granite, and even-grained granite are common. Fragments of rhyolite flow and pyroclastics are common, especially in the small bodies of the rock found near the pass. One such mudflow body, most likely residuum of a once much larger mass, forms a low sinuous mound that crosses the flat crest of the drainage divide and extends down the steep slope of the drainage valley to within a few feet of the present creek level. Examination of the upper parts show that the rock was overlain by pyroclastics.

Small nests of bedded coarse-grained clastic material are found included in the mudflow (fig. 4). This rock is made up of fragments of quartz, feldspar, and biotite crystals similar to those in the rhyolite tuff of the district, strongly cemented by silica. A small nest of the bedded material in the narrow elongate body of mudflow material near the Blue Ridge claim (pl. 1) contains carbonized plant stalks.

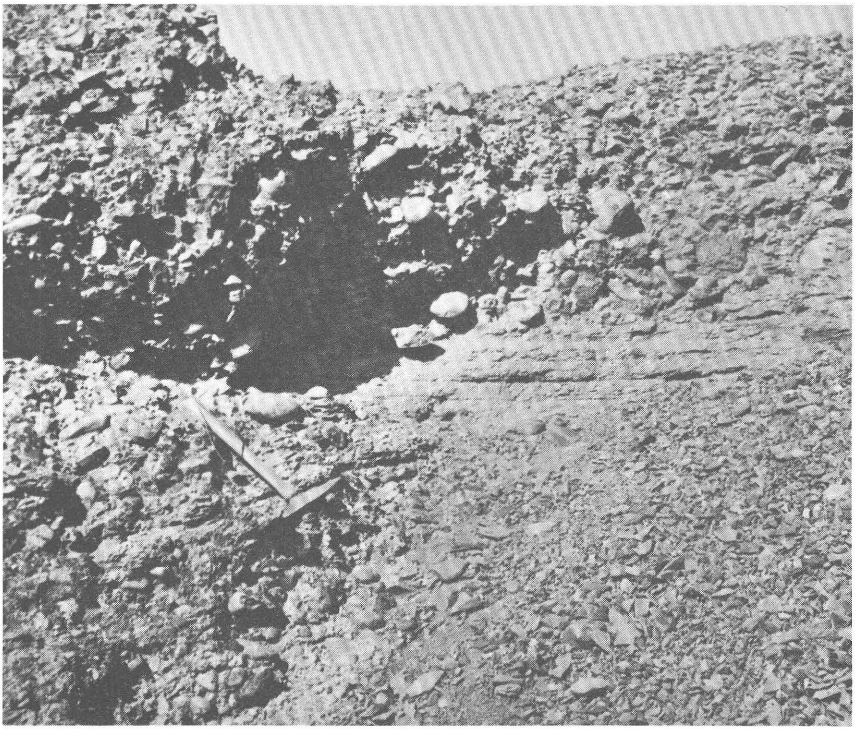

FIGURE 4.—Mudflow, showing nest of bedded tuff, along Flume Creek near its junction with Agency Creek.

The composition of this rock and its position and relation to other rock units indicate that during the stage of volcanic activity, when rhyolitic material was ejected, earlier stream gravels were mixed with volcanic muds and water to form mudflows. The nest of bedded material—sand and woody debris—probably represent local deposition in small surface depressions by more freely flowing water, possibly during lulls in the general movement of the mudflow mass. C. P. Ross (1937) has described similar rocks in the Germer tuffaceous member of the Challis volcanics, in the Bayhorse region of Idaho.

AGE OF THE VOLCANIC ROCKS

Umpleby (1913) in his report on the geology of Lemhi County stated that basalts are interbedded with the Miocene lake beds of Lemhi Valley; basalts also underlie the lake beds and cover erosional surfaces that cut across them. From these relations he dated the flows as late Oligocene to Pliocene in age. W. B. Myers (1952) dated rhyolitic and basaltic volcanic rocks in the Willis quadrangle near Dillon, Mont., as Oligocene.

The volcanic rocks in the Lemhi Pass area were deposited on a mature topography that includes remnants of an Eocene erosion surface, described by Umpleby (1912), and also valley slopes of the present drainage system. Some of these volcanic rocks appear to be overlapped by Miocene lake beds along the flanks of the Range. These relations support the ages already given to volcanic rocks elsewhere in the region and suggest a middle Tertiary age for the volcanic rocks in the Lemhi Pass area as well.

LAKE BEDS

The lake beds that border the west edge of the area are part of a series of beds that fill intermontane basins in southwest Montana and northeast Idaho (Atwood, 1916). They extend throughout the valley of the Lemhi River, overlap high on the foothills of the mountain ranges, cross the low wind gaps at Bannock and Monida Passes, and join with the valley fill along the Deer Lodge and Beaverhead Rivers in Montana. These have been called Bozeman lake beds by Peale (1896) and dated as Oligocene to Pliocene in age (Pardee, 1913).

The thickness of the lake beds in Lemhi Valley has been estimated by Umpleby (1913) as about 4,000 feet. The Salmon River has cut through them to a depth of about 1,800 feet near Salmon, Idaho. The lake beds are principally light-gray to buff shales, shaly sandstones, and sandstones; they are semiconsolidated and easily eroded. Several lignitic beds are in the upper part, and much tuffaceous material and some conglomerate are present.

QUATERNARY DEPOSITS

Unconsolidated material constitutes the Pleistocene to Recent deposits of the area. Boulders and coarse conglomerate of probable glacial origin occur on the slopes of the mountains; valley fill, some of which is recently incised, is unevenly distributed along the stream valleys.

Several unconsolidated conglomeratic deposits and many loose boulders in the higher parts of Lemhi Pass are considered to be Pleistocene glacial material. The largest unconsolidated deposit lies near the junction of North and South Frying Pan Creeks and near the crest of the drainage divide, northeast of the Wonder Lode vein. This material was deposited on the steep slopes of gorges and near the upper rims of drainage basins. The constituents are rounded pebbles and boulders, as much as 2 feet across, of quartzite, micaceous quartzite, and granite in a fine matrix of clayey sand. In other places, indicated on plate 1, loose boulders of similar material are scattered or arranged in belts along slopes or in basins throughout the area.

Alluvial deposits fill the bottoms of most of the lower reaches of the streams in the district. The amount of this fill increases toward the mouth of the stream, where a wider flood plain is developed. Flood plains on the eastern slope of the range in Montana are higher and closer to the mountain front than those in Idaho. The valley fill is poorly sorted, unconsolidated material, composed of rounded to subrounded boulders and pebbles in a sandy matrix. Most of the rudaceous material is gray quartzose Belt rock. Light-colored vitreous quartzite and coarse-grained granite pebbles derived from the glacial till and older conglomerate are common.

STRUCTURAL FEATURES

The Precambrian rocks in the Lemhi Pass area were folded and faulted by the forces that produced the Beaverhead Mountains and other ranges of east-central Idaho and southwest Montana. Tertiary rocks of the district also are folded and faulted but to a much lesser degree. So far as known, the folds are small, and the major structural features in the area are numerous normal faults. Some of the faults are long and continuous structures forming wide broken-rock zones that are physiographically conspicuous, but most of the faults appear to be relatively short and only a few feet wide. Many such faults that are present along the Continental Divide south of the pass trend principally north to northwest, but other faults in the same area have diverse trends. Faults are conspicuous throughout the area even though much of the terrain supports heavy forest. Some of the drainage is alined along faults, and elsewhere fault traces are emphasized by numerous springs, hanging troughs and ponds, ridge saddles, changes in relief, and landslides that have broken from the fault plane on steep slopes. The faults all have steep to near-vertical dips.

No great displacement appears to have occurred along any of the faults, but recurrent movement has persisted to recent times. Throughout the mapped area faults are partly covered by volcanic rocks. In several places, overriding flows and pyroclastic rocks have sharp margins at places along a fault trace, or have linear spring zones and sudden changes in slope. Postvolcanic activity along these faults has resulted in fracturing rather than displacement; the fracturing has influenced erosion and allowed fault features to appear through the volcanic sheet.

STRUCTURE OF PRECAMBRIAN ROCKS

Beds of the Belt series in most of the area have a general northerly dip ranging from about 20° to 50°. Minor folds are present, and more complex folding is suggested by some of the mapping data. Two small anticlinal folds have been mapped, one of which appears to be an overturned fold that is crossed by the Agency Creek drainage near Cow Creek tributary. Bedding in the Belt rocks dips much more steeply than a conspicuous fracture cleavage in the same beds. Fracture cleavage related to bedding in this manner suggests that the beds are overturned (Shenon and McConnel, 1940). If this fold is overturned, the axis is inclined towards the west and plunges gently southward.

In the northern part of the area, the axis of an eastward-trending anticlinal flexure is crossed by Flume Creek north of the Lemhi Pass road. Massive gray micaceous quartzite near the Lemhi Pass road dips 70° S.; the bedding flattens to the north and within a short distance dips 4° N. An accompanying syncline is suggested in rocks south of this anticline, near the Lemhi Pass fault zone; however, the rocks are highly disturbed, and no evidence of folding is visible in outcrop.

The most prominent structural feature in the area is the zone of faulting called the Lemhi Pass fault, which bounds the mapped area on the north. The zone contains a principal fault that crosses the full width of the mapped area, forming a zone 350 to 1,000 feet wide. This zone disappears under the ash flows and lake beds of Lemhi Valley on the west side of the area. The dip of the faults is generally south at a moderate to steep angle (60° or more), but the southernmost subsidiary fault near the Buffalo mine seems to dip north at about 45°. The fault zone is well expressed at the surface west of the divide at Lemhi Pass by a connecting series of low saddles and basins, in which many flowing springs make a hummocky topography (fig. 5). Ghoul Basin and the Flume Creek basin lie along this fault zone. Movement along the faults in the Lemhi Pass fault zone probably totals several hundred feet. The amount of displacement is inferred from the shape of the profile and the present relief across the zone.

Another major fault zone extends northward from the Yearian Creek basin, in the southern part of the mapped area. This zone, broader than the Lemhi Pass zone, does not seem to be as persistent along strike. A topographic depression of hummocky terrain in which are numerous flowing springs, ponds, and lakes also is formed along this zone; landslides are abundant along the margins of the fault zone.

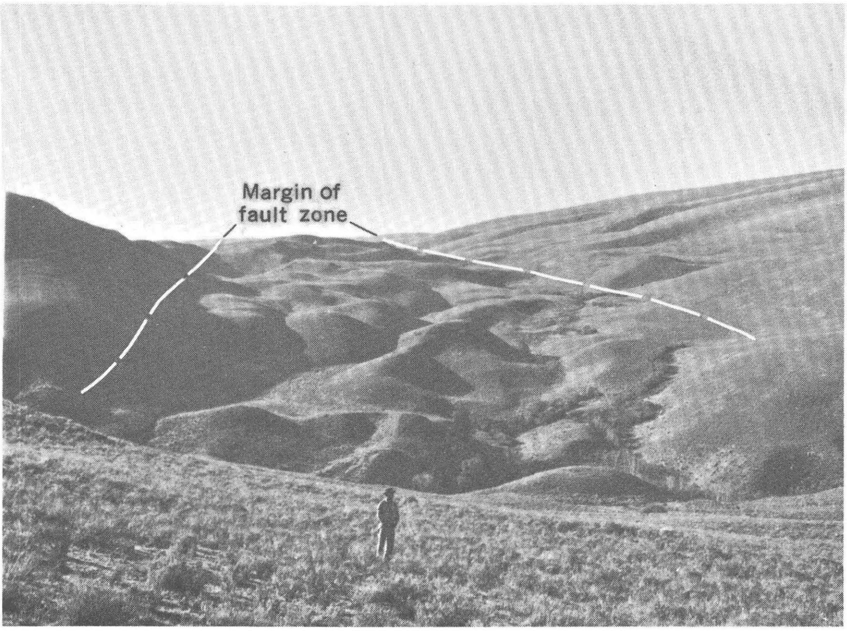

FIGURE 5.—View of Lemhi Pass fault zone manifested by the depressed form, hummocky terrain, and springs along the north side. Looking west along line of fault from east side of Flume Creek gulch.

STRUCTURE OF TERTIARY ROCKS

Structures within the Tertiary flows and pyroclastic rocks and particularly in the bedded pyroclastic rocks indicate some readjustments after their deposition. In places, the bedded tuffs are inclined as much as 35°, indicating considerable postvolcanic tilting in the area. The Tertiary lake beds of the Lemhi Valley also were uplifted and tilted. The lake beds along the flanks of the Beaverhead range in the Lemhi Pass area are generally inclined 20°–25° E. Umpleby (1913) states that the lake beds in Lemhi Valley show faulting as well as broad folding. Generally these structures are related to anticlinal folding, the axis of which trends north, down the valley.

GEOMORPHOLOGY

The Lemhi Pass area, situated as it is astride the Beaverhead Mountains, contains a host of landforms that reflect the geologic history of the area and region, particularly during the Tertiary and Quaternary periods. The most distinct feature among landforms in the area is relatively flat or gently rolling terrain in the high areas along the Continental Divide, between altitudes of 7,300 and 9,100 feet. The rolling uplands are readily apparent because they contrast with the steep slopes and rugged gorges that encroach upon them. At Lemhi Pass a gently rolling grassland extends for about 2 miles southward along the Continental Divide before it ends abruptly at a stretch of moderately rough crestline terrain. Several miles south is another segment of an almost level grassy upland, somewhat higher in altitude than the surface at Lemhi Pass. Several cirques embay this upper grassy plain.

Much has been written about a Tertiary summit peneplain and erosion surfaces in east-central Idaho (Umpleby, 1912; Mansfield, 1942; Ross, 1934, 1937). Umpleby (1912) recognized an extensive "summit peneplain" in the region and presented evidence of its existence in Eocene time. In the Castro quadrangle to the west of Lemhi Pass, Ross (1934) found evidence of two stages of mature topography in Tertiary time, one prevolcanic, probably Oligocene in age, and one that cut across the Oligocene volcanic rocks, which he dated as late Oligocene or early Miocene. Remnants of the erosion surface in the Lemhi Pass area probably correlate with the Tertiary erosion surfaces to the west (Ross, 1934, 1937).

At Lemhi Pass, a thin veneer of welded tuff covered both the high erosion surface and also rough, dissected topography, indicating that a surface existed here that had been in a late stage of dissection prior to the volcanic activity. This relation suggests a prevolcanic age for the surface at Lemhi Pass, which would correlate with the prevolcanic surface of Ross. This prevolcanic landscape at Lemhi Pass was apparently one of considerable relief. The intercalation of poorly sorted boulder conglomerates with the volcanic rocks in the higher parts of the area indicates that torrential streams brought in the coarse aggregate of several rock types from some distance.

Glaciation of the rejuvenated mountain system left several prominent cirques on the east side of the Continental Divide, in the southern part of the mapped area. Even though heavily forested, the multilevel moraines are distinct features within the basins, some of which contain small lakes and marshes.

In the slightly lower elevations at Lemhi Pass, the cirque features give way to shallow basins at the heads of the present drainages. These basins do not show the grouting effect of glaciers, but it is fairly certain that they are in part due to ice and snow action. Most of these basins contain abundant unconsolidated boulder conglomerate and loose scattered boulders, at places arranged in belts that contour the slopes. These boulder deposits are shown in several places on plate 1.

After the period of Pleistocene glaciation, apparent stability existed in which the mountain gorges and channels were partly filled with an alluvial aggregate of silt, sand, pebbles, and boulders. The streams widened their flood plains as the grade was lowered, cutting into the Belt series and at places across the volcanic rocks. Uplift along the mountain range, subsequent to the valley filling, or erosion along the Lemhi River, which lowered the local base level, has left a number of terraces along the drainage channels. These terraces are as much as 50 feet above the present grade of the stream.

Many landslides scars and small mudflows are recent features on the steep slopes at higher altitudes in the area. One such mudflow on Agency Creek has broken away where faults cross the slope, and the moving mass has followed a sinuous walled channel to the creek level (fig. 6). Slopes of the landslide scars generally range from 15° to 30°, although some are steeper.

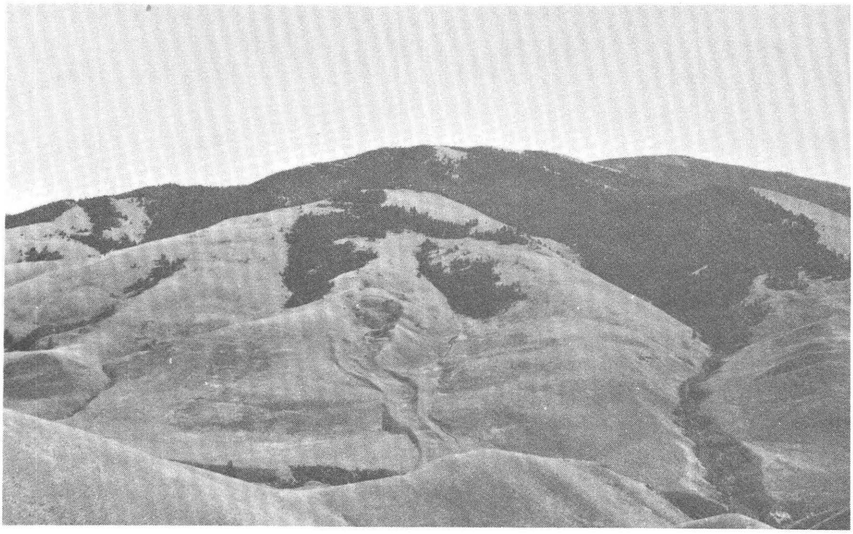

FIGURE 6.—Mudflow scar on Belt rocks, Agency Creek, Lemhi County, Idaho. The sinuous course, bounded by natural levees of rock debris, winds down across a terrace cut on volcanic material. The scar channel heads at two parallel faults that trend along the slope of the valley.

