Information Circular 9103

Uranium Occurrences in the Northern Darby Mountains, Seward Peninsula, AK

Jeffrey Y. Foley and James C. Barker

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PREFACE

This is one of a series of Bureau of Mines reports that present the findings of reconnaissance-type mineral assessments of certain lands in Alaska. These reports include data developed by both industry and government studies.

Assessing an area for its potential for buried mineral deposits is a difficult task because no two deposits are identical. Moreover, judgments prior to drilling, the ultimate test, frequently vary among evaluators and continue to change as a result of more detailed studies.

Included in these reports are estimates of the relative favorability for discovering mineral deposits similar to those mined elsewhere. Favorability is estimated by evaluation of outcrops, and analyses of data, including mineralogy, geochemistry, and evaluation of rock-forming processes that have taken place. Related prospects and the environment in which they occur are subjectively compared to mineral deposits and environments in well-known mining districts. Recognition of a characteristic environment allows not only the delineation of a trend but also a rough estimate of the favorability of conditions in the trend for the formation of minable concentrations of mineral materials.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter	lb	pound
cps	count per second	mi^2	square mile
ft	foot	mm	millimeter
ft^2	square foot	pct	percent
ft^3	cubic foot	ppm	parts per million
g	gram	wt pct	weight percent
in	inch		

URANIUM OCCURRENCES IN THE NORTHERN DARBY MOUNTAINS, SEWARD PENINSULA, AK

By Jeffrey Y. Foley[1] and James C. Barker[2]

ABSTRACT

In 1980, the Bureau of Mines investigated the northern Darby Mountains on the Seward Peninsula, AK, for radioactive mineral deposits. Uranium is concentrated in silicified shear zones in biotite quartz monzonite of the Darby pluton. The shear zones are best exposed in steep, narrow, avalanche gullies; they are characterized by radiometric anomalies and by uranium and thorium geochemical anomalies. Radiometric and geochemical anomalies are also found over altered biotite quartz monzonite where there are no visible shear zones. The radiometric and uranium anomalies are often spatially, but apparently not genetically, associated with alkaline mafic and felsic dikes. Similar geochemical and radiometric anomalies over discolored altered zones and geochemical anomalies in sediments downstream from the altered zones indicate that additional areas may also be favorable targets for uranium deposits. Analyses of panned, heavy mineral concentrates show no significant concentrations of uranium or thorium in resistant heavy minerals. This indicates that radioactive elements in the Darby pluton are concentrated in soluble, nonresistant minerals that may constitute a recoverable uranium resource.

[1]Physical scientist.
[2]Supervisory physical scientist.
Alaska Field Operations Center, Bureau of Mines, Fairbanks, AK.

INTRODUCTION

In 1980, the Bureau of Mines conducted reconnaissance mineral investigations in the northern Darby Mountains and Selawik Hills regions in northwestern Alaska. The investigations were requested and partially funded by the Bureau of Land Management to improve that agency's mineral resource inventory data for the two regions. This report addresses only the investigation of the northern Darby Mountains region (fig. 1); data on the Selawik Hills will be included in a separate report.

The objective of this investigation was to evaluate the potential for uranium deposits in the northern portion of the Darby Mountains pluton. Previous reports citing the favorability for uranium in the area were reviewed. Preliminary field reconnaissance of linear structural features and discolored zones led to site-specific investigations of areas found to be favorable for uranium deposits.

Other mineral occurrences and deposits in addition to those containing uranium are present in the Darby Mountains. Lead and silver deposits occur in the Omilak area (*18*).[3] Tin, gold, copper, molybdenum (*16*), columbium,[4] and coal (*26*) occur in the northern Darby Mountains, and nonradioactive graphite lenses are present in the lower Vulcan Creek Valley.

GEOGRAPHY

The Darby Mountains are located on the southeastern Seward Peninsula in northwestern Alaska. The mountains extend northward from Cape Darby, on Norton Sound, to the eastern end of the Bendeleben Mountains (fig. 1). Although there are no roads in the region, winter trails provided miners and prospectors access to the region in the past. Most recent geologic and mineral investigations have been conducted with helicopter support. Improved gravel airstrips are located at Moses Point, Omilak, White Mountain, Golovin, and Boulder Creek. An airstrip on Otter Creek is now overgrown and unusable.

The Darby Mountains rise from sea level to over 3,200 ft in elevation (fig. 2). Pleistocene glaciation in the higher

[3]Italic numbers in parentheses refer to items in the list of references preceding the appendix at the end of this report.

[4]Preliminary investigations of radioactive placers on Vulcan Creek-Clear Creek, Radium Gulch, and Bear Creek, Seward Peninsula, AK (BM-4606-2, 1956), performed by the Bureau of Mines for the U.S. Atomic Energy Commission.

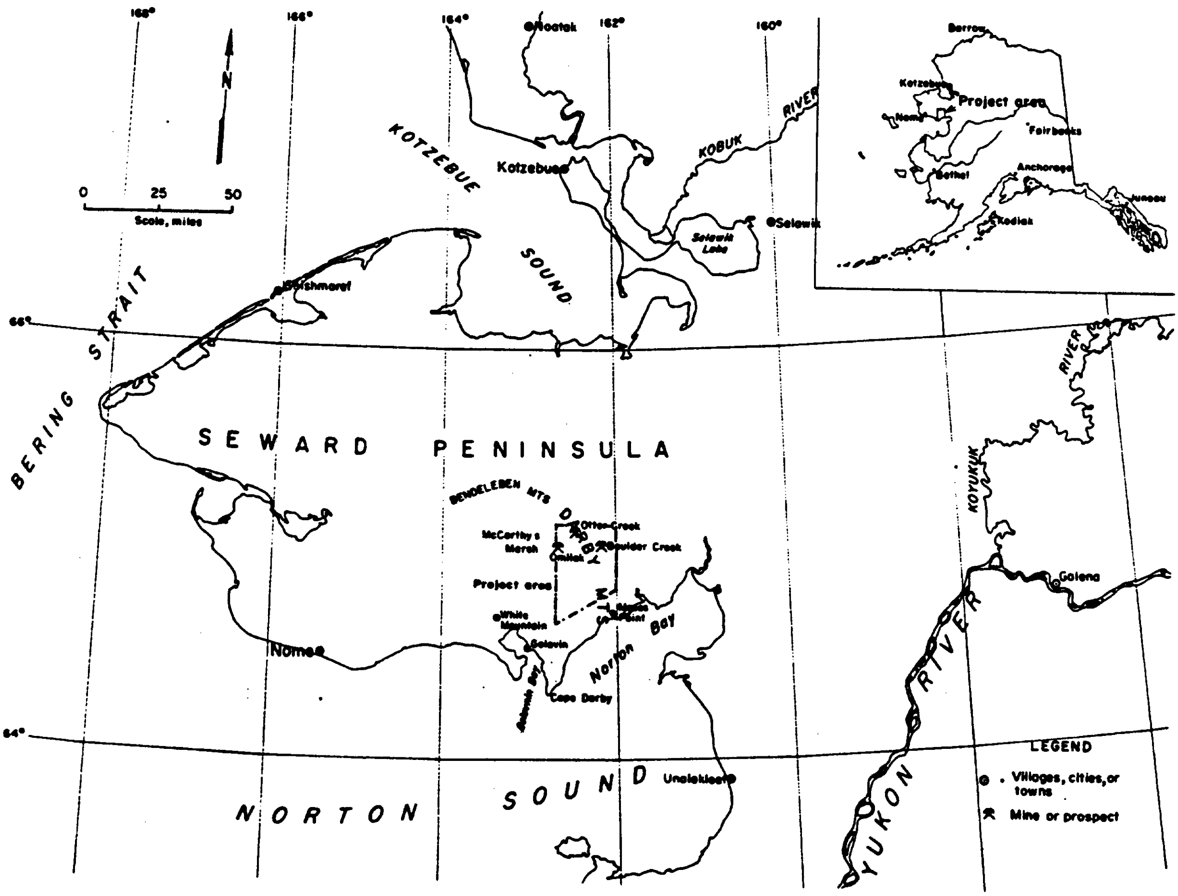
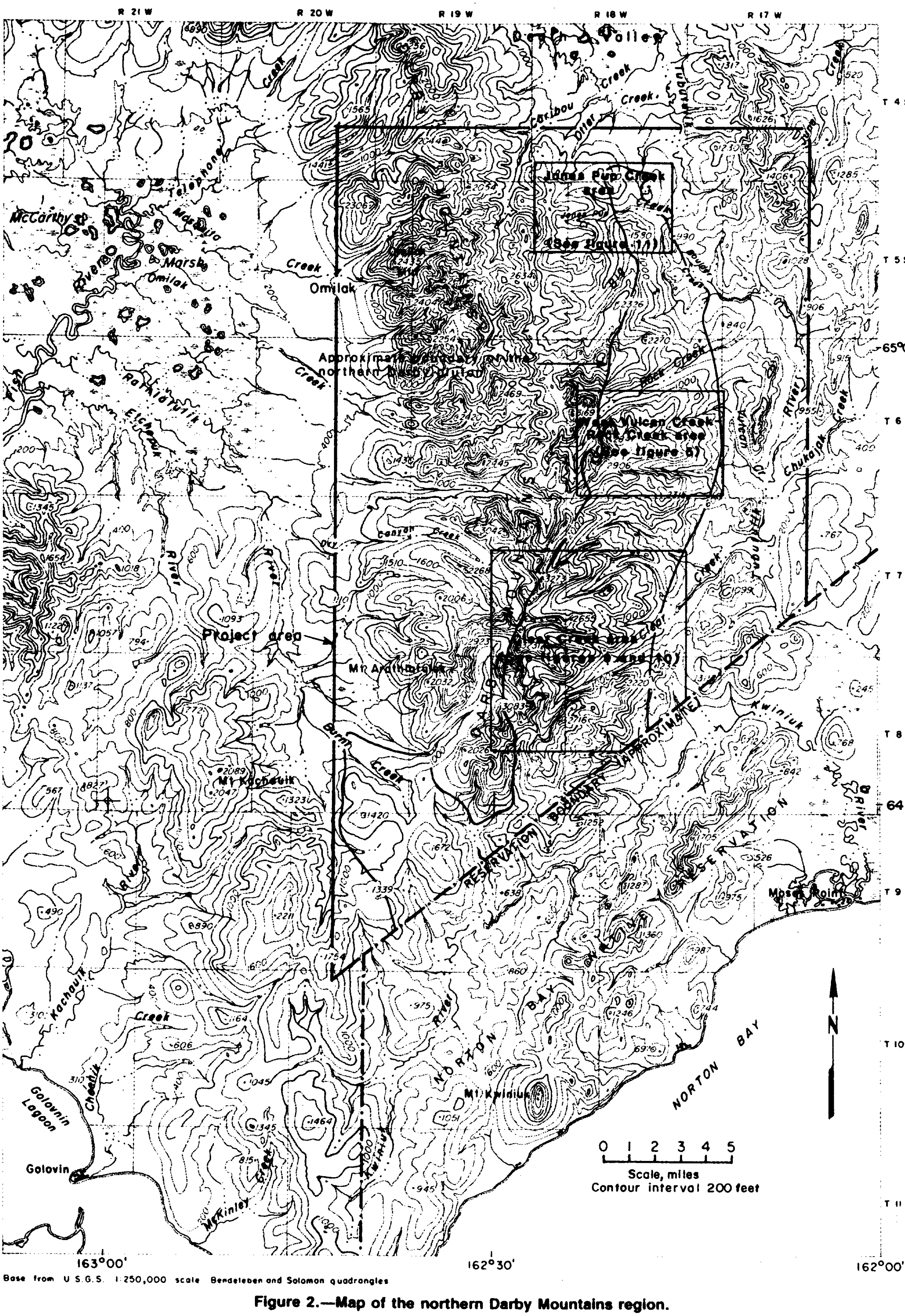


Figure 1.—Location map.



Base from U.S.G.S. 1:250,000 scale Bendeleben and Solomon quadrangles

Figure 2.—Map of the northern Darby Mountains region.

regions formed prominent moraines, cirques, aretes, and U-shaped valleys. Hanging valleys and glaciofluvial deposits occur in the vicinities of Rock Creek and upper Clear Creek in the northeastern part of the mountain range. Outcropping bedrock is generally limited to higher ridges where granite tors are frequently present. Frost-fractured rubble is abundant on most hillsides.

The southeastern Seward Peninsula is within the zone of discontinuous permafrost. Permafrost probably underlies most, if not all, of the poorly drained lowlands adjacent to the Darby Mountains. This is particularly true in the McCarthys Marsh and Death Valley areas.

Vegetation type varies in the Darby Mountains. Vegetation is generally sparse at elevations above approximately 1,000 ft where it is limited to willow brush and tundra species. On the east side of the range, lower valleys are thickly vegetated with dense spruce forests. The west flank of the Darby Mountains is windswept and treeless.

The climate is subarctic with a strong maritime influence from the Bering Sea. Prolonged periods of fog and light rain and occasional gales are common in the summers. The effective field season for geologic investigation and prospecting is from early June to mid-September.

LAND STATUS

The project area (fig. 3) is administered by the Fairbanks District Office of the Bureau of Land Management. The northern Darby Mountains are under multiple-use classification and are open to mining claim location under the 1872 mining law. There are numerous unpatented mining claims and several unresolved private land holdings within the area.

HISTORY

PREVIOUS WORK

Geologic maps of the Darby Mountains region include "Preliminary Geologic Map of the Eastern Solomon and Southeastern Bendeleben Quadrangles" (*15*), "Geologic Map of the Bendeleben Quadrangle" (*10*), and maps of the Bendeleben and Solomon quadrangles published in "Geology, Ore Deposits, and Mineral Potential of the Seward Peninsula, Alaska" (*21*).

Mendenhall, in 1910, and Smith and Eakin, in 1911, were the first to describe the geology of the Darby Mountains (*25*). A summary of their observations is contained in a 1953 report by West (*28*), that is the first of numerous reports on reconnaissance investigations for radioactive mineral deposits in the Darby Mountains and adjacent areas. West concludes that an unidentified uranium-titanium-niobate mineral is the chief source of radioactivity in heavy mineral fractions of alluvial sediment samples from Clear Creek and Vulcan Creek. In 1956, the Bureau investigated the Clear Creek area for placer deposits of radioactive minerals and columbium, however, no deposits of economic grade were reported.[5]

Previous investigators cited the Darby Mountains as favorable for deposits of several metals in addition to uranium and thorium. Herreid (*6*) reported on lead-zinc-silver deposits at Omilak and tin at Caribou and Otter Creeks. In 1971, Miller and others (*14*), and in 1973, Miller and Grybeck (*17*) released geochemical data on the Darby Mountains that indicated several prospective areas for base metals, tin (Otter Creek), and columbium (Clear Creek). Miller and Grybeck (*17*), and Miller and Bunker, in 1975 (*12-13*), report that the Darby pluton has an anomalously high average content of uranium and thorium. Miller and Bunker report arithmetic mean values for rock samples of 11 ppm U and 59 ppm Th, and they suggest that the Darby pluton is a likely host for economic concentrations of uranium and thorium. Owing to an abundance of dikes at the western margin of the Darby pluton, Jones (*8*), in 1976, also recommends the area be investigated for uranium mineralization.

In 1975, the U.S. Energy Research and Development Administration (now a part of the U.S. Department of Energy) initiated a series of uranium investigations on the Seward Peninsula that continued for several years. During the first year, an airborne geophysical survey of the peninsula and the adjoining Selawik region was made by Texas Instruments Inc. (*26*). Both magnetic and radiometric surveys were conducted. The following year, hydrogeochemical surveys were performed in cooperation with Los Alamos Scientific Laboratories (*22-23*) and a review of the relevant literature and limited field checking were done by Eakins and Forbes (*4*), Forbes (*5*), and Jones and Forbes (*9*). In Eakins' review of uranium potential throughout Alaska (*3*), the Darby pluton is described as probably the most interesting uranium exploration target among the numerous plutons on the Seward Peninsula. In 1978, C. C. Hawley and Associates, Inc. (*2*) investigated anomalies or indications of uranium reported by earlier workers. The report indicated that anomalous, uraniferous, intrusive phases may exist in the northern and central Darby pluton (*2*, pp. III-11—III-12).

