STUDIES RELATED TO WILDERNESS

EAK
AREA,

GEOLOGICAL SURVEY BULLETIN 1491

Mineral Resources of the Lone Peak Wilderness Study Area, Utah and Salt Lake Counties, Utah

By CALVIN S. BROMFIELD, U.S. GEOLOGICAL SURVEY
and LOWELL L. PATTEN, U.S. BUREAU OF MINES

With a section on
INTERPRETATION OF AEROMAGNETIC DATA

By DON R. MABEY, U.S. GEOLOGICAL SURVEY

STUDIES RELATED TO WILDERNESS—STUDY AREA

GEOLOGICAL SURVEY BULLETIN 1491

An evaluation of the mineral potential of the area

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STUDIES RELATED TO WILDERNESS

STUDY AREAS

In accordance with the provisions of the Wilderness Act (Public Law 88-577, September 3, 1964) and the Joint Conference Report on Senate Bill 4, 88th Congress, the U.S. Geological Survey and U.S. Bureau of Mines have been conducting mineral surveys of wilderness and primitive areas. Studies and reports of all primitive areas have been completed. Areas officially designated as "wilderness," "wild," or "canoe" when the Act was passed were incorporated into the National Wilderness Preservation System, and some of them are presently being studied. The Act provided that areas under consideration for wilderness designation should be studied for suitability for incorporation into the Wilderness System. The mineral surveys constitute one aspect of the suitability studies. This report discusses the results of a mineral survey of some national forest lands in the Lone Peak study area, Utah, that are being considered for wilderness designation. The area studied is in the central Wasatch Range, southeast of Salt Lake City.

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STUDIES RELATED TO
WILDERNESS—STUDY AREAS

MINERAL RESOURCES OF THE LONE PEAK WILDERNESS STUDY AREA, UTAH AND SALT LAKE COUNTIES, UTAH

By CALVIN S. BROMFIELD, U.S. Geological Survey,
and LOWELL L. PATTEN, U.S. Bureau of Mines

SUMMARY

The mineral survey of the Lone Peak wilderness study area by the U.S. Geological Survey and the U.S. Bureau of Mines during 1973 and 1974 covered 53 square miles (137 km^2) in the rugged central Wasatch Range near Salt Lake City, Utah. The study by the U.S. Geological Survey consisted of geological, geochemical, and geophysical investigations; the study by the U.S. Bureau of Mines covered a search of public records for mining-claim locations and the mapping, sampling, and examining of prospect workings and mineralized areas. The area lies at the west end of an east-northeast alinement of mid-Tertiary intrusive rocks that define a mineral belt containing silver-lead-zinc deposits. The highly productive Park City district and the Cottonwood-American Forks districts are within the belt to the northeast of the study area. Mineral commodities in the area include molybdenum, silver, lead, tungsten, zinc, and copper. Part of the area may have a future potential for minable deposits containing molybdenum but little economic potential for other metals. The area has little or no potential for coal, oil, gas, and geothermal resources.

The Lone Peak area is underlain chiefly by Precambrian and Paleozoic sedimentary rocks and by a mid-Tertiary stock of quartz monzonite. The northern part is underlain predominantly by the quartz monzonite of the Little Cottonwood stock and by smaller peripheral areas of Precambrian sedimentary rocks and a thin sequence of Paleozoic beds. South of the stock, and separated from it by the Deer Creek fault, the area is underlain by younger Precambrian sedimentary rocks and a much thicker section of Paleozoic rocks. These sedimentary rocks are arched into a dome and broken by a complex of generally east-west faults. The sections of Paleozoic rocks of diverse thicknesses exposed north and south of the Deer Creek fault have been brought together in the central Wasatch Range by the Charleston-Nebo thrust of Late Cretaceous age, now concealed in the hanging wall of the Deer Creek fault.

The investigations resulted in the collection of 561 samples: 291 stream sediment and 270 rock samples. Many of the rock samples were collected from mines and prospects. The aeromagnetic data reflect and define the limits of intrusive igneous bodies, some of which contain submarginal-grade molybdenum deposits and minor occurrences of tungsten.

According to U.S. Bureau of Land Management records, 12 claims have been patented in the Lone Peak study area: 6 in the Silver Lake mining district, and 6 in the White Pine Fork area. Over the years numerous unpatented mining claims have been located, but because of poor descriptions in the records, many could not be positively identified on the ground. In 1974, no mines were being operated and signs of recent activity were few.

Three areas within the Lone Peak study area have attracted prospecting activity in the past:

1. The Silver Lake mining district, on the east side of the study area, has several narrow northeast-trending silver-lead veins, and one small carbonate-replacement deposit. None of these has yielded any recorded production, though it is probable a few tons of ore may have been shipped from the replacement deposit. Between 1902 and 1974, the Milkmaid mine just outside the boundary of the study area near Silver Lake produced 61 tons (55t) of high-grade lead-silver ore.

   In addition, tungsten occurs north of Deer Creek in scheelite-bearing tactite in metamorphosed Paleozoic carbonate rocks near the Little Cottonwood stock. A 77-ton (70-t) shipment made in 1943, shortly after discovery, contained 30 units of WO_3.
2. The Alpine mining district on the southwest boundary of the study area contains sparse amounts of oxidized lead-zinc material evidently in brecciated Paleozoic carbonate rocks in or near faults. No production has been recorded.
3. The White Pine Fork area in the northeastern part of the study area contains low-grade molybdenite mineralization.

A hundred years of prospecting in the Silver Lake and Alpine districts has failed to develop profitable orebodies of even moderate size. Continued prospecting might disclose a few small orebodies, but the possibility of developing a moderate- or large-size mine seems unlikely. The mineral potential for silver-lead or zinc orebodies in either area must be considered slight. Further exploration in the carbonate rocks of the Silver Lake area might disclose other scheelite-bearing tactite lenses. However, few of our samples were anomalous in tungsten, and these contained so little as to suggest that the possibility of finding considerably larger tactite orebodies, is slight.

The low-grade molybdenite occurence in association with an area of hydrothermal alteration in the quartz monzonite of the mid-Tertiary Little Cottonwood and White Pine stocks in White Pine Fork is a potentially significant, but unproved, mineral resourced. Though partly explored in the past by drilling, more extensive exploration is needed to prove or disprove the potential.

Little evidence was seen in other parts of the study area to suggest the presence of even marginal or submarginal metallic mineral deposits in any near-surface environment. No surface oil or gas indications are known, and the structural complexity, occurrence of mid-Tertiary intrusive rocks, and deep erosion suggest that oil or gas potential is minimal. Nevertheless, the tenuous possibility that oil or gas could exist in stratigraphic or structural traps in sedimentary rocks in the lower plate of the concealed Charleston-Nebo thrust cannot be eliminated. Large deposits of structural stone, limestone, and small deposits of sand and gravel are found in the study area, but these common materials are abundant elsewhere in Utah, adjacent to markets.

Geothermal conditions deep beneath the study area are unknown; but no hot springs, young igneous rocks, or other surface evidence suggest a potential for production of geothermal energy.

INTRODUCTION

The Lone Peak study area described in this report comprises about 34,000 acres (137,600 ha, or about 53 mi² (140 km²)) in the central Wasatch Range, immediately adjoining suburban Salt Lake City (fig. 1). It occupies parts of Salt Lake and Utah Counties, and includes parts of the Wasatch and Uinta National Forests. A study of the mineral resources was requested by the U.S. Forest Service to help determine the suitability of the area for inclusion into the National Wilderness System. The study area is unique among areas under consideration for wilderness designation in that it borders a metropolitan area. The boundary of the study area is given on plates 1 and 2.

The study area is easily accessible from good roads. State Highway 210, an oil-surfaced all-season road, in Little Cottonwood Canyon skirts the north boundary; State Highway 80 in American Fork Canyon skirts the south edge of the area. A secondary road continues up American Fork Canyon from its junction with South Fork along the southeast boundary of the area and reaches Granite Flat and Silver Lake Flat campground adjacent to the Lone Peak area on the east. Two four-wheel drive roads extend into the area—one up White Pine Fork to White Pine Lake in the northeast corner of the area, and one up Dry Creek Canyon about 2 miles northeast of the town of Alpine.

Forest Service trails passable by foot or horseback from spring through fall months give access from White Pine Fork to Red Pine

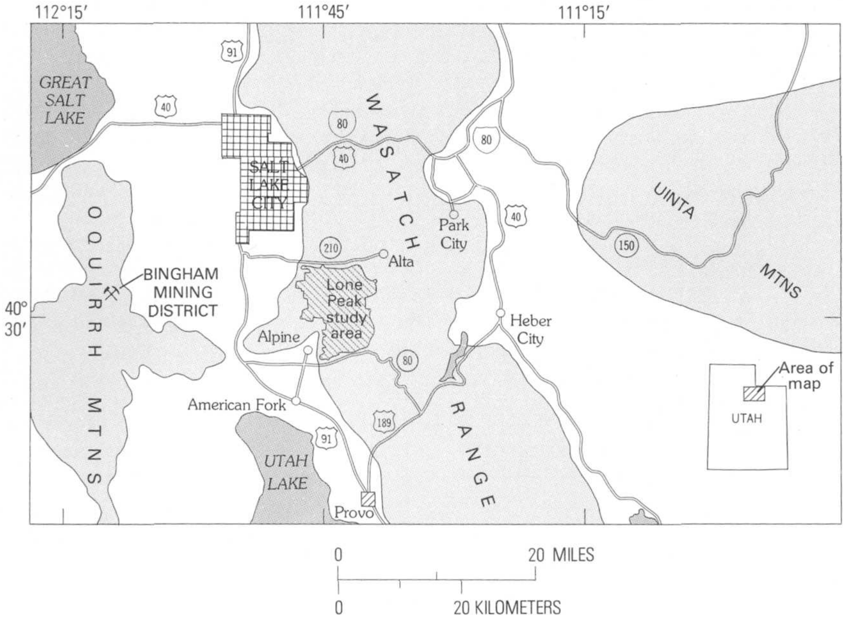


FIGURE 1.—Index map showing location of Lone Peak wilderness study area, Utah.

Fork and Maybird Gulch, popular hiking and camping areas. In Dry Creek Canyon a good trail extends from the road end and crosses the Lone Peak area, reaching the Granite Flat campground on the east. Other trails extend to Lake Hardy and Bells Canyon Reservoir.

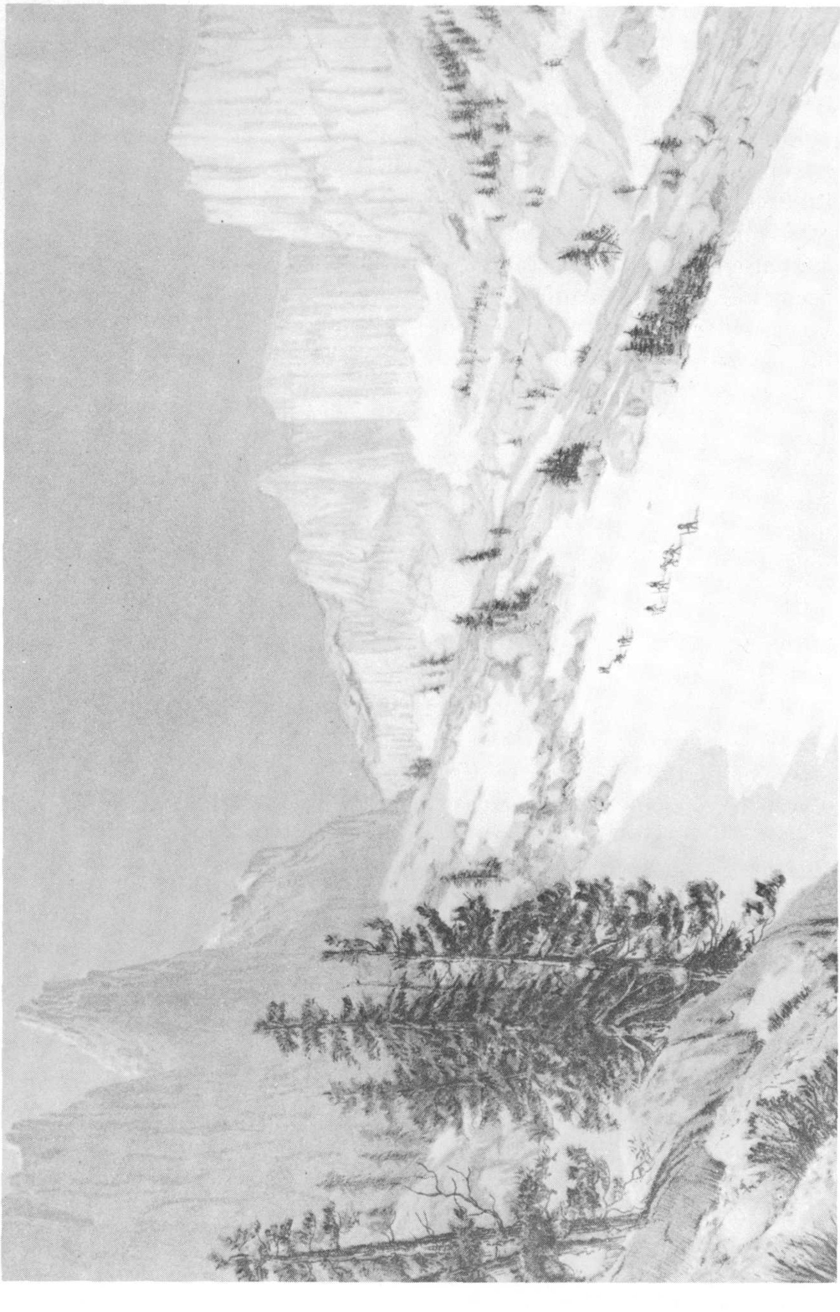
The Lone Peak area is centered on some of the most rugged and spectacular parts of the central Wasatch Range. Topographically, the northern half of the area is dominated by a sinuous knife-edge divide which separates the waters of Dry Creek Canyon on the south from those that drain into Little Cottonwood Canyon on the north. At the west end of the ridge, the lofty granite pinnacle of Lone Peak (11,253 ft (3,430 m)) dominates the skyline on the mountain front. At the east end of the ridge are Twin Peaks, the highest summits in the area (11,489 ft and 11,433 ft (3,502 m and 3,485 m)). The maximum relief in the area is in excess of 6,000 feet (1,800 m) between the mouth of Little Cottonwood Canyon and the summits of Lone Peak and Twin Peaks.

The north flank of the ridge between Lone and Twin Peaks is deeply scored by north-trending glacially carved hanging valleys which head in steep-walled amphitheaterlike basins or cirques under sharp ridges and spurs strewn with talus. These valleys are tributary to the glacially scoured U-shaped Little Cottonwood Canyon. The most spectacular of the canyons along the north side of the area is the great rock gorge of Bells Canyon (fig. 2), which heads in a rock-glacier-floored basin at the foot of Lone Peak.

The southern half of the Lone Peak wilderness study area is dominated topographically by Box Elder Peak (11,101 ft (3,384 m)) and by spurs and ridges radiating out from its summit. Southward, the ridges and spurs descend precipitously in a spectacularly rugged terrain to American Fork Canyon. The relief between Box Elder Peak and the mouth of American Fork Canyon is slightly more than 6,000 feet (1,830 m).

Timberline ranges from 11,000 feet (3,350 m) to only about 9,600 feet (2,900 m) in some of the rock glacier-floored cirques. The upper slopes, below timberline, support a spruce-fir forest; groves of aspen and a thick brushy undergrowth are common in Deer Creek and Dry Creek Canyon, in general above elevations of 7,000 feet (2,000 m). Along major water courses willow, alder, and other thick underbrush are also common. Along the mountain front and on

FIGURE 2. (facing page).—Exploration party of the historic Fortieth Parallel Survey in Bells Canyon about 1869. Closely jointed monzonite forms walls and floor of canyon. Illustration from King (1878).



lower slopes elsewhere in the area, dense stands of scrub oak are found.

The climate ranges from temperate semiarid along the west margin, near the foot of the Wasatch Range, to subarctic in the higher cirques. Thus, mean annual temperature is about 55°F at the mountain front and about 35°F at Alta near the northeast corner of the study area. Precipitation increases with altitude, from 15 to 20 inches (35 to 50 cm) along the west mountain front to perhaps 55 inches (140 cm) at Alta. The maximum precipitation occurs as snow from December to April. Annual snowfall is about 350 inches (890 cm) at Alta. Avalanche hazard is high during winter and spring months, especially along Little Cottonwood Creek and its tributaries.

The economy of the area in recent years is based primarily on tourists—skiers in the winter at the resorts of Snowbird and Alta in Little Cottonwood Canyon, and hikers and campers in the summer months. In the past, particularly in the latter part of the 19th century, base- and precious-metal mining in the Cottonwood-American Forks mining district, which fringes the Lone Peak study area on the northeast, supported a small population.

