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Characterization of Ketchem Dome Tin Prospect, East-Central Alaska

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UNITED STATES DEPARTMENT OF THE INTERIOR

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

ft	foot	oz/st	troy ounce per short ton
in	inch	pct	percent
lb	pound	ppm	part per million
μm	micrometer	wt pct	weight percent
m.y.	million years		

CHARACTERIZATION OF KETCHEM DOME TIN PROSPECT, EAST-CENTRAL ALASKA

By D. C. Dahlin,[1] L. L. Brown,[2] and J. D. Warner[3]

ABSTRACT

The Bureau of Mines investigated the Ketchem Dome tin prospect in east-central Alaska to evaluate the tin resource. The studies included field investigations, mineralogical characterization, and concentration of the tin-bearing minerals. The tin mineralization consists of cassiterite (SnO_2), which occurs as grains disseminated in a greisen (quartz-mica) matrix. A bulk sample from the largest and best-developed greisen vein exposed at Ketchem Dome contained 0.51 pct Sn. Concentration of the cassiterite by gravity table methods resulted in a product that contained 56 pct of the tin at a grade of 41.4 pct Sn. The mineralization exposed at Ketchem Dome is typical of greisen found in the area and elsewhere in interior Alaska.

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INTRODUCTION

Tin is a relatively scarce element in the Earth's crust, but it is an indispensable material in many industrial applications. It is used as a protective coating for metals such as tinplate and as an alloying element in solders, bronze, babbitt, and other metals. The primary end-uses of tin in the United States are cans and other containers, chemicals, machinery, electrical equipment, and applications in transportation and construction. Tin has strategic importance in solders for sophisticated defense electronics equipment and computers and in military vehicles, containers, parts, and fittings (1).[4]

Although the United States is considered to be the world's major consumer of tin and the largest producer of secondary tin, domestic primary tin production is almost entirely from imported ore, primarily from Southeast Asia and South America (2). Only a small fraction of the U.S. tin requirement is met by domestic mines, and domestic reserves are small.

In October 1985, the economics of producing and marketing tin on the world market dramatically changed. At that time, the International Tin Council, formed by major producers and consumers of tin to stabilize supply and prices, ran out of funds to support the price of tin, and, consequently, the price dropped to approximately half its former value (3). The lower prices had a significant negative effect on high-cost operations such as the old, underground mines in Bolivia and the gravel-pump operations that have accounted for about two-thirds of the production from Malaysia. All producers reevaluated their tin mining industries, and mines were closed in Australia, Bolivia, Malaysia, Thailand, and the United Kingdom (4-5). Lower tin prices would benefit the United States, and U.S. consumption is expected to show slower growth between 1986 and 1993. However, the uncertainty of foreign sources dictates that domestic resources be evaluated for their potential.

The Bureau of Mines has a continuing program for investigating critical and strategic mineral resources in the United States. Warner (6) provided a detailed summary of the Bureau's efforts to identify tin, tantalum, and columbium resources in Alaska and presented an extensive list of references. Alaska contains both placer and lode tin occurrences. Historically, most of the State's tin production has been from placer deposits on the Seward Peninsula, but lode deposits account for most of the reserves and resources. The lode occurrences can be categorized in five groups, as follows: greisen, vein, skarn, pegmatite, and volcanogenic massive sulfide. The Ketchem Dome prospect is a greisen occurrence.[5]

This report describes a preliminary evaluation of the tin resource at Ketchem Dome, an established tin prospect with good exposure of the mineralization. The study was done because the prospect is thought to be typical of similar occurrences in the area and in other parts of interior Alaska. Also, the form, alteration mineralogy, geologic setting, and the tin head grade indicate that it is similar to greisen veins mined elsewhere in the world.

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[4]Underlined numbers in parentheses refer to items in the list of references at the end of this report.

[5]"Greisen" refers to hydrothermally altered granitic rock composed primarily of quartz, mica, and topaz. The mica is usually muscovite or chlorite; among the common accessory minerals are tourmaline, fluorite, rutile, cassiterite, and wolframite.

LOCATION AND PROSPECT HISTORY

The Ketchem Dome tin prospect is located approximately 5 miles southwest of Circle Hot Springs in the north-central portion of the Circle (B-2) Quadrangle, in east-central Alaska (fig. 1). The prospect lies 1 mile to the west of, and approximately 1,300 ft above, a gravel road the leads north to a year-round road between Central (90 miles northeast of Fairbanks on the Steese Highway) and Circle Hot Springs.

The Ketchem Dome area was originally staked in 1977 by Resource Associates of Alaska, Inc., Fairbanks, AK (7), which optioned the property to Houston Oil and Minerals Co. (now Tenneco Minerals Co., Lakewood, CO). Geologists with Houston Oil and Minerals Co. located tin-bearing greisen vein mineralization on a small ridge extending northeastward from the northern flank of Ketchem Dome (figs. 2-3). The option on the property was subsequently dropped by Houston and acquired by an individual placer gold miner from Fairbanks. Bureau geologists mapped and sampled the Ketchem Dome prospect in 1984.