An elongate depression, several hundred feet long, on the crest of the divide at the head of South Frying Pan Creek seems to duplicate a small landform described and termed "ridge-crest depressions" by Ross (1934, p. 91). The south end is abrupt at a fault scarp, whereas the other end gradually loses its identity as the divide crest slopes downward. The origin of this depression is not readily apparent from field data. A mantle of soil covers the micaceous quartzite bedrock, but contiguous outcrops give no evidence of faulting.

MINERAL DEPOSITS

Quartz veins and irregular siliceous replacement bodies containing copper, gold, and thorium cut the Precambrian Belt rocks in the Lemhi Pass area. About 45 such quartz veins and bodies are exposed, and of these about one-half contain thorite as an accessory mineral. Most of the veins have been prospected for copper, and several have been rather extensively explored and developed. Copper has been produced only from the Copper Queen mine and the Blue Bird mine near Agency Creek in Idaho.

These deposits are predominantly localized in an elongate north-trending zone, about 10 square miles in area, extending from slightly north of Lemhi Pass southward into Beaverhead County, Mont.

The deposits have a great range in size and are as much as 1,200 feet in outcrop length and 30 feet in thickness. This thickness, however, is not uniform, and most of the veins pinch down to a few inches. The larger deposits seem to persist at depth. A vein at the Copper Queen mine has been explored to a depth of more than 400 feet, and at the Last Chance deposit diamond-drill holes have cut veins at depths of 200 to 250 feet. The Wonder Lode vein, which crosses the gulch of the South Fork of Agency Creek, is exposed for 300 feet vertically.

The veins were formed by fissure-filling and wall-rock replacement, along zones of shearing and faulting in the micaceous quartzite of the Belt series. Recurrent movement along the faults has broken and sheared most of the vein material.

In different parts of the area, different minerals predominate or are conspicuous in the veins.

MINERALOGY

Minerals that have been found in the deposits in the district, in approximate order of decreasing abundance, include: quartz, hematite, hydrous iron oxides, barite, siderite, calcite, bornite, covellite, thorite, thorogummite, monazite, chalcopyrite, molybdenite, sphalerite, rutile, fluorite, gold, hydrous manganese oxide, and copper carbonates. Copper minerals and native gold have been the principal minerals sought in the deposits, but recently the thorium and rare-earth minerals have taken precedence. These minerals—thorite, thorogummite, and monazite—other than being radioactive, are not conspicuous in the veins and probably had not been noticed previously.

Quartz.—Quartz, the most abundant mineral of the deposits in the Lemhi Pass area, is generally coarsely crystalline, vitreous, and milky white to translucent gray. Most of it is fractured and stained, and its original form may be almost obliterated. At places, particularly along the margins of a vein, coarse semiclear vein quartz grades outward into a darker cryptocrystalline variety which retains the features of the fine-grained wall rock. Quartz was the first mineral deposited in the veins; it also crystallized during one or two later stages. It has been locally replaced by carbonate minerals in a few veins, as at the Wonder Lode vein.

Hematite.—Specular hematite is a common mineral in the veins and occurs also along joints in the country rock that are not necessarily associated with the veins. It fills thin fractures and forms bands and irregular masses as much as several inches wide in the vein filling. The thin tabular crystals of this mineral are splendent on fresh surfaces, but the more massive occurrences in veins are commonly vuggy and partly altered to limonitic material. Hematite is spatially and paragenetically associated with thorite in the deposits and appears to have been one of the last minerals to crystallize.

Hydrous iron oxides.—Hydrous iron oxides are common in all the veins and are especially abundant in some. A porous, punky, light ocherous material, and dense brown massive material, at places silicified to a jasperoid, are common. At the Wonder Lode much black earthy hydrous iron oxide and admixed manganese oxide have formed by oxidation of manganese-bearing siderite. No effort was made to identify the different limonite minerals during this survey; Trites and Tooker (1953), however, identified goethite and lepidocrocite.

Barite.—Barite is widespread in the area but apparently is confined to veins that contain thorite. The Wonder Lode, Last Chance, and Radio veins contain local concentrations of barite, as compact dense cryptocrystalline masses and rarely as white to pinkish bladelike crystals. Small cavities in some veins contain small barite plates as part of the vug filling. Clear crystalline barite with a light blue-green color is found at the Radio claims, in layers parallel to the wall of the vein; this greenish barite is bordered by a granular pinkish form.

Barite appears to have been precipitated during an intermediate stage of the paragenetic sequence, simultaneously with and immediately after siderite.

Siderite.—Siderite is most abundant at the Wonder Lode claim, where it is the principal gangue mineral in much of the vein. Abundant siderite was found in the district in only one other vein, a small vein on the Black Bull No. 2 claim. The siderite in the Wonder Lode vein is light tan to white, coarsely to finely crystalline, and commonly highly sheared and fractured; apparently it is manganese rich, for all fractures and surfaces are filled or coated by black hydrous manganese iron oxides. Gray calcareous material coats siderite at some places.

Calcite.—Calcite is a rare mineral in the Lemhi Pass area and probably is an alteration product of siderite. It fills minute fractures that cut the siderite vein at the Wonder Lode claim.

Thorite.—Thorite ($ThSiO_4$) forms irregular dark red-brown streaks and masses along fractures in the veins and minute crystals in quartz, barite, and siderite. The massive material has vitreous luster on a fresh fracture, but upon exposure it weathers to a dull earthy appearance.

Thorite in minute crystals disseminated in fractured quartz, barite, and siderite has been examined in thin sections from the Trapper, Wonder Lode, and Last Chance veins. It ranges in color from red brown to light orange to colorless; it is commonly isotropic, owing to alteration to a metamict state. The index of refraction ranges from 1.73 to 1.80 but averages about 1.75, the lighter colored variety having the higher index. The crystals are prismatic, generally broken, and are 0.07 mm to 0.1 mm across.

Considerable confusion exists in the literature as to the identification of thorite and the thoritelike minerals. This uncertainty results from the tendency of thorite to become metamict, then to assume some essential water and finally another crystal form (Frondel, 1953; Pabst, 1952).

X-ray diffraction patterns were made on the more massive thorite from Lemhi Pass veins. The mineral had been carefully handpicked and then further separated and purified by heavy liquids and a Frantz magnetic separator. Before ignition the material was found to be completely isotropic to X-rays, thereby indicating complete metamictization. After igniton on a Meeker burner at about 800°C the ThO_2 X-ray diffraction pattern was evident—a reaction that is normal for thorite under these conditions (Pabst, 1952; Frondel, 1953).

A less carefully chosen sample of thorite material was selected and run for X-ray diffraction pattern to ascertain the bulk condition of the thorite before ignition. This material gave a slightly diffuse but distinct pattern for crystalline thorite, $ThSiO_4$. Therefore, thorite in both forms—crystalline and metamict—is mixed at Lemhi Pass.

Besides the presence of crystalline and metamict thorite, thorium in a hydrated mineral, thorogummite (Frondel, 1953), is indicated by both optical and X-ray data. Supporting evidence is the fact that optically much of the material is not completely isotropic but shows some faint crystal order.

In this report thorite will be used to designate both the thorite and the altered forms.

A mineral with high refractive indices and high birefringence was found in minute aggregates associated with thorite crystals and as isolated blebs in quartz in several thin sections from the Trapper No. 1 vein and the Last Chance vein. Indices of this mineral, checked in oils, are N_o 1.80 and N_e 1.84. Excellent interference figures are biaxial positive with a small 2V angle of approximately 10°. These optical properties suggest that the mineral is monazite, a rare-earth phosphate. Several attempts were made to separate and produce X-ray powder patterns of this extremely finely disseminated mineral. No definite pattern other than that of quartz was obtained.

Chalcopyrite.—Chalcopyrite, though not generally abundant, occurs in sparse amounts in most of the veins. In general, it seems to be less common in the thorite-rich veins than in other veins of the area. An exception is the small vein on the Black Bull claims, at the mouth of the south fork of Agency Creek, which is rich in chalcopyrite as well as thorite. At the Copper Queen mine, chalcopyrite is one of the principal ore minerals. Other workings outside of the principal vein area, such as the Fishcan mine, overlooking Lemhi Valley, and the copper workings on Pattee Creek, contain principally chalcopyrite.

Chalcocite.—Chalcocite is rare and was not seen; but it is reported in mining records to occur in the ores of the Copper Queen mine along with chalcopyrite, bornite, and covellite.

Bornite.—Bornite, the peacock ore of copper, is the principal primary ore mineral at the Copper Queen mine. It is also present at the Idaho Pride and Blue Bird workings. At the Copper Queen, bornite is so abundant at places that it displaces quartz as the most abundant mineral in the vein. It is closely associated with chalcoyprite, which is much less abundant, and with covellite, which forms coatings on all exposed surfaces. Microscopic examination of polished sections from the Copper Queen and Black Bull veins shows no intergrowth of bornite and chalcocite, a relation generally present where the minerals exist.

Covellite.—Covellite occurs as a secondary mineral in both the Copper Queen and Idaho Pride veins, where it coats much of the bornite. The characteristic deep indigo color of this mineral makes it easily recognizable in hand specimen. In polished section covellite is seen to be intimately intergrown with bornite.

Molybdenite.—Molybdenite is not common in the district nor was it found in place in the vein deposits. It was recognized in rock found on the dumps of the Copper Queen mine and miners report that it is in the workings. The mineral forms isolated crystals, as much as 6 mm across, in a small otherwise barren quartz-hematite vein. It was also present in the bordering alteration zone in the Belt host rock.

Sphalerite.—Sphalerite also is not common in the district and was not found in place. It occurred in ore from a short adit in the lower exposure of the Wonder Lode vein, associated with chalcopyrite and thorite. It is a dark dense variety evidently high in iron.

Rutile.—Rutile was found at two places in the area: the Blue Boar–Blue Ridge vein and the Trapper No. 1 vein. In the Blue Boar–Blue Ridge vein, elongate crystals are as large as 3 mm across and 3 cm long; irregular crystalline blebs, however, are more common. Both forms are disseminated in varicolored quartz and hematitic jasperoid. In the Trapper No. 2 vein, microscopic crystals of rutile associated with barite and fine-grained granular blebs of monazite are clustered in quartz. The rutile is honey brown to yellowish and is readily recognized by its very high luster and relief.

Fluorite.—Fluorite was found in a small quartz vein in the extreme northern part of the mapped area on the ridge southwest of the No Pay mine. It occurs in small purplish microcrystalline masses mixed with white coarsely crystalline quartz.

Gold.—Native gold occurs with the quartz and copper sulfide minerals in the Copper Queen vein and particularly in the Blue Lupine subsidiary vein that crosses the Copper Queen vein. Specimens containing free gold were found on the dump of the Blue Lupine vein.

Copper carbonates.—Copper carbonates, principally malachite, coat rock fragments wherever copper minerals are exposed. Malachite has been of importance only at the Copper Queen mine, where it was one of the ore minerals.

CLASSIFICATION

The quartz veins in the district can be classified into four types on the basis of mineral association. These types are quartz-hematite-thorite veins, quartz- and copper-bearing sulfide-thorite veins, quartz- and copper-bearing sulfide veins, and quartz-hematite veins.

Quartz-hematite-thorite veins are the most numerous in the district and contain most of the thorium reserves. They are composed of white quartz, generally stained red brown, that contains zones rich in white to pink barite. Small red-brown streaks, masses, and stains of thorite appear generally evenly distributed through the vein, although the ThO_2 content of vein rock ranges from 0.02 to 3.2 percent. Specularite is common to abundant, occurring in masses and as small disseminated flakes. Irregular-shaped bodies that are difficult to classify as veins are also included in this group. These bodies have the same composition as the veins but occupy zones of more complex cross fracturing. Replacement of the Belt rock over a large width has resulted in more equidimensional shapes. The veins and replacement bodies of this type are highly fractured. Radioactivity is high, ranging from 0.2 to as high as 2.5 mr per hour.

Of the quartz- and copper-bearing sulfide-thorite veins in the area, there are only two: the large Wonder Lode vein on the south fork of Agency Creek and a small vein on the Black Bull No. 2 claim near the mouth of the same creek. Barite, sphalerite, molybdenite, siderite, and calcite are locally common. Copper minerals are abundant, and the Wonder Lode vein supplied some ore-grade material to the mill at the Copper Queen mine. These veins are highly radioactive, ranging as high as 15 mr per hour, because of abundant thorite; ThO_2 content amounts to more than 3 percent of the rock at places.

Quartz- and copper-bearing sulfide veins that contain varied amounts of bornite, chalcopyrite, secondary copper and iron minerals and some gold, are the most widespread in the area. These veins, more than any other type, have been explored for possible ore-grade material, and several have been mined in the past. This type includes the well-developed Copper Queen vein, the Idaho Pride group of veins, the No Pay vein, the Fishcan and Last Chance veins on the Lemhi River, the Blue Bird vein, and the unnamed deposits on upper Pattee Creek. They are not radioactive.

Quartz-hematite veins are not numerous but are scattered throughout the Lemhi Pass area. These veins are small and are essentially composed of white massive quartz and gray, black, and brown iron oxides. Some of the veins contain minor amounts of fluorite, rutile, and barite, and some of them are slightly radioactive (less than 0.15 mr per hour). The radioactivity is concentrated in the hydrated iron oxides. Veins of this type include those at Blue Boar claim, Stenson's Buffalo prospect, and the Silver Queen claims on Pattee Creek.

RELATIONS AMONG VEINS

The mineral assemblages in the veins in the vicinity of Lemhi Pass suggest a zonal distribution of copper and thorium. Veins containing dominantly copper minerals and veins containing thorium occur in different areas (fig. 7). Veins that contain largely copper minerals and no thorite are in the northeastern part of the area, and those that contain thorite are in the western and southern part. Between these areas are two veins that contain both copper and thorium.

Preliminary microscopic examination of the vein minerals and their relations in the different veins shows that thorite, whenever present, formed late in the paragenetic sequence of mineral deposition. In the quartz-hematite-thorite veins it occurs along the late fractures with specularite. In the two copper-bearing thorite veins it fills late fractures also, and some of these fractures cut copper minerals. The

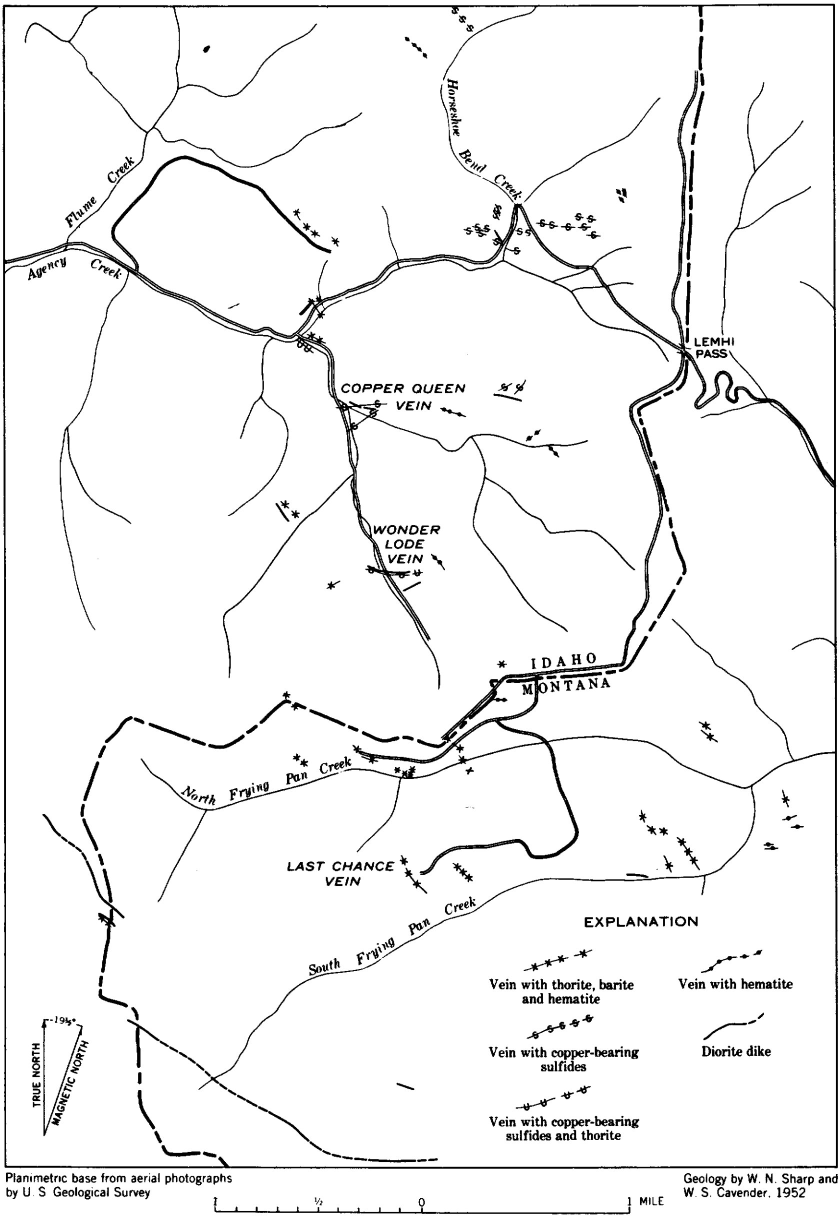

FIGURE 7.—Map showing veins and relations of vein groups in part of Lemhi Pass area, Idaho and Montana.

areal geologic mapping indicates that the different veins in the area are virtually contemporaneous, but that thorium was introduced late is manifested in several ways. A feature that in a manner suggests this conclusion is found in the deposit at the Copper Queen mine, which is near the boundary of thorium-bearing veins.

In the lower adit level of the mine, about 350 feet from the portal, a small 1- to 2-inch vein cuts across the main northeast-trending Copper Queen vein almost at right angles. This narrow copper-bearing vein is radioactive and thorite bearing (table 3), whereas the main vein is nonradioactive.