PREVIOUS INVESTIGATIONS

The first geologic work covering the general region that includes the Lone Peak area was done by geologists of the Fortieth Parallel Survey in 1869 (King, 1878). Atwood (1909) made a study of glaciation of the region. Hintze (1913) and Butler and Loughlin (1916) made reconnaissance studies of the complex structure and stratigraphy of the Cottonwood-American Forks mining district, and Butler and Loughlin also discussed the mineral deposits. A more detailed study of the geology and ore deposits of the Cottonwood-American Forks mining district is given by Calkins and Butler (1943). Buranek (1944) and Sharp (1958) described the molybdenum and tungsten deposits in White Pine Fork, within the study area boundary. Crittenden, Sharp, and Calkins (1952) and Crittenden (1964) discussed the stratigraphy and structure in the central Wasatch Range. Radiometric dates of intrusive rocks in the central Wasatch are given by Crittenden and others (1973).

Detailed geologic maps of most of the study area have been published in the geologic quadrangle map series of the U.S. Geological Survey; these include the Timpanogos quadrangle (Baker and Crittenden, 1961) and the Dromedary Peak and Draper quadrangles (Crittenden, 1965a, b). The Lehi quadrangle, which includes in its northeast corner a small segment of the study area, was mapped for a thesis presentation by Bullock (1958).

PRESENT INVESTIGATIONS

Field investigations of the Lone Peak study area by the U.S. Geological Survey and U.S. Bureau of Mines were made during the summers of 1973 and 1974. This report summarizes the reconnaissance studies conducted in July and August 1974 by C. S. Bromfield and assistant N. A. Anderson for the Geological Survey, and the parallel investigations conducted by L. L. Patten and assistants T. J. Holloran and D. F. Bush for the U.S. Bureau of Mines during parts of the summers of 1973 and 1974. The fieldwork was accomplished through many miles of foot traverses. A helicopter was used to facilitate access to some of the less accessible areas.

Inasmuch as good geologic maps were available, most of the field effort of the U.S. Geological Survey party was devoted to geochemical sampling. Stream-sediment samples were taken along major drainages and from lesser tributaries. In addition, many samples of mineralized, altered, and nonmineralized rocks were taken. Analyses on rock and stream sediments collected by the U.S. Geological Survey field party were done in a mobile field laboratory under the direction of Charles L. Whittington of the Geological Survey.

The U.S. Bureau of Mines mineral survey consisted of a study of relevant literature; a review of U.S. Bureau of Land Management records; a search for mining-claim locations in the Salt Lake and Utah County records; examination of mining claims, prospects, and workings; and a general reconnaissance of the area. Samples collected by the Bureau of Mines party were analyzed in the U.S. Bureau of Mines laboratory in Reno, Nev.

ACKNOWLEDGMENTS

Grateful acknowledgment is extended to U.S. Forest Service officials, local residents, and others who facilitated the work of the mineral survey. In particular, we acknowledge help received from Rangers Gerry Gelock and John E. Whitsen of the Pleasant Grove Ranger Station, Pleasant Grove, Utah, and Rangers G. Lynn Sprague and William L. Thompson of the Wasatch Forest Ranger Station at Salt Lake City.

We thank several residents who gave freely of local information and granted permission to cross private lands. In particular, we thank Ray Dowding, Lynn Hale, and Wayne R. Michelson.

Earshel W. Newman, mining engineer of Salt Lake City, provided valuable background on the American Fork district; and B.

J. Sharp, geologist with the Energy Research and Development Administration (now Department of Energy) provided information on the tungsten occurrence in White Pine Fork.

Finally, we thank the Bear Creek Mining Co. and the Midwest Oil Corp. for information received on the molybdenite occurrence in White Pine Fork.

GEOLOGY

By CALVIN S. BROMFIELD, U.S. GEOLOGICAL SURVEY

The Wasatch Range rises from the valley along its western front in a bold escarpment. Its foot is bounded by the Wasatch fault zone, a great frontal fault system along which the range was uplifted several thousand feet between mid-Tertiary time and the present. Erosion has deeply etched the rising mountains and has revealed a complex internal structure of folds and faults. In the central Wasatch Range, in the region encompassing the Lone Peak area, folded and faulted sedimentary and volcanic rocks ranging in age from Precambrian to Tertiary have been intruded by mid-Tertiary plutons of intermediate composition. The plutons form a west-trending belt extending 28 miles (50 km) across the central Wasatch (fig. 3). Important ore deposits of silver, lead, and zinc spatially associated with the intrusive belt have been mined in the Park City mining district, 8 miles east (15 km) of the Lone Peak area; smaller, but significant, deposits have been mined in the Cottonwood-American Forks mining district, which adjoins the study area on the northeast.

The northern part of the Lone Peak area is underlain chiefly by quartz monzonite of the Little Cottonwood stock, the largest and most westerly of the plutons (fig. 3). The stock and satellitic dikes were emplaced along and near the axis of the Uinta anticline, a west-trending uplift of probable Late Cretaceous age which is the dominant geologic feature of the central Wasatch Range north of the Deer Creek-Charleston-Nebo fault zone (fig. 3). This structure, the westward extension of the broad anticline that forms the Uinta Mountains to the east, cuts transversely across the north trend of the Wasatch Range, is truncated on the west by the Wasatch fault system, and plunges to the east. North and east of the area, erosion of the anticline exposes a thick series of Precambrian sedimentary rocks (including quartzites, minor amounts of slate, and tillites), a relatively thin section of Paleozoic rocks thought to have been deposited near the west edge of the North American craton, and continental and marine Mesozoic rocks. This series of sedimentary rocks dips northeast, east, and southeast away from the axis of the anticline. Only two small areas of younger Precambrian and Paleozoic sedimentary rocks are within the northern part of the Lone Peak area, one on the eastern boundary and the other near the northwestern boundary (pl. 1).

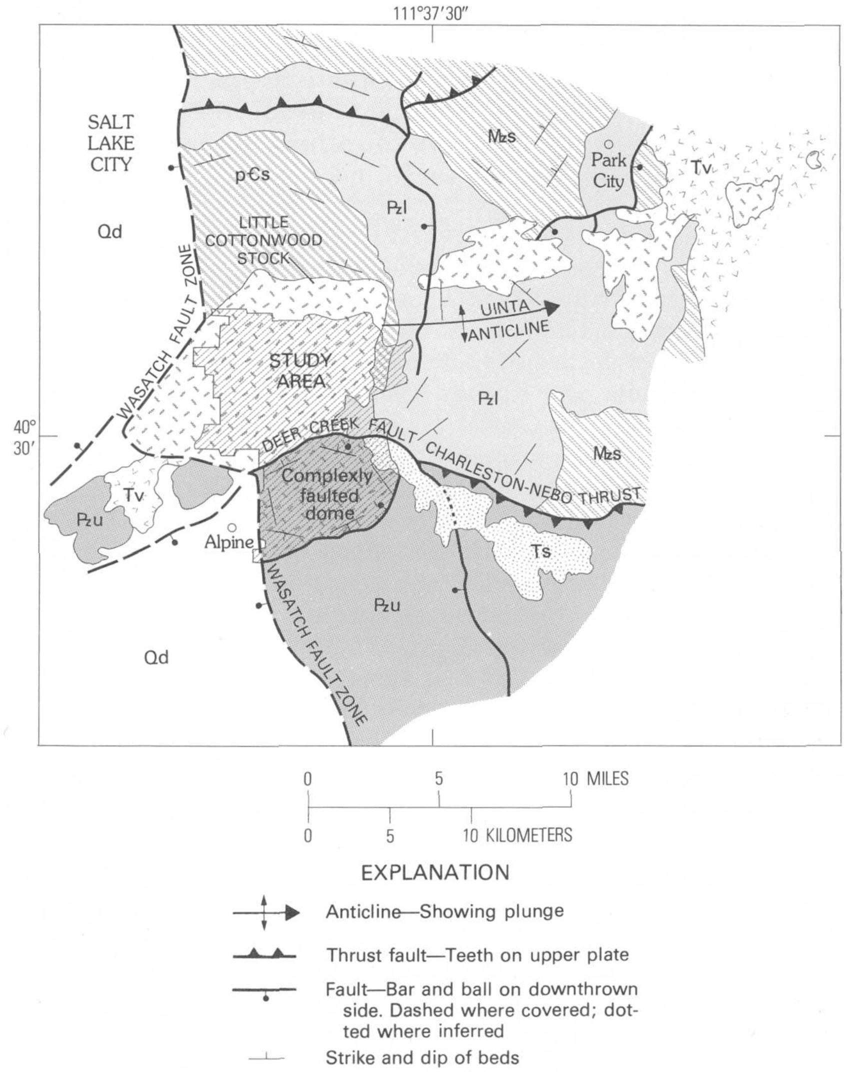


FIGURE 3.—Relation of Lone Peak wilderness study area to some of the major tectonic features of the central Wasatch Range. Qd, Quaternary deposits; Ts, Tertiary sedimentary rocks; Tv, Tertiary volcanic rocks; Ti, Tertiary stocks; Mzs, Mesozoic strata; Pzl, Paleozoic strata in lower plate of Charleston-Nebo thrust; Pzu, Paleozoic strata in upper plate of Charleston-Nebo thrust; p€s, Precambrian strata.

South of the Little Cottonwood stock, and separated from the stock by the Deer Creek fault, mainly younger Precambrian and Paleozoic sedimentary rocks underlie an area that is arched into a small dome or anticline and broken by a complex of eastward trending faults (fig. 3, pl. 1). The Paleozoic rocks, in marked contrast to the thin-shelf sequence exposed north and east of the stock, are a thick miogeosynclinal sequence of quartzites, shales and carbonate rocks of Cambrian, Mississippian, and Pennsylvanian age. These diverse sections of Paleozoic rocks are thought to have been brought together in the central Wasatch Range by thrust faulting in Late Cretaceous time.

SEDIMENTARY ROCKS

Sedimentary rocks exposed in the Lone Peak area range in age from late Precambrian to Quaternary. The sequence of formations is shown in table 1. The sedimentary rocks in the central Wasatch Range have been described in detail by Calkins and Butler (1943) and Baker, Huddle, and Kinney (1949), and in current, somewhat revised terminology by Crittenden and others (1952) and Crittenden (1964). The Mississippian rocks have been described by Crittenden (1959); those sedimentary rocks of the Timpanogos quadrangle, which includes the southern half of the Lone Peak area, have been described in the text that accompanies the geologic map of that area (Baker and Crittenden, 1961). Description of the Quaternary deposits and history of Little Cottonwood and Bells Canyons have been given by Richmond (1964), and of the southern part of the area by Baker and Crittenden (1961).

Some of the carbonate rocks of Paleozoic age contain replacement ore deposits in the adjacent Cottonwood-American Forks mining district. The Precambrian rocks have been of little importance as hosts for ore deposits.

PRECAMBRIAN ROCKS

The upper Precambrian rocks exposed in the eroded core of the Uinta anticline just north of the area (fig. 3) compose an extensive section of clastic sedimentary rocks which has a total exposed thickness of nearly 20,000 ft (6,000 m). The Precambrian sequence has been divided into three units. A lower unit, the Big Cottonwood Formation, makes up most of the Precambrian sequence, and at its type locality in Big Cottonwood Canyon, consists of about 16,000 feet (5,000 m) of quartzite, and a minor amount of interbedded shales. A middle unit, the Mineral Fork Tillite, consists chiefly of a distinctive, dark-hued, poorly sorted conglomeratic sandy mudstone or tillite. The upper unit, the Mutual Formation, is made up of quartzites, grits, and minor amounts of conglomerate and shale.

TABLE 1.—*Sedimentary and volcanic rocks of the Lone Peak wilderness study area, Utah*

Age	Unit	Dominant lithology	Thickness in study area (feet)
Tertiary	Tibble Formation	Red pebble to boulder conglomerate and minor amounts of shale, sandstone, and thin lenticular algal limestone.	2,500 (760 m)
Oligocene-Eocene	Traverse Volcanics of Slentz, 1955	Chiefly andesitic porphyry flows. Poorly exposed. Present only west of boundary study area in Traverse Range. Dated by K-Ar methods as 37.3 m.y.±1.1 (Crittenden and others, 1973).	0-1,000 (300 m)
		---UNCONFORMITY---	
Pennsylvanian	Oquirrh Formation	Upper member: light-colored, thin- to thick-bedded, fine- to medium-grained sandstone and quartzite, slightly limy; interbedded with medium- to dark-gray limestone. Occurs only south of Deer Creek fault.	2,000 (610 m)
		Bridal Veil Limestone Member: medium- to dark-gray, thin- to thick-bedded limestone. Total thickness of Oquirrh Formation southeast of area is about 26,000 feet (7,900 m). Occurs only south of Deer Creek fault.	1,200 (370 m)
Early Pennsylvanian and Late Mississippian	Manning Canyon Shale	Black limy shale and gray to black limestone and interbedded fine to gritty sandstone and quartzite. Occurs only south of Deer Creek fault	1,800 (550 m)
Late Mississippian	Great Blue Limestone	Dark-gray to black shaly limestone, thin-bedded; weathers medium to light gray; a few beds of dark-brown and black shale; rusty-weathering sandy siltstone at base. Occurs only south of Deer Creek fault.	2,800 (850 m)

TABLE 1.—*Sedimentary and volcanic rocks of the Lone Peak wilderness study area, Utah*—Continued

Age	Unit	Dominant lithology	Thickness in study area (feet)
Late Mississippian	Doughnut Formation	Dark-gray to black shaly limestone, and interbedded black shale, thin-bedded; rusty-weathering black shale and fine-grained quartzite at base. Occurs only north of Deer Creek fault; where in contact with the Little Cottonwood stock it is recrystallized, and in part leached and converted to calc-silicates.	300-1,200 (90-370 m)
	Humbug Formation	Gray limestone, medium-bedded; underlain by interbedded tan and light-gray, thin- to thick-bedded limestone and dolomite, and tan limy sandstone.	800 (240 m)
Late and Early Mississippian	Deseret Limestone	Dark-gray to black limestone and dolomite, medium- to thick-bedded; contains abundant chert as thin lenses and beds.	420 (130 m)
Early Mississippian	Gardison Limestone	Dark-gray, thick-bedded limestone and dolomite, cherty; underlain by thin-bedded blue-gray fossiliferous limestone.	600 (180 m)
	Fitchville Formation	Upper part dark-gray massive dolomite; lower part light- to medium-gray dolomite; basal 3-10 feet (1-3 m) of tan-weathering crossbedded vuggy dolomitic sandstone with well-rounded frosted quartz grains to 2 mm in diameter.	100-175 (30-50 m)
		UNCONFORMITY	
Middle Cambrian	Maxfield Limestone	Dark-gray oolitic to pisolitic limestone. In places the Maxfield has been eroded away and overlying Mississippian rocks lie on the upper or even the middle member of the underlying Ophir Formation.	0-200 (0-60 m)

TABLE 1.—*Sedimentary and volcanic rocks of the Lone Peak wilderness study area, Utah*—Continued

Age	Unit	Dominant lithology	Thickness in study area (feet)
Middle Cambrian	Ophir Formation	Upper member of brown shale and calcareous sandstone; 250 feet (75 m). Middle member of pale-gray limestone characterized by wavy layers of tan-weathering siliceous silty dolomite which stand in relief; 90 feet (25 m). Lower member chiefly olive-green micaceous shale, siltstone, and thin rusty quartzite; fucoidal marking, and worm trails common; 160 feet (50 m).	500 (150 m)
Middle and Early Cambrian	Tintic Quartzite	White, buff, pale-pink, and rusty quartzite, thin- to thick-bedded, fine- to coarse-grained; pebbly in part.	1,300 (400 m)
----------------------	----------------------	UNCONFORMITY	----------------------
Late Precambrian	Mutual Formation	Greenish-gray and grayish-red sandstone, conglomerate, and shale.	0-1,300 (0-400 m)
	Mineral Fork Tillite	Rusty- and olive drab-weathering tillite containing well-rounded pebbles, cobbles, and boulders in a matrix of poorly sorted graywacke. Boulders are of quartzite, limestone and dolomite, schist, gneiss, and a little granite. Interbedded with crossbedded sandstone, and siltstone.	250-300 (80-90 m)
	Big Cottonwood Formation	Rusty- to buff-weathering quartzite, massive; and gray to dull purple shale. Base not exposed.	400 (120 m)

The Precambrian, though widespread just to the north, has a rather restricted outcrop within the boundary of the Lone Peak area. The Big Cottonwood Formation occurs in a limited exposure on the north side on the mouth of Bells Canyon; in a septum or pendant in the Little Cottonwood stock along the front of the Wasatch Range south of Bells Canyon; in a narrow band along the eastern contact of the Little Cottonwood stock where the formation is overlain with slight angular unconformity by Lower and Middle Cambrian Tintic Quartzite; and in a small exposure along the southeast margin of the area in the bottom of American Fork Canyon where it is overlain by Mineral Fork Tillite. The tillite and the overlying Mutual Formation occur north of Timpanogos National Monument between Tank Canyon and Swinging Bridge Creek, and along the front of the Wasatch Range at the mouth of Preston Canyon at the southeast margin of the area.