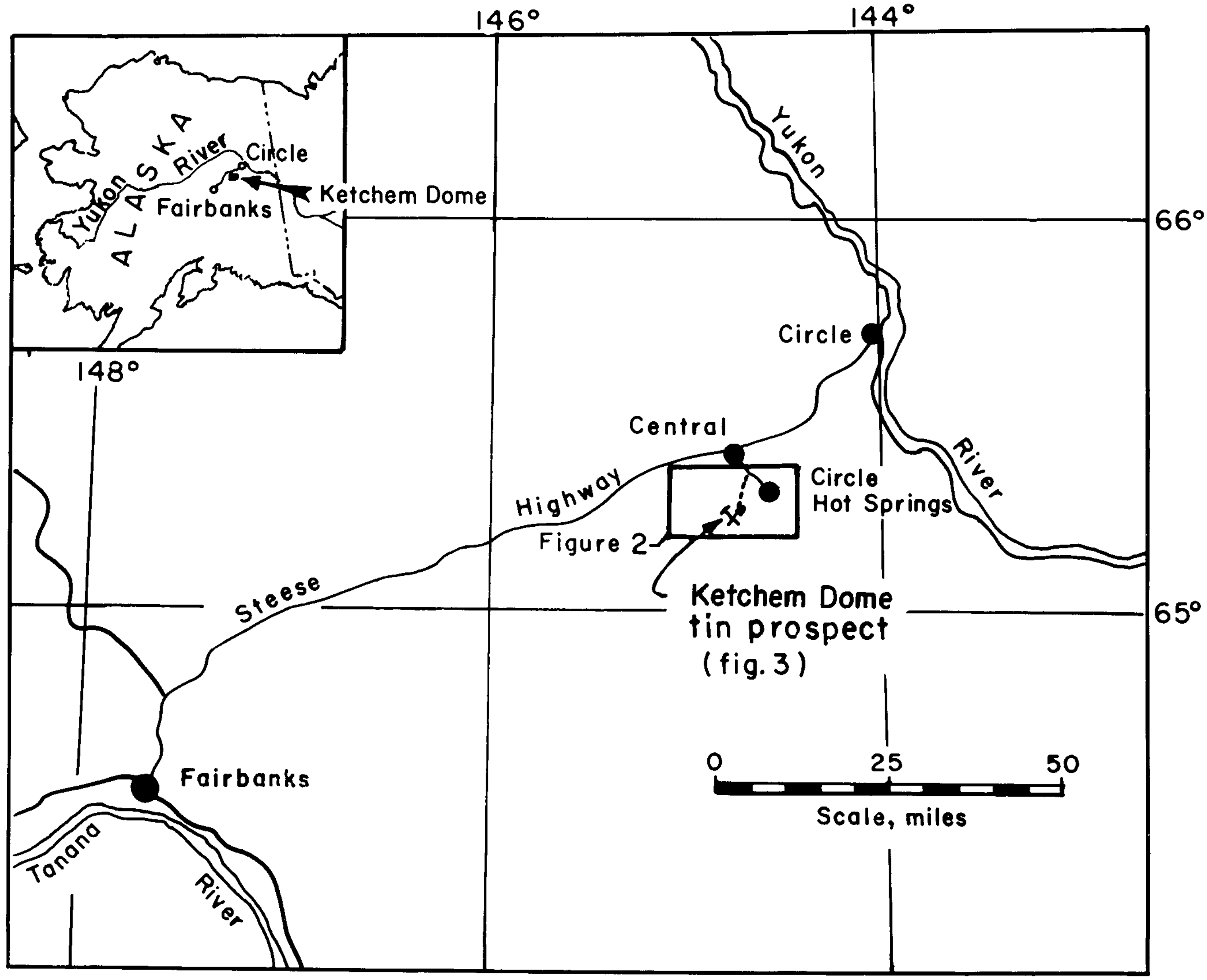


FIGURE 1.—Location of Ketchem Dome tin prospect.