At several places in the area thorite is localized in irregular-shaped silicified breccia zones. These zones, containing specularite and thorite thinly disseminated in the country rock, apparently are not associated with a vein. Relating these few apparent facts it might appear that thorium-bearing, silica-rich solutions invaded previously unmineralized broken country rock as well as copper-bearing quartz veins.

RELATIONS OF VEINS TO FAULTS

The veins in the Lemhi Pass area occupy faults, and the fractures and shear zones along faults that cut the Belt rocks. These mineralized faults and shear zones are small and few in number relative to the sizes and number of faults in the district. It appears that at least two and possibly three major periods of movement have broken the Precambrian rocks of the district. The early faulting provided the channels for solutions and sites for the quartz veins; later readjustment in the area was mostly along numerous new faults (some with relatively large displacement) that are not mineralized. The veins were fractured and sheared by recurring movement along some of the early faults, and alteration and recementation of the original vein rock resulted. In some veins three stages of fracturing and recementing can be defined.

Several veins of both thorium-bearing and copper-bearing groups are included within the wide Lemhi Pass fault zone. These are the Buffalo group of quartz-hematite-thorite veins and the Idaho Pride group of quartz- and copper-bearing veins. Veins of both types show fractures that have been filled with silica, hematite, and—in the Buffalo veins—probably thorite. Most of the recementing of these veins has been along the early fractures. The late movement of the Lemhi Pass fault and its subsidiary fractures has reshattered these veins, displacing some parts slightly, and in general greatly disrupting their original structure. Much alteration has resulted in near-surface parts of these veins, but little or no recementation has taken place.

DEPOSITS AND MINES

QUARTZ-HEMATITE-THORITE VEINS

Quartz veins that contain hematite and thorite and almost no sulfides make up the bulk of the veins south and west of the Continental Divide (fig. 7). The major veins of this group are the Trapper No. 1 vein and the Last Chance vein on North and South Frying Pan Creeks. Veins of this group generally are not as large as some that contain abundant copper-bearing sulfides; however, some veins are locally as much as 40 feet wide. Some of the deposits of this group, such as the Lucky Strike, are not veins in the strict sense of the term but are irregular or roughly lensing masses. This deviation from the normal vein form is not found in the other groups of veins.

LAST CHANCE CLAIMS

The Last Chance claims are on the north slope of South Frying Pan Creek valley in sec. 29, T. 10 S., R. 15 W., Beaverhead County, Mont. A passable truck or jeep road connects the claims with the county road at Lemhi Pass.

This property was first staked as a lode claim by R. A. Wellborn of Armstead, Mont.; in July 1950 it was leased to the Elkhorn Mining Co. of Boulder, Mont. A Defense Minerals Administration exploration contract was granted the Elkhorn Mining Co. in September 1951 to explore the claim by bulldozing and diamond drilling.

The bulldozer work was accomplished and two (DDH 1, DDH 3, pl. 2) of five planned diamond-drill holes were drilled in 1952. A third drill hole (DDH 4, pl. 2) was started but not completed. Work was not resumed in 1953 as planned, and the contract therefore was terminated before completion of the project.

The Last Chance vein—a large, slightly sinuous quartz vein—is exposed for about 1,200 feet on the Last Chance claims. In general, the vein trends N. 50° W. and dips 50° to 65° SW. over most of its length; the northwestern segment dips 64° NE. The vein varies considerably in width but along most of the outcrop length it ranges from 10 to 15 feet. It is widest at the southern extremity, where it bulges to a width of 40 feet. In the central part it swells again to 25 feet in width. The vein gradually thins northward and finally becomes indistinct. Each of the two swellings of the vein forms a topographic promontory (pl. 2) that rises 10 feet or more above the normal contour of the surface.

Several subsidiary veins parallel the main structure; the largest of these, slightly east of the central part, is a 4-foot vein exposed for about 200 feet.

644011 O—62——3

The vein parallels a fault for its full length; the main shear plane is on its east wall. Some minor shear planes cut the main vein at the abrupt flexure (pl. 2). This flexure may indicate a small offset at this point in the vein, but sufficient detail was not present to associate a fault with this bending. The shape of the vein suggests that the central swelling and flexure is a cymoid structure. If so, a strong component of strike-slip movement is inferred.

In a zone 3 to 5 feet wide adjacent to the vein, the Belt rocks, which are normally hard and gray, are friable, whitish, or stained to brown red. Thin zones of greenish clay gouge are conspicuous along the shear contact on the east side. The contact of the vein with the wall rock is sharp, even though wall rock has been altered and replaced. At the southern end the vein includes much partly replaced country rock. Drill cores also show breccia fragments of bleached and altered micaceous quartzite surrounded by a vitreous quartz vein. (See logs on p. 68–74.)

The vein is composed predominantly of quartz and the iron oxides, including specularite, goethite, and lepidocrocite; barite is locally abundant. Sparse malachite indicates that minor copper-bearing sulfides, probably chalcopyrite, were originally present near the surface and may exist at greater depth. Irregular streaks, blebs, and minute crystals of thorite are distributed throughout the vein.

The quartz is vitreous, milky white, generally heavily stained, and minutely veined by red-brown iron oxides and dark-gray specularite. Small solution cavities are abundant at places. Generally they are lined with clayey material and barite crystals. White to pinkish barite in finely crystalline masses and veinlets replaces quartz to varying degrees along the vein. Most of the barite occurs in the quartz-poor center of the vein.

Thorite is not readily evident to the naked eye in this deposit because of the abundance of red iron-oxide staining as well as the smallness of the thorite crystals. Visible thorite occurs predominantly as small, irregular to rounded red-brown masses and smears along fractures in the vein. Minute crystals are disseminated in the quartz but are visible only in thin section. These crystals are generally broken and separated and are partly to completely metamict.

Spectrographic and chemical analyses of material from many places in the vein show small amounts of rare-earth metals of both the cerium and yttrium groups. A radioactive sample, AFT–233–50, from the southern part of the vein, which was submitted for partial spectrographic analyses, contained rare earths:

Percent of rare earths in radioactive sample AFT-233-50, Last Chance vein

[Partial spectrographic analysis by A. T. Myers]

Th	Y	Ce	La	Nd	Ca	Ba	Sr
x	0.0x	0.x	0.0x	0.x	0.0x	0.x	0.00x

Other spectrographic analyses (table 1) of material from diamond-drill cores give similar results for rare earths.

TABLE 1.—*Percent distribution of rare earths and thorium in samples from Last Chance vein*

[Spectrographic analyses by Charles Annell and Joseph Haffty, U.S. Geological Survey. Location of samples shown on pl. 12; samples described in table 3. Leaders (--) in measurement columns indicate none present]

Laboratory No.	Sample	x.0	0.x	0.0x	0.000x	0.000x
101831	LC DDH1-A	--	Th	Gd-Ce-Nd-Eu-Sm	Dy-Y-La	Yb
1018832	B	--	--	Th	Y	Yb
101833	C	--	--	Th	Y	Yb
101834	D	--	--	Th	Y	Yb
101835	E	--	Th	Ce-Nd-Y-Eu	La-Dy	Yb
101836	LC DDH3-A	--	Th	Ce-Gd-Nd	Eu-Y-La-Yb	--
101837	B	--	Th	--	Nd-Eu-Y-Yb	--
101838	C	--	Th	--	Nd-Y	--
101841	F	--	--	--	Y	--
101842	G	--	--	--	Y	--
101843	H	--	--	--	Y	--
101845	J	--	--	Th-Ce-Gd-Y-La	Nd-Eu-Y	--
	AFT-233-50	Th	Ce-Nd		--	--

The rare-earth content of the vein is attributed for the most part to monazite that is sparsely distributed along some small late fractures. Uranium is notably lacking, though ThO_2 ranges in amount from 0.05 to 2.1 percent. Complete sample data are given on pages 62–67.

The vein at the Last Chance was fractured and sheared by movement along the fault parallel to the vein. Many irregular minute fractures break the coarsely crystalline vein quartz parallel to the vein walls. Most of these fractures are recemented with fine-grained quartz and hematite. Within the barite-rich zones, little quartz is left unreplaced, and a banding of the barite by dark hematite-rich layers indicates a succession of fracturing, filling, and replacement. At places this barite-hematite rock is vuggy, with boxwork fillings of barite, hematite, and limonite. At other places the rock is broken into a breccia of hematite and barite recemented by both components. The massive red-brown blebs of thorite appear to be associated with postfracturing mineralization, whereas the crystalline thorite is asociated with the initial coarsely crystalline vein quartz.

TRAPPER NO. 1 CLAIM

The Trapper No. 1 claim is on the north slope of North Frying Pan Creek, a short distance north of the Last Chance property. It is in sec. 20, T. 10 S., R. 15 W., at an altitude of 7,100 to 7,200 feet (pl. 1). In 1952 the unpatented claim was owned by H. B. McKenney and W. G. Armeson of Dillon, Mont. Between 1950 and 1952 the owners improved an access road into the area from the county road at Lemhi Pass; they also explored the property by several hundred feet of bulldozer cuts, more than 250 feet of diamond drilling, and by several small prospect pits (Trites and Tooker, 1953).

The deposit labeled Trapper No. 1 claim on plate 3 is composed of slightly elongate masses of quartz and silicified rock that cut the gray micaceous quartzite of the Belt series. The masses that crop out appear to be parts of a quartz vein or irregular quartz body that has been broken and displaced by faulting. The largest mass, 60 feet wide and 100 feet long, dips steeply south (section *B–B′*, pl. 3) and trends almost due east. Small outcrops west of this mass indicate the presence of a silicified zone that is 600 to 700 feet long and 50 feet or more wide. To the southeast another mass has been offset from the largest mass along a north-northwest-trending fault; it has dimensions of about 50 by 50 feet and is bounded by parallel faults.

Like the other veins and deposits in the district, the Trapper No. 1 vein is in a fault zone. At least two closely spaced faults striking N. 10°–15° W. offset the vein. Also a strong fault or shear zone strikes N. 70° W. and dips 70° S. along the hanging wall of the vein. To the west this fault is exposed for a distance of 500 feet in small siliceous outcrops. The intersecting shear system at Trapper No. 1 has produced a highly broken vein difficult to reconstruct completely. The contact of the quartzose vein with the Belt country rock forms a distinct topographic break at the surface. The reef-like expression of the vein is due principally to the extreme hardness of the vein rock but is also partly explained by the fact that most of the contacts are shear surfaces. The wallrock is generally bleached and friable in these shear zones, particularly near the contact with the vein, and contain thin quartz veinlets along fractures.

The composition and mineral associations of the Trapper No. 1 vein are much the same as those of the Last Chance vein. The quartz is white to gray, vitreous, sheared, and stained. Hematite is also very abundant. Gray metallic masses and spangles of specularite fill large and small fractures; much of the hematite has been oxidized to limonite. Minute crystals of thorite are disseminated in the quartz, but most of the thorite occurs as blebs and smears along fractures and strongly altered zones. Crystals, though small, generally are broken, and the fragments are separated and apparently rearranged. Small masses of extremely fine grained monazite are intimately associated with thorite along some fractures. Rare earths detected in analyses of vein material probably come from monazite. Barite was not found in specimens or in the field at the Trapper No. 1 but was identified in heavy-liquid separations made in the Survey's laboratories. Small amounts of bornite as well as small sparsely distributed clusters of rutile crystals also are present in the vein.

Radioactivity and chemical analyses for thorium and uranium were run on several samples from the Trapper No. 1 vein (pages 64–65). Spectrographic analyses were made by Kiyoko Onoda on bulk samples of heavy and light separations from one sample AFT–311–50, (pl. 3), as well as a partial analysis on the whole rock, in order to determine characteristics of the vein material. The results are given below:

Percent distribution of rare earths and thorium in sample AFT–311–50, Trapper No. 1 vein

[Spectrographic analysis by Kiyoko Onoda]

	xx.	x.0	0.x	0.0x	0.00x	0.000x
Entire sample (partial analysis)	--------	Th	Ce, Nd, Ba	Y, La Ca	Sr	--------
Heavy fraction	Fe, Si	Th, Y	Ce, Al Sm, Nd Gd, Cu, Pb, Ba	Mg, Mn U, La, Ca, Ti, Ni, Sr, Cr	------	Ag, Be
Light fraction	Si	Fe, Th	Ce, Al, Sm, Nd, Gd, Mg, Ba	Pb, Mn, Y, La, Ca, Ti, Ni, Sr, Cu, V	Cr	Ag, Be

Radioactivity and chemical analyses show only small amounts of uranium. The noteworthy radioactivity of the deposit clearly is caused by thorium, values of which range from 0.01 percent to several percent in parts of the veins. Radiometric analyses of the heavy and light fractions gave values of 2.6 percent eU for heavy components and 0.39 percent eU for light components. These analyses and the spectrographic analyses indicate that most of the thorium is in heavy minerals.

The parts of the veins and siliceous masses available for examination are thoroughly stained and altered. Thorium and the rare earths apparently have an affinity for limonite and are commonly concentrated in zones of severe shearing and strong alteration.

Thorium and rare earths in places within the vein may have developed a zonal arrangement. Sample TWA–1 from near the central part of the vein mass analyzed 3.1 percent ThO_2 (page 64), but this sample represents only a section of vein 2 to 3 feet in width.

Soil along Frying Pan Creek below the Trapper No. 1 outcrops is radioactive. A sample (T–1A, page 64) contained 0.02 percent ThO_2 and 0.09 percent combined ThO_2 and rare-earth oxides.

TRAPPER NO. 4 CLAIM

The Trapper No. 4 claim is on the northern slope of Frying Pan Creek 1,200–1,500 feet east of the Trapper No. 1 claim. This property is part of the Trapper group owned by H. B. McKenney and W. G. Armeson of Dillon, Mont. A road has been constructed to the site and a series of bulldozer cuts expose the veins (fig. 8).

The Trapper No. 4 claim covers a relatively narrow quartz vein that trends N. 53° W. and dips 70–75° NE. The vein is strongest near its southern end, where it is 1½ feet wide; its length is inferred to be about 500 feet. Near the north border of the claim, a parallel

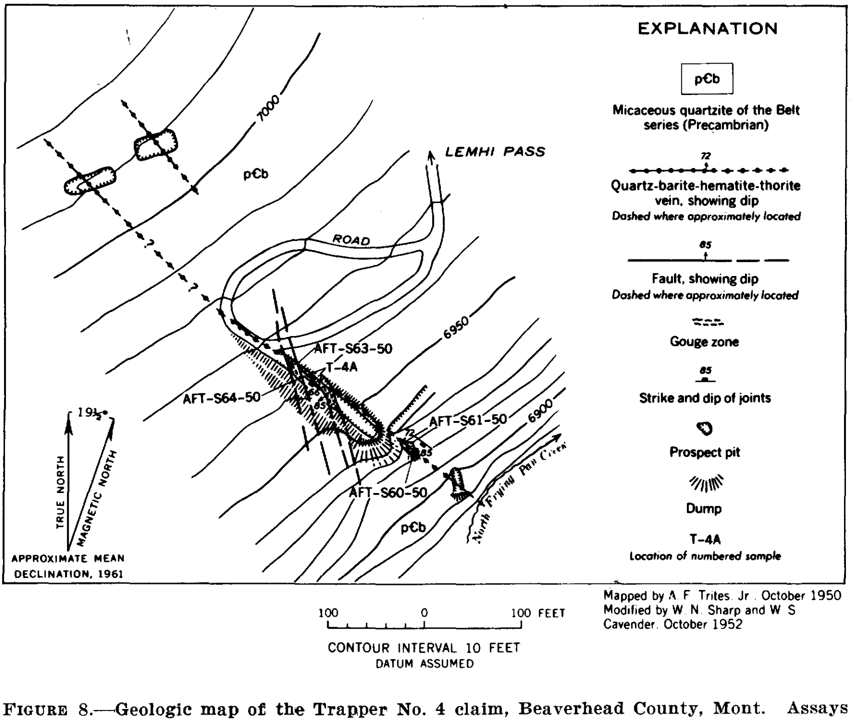

FIGURE 8.—Geologic map of the Trapper No. 4 claim, Beaverhead County, Mont. Assays of samples are given in table 3.

subsidiary vein of about the same dimensions lies 70–80 feet northeast of the principal vein; it is exposed for about 50 feet.

The principal vein is poorly exposed near its south end. A branching fault is exposed near the center of a bulldozer cut and intersects the vein at a small angle. The host rock and the vein here are highly comminuted, mixed, and stained with much limonitic material.

The veins at Trapper No. 4 claim are similar in composition to the massive deposits at Trapper No. 1 claim and to the vein at Last Chance claim, except that the Trapper No. 4 veins contain abundant dusty limonite. Thorite is localized along fractures and is disseminated as blebs in fractured quartz. The amount of thorite present is comparable to that in the Trapper No. 1 vein. The vein material and dusty limonite were analyzed for thorium and rare earths (p. 65). The vein material contained 0.02–0.5 percent thorium oxide. The limonite sample, which was extremely radioactive in the field, contained 2.1 percent ThO_2 and 3.6 percent $ThO_2+Re_2O_3$ combined; uranium content was very low.

LUCKY STRIKE CLAIMS

The Lucky Strike group of two unpatented claims is in sec. 20, T. 10 S., R. 15 W., Montana base line, Beaverhead County, Mont. They are on the northern slope of North Frying Pan Creek, a short distance northwest of the Trapper No. 1 claim. The property is accessible by the road to the Trapper claims. The Lucky Strike claims probably were staked in 1950, but by 1952 little exploration had been done.