The quartzites and shales of the upper Precambrian were deposited in shallow waters (Crittenden and others, 1952, p. 3). The conspicious dark-hued conglomeratic sandy siltstone, so characteristic of the Mineral Fork, is thought to have been deposited as till during an ancient ice age (Hintze, 1913, Crittenden and others, 1971).

The age and correlation of the upper Precambrian rocks in the central Wasatch are not firmly established from direct evidence. However, recent studies of these and similar rocks in Utah and Idaho has led to tentative correlations (Crittenden and others, 1971; Crittenden and Peterman, 1975). Crittenden and Peterman believe that the Big Cottonwood correlates with the Uinta Mountain Group, the upper unit of which yielded a Rb-Sr age of 952±5 million years (m.y.) (Precambrian Y). They regard the Mutual Formation as an equivalent of the Windermere Group (Crittenden and Peterman, 1975).

PALEOZOIC ROCKS

Paleozoic rock sequences of widely different thicknesses and nomenclature have been brought into close proximity in the central Wasatch Range by thrust faulting (fig. 3). These diverse sequences were called the "thick" and "thin facies" by Baker, Huddle, and Kinney (1949). In the Lone Peak area, the thin section is found north of the Deer Creek fault (pl. 1) and the thick section south of it. The different terminology applied to these rocks in or near the Lone Peak area is shown diagrammatically in figure 4.

The Cambrian units of both the thin and thick facies have the same terminology and similar thickness and character. They include the Lower and middle Cambrian Tintic Quartzite overlain by the middle Cambrian Ophir Formation and Maxfield Limestone. The latter is missing locally beneath an unconformity at the base of the Mississippian. The Lower Mississippian Fitchville Formation and Gardison Limestone, Lower and Upper Mississippian Deseret Limestone, and Upper Mississippian Humbug Formation also are common to the thin and thick facies, respectively north and south of the Deer Creek Fault. However, stratigraphically higher Paleozoic, rocks of the thin and thick facies differ markedly in terminology and thickness (fig. 4).

Thick section units in the study area include the Upper Mississippian Great Blue Limestone, the upper Mississippian and Lower Pennsylvanian Manning Canyon Shale, and the Oquirrh Formation. The latter formation is of Pennsylvanian age in the Lone Peak study area, though further south, where it reaches an estimated thickness of 36,000 feet (11,000 m), beds of Early Permian age are included. Of the units of the thin facies shown in figure 4, only the Upper Mississippian Doughnut Formation occurs in the study area; the other units crop out east and north of the limits of the study area. According to Baker and Crittenden (1961), the Doughnut has not yet been correlated with any well-defined part of the thick facies though it partly resembles the Upper Mississippian and Lower Pennsylvanian Manning Canyon Shale and also the lower part of the Great Blue Limestone (Upper Mississippian, fig. 4). The Doughnut Formation, which is in contact with the Little Cottonwood stock north of the Deer Creek fault, is extensively metamorphosed and bleached in the Lone Peak area.

The "thin facies" of Paleozoic rocks is interpreted as having been deposited in shallow seas near the edge of the North American Paleozoic craton or shelf. The "thick facies" was deposited in the Paleozoic miogeosyncline to the west, and was transported to its present position by thrust faulting in Laramide time.

A former cover of several thousand feet of marine Permian and marine and continental Mesozoic rocks, removed from the area by erosion, is preserved now only in nearby areas (fig. 3) to the north and east.

TERTIARY ROCKS

After erosion removed most Permian and Mesozoic rocks in the study area, the surface was covered by gravels and tuffaceous muds of the Tibble Formation. The original extent of this cover is not known, but in the Lone Peak area, the Tibble is preserved only locally in the downfaulted block on the south side of the Deer Creek fault along Deer Creek near its junction with American Fork

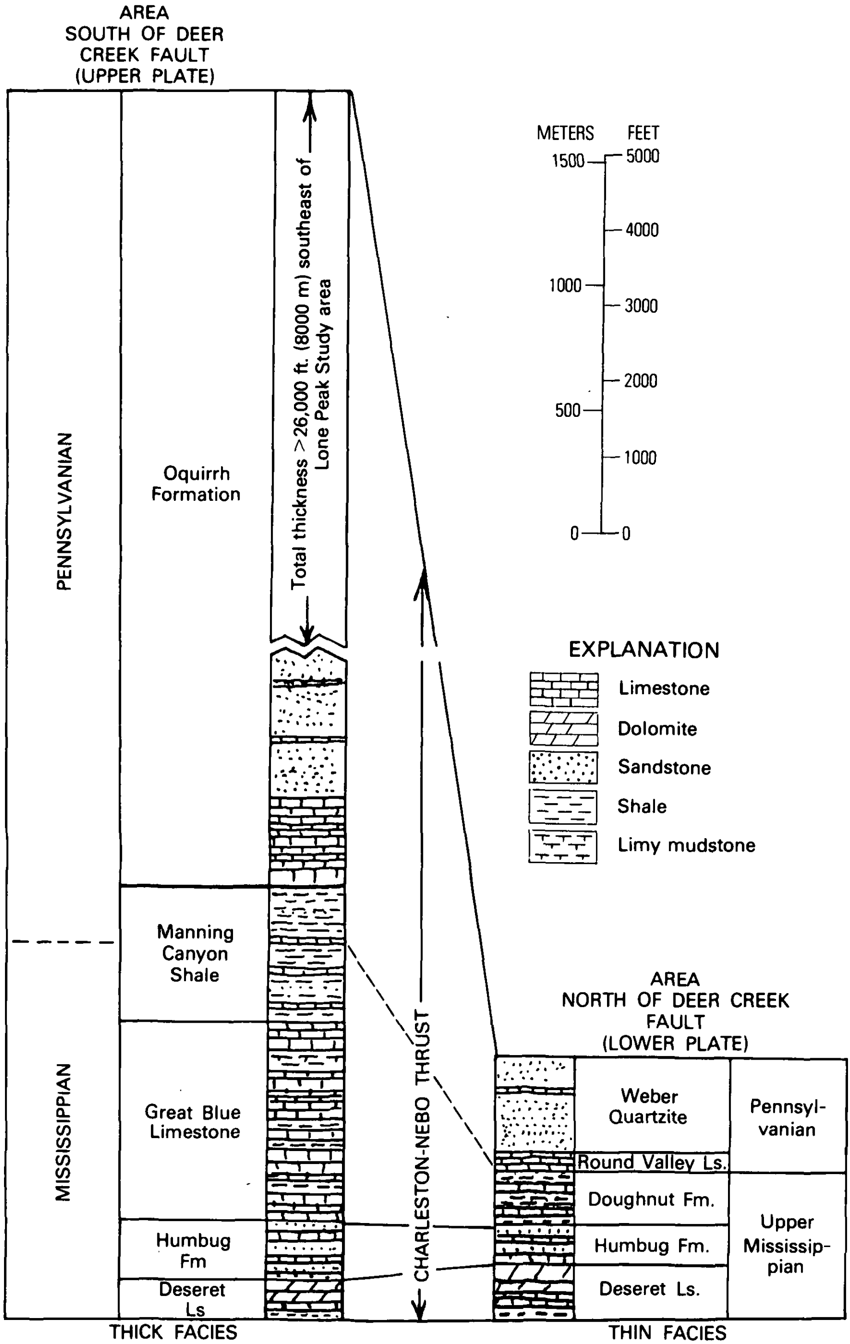


FIGURE 4.—Comparison and correlation of Mississippian and Pennsylvanian sections north and south of Deer Creek fault in Lone Peak wilderness study area.

Canyon (pl. 1). In that area, the Tibble unconformably overlies Pennsylvanian and Mississippian sedimentary rocks.

Some of the boulders in the gravels are of volcanic rock, some are of Mesozoic or older sedimentary units, but none are derived from the Little Cottonwood stock or from contact metamorphic rocks related to intrusion of the stock. Baker and Crittenden (1961) believed that the formation was deposited from streams peripheral to areas in which volcanic rocks were being accumulated and suggested that it may correlate with the lower Oligocene Keetley Volcanics near Park City or with the Eocene and Oligocene Norwood Tuff near Morgan.

West of the Wasatch fault and the study area boundary in a low hilly area, a poorly exposed sequence of intermediate flows and breccias of Tertiary age overlies the Oquirrh Formation (pl. 1). These have been called the Traverse Volcanics by Slentz (1955). A sample from these volcanics yielded an age of 37 m.y. (Crittenden and others, 1973).

QUATERNARY SURFICIAL DEPOSITS

Surficial deposits of Quaternary age are widespread in the Lone Peak area. They consist of moraines, rock glaciers, talus, stream gravels, and a few small landslides. Surficial deposits are combined as a single unit on plate 1, but they are shown in detail on previously published maps of the area (Crittenden, 1965a, b; Baker and Crittenden, 1961; Richmond, 1964).

During Pleistocene time, many of the high mountain valleys and basins were periodically occupied by glaciers. A complex history of repetitive glaciation has been deciphered by Richmond (1964) for Little Cottonwood and Bells Canyons. By far, most surficial deposits shown on plate 1 are probably remnants of the late Pleistocene glaciations of Bull Lake and Pinedale age, particularly the Pinedale. Twice since 2,000 B.C., small ice or rock glaciers have formed and have been melted away in cirques facing Little Cottonwood Canyon (Richmond, 1964, p. 40). The lack of appreciable surficial deposits south of Dry Creek Canyon and Wide Hollow (pl. 1), especially along American Fork, together with occurrence of the rugged V-shaped valley, suggests that this area was barren of glaciers.

TERTIARY IGNEOUS ROCKS

PORPHYRITIC QUARTZ MONZONITE OF THE LITTLE COTTONWOOD STOCK

The greater part of the northern two-thirds of the Lone Peak area is underlain by porphyritic quartz monzonite of the Little Cottonwood stock. The stock crops out over 31 square miles (80 km^2) within the study area and extends at least a mile west to the mountain front where it terminates against the Wasatch frontal fault system (pl. 1). Geophysical evidence suggests (Mabey and others, 1964) that a downfaulted portion of the stock may underlie the valley fill in the Salt Lake valley. About 1 mile north of the area, the margin of the stock is conspicuously displayed high on the ridge above Little Cottonwood Canyon (pl. 1) where it is in intrusive contact with upper Precambrian quartzites. In general, the Precambrian and overlying Paleozoic sedimentary rocks dip away from the contact to the northeast. Along and near the east boundary, the stock is in intrusive contact with both late Precambrian and Paleozoic sedimentary rocks which dip easterly and southeasterly away from the contact.

The quartz monzonite of the stock crops out in numerous bold cliffs, especially near the mouth of Little Cottonwood Creek along the north boundary of the area, at the headwalls of glacial cirques, and along the knife-edge ridge forming the Salt Lake–Utah County boundary (pl. 1).

Most of the outcrops are conspicuously jointed, a feature clearly shown on the aerial photographs of the region. Joints striking easterly to northeasterly and dipping at high angle are common throughout the area. Northerly striking west-dipping joints are also conspicuous in places, as in the steep cliff walls above Silver Glance Lake. In that area, the quartz monzonite is sheeted by joints striking about N. 10° E. and dipping about 45° W. Parallel joints are also conspicuous west of Coalpit Gulch along Little Cottonwood Creek, and just within the west boundary of the study area at the headwaters of Little Willow Creek. At the headwaters, most joints strike N. 25° W. and dip about 60°–75° W. Commonly, joint surfaces show a dark-brown stain. In places, fresh joint planes show coatings of epidote. Some joints carry anomalous amounts of some metals, as will be discussed in the section on mineral resources.

With rare exception, the porphyritic quartz monzonite is fairly uniform in appearance. Most of the outcrops of the stock are very light gray and most contain large phenocrysts of K-feldspar. The phenocrysts of K-feldspar range from 0.5 to 2 inches (1 to 5 cm) in longest dimension. These are nearly ubiquitous, but they vary in abundance, ranging even in short distances from a few percent to perhaps 20 percent of the rock.

The potassium feldspar phenocrysts are in a medium-coarse-grained groundmass consisting of quartz, plagioclase, potassium feldspar, biotite, and, in some specimens, small amounts of hornblende. Light-brown grains of sphene are visible in most rocks.

In thin sections, sphene, apatite, magnetite, and small amounts of zircon are seen to be the chief accessory minerals.

Several samples were examined under the microscope and a quantitative count was made of the constituent minerals. These are given in table 2, together with several other published estimates of the mineral composition of the Little Cottonwood stock. None of the thin sections includes any of the large feldspar phenocrysts; thus, the potassium feldspar estimate given in table 2 is somewhat lower than the actual potassium feldspar in the stock.

The stock contains numerous crudely rounded dark-gray inclusions which range in diameter from a few inches to several feet. The minerals that make up the inclusions are the same as those that make up the stock, but they occur in much different proportions. Plagioclase is the dominant light-colored mineral; orthoclase and quartz occur in only small amounts. The dark-colored minerals, biotite and hornblende, make up about 20–30 percent of the inclusions and account for the dark hue of the rock. One thin section from a specimen collected from the west flank of Lone Peak is of quartz diorite composition. Sphene occurs as well-formed microscopic crystals, as do abundant needles of rutile disseminated throughout the rock. The semiquantitative analysis shows 1 percent titanium, which reflects the relative abundance of sphene and rutile.

Radiometric age data, including concordant sphene and zircon fission-track ages and nearly concordant K-Ar dates, suggest that the Little Cottonwood stock was emplaced between 24 and 31 m.y. ago in late Oligocene or possibly early Miocene time (Crittenden and others, 1973, p. 177).

QUARTZ MONZONITE OF WHITE PINE FORK

A plug or small stock of mainly fine-grained light-colored quartz monzonite cuts the Little Cottonwood stock in the White Pine Fork area. Mapped by Crittenden (1965a) as leucocratic quartz monzonite, this crudely oval stock is about 1 mile (1.6 km) in diameter and occupies much of the ridge between White Pine Fork and Gad Valley on the east (pl. 1). Sharp (1958) called the stock centered on White Pine Fork the White Pine quartz monzonite. Crittenden and Sharp differ substantially on the shape and extent of the intrusive. As mapped by Sharp, the quartz monzonite of White pine Fork occupies an area somewhat larger than that of Crittenden and extends westward to the ridge between White Pine Fork and Red

TABLE 2.—*Modal composition in volume percent, of quartz monzonite of the Little Cottonwood stock*

[Does not include scattered potassium feldspar phenocrysts]

Samples------	RS-021	RS-089	RS-177	1	2	3
Quartz-------	35	25	33	25	32	20
Potassium feldspar---	17	18	29	19	17	20
Plagioclase--	38	44	30	42	42	42
Biotite------	9	6	7	12	8	7
Hornblende---	<1	4	<1	<1	<1	7
Opaque and accessory--	<1	3	<1	2	<1	4

Sample localities:

RS-021, Dromedary Peak 7½ min. quadrangle, about 10,000 ft (3,050 m) altitude, above White Pine Lake.

RS-089, Draper 7½ min. quadrangle, Bells Canyon, elevation about 9,600 ft (2,925 m).

RS-177, Dromedary Peak 7½ min. quadrangle, ridge northeast of Lake Hardy at about 10,400 ft (3,170 m).

1, Dromedary Peak 7½ min. quadrangle, top of ridge between Gad Valley and White Pine Fork (Sharp, 1958, p. 1418).

2, Dromedary Peak 7½ min. quadrangle, upper White Pine Fork (Sharp, 1958, p. 1418).

3, Dromedary Peak 7½ min. quadrangle, a third of a mile below powerhouse (now abandoned) in Little Cottonwood Canyon, near Hogum Fork (Butler and Loughlin, 1916, p. 176).

Pine Fork. The discrepancy in interpretation is the result of several factors, including close similarity in composition and mineralogy between the quartz monzonites of the White Pine and Little Cottonwood stocks, local gradational contacts between the two, widespread masking of rock textures by alteration and concomitant iron staining, and a considerable cover of forest, talus, and glacial moraine. Alteration and low-grade molybdenum mineralization associated with the intrusive of White Pine Fork is discussed in the section on the White Pine Fork area.

Typical quartz monzonite of White Pine Fork is a fine-grained (0.5-mm), light colored rock composed of white to glassy plagioclase, glassy light-gray quartz, biotite, and potash feldspar, both as irregular interstitial grains and as scattered phenocrysts with indistinct boundaries.

In some specimens, quartz appears as conspicuous ragged grains or quartz "eyes" 2–10 mm in diameter. Some granulation or brecciation was observed, both in outcrop and in thin sections. The rocks of the White Pine Fork stock seem to differ from those of the Little Cottonwood stock in being finer grained and lighter in color, and, according to Sharp (1958, p. 1421), they contain less biotite (possibly a secondary effect of the local alteration of biotite to sericite or muscovite).

