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UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

REPORT OF INVESTIGATIONS

INVESTIGATION OF THE MOUNT EIELSON ZINC-LEAD DEPOSITS MOUNT McKINLEY NATIONAL PARK, ALASKA

BY

NEAL M. MUIR, BRUCE I. THOMAS, AND ROBERT S. SANFORD

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INVESTIGATION OF THE MOUNT EIELSON ZINC-LEAD DEPOSITS, MOUNT McKINLEY NATIONAL PARK, ALASKA[1]

By Neal M. Muir,[2] Bruce I. Thomas,[3] and Robert S. Sanford[4]

CONTENTS

INTRODUCTION

The presence of the zinc-lead-copper deposits on the north slope of Mount Eielson, Mount McKinley National Park, Alaska, has been known for many years. The deposits were examined by J. C. Reed, a geologist of the United States Geological Survey during the summer of 1931. In the summer of 1943 the authors and Clyde Wahrhaftig, a geologist of the Geological Survey, examined the deposits.

ACKNOWLEDGMENTS

In its program of investigation of mineral deposits, the Bureau of Mines has as its primary objective the more effective utilization of our mineral resources to the end that they make the greatest possible contribution to national security and economy. It is the policy of the Bureau to publish the facts developed by each project as soon as practicable after its conclusion. The Mining Branch, Lowell B. Moon, chief, conducts preliminary examinations, performs the actual investigative work, and prepares

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1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used, "Reprinted from Bureau of Mines Report of Investigations 4121."

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the final report. The Metallurgical Branch, Oliver C. Ralston, chief, analyzes samples and performs beneficiation tests.

Particular acknowledgment is due to Heine Kenworthy, who conducted the beneficiation tests under the supervision of C. Travis Anderson; to Clyde Wahrahaftig of the Geological Survey, who completed the geologic and topographic maps, to Grant Pearson of the National Park Service; and to O. M. Grant and Mrs. Frank McGarvey for their assistance during the examination.

LOCATION AND ACCESSIBILITY

Mount Eielson is in south-central Alaska (fig. 1) and lies within the boundaries of Mount McKinley National Park. The zinc-lead deposits are located at approximately 63° 23' 30" north latitude and 150° 20' 00" west longitude (fig. 2).

McKinley Park railroad station is 348 miles north of Seward on the Alaska Railroad. A two-lane gravel highway connects the station with Camp Eielson and continues on to Kantishna. This road, although well-constructed, was built primarily for scenic purposes with occasional steep grades and unnecessary length. The deposits are 2 miles south of a point on the highway that is 70 miles from McKinley Park railroad station.

No road connects the zinc-lead deposits with the highway. A tractor road could be constructed at nominal cost. To obtain favorable grades, the road would start from a point approximately 4 miles northeast of Camp Eielson and would be about 5 or 6 miles long. Thorofare River can be crossed by tractor and trailer on the ice in winter and by fording in summer. During the warmest weather of the summer, haulage would be impeded by high water caused by rapid glacier melting. A tractor road would be sufficient for small mining and milling operation, but a large operation would require a permanent truck road.

PHYSICAL FEATURES AND CLIMATE

Mount Eielson rises just south of the eastward-trending depression that separates the Alaska Range proper from its northern foothill belt. Although it is part of the range, it seems somewhat isolated, being set off by Muldrow Glacier to the west and stream valleys to the north, east, and south.

The north slope of the mountain rises steeply from Copper Mountain bar, an old river bench with an average altitude of 3,500 feet (fig. 2). The mountain is composed of three heavily glaciated peaks (altitudes 5,720; 5,861, and 5,602 feet), which are connected by an east-west trending knife-like ridge. To the north of this ridge two deeply incised cirques flanked by sharp, northward trending ridges are major topographical features. Grant Creek rises in one of these and Granite Creek in the other.