MINERAL EXPLORATION

Numerous prospectors and mineral exploration companies briefly investigated the Darby Mountains region, but no technical reports or results were released to the public. Mining claim records, available for examination at the Alaska Division of Geological and Geophysical Survey, College, AK, indicate that recent lode discoveries exist to the west, east, and north of the present project area. Commodities of interest are not specified in the mining claim records. Of particular relevance to this study is a large block of lode claims, located in 1978, in the Boulder Creek area (fig. 3), where uranium occurs in Tertiary sedimentary rocks (*24*).

[5]Work cited in footnote 4.

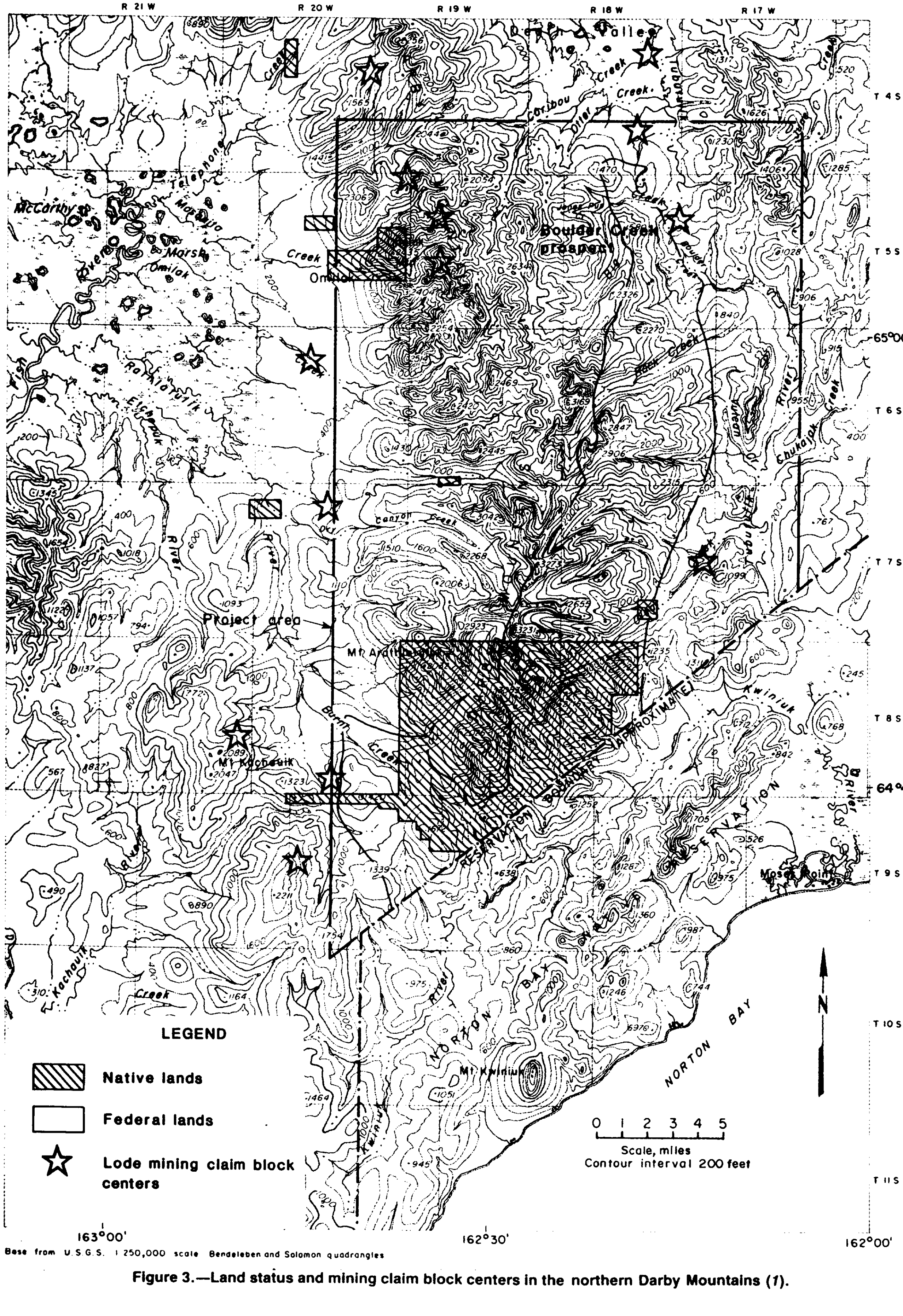


Figure 3.—Land status and mining claim block centers in the northern Darby Mountains (*1*).

GEOLOGIC SETTING

The Darby pluton underlies 150 mi^2 of the Darby Mountains that extend northward from Cape Darby for about 50 miles. The pluton intrudes Precambrian metamorphosed sedimentary rocks on the west and a sequence of Devonian limestone, dolomite, and phyllite on the east. Based on four postassium-argon age determinations, a Late Cretaceous age is assigned to the Darby pluton by Miller and Bunker (*12*).

The Darby pluton is described by Miller and Bunker (*12*) and by Jones (*8*). It is composed primarily of coarse-grained and porphyritic quartz monzonite with minor granodiorite and granite (*8, 12*) and is enriched in silica compared with other plutons of similar age in western Alaska that are described by Jones (*8*) and Patton (*19*). In the quartz monzonites of the Darby pluton, perthitic alkali feldspar and plagioclase occur in roughly equal amounts, and the rocks contain slightly less quartz than feldspar minerals. Biotite is the most abundant mafic mineral, constituting up to 5 pct of the rock. Hornblende, though common, is generally less abundant than biotite. Accessory minerals include magnetite, allanite, sphene, apatite, zircon, fluorite, and rutile. Alteration products include sericite, chlorite, clay minerals, and iron oxide.

Aplite dikes, often tourmaline-bearing, are common throughout the pluton, pegmatite dikes are present locally, and near the south end of the pluton, a swarm of lamprophyre dikes is reported (*12*). Lamprophyre and subalkaline, porphyritic dikes of intermediate composition are also present in the Vulcan and Rock Creek areas in the northern part of the pluton.

BUREAU OF MINES INVESTIGATIONS

The Bureau of Mines study of the Darby Mountains includes a literature review and geologic field investigations. Geochemical, mineralogical, petrologic studies, and ground radiometric surveys were conducted to supplement previous geologic reports.

Study of three selected areas (fig. 2) within the northern Darby Mountains, herein referred to as the west Vulcan Creek-Rock Creek, Clear Creek, and Jones Pup Creek areas, is detailed in this report. The three areas were selected during a brief geologic reconnaissance by the Bureau that focused on areas of discolored bedrock and rubble, linear structural features, anomalous metal concentrations in panned concentrates, and previously reported aerial radiometric anomalies.

PROCEDURES

Rock, soil, and stream sediment samples collected during this study were analyzed for silver, copper, lead, molybdenum, thorium, uranium, and zinc. Panned concentrates were analyzed for columbium, thorium, tin, uranium, and tungsten. Where other anomalous elemental concentrations were suspected, individual samples were analyzed for the corresponding elements. Analytical procedures are cited in the tables.

In this report, field sample numbers are listed with analytical results and descriptions in the tables. Map reference numbers refer to field sample locations on the illustrations, and radiometric stations were located at selected sample sites.

Chip samples that weighed about 10 lb each were collected at 27 sites in the Darby pluton and were analyzed for major oxides, uranium, and thorium. Analytical results and sample descriptions are presented in the appendix (tables A-1—A-2).

Gamma radiation measurements were recorded wherever changes in rock type, faults, or altered bedrock were observed.[6] These locations are referred to as radiometric stations and are identified by numbers in the text, tables, and on maps in this report. Because gamma radiation at a specific site varies with changes in atmospheric and ground water conditions, and because measurements will differ for various types of scintillation counters, qualitative statements such as "measurements six times background" are contained in this report. Such statements are intended to compare radioactivity at potentially mineralized areas with radioactivity over unmineralized areas. Background radiation levels that typically range from 250 to 500 cps, were determined by averaging three or four measurements over flat or unaltered bedrock or rubble; anomalous measurements ranged from 600 to over 20,000 cps. Gamma radiation has numerous sources, and geochemical analyses or other means are essential to identity radiation sources.

Radiometric measurements as high as six times background were observed over numerous artesian springs and wet areas. In some places, measurements were highly variable over areas measuring only tens of square feet. Measurements were typically highest over pools, springs, and downslope from areas of water-saturated organic soil where little or no rock was exposed. These observations indicate the presence of a gaseous gamma radiation source, possibly radon. Radon gas cannot, however, be distinguished from other gamma ray emitting sources with the instruments used during this investigation.

Rock and soil samples collected from zones with radiometric measurements of 600 cps to greater than 3,000 cps, or from two to six times background, frequently contained between 50 and several hundred parts per million uranium as determined by X-ray fluorescence analysis of samples from these zones. Uranium content in granitic rocks generally averages between 2.2 and 15 ppm (*20*). In this report, 40 ppm U is arbitrarily selected as the threshold value and higher values are interpreted as anomalous.

In the following discussions, the terms occurrence and prospect are frequently used. Occurrence is herein defined as identifiable uranium concentrations in either frost-riven rubble, scree, or outcrop. Prospect refers to uranium concentrations in either a definable zone or in a zone where geochemical or radiometric indications of uranium concentrations are interpreted to warrant further evaluation.

[6]Mount Sopris model SC-132 portable scintillation counters with upper detection limits of 20,000 cps were used to measure radioactivity. Reference to specific products does not imply endorsement by the Bureau of Mines.

PETROLOGY AND CHEMISTRY OF ROCKS FROM THE DARBY PLUTON

Although described by Miller and Bunker (*12*) as being relatively homogeneous and consisting mostly of quartz monzonite with minor granite, the northern Darby pluton was found to contain local segregations of quartz-deficient, potassium-rich rocks including syenite and alkali granite. These segregations have surface dimensions up to hundreds of feet across and show gradational contacts with the more abundant quartz monzonite. The pluton is also locally transected by rhyolite, aplite, and tourmaline-bearing pegmatite dikes. Results of major oxide, uranium, and thorium analyses of 20 samples of granitic and felsic dike rocks from the Darby pluton are in the appendix (table A-1, fig. A-1).

The Darby pluton is also intruded by lamprophyres and spatially related, more siliceous, porphyritic dikes with groundmasses similar to the lamprophyres. The lamprophyres are altered, fine-grained rocks of basaltic and andesitic composition. They are dark colored and contain euhedral biotite, amphibole, and more rarely, clinopyroxene or olivine in an altered groundmass of plagioclase, minor potassium feldspar, and very fine grained acicular amphibole. The plagioclase is mostly altered to white mica, epidote, carbonate, and clay minerals. Unidentified mafic phenocrysts, probably pyroxene and olivine, are partially replaced by carbonate, talc, chlorite, and opaque minerals, including magnetite and pyrrhotite. Spatially related porphyritic dikes contain phenocrysts of hornblende and altered plagioclase up to 0.7 in long in a groundmass that resembles that of the lamprophyres. These rocks also contain corroded quartz xenocrysts with biotite and chlorite reaction rims. Results of major oxide, uranium, and thorium analyses, and descriptions and locations for five lamprophyres and two siliceous porphyritic dike samples of andesitic composition from the Darby Mountains are in the appendix (table A-2, fig. A-1).

An alkalies-silica diagram containing plots of dike samples listed in table A-2 is shown in figure 4. Samples 6, 10, and 16 through 18 are lamprophyres, and they plot in the alkaline field of the diagram. Samples 14 and 27 are more-siliceous porphyritic dikes and they both plot in the subalkaline field.

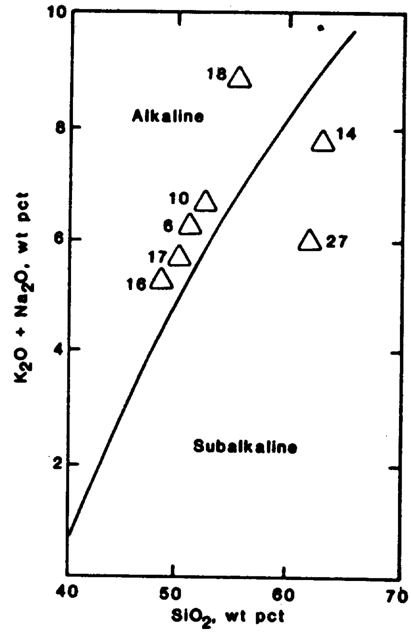


Figure 4.—Alkalies ($K_2O + Na_2O$) versus silica (SiO_2) diagram showing plots of dike rock samples from the Darby Mountains. The curve separates fields for alkaline and subalkaline rocks (*7*). Analyses and sample descriptions are in table A-2.

Because the altered groundmasses in the alkaline lamprophyre dikes and the groundmass in siliceous, subalkaline, porphyritic dikes are similar, and because the rocks are commonly spatially related, it is possible that the rocks are genetically related. The position of porphyritic dikes compositions in the subalkaline field of the alkalies-silica diagram is evidence to the contrary, but this may be explained by the presence of corroded quartz xenocrysts. Quartz xenocrysts may have been derived from quartz monzonite of the Darby pluton during intrusion of the dikes. The assimilation of silica from corroded xenocrysts could explain the position of the porphyritic dike rocks in the subalkaline field of figure 4.

EVALUATION OF PANNED CONCENTRATE ANALYSES

In a gross sense, the amount of resistant uranium- and thorium-bearing silicate minerals in pan concentrated alluvium samples indicates the manner in which uranium and thorium enrichment has occurred in uranium-bearing plutons. The presence of resistant radioactive minerals as a major component would indicate that uranium is concentrated in resistant minerals, which are of little economic significance. Conversely, the absence of uranium or thorium minerals in panned concentrates derived from a uranium- and thorium-rich pluton would indicate favorability for economic concentrations of uranium.

To determine if resistant uranium- or thorium-bearing silicate minerals are persistently present in alluvium from the Darby Mountains, heavy mineral concentrates from selected active stream channels were reduced by panning to near black sand consistency for semiquantitative, X-ray fluorescence analysis. The sample volume, weight of the recovered concentrate, and sample locations are presented in the appendix (table A-3, fig. A-2). Analytical results can be compared to a study of 1,069 heavy mineral concentrations from Alaska by Thomas and Sainsbury (*27*). Thomas and Sainsbury interpreted threshold values of 336 ppm for Cb, 400 ppm for Th, 500 ppm for Sn, 1,000 ppm for W, and any detectable uranium.

Low uranium and thorium values in the panned concentrates from streams draining the Darby pluton indicate that resistant radioactive minerals like zircon, apatite, allanite, or monazite are not abundant in alluvium from the sampled streams. Therefore, uranium- or thorium-bearing silicate accessory minerals within the Darby pluton are probably not the only source of high background concentrations of these elements or anomalous radioactivity. The negative results are interpreted to mean that the Darby pluton, or one of its constituent igneous phases, contains soluble uranium in leachable minerals such as uraninite, biotite, or hornblende. The analytical data suggest that future reconnaissance for tin, tungsten, and columbium may also be warranted.

MINERAL INVESTIGATIONS

WEST VULCAN CREEK-ROCK CREEK AREA

High radiometric measurements and uranium analyses indicate that anomalous uranium concentrations are present in the vicinity of Rock Creek and the west fork of Vulcan Creek (fig. 5). This area corresponds to a "preferred aerial radiometric anomaly" reported by Texas Instruments (*26*), and to ground radiometric anomalies discussed by Eakins (*3*) and Hawley (*2*). Stream sediment samples from the area are also reported to contain up to 50 ppm U (*2*). Hawley (*2*, pp. 7–14) reports "vein and pipelike (?) masses" up to 5 ft wide of argillized and iron-stained rock that locally contain up to 90 ppm U.

This investigation delineated eight uranium prospects in the west Vulcan Creek-Rock Creek area. In most of the eight areas, high radiometric measurements were recorded over hydrothermally altered quartz monzonite and quartz veins. Veins and altered zones (fig. 5) are structurally controlled by high-angle shear zones with slickensides, fault gouge, and tectonic breccia. Hematite; black, iridescent manganese staining; quartz stockworks; massive, ferruginous quartz veins; jasper; drusy quartz in vugs; and silica cement in tectonic breccia characterize the shear zones. Shear zones are best exposed in upper portions of steep avalanche gullies that dissect higher slopes and ridges and along pronounced linear depressions on high slopes. Regolith typically masks altered zones in more gently sloping areas.