Both Sharp (1958) and Crittenden (1965a) indicate that the quartz monzonite of White Pine Fork intrudes the Little Cottonwood stock. Muscovite from a greisen associated with the molybdenum mineralization in the stock of White Pine Fork gave an age of 25.5 m.y. (Crittenden and others, 1973, p. 175). Probably the age difference between the two stocks is not great; both are considered to have been emplaced in mid-Tertiary time (Crittenden and others, 1973).

DIORITE OF BELLS CANYON

A small igneous body is in intrusive contact with the Precambrian Big Cottonwood Formation on the north side of Bells Canyon at its mouth (pl. 1). This small exposure, mapped as diorite by Crittenden (1965b), is distinctly different in appearance and mineral composition from the quartz monzonite of the Little Cottonwood stock.

In outcrop the rock, dark-greenish-gray and rusty-stained, is medium coarse grained, and is composed principally of plagioclase, biotite, and quartz. In the sample studied, the dominance of plagioclase, the content of quartz, and the virtual absence of potassium feldspar would classify the rock as a quartz diorite. In thin section, the rock is seen to be extensively altered. Calcite, chlorite, and coarse sericite or muscovite are common.

There is no direct evidence bearing on the age of this rock. However, inasmuch as no other intrusives in this region are known to be older than mid-Tertiary, the rock is considered tentatively to be mid-Tertiary.

DIKES

Dikes of three general types, mapped by Crittenden (1965a) as silicic, intermediate, and lamprophyric are shown on plate 1 as Tertiary dikes. Dikes are most common in the White Pine–Red Pine Forks in the northeast quarter of the Lone Peak area where all three general classes of dikes are found; but a few scattered dikes are mapped in the upper Dry Creek basin in the sedimentary rocks bordering the Little Cottonwood stock on the east, and one dike was observed as far west as Bells Canyon. Most of the silicic and intermediate dikes strike northeasterly, parallel to the trend of the Wasatch intrusive belt (fig. 2); the lamprophyric dikes trend chiefly north to slightly west of north. The northeasterly and northerly dike trends parallel joint sets within the Little Cottonwood stock. The thickness of dikes ranges from a few feet to a maximum of over 100 feet (30 m).

The dikes cut the Little Cottonwood stock (31-24 m.y.) and are thus no older than Oligocene. The silicic dikes in White Pine Canyon are locally pyritized and sericitized, thus suggesting they are no later than the pyritization and sericitization associated with molybdenite metalization found there. Lamprophyric dikes cut silicic dikes on the ridge between Maybird Gulch and Red Pine Fork and, in contrast to the silicic dikes, were not observed to be pyritized or affected by hydrothermal alteration; they, therefore, may be postmineralization in age.

STRUCTURE

Structurally, the Wasatch Range is an uplifted block of Precambrian, Paleozoic, Mesozoic and Cenozoic rocks that extends more than 100 miles (160 km) north from central Utah into Idaho. Though commonly included in the Southern Rocky Mountains physiographic province (Fenneman, 1931), the range marks the eastern edge of the Basin and Range province, and it shares with the block-faulted ranges of that province certain common characteristic features such as a complex internal structure of folds and faults and a great frontal fault system, known as the Wasatch fault, which bounds the range on the west. Along this fault, the Wasatch Range was uplifted several thousand feet between mid-Tertiary and recent time.

The arcuate Deer Creek fault, which reaches the front of the Wasatch Range at the mouth of Deer Creek, near Alpine (pl. 1), separates the Lone Peak study area into two geologically contrasting parts. That part of the area north of the Deer Creek fault is underlain chiefly by the Little Cottonwood stock. The stock was emplaced near the crest of a broad west-trending anticline of probable Late Cretaceous age, generally considered to be the westward extension of the Uinta anticline (fig. 3).

South of the Deer Creek fault, exposed upper Precambrian and Paleozoic sedimentary rocks are arched into a small dome and are broken by small flat faults and a complex of generally east-west high-angle faults. The Paleozoic rocks, in marked contrast to the thin-shelf sequence exposed north of the Deer Creek fault, compose a thick miogeosynclinal section of quartzites, shales, and carbonate rocks of Cambrian, Mississippian, and Pennsylvanian ages. The juxtaposition of these contrasting sequences of Paleozoic rocks in the central Wasatch Range is thought to be the result of regional thrusting of Late Cretaceous age (Baker and other, 1949).

FOLDING

Two major folds are reflected in the structure of the rocks in the study area: the Uinta anticline north of the Deer Creek fault and a smaller dome south of the fault.

Along the northeast margin of the area, north of the Deer Creek fault, sedimentary rocks dip moderately to steeply east and southeast, reflecting the axial area of the Uinta anticline. The Uinta anticline, the dominant structural element of the central Wasatch Range east of Salt Lake City, is a great upwarp with an amplitude of at least 20,000 feet (6,000 m) (Eardley, 1968, p. 3). The fold (referred to by Eardley as the Cottonwood uplift) is truncated on the west by the Wasatch fault zone and plunges eastward at about 30°. The axial area and at least a part of the south flank were engulfed by the Little Cottonwood stock. The original position of the fold axis is indefinite in the area of intrusion but probably emerges at the mountain front near the mouth of Little Cottonwood Creek. Figure 3 shows the broader relations of this fold, only a small part of which is reflected in the structure of the sedimentary rocks in the study area.

The dominant structural feature south of the Deer Creek fault zone is a prominent anticline or dome. Though this fold broadly determines the distribution of sedimentary rocks within the southern part of the study area, this distribution is considerably modified by faults that transect the anticline (pl. 1). The anticline, as viewed from near Alpine at the front of the range, is an impressive structural feature. From that area, the broad fold is reflected by the northerly dips along the ridge on the north side of Box Elder Canyon and on Box Elder Peak, and by the southerly dips along the south side of American Fork. The axis of the fold reaches the front of the range near Wadsworth Canyon, about 2 miles north of American Fork, and extends east to the southeast margin of the study area. The crestal zone is crossed by two tightly compressed subsidiary synclines (Baker and Crittenden, 1961) and associated minor overturned and locally recumbent folds. The anticline and secondary folds are cut by numerous faults.

FAULTING

DEER CREEK FAULT AND CHARLESTON-NEBO THRUST

The Deer Creek fault, a major normal fault, extends northeastward from the mountain front at Dry Creek to the divide about 1 mile north of Box Elder Peak, whence its trace trends easterly, leaving the area near Silver Lake Flat (pl. 1). The fault, which dips about 50°S. on the divide, separates the Little Cottonwood stock and a thin section of Paleozoic sedimentary rocks in the hanging-wall block on the north from the thick section of Paleozoic sedimentary rocks in the footwall block on the south. To understand the proximity of these two facies of Paleozoic rocks across the Deer Creek fault, one must look to the geology east and south of the Lone Peak area. As the result of several years of detailed mapping in this region, Baker recognized a major regional structural feature called the Charleston-Nebo thrust (fig. 3), which separated very dissimilar facies over a wide area (Baker and others, 1949; Baker, 1959). This overriding block, moving eastward perhaps tens of miles, telescoped two sections of sedimentary rocks in which the upper plate is perhaps ten times the thickness of the equivalent rocks in the overridden plate. The rocks above the thrust have come to be known as the thick facies, those below as the thin facies (Baker, 1959, p. 153). The Charleston-Nebo thrust has been traced westward by Baker (1964) and Baker and Crittenden (1961) to just east of the Lone Peak area where it apparently terminates against a large normal fault that is believed to be the continuation of the Deer Creek fault. According to Baker and Crittenden (1961) the thrust, offset by this fault, must be concealed at depth in the hanging wall of the Deer Creek fault and thus must underlie the part of the Lone Peak area south of that fault. The depth to the thrust plate in the hanging wall of the Deer Creek fault is unknown.

FAULTING SOUTH OF THE DEER CREEK FAULT

The mapping by Baker and Crittenden (1961) reveals a remarkably complex display of faults in the sedimentary rocks south of the Deer Creek fault and north of the Forest Gate fault (pl. 1) Displacements range from a few feet to several thousand feet. Most conspicuous and persistent are normal faults that strike easterly across the area, more or less parallel to the anticlinal axis. The largest of these extends, in a complicated splayed pattern, from near the head of Willow Canyon on the west to the east boundary of the area. The fault is downthrown on the south, and on the east side of Tank Canyon drops Mississippian Gardison Limestone against the Precambrian Mineral Fork Tillite. Another conspicuous normal fault extends northwest to the head of Box Elder Canyon from its intersection with the preceding fault near the east side of the area. This fault is downthrown on the southwest.

Numerous other faults cut the rocks. Small thrust faults in upper Tank Canyon, noted by Baker and Crittenden (1961) to be among the oldest faults in the area, were folded with the sedimentary rocks and later were cut by the normal faults.

FAULTING NORTH OF DEER CREEK FAULT

The most conspicuous faulting north of the Deer Creek fault is along the northeast margin of the study area and includes both overthrust and high-angle normal faults. The faults shown in this area on plate 1 are but a small part of an area of intricate faulting that extends several miles to the north and east. Several small thrusts shown on plate 1 along the east margin are part of a complex of Laramide thrust faults to the northeast in the Cottonwood-American Forks district, known collectively as the Alta thrust zone (Calkins and Butler, 1943, p. 54). Some of these thrusts bring older rocks over younger, and some younger over older. An example of the latter is the thrust fault on the east side of Silver Creek which brings Mississippian Doughnut Formation over Cambrian Ophir Formation and Maxfield Limestone.

The few high-angle faults shown along the northeast boundary (pl. 1) are, in general, small and have only a few tens of feet of displacement. Fissures of northeast strike are common adjacent to Silver Creek and some have been mineralized with silver and lead; movement apparently has been minor on these fissures.

Near the front of the Wasatch Range on the ridge between Little Cottonwood and Bells Canyons, a small patch of much-brecciated crinoidal limestone rests on brecciated quartzite near the base of the Big Cottonwood Formation (pl. 1). According to Crittenden, Sharp, and Calkins, (1952, p. 24), A. J. Eardley (oral commun., 1949) suggested that these relations might be due to thrusting.

JOINTING

The quartz monzonite of the Little Cottonwood stock is thoroughly jointed (fig. 5). Several sets that have diverse strike cut the rock, but joints of two sets are most conspicuous. A set with northeast-by-east strike dips steeply north or south and is approximately parallel to the axis of the Cottonwood uplift and to the intrusive belt across the Wasatch Range. Silicic and intermediate dikes tend to parallel this set. A second set with north to north-

FIGURE 5.—View toward east of closely jointed quartz monzonite of the Little Cottonwood stock on the east side of Hogum Fork.

northwest strike is of flatter dip, averaging between 40° and 75° W., and is about at right angles to the trend of the intrusive belt. Lamprophyre dikes tend to parallel this set. The northerly joint set apparently has some influence on topography; White Pine Fork and all the drainages west to and including upper Bells Canyon parallel this set.

These close-spaced intersecting joint sets so conspicuous on the high ridges between Dry Creek and Little Cottonwood Canyon are no doubt easily affected by frost wedging and lead to rock falls which have contributed to large block talus slopes and rock glaciers.

Joint surfaces are locally stained brown, probably with oxides of manganese and iron. Fresher surfaces were observed that were coated with epidote. These coated joint surfaces tend to be more resistant to erosion and they weather as raised ribs.

AEROMAGNETIC SURVEY

By Don R. Mabey, U.S. Geological Survey

Aeromagnetic data from two surveys are available for the Lone Peak study area. A regional survey made on east and west flight lines, 2 miles (3.2 km) apart and 2.3 miles (3.7 km) above sea level (Mabey and others, 1964), covers a large area in north-central Utah, including the Lone Peak study area. As part of the study reported here, a more detailed survey was flown on north and south flight lines 1 mile (1.6 km) apart and 2.3 miles (3.7 km) above sea level (pl. 3).

The regional survey and another aeromagnetic survey to the east (Crittenden and others, 1967, fig. 7) define a zone of high magnetic intensity that extends westward from the Park City area, through the Little Cottonwood Canyon area, across the south end of Jordan Valley and across the Oquirrh Mountains to Stockton. This major regional magnetic anomaly is coincident with the Oquirrh-Uinta mineral belt (Hilpert and Roberts, 1964) and includes several closed magnetic highs over Tertiary stocks. Similar magnetic zones are associated with the Deep Creek–Tintic and Wah Wah–Tushar mineral belts to the south. The regional magnetic data suggest that the exposed stocks in the Oquirrh-Uinta belt are part of a zone of more abundant intrusive rock at depth.

Major deposits of metallic minerals occur within or adjacent to this zone of high magnetic intensity. The highest magnetic intensity in the zone usually reflects the unaltered intrusive rock and perhaps magnetite-rich replacement bodies. Altered intrusive rocks are commonly reflected by magnetic lows where they are enclosed by unaltered intrusive rock or by no anomaly if they are enclosed by nonmagnetic rock.

The magnetic map of the Lone Peak study area illustrates part of the zone of high magnetic intensity associated with the Oquirrh-Uinta mineral belt. The closed high in the central part of the map area reflects the Little Cottonwood stock and the high in the northeast reflects the Alta stock. The crest of the magnetic high approximately parallels the topographic divide between Little Cottonwood Canyon and the drainages to the south, and the location of the crest of the magnetic high is controlled, in part, by surface topography on the intrusive rock. The extent and character of the anomaly reflect the extent and configuration of the sides of the intrusive mass.

The magnetic anomaly indicates that in the study area the Little Cottonwood stock is nearly uniformly magnetized except in the northeast corner. South of Dry Creek Canyon, the magnetic anomaly indicates that the stock border is nearly vertical but is located about 2,000 feet (700 m) south of the exposed contact. On the southeast, high on the divide between Deer Creek and Silver Creek, the contact of the stock with the Doughnut Formation is known to be flat (fig. 17), but farther southeast, toward Silver Lake Flat, the magnetic data suggest that the contact is nearly vertical. On the east, the border of the stock seems to be nearly vertical and to be approximately under the exposed contact. To the northeast, the magnetic data suggest that the Little Cottonwood and Alta stocks may be connected at depth.

Near the northeast corner of the study area, two magnetic features—one positive, one negative—reflect magnetization intensities different from those of the rest of the Little Cottonwood stock. There, a magnetic nose trends obliquely across Little Cottonwood Canyon near the mouth of White Pine Fork and continues along the north side of the canyon for several kilometers. Along part of this nose, the relief of the north wall of the canyon contributes to the anomaly, but a larger contribution is from rock north of the study area along the north edge of the stock that is more magnetic than the main mass of the stock. If the magnetic variations along the north edge of the stock are produced by a contact between the magnetic stock and nonmagnetic country rock, a nearly vertical contact about 900 feet (300 m) north of the exposed contact is suggested. Two possible explanations for the magnetic nose should be considered, but no geologic support for either has been reported. The preferred interpretation is that the stock is more magnetic along the northern border. A second interpretation is that the northern border of the stock may dip to the south with a zone of magnetite-enriched country rock dipping under the stock to produce the magnetic anomaly.

Three factors contribute to a closed magnetic low centered over Red Pine canyon and to the magnetic low trend extending from Red Pine canyon to the northwest: (1) the steep south wall of Little Cottonwood canyon, (2) the magnetic high to the north, and (3) the less magnetic rock underlying the area southeast of the younger quartz monzonite of White Pine canyon. The abundant dikes (pl. 1) suggest that a younger intrusive that may be less magnetic than the main stock may underlie this area. A second possibility is that the magnetic low defines the zone of alteration (fig. 15) of the main stock where the magnetization has been reduced by alteration of the magnetic minerals. A combination of these two sources of low magnetization is also possible.

MINERAL RESOURCES

By CALVIN S. BROMFIELD, U.S. GEOLOGICAL SURVEY

MINERAL SETTING

The Lone Peak study area lies astride an alinement of intrusive rocks that crosses the Wasatch Range in an east-northeast direction (fig. 6). Associated with this intrusive belt, east of the Lone Peak area, are important ore deposits that have yielded over $600 million in silver, lead, zinc, copper, and minor quantities of gold. The alinement of the intrusives, if projected westward across the Salt Lake Valley, intersects the giant porphyry copper deposit and associated important lead-zinc deposits at Bingham Canyon. Still farther west along this line is a small area of extrusive rocks in the Stansbury Range. The coincidence of this alinement of igneous rocks with concentrations of metallic ore deposits was sufficiently obvious to have been noted by Emmons (in King, 1878, p. 459; Emmons, 1903, p. 145), on the basis of his fieldwork of 1869. Subsequently, many geologists have alluded to this feature variously as the Bingham-Park City uplift (Butler and others, 1920; Beeson, 1925; Calkins and Butler, 1943); the Uinta-Cortez axis or mineral belt (Roberts and others, 1965; Tooker, 1971), and Uinta-Oquirrh mineral belt (Hilpert and Roberts, 1964).