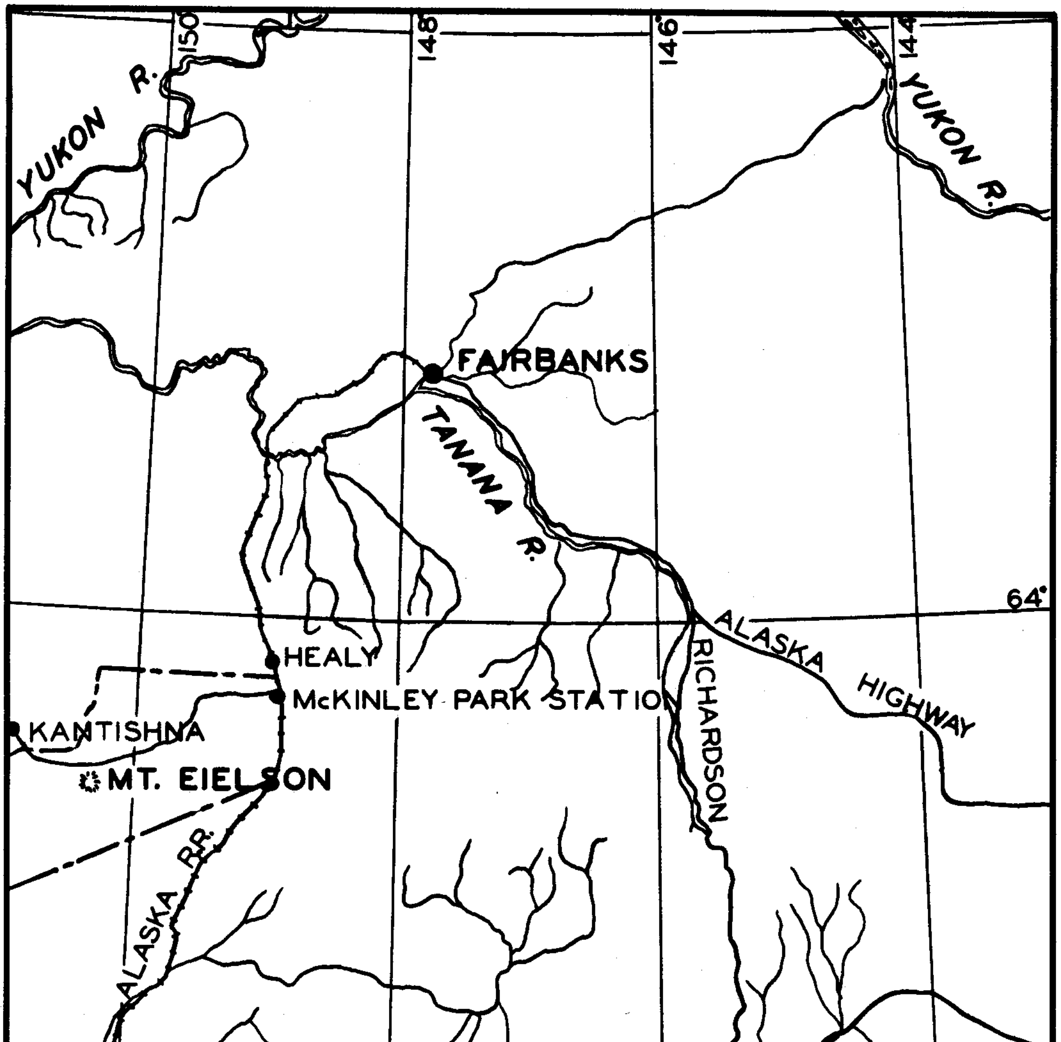

Figure 1. - South-central Alaska.