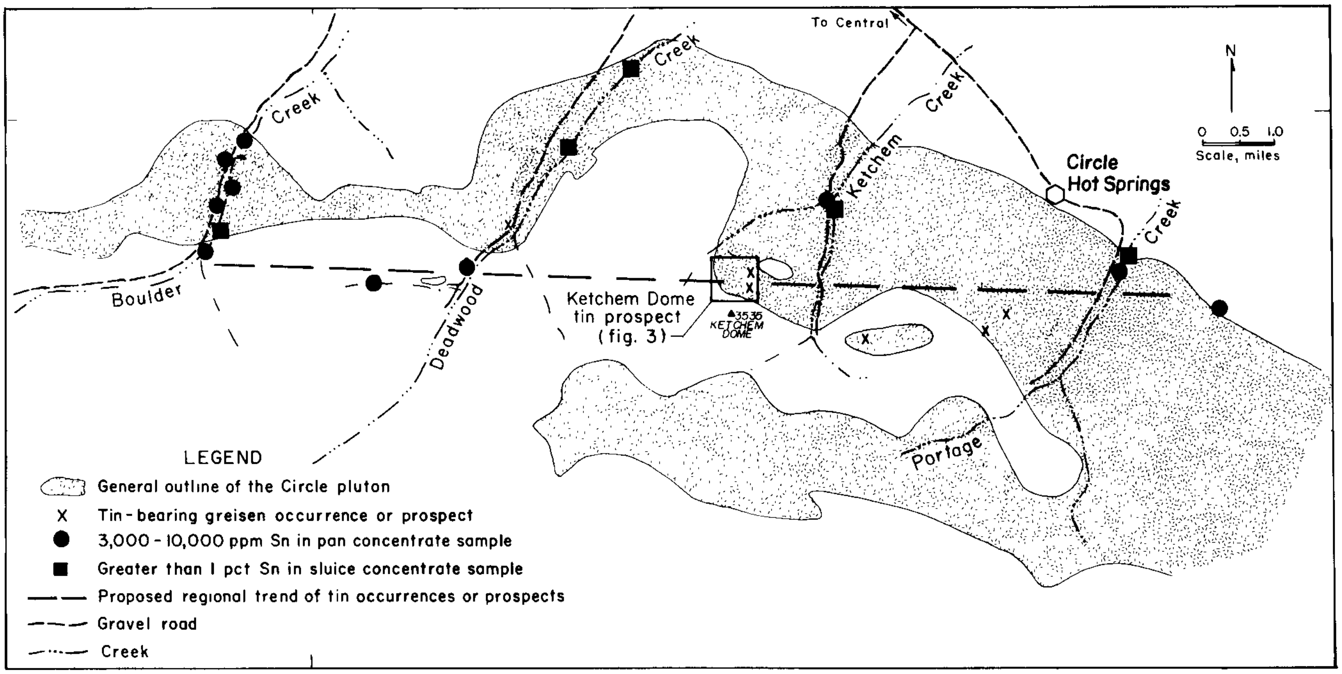


FIGURE 2.—Generalized outline of a portion of the Circle intrusion showing location of tin occurrences and proposed regional trend.

GEOLOGY

Tin-bearing greisen vein mineralization near Ketchem Dome cuts a leucocratic (light-colored) seriate phase of the Circle Hot Springs biotite granite pluton near its contact with hornfelsed sedimentary rocks of Paleozoic and/or Precambrian (?) age (8, figs. 2-3). The pluton is a deeply eroded composite intrusion that forms a crudely horseshoe-shaped outcrop pattern that extends approximately 8 miles to both the northwest and southeast from Ketchem Dome and has been dated at 60.5±1.8 m.y. by the potassium-argon method (9). One thin section of the leucocratic phase of the pluton collected near Ketchem Dome contained approximately 36 pct quartz, 33 pct orthoclase, 26 pct plagioclase (oligoclase), and 5 pct biotite. Minor amounts of accessory muscovite and possibly topaz, as well as fluorite, zircon, and opaque minerals were also observed.

Four hand-excavated trenches expose the greisen vein near Ketchem Dome (fig. 3). The greisen is mineralogically zoned, with a selvage of muscovite-altered granite that grades into a core of dense, black, chlorite- and sericite-altered granite with traces of limonite after pyrite and veinlets of quartz. Purple fluorite occurs on fractures, and topaz is locally associated with more pervasive alteration.

The largest and best-developed greisen vein is exposed in the two northern trenches (fig. 3). The vein is 3 ft wide and strikes west-northwest for approximately 20 ft between the two trench exposures and is then lost in rubble on both sides of the ridge. Similar greisen vein material was found in float on strike of the greisen vein to the east, near the gravel road that parallels Ketchem Creek. This suggests that the greisen vein may extend eastward at least 5,000 ft along strike.

The tin mineralization exposed near Ketchem Dome is typical of greisen found elsewhere in the Circle Hot Springs pluton and in interior Alaska. The vein at Ketchem Dome occurs along a proposed regional trend of tin occurrences and