Although the concentration of ore deposits along the mineral belt is a fact long ago observed, it should be emphasized that minable deposits are not uniformly distributed within the belt but occur in clusters. In the Wasatch mineral belt, important deposits have been found to be clustered in two general areas: the Cottonwood-American Fork area on the west and the Park City area on the east. The Park City area or mining district has been by far the most important of these concentrations of mineral deposits; the deposits of the Cottonwood-American Fork area, though considerably less important, have nevertheless yielded considerable quantities of silver and lead.

The major production of metals in the Park City district, 8 miles (13 km) east of the Lone Peak area, has come from limestone-replacement deposits, most importantly from the Permian Park City Formation (Boutwell, 1912), but also from Mississippian Humbug and Lower Triassic Thaynes Formations (Barnes and Simos, 1968). The ore bodies were large; the Park Utah west ore body alone yielded nearly as much metal between 1920 and 1932 as 100 years of production from the Big and Little Cottonwood districts combined.

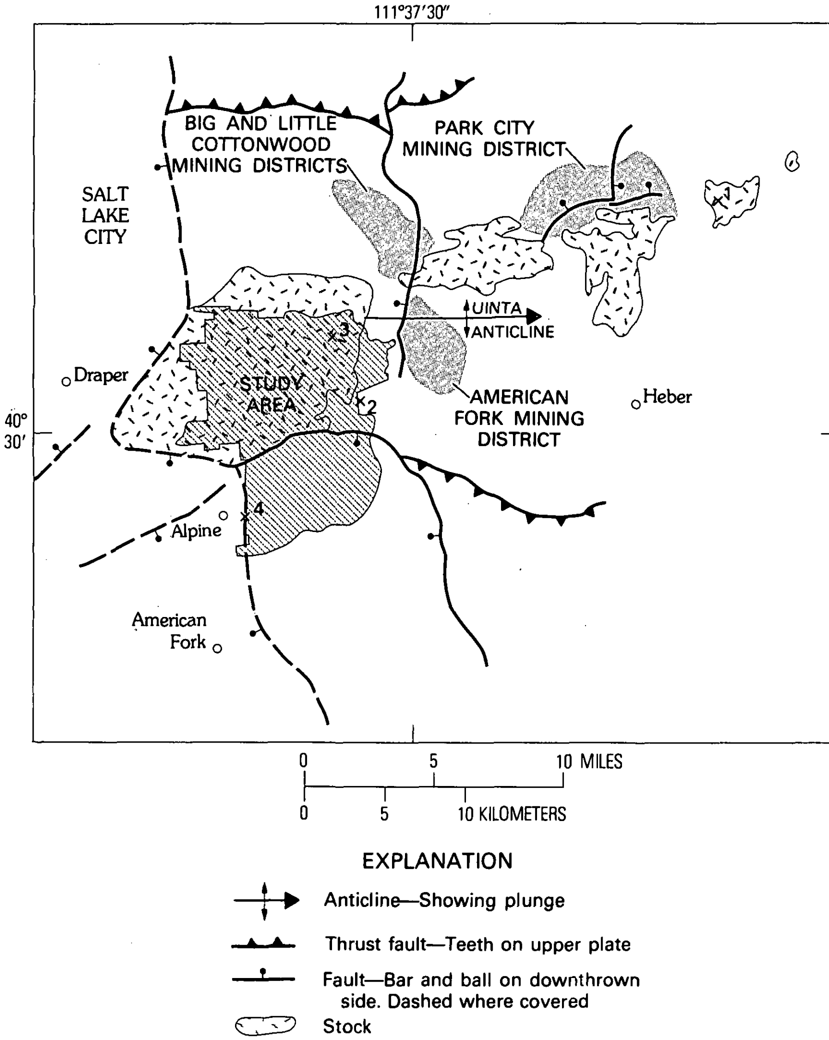


FIGURE 6.—Relation of Lone Peak wilderness study area to Wasatch mineral belt showing stocks (hachured), and mining districts with numerous mines and prospects (stippled). Other minor mineralized areas are (1) hydrothermal alteration in Keetley Volcanics (Oligocene) east of Park City, (2) Silver Lake mining district, (3) molybdenum anomaly and associated hydrothermal alteration in White Pine Fork, and (4) Alpine mining district.

The Big and Little Cottonwood districts and the American Fork district, named from the drainages within which they lie and here called collectively the Cottonwood-American Fork district, are close to the Lone Peak area on the northeast and lie between it and the Park City district (fig. 6). As with the Park City district, the major production has come from carbonate-replacement ore bodies, principally from carbonate members of the Cambrian Ophir and Maxfield, the Mississippian Fitchville, and the lower part of the Mississippian Gardison (Calkins and Butler, 1943, p. 94).

Metals valued at about $45 million have been produced from the combined Cottonwood-American Fork districts (table 3). Three quarters of the production came from the Big and Little Cottonwood districts; most of this came from mines on the north side of Little Cottonwood Creek about 3 miles (5 km) northeast of the study area. The remaining one quarter of the production came from mines in the American Fork district, primarily from ore bodies on Miller Hill about 2 miles (3 km) east of Silver Creek and the east boundary of the study area.

Factors important to the mineral evaluation of the Lone Peak study area are its position within the mineral belt, its close geographic relationship to the Cottonwood-American Fork mining district, its complicated structure, and the presence in it of intrusive rocks and of favorable carbonate host rocks. Because the geologic environment is similar in some respects to that of the other mining districts along the mineral belt, a careful study was made of known mines and prospects and of other potentially mineralized localities in the area.

The early prospectors clearly covered the Lone Peak area in the first wave of intense prospecting in the latter half of the 19th century. No significantly productive silver-lead deposits of the type mined in the adjacent Cottonwood-American Fork district were found, though small but unrecorded production of these metals is probable as evidenced by prospects in the Silver Lake district, which overlaps the east boundary of the area, and in the Alpine district on the west boundary. Of more potential significance is molybdenite mineralization in quartz monzonite of White Pine Fork. Minor occurrences of tungsten are found with the molybdenite and are known from the Deer Creek area (Calkins and Butler, 1943, p. 93).

No coal, oil, or gas has been produced from the area, and there seems little potential for these. Though small deposits of sand and gravel and abundant structural stone could be produced, these are readily available in abundant quantities closer to the market than the study area.

METHODS OF EVALUATION

To accomplish the evaluation of the mineral resources of the Lone Peak study area, all pertinent reports were studied for

TABLE 3.—*Production of metals in Cottonwood-American Fork district from 1867 to 1972*

[Source published records, chiefly from U.S. Bureau of Mines]

District	Gold (ounces)	Silver (ounces)	Pb (tons of metal)	Zn (tons of metal)	Cu (tons of metal)	Total value
Big and Little Cottonwood-----	30,647	17,506,749	125,991	6,183	9,075	$38,359,089
American Forks---	45,043	2,390,736	18,198	2,771	1,224	6,393,099

information of the area; modern geologic maps, which were available for most of the area, were compiled; and the geology, especially as it pertains to potential for mineral resources, was studied in the field. Numerous samples were collected and analyzed. The study area was examined for evidence of mineral deposits. Special attention was given to areas with known deposits, to other areas with similar environments, and to areas with hydrothermally altered rocks. All mines and prospects were visited and a search was made for mining claims in records at the Salt Lake and Utah County courthouses. The area was flown and an aeromagnetic map was made.

SAMPLING AND ANALYTICAL PROGRAM

Several hundred samples were collected and analyzed to provide chemical data necessary for the resource appraisal of the Lone Peak study area. These consisted of 291 stream-sediment samples and 176 rock samples of various types of unaltered and mineralized rocks. The U.S. Bureau of Mines, in addition, collected 94 samples from prospects and mine workings, chiefly from veins, lodes, and dumps. The several sample types are described below. U.S. Geological Survey sample localities are shown on plate 2. Localities of the Bureau of Mines samples are shown on area maps in the section on mines and prospects.

UNALTERED ROCKS

Fifty-two samples chosen to be representative of several major rock units of the Lone Peak area were collected and analyzed spectrographically and by atomic absorption to provide information on the background content of metallic and nonmetallic elements.

ALTERED AND MINERALIZED ROCKS AND VEINS

Altered mineralized rocks, fault breccias, and veins were looked for and sampled for their metal content. Grab samples of these rocks were taken principally from outcrops but also from a few mine dumps. Indications of mineralization in these samples included iron-stained joints, alteration to clay minerals, pyrite impregnations, and visible ore minerals such as sphalerite and galena. These samples are highly selective and were collected to determine the presence of valuable elements. Thus, the analytical results are not representative of any specific mineralized zone. Representative samples were collected by the U.S. Bureau of Mines. These are systematic chip samples taken across veins or other lodes where these crop out at the surface or are exposed in the few accessible workings in the area. In addition, composite grab samples were taken at regular intervals across some dumps. These samples are discussed in greater detail in the section on mines and prospects.

STREAM SEDIMENTS

Collection and analysis of stream sediments provide a rapid technique for reconnaissance evaluation of large areas. Stream-sediment samples represent a composite of material derived from the chemical and mechanical weathering of the rocks in the catchment or basin areas. Fine-grained stream sediments, in particular clays and silts, tend to absorb metallic ions from stream waters, and they thus reflect metals that are present in the drainage basin. For this reason, several handfuls of finer materials were collected at intervals along all the trunk streams and many of the tributaries in the area. The samples were dried, sieved to minus-80 mesh, and mixed, and then a 10-mg split was analyzed.

Several samples of sand and gravel from streambeds were panned. The concentrates were examined for gold and other heavy minerals and were then scanned by ultraviolet light. Trace amounts of scheelite were found in concentrates from the northern drainage of Deer Creek. No gold or other significant heavy minerals were found in any of the panned concentrates.

Analytical determinations on samples collected by the U.S. Geological Survey field party were done chiefly in the field in mobile laboratories of the Geological Survey. All the samples were scanned for 30 elements by a 6-step semiquantitative spectrographic method (Grimes and Marranzino, 1968). Because of the relatively high detection limits of zinc and gold by semiquantitative methods for these metals, all samples were analyzed by atomic absorption methods. In addition, all samples were checked for mercury by mercury detector. The spectrographic analyses were done by E. S. Cooley, and all chemical analyses by C. L.

Whittington, both of the U.S. Geological Survey. Z. C. Stephenson made eU determinations by laboratory scintillation counter on stream sediments and rock samples in the Denver laboratories of the U.S. Geological Survey. For greater accuracy, a few weakly anomalous samples were further checked for uranium by paper chromatography but showed virtually no positive results.

Fire assays and semiquantitative spectrographic analyses of samples collected by the U.S. Bureau of Mines party were made by the Bureau's laboratory at Reno, Nev. Samples showing anomalous quantities of potentially valuable elements by spectrograph were reanalyzed by various other methods.

Only data for gold, silver, copper, lead, zinc, molybdenum, and tungsten are tabulated in this report or are generalized on geochemical maps of specific elements. The complete analytical data for 30 elements on all samples collected by the Geological Survey are stored on magnetic tape of an IBM 360 computer and are available to the public from the National Technical Information Service (Whittington and others, 1975).

GEOCHEMICAL PATTERNS

Tables 4 and 5 (following "References Cited") give the analytical results for selected metals in stream sediments and rock samples. One or more metals are anomalous in numerous samples of stream sediments and rocks; the distribution of anomalous samples for seven different metals is plotted in figures 7 through 14. Threshold anomalous values of metals in stream sediments and rocks were chosen in part arbitrarily by visual inspection of histograms of the metal analyses and by consideration of average metal content of fresh rocks collected from the study area or of similar rock types given in the literature. For some metals, threshold values were chosen by plotting on probability paper the cumulative frequency distribution curves for the metals and by picking values at or near sharp inflection points on the upper end of these curves.

Study of available geologic and historical knowledge of the Lone Peak area indicates that silver and lead have been recovered in the vicinities of Silver Creek-Deer Creek and Alpine, that low-grade disseminated molybdenum occurs in White Pine Fork, and that small amounts of tungsten have been found in both White Pine Fork and Deer Creek. The distribution of metal concentrations illustrated by the plots of figures 7 through 14 reflects clearly the known occurrence of metal concentrations. Thus, in the Silver Creek-Deer Creek and Alpine areas, amounts of silver and lead, together with their congener zinc, are anomalous. In the White

Pine area, amounts of molybdenum and tungsten, together with silver, copper, and zinc, are anomalous. West of White Pine Fork in Red Pine Fork, one or more metals are anomalous in a cluster of samples, and the anomaly probably reflects the outer fringe of mineralization related to the known occurrence of metal concentration in White Pine Fork. Elsewhere, one or more metals are anomalous in a few scattered samples, but none of the anomalies is believed to reflect economic concentrations at or near the surface.

Figure 7 shows a conspicuous molybdenum anomaly in White Pine Fork, in the northeast part of the study area. As expected, the anomaly reflects the known low-grade molybdenum metalization in White Pine Fork and suggests that similar metalization extends into Red Pine Fork on the east. Background molybdenum in both stream sediments and rocks is less than 5 ppm, the limit of sensitivity of the analytical technique that was used. Levinson (1974, p. 43) gives an average crustal abundance value of 2 ppm for soil, and 1 or 2 ppm for granite or granodiorite. Anomalous stream-sediment samples in White Pine and Red Pine Forks range from 5 or 300 ppm molybdenum and extend downstream in both drainages from about the 9,400-foot contour. Rock samples in the same area, mostly of iron-stained quartz monzonite with varying amounts of disseminated pyrite, contain molybdenum in the range of 5 to 700 ppm.

Beyond the White Pine–Red Pine Forks area, only a few thinly scattered rock and stream-sediment samples contain anomalous amounts of molybdenum. Most coherent is an intermittent train of anomalous stream-sediment samples in Dry Creek. Most of these samples contain 5–10 ppm molybdenum; one contains 15 ppm.

Copper has a background value of about 20 ppm in stream sediments from both the streams draining the Little Cottonwood stock and the Paleozoic terrane to the south. The range in values shown as anomalous is from 100 to 1,500 ppm. Anomalous copper in stream sediments is found chiefly in the drainages of White Pine Fork and Red Pine Fork (fig. 8) in association with the molybdenum mineralization there. The copper may be derived from the copper sulfide chalcopyrite, a common associate of porphyry molybdenite deposits. Disseminated pyrite is widespread in both White Pine Fork and Red Pine Fork, and chalcopyrite is largely soluble in the oxidized-acidic environments that, in general, result from weathering of pyrite. No chalcopyrite was observed in outcrop, however, and among rock samples, only two samples are anomalous at the level of 300 ppm or greater. One of these, a highly pyritized quartz monzonite, contained 1,000 ppm (RM108, table 5).