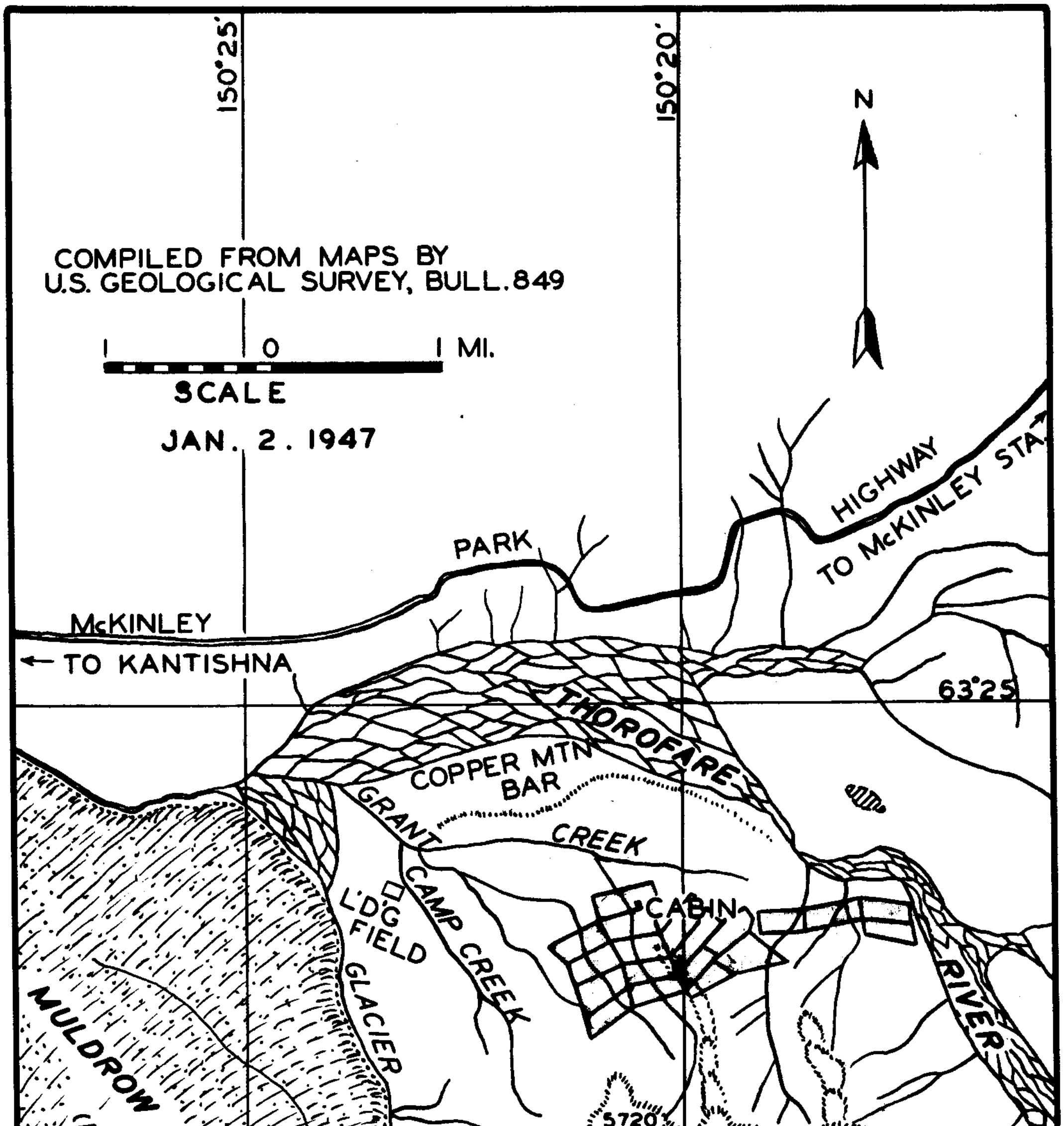

Figure 2. - Mount Eielson and vicinity.

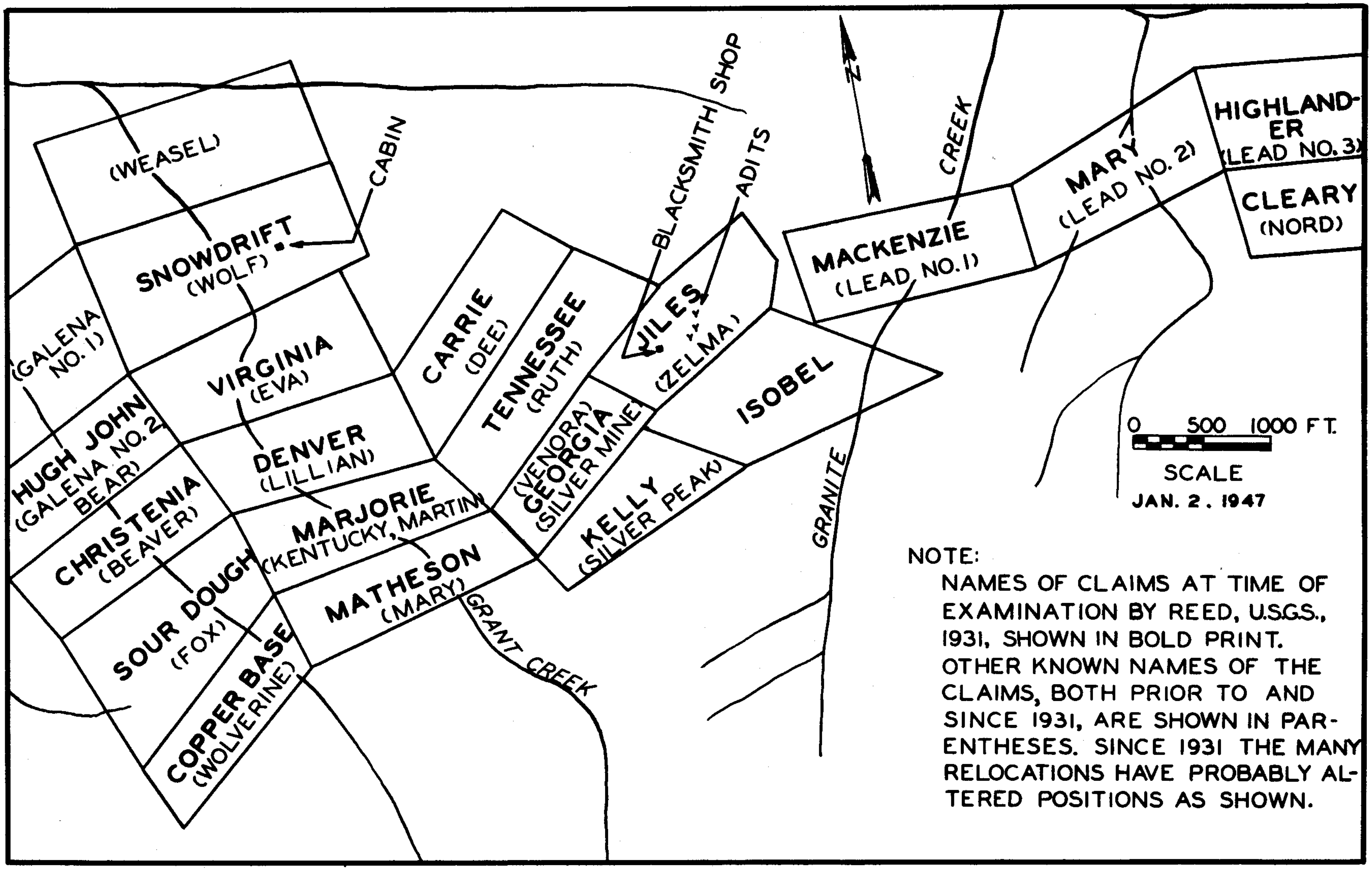

Figure 3. - Claim map, Mount Eielson.

The mineralized zone trends east-west and extends almost 4 miles along the north flank of the mountain immediately above and south of gentle morrainal slopes leading down to the flats of the Thorofare River. The claims lie between altitudes 3,300 and 4,250 feet.

The deposits are above timber line, which is at about 2,000 feet in this region. Only a few shrublike willow and cottonwood trees border Thorofare River and a few of the creeks. All mine timber would have to be brought from low country 20 miles to the north or west. This could be accomplished with tractor-drawn sleds in winter.