Ferruginous quartz veins typically have elevated radioactivity with measurements over the veins as high as six times background. Secondary uranium minerals were rarely recognized. Scarce sulfide minerals including pyrite, marcasite, molybdenite, galena, and chalcopyrite were also observed, but boxworks after leached sulfide minerals are more common. Other minerals in the veins include chlorite, sericite, goethite, hematite, and clay minerals. Pitchblende was identified in a radioactive hand specimen from radiometric station 60 on the basis of microhardness and reflectivity measurements made during petrographic examination of a polished section. The pitchblende is intergrown with pyrite and hematite in quartz-sericite greisen (fig. 6).

West Vulcan Creek Prospect 1

Radiometric measurements up to six times background were recorded over frost boils near a porphyritic dike outcrop (fig. 7, radiometric stations 23 and 24). Pits excavated at these stations reveal hematitic mud and regolith derived by weathering of altered quartz monzonite. Quartz phenocrysts in the regolith are altered to a sooty black color, possibly by radioactivity. Because radiation in the pit at station 23 exceeded the calibration limit of the scintillometers, excavation was discontinued at a depth of 5.5 ft. Samples of decomposed rock from test pits at stations 23 and 24 contained between 160 and 1,290 ppm U and very little thorium (table 1). This material was panned to determine the presence of radioactive minerals among the heavy accessory minerals in the decomposed rock. The concentrate consisted of only a few grains of magnetite or other unidentified heavy minerals and was neither radioactive nor fluorescent.

At radiometric station 20, approximately 200 ft east of radiometric stations 23 and 24 where anomalous uranium was detected in a soil samples, frost boil rubble includes fragments of quartz-sericite greisen with boxworks. At a depth of 2 ft in a test pit at this site, soils register radiometric measurements up to five times background.

High radiometric measurements were also recorded elsewhere in the area (stations 22 and 25). Quartz monzonite boulders and outcrops in the area are frequently two to three times more radioactive along fracture planes than over unfractured portions of the boulders. Analyses indicate that uranium is locally concentrated along such fractures (field sample S016867, table 1). Also, samples of hematitic soils from station 26, proximal to a porphyritic dike, and upslope from station 25, contain up to 183 ppm U.

Conspicuous mafic to intermediate, porphyritic felsic dikes are abundant in the vicinity of west Vulcan Creek, prospect 1. The dikes contain phenocrysts of quartz, plagioclase, amphibole, and biotite and commonly secondary carbonate. Plagioclase phenocrysts in some of the dikes near stations 23 and 24 are totally altered to clay minerals. Radiometric measurements over the dikes are typically half those of measurements over the surrounding, unaltered, quartz monzonite. A sample of a carbonate altered porphyritic dike (field sample S016863, table A-2), near radiometric station 23, contained 68 ppm U and 12 ppm Th. Similar dikes from elsewhere in the study area contain less than 70 ppm U. The dikes, although slightly enriched in uranium, apparently are not the source of uranium in the vicinity of west Vulcan Creek prospect 1. However, the dikes may serve as barriers to the migration of uranium dissolved in ground water. Therefore, secondary uranium deposits may occur proximal to the dikes.

West Vulcan Creek Prospect 2

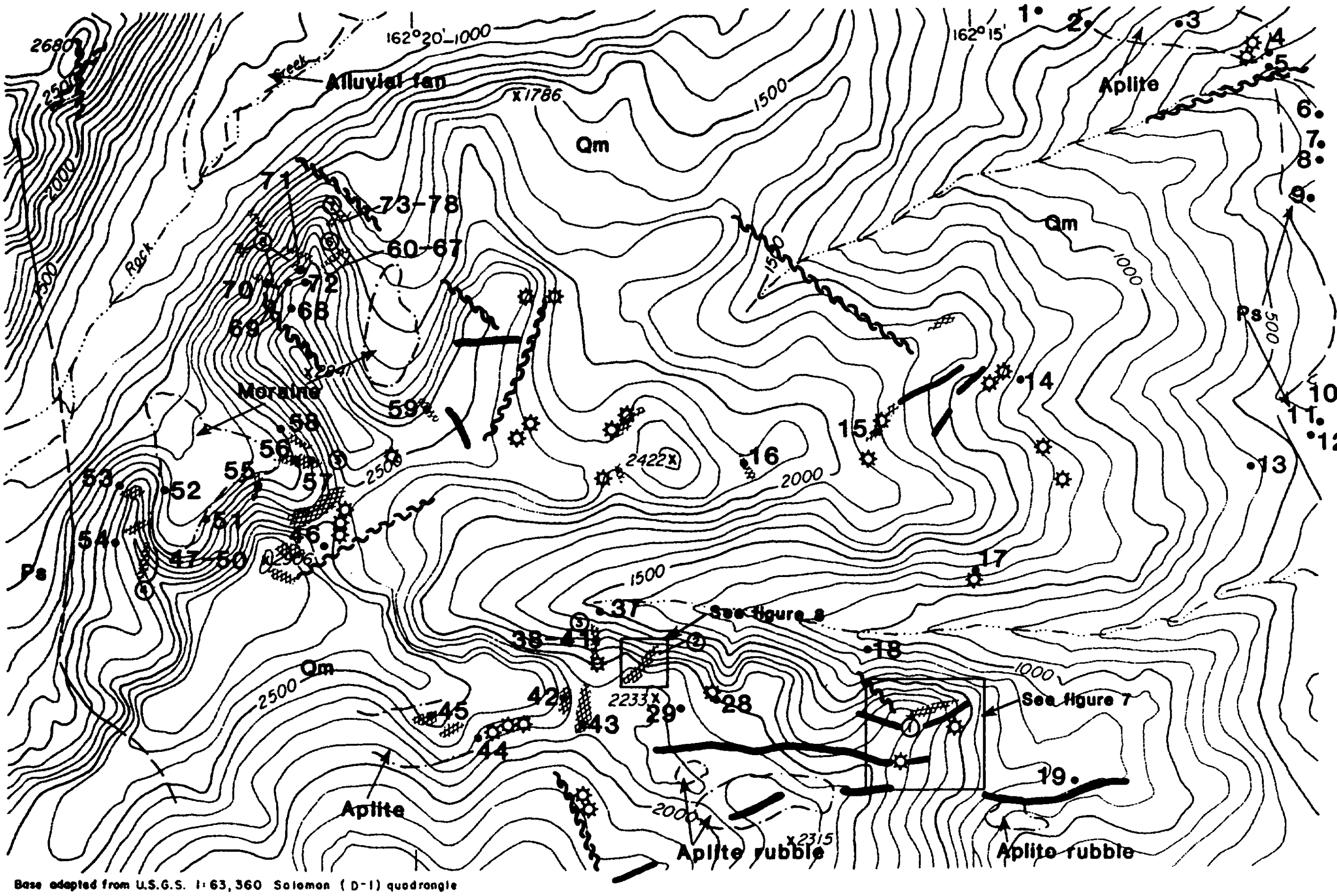
At west Vulcan Creek prospect 2, a hydrothermally altered, iron-stained, 40-ft-wide shear zone is exposed at the head of a steep avalanche gully (fig. 8). The nearly vertical shear zone strikes N 60° E, parallel to the strike of the gully, and is covered with scree at the top and bottom of the gully. The core of the shear zone is made up of irregular, 6- to 10-ft-wide pods of massive, iron-stained quartz. Secondary minerals in the core of the shear zone include hematite goethite, sericite, and manganese oxides.

The margins of the silica-rich core are brecciated and contain numerous vugs with drusy quartz and boxworks after leached sulfide minerals. An unidentified, yellow, secondary (uranium ?) mineral was observed on the weathered surface of radioactive, massive, red-stained quartz at this location. Marginal to the silica-rich core is chlorite-rich, argillically altered quartz monzonite with numerous closely spaced shears.

Radiometric measurements over the core of the shear zone ranged from one and one-half to six times background measurements. Radiometric measurements decrease rapidly within a few feet of the silica-rich core. Grab samples of vein quartz with hematite, and stained with other iron and manganese oxides, contained from 83 to 435 ppm U (table 2). Altered quartz monzonite from the margins of the shear zone contained from 10 to 24 ppm U.

West Vulcan Creek Prospect 3

Radiometric measurements greater than three times background were observed over ground water seeps that



Base adapted from U.S.G.S. 1: 63,360 Solomon (D-1) quadrangle

N

0 0.5 1

Scale, miles

Contour interval 100 feet

LEGEND

Alkaline lamprophyre and related subalkaline porphyritic dikes

Qm — Quartz monzonite and associated granitic rocks of the Darby pluton

Ps — Undifferentiated Paleozoic sedimentary and metasedimentary rocks

Contact, dashed where inferred

Fault, shear zone, or joint with prominent surficial expression

Altered shear zones, quartz veins, and altered quartz monzonite with associated uranium and radiometric anomalies

Extent of labeled feature

Prospect described in text

Radioactive springs and pools

•78 Radiometric stations and sample locations

Figure 5.—Geology, sample locations, and mineral occurrences in the west Vulcan Creek-Rock Creek area.

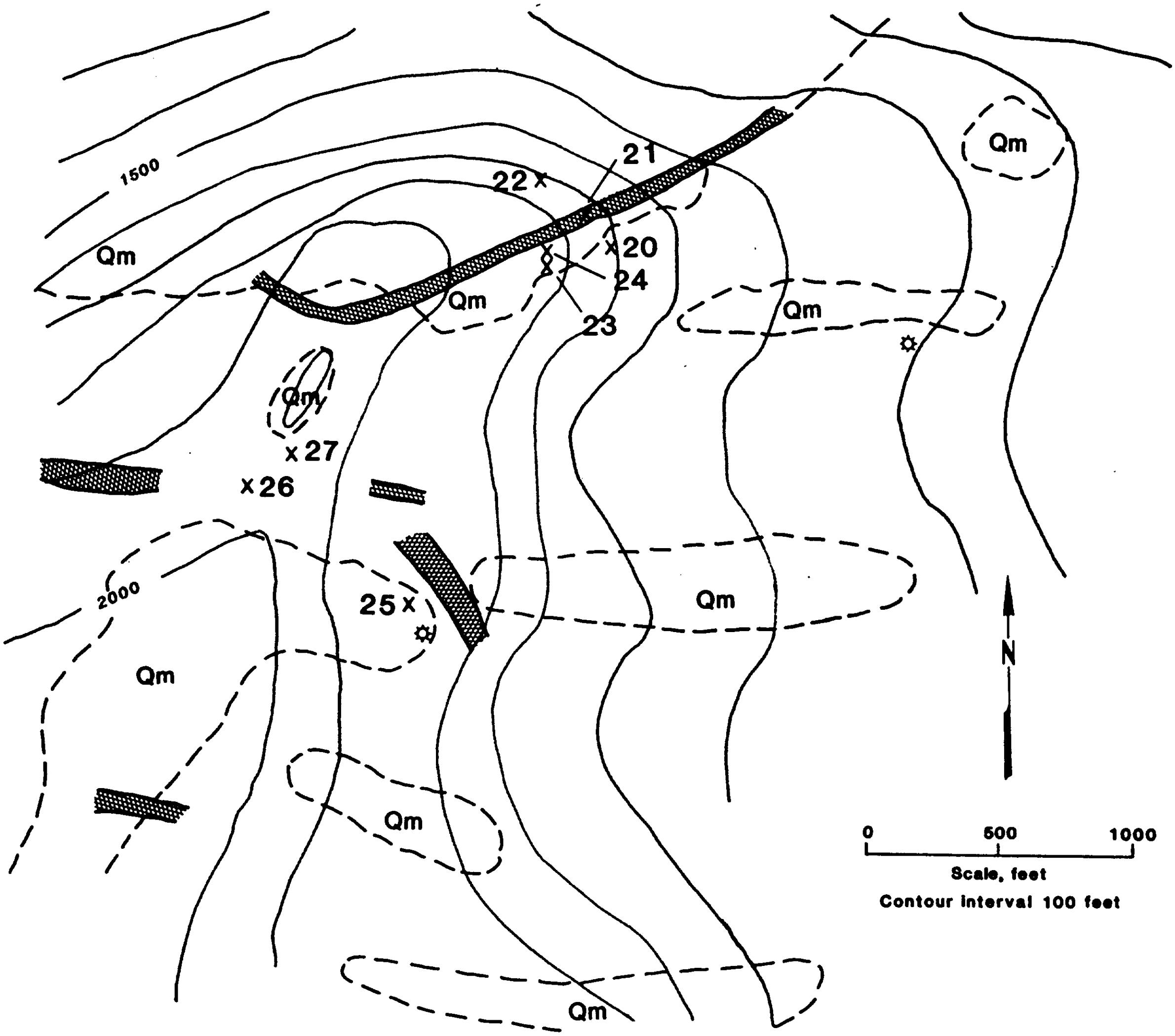
Figure 6.—Photomicrograph of radioactive greisen with pitchblende from Rock Creek prospect 6. An intergrowth of opaque pyrite (py), hematite (hm), and pitchblende (pb) occur in clear quartz (q) and translucent sericite (s). The clear high relief mineral is apatite (ap). Photograph taken in plane polarized light.

Table 1.—Analyses, parts per million, and descriptions of samples from west Vulcan Creek prospect 11[1]

Sample	Map No.	Ag	Au	Bi	Co	Cu	Mo	Pb	Th	U	Zn	Sample type	Description
SO16866 . . .	20	0.28	<0.03	10	NA	70	1	78	NA	25	77	Rock	Sericite and quartz greisen with boxworks in frost-riven rubble.
SO16870A . .	20	.50	NA	NA	10	21	5	96	NA	160	140	Regolith . .	From 5-ft-deep pit in decomposed quartz monzonite and silt (1,500 cps).
SO16870B . .	20	NA	NA	NA	10	22	4	102	NA	160	NA	. . do	Do.
SO16871 . . .	20	.40	NA	NA	NA	48	8	1,050	NA	423	205	. . do	From 1-ft level in same pit as SO16870. Soil is more radioactive, approximately 3,500 cps at this level.
SO16860 . . .	21	NA	NA	NA	NA	NA	NA	NA	21	14	NA	Rock	Altered, fine-grained porphyritic dike with phenocrysts of quartz, plagioclase, amphibole, and biotite. Minerals are replaced by chlorite and iron oxide. Quartz phenocrysts have reaction rims of chlorite and iron oxide. Feldspars are altered to clay.
SO16874 . . .	22	NA	NA	NA	NA	NA	NA	NA	170	31	NA	. . do	Chip sample across a 24-in east-striking fracture zone (1,400 cps).
SO16869 . . .	23	.40	<.03	26	2	180	12	35	80	1,110	54	. . do	Decomposed quartz monzonite from 4-ft depth in pit. Narrow bands of hematite and clay in walls of pit. Radioactive measurements in the pit exceeded 20,000 cps. Radiometric measurement at the surface was 415 cps.
SO16872 . . .	23	.17	<.03	22	NA	80	9	27	NA	860	40	. . do	Decomposed quartz monzonite at bottom of 5.5-ft pit (12,000 cps).
SO16861 . . .	24	.2	<.03	28	NA	41	<1	14	NA	46	91	. . do	Subalkaline porphyritic dike with decomposed feldspar phenocrysts.
SO16862D .	24	.04	<.03	20	NA	20	1	20	NA	1,290	28	Soil	Decomposed quartz monzonite grus and hematitic, clayey soil at 1.5-ft depth. Quartz phenocrysts are sooty black in color.
SO16867 . . .	25	5.2	NA	NA	NA	5	5	21	549	101	76	Rock	Fractured quartz monzonite boulders with quartz porphyry and aplite dikes. Radioactivity is concentrated along fracture planes. Sample consists of chips from radioactive fractures.
SO16868A . .	26	.61	NA	NA	10	13	5	25	NA	183	35	Soil	Red-colored mud in frost boil, sample taken from approximately 8-in depth.
SO16868B . .	26	NA	NA	NA	10	17	2	22	NA	150	NA	. . do	Do.
SO16863 . . .	27	NA	NA	NA	NA	NA	NA	NA	<20	18	NA	Rock	Fine-grained, carbonate-altered felsic dike.

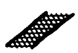
NA Not analyzed.

[1]Ag, Au, Bi, Co, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 7.



Base adapted from U.S.G.S. 1:63,360 scale Solomon D-1 quadrangle (Section 35, Township 6S, Range 18W)

LEGEND



Light to dark green, altered porphyritic felsic dikes

Qm — Quartz monzonite and associated granitic rocks of the Darby pluton, dashed line shows approximate extent of outcrop and rubble

☼ — Radioactive springs and pools

x 27 — Radiometric stations and sample locations

Figure 7.—Sketch map of west Vulcan Creek prospect 1.