Within the area bounded by the claims, several lens-shaped zones in the Belt rocks appear to be highly altered by silicification to a quartzose rock. Some parts of the zones are masses of quartz and stand as reeflike features above the surface. One zone includes a smaller lens of only moderately altered Belt rock. The elongate quartzose bodies are as much as 100 feet wide and appear to extend 200 to more than 700 feet across the claims. While not exactly veins in the proper sense of the term, the zones are so designated on the map (pl. 3).

Two series of faults are present in the area: one trends northwestward and the other trends generally northeastward. Some of the quartzose and altered zones appear to parallel local shearing. The southernmost quartzose zone of the Lucky Strike claims crops out just north of the road and is bounded on the south by a well-exposed fault surface. The long dimension of this zone parallels the fault trend. The major quartzose zone of the area appears to parallel the northeastward-trending fractures.

The contacts of the zones are gradational at places, and they are shear planes at other places. Contacts are generally difficult to locate within 2 to 3 feet, except for those of the massive quartz bodies within the zones. Even though they are within the silicified zones, the quartz bodies are easily separable, principally because of their reef-like exposure. Much greenish sericite occurs with the partly replaced country rock. Although not conspicuous, staining does exist along fractures near the contact between silicified rock and unaltered country rock.

The quartzose bodies at the Lucky Strike claims are similar in composition to the Trapper No. 1 and Last Chance veins, except for the associated large masses of partly replaced or silicified micaceous quartzite that are not found at the other localities. The quartz is white to tan to gray, sugary to coarsely crystalline, and minutely fractured. Some of the fractures are filled with veinlets of gray specularite and hydrous iron oxides. Vitreous red-brown blebs and minute crystals of thorite are concentrated along narrow zones, more or less throughout the quartz. The quartz is radially cracked around this radioactive material. In zones of highest radioactivity, thorite is associated with specularite as crystals and irregular blebs. This association of specularite and thorite seems to suggest that these two minerals are closely allied in time of deposition. Specularite is vuggy where it is concentrated, and little or no limonitic material has formed.

The silicified rock ranges from buff to pink to gray. The relict granular nature of the original rock is preserved, but the bedding has been obliterated. As with the massive quartzose bodies, the silicified rock also shows much local fracturing and is minutely veined with specularite. The outcrop area of this silicified rock is slightly radioactive, probably because a small amount of thorium is present throughout. Some small local concentrations of thorium are present, although the major part of the thorium is apparently in the secondary iron oxides and other fracture fillings.

Samples taken in and across the different zones show that the ThO_2 content of the quartzose rock is about 0.01 percent and that of the quartz masses ranges from 0.01 to 0.7 percent. The rare-earth content of the samples was small.

The radioactivity of these deposits, particularly of the reeflike quartz masses, is easily detected with a radiation meter. At places the associated radioactivity measures 0.2 mr per hr, which is 10 times the normal background in the region. The anomalous response is partly caused by the large mass of material and partly by the even distribution of the radioactive components.

BUFFALO CLAIMS

The Buffalo claims—the Buffalo and the Buffalo No. 1—are in sec. 10, T. 19 N., R. 25 E., Lemhi County, Idaho (labeled Buffalo mine, pl. 1). The property is accessible by a side road that leads northwest from the county road, a quarter of a mile east of the crossing at Flume Creek. The claims, which extend north from Agency Creek over the small drainage divide into the Flume Creek basin, were originally held by G. E. Shoup and Earl Pyeatt of Salmon, Idaho. In 1953, ownership was transferred to Irvin C. Porter, also of Salmon.

The principal quartz vein exposed on the Buffalo claim was first explored by prospect pits and a short adit, probably at the time of the intial development in the region, about the beginning of the century. Between 1949 and 1951, several short bulldozer cuts were made, to explore all the veins and to open the old adit of the underground workings. In 1952, G. E. Shoup developed the old Buffalo adit and constructed a good road to it.

The two Buffalo claims cover two quartz veins (pl. 1). The eastern vein, which trends N. 50° W., is on the Buffalo claim and is explored by the adit; the western vein, which trends N. 80° W. to N. 30° W., is on the Buffalo No. 1 claim. Both veins are in the Lemhi Pass fault zone and consequently are highly crushed, as is the surrounding Belt country rock. The Buffalo No. 1 vein apparently has been segmented by faulting and the segments have been somewhat displaced, resulting in a sweeping change in strike to a more northerly direction. The two veins, 6 to 10 feet wide, crop out for several hundred feet. Most of these outcrops are reflected as low mounds, and at places they are associated with a collection of quartz vein rubble.

The Buffalo vein consists largely of white vitreous quartz, unstained though extremely crushed. Figure 9 shows the sheared areas and faults in this vein. The vein also contains abundant thin veinlets and large masses of gray hematite. The veinlets are distributed throughout the vein, whereas the masses, from 1 to 2 feet across, are at or near the contacts of the quartz with the country rock. Chalcopyrite is sparse but is conspicuous because of associated spots of green copper carbonate staining. Chalcedony occurs as cement in the broken vein and as mammillary coatings on small cavities.

Most of the Buffalo vein is not radioactive and is apparently barren of thorium minerals. In contrast, the hematite masses and the vein surrounding them are consistently radioactive, as much as 0.2 mr per hr.

The Buffalo No. 1 vein is much more stained and altered than the Buffalo vein. Much of the vein is rounded rubble mixed with crushed and altered country rock, in a narrow zone that has no dis-

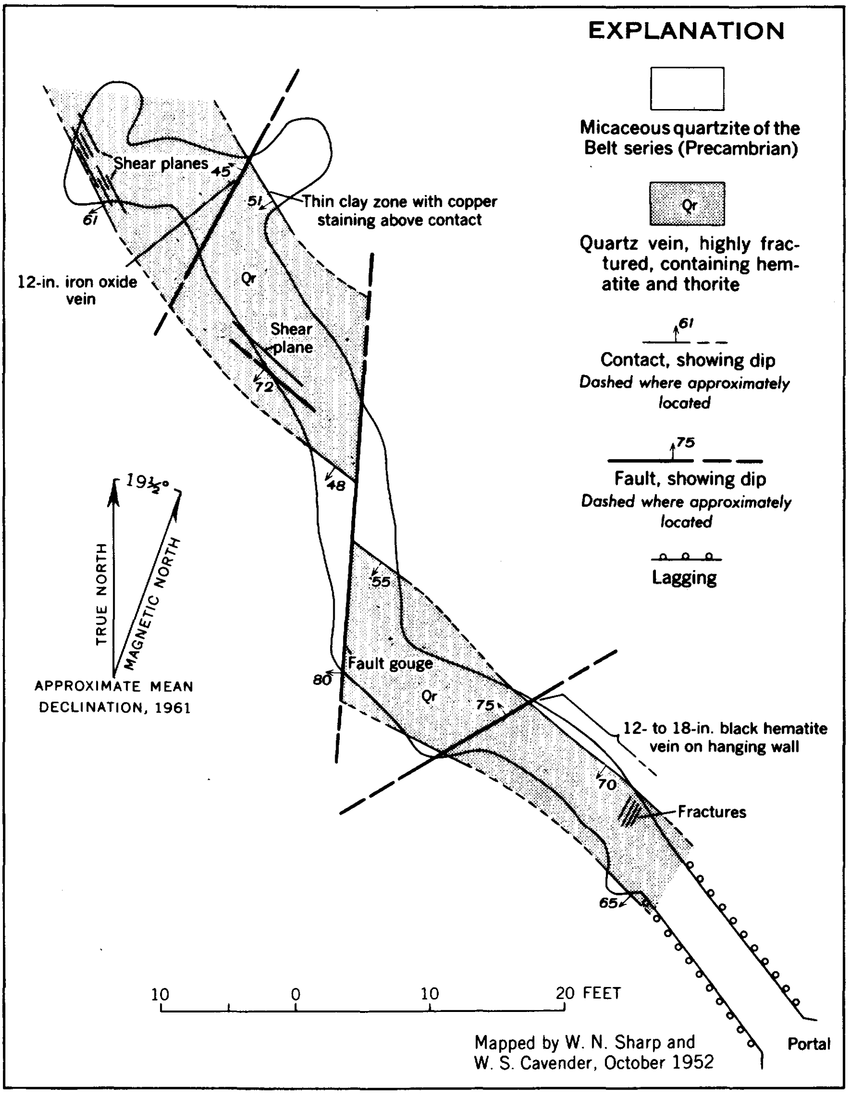

FIGURE 9.—Geologic map of the Buffalo mine, Lemhi County, Idaho.

tinct boundary. The Buffalo No. 1 vein appears to have the same composition as the Buffalo vein, although its features are masked by a heavy limonitic coating and staining. Thorite seems to be more abundant. The general level of radioactivity of the vein is high and radioactivity increases greatly over zones particularly rich in limonitic material. Spectrographic studies indicate that the limonite contains thorium.

Analyses of several samples from both Buffalo and Buffalo No. 1 vein show from 0.04 to 1.0 percent ThO_2.

BROWN BEAR AND FRYING PAN CLAIMS

The Brown Bear and the Frying Pan are two adjoining claims one-half mile southwest of the junction of North and South Frying Pan Creeks. They lie just south of the section line in sec. 28, T. 10 S., R. 15 W., Beaverhead County, Mont. Access is by a U.S. Forest Service road, south from Lemhi Pass for 2¼ miles, across North Frying Pan Creek, then east a quarter of a mile along the drainage divide to the property. The terrain is gently rolling grassland spotted with isolated dense thickets of lodgepole pine. Several springs issue along faults that cut through the area (pl. 2). Both claims are owned by R. A. Wellborn and associates of Armstead, Mont., and were located in 1949 and 1950. The Brown Bear property was leased in 1950 to the Elkhorn Mining Co. of Boulder, Mont. The claims are developed by 7 bulldozer cuts from 2 to 6 feet deep and 50 to 140 feet long. Five of these cuts expose small quartz veins containing abundant hematite and some thorite. The veins trend northwestward, and all are within a zone 300 feet wide. They are for the most part inconspicuous and crop out in only two places at the ends of the zone (pl. 4).

The veins exposed in cuts are 6 to 8 inches wide and dip steeply to the southwest. They cut fine-grained light-gray Belt rocks, which are bleached and friable along the vein zones. All the veins occupy faults and are generally minutely fractured. Fracturing is predominantly parallel to the strike of the vein. The veins at Brown Bear and Frying Pan claims are similar in composition to other veins already described. Highly fractured white quartz has been recemented with silica and refractured. The late fractures are filled with specularite, thorite, and hydrous iron oxides. Some thorite is disseminated as small blebs in quartz, but most of it occurs with limonitic material in fractures. The thorite is isotropic and light to dark orange red and has a refractive index of about 1.88. Pink to white barite forms small veinlets in late fractures that cross shear planes in the vein. Brown and black hydrous iron oxides, probably manganese-rich, are abundant in fractures parallel to the vein and in masses that are locally silicified to jasperoid.

RADIO CLAIM

The Radio claim is north of North Frying Pan Creek, a short distance northwest of its junction with South Frying Pan Creek in sec. 21, T. 10 S., R. 15 W., Beaverhead County, Mont. (pl. 1).

The first prospect pit on the Radio vein was dug probably early in the century and has since partly caved. In 1949 the present claim was located by R. A. Wellborn and Frank Stocker of Medicine Lodge, Mont. Recent development work includes two shallow bulldozer cuts about 40 to 50 feet long. These two trenches, about 300 feet apart, expose very thin quartz veins that are radioactive.

The two narrow quartz-hematite-thorite veins exposed in the bulldozer cuts at the Radio claim are from 1 to 6 inches wide and trend about N. 55° W. The outcrop on which the old prospect pit was dug appears to be about 2 feet thick and may be a local swelling in one of the minor veins exposed in the southernmost trench. A considerable amount of float in line between the trench and pit suggests the vein is 100 to 150 feet long. The country rock is a fine-grained light-gray micaceous quartzite locally bleached and stained along small shears that trend N. 12° W. The veins are also in zones of shearing, and the rock is broken and fractured, though not extensively stained.

The veins at the Radio claims are mostly quartz with abundant hematite and black and brown hydrous iron oxides. Most of the hydrous oxides are silicified to a jasperoid. Barite is common in white to pinkish cryptocrystalline masses and streaks, at places bordered by clear, crystalline, greenish barite. Thorite occurs both as small blebs and as altered forms in the limonitic material. Malachite, probably originating from a small amount of chalcopyrite, occurs along ground-water seepage channels.

The vein, exposed in the prospect pit, is fractured parallel to the walls. Elongate masses and overlapping lenses of black hydrous manganese and iron oxides and hematite occur along these fractures and parallel to them. The black oxide constitutes 20 percent of the vein material at places. Brown jasperoid also occurs along fractures in white quartz and at places as a core stringer enclosed in a band of greenish barite, which is in turn bordered by black manganese and iron oxides. Thorite is sparsely present in black manganese and iron oxides, in white quartz, in barite, and along fractures. This arrangement of thorite in the vein, particularly along fractures, suggests that thorite was late in the sequence of mineralization.

Vein material analyzed for radioactive components contains as much as 1.5 percent ThO_2.

BULL MOOSE CLAIM

The Bull Moose claim is high on the slope, east of the junction of North and South Frying Pan Creeks, in sec. 22, T. 10 S., R. 15 W., Beaverhead County, Mont. Access to the claim is possible by jeep by way of the Selway ranch on Trail Creek. The claim was located in 1949 by R. A. Wellborn and J. H. Selway. It is developed by 2 bulldozer cuts, each 80–90 feet long, one of which exposes a small radioactive quartz veinlet that trends N. 43° W. (fig. 10).

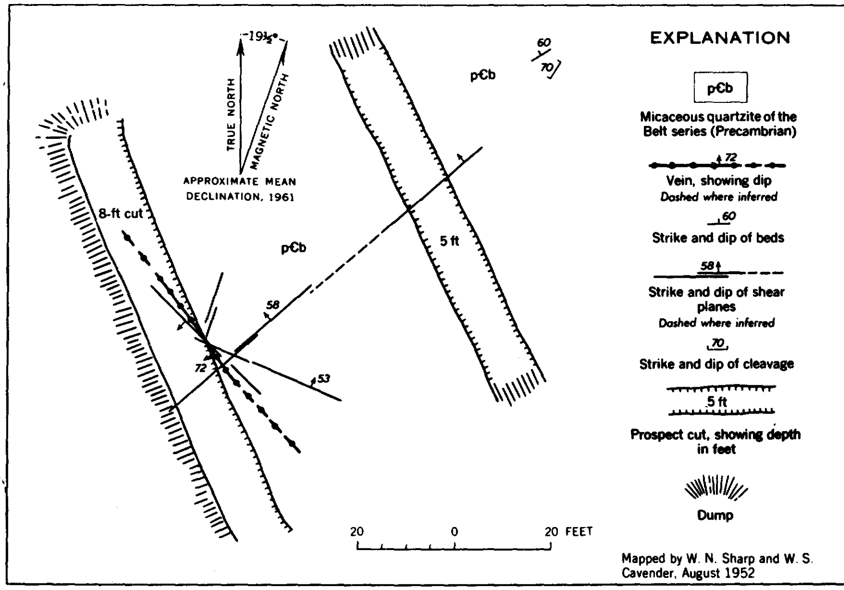

FIGURE 10.—Geologic sketch map of the Bull Moose vein and workings, Beaverhead County, Mont.

The veinlet ranges from 1 to 4 inches in width and is about 60 feet long. The sketch map shows the major directions of fractures that break the Belt country rock and the vein. The vein is typical of the area, being composed of coarsely crystallne white quartz, abundant hematite, black hydrous manganese-rich iron oxides, and a little thorite. Samples of this vein were not analyzed for thorium but radioactivity of the material, 40 times that of the background, is comparable to other veins of this type in the district, and analysis would probably show similar percentages of ThO_2.

BLACK BULL CLAIMS

The Black Bull group of claims is on Agency Creek at the turnoff to the Copper Queen mine in sec. 15, T. 19 N., R. 25 E., Lemhi County, Idaho. The group includes the Black Bull Fraction, the Black Bull No. 2, and the Black Bull No. 3, which together cover both slopes of the Agency Creek gulch and the south fork of Agency Creek at its mouth. The Black Bull No. 2 claim, located mostly along the south fork of Agency Creek, is described in a later section, on veins that contain copper minerals and thorite.

These claims were located in 1952 by E. P. Peron, of Salmon, Idaho, to cover several deposits of radioactive siliceous rock and small quartz veins. Small prospect pits have been dug and several samples have been collected and analyzed by the claimant.

The largest deposit of radioactive rock is on Black Bull Fraction claim; it extends across Agency Creek and the county road about 1,000 feet above the Copper Queen turnoff. This deposit is about 100 feet wide and extends up the valley slope N. 50° W. for several hundred feet to a point near the Buffalo mine fault (pl. 1). The same siliceous rock extends southeast across the creek and road and forms a vertical-walled mass on the opposite slope. The long dimension of this mass parallels the main direction of shearing. Other zones of shearing trend N. 16° E. and N. 84° W.

The rock is a fault-brecciated micaceous quartzite of the Belt series recemented with cryptocrystalline quartz and altered into a highly siliceous and very tough material. Relict features of brecciation and original rock texture are preserved. The rock ranges from gray to pink to tan. In detail, however, the color is the result of a mottling of several colors, the red and gray of numerous minute veinlets of hematite, and the light gray of quartz. Thorite is not visible, but the vein material is moderately radioactive—as much as 0.2 mr per hr. This suggests that the thorium is contained in or obscured by the iron-rich components of the rock. Samples of the rock analyzed contain 0.04 and 0.08 percent ThO_2.

A diorite dike is spatially associated with the silicified zone at the Black Bull claim north of the road. It is exposed for 200 feet parallel to the slope of the valley, trends N. 50°–55° E., and dips 51° NW. into the hill. This trend is almost normal to the long axis of the radioactive siliceous zone. The dike is in contact with the siliceous rock zone on its southwest side, at which point it apparently terminates.