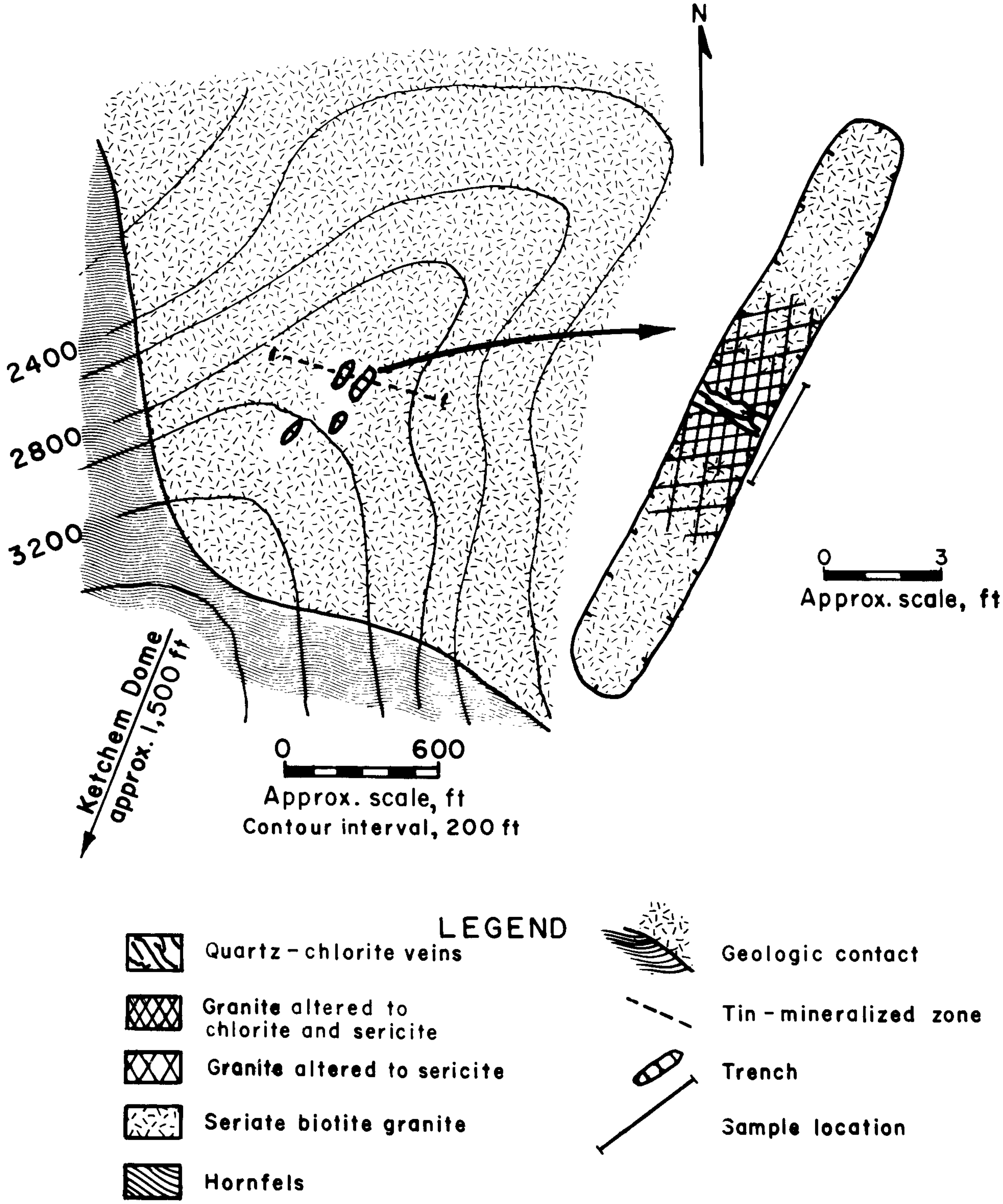


FIGURE 3.—Ketchem Dome prospect with detail of trench.

prospects that is associated with the Circle Hot Springs pluton and extends from Boulder Creek easterly to beyond Portage Creek (fig. 2). This trend includes both tin lode and placer mineralization. Tin lode mineralization along the trend and elsewhere in interior Alaska is typically iron- and chlorite-rich and generally occurs in veins and along faults or shear zones within moderately deeply eroded composite biotite-granite plutons. The mineralized veins or faults are invariably 3 ft or less in width and can usually only be traced along strike for a few tens of feet or less. In some instances, however, several closely spaced greisen veins occur in widths ranging from 10 to 100 ft and may be discontinuously traceable in rubble for several hundred to several thousand feet along strike.