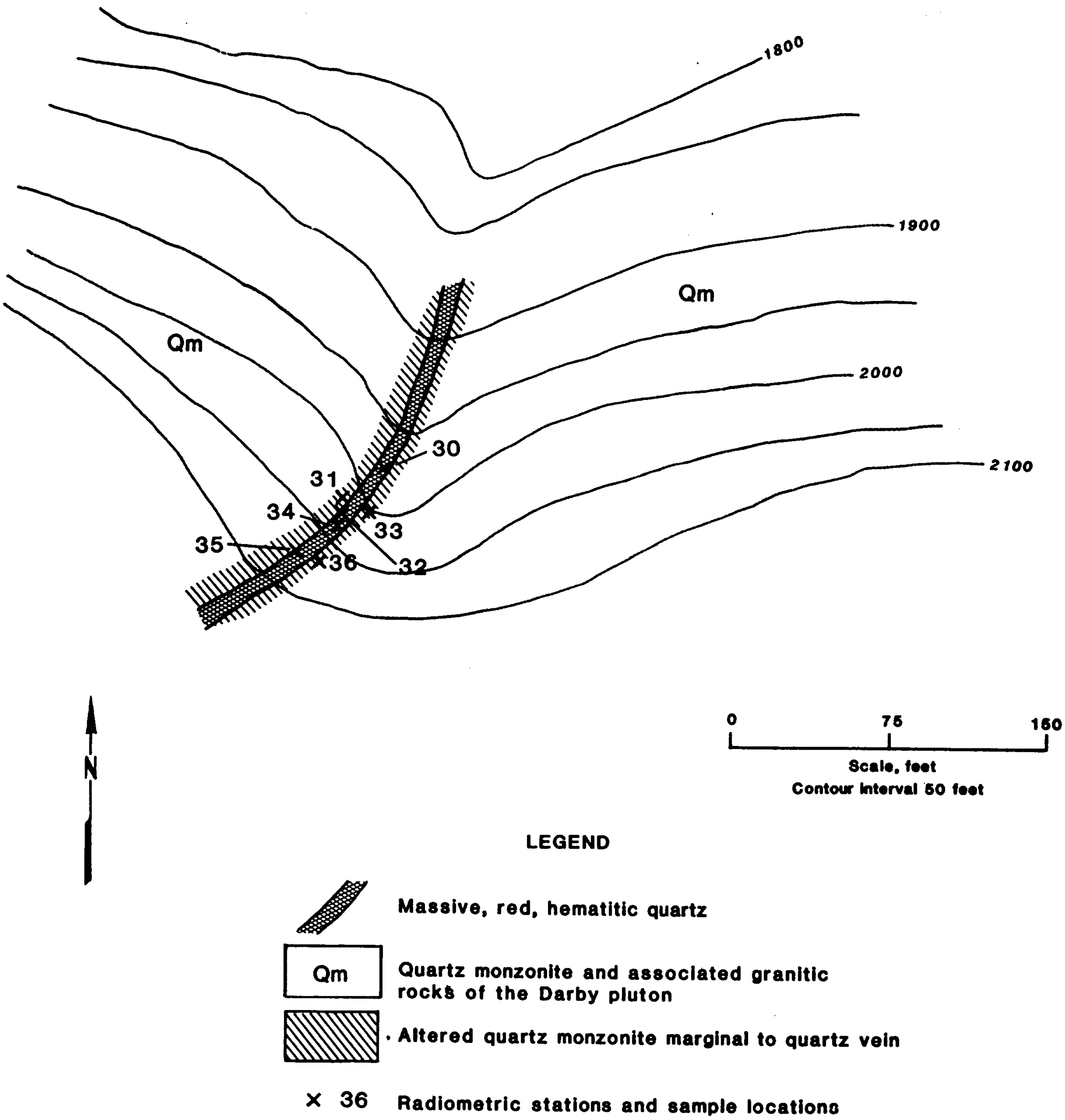


Figure 8.—Sketch map of west Vulcan Creek prospect 2.

Table 2.—Analyses, parts per million, and descriptions of samples from west Vulcan Creek prospect 2[1]

Sample	Map No.	Ag	Cu	Mo	Pb	Th	U	Zn	Sample type	Description
SO16497 . .	30	NA	[2]<100	NA	[2]3,000	22	83	NA	Rock	Fine-grained, hematitic, siliceous replacement zone with manganese staining.
SO17551 . .	31	NA	[2]200	NA	[2]200	75	24	NA	. . do	Kaolinized and sheared, biotite-quartz monzonite with quartz stockworks marginal to shear zone.
SO17552A .	32	0.25	110	7	550	NA	360	188	. . do	Hematitic quartz vein with boxworks.
SO17552B .	32	.65	145	5	560	NA	435	150	. . do	Hematitic quartz vein with boxworks (2,000 cps).
SO17552C .	32	NA	205	12	710	NA	380	NA	. . do	Do.
SO16875B .	33	.4	100	8	15	NA	10	21	. . do	Altered biotite-quartz monzonite with clay, chlorite, and sericite.
SO16875C .	34	.75	69	5	79	NA	178	95	. . do	Hematitic quartz vein with boxworks.
SO17554 . .	35	.20	70	14	36	NA	315	98	Decomposed rock.	From 2-ft-deep pit in an altered, cataclastic, chloritic siliceous zone with manganese and iron staining.
SO17556 . .	35	.28	10	5	35	NA	114	49	Soil	Soil from same pit as SO17554.
SO17555 . .	36	.19	81	5	14	38	12	14	Rock	Propylitically altered biotite-quartz monzonite.

NA Not analyzed.

[1]Ag, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 8.

[2]Semiquantitative emission spectrography analyses by Technical Services Laboratories, Spokane, WA.

Table 3.—Analyses, parts per million, and descriptions of samples from west Vulcan Creek prospect 3[1]

Sample	Map No.	Ag	Bi	Cu	Mo	Pb	Th	U	Zn	Sample type	Description
SO16881 . .	37	0.50	NA	11	7	55	NA	37	76	Rock . .	Altered granite rubble.
SO17557 . .	38	.11	2	73	12	26	NA	47	40	. . do . .	Fine-grained quartz, white mica, epidote, clays, and hematite along fractures in coarse-grained granitic host.
SO17558 . .	39	.19	NA	82	<2	45	37	73	55	. . do . .	Altered and sheared quartz monzonite.
SO17559 . .	40	.31	NA	120	1,600	39	38	89	38	. . do . .	Altered and sheared biotite-quartz monzonite.
SO17560 . .	41	NA	NA	NA	NA	NA	NA	NA	NA	. . do . .	Medium-grained, hypidiomorphic quartz-monzonite with iron oxide and amorphous, opaque minerals along fractures. Minor white mica and clays after feldspars.

NA Not analyzed.
[1]Ag, Bi, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 5.

emanated from fractures along an altered and deeply leached shear zone exposed in a north-trending gully (fig. 5). Propylitically and argillically altered quartz monzonite is exposed for a minimum width of 40 ft along 800 ft of strike length at this location. Closely spaced shear planes strike north, parallel to the strike of the gully. Unlike other uranium anomalies and occurrences in the west Vulcan Creek-Rock Creek area, only minor silica and hematite replacement were observed at this location. Grab samples of altered quartz monzonite and iron-stained, discontinuous quartz fracture fillings in granitic rock from this prospect contained from 38 to 55 ppm U (table 3). A sediment sample from a pool at the mouth of the ground water seep contained 76 ppm U.

Rock Creek Prospect 4

Numerous quartz veins and abundant vein quartz rubble were observed along 1,000 ft of the base of a high cirque wall, at the head of Rock Creek. Where observed in bedrock, quartz veins are leached and the wall rock is altered to clay. Veins range up to several feet thick, but smaller veinlets, less than an inch thick, are more common. The quartz veins have nearly vertical dips with variable strikes. The veins are coated with secondary drusy quartz. Relict pyrite and traces of other sulfide minerals were also observed in vein quartz at several sites. A grab sample from a hematitic quartz vein at radiometric station 49 (fig. 5) contained 153 ppm U and 236 ppm Th (table 4). A thin section of this rock contains fine-grained quartz and carbonate mineral with minor sericite, hematite, and accessory pyrite. During investigation of this area, scintillometers were rendered unusable by rain, and radiometric measurements are not available.

Quartz monzonite exposed throughout the cirque is hydrothermally altered and discolored. Fine-grained epidote and chlorite impart a light green color to less altered rocks. Locally, the quartz monzonite contains quartz stockworks and veins, cryptocrystalline silica coatings and masses, abundant hematite, clay minerals, carbonate, and minor sericite. The latter, more altered rocks are various shades of red because of the abundant iron oxide. Two samples of altered quartz monzonite from this area contained 10 and 38 ppm U.

Rock Creek Prospect 5

Several closely spaced, parallel, silicified shear zones are poorly exposed in a steep narrow gully at prospect 5 (fig. 5). The zones strike west-northwest with a steep northerly dip. At one outcrop within the gully, a 1.5-ft-wide silicified zone with hematite, chlorite, and secondary quartz veins contains disseminated pyrite and rare chalcopyrite. Other outcrops and float are leached of sulfide minerals. The presence of boulder-sized rubble in the gully (station 57) indicates that silicified shear zones range in width from 1 to 4 ft or more and are typically bordered by narrow zones of clay and fault gouge. Generally, the leached and silicified zones yielded radiometric measurements of about two times background. Two chip samples of leached hematite quartz vein rubble from this prospect contained 140 and 170 ppm U and anomalous concentrations of lead (table 4).

Rock Creek Prospect 6

A silicified and iron-stained, northeast-striking shear zone is exposed for 500 vertical ft, in a steep, east-facing gully in a cirque wall, at the head of Rock Creek (fig. 5). Steeply dipping quartz veins, containing banded jasper with hematite and narrow, parallel seams of pyrite-bearing fluorite-greisen, occur in altered quartz monzonite at the prospect. The jasper bands are up to 2 in thick and are concentrated in a 1-ft-wide central portion of the quartz veins.

The quartz veins pinch and swell to maximum thicknesses of 4 ft, and radiometric readings were typically two to three times that of the surrounding area. Pitchblende was identified in a high-graded specimen (from station 60, table 4) of radioactive greisen from this location (fig. 6). Isolated chips of the jasperoidal vein material (stations 62, 64, and 66) are exceedingly radioactive and locally contained up to 0.76 pct U.

Quartz monzonite adjacent to this shear zone is hydrothermally altered, and contains abundant chlorite and hematite with minor disseminated pyrite and clay minerals. A rosette of molybdenite was observed in an outcrop of iron-stained, aplite dike that parallels the shear zone (station 61) 30 ft to the east. Carbonate altered, lamprophyre dike rock of unknown orientation, and with phenocrysts of clinopyroxene, biotite, and olivine, was also observed in rubble at the ridge crest above the mineralized zone.

Rock Creek Prospect 7

A poorly exposed, silicified, hematitic shear zone occurs in propylitically altered, medium-grained, biotite-quartz monzonite (fig. 5). Because of poor exposure, the dimensions of this feature are unknown. No radiometric measurements were made at this prospect, but samples of frost-fractured rubble along the shear zone contained from 7 to 155 ppm U (table 4).

Rock Creek Prospect 8

Quartz veins, vein quartz rubble, and radiometric measurements, up to five times background over hematite-rich quartz boulders, were observed in an east- to southeast-striking gully at Rock Creek prospect 8 (fig. 5). The quartz

Table 4.—Analyses, parts per million, and descriptions of samples from Rock Creek prospects 4 through 8[1]

Sample	Map No.	Ag	Cu	Mo	Pb	Th	U	Zn	Sample type	Description
							PROSPECT 4			
SO17661	47	NA	NA	NA	NA	NA	NA	NA	Rock	Fine-grained, porphyritic lamprophyre dike with carbonate pseudomorphs replacing olivine phenocrysts. These and clinopyroxene phenocrysts are in a chloritized and clay-altered groundmass with abundant green and brown amphibole euhedra. Felsic minerals are replaced by clays, epidote, and carbonate.
SO17660	48	0.3	2	<2	30	NA	38	5	..do	Light-green, silicified quartz monzonite.
SO17659	49	NA	50	8	300	236	153	NA	..do	Abundant hematite and carbonate in silicified quartz monzonite with minor limonite.
SO17658	50	2.8	85	<2	45	55	10	60	..do	Coarse-grained quartz monzonite with abundant clay and iron oxide.
							PROSPECT 5			
SO17625A	56	0.4	110	30	660	53	170	145	Rock	Chip sample from leached, hematitic quartz vein rubble.
SO17625B	56	NA	163	65	890	NA	140	NA	..do	Do.
AO17626	57	1.0	88	5	31	49	68	34	..do	Channel sample across a leached, 2.5-ft-wide, partially silicified shear zone.
							PROSPECT 6			
SO17589A	60	0.90	140	5	410	260	1,961	500	Rock	Hematite, fluorite, pyrite, and pitchblende in quartz-sericite greisen. Sample contains 3 ppm Co.
SO17589B	60	NA	NA	301	589	NA	1,990	NA	..do	Do.
SO17570	61	1.60	105	285	700	NA	345	39	..do	Molybdenite rosette and disseminated pyrite in iron-stained, silicified aplite.
SO17568	62	1.4	100	20	350	132	284	20	..do	Banded jasper adjacent to quartz vein.
SO17567	63	.15	51	3	26	NA	23	43	Soil	Decomposed, iron-stained regolith adjacent to mineralized zone.
SO17566	64	3.6	230	535	2,450	50	7,670	110	Rock	Banded jasper adjacent to quartz vein with pyrite in altered quartz monzonite. Sample contains 1 ppm Co.
SO17565A	65	1.0	160	57	190	NA	253	50	..do	Altered quartz monzonite with pyrite in quartz veinlets.
SO17565B	65	NA	NA	47	181	NA	190	NA	..do	Do.
SO17564	66	.37	70	5	72	NA	565	11	..do	Banded jasper cut by white quartz veinlets.
SO17563	67	.5	10	3	20	NA	18	59	..do	Vuggy quartz and hematite in altered quartz monzonite.
							PROSPECT 7			
SO17542	73	3.00	110	5	44	NA	7	27	Rock	Iron-stained hematitic quartz with minor pyrite.
SO17541	74	.45	120	<2	11	54	27	15	..do	Iron-stained hematitic quartz.
SO17540	75	1.40	115	10	65	58	155	20	..do	Propylitically altered, biotite quartz monzonite with heavy iron and manganese staining.
SO17539	76	.5	60	<2	31	NA	34	85	..do	Propylitically altered biotite quartz monzonite.
SO17538	77	.7	60	<2	31	NA	34	85	..do	Propylitically altered and leached biotite quartz monzonite with manganese staining.
SO17537	78	1.8	135	5	65	NA	48	41	..do	Propylitically altered and leached biotite quartz monzonite.
							PROSPECT 8			
SO17620A	69	1.6	150	20	900	32	59	700	Rock	Sample taken from boulders of hematitic and chloritic vein quartz rubble over a 2-ft-wide area.
SO17620B	69	NA	NA	41	1,100	NA	58	NA	..do	Do.
SO17619	70	NA	NA	NA	NA	NA	NA	NA	Rock specimen.	Vein rubble containing galena and pyrite.
SO17621A	71	10.5	135	240	1,250	64	1,000	49	Rock	High-graded, hematitic quartz with minute grain of gray sulfide mineral. Collected from vein rubble in 6-ft-wide area at 2,500-ft elevation. Radiometric measurements up to 5 times background recorded over some boulders.
SO17621B	71	NA	NA	147	810	NA	270	NA	..do	Do.
SO17616A	72	17.0	230	5	900	164	447	30	..do	Pyritic and hematitic quartz lens about 0.3-ft thick and less leached than remainder of the 12-ft-thick vein. Map No. 72 is on ridge crest at head of the gully. Sample contains 500 ppm Bi.[2]
SO17616B	72	NA	NA	217	1,200	NA	430	NA	..do	Do.
SO17618	72	.5	76	45	60	NA	229	50	Soil	Red-weathering soil, overlying hematitic quartz-biotite vein approximately 10 to 12 ft wide at ridge crest. Sample contains 8,000 ppm Ba.[2]

NA Not analyzed.

[1]Ag, Co, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 5.