The country rock is strongly sheared along the trend of the dike, and the contact is a shear plane. A schistosity has developed in the border zone of the dike as well as in the country rock. The broken country rock is stained at places with a coating of red hematite along the shear planes. This zone of dike rock and the sheared and stained Belt rock is not radioactive.

URANIUM QUEEN CLAIM

The Uranium Queen claim lies atop a high point on the northwest drainage divide of a canyon, a quarter of a mile south of the Copper Queen mine, in sec. 22, T. 19 N., R. 25 W., Lemhi County, Idaho (pl. 1). The property, which was owned in 1952 by E. P. Peron, of Salmon, Idaho, is reached by foot from the Copper Queen road.

The deposit is a quartz vein, 2 to 3 feet wide, that trends sinuously across a knoll on the drainage divide with a strike of N. 20°–43° W. and dip of 60°–63° NE. The vein is mottled and is predominantly a white and red-stained, minutely veined quartz. The border zones are varicolored silicified micaceous quartzite of the Belt series. Thorite is rarely discernible in the rock, but its presence is suggested by high radioactivity along the vein. Limonitic material and hematite are locally abundant along the footwall of the vein. This oxide-rich zone is the most radioactive; the highest reading is 1.0 mr per hr. An analysis of the most radioactive material gave 0.21 percent ThO_2.

A fault generally parallels the footwall of this vein. It trends N. 40° W. and dips 42° SW. Near the top of the knoll it apparently cuts through the vein where the reeflike topographic expression of the vein ends.

THREE-AND-ONE CLAIM

The Three-and-One claim is high on the northwest slope of a drainage gulch, half a mile southwest of the Wonder Lode claim (pl. 1). It is reached on foot by following the gully southwest from the Wonder No. 4 discovery post, on the roadway. The property is owned by E. P. Peron and a Mr. Woodman, of Salmon, Idaho.

The property is developed by a single 8- by 10-foot cut into the steep slope of the gulch. This cut partly exposes a limonite-stained shear zone that strikes N. 30° E. and dips 89° SE. A highly broken vein of clear quartz, 6 inches to 1 foot thick, occurs within the shear zone. The vein is extremely weathered, and powdery yellow ocher is abundant as coatings and fillings between rock fragments. The quartz is vuggy and rich in limonite and the entire exposure shows evidence of much leaching and alteration. Thorite was not recognized in this highly altered rock, but the material is moderately radioactive. Abnormal radioactivity (0.2 mr per hr) was particularly notable in zones rich in limonite. Analysis of one sample gave a content of 0.11 percent ThO_2. Uranium content was insignificant.

QUARTZ- AND COPPER-BEARING SULFIDE-THORITE VEINS

Quartz veins that contain both copper-bearing minerals and thorite are only two in number—the Wonder Lode vein and the Black Bull No. 2 vein. They are interestingly unique among the veins of the district, because they change at places from quartzose veins to carbonate veins. The carbonate part of the vein is the result of the replacement of the quartz by siderite and accompanying minerals. The carbonate veins contain substantially more thorite than any quartzose vein in the district. This feature suggests a partial relation in time between the deposition of thorite and the carbonate alteration.

WONDER LODE CLAIMS

The Wonder Lode group of claims is on the south fork of Agency Creek, approximately three-quarters of a mile south of the Copper Queen mine and mill site, in secs. 22 and 23, T. 19 N., R. 25 E., Lemhi County, Idaho. The group consists of five contiguous lode claims named Wonder Lodes Nos. 1 to 5 and an overlapping tunnel-site claim. The Copper Queen mine road (pl. 1) continues up the gulch to the Wonder Lode claims and is passable throughout the summer. James Quinn located the original five claims, probably in 1923; at that time they were called the Wonder Lode and the Buckhorn mining claims. These claims later came under the ownership of Ray and Clair Pierce of Salmon, Idaho. Some exploration work was done during this period; 8 short adits, 20–40 feet long, were driven on various levels, and a few prospect pits were dug. Some ore containing copper and zinc was supplied to the mill at the Copper Queen mine. In October 1951 an option to lease the property was granted to Frank Eichelberger and associates of Spokane, Wash.; they turned over all rights and title to Defense Metals, Inc., of Kellogg, Idaho. In August 1952 an exploration contract was granted to Defense Metals, Inc., by the Defense Minerals Exploration Administration to aid in the exploration of the vein for thorium. As a result, 10 bulldozer cuts were made across the vein and a limited underground development program was begun.

The Wonder Lode deposit consists largely of a single fissure-filling vein that cuts gray fine-grained micaceous quartzite of the Belt series. This vein trends generally eastward across the gulch of the south fork of Agency Creek and is traceable for more than 1,200 feet horizontally and 300 feet vertically. It ranges from 4 to 10 feet in width. Several small subsidiary quartz veinlets ½–1 inch wide trend parallel to or fan away from the major vein on the south side. Diorite dikes parallel both sides of the vein.

The Wonder Lode vein lies in a zone of faulting that affects not only the entire vein along its exposed length, but also the country rock for as much as 100 feet on either side (pl. 5). As a consequence, the vein is extensively broken, altered, and weathered. Thick gouge zones are common at places in and near the vein, and the fractured country rock is coated with red-brown hematite. The zones of hematite stain are not all close to the vein; some occur in fractured country rock along faults subsidiary to the Wonder Lode fault, several hundred feet from the vein. The faulting along the vein trends east across most of the claims area. Near the eastern edge the fault and the vein, which becomes quite narrow, abruptly trend northeast. At this site, a slight drainage depression has been formed in which there is a deep cover of loose rock and soil. The fault and the thinning quartz vein continue into this covered zone but are not traceable beyond it.

Some of the structure at the Wonder Lode vein may be distorted by surface movement on the very steep slope of the apparently deep zone of fractured rock. Each fragment appears to be nearly in place, yet the amount of creep of the mantle of broken rock may be different from place to place.

At least two north-trending faults cut the Wonder Lode vein. One, near the center of its exposed length, offsets the eastern part approximately 30 feet to the north. This fault dips 84° W., and much of the slip on this fault was probably diagonal.

A second crosscutting fault, in the gully of a tributary drainage, abruptly terminates the vein and one of the diorite dikes on the west. The movement on this crosscutting fault must be of large magnitude, as no evidence of the vein, the fault along the vein, or the dike was found across this fault zone within several hundred feet.

The diorite dikes trend almost parallel to the Wonder Lode vein and dip steeply south. Although the north dike is about 5–20 feet wide and the south dike about 10 feet, neither is topographically prominent. The weathering of the dike rocks is very complete near the surface, and much of the material is a soft, earthy green mass that contains a few rounded masses of less altered rock; consequently, a shallow rubble or soil cover obscures the dike.

Thin sections were cut from both dikes for comparison. Both are fine- to medium-grained dark-green to gray-green rocks. They are composed of plagioclase, biotite, augite, hornblende, clinozoisite, magnetite, quartz, and alteration minerals including allophane, chlorite, and epidote.

The rocks are composed predominantly of plagioclase (about oligoclase in range) and augite or hornblende. The principal mafic mineral in the north dike is augite; hornblende is subordinate. This relation is reversed in the south dike.

The Wonder Lode vein changes greatly in composition from its lowest exposures at the creek level to the highest exposures on the east slope of the gulch. West of the road in the gulch the vein is composed largely of quartz, whereas on the eastern slope of the gulch it is composed predominantly of siderite and barite. A few small residuums of quartz are found.

The vein is radioactive and shows evidence of copper minerals throughout its outcrop length. West of the creek the quartzose part

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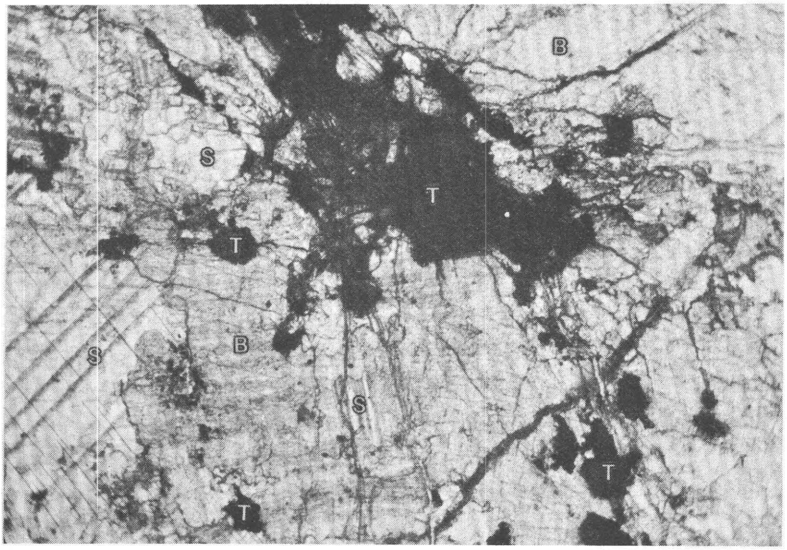
is slightly less radioactive than the predominantly siderite-barite part of the vein and contains substantially more copper. Chalcopyrite is the common copper-bearing mineral; alteration and weathering have produced some malachite and azurite coatings and impregnations. Marmatite, the dark iron-rich variety of sphalerite, also is present in this part of the vein. Locally, however, small zones of a transparent greenish sphalerite are present. Thorite, as brick-red blebs and irregular masses, is sparsely distributed in coarsely crystalline quartz; both the thorite and quartz were affected by late fracturing. The mineral has been smeared out by shearing and is obscured by the abundant dark-brown to reddish oxides of iron. A substantial amount of the thorium is probably held as a hydrated form in the iron oxide. Thorite is most abundant in the matrix that fills in between quartz fragments. In this matrix, quartz, hematite, chalcopyrite, covellite, thorite, and sphalerite are intimately mixed. The vein is strongly altered and oxidized; hydrous iron oxides and copper carbonates are the most abundant oxidized minerals.

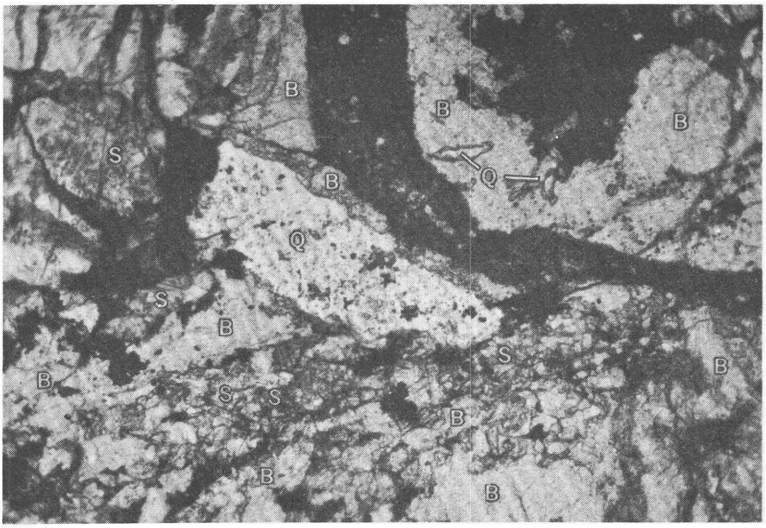
Siderite rather than quartz is the most abundant vein mineral on the eastern side of the creek. At places barite also is abundant. Black hydrous oxides of manganese and iron fill all fractures, cover all weathered surfaces, and generally obscure the vein filling. As a consequence the vein is black at places, slightly mottled by the lighter colored minerals. Light-tan siderite forms coarse to fine crystalline masses; where finely crystalline it is intimately mixed with white barite. These two minerals are closely related paragenetically; at places both appear to be contemporaneous, in other places siderite apparently is the earlier. In thin section both siderite and barite are seen to replace quartz (fig. 11). Figure 11A shows the barite-siderite relation in a sample from cut 4. In this and in the other thin sections, the barite studied is abundant along fracture zones through siderite.

Quartz is sparse in the eastern part of the Wonder Lode vein, but most thin sections contain relict fragments, and fragments of quartz can be seen in hand specimens.

Small prismatic crystals and irregular blebs and masses of thorite are abundant in all exposures of the siderite-rich part of the vein. At places clots and elongate parallel zones of these masses and crystals are interspersed with barren zones. These thorite-rich zones range from 1 to 8 inches across and are apparently controlled by an early shearing in the plane of the vein. The minerals of the thorite-rich zones are all highly broken by a complex pattern of intersecting fractures. Some thorite and specular hematite overlying certain of these fractures appear to be unbroken and, therefore, of later age. Figure 11A shows the association of thorite as massive blebs and crystals with



A. Thorite (T) in barite (B) and siderite (S). Associated radial cracks are filled with hydrous iron oxides. Crossed nicols. × 80.



B. Relict quartz grains (Q) partly replaced by barite (B) and siderite (S). Crossed nicols. × 80.

FIGURE 11.—Photomicrographs of vein rocks, Lemhi Pass area.

siderite and barite, and some of the intricate net of fracturing. Some of the fractures are short and radiate from each mass of the radioactive mineral. The larger fractures parallel the vein and cut most of the constitutents of the rock. Dark hydrous iron manganese oxides fill and cement most of the fractures and also form a stained zone around each fragment or crystal of siderite. Calcite fills scattered fractures that cut across the oxide-filled breaks; it appears to be a very late mineral. The more barren zones in the siderite vein appear to be richer in the black hydrous oxides of iron and manganese and contain more coarsely crystalline siderite.

A camera lucida drawing of thorite crystals in siderite enclosed in barite is shown on figure 12. Siderite has been crushed, altered, and stained in large areas along the parallel shear planes. Fractures in the barite have been filled with late calcite. Thorite seems to be associated specifically with siderite here; however, this is not always the relation.

Several stages of mineralization appear to have occurred in the Wonder Lode vein. Siderite, barite, and minor thorite replaced the primary quartz that had been fractured at some prior time. The time relation of siderite and barite is not clear; both replace quartz and are interchangeable in their relationship. Both minerals enclose scattered crystals and blebs of thorite. The vein was again fractured, and hematite and the bulk of the thorite were introduced. Alteration products of the siderite, and probably of the hematite, filled some of these fractures and subsequent fractures as hydrous oxides of iron and manganese. These alteration products, rich in manganese, indicate that the siderate contains substantial $MnCO_3$ and probably approaches manganosiderite in composition. Still more recent fractures are filled with white calcite. Hydrous iron-oxide veinlets cut some of these calcite veinlets and stain much of the rock mass. This paragenetic sequence is similar to that postulated for the Last Chance vein.

Several samples of the Wonder Lode vein were collected by various persons for analyses. Most of these were analyzed only for uranium, thorium, and rare-earth content. Uranium content is very low, as is common of the veins of the Lemhi Pass area. The rare-earth content also is low in this vein, relative to values from the Trapper and Last Chance veins (table 2). In contrast, thorium values were consistently high, ranging as high as 2.56 percent; one grab sample from adit 1 was calculated to contain 3.2 percent ThO_2. A suite of samples assayed by the U.S. Bureau of Mines at Albany, Oreg., contains between 1.5 and 2.8 percent copper.

The Wonder Lode vein is highly radioactive, in contrast to the country rock, which is very low in radioactivity. The intensity of the radioactivity nevertheless varies considerably from place to place. The highest recorded is 2.0 mr per hr along the eastern slope outcrop on the vein.

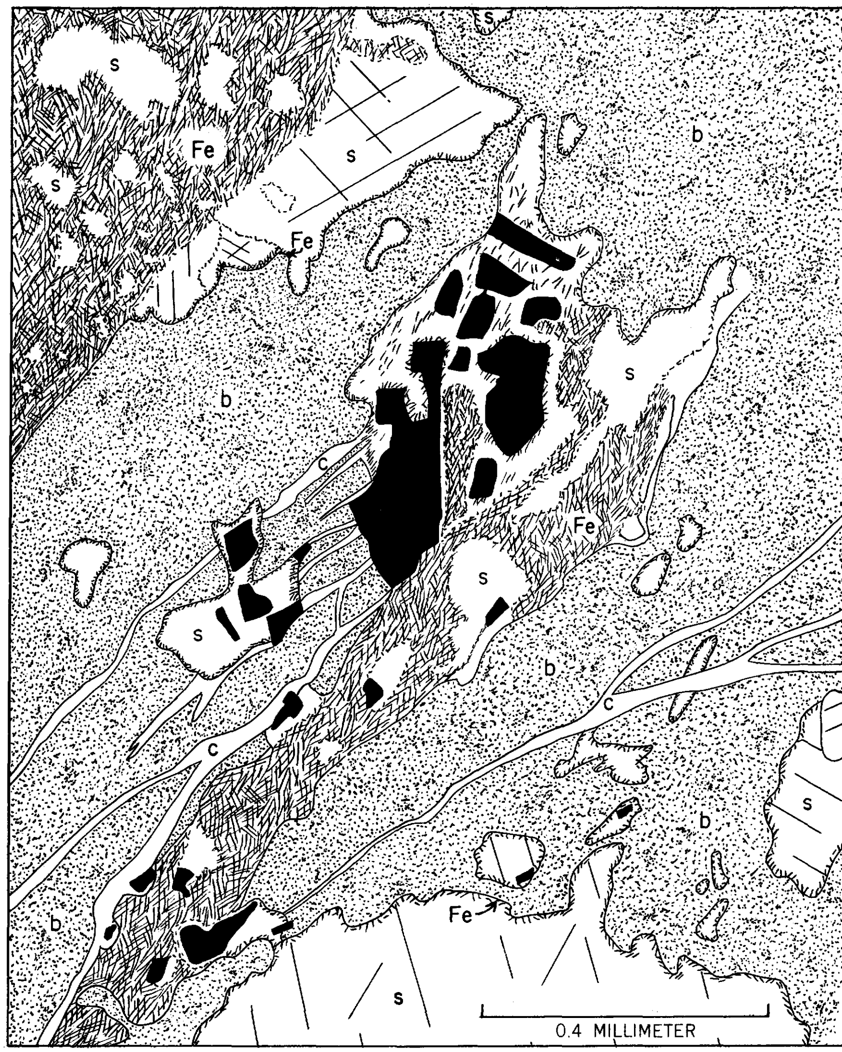


FIGURE 12.—Camera lucida drawing showing thorite crystals (black) in remnants of siderite (s) in barite (b). Hydrous iron oxides (Fe) stain borders of siderite and zones along fractures. Calcite (c) fills late fractures.