According to the geochemical table of Levinson (1974), average

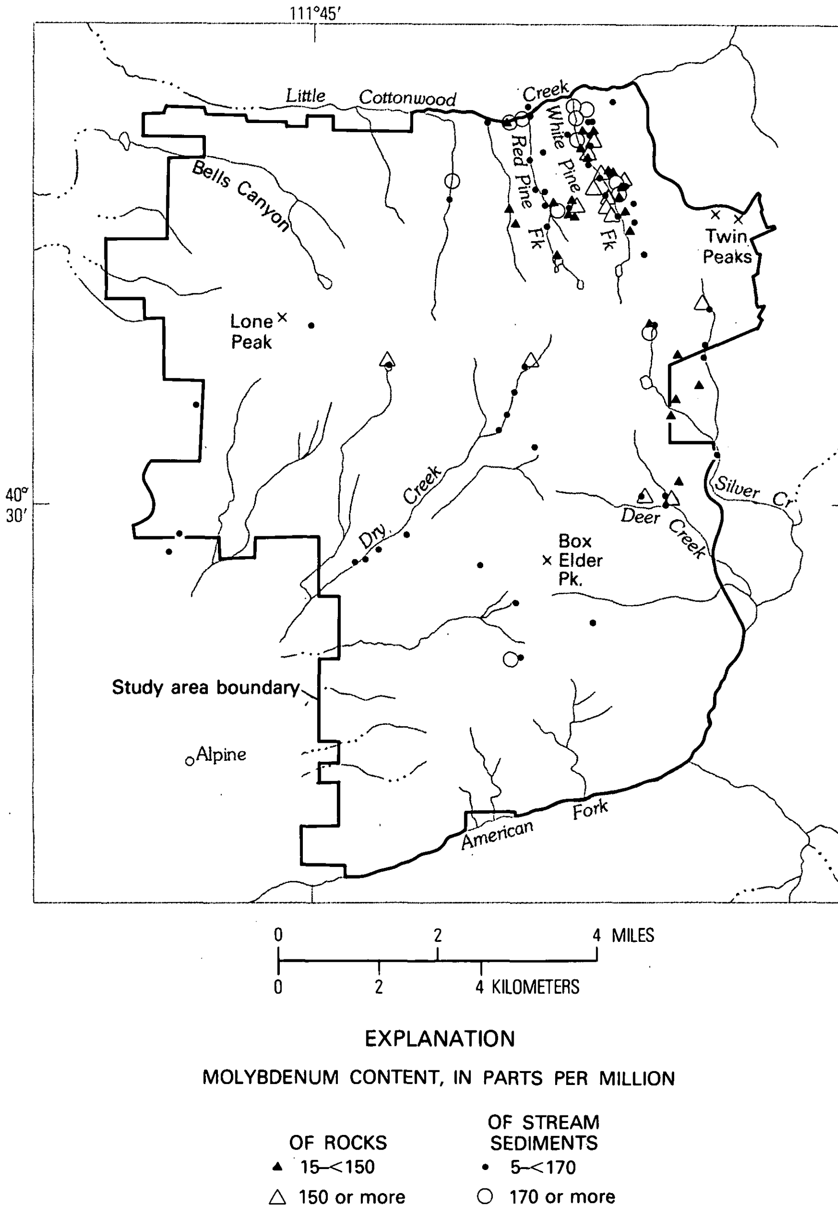


FIGURE 7.—Distribution of molybdenum in the Lone Peak wilderness area.

granodiorite and granite contain 30 and 10 ppm copper, respectively. Average quartz monzonite of the Little Cottonwood stock contains no more than 7 ppm. Several rock samples with anomal-

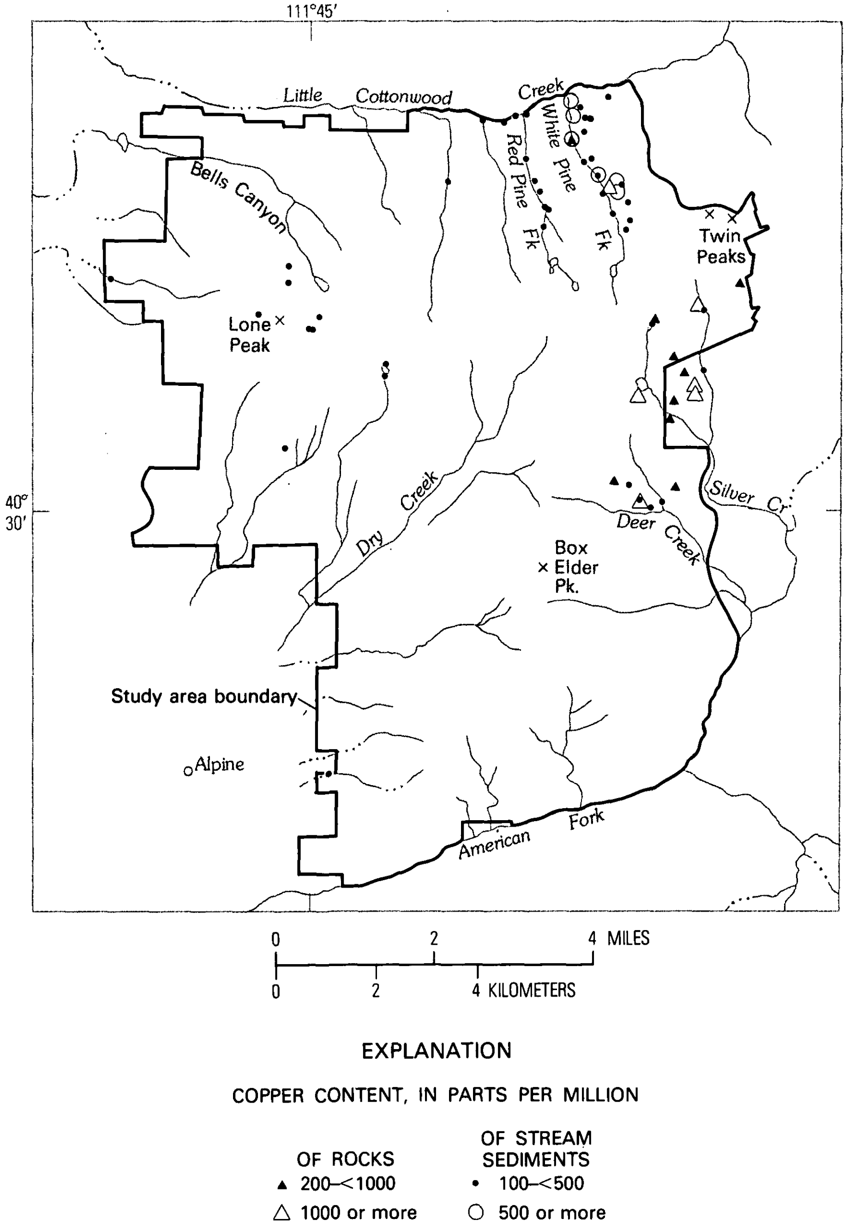


FIGURE 8.—Distribution of copper in the Lone Peak wilderness study area.

ous copper were collected in the Silver Creek-Deer Creek area, and they reflect known mineralization. Most of the samples were selected from small dumps, and a few contain visible chalcopyrite.

One sample (RM056, table 5) near Silver Glance Lake, which represents heavily iron-stained joints, contained 700 ppm copper.

Silver has a background value in stream sediments and rocks of less than 0.5 ppm, the sensitivity limit of the analytical method. In stream sediments, it was detected in only two samples, at the levels of 5 and 7 ppm. Both were taken from the Silver Creek drainage basin just outside the study area on the east (fig. 9) and probably reflect contamination from old lead-silver mine dumps along Silver Creek. Similarly, two anomalous samples taken near Alpine reflect a small lead-zinc deposit in Paleozoic carbonate rocks at that locale. The most conspicuous pattern of anomalous silver in stream sediments occurs in the northeastern part of the area, chiefly in White Pine Fork and adjacent Red Pine Fork. In this area several weakly anomalous stream-sediment samples at the level of 1-3 ppm are associated with low-grade molybdenum mineralization and with hydrothermal alteration.

As expected, some of the rock samples from the White Pine Fork and Red Pine Fork area (fig. 9) contain anomalous amounts of silver greater than 2 ppm. Areas of anomalous silver in rocks are found in the Silver Creek–Deer Creek area (fig. 9) and reflect known mineralization.

The background value of zinc in stream sediments of the area is about 90 ppm. Values range from 20 to 850 ppm. A cluster of anomalous stream-sediment samples was collected from White Pine Fork and Red Pine Fork in the northeast corner of the area. Another smaller string of anomalous samples was collected along the east fork of Silver Creek (fig. 10). One sample (SC059, table 4) ran 830 ppm. These samples, the latter in particular which is on the creek directly downslope from old dumps, probably reflect contamination from old mining operations in the area just east of the study area boundary.

In marked contrast to the strong zinc stream-sediment anomaly in White Pine Fork and Red Pine Fork, only four altered rock samples collected in this area contained zinc at levels of 100–150 ppm. Possibly the acid environment provided by oxidizing pyrite that is so widespread in these drainages has facilitated the leaching of zinc sulfide. The few highly anomalous rock samples in the Silver Creek–Deer Creek and Alpine areas (fig. 10) were specimens collected from dumps and prospects. Similarly, the single anomalous rock sample taken near the headwaters of Box Elder Creek is from a selected sample of iron-stained limestone from a small prospect. (See p. 73.)

The stream-sediment and rock-sample background values for

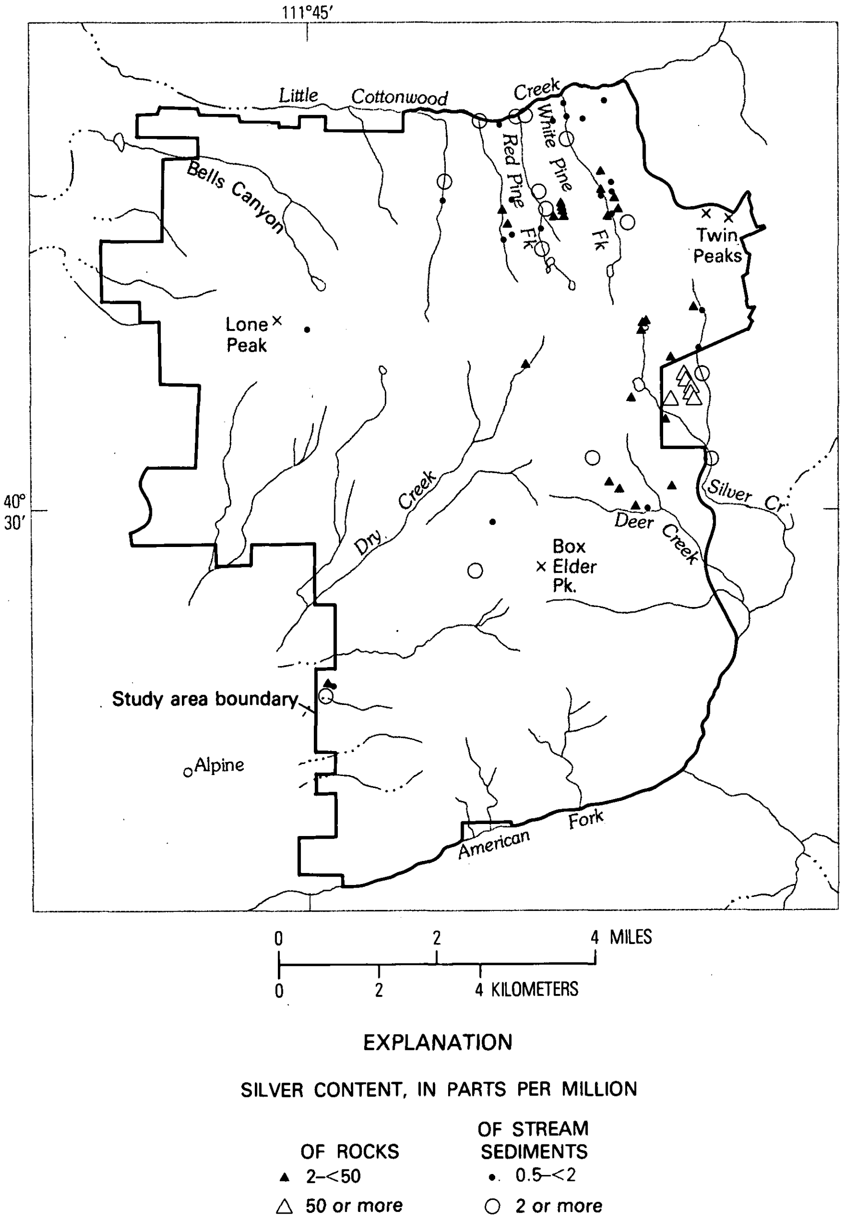


FIGURE 9.—Distribution of silver in the Lone Peak wilderness study area.

tungsten are probably far less than 50 ppm, the sensitivity limit of the semiquantitative method used. This rather high sensitivity is considerably above general rock-abundance values for tungsten of

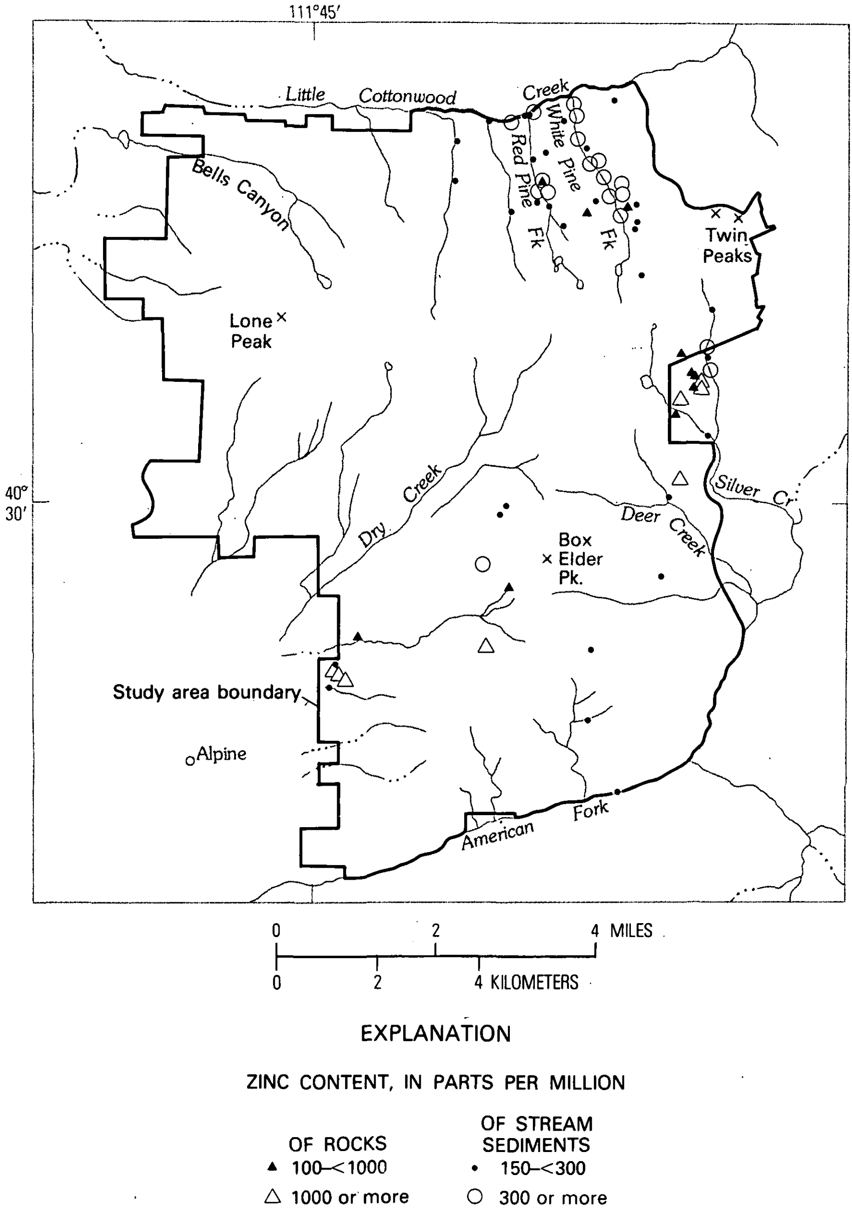


FIGURE 10.—Distribution of zinc in the Lone Peak wilderness study area.

1-2 ppm given in geochemical tables (Levinson, 1974). The tungsten contents of a very few stream sediments or rocks rise above this limit, and most of these samples are scattered between White

Pine Fork and Maybird Gulch to the west (fig. 11). Scheelite is known to occur along joint planes in the quartz monzonite in this area (Sharp, 1958). Six samples of altered rock taken in this area showed tungsten at levels of 70 and 100 ppm. Two stream samples and three rock samples in the Silver Creek-Deer Creek area contain anomalous tungsten. A sample of tactite from a dump in Deer Creek contained 1,000 ppm tungsten (RM003, table 5, pl. 2). A tactite lens in this vicinity has yielded a small production of scheelite.

Lead is at the same time the most widespread and the most enigmatic of the anomalies in stream sediments (fig. 12). Values of at least 200 ppm are scattered throughout the area underlain by the Little Cottonwood stock, though south of the Deer Creek fault in the Paleozoic terrane such values are rare (fig. 12). The anomalous values of lead in White Pine Fork and adjacent Red Pine Fork are coincident with anomalous values of molybdenum, copper, silver, zinc, and tungsten (figs. 7-11) and are not an unexpected accompaniment of the hydrothermal alteration and molybdenum mineralization recorded in the rocks there. Similarly, anomalous lead in the Silver Creek and Alpine areas can be explained on the basis of lead-zinc metalization in those areas. Other widespread anomalous lead values of at least 200 ppm in stream-sediment samples in Bells Canyon and south and west of Lone peak apparently are in areas of fresh quartz monzonite that show no obvious mineralization. The median value of lead in stream-sediment samples in the intrusive terrane is 100 ppm.

The high lead background in stream-sediment samples collected from the area underlain by the stock is probably in part due to the high average lead content of the stock, of the potassium feldspar phenocrysts, and of the joints that cut the stock. The average lead content of 16 samples of the quartz monzonite of the Little Cottonwood stock was about 50 ppm; the range was from 20 to 100 ppm. Fleisher (1976), calculated an arithmetic average of 22 ppm lead and a median of 16 ppm from 317 published analyses of granodiorite and adamellite (quartz monzonite). The average lead content of the Little Cottonwood stock is thus more than twice the average obtained by Fleisher. Lead can substitute in part for potassium in potassium feldspars. Five samples of potassium feldspar (table 6) had a range from 70 to 300 ppm. Slawson and Nackowski (1959) reported an average of 55+18 ppm for lead in potassium feldspars from the Little Cottonwood stock. Another possible source of lead in stream sediments is from weathering of joint planes; nine samples taken from these joint planes ranged from 10 to 1,000 ppm lead (table 7).