[2]Semiquantitative emission spectrography analyses by Technical Services Laboratories, Spokane, WA.

veins nearly parallel the strike of the gully, and are best exposed between the 1,600- and 2,500-ft elevations at the crest of a knife-edged ridge and along the steep west-facing slope. At the head of the gully, closely spaced quartz veins and silica-replaced, leached hematitic lenses with relict pyrite are concentrated in two separate vein systems. One vein system strikes N 85° E, dips steeply to the north, and is 12 ft wide (station 72). Silicified hematitic lenses, up to 10 in thick in argillically and propylitically altered quartz monzonite, are associated with the closely spaced quartz veins. Along the ridge, 10 ft southeast, is a second, parallel, deeply weathered, 15-ft-wide quartz biotite vein system (station 72). Near the veins, the host rock is leached and decomposed. Radiometric measurements over the two vein systems range from three to four times background.

Samples from both vein systems and from rubble

Table 5.—Analyses, parts per million, and descriptions of miscellaneous samples from the west Vulcan Creek-Rock Creek area[1]

Sample	Map No.	Ag	Cu	Mo	Pb	Th	U	Zn	Sample type	Description
SO16469A ...	1	0.50	15	2	36	NA	6	40	Soil	Soil sample from prominent saddle in quartz monzonite. No anomalous radiometric readings.
SO16469B ...	1	NA	NA	2	45	NA	10	NA	..do	Do.
SO16470	2	[2]<10	[2]<10	[2]<10	[2]<100	NA	NA	[2]<1,000	Rock	Fine-grained, altered, pyroxene-biotite lamprophyre dike rubble with less than background radiation. Sample contains 1,000 ppm Ba.
SO16471	3	[2]<10	[2]<10	[2]<10	[2]<100	NA	NA	[2]<1,000	..do	Chips of aphanitic, quartz porphyry dike swarm.
SO16475	6	.80	39	110	16	NA	1	25	..do	Calc-silicate rubble with disseminated pyrrhotite. Sample contains 6 ppm W.
SO16476	7	1.00	680	5	12	<20	5	16	..do	Sooty, graphitic schist striking 30°, rusty weathering, with finely disseminated pyrite. Strikes N 15° W with vertical dip.
SO16477	8	1.9	180	20	24	NA	11	35	..do	Chip sample across a 10-ft-thick graphite bed with vertical dip, striking N 50° W. Grades into graphitic schist. Slightly above background radioactivity.
SO16882	9	.41	17	<2	16	<20	2	20	..do	Calc-silicate rubble with disseminated pyrrhotite. Sample contains <5 ppm W.
SO16886	10	1.8	42	4	22	NA	2	75	..do	Do.
SO16885	11	1.6	120	2	48	NA	2	74	..do	Do.
SO16884	12	.60	25	2	18	NA	1	38	Soil	Soil overlying contact between quartz monzonite and calc-silicate to marble.
SO16883	13	.60	15	3	24	NA	3	60	..do	Soil overlying quartz monzonite near calc-silicate contact.
SO16898	14	[2]<10	[2]<10	[2]<10	[2]<100	NA	NA	[2]<1,000	Rock	Chips of lamprophyre dike rubble. Sample contains 2,000 ppm Ba[2] and 600 ppm Sr.[2] No anomalous radioactivity
SO16889	15	.62	9	5	31	NA	79	12	..do	Silicified rubble with hematite and boxworks.
SO16899	16	[2]<10	[2]<10	[2]<10	[2]<100	25	31	[2]<1,000	..do	Chloritized granite with silicified breccia zones, minor boxworks and background radioactivity. Trace of zone projects 400 ft to radioactive ground water seep. Sample contains 40 ppm Be.[2]
SO16236	17	NA	NA	NA	NA	33	<1	NA	..do	Sheared and leached quartz monzonite with smokey quartz outcropping above radioactive seep (2 times radiometric background).
SO16896	18	.3	10	5	26	NA	136	45	Sediment..	Silt.
SO16233	19	.5	5	24	30	NA	65	62	Soil	Sample from iron-stained frost boil in vicinity of dike rubble. Radiometric readings were 2 times background.
SO16865	28	.3	9	3	18	NA	20	30	..do	Soil from ground water seep where radiometric readings were 2 to 3 times background. Sample contains 80 ppm Cb[2] and 40 ppm Ga.[2]
SO16864	29	4.0	5	<2	380	NA	45	2,100	Rock	Leached and altered, fine-grained quartz monzonite with boxworks and siderite veinlets. Occurs in a 40-ft-wide rubble train. Slightly above background radioactivity.
SO16877A ...	42	.5	11	4	85	NA	4	60	Soil	A shear zone of undetermined width and striking N 5° W is propylitically altered and contains hematite. Some quartz stockworks and manganese staining are present. No above background radiation was observed. Sample contains 50 ppm Cb.[2]
SO16877B ...	42	1.0	14	5	760	NA	62	660	..do	Propylitically altered quartz monzonite and hematitic gossan. Material is thoroughly leached and locally stained with manganese (2 times radiometric background). Sample contains 50 ppm Cb.[2]
SO16877C ...	42	NA	NA	15	5,000	NA	42	NA	..do	Do.
SO16878	44	1.5	15	<2	31	NA	51	25	..do	Brown, organic soil from nearby ground water seeps, aligned with linear depression which yields 3 times radiometric background measurements over water.
SO16879	45	NA	NA	[2]100	[2]800	<20	11	NA	Rock	Cataclastic, hematitic quartz with boxwork zone trends N 70° E. No above background radiometric measurements were recorded.
SO16880	46	2.5	7	4	17	NA	30	14	..do	Propylitically altered, medium-grained biotite quartz monzonite.
SO17662	51	.3	14	10	64	NA	48	64	Sediment..	Silt.
SO17656	52	.1	9	5	38	NA	40	23	..do	Do.
SO17637	53	NA	NA	NA	NA	57	52	NA	Rock	Leached, east-striking, 1-ft-wide quartz vein in an altered and sheared quartz monzonite.
SO17657A ...	54	1.9	63	<2	350	82	53	3,900	..do	Altered granitic rock with secondary quartz, pyrite, carbonate, hematite, and unidentified opaque minerals. Radiometric readings of 1.5 times background. Sample contains 100 ppm each Y, Cb, and Sn.[2]
SO17657B ...	54	NA	NA	3	495	NA	34	NA	..do	Do.
SO17665	55	1.2	58	4	10	44	14	43	..do	Pod of hematitic silica in propylitically altered shear zone exposed in small gully.
SO17622	58	.7	26	5	44	NA	13	46	Soil	Sandy soil from fault trace.
SO17593	59	15.0	310	5	2,100	NA	99	100	Rock	Hematite and jasper in quartz vein along fissure in altered quartz monzonite.
SO17587	68	.95	24	<2	20	NA	5	56	..do	Carbonate altered, alkaline lamprophyre dike.

NA Not analyzed.

[1]Ag, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 5.

[2]Semiquantitative emission spectrography analyses by Technical Services Laboratories, Spokane, WA.

downslope from the veins contain anomalous uranium concentrations. Two samples of hematite-rich quartz rock with accessory pyrite from the first vein system, contained 40 and 447 ppm U. Red-weathering soil overlying the second vein system contains 229 ppm U. Samples of hematite-rich quartz boulders in rubble at the 2,500-ft elevation contained 270 and 1,000 ppm U (station 71, table 4). Radiometric measurements over some boulders at this site exceed 2,000 cps, about five times measurements over surrounding areas.

Additional Sampling in the West Vulcan Creek-Rock Creek Area

Additional soil, rock, and stream sediment sampling indicates that other uranium occurrences may be present in this area. Samples listed in table 5 that contain anomalous levels of uranium represent float or material from locations where weathering and colluvium cover is so complete that bedrock structures cannot be further described.

CLEAR CREEK AREA

The Clear Creek area was investigated because of previous reports of radiometric anomalies and uranium-columbium minerals in placer gravels (reference 2 and work cited in footnote 4). Altered quartz monzonite and aplite were observed along linear structural features at the head of Clear Creek. Sample locations are shown in figure 9 and analytical data are listed in table 6. Geology of the Clear Creek area is shown in figure 10.

No uranium prospects were identified in the Clear Creek area, though samples containing up to 260 ppm U were noted (table 6). Colluvial cover is more extensive than observed in the Vulcan-Rock Creek area and numerous discolored zones were noted in quartz monzonite bedrock along ridges at the heads of Clear Creek tributaries.

Hawley (*2*, p. III-12) reports up to 80 ppm U in soil samples from a gossan at the head of Clear Creek, near the divide between Clear Creek and Canyon Creek. This site was not found again, but a sample of altered quartz monzonite (station 42) collected by the Bureau 0.5 mile south of the reported location, contained 47 ppm U. A syenite dike intrudes the quartz monzonite near this location. Radiometric measurements over the altered zone are one and one-half to two times measurements over surrounding areas.

Three other sites sampled by the Bureau in the Clear Creek drainage basin contained anomalous uranium. A soil sample from leached, iron-stained regolith overlying altered quartz monzonite at station 35 contained 77 ppm U. Several other samples of leached, altered quartz monzonite float from the area contained from 14 to 20 ppm U. Radioactive ground water seeps occur south and west and within several thousand feet of station 35.

The second site of anomalous uranium concentration is a 1-ft-thick aplite dike (station 3). A sample from this site contained 103 ppm U and anomalous levels of beryllium, columbium, and lead. A second aplite dike that outcrops at station 4, about 400 ft northeast of station 3, contains 21 ppm U.

The third site of anomalous uranium includes sample stations 27 and 28. Stream sediment samples from these locations contained 110 and 250 ppm U. Iron-stained soil and leached vein quartz in float are located approximately 1,000 ft upslope from these samples but no above background radiometric measurements were recorded.

At station 61, hematitic quartz monzonite scree contains quartz veinlets with unidentified sulfide minerals. Although no uranium concentrations were detected, analyses indicate enrichment of thorium and bismuth.

Miller and Grybeck, in 1973, described a copper-lead-zinc-silver prospect at the head of Dry Canyon Creek in the northwest corner of figure 10 (*17*). Sphalerite, galena, chalcopyrite, and pyrite, but no radioactive minerals, were reported. This prospect was examined by the Bureau to determine if uranium and thorium are associated with the base metals. A sample from station 48 (fig. 9) was collected from a gossan along a faulted contact between the Darby pluton on the east and calc-silicate rock grading to silicified limestone on the west. Material from station 49, west of the faulted contact, was collected from the lower of two prospect pits which expose a N 72° E striking, 3- to 4-ft-wide, siliceous, sulfide-bearing mineral vein. At station 50, 200 ft upslope from station 49, a northeast-striking, near vertical quartz vein is exposed in another prospect pit. This vein contains pyrite-rich, silicified gangue in brecciated, silicified, and iron-stained marble. Eleven prospect trenches are located upslope and to the west of station 50. These pits contain iron-stained and altered limestone, calc-silicate, and biotite schist all cut by siliceous veins. Amphibole, plagioclase, chlorite, pyroxene, quartz and carbonate and sulfide minerals are all present in the siliceous veins. Radiometric measurements and chemical analyses listed in table 6 indicate no radioactive minerals are present in the veins. The mineralization in this area is apparently unrelated to the hydrothermal uranium occurrences in the Darby Mountains.

JONES PUP CREEK AREA

An investigation of the northernmost portion of the Darby pluton was conducted by the Bureau from a spike camp located near the mouth of Jones Pup Creek, a tributary to Big Creek. The area was investigated because of favorable aerial radiometric measurements reported by Hawley (*2*), and proximity of Jones Pup Creek to the Boulder Creek uranium prospect near the Death Valley Tertiary basin (fig. 3). The local geology, radiometric stations, and sample locations are shown in figure 11. Results of geochemical analyses of rock, soil, and stream sediment samples are presented in table 7.

No uranium deposits were identified in the area, but elevated uranium concentrations and high radiometric measurements were noted at several locations. A sample collected from a stream that drains quartz monzonite at station 67 contains 48 ppm U. Clay-altered quartz monzonite occurs in a 100-ft-wide zone adjacent to a contact with vesicular basalt at stations 70 and 71. Radiometric measurements at stations 70 and 71 were up to two times background, however, no anomalous uranium was detected in samples. A soil sample collected at station 73, near the western contact of the Darby pluton, contained 37 ppm U and 990 ppm Pb. The sample was from a 1-ft depth in dry, organic-rich soil that had a radiometric measurement of two times background. No other radiometric anomalies were encountered in the Jones Pup Creek area and no vein-type uranium occurrences were observed.

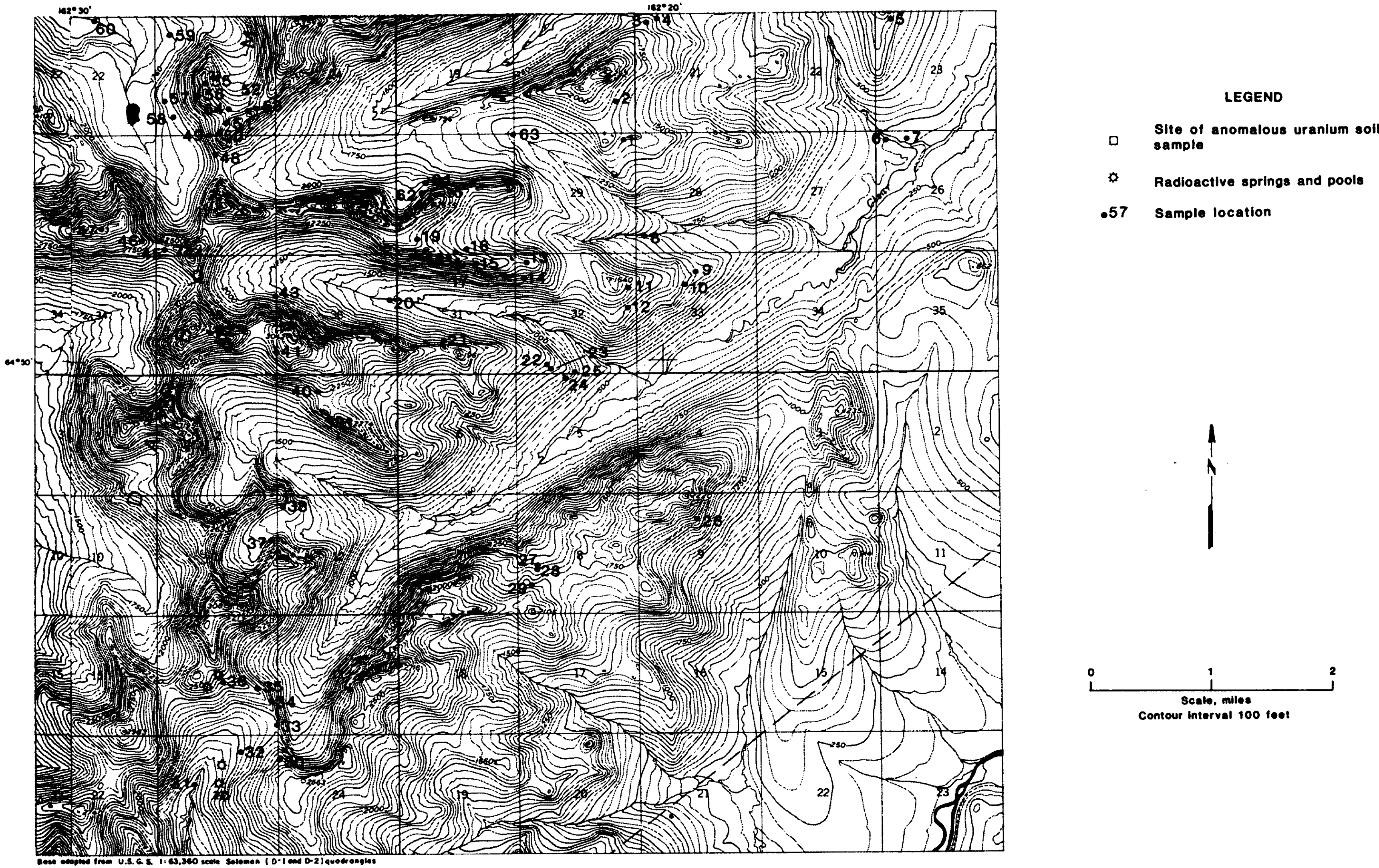


FIGURE 9

Figure 9.—Sample locations and mineral occurrences in the Clear Creek area. The anomalous uranium soil samples were reported in reference 2.