MINERALOGY

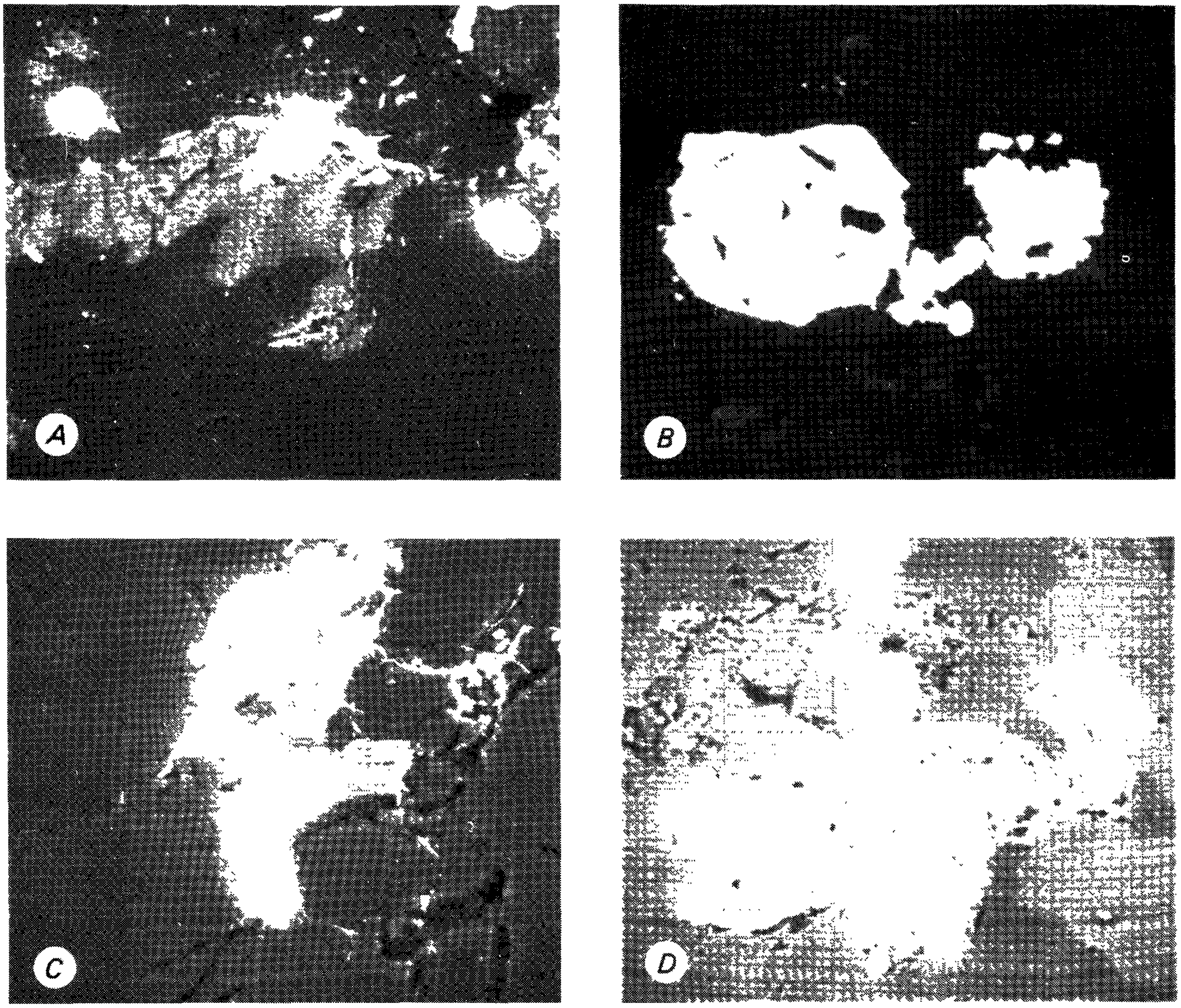
BULK SAMPLE

A 120-lb channel sample was collected from the 3-ft-wide greisen vein exposed in the northeastern trench at Ketchem Dome (fig. 3). Representative hand specimens were selected from the bulk sample for mineralogical characterization studies. The remainder was crushed and split for chemical analysis and physical concentration tests. The head analysis of the bulk sample was, in percent, 0.51 Sn, 72.9 SiO_2, 9.80 Al_2O_3, 7.80 Fe, 2.29 K_2O, 0.15 total rare-earth oxides, 0.02 S, <0.01 Cb, <0.01 Ta, and <0.01 Ce, and, in ounces per short ton: 0.02 Ag, 0.003 Au, <0.0003 Pt, and <0.0003 Pd. The hand specimens consisted primarily of approximately equal amounts of quartz and chlorite with small amounts of a large number of accessory and alteration minerals. The quartz was granular, translucent, and moderately fractured, and the chlorite occurred as dark green to black agglomerations and streaks.

The fine-grained accessory and alteration minerals were scattered throughout the rock. They were associated with both the quartz and the chlorite as inclusions and along grain boundaries and fractures. Although the sample contained 0.5 pct Sn, no cassiterite was observed in the hand specimens. Iron-oxide minerals and stains occurred in small amounts, primarily along healed fractures in the rock, and a few random clots of sericite were observed. One of the specimens contained a small amount of purple fluorite that appeared to be preferentially associated with chlorite masses; the specimen also contained some small grains of muscovite.

Selected portions of the hand specimens were cut and encapulated in plastic mounts, and polished surfaces of the rocks were prepared for scanning electron microscope (SEM) examination and energy-dispersive X-ray analysis (EDXA). Essentially the same mineralogy was determined as described above. However, a few small grains of cassiterite were disseminated in both the quartz and the micas (chlorite and muscovite). The cassiterite grains in the quartz ranged up to about 100 µm in diameter, while those associated with the micas were generally much smaller (from 1 to 40 µm, with most in the smaller end of the range).