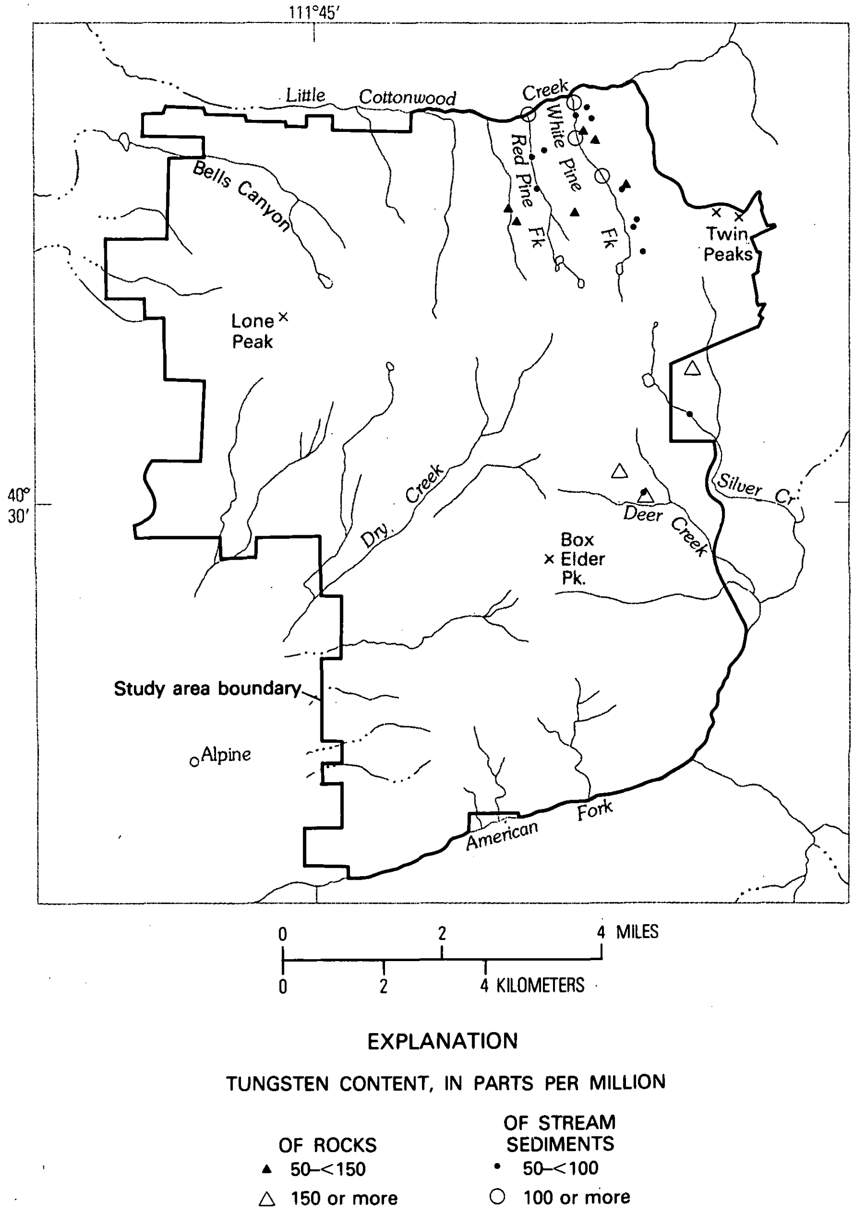


FIGURE 11.—Distribution of tungsten in the Lone Peak wilderness study area.

Anomalous lead in rocks and stream sediments (fig. 12) elsewhere mainly reflects areas of known mineralization. Thus, highest values were from mineralized rocks in the Silver Creek-

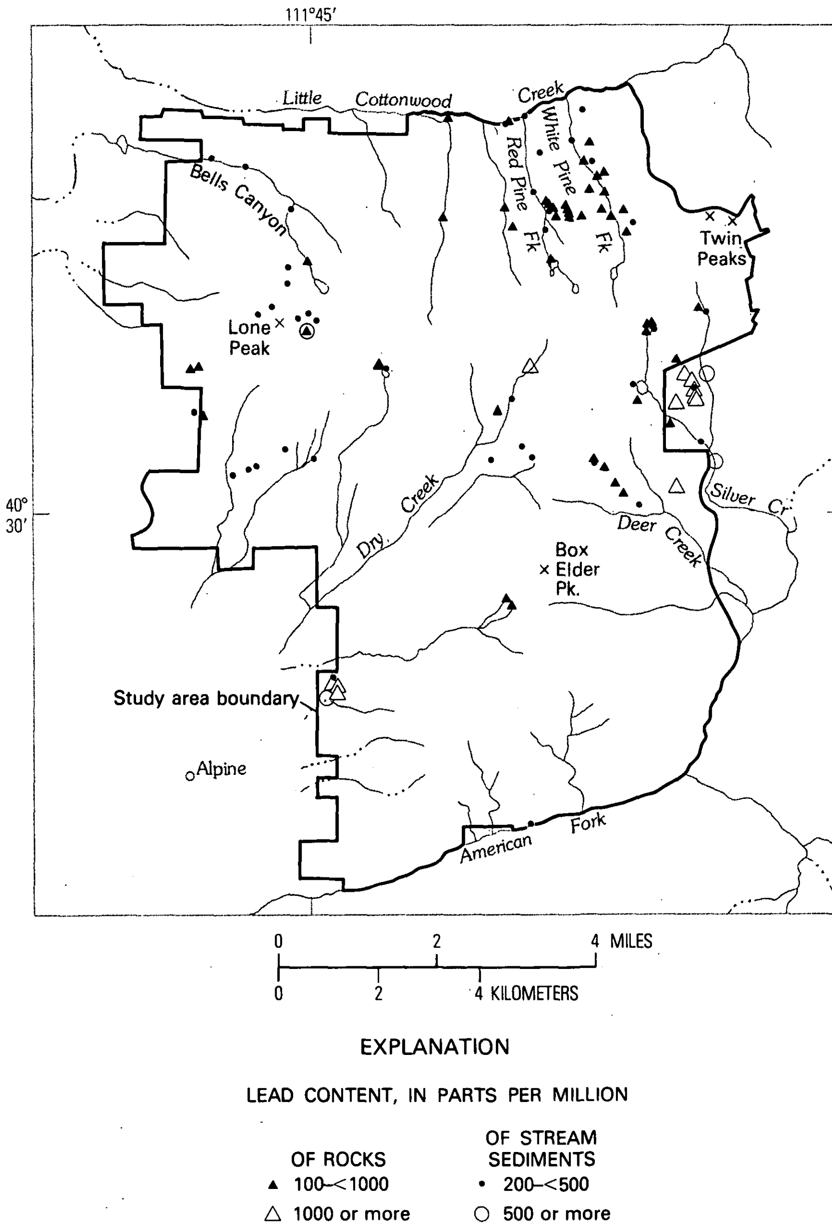


FIGURE 12.—Distribution of lead in the Lone Peak wilderness study area.

Deer Creek area and in the Alpine area and merely confirm known lead metalization. Galena was visible in some samples from Silver Creek. At Alpine no galena was visible and the lead indicated in

TABLE 6.—*Semiquantitative spectrographic analyses (in parts per million) for lead and barium in potassium feldspar phenocrysts from the quartz monzonite of the Little Cottonwood stock, Lone Peak Wilderness study area.*

[The symbol H indicates element present in amounts greater than the content given]

Sample No.	Pb	Ba
RS052	150	>5,000
RS098	300	>5,000
RS173	70	500
RS175	70	5,000
RS176	100	>5,000

TABLE 7.—*Semiquantitative spectrographic analyses for lead, copper, molybdenum, and silver and atomic absorption analyses for gold and zinc in samples from iron stained joint planes that cut the Little Cottonwood stock (in parts per million)*

[Numbers in parentheses indicate sensitivity limit of method used. Symbol H indicates that an undetermined amount of element was detected below the sunsitivity limit]

Sample No.	Pb (10)	Cu (5)	Mo (5)	Ag (0.5)	Au (0.05)	Zn (5)
RM014	1,000	20	300	2	<0.05	15
RM033	500	5	<5	<.5	<.05	50
RM053	100	<5	<5	<.5	<.05	35
RM056	10	700	10	<.5	<.05	30
RM057	150	100	<5	2	<.05	25
RM058	70	10	<5	<.5	<.05	10
RM059	200	50	100	5	<.05	<5
RM069	300	20	<5	7	<.05	50
RM110	100	100	700	2	<.05	20
RM150	200	15	30	5	<.05	20

the analyses of a few samples is probably in the form of lead carbonate (cerussite).

Gold analyses were made for all samples of stream sediments and rocks, but only a few samples were found to contain gold above the analytical limit of 0.05 ppm (fig. 13). None of the rocks or stream sediments contained as much as 1 ppm gold (1 troy ounce per ton is equivalent to about 34 ppm). Most of the anomalous samples were taken between the two forks of Silver Creek in an area of past mining activity for silver and lead; the localities were coincident with those containing silver or lead. A few weakly

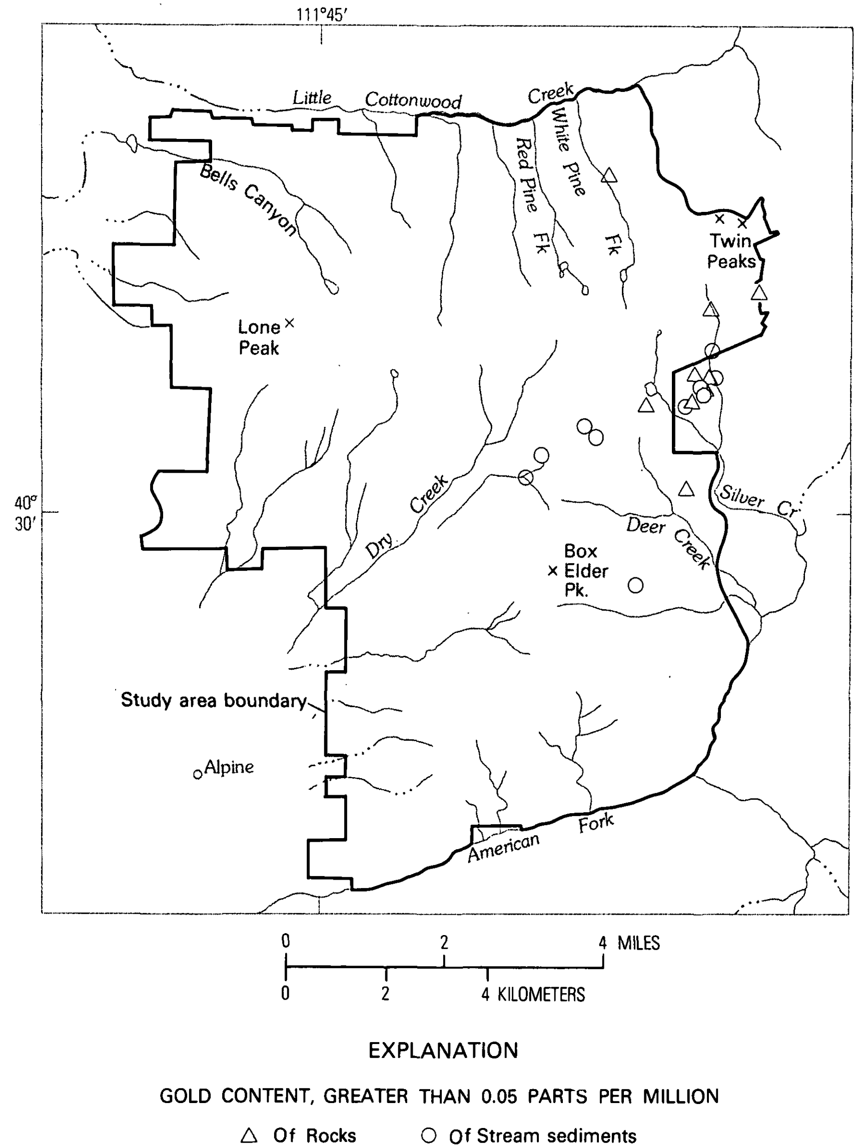


FIGURE 13.—Distribution of gold in the Lone Peak wilderness study area. Maximum gold content of stream sediments or rocks is 0.6 ppm.

anomalous stream-sediment samples were taken near upper Dry Creek basin.

Arsenic and antimony were not detected in any stream-sediment samples; bismuth was present in several samples, especially in the White Pine Fork-Red Pine Fork area and the Silver Creek-Deer

Creek area (fig. 14). Bismuth, and to a lesser extent arsenic and antimony, occurs in rock samples from the latter area in association with samples high in one or more other metallic elements, particularly silver or lead.

In summary, anomalies of molybdenum, copper, silver, zinc, tungsten, lead, and gold reflect known areas of mineralization in White Pine Fork, the Silver Lake district, and the Alpine district. Anomalous lead in stream sediments is widespread in areas underlain by the quartz monzonite of the Little Cottonwood stock and is believed to reflect the high average lead content of the stock, both in potassium-feldspar phenocrysts and along joints, rather than any potential for lead deposits. Bismuth, antimony, and arsenic, characteristic minor elements accompanying metallic sulfides, similarly reflect known areas of mineralization.

The analytical results of 20 other elements, ranging from the common elements such as calcium and iron to rare-earth elements such as lanthanum and yttrium, indicated only normal contents.

ECONOMIC GEOLOGY AND APPRAISAL OF AREAS

WHITE PINE FORK AREA

The presence of molybdenite in the northeastern part of the Little Cottonwood stock has evidently long been known. Hess (1908, p. 239) stated that molybdenite was known to occur in a canyon on the south side of Little Cottonwood Canyon, and Calkins and Butler (1943, p. 91) reported molybdenite in quartz veins that cut the stock in Gad Valley, just east of White Pine Fork, and just outside the Lone peak study area. The molybdenite occurrence within the study area, in White Pine Fork, was described briefly by Buranek (1944) and, in greater detail, by Sharp (1958). Erickson and Sharp (1954) reported finding scheelite on joint planes, peripheral to the molybdenite occurrence in the White Pine Fork area. No production has come from the area.

White Pine Fork heads in a high basin southwest of Twin Peaks near White Pine Lake and flows north into Little Cottonwood Creek, which it joins about 2 miles (3 km) west of Alta, along the northeast edge of the study area (pl. 2). Because iron-stained and altered rocks and anomalous stream sediments and rocks are found locally between the valley of White Pine Fork on the east and Maybird Gulch on the west, the whole area is included in the White Pine Fork area as designated here.

Geologically, the distribution of rocks in the area is simple (fig. 15; pl. 1); the area is underlain by porphyritic quartz monzonite of the Little Cottonwood stock. In White Pine Fork and eastward into

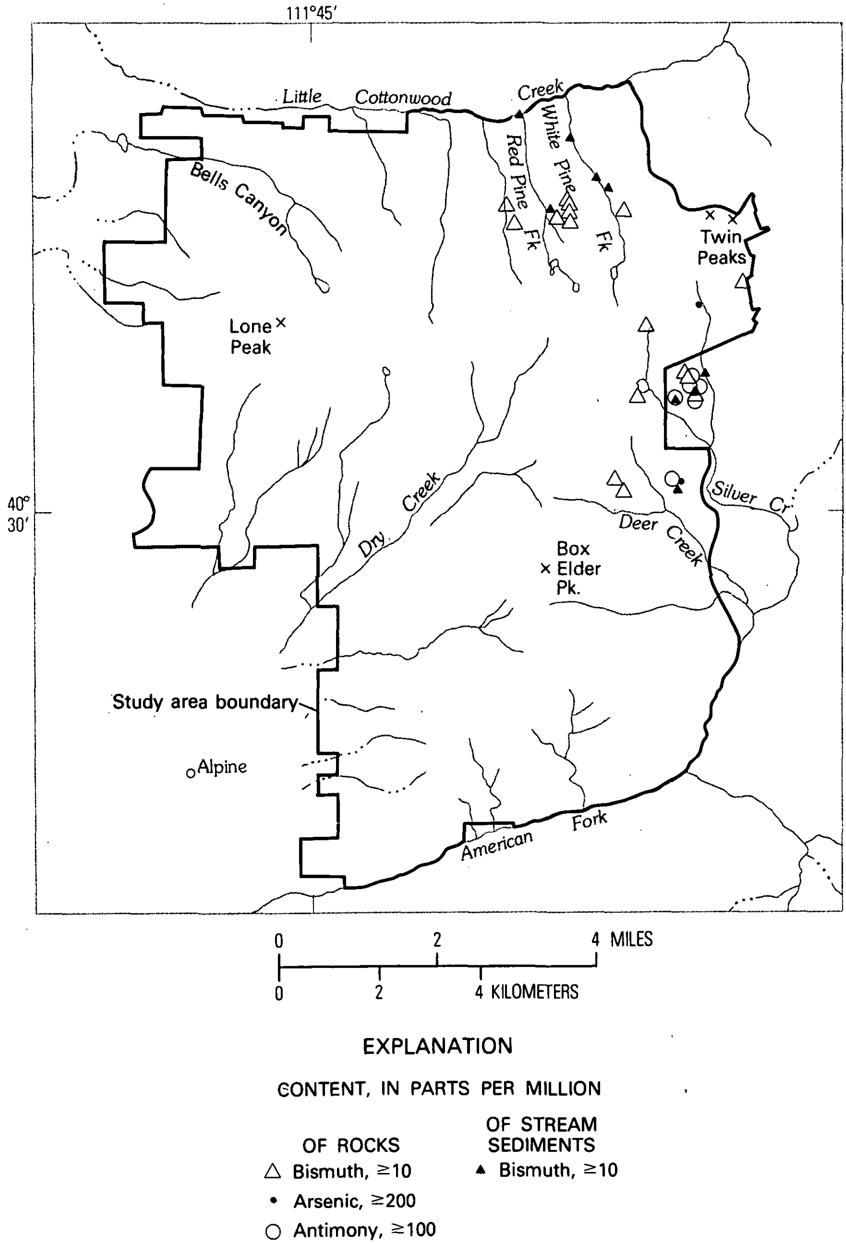


FIGURE 14.—Distribution of bismuth, arsenic, and antimony in the Lone Peak wilderness study area.