Table 6.—Analyses, parts per million, and descriptions of samples from the Clear Creek area[1]

Sample	Map No.	Ag	Cu	Mo	Pb	Th	U	W	Zn	Sample type	Description
SO18172..	1	0.37	5	7	30	NA	3	NA	7	Rock....	Leached intrusive rock with secondary quartz veining and mafics altered to chlorite.
SO18173..	1	1.10	5	3	15	NA	1	NA	5	..do....	Do.
SO18171..	2	.16	2	NA	9	NA	8	NA	25	..do....	Representative chips of biotite-hornblende-quartz monzonite.
SO18170..	3	1.90	4	2	1,105	59	103	16	<4	..do....	1-ft-wide aplite dikes with unidentified dark green mineral. Sample contains 20 ppm Be,[2] 24 ppm Ta,[3] 120 ppm Cb.[3]
SO18169..	4	1.50	5	<2	76	NA	21	NA	7	..do....	Aplite dike.
SO10524..	5	.20	2	<2	33	12	3	NA	50	..do....	Schistose, calc-silicate.
SO10510..	6	.46	41	<2	14	<20	3	<5	33	..do....	Pyrrhotite-bearing, calc-silicate.
SO10509..	7	[2]<10	[2]100	[2]<10	[2]<100	NA	11	NA	[2]<1,000	..do....	Calc-silicate boulders with pyrrhotite.
SO16243..	8	.40	12	<2	26	NA	19	NA	49	Soil.....	Chlorite, sericite, quartz, and hematite in altered rubble from creek bank. Radiometric readings slightly above background.
SO10564..	9	[2]<10	[2]50	[2]<10	[2]<100	25	9	<5	[2]<1,000	Rock....	Prophyritic quartz monzonite.
SO10570..	10	[2]<10	[2]<10	[2]<10	[2]<100	NA	10	6	[2]<1,000	..do....	Altered pink syenite.
SO10567..	11	[2]<10	[2]10	[2]<10	[2]<100	NA	6	<5	[2]<1,000	..do....	Mafic segregation in biotite-quartz monzonite.
SO16555..	12	[2]<10	[2]<10	[2]<10	[2]<100	41	4	NA	[2]<1,000	..do....	Propylitically altered granitic rock with iron and manganese staining.
SO10566..	13	[2]<10	[2]<10	[2]<10	[2]<100	NA	15	<5	[2]<1,000	..do....	Chloritic and hematitic altered quartz monzonite rubble.
SO16556..	14	[2]<10	[2]<10	[2]<10	[2]<100	40	8	NA	[2]<1,000	..do....	Unaltered leucogranite.
SO10569..	15	[2]<10	[2]50	[2]<10	[2]200	NA	9	16	[2]<1,000	..do....	Chloritic and hematitic altered biotite-hornblende-quartz monzonite.
SO16557..	16	[2]<10	[2]<10	[2]<10	[2]<100	56	8	NA	[2]<1,000	..do....	Propylitically altered granite with chloritic quartz veining over an area 10 ft across.
SO10568..	17	.48	6	4	10	77	9	8	28	..do....	Altered biotite-hornblende-quartz monzonite with sulfides.
SO16559..	18	[2]<10	100	[2]<10	[2]<100	<20	3	NA	[2]<1,000	..do....	Aplite dike with disseminated pyrite.
SO16558..	19	[2]<10	[2]<10	[2]<10	[2]100	63	14	NA	[2]<1,000	..do....	Quartz monzonite, sample contains 1,000 ppm Ba.[2]
SO10477..	20	NA	NA	NA	NA	NA	NA	NA	NA	Sediment.	Silt.
SO15711..	21	NA	NA	NA	NA	NA	10	<5	NA	Rock....	Quartz monzonite.
SO17328..	22	.2	2	1	36	106	11	NA	51	..do....	Coarse-grained altered syenite.
SO17327..	23	1.5	3	4	19	NA	14	NA	35	..do....	Fine-grained felsic dike with black dendritic coatings. Sample contains 1,000 ppm Ba.[2]
SO10572..	24	.2	9	5	6	1	6	NA	8	..do....	Vuggy, limonite-coated altered granite and quartz.
SO10571..	25	3.0	23	<2	36	NA	3	NA	40	..do....	Drusy quartz with iron oxides.
SO10508..	26	.5	72	3	13	<20	5	NA	29	..do....	Pyroxene hornfels rubble at limestone-quartz monzonite contact.
SO16485..	27	.3	10	4	16	NA	110	NA	30	Sediment.	Silt.
SO16486..	28	.1	10	4	41	NA	250	NA	13	..do....	Do.
SO16300..	29	.39	6	8	17	NA	11	NA	50	Soil.....	Iron-stained soil.
SO16487..	29	[2]<10	[2]300	[2]<10	[2]<100	<20	9	NA	[2]<1,000	Rock....	Leached, iron-stained, siliceous vein.
SO16297..	30	1.00	4	6	10	NA	8	NA	7	..do....	Propylitically altered granite with quartz veins.
SO12336..	31	.5	20	5	18	NA	37	NA	51	Sediment.	Silt.
SO16295..	33	<.09	5	8	9	NA	2	NA	7	Rock....	Altered pyritic zones occurring up to 12 ft on either side of a lamprophyre dike.
SO16294..	34	.29	8	5	9	NA	6	NA	5	..do....	Quartz vein with pyrite about 2 ft thick.
SO16298..	35	.55	2	16	25	NA	77	NA	63	Soil.....	Deeply leached zone of undetermined width.
SO17629..	36	.36	71	<2	15	52	14	NA	24	Rock....	Shear zone with chloritic and propylitic alteration, some boxworks and gossan, radiometric readings were 2 times background.
SO16482..	37	.32	48	5	45	48	10	NA	83	..do....	Light green, altered quartz monzonite.
SO16484..	38	.46	17	5	9	57	9	28	350	..do....	Do.
SO16580..	39	[2]<10	[2]50	[2]<10	[2]800	32	8	NA	[2]<1,000	..do....	Altered quartz monzonite rubble. Sample contains 2,000 ppm Ba,[2] 9,000 ppm Zr.[2]
SO16581..	40	[2]<10	[2]30	[2]<10	[2]<100	28	7	NA	[2]<1,000	..do....	Altered quartz monzonite rubble.
SO16583..	41	NA	[2]10	NA	[2]100	<20	3	NA	NA	..do....	Tourmaline-bearing aplite.
SO16478..	42	[2]<10	[2]<10	[2]<10	[2]<100	41	47	NA	[2]<1,000	..do....	Altered quartz monzonite at head of Clear Creek.
SO15709..	43	.2	98	<1	13	61	24	<5	28	..do....	Altered quartz monzonite with hematite.
SO16479..	44	[2]<10	[2]<10	[2]<10	[2]<100	29	17	NA	[2]<1,000	..do....	Prophyritic alkaline dike with corroded feldspar phenocrysts. Sample contains 1,000 ppm Ba.[2]
SO16574..	45	[2]<10	[2]20	[2]<10	[2]<100	26	18	NA	[2]<1,000	..do....	Quartz replacing granular felsite dike.
SO16573..	46	[2]<10	[2]10	[2]<10	[2]<100	<20	1		[2]<1,000	..do....	Iron-stained, quartz-pyroxene-epidote hornfels.
SO16571..	47	NA	NA	NA	NA	18	1	5	NA	..do....	Foliated, amphibole-pyroxene-plagioclase-chlorite-sphene.
SO16575..	48	.78	155	3	21	NA	7	NA	40	..do....	Gossan along fault zone.
SO16576..	49	24.0	4,300	NA	4,500	72	.8	9	750	..do....	Pyrite and chalcopyrite in green, siliceous vein exposed in lower prospect pit.
SO16570..	50	4.4	94	<2	410	NA	6	NA	1,430	..do....	Gossan from upper pit.
SO16569..	51	1.5	60	7	30	NA	3	NA	7	..do....	Dark, fine-grained, massive dike with pyrrhotite.
SO16566..	52	.2	46	<1	64	17	3	NA	103	..do....	Carbonate altered hornblende lamprophyre dike.
SO16565..	53	NA	NA	NA	NA	73	12	NA	NA	..do....	Biotite-quartz monzonite with minor hornblende.
SO16568..	54	.2	32	3	190	16	50	NA	225	..do....	Altered andesite.
SO16562..	55	.55	15	3	55	NA	40	NA	95	..do....	Altered pyroxene in plagioclase groundmass with pyrite.
SO16563..	56	.43	2	<2	5	NA	2	NA	4	..do....	Weakly banded quartz-feldspar-muscovite rock.
SO16453..	57	NA	NA	NA	NA	9	<.2	NA	NA	..do....	Fine-grained, hornblende-2 feldspar schist.
SO16455..	58	6.6	3	10	65	NA	12	NA	125	..do....	Dark, fine-grained calc-silicate. Sample contains 40 ppm Be.[2]
SO16390..	59	.4	29	2	70	NA	22	NA	25	Sediment	Silt.
SO16398..	60	.4	15	2	18	NA	4	NA	41	..do....	Do.
SO17501..	61	.2	25	2	57	146	11	NA	23	Rock....	Hematite-stained, biotite-quartz monzonite scree with quartz veinlets up to 0.25 in, containing unidentified sulfide minerals. Sample contains 3,000 ppm Bi.[2]
SO17502..	62	.2	5	5	29	64	17	NA	28	..do....	Intense chlorite alteration with pyrite in rubble.
SO17503..	63	.5	10	3	20	NA	19	NA	59	Sediment	Sample contains 100 ppm Cb,[2] 50 ppm Y.[2]

NA Not analyzed.

[1]Ag, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th and W by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 9.

[2]Semiquantitative emission spectrography analyses by Technical Services Laboratories, Spokane, WA.

[3]X-ray fluorescence analyses by Technical Services Laboratories, Spokane, WA.

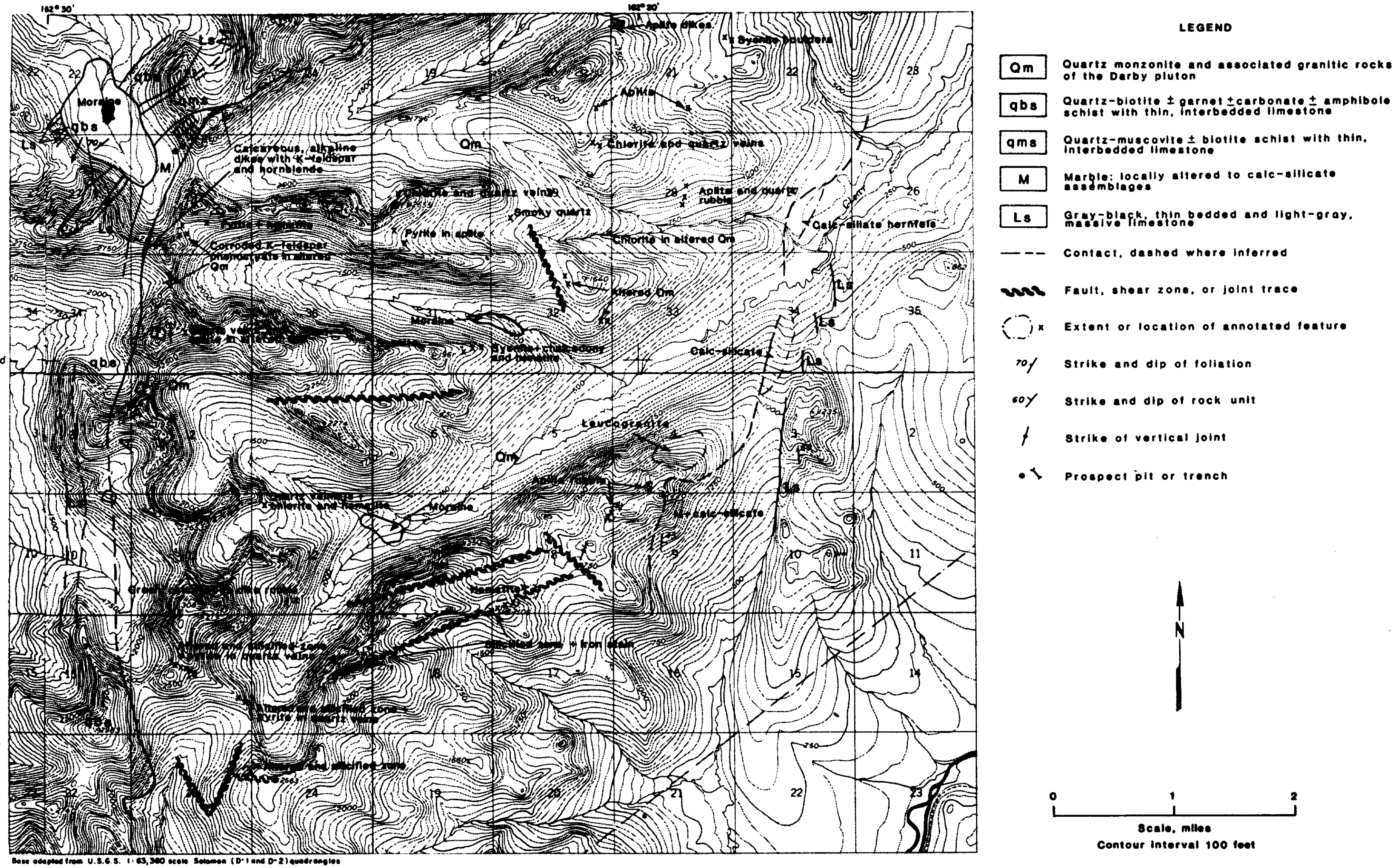


Figure 10.—Geology of the Clear Creek area.

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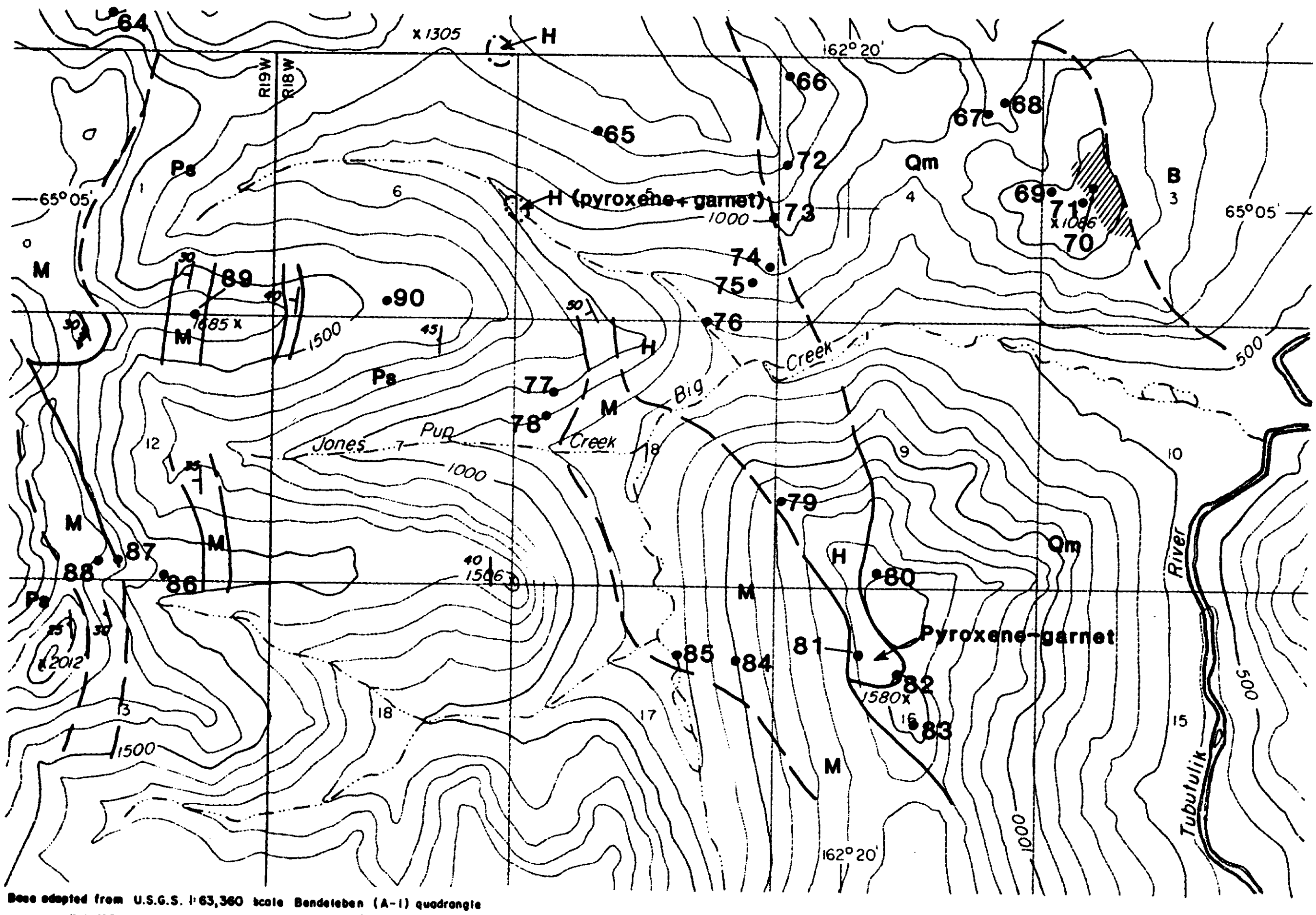

Base adapted from U.S.G.S. 1:63,360 scale Bendeleben (A-1) quadrangle

0 0.5 1

Scale, miles

Contour interval 100 feet

LEGEND

B	Basalt
Qm	Quartz monzonite and associated granitic rocks of the Darby pluton
(hachured)	Altered rocks of the Darby pluton
Ps	Intercalated metamorphosed sedimentary rocks, including quartz-biotite ± garnet schist, thin bedded marble, foliated and massive calc-silicate rocks
M	Massive gray marble
H	Thermally altered equivalents of Ps and M; these occur adjacent to the Darby pluton
	Lithologic contact, dashed where inferred
	Extent of labeled feature
45	Strike and dip of foliation
30	Strike and dip of axial plane of fold and direction of plunge
35	Strike and dip of rock unit
• 90	Radiometric stations and sample locations

Figure 11.—Geology and sample locations in the Jones Pup Creek area.