BLACK BULL NO. 2 CLAIM

The Black Bull No. 2 claim is largely in sec. 15, T. 19 N., R. 25 E., Lemhi County, Idaho. It is south of the Lemhi Pass road on Agency Creek at the mouth of the south fork, about a quarter of a mile northwest of the Copper Queen mine and mill. The claim is one of a small group located in 1952 by E. P. Peron, of Salmon, Idaho, to cover several outcropping veins and replacement bodies that showed signifi-

TABLE 2.—*Percent distribution of rare earths and thorium in samples from Wonder Lode vein*

[Semiquantitative spectrographic analyses by K. E. Valentine, U.S. Geol. Survey. Location of samples shown on pl. 5; samples described in table 3. Leaders (..) in measurement columns indicate element not present]

Laboratory No.	Sample	x.0	0.x	0.0x	0.00x	0.000x
103576	Won-C-1	....	Th	Nd-Ce-La	Dy-Eu-Y-Pr	Yb
103577	-2	....	Th	....	Y	Yb
103578	-3	....	Th	Ce-Nd	Y	Yb-Eu
103579	-4	Th	Y	Ce-Er	Dy-Nd-Yb-Eu	....
103580	-5	....	....	....	Y	Yb
103581	-6	Th	Nd-Ce	Gd-La-Er	Dy-Eu-Y-Pr-Lu	....
103582	-7	Th	Y	Er-Gd-Ce-Nd	Dy-Eu-La-Yb-Lu	....
103583	-8	Th	Y	Gd-Ce-Nd-Er	Dy-Eu-Yb-La-Lu	....
103584	-9	Th	....	Gd-Ce-Nd-Y	Dy-Eu-La-Lu	Yb

cant radioactivity. Two veins crop out on the Black Bull No. 2 claim; two short adits and a short tunnel that follow the veins probably date back to the time when the Copper Queen mill was processing copper ore.

The major vein or Black Bull No. 2 vein is exposed along the south side of the south fork of Agency Creek; it strikes N. 70°–80° W., and dips nearly vertical. It is 2–4 inches wide and can be projected northwestward from the exposures at the tunnel to a prospect pit on the high nose overlooking the junction of the creeks; the vein with this projection is nearly 300 feet long. The vein is largely filled by quartz, but it contains chalcopyrite and small amounts of bornite and covellite as well as noteworthy amounts of thorite. Barite encloses both copper minerals and hematite. The prospect pit on the north extension, although in good alinement with the shear vein at the creek, contains siderite as a major component, with some barite. Thorite, in the northern part of the vein, is scattered along the fracture zones where carbonate minerals, barite, and hematite have replaced the quartz. The Black Bull No. 2 vein is highly radioactive. Maximum readings approached 1 mr per hr on the vein and at the tunnel, and 0.2 mr per hr at the prospect pit. ThO_2 content in analyzed samples was as much as 0.29 percent.

Across the south fork of Agency Creek, about 30 feet above the road to the Copper Queen mine, a short elbow adit cuts a small radioactive carbonate vein. This vein strikes N. 70°–80° W. and dips 64° S. It is a small fissure that is filled by siderite, barite, thorite, and hydrated iron oxides. The vein, although inconspicuous, can be traced for 150–200 feet. It is similar in composition to the upper Wonder Lode vein. A sample from this vein contained 0.02 percent ThO_2.

QUARTZ- AND COPPER-BEARING SULFIDE VEINS

Quartz- and copper-bearing sulfide veins are the most abundant type in the Lemhi Pass district. As shown in plate 1, they are largely concentrated in the northern part of the area, just west of the pass. The veins range in width from 6 inches to 15 feet and generally are persistent in length; the Copper Queen vein has been exposed underground for more than 700 feet. In general, these veins contain predominantly copper-bearing sulfide minerals, their alteration products, hematite, and some free gold; they are not radioactive. Most of the outcropping veins were explored early in the history of the district by cuts, adits, and pits; but the Copper Queen and Blue Bird mines are the only ore producers of this type.

COPPER QUEEN MINE

The Copper Queen mine, the principal mine in the area, is on the south fork of Agency Creek, about a mile north of the Wonder Lode property, in sec. 15, T. 19 N., R. 25 E., Boise Meridian, Idaho, base line. It has a long history dating from 1883, when the claims were located. In 1899 the property, which consisted of 5 claims, 2 patented, came under the ownership of T. E. G. Lynch of Digby, Nova Scotia, Canada. The mine was first operated in 1905 and since then has been under lease by several different groups. Prior to 1920, ore valued at $100,000 was shipped. In 1908 two cars of ore were shipped that assayed 45 percent copper, 8 ounces silver, and $20 gold per ton. In 1911, 448 tons of sorted ore was shipped to Salt Lake City; this ore assayed 29.4 percent copper, 5.2 ounces silver, and 0.81 ounces gold. Another old assay of the Copper Queen Mining Co. shows that 18 cars of ore averaged 28.3 percent copper, 6 ounces silver, and $24.75 gold per ton, (Stevens, 1908, p. 592; Weed, 1912, p. 285; 1916, p. 401; 1926, p. 788; 1931, p. 951). The latest attempt of a lessee to operate the mine was in 1949. The mine has been flooded since then and the mill has fallen in ruins.

At the Copper Queen mine area, a network of white quartz and copper-bearing sulfide veins and replacement bodies fill a fault breccia zone that trends N. 40°–70° E. The general plane of the fault is warped; it dips northwest, at some places 30°, at others 80°. This fault has strongly broken the light-gray to tan micaceous quartzite of the Belt series across a zone 10–20 feet wide. Sericitic gouge zones generally stained with copper minerals are numerous.

Several subsidiary veins parallel or nearly parallel the major vein; one of these, the Blue Lupine, intersects the Copper Queen at a small angle (pl. 1).

At least two thick dioritic dikes cut the Belt rocks in the Copper Queen workings and are in turn cut by the fault and the quartz vein. These diorite masses in the mine are known as the east dike and the west dike (pl. 6).

The Copper Queen vein is massive white quartz that contains bornite, chalcopyrite, chalcocite(?), gold, hematite, and the secondary minerals covellite, malachite, and limonite. Bornite is by far the most abundant metallic mineral and in many places is the complete interstitial filling between breccia fragments of the country rock. At places it is intimately mixed with vein quartz and seems to follow an earlier fracturing in the quartz. Chalcopyrite is unevenly scattered throughout the vein filling but is always associated with bornite. Covellite coats all bornite that has been exposed to air. Small amounts of gold, closely associated with bornite, are found in blebs as much as three-eighths inch in diameter. One of the miners who had worked in the mine reported that gold was more abundant where the vein cut diorite. Several specimens of vein material from the Blue Lupine dump contained small blebs of gold. Small amounts of cubanite were noted in one polished section. Chalcocite is reported from the vein at depth but was not seen by the authors. A specimen containing molybdenite in a thin quartz stringer was found on the dump of the shaft.

A crosscutting veinlet on the main adit level of the Copper Queen mine, north of the main vein, was found to be significantly radioactive—10 times the background. This veinlet (see pl. 6), mineralogically similar to the Copper Queen vein, contained 0.17 percent ThO_2. The thorium was probably introduced into this veinlet at a later time than the Copper Queen vein material and the veinlet should be considered to be part of the group of veins that contain both copper-bearing sulfides and thorite.

BLUE BIRD MINE

The Blue Bird mine is in sec. 14, T. 19 N., R. 25 E., Lemhi County, Idaho, a mile west of Lemhi Pass on the flat upland surface overlooking the valley of the north fork of Agency Creek. The mine was active for only a short time during the interval between 1911 and 1922, when 8 tons of ore was produced. This ore contained 1,432 pounds of copper, 68 ounces of silver, and 3.6 ounces of gold (Weed, 1926, p. 788). The Blue Bird mine explores a group of three or four white quartz veins, all of which are within a few hundred yards of each other. The old workings include a main shaft less than 50 feet deep and a drift. This drift has caved from the surface for 30 to 40 feet. Several other shallow shafts and pits have been cut on the same vein and other less prominent associated veins.

The main vein at the Blue Bird mine is approximately 3 feet wide and pinches to a thin stringer within a distance of 100 feet. It trends about N. 45° E. and dips nearly vertically. The country rock along the vein is bleached and stained at places with red hematite and limonite.

All the veins at the Blue Bird mine are composed of fractured coarsely crystalline white to clear quartz, with interstitial hematite, limonite, chalcedony, chrysocolla, copper carbonates, hydrous copper oxides, and some barite. As only copper oxides and other secondary minerals were noted, the workings apparently are all in the oxidized zone. The original copper minerals were probably chalcopyrite and bornite. The veins are not radioactive.

IDAHO PRIDE GROUP OF CLAIMS

A group of quartz veins that contain copper-bearing sulfides is exposed at Horseshoe Bend Creek. These veins are covered by several claims including the Idaho Pride, Azurite, and Stage Coach claims, most of which have been or are still owned by G. E. Shoup of Salmon, Idaho. Only exploratory work has been done on the claims, and several short adits, opencuts, and pits are present.

The veins are parallel to nearly parallel and lie in the Lemhi Pass fault zone, a mile west of the pass. The veins are from 6 to 18 inches wide and generally follow shear planes in the fault zone. On the east side of Horseshoe Bend Creek three separate vein zones cut through gray micaceous quartzite of the Belt series. The largest of these zones, which has been explored by long cuts, contains three 6- to 12-inch quartz veins separated by a few feet of dark micaceous gouge and broken country rock.

The veins as a group are similar in composition to the Copper Queen vein, except for lesser amounts of copper minerals contained. They consist predominantly of massive white quartz that is fractured and sheared along the length of the vein. Bornite is the principal copper sufide; chalcopyrite is less abundant. Copper carbonates fill fractures and generally stain the quartz and country rock. Chrysocolla and green chalcedony are also abundant as fracture fillings. Hematite (specularite) is a late mineral and fills fractures as much as one-half an inch in width that parallel and crosscut the vein. The abundant limonitic material undoubtedly is an oxidation product of the hematite. The veins are not radioactive.

NO PAY MINE

The No Pay mine is on Horseshoe Bend Creek in sec. 11, T. 19 N., R. 25 E., Lemhi County, Idaho, three-fourths mile north of the Lemhi Pass road. It is owned by Keith and Don Davis of Tendoy, Idaho, and appears to have been worked early in the present century. The workings consist of a slightly irregular adit that follows a quartz vein for somewhat more than 100 feet (fig. 13).

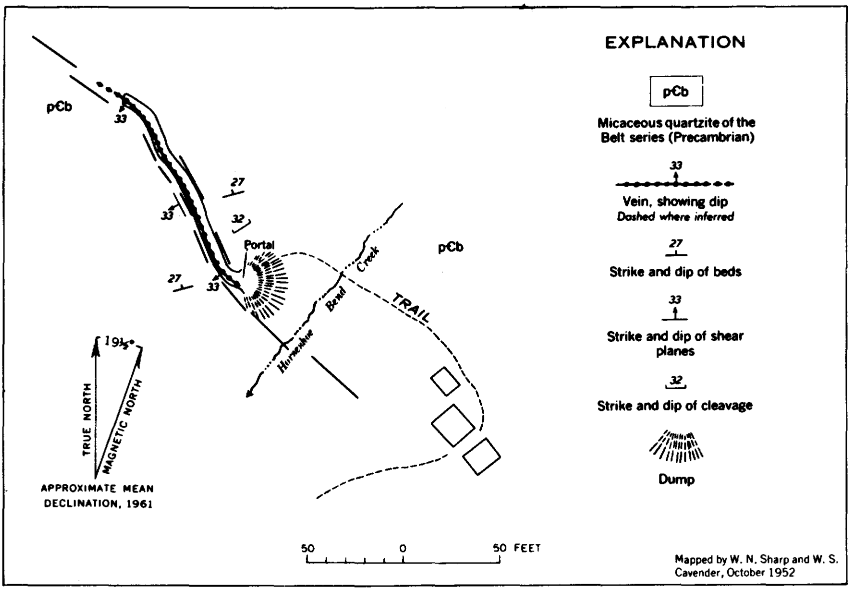


FIGURE 13.—Geologic map of the No Pay mine, Lemhi County, Idaho.

A prominent 100-foot fault zone crosses Horseshoe Bend Creek at the No Pay mine. This fault zone trends about N. 43° W. and dips 33° SW. Movement appears to have been normal and some drag is discernible. The bedding in the Belt rocks is otherwise undisturbed in this part of the district and has a strike of N. 70°–75° E. with a dip of 20°–30° NW.

The vein is about a foot thick and is filled by white quartz, black hydrous copper oxide, bornite, malachite, azurite, chrysocolla, and specular hematite. Copper oxides fill smaller fractures in the country rock, and seams of hematite lie along the borders of the quartz vein. Bornite is only sparsely present. The vein is not radioactive.

PATTEE CREEK WORKINGS

A group of old workings is near the site of an abandoned ranch on Pattee Creek, 4 miles from its confluence with the Lemhi River, in sec. 12, T. 19 N., R. 24 E., Lemhi County, Idaho. Neither the name nor the history of the workings is known.

Two short adits have been driven on a quartz vein near the north side of the fault zone on the east side of the creek. A third adit on the west side of the creek enters into a zone of sericitized Belt rocks where no vein is visible (pl. 1). The quartz vein on the east side of the creek is 1 to 4 feet thick, strikes N. 55° E., and dips 12° SE. The hanging wall of this flat-lying vein is a low-angle normal fault; the overlying rock mass appears to have moved eastward. The vein consists of coarsely crystalline white quartz that contains bornite, chalcopyrite, and hematite. Secondary copper and iron minerals are abundant as fracture fillings and stainings. The vein material is not radioactive and evidently not rich enough in copper to constitute ore.

FISHCAN AND LAST CHANCE ADITS ON LEMHI RIVER

The Fishcan and Last Chance adits are 2 miles north of the town of Lemhi, Idaho, on the east side of the Lemhi River valley in sec. 16, T. 18 N., R. 24 E. (pl. 1). The property is believed to have been owned in 1952 by Roy Stenson and G. E. Shoup of Salmon.

At the Last Chance claim, two adits, one above the other, enter the steep slope about 200 feet apart. The lower adit, about 175 feet long, is driven on a 4-inch quartz vein that trends N. 85° E. in greenish-gray sheared Belt rocks. The bedding of the country rock strikes N. 50° W. with a dip of 18°–20° SW. The upper adit is 30 feet long on a similar quartz vein that is not traceable to the lower adit. The veins consist of white massive quartz which generally contains several percent of copper-bearing minerals, principally chalcopyrite, hydrous copper oxide, and malachite. Hematite and limonitic minerals also are common.

The Fishcan mine, several hundred feet higher on the slope, consists of an old caved shaft on a small copper-bearing quartz vein. Dump material, similar to material at the lower vein, was the only evidence of vein visible at this location.

Radioactivity generally was not above the normal background; however, a slight increase in background count was noted at the upper Last Chance adit. A sample of the Last Chance vein contained 0.006 percent uranium and 0.03 percent ThO_2; no radioactive minerals could be found.

QUARTZ-HEMATITE VEINS

Quartz-hematite veins are widely scattered across the northern part of the Lemhi Pass area. The veins generally are small and inconspicuous; however, a number of them have been explored.

BLUE RIDGE AND BLUE BOAR PROSPECTS

The Blue Ridge and Blue Boar veins crop out up the gully that enters the south fork of Agency Creek from the east at the Copper Queen mine. The Blue Ridge vein is near the spring-filled basin at the head of the gully; the Blue Boar vein is high up on the north drainage slope about 2,500 feet from the Blue Ridge vein (pl. 1).

The small veins at both the Blue Ridge and Blue Boar prospects follow zones of brecciation in the gray- to brown-stained micaceous quartzite country rock. The Blue Ridge vein trends N. 45° W. and dips steeply to the north; the Blue Boar vein trends N. 70° W., and dips 55° N. The Blue Ridge vein crops out as a low reef for 40 feet and has been explored by a shallow shaft and several prospect pits. The Blue Boar vein is exposed by a 10-foot cut in the steep slope.

These two veins are not radioactive and they differ in composition from the other veins of the district. They contain abundant jasperoid, montmorillonite, rutile, and pyrite, as well as white quartz and hematite. The vein filling consists of breccia fragments of micaceous quartzite country rock and white vein quartz that are cemented and filled by dark-gray vitreous coarsely crystalline quartz. The quartz owes its gray color to the abundant included hematite. The wallrock fragments have been greatly altered and at places are converted to varicolored jasperoid. Honey-brown rutile with an adamantine luster forms small irregular masses in the gray quartz, and roughly prismatic, striated crystals in the white vein quartz. Much of the rock is honeycombed with small irregular cavities, some of which are lined with drusy quartz and others partly filled with a siliceous boxwork. Most of these cavities, however, are filled with a pinkish to buff montmorillonite clay. Cube-shaped cavities, probably after pyrite crystals, are also locally numerous.

These veins show the results of considerable alteration and replacement. Silicification has been the most prominent alteration process as shown by the complete reconstitution and cementing of the wallrock fragments. The abundant gray quartz and the hematitic breccia-filling, which contains solution cavities filled with clay, gives support to the concept that a hot-spring or a sulfate-acid solution was active for a time along this vein and accounts for the present condition of the Blue Ridge and Blue Boar veins. The presence of rutile in different forms, both in fragments of white vein quartz and in the dark hematite-rich silica, suggests that this mineral was probably present originally and has persisted, although perhaps recrystallized.