Water for milling is available. Grant Creek has flow enough to furnish part of the power for milling during the summer months.

Winters are long and cold and summers are moderate. Precipitation is light, falling mostly as rain during the summer months. McKinley Park station has a comparable geographic position with respect to the Alaska Range, and weather statistics assembled over a period of 7 years are as follows:

Maximum temperature, degrees Fahrenheit	89
Minimum temperature, degrees Fahrenheit ....minus	54
Average number of days per year with temperature over 70 degrees Fahrenheit	41
Average number of days per year with temperature below 32 degrees Fahrenheit	133
Average number of days per year with temperature below 0 degrees Fahrenheit	32
Average annual mean temperature, degrees F.	28.2
Average annual snowfall, inches	59.5
Average annual precipitation, inches	14.38

The climate, while rigorous, would prove no serious hindrance to maintaining year-round underground operations. Mining by open-cut methods would be limited to 8 months a year. Snow is not removed from the park highway at present. Because of the low temperatures, snow is dry and drifts easily so that it is easy to remove, but it would be very difficult to keep the highway open.

HISTORY

The following historical outline was obtained from O. M. Grant, of Fairbanks, Alaska, who has been familiar with the Mount Eielson district since its discovery. The first four mining claims were staked by J. B. and Fannie Quigley in 1920; later that year, two claims were staked by Biglow and Perry. In 1921, O. M. Grant and F. G. Jiles located several claims.

During subsequent years many claims reverted to the public domain, some have been restaked with different boundaries and different names. The claim map (fig. 3) show both the present and former names. As nearly as is known, O. M. Grant, John Anderson, and Mrs. Frank McGarvey, all of Fairbanks, are the present owners.

Very little development work has been done. There are three short adits on the Jiles claim, two of which are caved, and a large number of small prospect pits and open cuts.

There has been no production from the district.

ORE DEPOSITS

General Geology

The general geology of the Mount Eielson district has been summarized by John C. Reed[5] as follows:

> The most widely distributed rocks of the district include a thick series of thin-bedded limestone, calcareous shale, and graywacke of Paleozoic, probably Devonian, age. These sediments are cut by a mass of granodiorite, which forms most of Mount Eielson and which was intruded probably in late Mesozoic time. The intrusive has sent a multitude of dikes and sills into the associated sediments.
>
> Material given off by the granodiorite has permeated the enclosing sediments and selectively replaced them with minerals of the epidote group and to a somewhat lesser extent with sphalerite, galena, chalcopyrite, and pyrite ......
>
> An ore-bearing zone can be definitely traced for about 4 miles along the north side of the granodiorite mass. Its width on the surface is not uniform, but its thickness is about 2,000 feet. Sphalerite is the most abundant sulphide and is several times as abundant as galena. Chalcopyrite is present in minor quantities. The small amount of silver in the ore appears to be irregularly distributed.

According to Clyde Wahrhaftig,[6] the oldest rocks in the vicinity of the ore deposits are limestones, phyllites, and quartzites that have been recrystallized, and some of them have been intensely sheared. In places, the original material has been replaced in part or wholly by hydrothermally introduced material.

A large stock of granodiorite underlies most of Mount Eielson, and dikes from this stock have intruded the sediments in the vicinity of the ore deposits.

5/ Reed, J. C., The Mount Eielson District, Alaska: Geol. Survey Bull. 849(d), 1933, p. 231.

6/ Wahrhaftig, Clyde, Zinc Deposits of the Mount Eielson District, Alaska: U. S. Geol. Survey Information Service Release, June 15, 1944, 7 pp., 6 maps.