Many of the fine-grained accessory and alteration minerals were examined and chemically analyzed with the SEM. Figure 4 shows examples of some of the accessory minerals in the rock matrix. Some of the minerals could be named, but others were unidentifiable because their compositions do not correspond to those of any known minerals. These unidentified particles may not warrant new mineral names, but they are chemically unique. Minerals found in the polished surfaces of the rock included apatite, barite, calcium-cerium oxide, cerium-iron phosphate, chalcopyrite, chromite, columbium-tantalum multiple oxides (ferrocolumbite, kobeite, petschekite, tapiolite, yttrocolumbite, and others), garnet (almandite), monazite, pyrite, pyrrhotite, thorite, thorium oxides, thorium phosphate, uranium oxides, yttrium and other rare-earth oxides, and zircon. (The



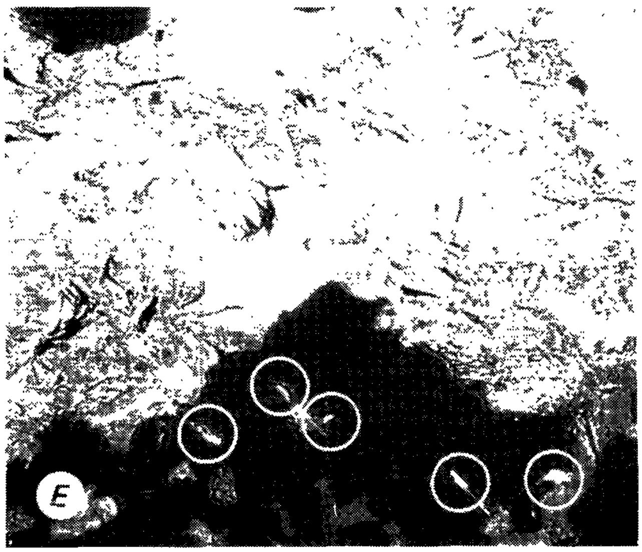


FIGURE 4.—SEM photomicrographs of some of the accessory minerals in the rock matrix. *A*, Cassiterite (circled) with feldspar (light), muscovite (gray), and quartz (black) (X 250); *B*, cassiterite in quartz (X 400); *C*, two multiple-oxide minerals that contain uranium in quartz (X 500); *D*, yttrium-cerium phosphate (light) on apatite (light gray) in feldspar (dark gray) and quartz (black) (X 500); *E*, columbium-tantalum minerals (circled) with feldspar (light), muscovite (bladed gray), and quartz (black) (X 200).

order of abundance could not be accurately established because of the small amounts involved, so the minerals are listed alphabetically.)

TIN CONCENTRATE

The tin concentrate prepared from the bulk greisen sample consisted of, in percent, 55 cassiterite, 20 chlorite, 15 quartz, 4 iron-oxide minerals, 2 sulfides, and 2 apatite, and trace amounts of garnet, barite, ilmenite, magnetite, and fluorite. Other trace minerals were present but were not identified. Figure 5 shows an SEM photomicrograph of the tin concentrate with corresponding tin, iron, and silicon distribution maps. Bright areas in each map indicate element concentrations.