SILVER QUEEN CLAIMS

The Silver Queen group of claims is 2¾ miles up Pattee Creek gulch from the Lemhi River (pl. 1). The claims cover the ridge on the north side of the valley and were staked by Jack Rucker of Tendoy, Idaho. The workings consist of a series of pits, cuts, and shallow inclined shafts. Some of the workings expose small quartz-hematite veins 1–2 inches wide; others expose brown-stained shear zones in the micaceous quartzite country rock.

A conspicuous fault zone trends westward across the Silver Queen claims, dipping 83° N. A coarse-grained biotite-rich diorite dike lies on the hanging-wall side of this fault zone; it is broken at places by the fault. This dike trends about N. 85° E. and appears to dip north, like the fault. The dike is about 20 feet wide, and it can be traced in cuts for several hundred feet.

The small veins covered by the claims are filled with white quartz, hematite, and hydrous iron oxides. One 2-inch vein contains abundant iron oxides and is slightly radioactive (0.1 mr per hr max); it assayed 0.014 percent eU, 0.001 percent U, and 0.062 percent ThO_2 (table 3). None of the other veins or workings were radioactive.

SUMMERWELL ADIT

The Summerwell adit is high on the north slope of the Agency Creek valley, a short distance east of the Buffalo mine turnoff. The adit was driven by a man named Summerwell, who at one time lived nearby on Agency Creek. The adit is 220 feet long, and several short crosscuts turn from it; a flooded winze extends below the adit level.

The adit cuts well-bedded micaceous quartzite that is interbedded with thin strata of argillite. The bedding is very regular throughout, striking N. 50° W. and dipping 26° NE. (fig. 14).

Three intersecting faults are conspicuous near the face of the adit; one of these is a reverse fault. No veins or mineralized rock are evident anywhere in the workings, but gouge is abundant in the fault zones. On the surface 100 feet above the main adit, a small opencut exposes a thin quartz veinlet that at places is stained copper green. The adit may have been driven in an attempt to cut this vein.

STENSON'S BUFFALO PROSPECT

Stenson's Buffalo prospect is on a small quartz vein that crosses the drainage divide west of Horseshoe Bend Creek, 1,000 to 1,500 feet southwest of the No Pay mine. The property was owned in 1952 by Roy Stenson and G. E. Shoup of Salmon, Idaho. The vein has a maximum width of 1½ feet and apparently it pinches out within 100

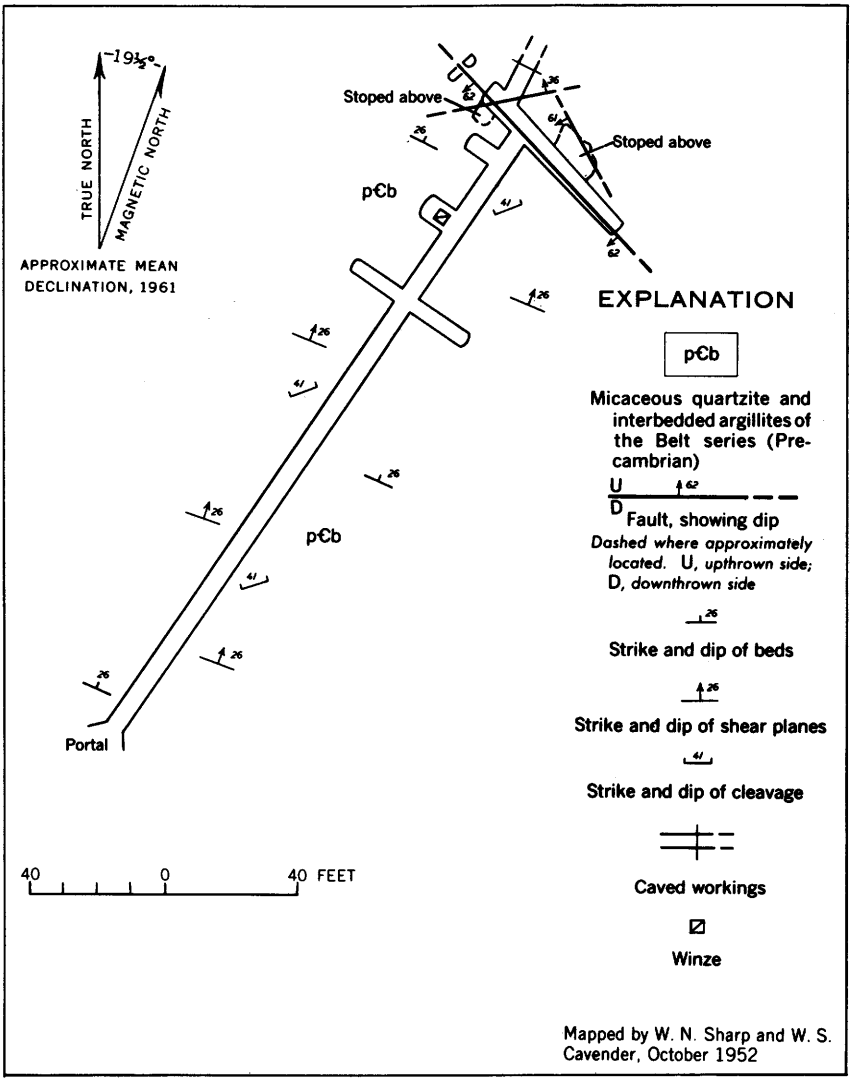


FIGURE 14.—Geologic map of the Summerwell adit, Lemhi County, Idaho.

feet. On the crest of the ridge it trends N. 59° W. and dips 48° to 52° SW. A narrow shear zone parallels this vein. The vein is filled with white quartz and much hematite and hydrous oxides of iron. It differs from nearby veins in that it contains small amounts of earthy purple fluorite. The vein is slightly radioactive at those places that are rich in limonitic minerals; no radioactive minerals were seen.

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BASIC DATA

644011 O—62——5

TABLE 3.—*Analytical data*

[Samples collected in the Lemhi Pass area, Idaho and Montana. Radiometric and chemical analyses by the U.S. Geol. Survey, except as noted. Analysts (U.S. Geological Survey): Radiometric—J. N. Rosholt, Jr., S. P. Furman, and B. A. McCall; chemical—J. S. Wahlberg, Harry Levine, E. C. Mallory, Jr., J. P. Schuch, J. W. T. Meadows, R. F. DuFour, and Wayne Mountjoy; N. F., looked for but not found]

Laboratory No.	Sample	eU (percent)	U (percent)	ThO_2 [6] (percent)	Re_2O_3 [1] (percent)	Ra (gr per gr)	Location	Remarks
Wonder Lode vein								
77755	Won-C-1	0.054	0.002	[2] 0.23			Cut 1, east side of creek	5-ft sample across vein.
77756	Won-C-2	.027	<.001	[2] .14			Cut 2, east side of creek	2-ft sample across vein.
77757	Won-C-3	.071	.001	[2] .27			Cut 3, east side of creek	4-ft sample across vein.
77758	Won-C-4	.19	.001	[2] 1.20			Cut 4, east side of creek	8-ft sample across vein.
77759	Won-C-5	.012	.001	[2] .03			Cut 5, east side of creek	2.5-ft sample across vein.
77760	Won-C-6	.17	.001	[2] .96			Cut 6, east side of creek	1-ft sample across branch vein.
77761	Won-C-7	.16	.001	[2] .90			Cut 7, east side of creek	6-in. composite sample of 6 small veins.
77762	Won-C-8	.31	.001	[2] 1.50			Cut 8, east side of creek	1-ft composite samples of 3 small veins.
77763	Won-C-9	.17	.001	[2] 1.20			Cut 9, east side of creek	1.5-ft sample across branch vein.
43539	AFT-S18-50	.031	.003	[3] .17			Adit 1, lower adit, west side of creek	Grab sample.
43540	AFT-S19-50	.12	.002	[3] .67			Adit 2, west side of creek	Do.
43541	AFT-S20-50	.12	.004	[3] .67			Adit 3, west side of creek	Do.
43542	AFT-S21-50	.57	.002	[3] 3.2			Adit 1, lower adit east side of creek	Do.
74431	W-122-50	.042	.003	.03	*.04*		From caved pit on vein, west side of creek.	3.5-ft sample across vein.
74432	W-124-50	.49	.001	2.56	*2.36*		Adit 4, cut 4, east side of creek	1.5-ft grab sample from rich part of vein.
74447	CQ-M1-50	.061	.002	.02	*.25*		Mill heads from west side of creek	Grab sample of ore at mill.
Last Chance vein (pl. 12)								
70652	LC-B	0.008	0.001	0.05	*0.06*		Pit on satellite vein NW. of road cut	Chip sample across 3- to 4-ft vein.
70653	LC-E	.021	.001	.06	*.05*		Prominent enlargement of vein NW. of roadcut.	Chip sample across 20-ft vein outcrop.
70654	LC-G	.19	.005	.93	*1.70*		First trench NW. of "E" location	Chip sample across 3- to 4-ft vein.
70655	LC-H	.017	.001	.05	*.05*		Second trench NW. of "E" location	Chip sample across 4-ft vein.

54266	KW-LC-1	.059	.001	.31		3×10^{-12}		Chip sample across 3 ft of 10-ft vein.[5]
54267	KW-LC-2	.10	.002	.53		7×10^{-12}	Roadcut across vein	Chip sample across 3 ft of 10-ft vein.[5]
54268	KW-LC-3	.41	.003	2.1		1.4×10^{-11}		Chip sample across 4 ft of 10-ft vein.[5]
54269	KW-LC-5	.36	.002	1.8		2.0×10^{-11}	Outcrop, 30 ft SE. of roadcut	Channel sample across 8-ft outcrop.
54270	KW-LC-6	.32	.003	1.7		2.5×10^{-11}	Small pit on prominent outcrop; 150 ft SE. of roadcut	Grab sample from pit.
D-44638	AFT-S24-50	.10	.003	[3].6			do	Grab sample from cherty lens.
-44639	AFT-S25-50	.43	.005	[3]2.1		1.5×10^{-11}	Small pit on prominent outcrop; 210 ft SE. of roadcut	Chip sample across 1 ft of vein.
-44640	AFT-S26-50	.44	.004	[3]2.1			Outcrop of vein 60 ft SE. of roadcut	Chip sample across 1 ft of vein.
-46746	AFT-S32-50	.15	.002	.79		4.4×10^{-12}	Roadcut across vein	Chip sample across 5 ft footwall side of vein.
-46747	AFT-S33-50	.041	.001	[3].23			do	Chip sample across 5 ft hanging-wall side.
-46748	AFT-S34-50	.009	.001	[3].05			Prominent enlargement of vein NW. of roadcut	Chip sample across 25 ft of vein.
-46749	AFT-S35-50	.014	.001	[3].07			SE. end of vein outcrop	Chip sample across 40 ft of vein.
526176 [4]	LC-DDH-1A			0.3	*0.5*		Diamond-drill hole 1	Core interval in feet: 224.0–226.4
526177 [4]	LC-DDH-IB			*N.F.*	*.07*		do	226.4–227.1
526180 [4]	LC-DDH-1E			.3	*.5*		do	233.0–239.0
526181 [4]	LC-DDH-3A			.4	*.4*		Diamond-drill hole 3	264.6–266.2
526182 [4]	LC-DDH-3B			.2	*.3*		do	266.2–267.5
526183 [4]	LC-DDH-3C			N.F.	*.2*		do	267.5–269.0
526190 [4]	LC-DDH-3J			N.F.	*.2*		do	277.6–284.6
D-74436	LC-DDH-1S	0.046	0.001	.04	*.23*		Diamond-drill hole 1	Bottom sludge sand.

Lucky Strike claims (pl. 3)

D-74438	LS-PT-1	0.028	0.001	0.02	*0.07*		Lucky Strike No. 1 claim. Large prominent outcrop of quartzose rock near state line.	Chip sample across 45 ft of outcrop.
-74439	LS-PT-2	.004	<.001	.01	*.01*		Silicified zone, 150 ft SE. of sample LS-PT-1, Lucky Strike No. 1.	Chip sample across 45 ft of outcrop.
-74440	LS-PT-3	.008	<.001	.01	*.01*		Quartzose zone, 50 ft west of sample LS-PT-2, Lucky Strike No. 1.	Chip sample across 28 ft of outcrop.

See footnotes at end of table.

TABLE 3.—*Analytical data*—Continued

Laboratory No.	Sample	eU (percent)	U (percent)	ThO_2 [6] (percent)	Re_2O_3 [1] (percent)	Ra (gr per gr)	Location	Remarks
Lucky Strike claims (pl. 3)—Continued								
D-74441	LS-PT-4	0.033	0.001	0.01	*0.13*		Quartzose zone, in small outcrop 210 ft NW. of sample LS-PT-3, Lucky Strike No. 1.	Chip sample across 20 ft of outcrop.
-74442	LS-PT-5	.030	.003	.02	*.45*		Southernmost outcrop of quartzose rock, near mine road, Lucky Strike No. 1.	Chip sample across 45 ft of 65-ft outcrop.
-74443	LS-PT-6	.012	.001	.01	*.04*		do	Chip sample across 20 ft of outcrop; adjoins sample above.
-74437	LS-64	.13	.006	.6	*0.64*		Quartzose zone in NW part of area near LS-PT-4.	Grab sample of area of high radioactivity.
	AFT-LS-1	.21	.002	.1			Near samples LS-PT-5 and -6 above	Grab samples from outcrop.
	AFT-LS-2	.20	.001	.1			Lucky Strike No. 2 claim vein 200 ft NW. of NW. corner, Lucky Strike No. 1. (see pl. 1.)	Grab sample from pit.
Trapper No. 1								
D-69520	T-1A	0.009	0.000	0.02	0.09		Edge of creek below main outcrop	Sample of soil.
	T-WA-1	.67	N.F.	3.1			Prospect pit in SE. block of quartzose vein.	Grab sample of very radioactive zone.
D-46750	AFT-S36-50	.12	.006	.66			NE. corner of NW. block of quartzose vein.	Chip sample of vein.
-46751	AFT-S37-50	.023	.002	[3].1			NW. block of quartzose vein	Composite chip sample from south dipping fracture surfaces.
-46752	AFT-S38-50	.13	.006	.56			SE. block of quartzose vein	Chip sample across east part of vein.
-46753	AFT-S39-50	.13	.006	.68			SE. block; discovery pit	Chip sample across west part of vein.
-46754	AFT-S40-50	.029	.002	[3].15			NW. block of quartzose vein	Composite chip sample of surface outcrop.
-46760	AFT-S46-50	.014	.001	[3].07			NW. block; bulldozer trench on south side.	Composite chip sample of hanging wall.

-46761	AFT-S47-50	.025	.001	[3] .14			Upper bulldozer trench above NW. block.	Composite grab sample of small outlier veins.
-46762	AFT-S48-50	.004	.002	[3] .01			NW. block; bulldozer trench on south side.	Grab sample of gouge on hanging wall of vein.
-46763	AFT-S49-50	.074	.002	[3] 0.4			Upper bulldozer trench above NW. block.	Grab sample of small vein.
Trapper No. 4 (fig. 8)								
D-69521	T-4A	0.38	0.007	2.11	3.60		Main bulldozer cut along quartz vein.	Grab sample of loose limonite from vein at fault.
-46774	AFT-S60-50	.016	.002	[3] .08			Discovery pit at south end of main dozer cut.	Grab sample of gougy material along vein.
-46775	AFT-S61-50	.10	.006	[3] .56			do	Chip sample across 1.5-ft vein.
-46776	AFT-S63-50	.011	.001	[3] .05			East wall of main bulldozer trench	Chip sample across 15 ft of fault gouge.
-46777	AFT-S64-50	.005	.001	[3] .02			Floor of main bulldozer trench	Grab sample of iron oxide streaks in fault zone.
Buffalo claims								
D-77770	B-Ad-1	0.061	0.001	[3] 0.34			Adit on Buffalo claim	Grab sample, composite of vein in adit.
-77771	B-192	.008	.001	[3] .04			Cut across vein above Buffalo adit	Chip sample across 28-ft vein.
	AFT-B1	.085	.006	[3] .45			Prospect on Buffalo No. 1 claim	Grab sample across 5-in. vien.
D-77768	B-A-150	.010	.001	[3] .056			do	Grab sample.
-43536	AFT-S15-50	.18	.008	1.0			Prospect pit at Buffalo No. 1 location marker.	Grab sample from pit dump.
Radio claim								
	AFT-S23-50	0.26	0.008	[3] 1.5			Prospect pit, southern part of claim area.	Grab sample of vein material from dump.

See footnotes at end of table.

TABLE 3.—*Analytical data*—Continued

Laboratory No.	Sample	eU (percent)	U (percent)	ThO_2 [6] (percent)	Re_2O_3 [1] (percent)	Ra (gr per gr)	Location	Remarks
Brown Bear claim								
------------	AFT-S30-50	0.017	0.001	[3] 0.09	------------	------------	Outcrop of vein 150 ft NW. of NW. trench.	Chip sample across 3 ft of vein.
------------	AFT-319-50	1.25	N.F.	[3] 7.0	------------	------------	NE. trench	Selected composite sample of 6-in. vein.
Black Bull claim								
D-74433	W-135	0.11	0.001	0.29	0.22	------------	Black Bull No. 2 claim; tunnel on vein at edge of south fork of Agency Creek.	Composite grab sample of 2- to 3-in. quartz vein.
-74434	CQ-134	.035	.002	.02	.02	------------	Black Bull No. 2 claim; adit 200 ft north of tunnel by Copper Queen road.	Grab sample of 2-in. carbonate vein.
-74428	B1Bu-133	.030	.005	.03	.44	------------	Black Bull No. 2 claim; nose south side of mouth of south fork of Agency Creek.	Grab sample of 1- to 2-in. quartz-carbonate vein.
-74429	B1Bu-136	.010	.003	.03	.09	------------	Black Bull No. 3 claim; ¼ mi. west of cabin on Lemhi Pass road.	Grab sample of fluorescent coating on tuffaceous rock.
-74430	BB-A-149	.018	<.001	.04	.03	------------	Black Bull Fraction; discovery pit	Grab sample of quartzose rock from pit. 4-ft sample.
-77764	BB-A-149C	.018	<.001	.08	------------	------------	Black Bull Fraction	Composite sample across 40 ft of quartzose ore rock.
Uranium Queen claim								
D-77766	UQ-W-162	0.038	0.001	[3] 0.21	------------	------------	Discovery pit	Chip sample across 2-ft quartz vein.