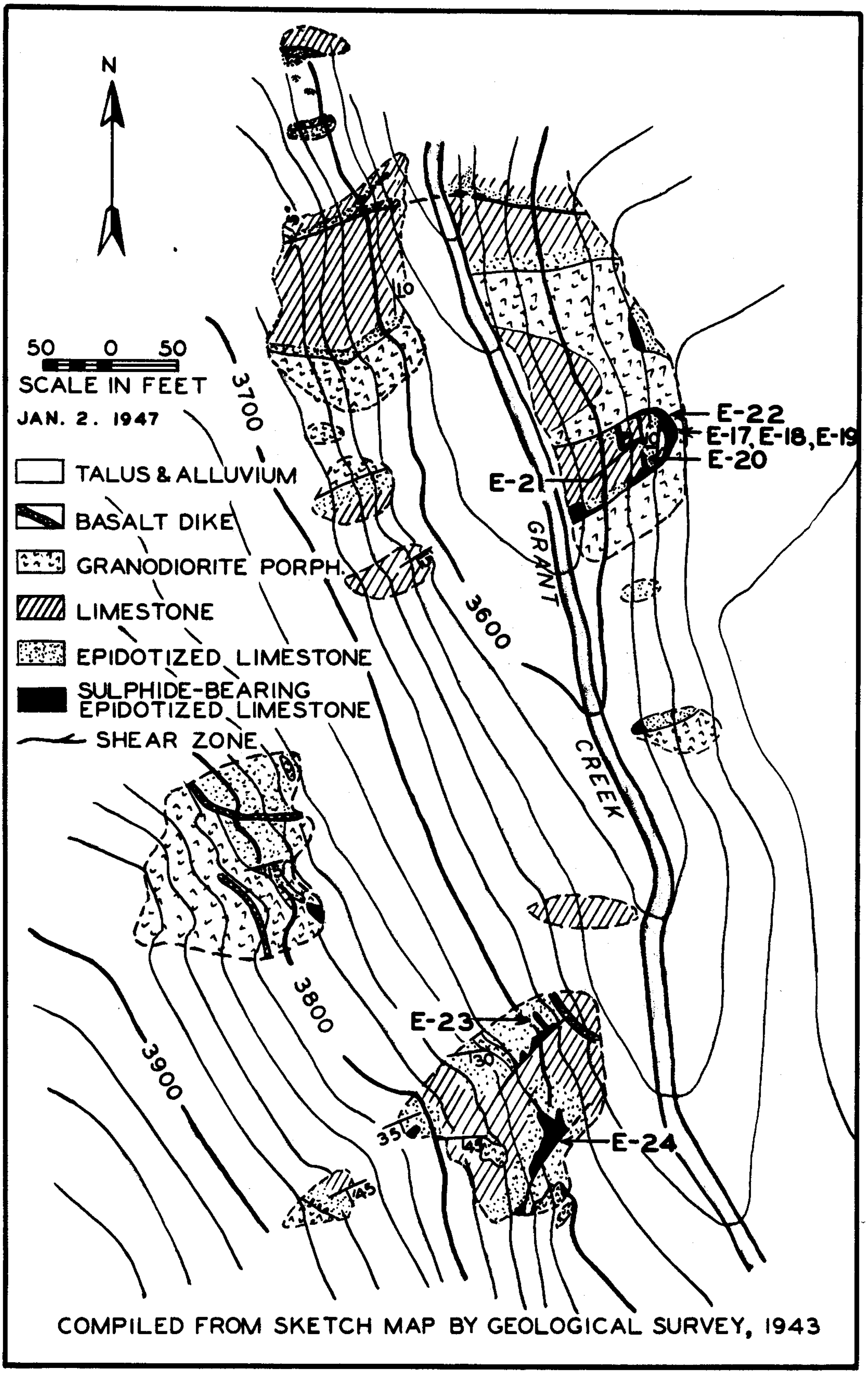

Figure 4. - Virginia and Denver claims.