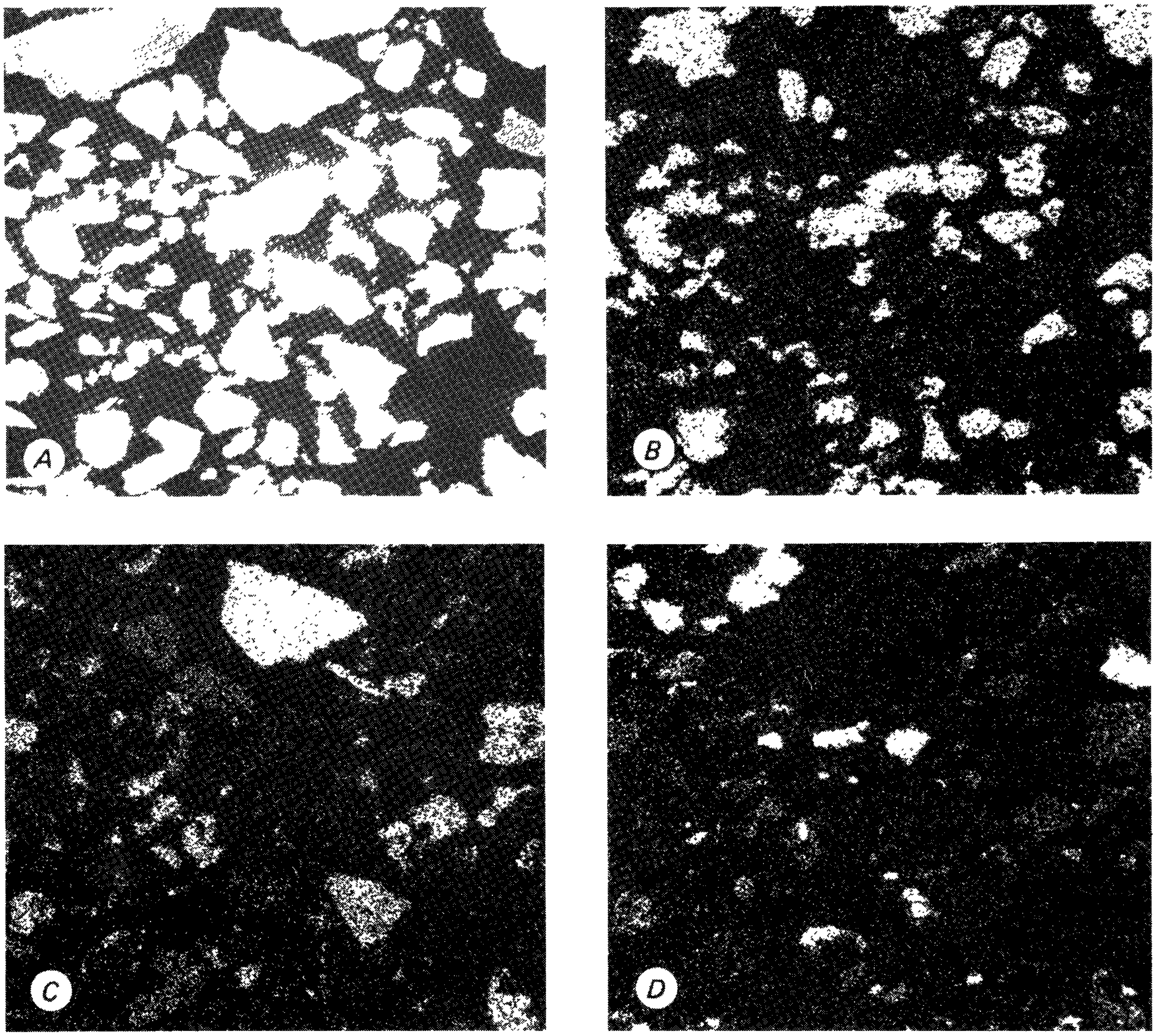


FIGURE 5.—SEM photomicrograph (*A*) and element distribution maps (*B* tin; *C* iron; *D* silicon) of the tin concentrate (X 120).

EDXA of six randomly selected cassiterite grains in a polished surface prepared from the concentrate gave the following results:

Cassiterite grain	SnO_2	Cb_2O_5	Fe_2O_3	Al_2O_3
1.............	98.2	0.89	0.13	0.79
2.............	97.1	1.21	ND	1.67
3.............	97.1	.57	.25	2.09
4.............	98.5	ND	.50	1.00
5.............	97.6	1.42	ND	.99
6.............	97.3	.34	.64	1.41

ND Not detected.

Although one would expect the cassiterite composition to be relatively uniform within a deposit, the grains showed a relatively wide range in the amounts of substituted or included elements.

Although liberation was good at 100 mesh, some of the cassiterite was locked with other minerals present in the concentrate. SEM images of polished surface mounts prepared from the concentrate showed cassiterite locked in particles less than 1 μm in size. Figure 6 shows cassiterite grains intimately locked with gangue.

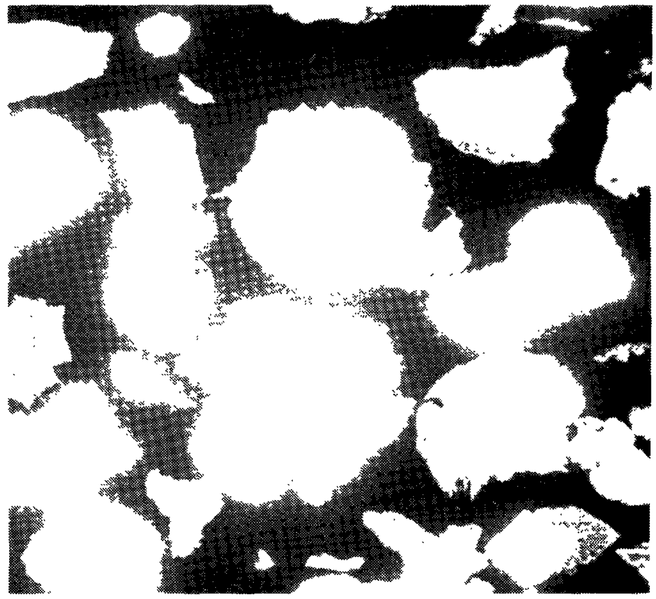


FIGURE 6.—Cassiterite (light) locked with iron and silicate gangue (X 180).