Table 7.—Analyses, parts per million, and descriptions of samples from the Jones Pup Creek area[1]

Sample	Map No.	Ag	Cu	Mo	Pb	Th	U	W	Zn	Sample type	Description
SB18164..	64	0.64	6	<2	105	NA	NA	NA	130	Rock	Bleached limestone with secondary carbonate coatings and calcite stockworks.
SB17309..	65	[2]<10	[2]10	[2]<10	[2]<100	NA	0.4	NA	79	..do	Carbonate and chlorite in quartz-pyroxene hornfels.
SB17319..	66	NA	NA	NA	NA	94	4	NA	NA	..do	Coarse-grained, biotite-quartz monzonite.
SB16909..	67	.5	10	5	30	90	48	NA	68	Sediment.	Silt.
SB16908..	68	.4	11	4	24	68	18	NA	90	..do	Do.
SB17318..	69	NA	NA	NA	NA	127	22	NA	NA	Rock	Medium-grained, granular biotite-quartz monzonite. No above-normal radiometric measurements.
SB16911..	70	1.5	38	6	24	NA	4	NA	75	..do	Vesicular basalt.
SB16910..	71	.50	10	<2	20	NA	16	NA	10	..do	Kaolinized quartz monzonite zone in 50- to 100-ft-wide area with hematite staining at contact with overlying basalt (2 times radiometric background).
SB17316..	72	NA	NA	NA	NA	91	11	NA	NA	..do	Seriate biotite-quartz monzonite, with perthitic alkali feldspar and sericite altered plagioclase.
SB17315..	73	.5	18	2	990	NA	37	NA	74	Soil	Organic-rich soil sample at 1-ft depth over radiometric anomaly of 2 times background.
SB17314..	74	NA	NA	NA	NA	80	22	NA	NA	Rock	Biotite-quartz monzonite with mortar texture.
SB17313..	75	[2]<10	[2]10	[2]20	[2]<100	NA	1	7	19	..do	Pyroxene-plagioclase-quartz hornfels.
SB16906..	76	NA	22	NA	NA	NA	1	NA	99	Sediment.	Silt.
SB17308..	77	[2]<10	[2]50	[2]<10	[2]<100	15	1	NA	[2]<1,000	Rock	Quartz-biotite-garnet schist.
SB17307..	78	[2]<10	[2]30	[2]<10	[2]<100	NA	NA	NA	[2]<1,000	..do	Foliated greenstone with carbonate alteration.
SB16901..	79	.53	15	<2	35	NA	3	NA	18	..do	Foliated marble.
SB15750..	80	[2]<10	[2]50	[2]<10	[2]<100	37	16	<5	[2]<1,000	..do	Coarse-grained biotite-quartz monzonite.
SB15751..	81	[2]<10	[2]20	[2]<10	[2]<100	<20	11	<5	[2]<1,000	..do	Aplite dike from near pluton contact with tactites.
SB15753A.	82	[2]<10	[2]20	[2]<10	[2]<100	<20	5	19	[2]<1,000	..do	Calc-silicate at pluton margin.
SB15753B	82	.22	40	5	17	NA	2	NA	90	..do	Foliated calc-silicate at pluton margin.
SB16902..	83	.24	5	6	5	<20	4	<5	5	..do	North-striking quartz veinlets in quartz monzonite.
SB15749..	84	.8	15	5	72	NA	1	NA	105	Sediment.	Silt.
SB15748..	85	1.0	16	3	29	NA	3	NA	86	..do	Do.
SB17302..	86	.2	11	4	10	NA	1	NA	32	Rock	Interbedded marble and calc-schist with iron staining.
SB17000..	87	.2	3	4	18	NA	.6	NA	5	..do	Hematite vein in marble.
SB17303..	88	.12	6	<2	68	NA	2	NA	20	..do	Marble cut by hematite, chlorite, and calcite veinlets.
SB17304..	89	.12	4	<2	5	NA	<1	NA	5	..do	Chlorite and hematite in quartz vein cutting marble.
SB17305..	90	.2	8	2	4	NA	<.2	NA	18	..do	Vein quartz with hematite and chlorite.

NA Not analyzed.
[1]Ag, Cu, Mo, Pb, and Zn were analyzed by atomic absorption, U by X-ray fluorescence, and Th and W by colorimetric procedures, Technical Services Laboratories, Spokane, WA. Sample locations are shown in figure 11.
[2]Semiquantitative emission spectrography analyses by Technical Services Laboratories, Spokane, WA.

SUMMARY AND RECOMMENDATIONS

Investigations in the Darby Mountains by government and university geologists targeted the Darby pluton as a potential host for deposits of uranium and thorium. During the summer of 1980, work by the Bureau of Mines substantiated the earlier conclusions by locating vein-type uranium deposits and uraniferous zones in altered quartz monzonite in the northern Darby Mountains. Where exposed in steep mountainside gullies, the vein deposits and altered shear zones typically yield above-background gamma radiation measurements, and anomalously high geochemical uranium values. Geochemical sampling of altered zones in the pluton, overlying soils, and sediments from streams draining the pluton, indicates additional areas may contain similar uranium occurrences. Leached and weathered bedrock, and scree and soil cover on gentler slopes, ridges, and saddles generally mask radiometric and geochemical evidence of radioactive minerals.

Analyses of panned, heavy mineral concentrates show no significant concentrations of uranium or thorium in resistant heavy minerals. The negative results of the pan concentrate survey and the discovery of vein-type uranium deposits indicate that uranium in the Darby pluton is concentrated in soluble, nonresistant minerals and may be recoverable.

Additional mineral exploration is warranted in the Darby Mountains. Future exploration would be expected to reveal more uranium vein deposits, particularly in the west Vulcan Creek-Rock Creek area. Evaluation of possible low grade, large tonnage uranium deposits indicated by the concentration of discolored altered zones in cirques along the northwest side of the divide between upper west Vulcan Creek-Rock Creek is recommended. Results of geochemical analyses indicate that uranium is associated with lead, zinc, and to a lesser extent, silver and molybdenum. These elements may serve as geochemical pathfinders during future exploration. Mineral occurrences other than uranium are known, or are indicated in the northern Darby Mountains. Silver, lead, molybdenum, copper, gold, tin, zinc, and coal deposits are reported. Also, graphite lenses were observed in the Vulcan Creek Valley. Analyses of panned heavy mineral concentrates indicate that tin, tungsten, and columbium deposits may also exist.

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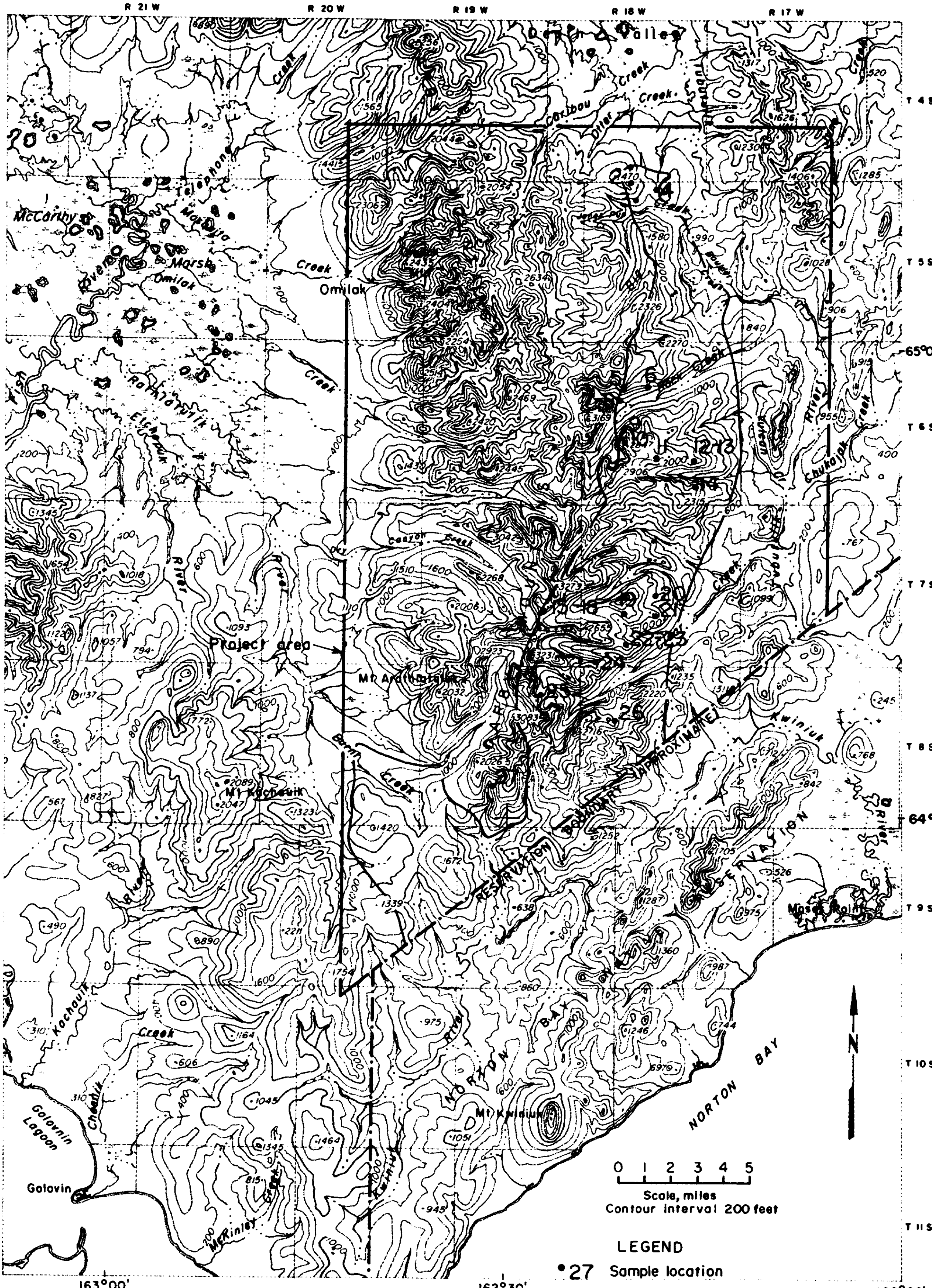
APPENDIX

Table A-1.—Major oxide,[1] thorium,[2] and uranium[3] analyses and descriptions of granitic rock samples from the Darby pluton

Sample	Map No.	Plasma analysis, wt pct Al_2O_3	CaO	FeO	Fe_2O_3	K_2O	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	LOI	Total	U, ppm	Th, ppm	Description
SB17319..	1	13.75	0.82	0.70	0.75	3.80	0.23	0.03	3.58	0.06	75.61	0.22	0.22	99.37	94	4	Coarse-grained porphyritic biotite-quartz monzonite with smoky-quartz.
SB17316..	2	13.21	.93	1.12	.65	3.71	.32	.04	3.66	.17	73.94	.23	.45	98.43	11	91	Seriate, biotite-quartz monzonite.
SB17314..	3	12.87	.69	.56	.84	4.17	.15	.02	3.59	.15	74.88	.18	.44	98.54	22	80	Coarse-grained quartz monzonite.
SB17318..	4	15.55	.41	.56	.52	5.85	.10	.02	3.72	.07	68.56	.28	1.07	96.71	22	127	Medium-grained granular biotite-quartz monzonite.
SO17515..	5	13.83	1.49	1.70	1.25	4.45	.46	.04	3.37	.07	71.83	.23	.25	97.97	52	4	Medium-grained quartz monzonite with mortar texture and euhedral, zoned allanite.
SO17649..	7	14.31	1.18	.84	2.05	5.10	.41	.04	3.32	.09	70.63	.39	.42	98.78	62	1	Fine-grained hypidiomorphic quartz monzonite with micro-granophyric intergrowth of feldspar and quartz.
SO17650..	8	14.37	1.72	.98	1.10	4.59	.57	.05	3.51	.09	70.00	.27	.32	97.57	45	2	Porphyritic biotite-quartz monzonite with granophyric intergrowths of quartz and feldspar.
SO17573..	9	13.25	1.19	.56	1.38	4.79	.41	.04	3.32	.09	72.44	.24	.33	98.04	46	6	Granular hornblende-biotite granite with perthite phenocrysts and 3-mm-thick quartz veinlet and 0.5-cm quartz phenocrysts.
SO17357..	11	13.00	.80	.56	.97	4.34	.26	.03	3.33	.07	73.90	.22	.10	97.58	97	6	Medium-grained, granular quartz monzonite.
SO17351..	12	2.95	.88	.70	.76	3.66	.22	.05	3.58	.06	75.10	.20	.10	98.26	NA	NA	Coarse-grained biotite-quartz monzonite.
SO17354..	13	12.52	.44	.70	.08	3.75	.05	.01	3.71	.04	76.28	.06	.22	97.86	NA	NA	Aplite dike in quartz monzonite.
SO16565..	15	14.00	1.54	1.26	.86	4.69	.57	.06	3.41	.10	72.44	.27	.16	99.38	12	73	Coarse-grained porphyritic biotite-quartz monzonite with accessory hornblende, sphene, chlorite, aplite, zircon, and opaque minerals.
SO17334..	19	15.67	1.80	.98	1.60	4.60	.65	.07	3.96	.17	68.30	.36	.11	98.27	68	12	Pegmatitic quartz monzonite with biotite, hornblende, chlorite, sphene, and opaque minerals.
SO10528..	20	15.47	1.94	.98	1.54	5.22	.67	.07	3.72	.12	68.89	.31	.11	99.04	62	3	Coarse-grained, porphyritic quartz monzonite with biotite, hornblende, and perthitic K-feldspar. Accessory sphene, chlorite, and opaque minerals.
SO17333..	21	15.83	1.74	1.12	1.66	4.51	.71	.07	3.78	.16	68.99	.33	.23	99.13	69	7	Biotite and chloritized hornblende in coarse-grained porphyritic quartz monzonite. Accessory sphene and opaque minerals.
SO10522..	22	18.10	3.63	3.08	2.67	4.41	1.90	.17	4.42	.50	58.06	.64	.19	97.77	NA	3	Fine-grained, hypidiomorphic, mafic segregation with corroded K-feldspar xenocrysts, in quartz monzonite; hornblende, biotite, and sphene in granular and lobate plagioclase (abundant apatite).
SO10523..	23	15.24	1.95	1.12	1.45	4.78	.67	.06	3.68	.16	69.38	.33	.00	98.82	70	4	Coarse-grained, micrographic quartz monzonite with hornblende and biotite. Accessory sphene and opaque minerals.
SO17328..	24	17.27	1.02	1.82	1.88	5.79	.87	.08	4.50	.18	63.74	.47	.54	98.16	106	NA	Coarse-grained, hornblende syenite with sphene, allanite, opaque minerals, and chlorite.
SO16483..	25	14.73	1.84	.98	1.45	4.72	.64	.05	3.58	.13	70.00	.30	.10	98.52	64	6	Seriate biotite-quartz monzonite with accessory chlorite and sphene.
SO10506..	26	17.75	1.77	.98	2.00	4.81	.70	.07	3.53	.11	69.29	.35	.15	98.51	80	9	Coarse-grained, hypidiomorphic quartz monzonite with hornblende, biotite, and accessory sphene, allanite, and opaque minerals.