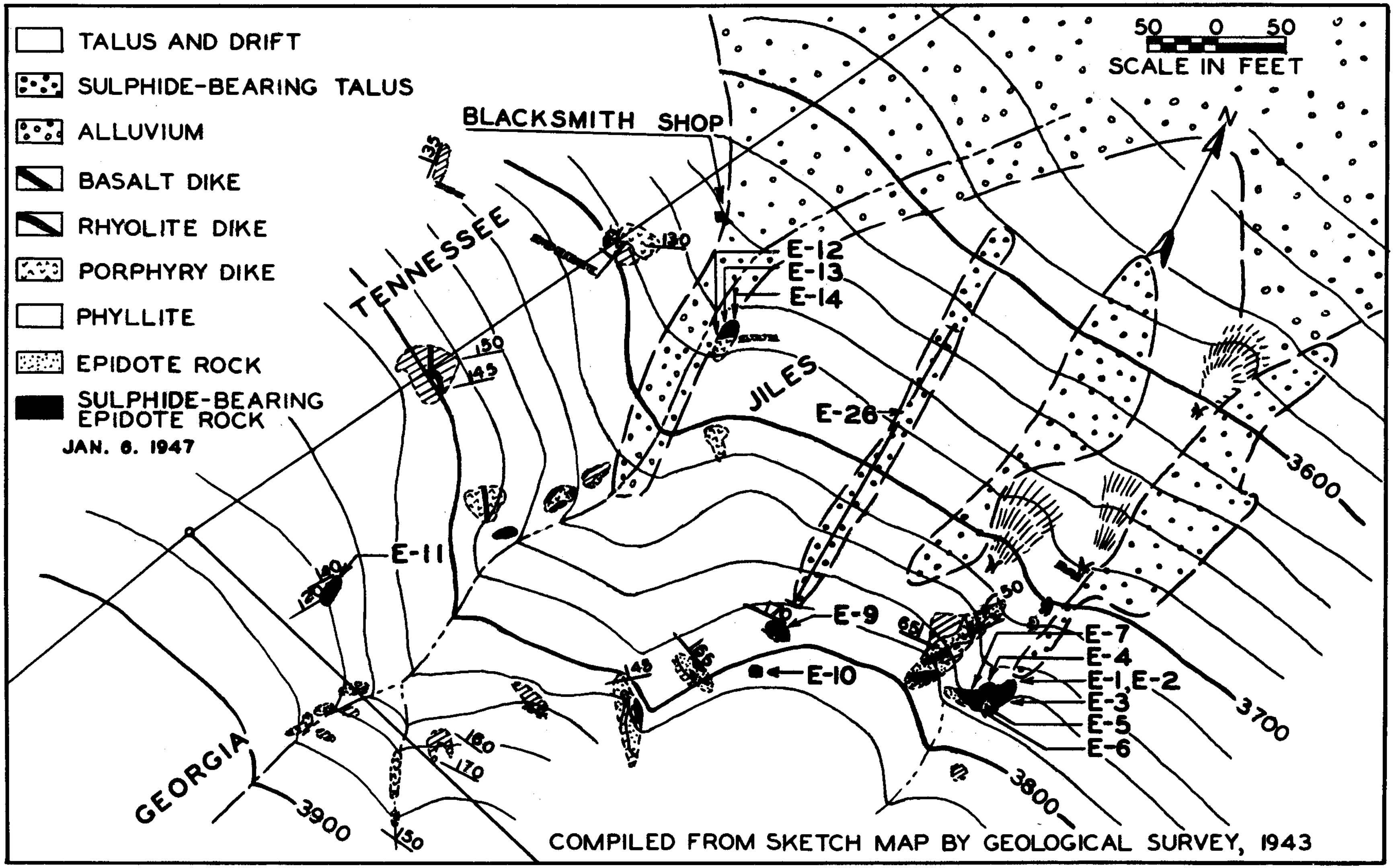

Figure 5. - Jiles and Georgia claims, Mount Eielson.

Structure

On the north slope of Mount Eielson, in the vicinity of the ore deposits, the sediments generally dip toward the north; locally they have been contorted.

The general strike of the dikes in the canyon of Grant Creek is east and the dip is steep or vertical.

Mineralization

Shear zones have been noted in the vicinity of the zinc-lead deposits. They appear to be earlier than or contemporaneous with the intrusions of granodiorite porphyry and quartz-diorite porphyry. Locally, the shear zones have afforded channels for the ore-forming fluids. Other channels were afforded by the contacts of the dikes with the sediments.

During and after the intrusion of the porphyry dikes, quantities of quartz, epidote, and calcite were introduced into the sediments by hydrothermal solutions. Limestone was replaced along contacts and shear zones by hornfels.

Sphalerite, galena, chalcopyrite, and pyrite replaced some of the hornfels and were deposited along fractures and grain boundaries of the rock.

A small amount of supergene alteration has taken place and resulted in the formation of thin crusts and stains of secondary zinc, lead, iron, and copper minerals.

INVESTIGATION BY THE BUREAU OF MINES

The Mount Eielson zinc-lead deposits were examined by the Bureau from July 30, 1943, through August 24, 1943. Camp was established at the Forest Service shelter cabin 1 mile west of the deposit. The program consisted in cleaning out a large number of trenches, test pits, and open cuts. Twenty-three channel samples were cut in surface trenches and pits. Three grab samples were taken from the surface of talus slopes below the outcrops. (See figs. 4 and 5.) These samples were slightly oxidized, and oxidation interfered with the flotation tests that are discussed in the following chapter. An examination of the one adit that is now open indicates that the oxidation is only superficial.

The samples were sent to a private firm for analysis; results are shown in the following table.

TABLE 1. - List of channel samples, Grant property, Mt. Eielson District, Alaska, taken by N. M. Muir, mining engineer, Bureau of Mines, August 1943

Sample	Width vein sampled, feet	Analysis					Name of working	Location	Comments
		Percent			Ounces a ton				
		Lead	Zinc	Copper	Gold	Silver			
E-1	3.0	3.85	5.0	0.15	0.0	1.70	Jiles claim "Big Cut"	East face cut from north wall in southerly extension of main cut.	Fractured, weathered epidote with sphalerite and galena.
E-2	2.4	2.08	6.0	-	-	1.82	do.	Southerly from E-1 to south wall of easterly extension of cut.	Epidote with some sphalerite and galena.
E-3	4.5	2.60	4.6	0.20	0.0	0.74	do.	13 feet west from face of easterly extension of cut on sloping side of cut.	Hard and tough limestone and epidote with sphalerite and galena.
E-4	3.0	4.30	4.7	0.25	0.0	2.00	do.	13 feet west from face of easterly extension; northerly from E-1 to 1 foot above floor of cut.	Hard and tough epidote with considerable galena and sphalerite.
E-5	5.8	1.46	4.0	0.10	0.0	1.34	do.	16 feet west from easterly face on wall of cut 2 feet above floor.	Epidote and altered broken limestone with some galena and sphalerite.
E-6	2.0	4.68	7.5	0.40	0.0	2.14	do.	Southerly from E-5, 5 feet above floor cut.	Weathered, altered limestone and epidote with sphalerite and galena.
E-7	12.5	1.97	3.64	-	-	1.80	do.	From 2.0 feet south of south wall of easterly extension to south end of E-5, taken 1.5 feet above floor of cut.	5 feet of sample carries most of the sulfides 7.5 feet of sample with scattered sulfides.

Continued --

TABLE 1. - List of channel samples, Grant property, Mt. Eielson District, Alaska, taken by N. M. Muir, mining engineer, Bureau of Mines, August 1943 (cont'd.)