Three-and-One claim

D-77767	3 and 1-W-162	0.021	0.001	[3] 0.11	----------	----------	Discovery pit	Grab sample from 6-in. to 1-ft quartz vein.
Copper Queen mine								
D-77769	CQ-Ad-1	0.034	0.005	[3] 0.17	----------	----------	Main adit level; 350 ft from portal	Chip sample across 6-in. radioactive quartz vein.
Last Chance adit on Lemhi River (pl. 1)								
D-69522	LC-1(FC)	0.008	0.006	0.03	----------	----------	Adit No. 2	Grab sample from quartz vein.
Silver Queen group of claims								
D-77765	RUK-1	0.014	0.001	0.062	----------	----------	On Pattee Creek	Grab sample from 2-in. quartz vein.

[1] Rare earth oxides; percent Re_2O_3 and ThO_2 combined where italic.
[2] See table 2 for spectrographic analyses.
[3] Calculated with factor of 5.6.
[4] Samples analyzed by Lindsey Chemical Co., West Chicago, Ill.
[5] Samples taken from east to west across 10-foot vein.
[6] ThO_2 values by chemical methods are subject to analytical deviation of about 10 percent.

TABLE 4.—*Logs of diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*

[Drilled under contract with the Defense Minerals Administration]

	Depth interval (feet)	*Core recovered (feet)*
Hole 1:		
Altitude of collar 7433 feet, bearing N. 43° E., inclination 45°, total depth 239 feet.		
Soil, overburden	0–11	0
Argillite, gray; fractures parallel to hole; brown staining in fractures; bedding 60° to core	11–26	3. 5
(Micaceous quartzite, highly fractured)? core and water lost	26–30	0
Argillite, gray, slightly schistose	30–31	0. 8
Argillite, upper 0.5 foot; then, micaceous quartzite, light greenish gray, fine-grained; bedding 55° to core; bedding shown by biotite layers; brown-stained fractures across and parallel to bedding	31–35. 3	3. 0
Micaceous quartzite (same as above)	35. 3–40. 8	3. 6
Micaceous quartzite (same as above) fractures cut core at 30° to core; more fractures at base	40. 8–45. 6	5. 3
Micaceous quartzite, upper 3 ft; then, argillite, gray-green; minor biotite; fractures cemented with limonite; base is sandy and micaceous	45. 6–50. 6	5. 0
Micaceous quartzite, gray-green; fractured and bleached; fractures stained; darker color at bottom	50. 6–52. 7	2. 0
Micaceous quartzite, light gray-green; fractures 35° to core	52. 7–54	1. 0
Argillite and micaceous quartzite, mottled greenish-gray; fractured and stained along fractures; ½-in. quartz vein at 56.6 ft at 30° to core; ½-in. quartz vein at 57 ft; darker color and more micaceous at bottom	54–60	3. 5
Argillite, gray, silty	60–66	0. 1
Micaceous quartzite, dark gray-green; bedding 75° to core; quartz vein with chlorite and hematite in upper part. Bottom of BX-core	66–70	2. 5
(Micaceous quartzite)?; no core recovery	70–80	0
Micaceous quartzite, gray, fine-grained; bedding 70° to core; ½-in. quartz vein at 85 ft; ½-in. quartz vein at 90 ft, 35° to core	80–90. 5	10. 5
Argillite, greenish, upper 2 ft; then, micaceous quartzite, gray, fine-grained; bedding marked by biotite-rich layers, 65° to core; ½-in. quartz vein at 92 ft; 1½-in. quartz vein at 96.5 ft; ½-in. quartz vein at 98 ft	90. 5–100	9. 5
Micaceous quartzite, gray-green, fine-grained; 2-in. fracture zone at 102 ft, stained	100–110	10. 0
Micaceous quartzite, dark-gray; poor bedding; minor stained fractures; small quartz vein at 114 ft	110–119. 5	9. 5

TABLE 4.—*Logs of drill holes for diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*—Continued

[Drilled under contract with the Defense Minerals Administration]

Hole 1—Continued Altitude of collar 7433 feet, etc.—Continued	Depth interval (feet)	Core recovered (feet)
Micaceous quartzite, gray, fine-grained	119. 5–120	0. 5
Argillite and micaceous quartzite, gray, fractured; more micaceous quartzite at base; bedding 55° to core; several thin quartz veins	120–125	5. 0
Micaceous quartzite, light greenish-gray to gray, fine-grained; fractured	125–132	6. 3
Micaceous quartzite, gray to greenish-gray; thinly fractured	132–135	2. 0
Micaceous quartzite, gray to greenish-gray; highly fractured; hematite streaks at 138 and 140 ft	135–145	4. 0
Argillite and micaceous quartzite, gray to grayish-pink; highly fractured; thin gouge seams	145–150	3. 0
Argillite, pinkish-green; highly fractured and stained; bedding 55° to core; several thin quartz veins	150–157	2. 3
Argillite, light-gray; highly fractured	157–163	2. 0
Argillite rubble, gray, iron-stained	163–164. 5	1. 0
Argillite and quartz vein rubble	164. 5–166. 5	0. 2
Argillite and quartz vein rubble	166. 5–167. 5	0. 2
Argillite, gray to greenish-gray and quartz-vein rubble	167. 5–172	1. 0
Micaceous quartzite, light greenish-gray; biotite along bedding, 50° to core; fractured and stained	172–180	2. 6
Micaceous quartzite, light greenish-gray; fractured	180–190	0. 7
Argillite, light-gray; fractured	190–191	0. 9
Argillite, gray mottled with white; fractured and stained	191–192. 5	2. 0
Argillite, mottled gray; bedding is contorted	192. 5–193. 5	1. 0
Micaceous quartzite, light-gray to white, fine-grained	193. 5–204	2. 0
Micaceous quartzite, altered to white, fine-grained; fractured and stained; thin quartz veins at 209 and 213 ft	204 –214	3. 0
Micaceous quartzite, gray, stained; 2-in. quartz vein	214 –216. 2	0. 5
Micaceous quartzite, white, altered; quartz vein at 223.5 ft; probably narrow contact zone of shearing; 4 in. of quartz vein recovered with altered and silicified micaceous quartzite	216. 2–224	1. 3
Quartz vein, broken and stained	224 –226. 4	0. 4
Quartz vein, broken and stained	226. 4–227. 1	0. 6
Quartz vein, highly stained; shows evidence of faulting; rubble of vein is recemented	227. 1–229. 2	1. 0

TABLE 4.—*Logs of drill holes for diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*—Continued

[Drilled under contract with the Defense Minerals Administration]

	Depth interval (feet)	*Core recovered (feet)*
Hole 1—Continued		
Altitude of collar 7433 feet, etc.—Continued		
Quartz vein rubble, highly stained	229. 2–231. 2	0. 8
Quartz vein rubble; out of vein at 231.5 ft, into soft altered and crushed micaceous quartzite; no bit resistance; no core but sludge of stained sand recovered; did not lose water in hole. Bottom of hole	231. 2–239	0. 1
Hole bottomed, 239 ft (August 31, 1952).		
Total hole core, 233 ft.		
Total core recovered, 114.2 ft.		
Recovery, 51 percent.		
Drilling method:		
0–26 ft: Drilled NX; cased BX.		
26–70 ft: Drilled BX; cased AX.		
70–239 ft: Drilled AX.		
Hole 3:		
Altitude of collar—7475 ft, bearing N. 40° E., inclination −45°, total depth, 303 ft.		
Soil, overburden	0–26	0
Micaceous quartzite, light-gray to buff, fine-grained; stained, weathered, friable; bedding 35° to core	26–40	2. 3
Micaceous quartzite, altered and bleached to light gray to buff; fine grained, lightly stained; zone of gray argillite and fine near center; beds are 30° to core; cleavage is 50° to core	40–50. 5	2. 0
Argillite, gray, soft; stained fractures at base; bedding 40° to core; cleavage 45°–50° to core. Bottom of BX core	50. 5–61	2. 2
Micaceous quartzite, light-gray, fine-grained, weathered, friable; stained and broken at top; bedding 30° to core	61–71	1. 2
Micaceous quartzite, light-gray, fine-grained; bedding 33° (top), 40° (middle), and 30° (base) to core; upright, graded bedding	71–81	2. 4
Micaceous quartzite, light-gray, fine-grained; thin quartz-hematite vein at base	81–96	0. 6
Micaceous quartzite and argillite interfingered; beds at 35° to core; cleavage in argillite at 47° to core	96 –97. 5	1. 4
Micaceous quartzite and argillite interfingered in upper part; center is thin-bedded micaceous quartzite; base is bleached micaceous quartzite	97. 5–109. 5	1. 3
Micaceous quartzite, gray, fine-grained, poorly bedded in upper 1 ft; then 0.75 ft micaceous quartzite, coarser grained, bedding 40° to core; then 0.3 ft argillite, dark-gray; lower part, micaceous quartzite, dark-gray, coarse-grained, poorly bedded	109. 5–112. 1	2. 7

TABLE 4.—*Logs of diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*—Continued

[Drilled under contract with the Defense Minerals Administration]

Hole 3—Continued Altitude of collar—7475 ft, etc.—Continued	*Depth interval (feet)*	*Core recovered (feet)*
Micaceous quartzite, gray, fine-grained, with reddish hematite stain; bedding 35° to core; at 113.3 ft, ¼-in. quartz at 30° to core; associated 2-in. fracture zone; at 114.7 ft, ¼-in. quartz-hematite vein 45° to core; micaceous quartzite stained red for 6 in. across veinlet; staining 35° to core; micaceous quartzite highly fractured, more micaceous at base	112. 1–117. 7	5. 3
Micaceous quartzite, gray, fine-grained, with reddish hematite strain; fractures normal to core; at base, rubble zone of fault seam, highly stained, probably where core was lost	117. 7–119. 9	1. 3
Micaceous quartzite, gray, fine-grained, with reddish hematite stain; fractured	119. 9–121. 2	1. 0
Micaceous quartzite, gray, fine-grained, with reddish hematite stain; darker, more micaceous at center; near top, two ¼-in. quartz veins and a 1-in. shear zone recemented with iron oxide; shears normal to core; fewer fractures in lower 3 ft; bleached along fractures	121. 2–129. 7	4. 1
Micaceous quartzite, coarse at top and base; bedding 50° to core; in center, bleaching along fractures; hematite-filled fractures about 134.5 ft, 70° to core; beds 30° to core	129. 7–136	4. 7
Micaceous quartzite, gray, very fine grained to coarse-grained; thin quartz vein at 137 ft; beds 30° to core	136–145. 2	4. 4
Micaceous quartzite, gray, very fine grained to very coarse grained, micaceous; two ⅛-inch altered hematite seams along bedding at base; strike of cleavage, 45° from strike of bedding, dips 40° to core and steeper than bedding	145. 2–149. 3	3. 4
Micaceous quartzite, gray, fine-grained, bedding at 30° to core; fractures 40° to core and red-stained for one-half inch	149. 3–157. 5	2. 3
Micaceous quartzite, gray, fine-grained; at top, ½-in. quartz vein at 30° to core contains specularite	157. 5–160	2. 5
Micaceous quartzite, gray, fractures cemented with iron oxides; at 163.8 ft a ½-in. quartz-hematite-chlorite vein 60° to core; another vein at 165.3 ft; bedding 27° to core	160 –169. 5	6. 2
Micaceous quartzite, gray, fractures cemented with iron oxides; more fractured near top	169. 5–179. 5	3. 6
Micaceous quartzite, gray, fractures cemented with iron oxides; bedding distinct at top, 25° to core	179. 5–186. 4	2. 8

TABLE 4.—*Logs of diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*—Continued

[Drilled under contract with the Defense Minerals Administration]

Hole 3—Continued Altitude of collar—7475 ft, etc.—Continued	*Depth interval (feet)*	*Core recovered (feet)*
Micaceous quartzite, poorly bedded; at top a ⅛-in. quartz vein, pinkish cast for 1 ft below; quartz veinlet at base; core is rubble at base	186. 4–199. 7	3. 4
Micaceous quartzite, poorly bedded; cleavage is 50° to core	199. 7–200	0. 3
Micaceous quartzite, fine-grained to coarse-grained, highly fractured; upper part cemented by iron oxides	200–210	1. 8
Micaceous quartzite, light-gray, bedding 30° to core; highly broken core	210–215	1. 5
Argillite, and micaceous quartzite, light-gray to gray; fractures every 3 in., 70° to hole; at 219.5 ft, 2 or 3 small quartz veins; small faults offset veins	215–222. 1	7. 1
Argillite and micaceous quartzite, light-gray to gray; rubble; evidence of small quartz vein	222. 1–222. 8	0. 6
Micaceous quartzite, coarse-grained, interbedded with gray argillite; fractured	222. 8–229. 6	1. 0
Micaceous quartzite, light-gray, argillaceous, bleached, mottled; irregular bedding; 2 small quartz veins; bedding is 20° to core; cleavage 40° to core	229. 6–239. 6	2. 0
Micaceous quartzite, gray, fine-grained, bleached at base; two quartz veinlets	239. 6–249. 6	1. 4
Micaceous quartzite, white, bleached, friable, badly broken; upper part probably in fault zone	249. 6–253. 5	3. 9
Micaceous quartzite, white, bleached, friable, badly broken	253. 5–253. 8	0. 3
Micaceous quartzite, white, bleached, friable, less broken; ¼-in. quartz-hematite vein altered to porous limonite and quartz seam	253. 8–255	1. 0
Micaceous quartzite, white, friable, bleached, badly broken; bedding 35° to core; lower foot silicified; interbed of 4 in. of bleached micaceous quartzite, then quartz vein stained red at 263 ft	255–264. 6	1. 9
Quartz vein; core is highly broken, quartz-vein breccia recemented with specularite and limonite; brown to red to gray; mottled and veined; shearing 40° to core	264. 6–266. 2	1. 8
Quartz vein, highly broken recemented with specularite and limonite; very rubbly at top; heavy red iron stain	266. 2–267. 5	1. 3
Quartz vein, white, vuggy, with specularite; at base are unreplaced pieces of micaceous quartzite; farther down is micaceous quartzite, altered to white-brown soft sand	267. 5–269	1. 5

TABLE 4.—*Logs of diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*—Continued

[Drilled under contract with the Defense Minerals Administration]

	Depth internal (feet)	*Core recovered (feet)*
Hole 3—Continued		
Altitude of collar—7475 ft, etc.—Continued		
Quartz vein and altered micaceous quartzite breccia; vein appears to dip 60° to core; vugs along center of vein	269 –271. 2	2. 2
Quartz vein and altered micaceous quartzite breccia, stained red	271. 2–273	2. 0
Quartz vein and altered micaceous quartzite breccia; base is mostly rubble of micaceous quartzite	273 –274. 6	1. 2
Micaceous quartzite and quartz vein rubble	274. 6–275. 3	0. 8
Quartz vein, white, glassy; specularite in vugs in quartz; hematite veinlets cut core at various angles	275. 3–277	0. 5
Quartz vein rubble; shear zone at top cemented with iron oxide	277 –277. 6	0. 5
Quartz vein, rich in specularite; vuggy; mottled color; rubbly at base; hanging wall contact of major vein; no core below 279 ft; probably soft altered micaceous quartzite	277. 6–284. 6	1. 7
Quartz vein rich in specularite; 4 in.; rest of core is light gray-green argillite with brown limonite-stained fractures	284. 6–285. 6	0. 9
Quartz vein, 5 in. wide, with specularite; vuggy, some unreplaced micaceous quartzite breccia; lower part is bleached light-gray altered friable micaceous quartzite with limonite-stained fractures	285. 6–294. 5	1. 8
Micaceous quartzite, white, altered, friable; ¾-in. quartz veinlet near top	294. 5–298. 5	2. 1
Micaceous quartzite, bleached; poor core	298. 5–301	2. 5
Micaceous quartzite, white, altered, friable; cut by and partly replaced by red to white quartz	301–303	2. 0

Hole bottomed (Sept. 29, 1952), 303 ft.
Total hole cored, 277 ft.
Total core recovered, 106.7 ft.
Recovery, 39 percent.
Drilling method:

0–26 ft: Drilled NX; cased BX.
26–61 ft: Drilled BX; cased AX.
61–303 ft: Drilled AX.

TABLE 4.—*Logs of diamond-drill holes on the Last Chance claim, Lemhi Pass area, Montana*—Continued

[Drilled under contract with the Defense Minerals Administration]

	Depth interval (feet)	*Core recovered (feet)*
Hole 4:		
Altitude of collar, 7552 feet; bearing N.50°E.; inclination, 45°; total depth, 95 feet.		
Soil, overburden	0–26	0
Micaceous quartzite, grayish-white, fine-grained; altered and soft	26–95	-----
Lost water at 54 ft and never recovered circulation. Pressure lost again at 95 ft and drilling discontinued Oct. 20, 1952.		

Total hole cored, 95 ft.
Total core recovered, none.

Drilling method:

0–26 ft: Drilled NX; cased BX.
26–60 ft: Drilled BX; cased AX.

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