LOI Loss on ignition. NA Not analyzed.
[1]Inductively coupled plasma analyses, Technical Services Laboratories, Mississauga, Ontario.
[2]X-ray fluorescence analyses, Bondar-Clegg, Lakewood, CO.
[3]Fluorometric analyses, Bondar-Clegg, Lakewood, CO.

NOTE.—Sample locations are shown in figure A-1.



Base from U.S.G.S. 1:250,000 scale Bendeleben and Solomon quadrangles

Figure A-1.—Major oxide rock sample locations.

Table A-2.—Major oxide,[1] thorium,[2] and uranium[3] analyses and descriptions of granitic dike rocks from the Darby Moutains

Sample	Map No.	Plasma analysis, wt pct													U, ppm	Th, ppm	Description
		Al_2O_3	CaO	FeO	Fe_2O_3	K_2O	MgO	MnO	Na_2O	P_2O_5	SiO_2	TiO_2	LOI	Total			
SO17525..	6	14.67	6.14	4.34	3.83	2.66	6.94	0.18	3.59	0.32	52.24	0.98	2.00	97.86	NA	NA	Very fine grained, panidiomorphic hornblende lamprophyre with carbonate minerals, talc, and opaque minerals replacing pyroxene phenocrysts.
SO17586..	10	15.68	6.24	3.50	3.44	3.63	4.92	.14	2.95	.67	52.60	.94	2.73	99.38	12	73	Chloritized fine-grained porphyritic biotite-pyroxene-hornblende lamprophyre.
SO16863..	14	16.20	3.10	NA	6.10	3.60	2.10	.13	3.90	.24	62.00	.35	NA	98.27	68	12	Green, fine-grained, carbonate altered, porphyritic dike rock.
SO16566..	16	16.21	8.01	3.78	4.18	2.20	7.17	.15	3.08	.44	48.81	1.20	2.38	99.04	62	3	Altered fine-grained, panidiomorphic hornblende-biotite lamprophyre with plagioclase altered to epidote and clay minerals. Minor carbonate minerals and 2 pct opaque minerals.
SO16567..	17	17.70	7.08	3.78	3.84	2.29	4.45	.13	3.40	.73	50.75	1.11	3.93	99.13	69	7	Altered, fine-grained hornblende-biotite lamprophyre with carbonate minerals, talc, chlorite, and opaque minerals replacing pyroxene phenocrysts.
SO16568..	18	19.58	1.13	.56	6.29	5.86	.55	.18	3.00	.87	55.40	1.25	3.37	97.77	NA	3	Altered fine-grained hornblende biotite lamprophyre with 5 pct opaque minerals.
SO16532..	27	14.84	5.74	3.50	1.51	2.86	4.52	.11	3.18	.20	61.68	.76	.37	98.82	70	4	Porphyritic dike rock with altered phenocrysts of biotite, hornblende, and plagioclase. Biotite reaction rim around corroded quartz xenocrysts. Abundant fine-grained, acicular amphibole. Accessory sphene, apatite, and opaque minerals.

NA Not analyzed.
[1]Inductively coupled plasma analyses by Technical Services Laboratories, Mississauga, Ontario.
[2]X-ray fluorescence analyses, Bondar-Clegg, Lakewood, CO.
[3]Fluorometric analyses, Bondar-Clegg, Lakewood, CO.

NOTE.—Sample locations are shown in figure A-2.

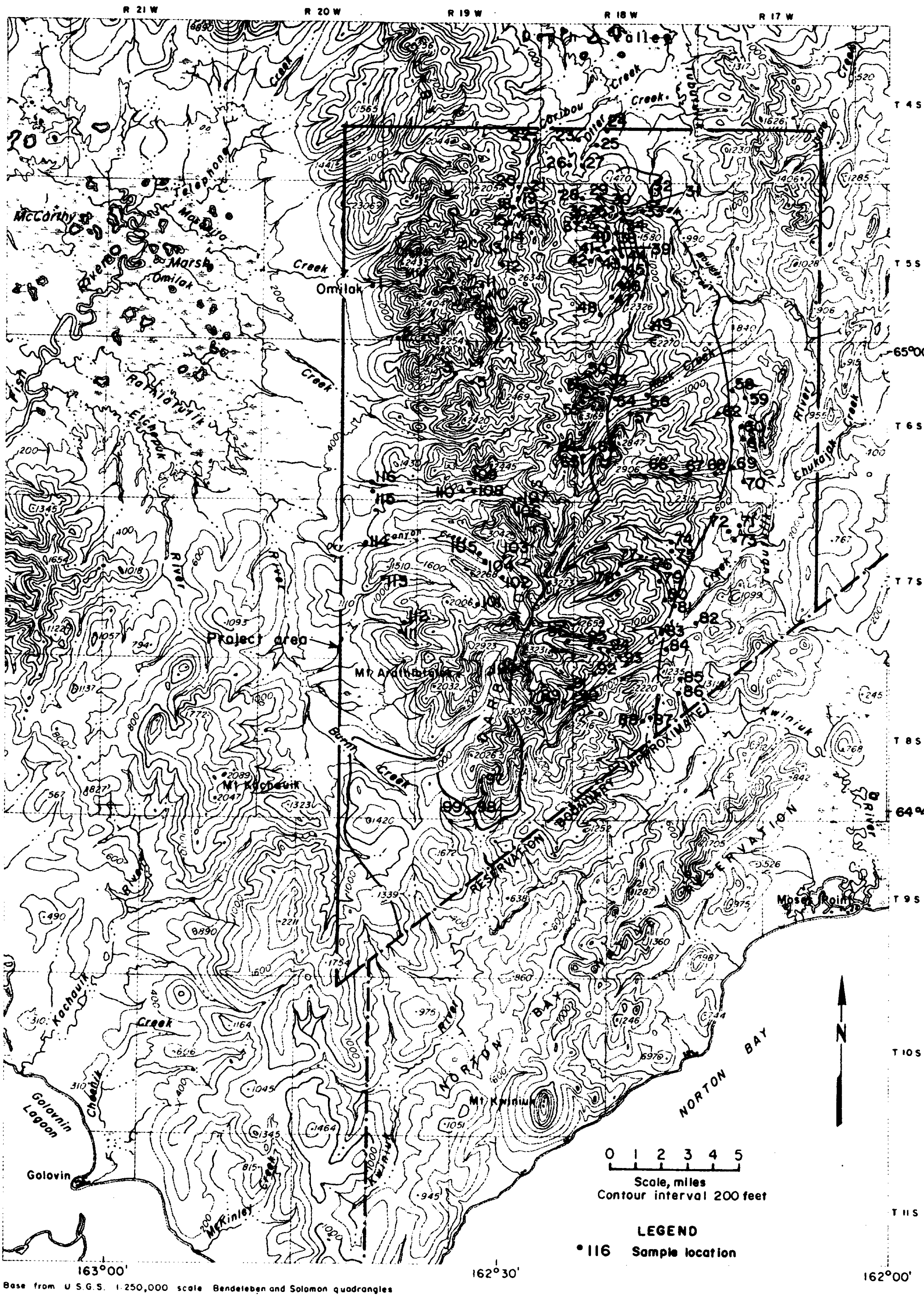


Figure A-2.—Panned concentrate sample locations.

Table A-3.—Analyses of panned concentrates from the Darby Mountains

Sample	Map No.	Original sample size, ft³	Recovered concentrate, g	Analyses,[1] ppm Cb	Sn	Th	U	W
SB17595...	1	0.17	12.9	ND	500	ND	ND	D
SB17598...	2	.17	6.0	ND	D	ND	ND	ND
SO17225..	3	.17	9.1	ND	ND	ND	ND	ND
SO17221..	4	.17	7.0	ND	ND	ND	ND	ND
SO17227..	5	.17	19.2	D	ND	ND	D	ND
SB17208...	6	.17	13.4	ND	ND	ND	ND	ND
SB17210...	7	.17	16.3	D	D	ND	ND	ND
SB16919...	8	.17	5.6	ND	ND	ND	ND	ND
SB16921...	9	.17	9.1	ND	ND	ND	ND	ND
SB16923...	10	.17	11.1	ND	ND	ND	ND	ND
SB16925...	11	.17	9.5	ND	ND	ND	ND	ND
SB16932...	12	.17	14.0	ND	ND	ND	ND	ND
SB16931...	13	.17	11.5	ND	ND	ND	ND	ND
SB16930...	14	.17	7.1	ND	ND	ND	ND	ND
SB16940...	15	.17	16.0	ND	ND	ND	ND	ND
SB16944...	16	.17	11.9	ND	ND	ND	ND	ND
SB16938...	17	.17	10.3	ND	ND	ND	ND	ND
SB16937...	18	.17	8.8	ND	ND	ND	ND	ND
SB16936...	19	.17	10.8	ND	900	ND	ND	ND
SB16935...	20	.17	8.9	ND	ND	ND	ND	ND
SB16934...	21	.17	8.7	ND	ND	ND	ND	ND
SB17247...	22	.17	11.5	ND	ND	ND	ND	ND
SB17232...	23	.17	9.1	D	ND	ND	ND	ND
SB17234...	24	.17	9.4	50	ND	ND	ND	D
SB17237...	25	.17	12.1	ND	5,000	ND	ND	3,000
SB17243...	26	.17	5.3	ND	ND	ND	ND	ND
SB17239...	27	.17	11.0	ND	4,000	ND	ND	6,000
SB17203...	28	.17	13.6	ND	100	ND	ND	1,000
SB17205...	29	.17	13.7	ND	200	ND	ND	2,000
SB15746...	30	.17	8.0	D	D	ND	ND	D
SB16905...	31	.17	7.8	ND	ND	ND	ND	2,000
SB16907...	32	.17	5.4	300	ND	ND	ND	D
SB16918...	33	.17	7.7	100	ND	ND	ND	ND
SB16904...	34	.17	13.4	D	D	ND	ND	D
SB15737...	35	.17	18.5	ND	60	ND	ND	1,000
SB15739...	36	.17	11.8	ND	100	ND	ND	2,000
SB15741...	37	.17	18.6	D	ND	ND	ND	D
SB16903...	38	.17	24.6	ND	600	ND	ND	2,000
SB16969...	39	.17	16.3	D	6,000	ND	ND	D
SB16971...	40	.17	27.9	D	90	ND	ND	900
SB16974...	41	.17	27.9	ND	60	ND	ND	D
SB16978...	42	.17	17.6	ND	ND	ND	ND	D
SB16976...	43	.17	15.5	D	ND	ND	ND	D
SB15747...	44	.17	12.0	D	D	ND	ND	700
SB16912...	45	.17	21.0	ND	200	ND	ND	D
SB16913...	46	.17	30.7	ND	D	ND	ND	D
SB16914...	47	.17	8.2	ND	ND	ND	ND	ND
SB16916...	48	.17	9.5	ND	ND	ND	ND	ND
SB17545...	49	.17	9.4	200	ND	300	ND	ND
SO17579..	50	.17	9.8	ND	ND	ND	ND	ND
SO17578..	51	.17	11.2	ND	ND	ND	ND	ND
SO17576..	52	.17	4.9	ND	ND	ND	ND	ND
SO16301..	53	.34	13.7	80	ND	ND	ND	3,000
SO17574..	54	.17	6.7	D	ND	ND	ND	ND
SO17635..	55	.17	5.8	300	ND	ND	ND	ND
SO17534..	56	3.2	48.9	D	ND	ND	ND	ND
SO17536..	57	.17	12.9	300	ND	ND	ND	ND
SO17638..	58	.17	7.5	500	ND	ND	ND	ND
SO17548...	59	0.17	8.2	500	ND	ND	ND	ND
SO15718...	60	.17	5.6	800	100	D	ND	ND
SO15716...	61	.17	12.4	400	D	D	ND	ND
SO16460...	62	.17	9.0	200	ND	ND	ND	ND
SO17527...	63	.17	3.7	300	ND	300	200	D
SO17531...	64	.51	23.3	D	ND	ND	ND	ND
SO17529...	65	.51	17.3	D	ND	ND	ND	ND
SO17360...	66	.51	6.1	200	ND	D	ND	ND
SO16888...	67	.17	11.2	200	ND	D	ND	D
SO15712...	68	.17	7.7	300	ND	D	ND	D
SO16839...	69	.17	4.2	400	ND	300	300	D
SO16843...	70	.17	10.3	D	ND	ND	ND	ND
SO16893...	71	.17	10.7	400	ND	D	ND	ND
SO16594...	72	.17	4.9	700	ND	200	400	ND
SO16592...	73	.17	10.4	200	ND	D	ND	ND
SO16239...	74	.17	3.3	400	D	200	ND	ND
SO16241...	75	11.5	100.0	200	100	300	200	ND
SO10484...	76	.17	27.5	200	ND	D	ND	1,000
SO10496...	77	.17	24.9	200	D	200	ND	2,000
SO19498...	78	.17	13.6	300	D	100	ND	1,000
SO10482...	79	.17	14.2	400	ND	100	ND	D
SO10479...	80	.17	18.6	100	ND	200	ND	D
SO10493...	81	.68	47.8	200	D	D	ND	D
SO16953...	82	.17	12.1	300	ND	400	ND	ND
SO16577...	83	4.0	118.6	D	ND	D	ND	ND
SO16560...	84	.17	10.2	300	D	D	ND	ND
SO17332...	85	.17	17.8	200	ND	ND	ND	ND
SO17330...	86	.17	7.3	D	ND	D	ND	ND
SO16950...	87	.17	7.9	D	ND	ND	ND	ND
SO16948...	88	.17	6.0	D	ND	D	ND	ND
SO10489...	89	.17	14.2	200	ND	300	ND	ND
SO17507...	90	6.0	76.7	D	ND	ND	ND	ND
SO10487...	91	.17	20.5	300	ND	200	ND	ND
SO10491...	92	.17	5.6	200	ND	200	ND	ND
SO16578...	93	4.8	447.1	D	ND	D	ND	ND
SO10473...	94	.51	74.1	100	ND	300	ND	ND
SO10475...	95	.51	24.7	200	ND	D	ND	ND
SO10476...	96	.51	9.2	300	ND	100	ND	ND
SO16527...	97	.17	4.8	D	ND	ND	ND	ND
SO16529...	98	.17	22.4	D	300	ND	ND	ND
SO16531...	99	.17	16.7	D	ND	ND	ND	ND
SO16551...	100	.17	15.4	100	200	ND	ND	ND
SO16553...	101	.17	10.6	D	200	ND	ND	ND
SO16399...	102	.17	15.6	D	1,000	ND	ND	D
SO16393...	103	.17	30.1	D	ND	ND	ND	ND
SO16397...	104	.17	21.6	D	ND	ND	ND	ND
SO16395...	105	.17	12.3	D	D	ND	ND	ND
SB18121...	106	.17	14.8	ND	50	ND	ND	ND
SB18110...	107	.17	14.1	D	D	ND	ND	ND
SB18250...	108	.17	9.9	ND	ND	ND	ND	ND
SB18247...	109	.17	10.2	ND	ND	ND	ND	ND
SB18501...	110	.17	18.2	ND	50	ND	ND	ND
SO16511...	111	.17	18.6	D	600	ND	ND	ND
SO16509...	112	.17	18.0	D	ND	ND	ND	ND
SO16507...	113	.17	11.2	D	ND	ND	ND	ND
SO16505...	114	.17	12.5	D	500	ND	ND	ND
SB16502...	115	.17	10.1	ND	600	ND	ND	ND
SO16503...	116	.17	34.6	D	D	ND	ND	ND

D Near detection level. ND Not detected.

[1]Detection limits for the elements listed were variable, depending on matrix absorption and enhancement effects, peak convolution problems, and system peaks. Approximate detection limits were as follows, in parts per million: Cb, 50 to 200; Sn, 50; Th, 100 to 500; U, 100 to 1,000; and W, 500 to 1,000.

NOTE.—Analyses by Bureau of Mines Juneau, AK, laboratory using semiquantitative X-ray fluorescence procedures. Sample locations are shown in figure A-2.