Sample	Width vein sampled, feet	Analysis: Percent Lead	Zinc	Copper	Ounces a ton Gold	Silver	Name of working	Location	Comments
E-8	1.5	3.74	4.20	-	-	1.42	Dee claim, Lakeview Cut.	5 feet east of discovery monument.	Chip sample along outcrop.
E-9	1.5	5.82	5.40	-	-	1.70	Jiles claim in Blacksmith Shop Gulch, No. 2 cut.	Cut No. 2 is on line of ridge sample from the face.	Altered material with galena and sphalerite.
E-10	4.0	2.81	3.94	0.25	0.0	1.50	Blacksmith Shop Gulch, Large No. 1 cut is near top of ridge, east side of Gulch.	10 feet below surface.	Limestone with sphalerite, galena, and chalcopyrite.
E-11	6.0	1.14	5.76	-	-	0.64	West side B. S. Gulch Top cut.	Badly broken formation, sample across apparent width.	Epidote, limestone, some galena, and sphalerite.
E-12	4.5	3.20	5.30	0.20	0.0	1.3	East side B. S. Gulch No. 4 or Bottom Cut 80 feet southeast of forge.	North side of cut from epidote band northerly.	Hard and altered epidote and limestone with limonite, sphalerite, and galena.
E-13	2.7	1.25	2.42	0.15	0.0	0.22	East side B. S. Gulch No. 4 or Bottom Cut 80 feet southeast of forge.	Northerly from E-12.	Very hard epidote and limestone.
E-14	5.0	4.10	5.00	0.25	0.0	1.62	East side B. S. Gulch No. 4 or Bottom Cut 80 feet southeast of forge.	Northeasterly from E-13 in bottom of cut.	Hard, blocky, epidotized limestone, considerable galena and sphalerite.

Continued --

TABLE 1. - List of channel samples, Grant property, Mt. Eielson District, Alaska, taken by N. M. Muir, mining engineer, Bureau of Mines, August 1943 (cont'd.)

Sample	Width vein sampled, feet	Analysis					Name of working	Location	Comments
		Percent			Ounces a ton				
		Lead	Zinc	Copper	Gold	Silver			
E-15	2.0	2.80	2.63	-	-	0.22	Venora Discovery Cut.	Face cut.	Chipped sample, limestone and epodite, with sphalerite and galena.
E-16	4.0	3.22	6.90	0.35	0.0	2.62	Venora No. 2 Cut	Lower face of cut.	Hard and altered limestone and epidote with considerable galena and sphalerite.
E-17	2.0	4.68	6.36	1.15	0.0	2.20	Grant Creek, Eva Cut No. 1-a.	Face of north or (a) cut, 8 feet in and 1 foot above floor.	Limestone with epidote and cherite, containing considerable galena, sphalerite, and chalcopyrite.
E-18	3.1	5.00	4.90	0.90	0.015	9.80	Grant Creek, Eva Cut No. 1-b.	Face between (a) and (b) cuts.	Hard, silicified limestone and epidote with considerable galena and sphalerite.
E-19	3.8	7.00	6.60	0.35	0.0	1.30	Grant Creek, Eva Cut No. 1-b.	Face, north section of cut.	Limestone with some epidote and appreciable amounts of galena and sphalerite.
E-20	9.0	2.60	3.00	-	-	1.20	Grant Creek, Cut No. 3; i.e. third cut below grassy bench.	From south end of cut northerly for 9.0 feet.	Limestone and epidotized limestone with sparse galena sphalerite.
E-21	7.8	7.18	7.20	-	-	1.66	Grant Creek, Eva Cut No. 3.	From 8 feet north of E-20, northerly for 7.8 feet.	Limestone and epidote with some good galena and sphalerite.
E-22	2.5	7.35	8.99	-	-	0.62	Grant Creek, Eva Cut No. 2.	Sample cut along bedding for 8 feet.	Soft and hard limestone with epidote and considerable good galena and sphalerite.

Continued --

TABLE 1. - List of channel samples, Grant property, Mt. Eielson District, Alaska, taken by N. M. Muir, mining engineer, Bureau of Mines, August 1943 (cont'd.)

Sample	Width vein sampled, feet	Analysis					Name of working	Location	Comments
		Percent			Ounces a ton				
		Lead	Zinc	Copper	Gold	Silver			
E-23	Grab	5.40	5.50	0.45	0.0	1.26	Lillian claim, Big Cliff on west side Grant Creek.	Grab of chipped and picked ore on north side of cliff.	Representative of six stringers ranging from 2 inches to 10 inches in width.
E-24	Grab	6.80	8.70	1.40	0.0	2.00	Lillian Claim, Big Cliff on west side Grant Creek.	Grab of chipped and picked ore on south side of cliff along "fault" ravine.	Represents about 2 feet of mineralization.
E-25	3.7	4.16	5.86	-	-	0.42	Wolf Claim, Cut No. 1, near mouth Grant Creek Canyon.	Face of cut near bottom.	Hard, blocky limestone with some good galena and sphalerite.
E-26	Grab	5.09	5.20	0.35	0.0	1.50	Talus slope east Blacksmith Shop Gulch.	Taken from an area 250 feet along the slope across a width from 10 to 20 feet.	Grab of picked and chipped samples weighing 65 pounds.

BENEFICIATION TESTS

During the Bureau's examination, 26 samples were taken. Eighteen samples, containing over 7 percent of combined lead and zinc, were composited for the metallurgical work. The tests described in the following paragraphs were conducted in the Bureau's laboratories in Rolla, Mo.

Physical Character

The ore consisted of galena and sphalerite associated with the gangue minerals epidote, calcite, and quartz in smaller amounts. Cerussite, iron, oxide, smithsonite, siderite, and chalcopyrite also were present in small quantities. The calcite appeared to be an alteration product of the epidote. Water-soluble salts giving an affirmative test for sulfate and calcium ions were present.