CONCENTRATION RESULTS

A gravity concentration test was conducted on the bulk sample of the tin-bearing greisen. The sample was stage-ground in rod mills to pass 100 mesh, but elaborate steps were not taken to prevent overgrinding. The size distribution of the ground sample is shown in table 1. The ground sample was then tabled on a slime deck of a wet shaking table to produce a rougher concentrate, coarse table tailings (those that settled and banded on the table), and slime tailings (those that washed off the table without settling). Recovery of concentrate was emphasized over concentrate grade. The rougher concentrate was tabled again in a cleaner step to produce the final tin concentrate. Concentrate grade was emphasized over recovery in the cleaner step. A flowsheet of the test procedure is shown in figure 7, and the results of the test are shown in table 2.

TABLE 1. - Size distribution of the rougher table feed

Size, mesh	wt pct	Cumulative wt pct retained
Plus 150......	27.9	27.9
150 by 200....	15.4	43.3
200 by 270....	6.5	49.8
270 by 400....	16.9	66.7
400 by 500....	6.8	73.5
Minus 500.....	26.5	100.0

The cleaner table concentrate contained nearly 56 pct of the tin at a grade of 41.4 pct Sn. These values compare favorably to those obtained from lode deposits in commercial operations. Although placer concentrates may be nearly pure cassiterite (70 to 75 pct Sn), concentrates from lode deposits are substantially lower in grade and may contain only 15 to 20 pct Sn. Recoveries range

TABLE 2. - Table concentration of the Ketchem Dome greisen bulk sample

Product	wt pct	Sn, pct	
		Analysis	Distribution
Rougher concentrate:			
Cleaner concentrate[1].....	0.7	41.4	55.9
Cleaner tailings.........	5.9	1.63	18.5
Rougher coarse tailings....	62.6	.08	9.6
Rougher slime tailings.....	30.8	.27	16.0
Composite or total......	100.0	.52	100.0

[1]Additional analyses, in pct: 11.2 Fe, 10.1 SiO_2, 2.95 Al_2O_3, 1.30 S, 0.40 F, 0.21 W, 0.19 total rare-earth oxides, 0.06 Cb, 0.05 Ce, <0.01 Ta; in oz/st: 0.01 Ag, 0.006 Au, <0.0003 Pt, and <0.0003 Pd.

from 50 to as much as 65 pct in sophisticated operations, but slime losses are a major problem (10).

The cleaner tailings contained an additional 18.5 pct of the tin that conceivably could be recovered using a more elaborate flowsheet. The rougher fine tailings contained 16 pct of the tin, and table 3 shows the size distribution. Because cassiterite is a brittle mineral, recovery might also be improved by more precise control of the grinding to prevent excessive fines and/or by treating the slime tailings on gravity or other equipment more suitable to fine-particle treatment than shaking tables.

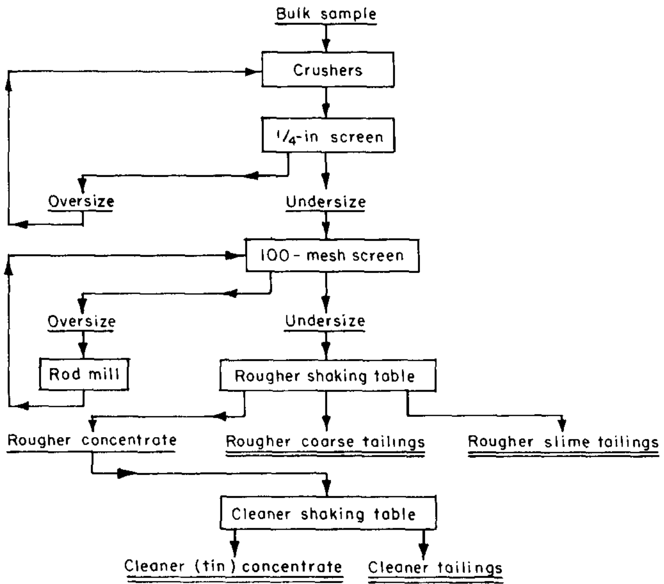


FIGURE 7.—Procedure used to concentrate the bulk sample.

TABLE 3. - Size distribution of the rougher table slime tailings

Size, µm	wt pct less than size
106..........................	100.0
75..........................	98.0
53..........................	92.4
38..........................	83.5
27..........................	72.5
19..........................	57.9
13..........................	44.7
9.4.........................	32.9
6.6.........................	20.9
4.7[1].....................	11.7

[1]Instrument does not analyze minus 3.3-µm particles.

CONCLUSIONS

The Bureau of Mines completed a preliminary evaluation of the tin resource at Ketchem Dome in east-central Alaska. Tin occurs as cassiterite in greisen mineralization that contains a large number of accessory minerals in small amounts. The greisen at Ketchem Dome is typical of greisen found elsewhere in the area and in interior Alaska.

A two-stage gravity concentration test recovered 56 pct of the tin at a grade of 41.4 pct Sn. These values compare favorably with results from commercial lode mining operations. Although optimum conditions and processes were not investigated, the potential exists for higher concentrate grade and better recovery.

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