The sulfides were closely associated and disseminated throughout the sample. The epidote was often cut by veinlets of galena approximately 80 microns in width. Microscopic examination of washed screen fractions showed that about 75 percent of the sulfides were free in the 65- to 100-mesh range, about 90 percent in the 100- to 150-mesh range, and about 95 percent in the 150- to 200-mesh range.

Chemical Character

The chemical analysis of the composite of samples E-1, E-2, E-3, E-4, E-6, E-8, E-12, E-14, E-16, E-17, E-18, E-19, and E-21 through E-26 was as follows:

Analysis, percent						
Pb		Zn		Cu	Fe	Insol.
Total	Nonsulfide	Total	Nonsulfide			
4.22	1.27	5.27	0.37	0.36	7.30	69.5

Treatment Procedure

1. Selective flotation.
2. Bulk flotation.

Selective Flotation

Flotation tests were made to concentrate the lead and then the zinc by differential flotation. No treatment method was found that would give satisfactory results. Apparently, the film of oxidation products present on nearly all of the galena particles prevented them from floating with the characteristic ease of clean galena. These tests were made on minus 100-mesh pulps.

Bulk Flotation

Several flotation tests were made at 65-mesh, in which the sulfides were floated and cleaned in bulk. Varied treatments were then tried to separate the lead and zinc minerals. The use of zinc depressants was not successful. Regrinding the bulk concentrate to minus 325-mesh before adding zinc depressants gave only slightly better results. Tests to depress the lead and float the zinc from the bulk concentrate gave somewhat better results, but grades and recoveries were lower than in commercial practice. The lead was easier to depress at coarse sizes, as separation depended on the presence or formation of an oxide film on the galena surfaces. A coarse grind, however, was disadvantageous because of locked lead and zinc mineral particles. Potassium dichromate was used as the lead depressant, and American Cyanamid reagent 633 added to the effectiveness of the dichromate. A typical batch flotation test is shown in detail below.

A charge of the composite sample of the ore crushed through 20-mesh was ground wet in stages to minus 65-mesh in a pebble mill. The thickened pulp was conditioned in a subaerated mechanical-type flotation cell diluted to a density of 25 percent solids with grind water, and the sulfides were floated. The sulfide rougher concentrate was cleaned three times and then subjected to a series of three lead-depressing treatments. The rougher tailing was sulfidized in an attempt to float the cerussite remaining after removal of the sulfides from the pulp. Zoolite-softened water was used for grinding and flotation. The results are as follows:

Product	Weight, percent	Analysis, percent				Percent of total			
		Pb				Pb			
		Total	Non-sulfide	Zn	Cu	Total	Non-sulfide	Zn	Cu
Sulfide lead concentrate .	5.20	41.9	2.45	12.5	1.73	51.0	8.2	12.4	23.2
Oxide lead concentrate	1.82	20.2	17.4	2.60	0.82	8.6	20.5	.9	3.8
Zinc concentrate	8.08	5.90	1.15	49.5	1.78	11.2	6.0	76.5	37.0
Sulfide middling	11.02	5.76	4.02	2.25	.88	14.8	28.7	4.8	25.0
Oxide lead middling	3.64	3.23	3.20	.97	.40	2.7	7.5	.7	3.8
Tailing	70.24	.71	.64	.35	.04	11.7	29.1	4.7	7.2
Calculated head	100.00	4.27	1.55	5.23	0.39	100.0	100.0	100.0	100.0

Operating data

Reagents	Pounds per ton of ore															
	Bulk flotation						Lead-zinc separation						Oxide flotation			
	Con.	Con.	R. 1	Cl. 1	Cl. 2	Cl. 3	Con.	Cl. 4	Con.	Cl. 5	Con.	Cl. 6	Con.	Con.	R. 2	Cl. 1
Copper sulfate	0.50															
Aerofloat 25		0.12														
Amyl xanthate		0.05												0.15		
Methyl amyl alcohol .			0.06	0.03	0.03	0.04										
Potassium dichromate.							0.20		0.05		0.05					
Reagent 633								0.05		0.025		0.025				
Sodium sulfide													2.00			
pH			8.1													
Time, minutes	3	5	5	3	3	3	3	3	3	4	3	5	3	3	5	2

Con. - Conditioner   Cl. - Cleaner   R. - Rougher

The tailing contained 0.30 percent of nonsulfide zinc. Sulfidization recovered only a small amount of lead in a low-grade concentrate. The grade could be raised by more cleanings, but increased recovery was not obtained by the use of more sodium sulfide. The sulfide middling contained much true middling and should be reground in a continuous circuit. Combining the oxide and sulfide lead concentrates would result in a product recovering 59.6 percent of the lead and containing 36.3 percent lead, 9.9 percent zinc, 1.49 percent copper, and 6.33 percent nonsulfide lead.

Summary

Due principally to locking and oxidation, this ore did not respond satisfactorily to concentration. The lead concentrate contained 36.3 percent lead and 9.9 percent zinc with a recovery of 59.6 percent of the lead. The zinc concentrate contained 49.5 percent zinc and 5.9 percent lead with recovery of 76.5 percent of the zinc.