Gad Valley, the stock is cut by a small stock or plug of light-colored, generally fine-grained intrusive rock mapped as leucocratic quartz monzonite by Crittenden (1965a) and called White Pine stock by Sharp (1958). Both stocks are cut by silicic, intermediate, and lamprophyric dikes.

The area underlain by the leucocratic quartz monzonite of the White Pine stock has been mapped somewhat differently by Crittenden (1965a) and Sharp (1958). Defining the boundary between the two rock types is difficult owing to the variable textures in the leucocratic quartz monzonite, the gradational contacts with the Little Cottonwood stock, a widespread alteration that tends to mask rock textures by iron-staining, and the broad cover of moraine and talus in the valley and along the lower slope of White Pine Fork. As mapped by Crittenden (1965a), the stock is crudely oval and extends about 1 mile from Gad Valley on the east to White pine Fork (pl. 2); as mapped by Sharp (1958), the stock extends west from White Pine Fork, nearly to Red Pine Fork.

The mid-Tertiary dikes that cut the stocks are not radial to the White Pine intrusive center. The silicic and intermediate dikes in general trend northeast by east, parallel one of the prevailing joint sets, and are parallel to the Wasatch intrusive belt. The dikes seem to be part of a dike zone that extends northeastward for several miles. In White Pine Fork these dikes have been altered and pyritized in places. Lamprophyre dikes tend to strike northerly, to cut the other dikes in Maybird Gulch, and seem to be younger.

ROCK ALTERATION AND MOLYBDENITE MINERALIZATION

The area centered on White Pine Fork, in the vicinity of the White Pine intrusive center, is marked by widespread hydrothermal alteration. Types of alteration include the addition of silica in the form of stringers and veins of quartz; pyritization in quartz veins, along joint planes, and disseminated through the igneous rocks; and metasomatism, manifested by sericitization of the igneous rocks and local formation of pink potassium feldspar in some quartz veins and adjacent wallrock. In the field, the most visible aspect of alteration is pervasive red iron staining of the country rock, reflecting the oxidation of pyrite. The zone affected by conspicuous iron staining and pyrite dissemination as roughly outlined on figure 15 is at least 8,000 feet (2,400 m) east-west, and perhaps half that much north-south. Within this area, the intensity of alteration is irregularly distributed and ranges from rocks that contain apparently fresh biotite, have only local pyrite, and show meager iron staining to quartz-sericite rocks that are stained dark red and contain abundant pyrite.

The most intensely altered and mineralized rock in the White Pine intrusive center is concentrated in the middle part of White

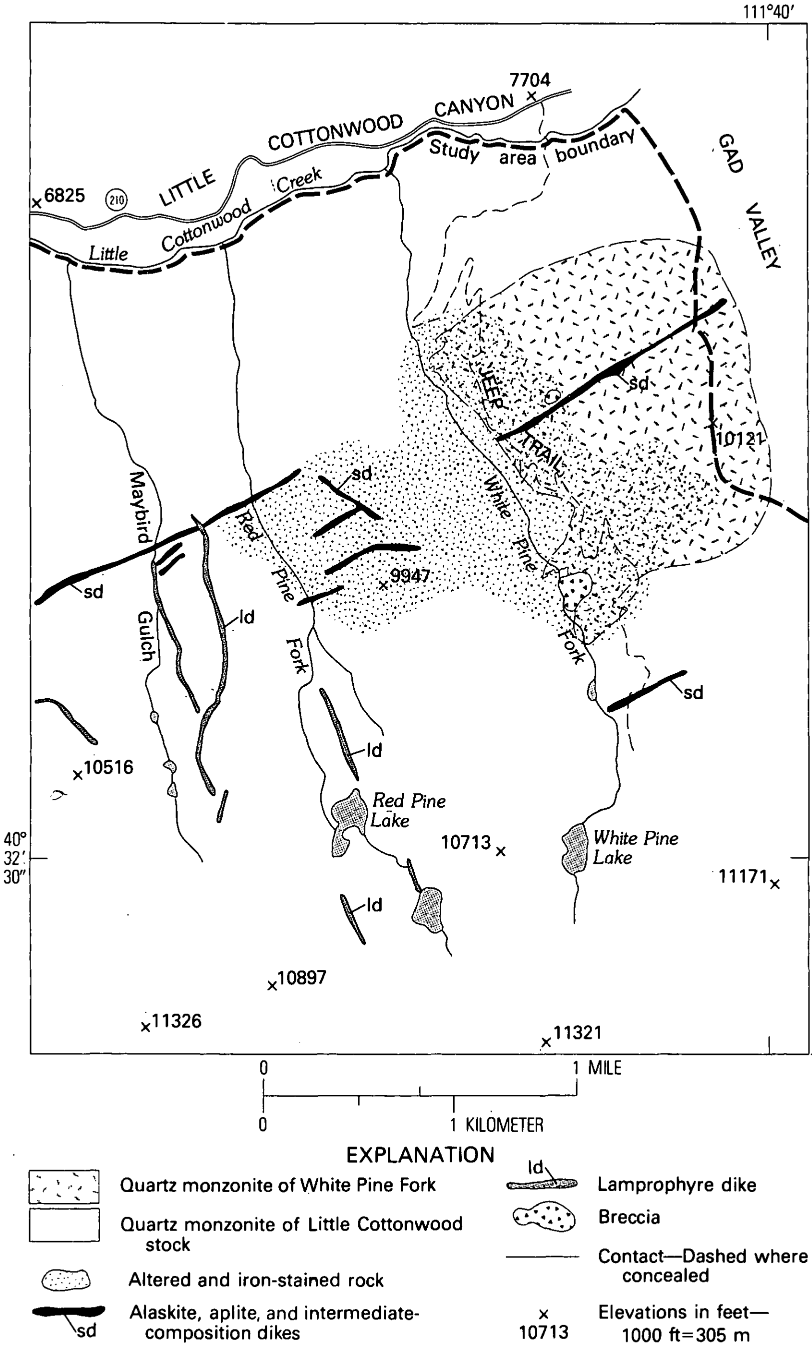


FIGURE 15.—Tertiary intrusives of the White Pine Fork area in the northeast corner of the Lone Peak wilderness study area. Modified from Crittenden (1965a).

Pine Fork, near the south edge of the area of hydrothermal alteration, at an elevation of about 9,000 feet (2,750 m). In that area, on the east side of White Pine Fork at creek level, a conspicuous gossan knob of brecciated igneous rock crops out in a rudely oval mass about 600 by 400 feet (180 by 120 m) in size (fig. 15). The outcrop is strongly stained by iron oxides in mottled hues of orange, brown, and red. The breccia is sericitized and pyritized and is interlaced with a network of anastamosing quartz in veins and irregular masses of various sizes (fig. 16). A few quartz veins are more regualr and trend northeast, parallel to one of the common joint sets in the stock. The quartz veins, in places coarsely crystalline and vuggy, contain pyrite and some pink potassium feldspar. Coarse sericite or muscovite is common as selvages along the quartz veins and is abundant in the altered breccia. Molybdenite occurs sparingly in quartz veins, as smears or coatings along fractures, and as disseminations in the altered rocks. Ferrimolybdite crusts and crystals are common.

Other sulfides are not common in the White Pine Fork area. Sharp (1958), who has made the most thorough published study of the area, reported finding some sphalerite and galena in quartz veins. Fluorite, not observed by us, was reported by Sharp (1958, p. 1427) on the ridge between Red Pine and White Pine Forks. Scheelite, which occurs in sparse amounts on joint planes in the White Pine Fork area, was believed by Sharp to be better developed in an area peripheral to that containing molybdenite.

As expected, the geochemical data for both rocks and stream sediments indicate highly anomalous molybdenum in the White Pine Fork area. As is illustrated in figures 7-10, this anomaly is associated with anomalies in zinc, copper, silver, and tungsten. None of the latter anomalies suggests economic concentrations of these metals; the anomalies probably reflect minor local occurrences of metallic sulfides, such as sphalerite and chalcopyrite, or of tungstates. These minerals in minor amounts are characteristically associated with low-grade molybdenite deposits (Clark, 1972, p. 739). Molybdenum values in rocks, selected in the field from among those that showed visible signs of mineralization, ranged from 20 to 700 ppm. Five samples of selected chips from iron-stained talus ranged from 50 to 300 ppm. It should be emphasized that the rock samples are highly selective of the most mineralized material that was found at each site and that the geochemical samples are not intended to determine grade of large volumes of rock. The results of detailed sampling are presented in the section on mines and prospects. No emphasis should be placed on the values for specific samples. Stream sediments anomalous in

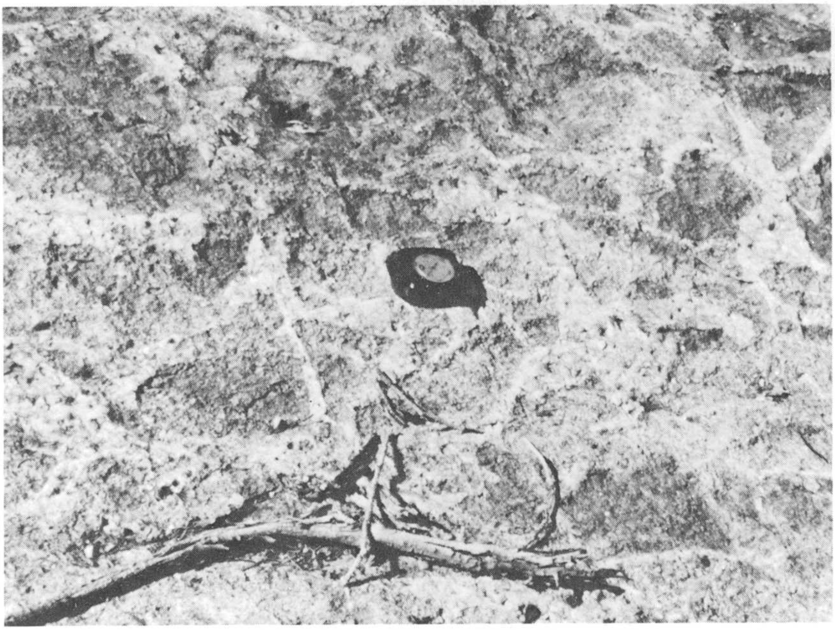


FIGURE 16.—Brecciated, altered, pyritized, and iron-stained quartz monzonite (Tertiary) laced with white quartz veinlets. The quartz monzonite contains a small amount of molybdenite in veins and disseminations. Forms prominent gossan knob at about 9,000 ft (2,740 m) in White Pine Fork. Scale indicated by altimeter.

molybdenum, zinc, and copper extend from near the breccia zone, then north along White Pine Fork to Little Cottonwood Creek. Molybdenum was found to be anomalous in fewer samples, both of stream sediments and rocks, in Red Pine Fork and Maybird Creek to the west.

Silver is anomalous in a few stream-sediment samples in White Pine Fork, Red Pine Fork, and Maybird Gulch at the levels of 0.5–3 ppm. Anomalous silver in rocks, chiefly at levels of 0.5–2 ppm seems to be clustered along the south side of the altered zone depicted in figure 15.

Tungsten, in the form of scheelite (or powellite), huebnerite, or wolframite, is a common associate in many low-grade molybdenum deposits, and is a byproduct at Climax, Colo. Tungsten, which has a 50-ppm level of detection by the spectrographic method used, was considered anomalous if detected at all. Only a few stream sediments and rock samples had detectable tungsten. Of the five analyzed talus samples, only two carried anomalous tungsten: one at 70 ppm (RM111, table 5), the other (RM168, table 5) at 1,000 ppm. Two reruns on this sample showed only 100 ppm tungsten. Sharp (1958, p. 1428) reported that one talus sample from White Pine Canyon contained 0.02 percent WO_3 (200 ppm). Only four mineralized rock samples contained tungsten, in amounts ranging from 70 to 100 ppm (RM117, 124, 150, 151, table 5).

Gold was not present in any of the stream sediments at the level of detection (0.05 ppm). Only one rock sample contained gold. This sample (RM017, table 5), of a molybdenite veinlet in a silicified igneous rock, contained 0.25 ppm gold.

In summary, in the White Pine area low-grade molybdenum mineralization is associated with multiple intrusion of mid-Teriary stocks and dikes and is accompanied by hydrothermal alteration. Though no production is recorded, our reconnaissance geochemical sampling confirms widespread anomalous molybdenum values and low but anomalous copper, zinc, and silver values. The sampling nowhere suggests the occurrence at the surface of any substantial body of molybdenum ore (an average of no less than 0.2 percent (2,000 ppm) MoS_2) or ore of other metals. Nevertheless, the low-grade molybdenite mineralization is a potentially significant but unproved mineral resource. Though partially explored in the past by drilling, more extensive exploration, beyond the scope of this reconnaissance investigation, would be needed to prove or disprove the potential of the area.

ALPINE MINING DISTRICT

The designation "Alpine mining district" has been applied to the area both north and east of Alpine (Butler and others, 1920, p. 283), low on the front of the Wasatch Range (pl. 2). The rocks cropping out in the area are the southern edge of the Little Cottonwood stock and sedimentary rocks ranging in age from late Precambrian to Paleozoic (pl. 1). The strata dip northwest, west, and northeast, reflecting their position on the west flank of the dome south of the Deer Creek fault (fig. 3). The rocks are complexly faulted by early thrust faults and later high-angle faults.

Almost all the known prospect diggings and small mines east of Alpine are between the mouth of Box Elder Creek and Wadsworth Canyon, but a few scattered shallow pits or adits are found as far south as Smooth Canyon. The workings east of Alpine all open into dark-gray Mississippian limestone and dolomitic limestone not far above a flat thrust fault that separates the Mississippian carbonate rocks from Cambrian Ophir Formation below. Some fragments of the Ophir Formation on the lowermost and most conspicuous dump north of Wadsworth Canyon (fig. 18) suggest that the thrust fault was intersected in the workings. Low-angle bedding faults and minor brecciation of carbonate beds were seen in several places.

The nature and controls of metal occurrence in the area east of Alpine are not well understood. According to Butler and Loughlin (1916, p. 224), the only ore found up to 1912 was in the Alpine Galena mine on the north side of Box Elder Canyon at its mouth. Butler and Loughlin reported that ore occurs in this mine as small masses of silver-bearing galena and lead carbonate along a bedding plane, which was followed downward about 50 feet to a small body of "leached replacement quartz, originally pyritic." At the time of the authors' visit in 1974, the Alpine Galena mine was completely caved. Meager observations at the surface and in a few other poorly accessible workings suggest that minor lead-zinc mineralization occurs as small irregular replacement masses in carbonate rocks along brecciated zones, in part more or less parallel to the bedding, possibly at or near the thrust fault between the Ophir and the overlying Mississippian carbonate rocks.

The dumps are barren of the primary sulfide minerals, galena, sphalerite, or pyrite. Secondary minerals occur but are inconspicuous. M. D. Crittenden, Jr. (written commun., 1974) found a little smithsonite at one of the prospects; we observed hemimorphite in association with iron oxides at a dump on the north side of Wadsworth Canyon. Selected samples of mineralized rock from dumps (samples RM039-042, table 5) show zinc and lead, scant silver, and no gold. The highest silver content was 5 ppm; two of the four samples contained no detectable silver.

The results of analyses of stream sediments support the visual impression of meager mineralization in the area east of Alpine (figs. 7-14). Very few stream-sediment samples contain more than trace amounts of lead, zinc, and silver. Sample SM-141 (pl. 2, table 4) collected at the mouth of Wadsworth Canyon contains 700 ppm lead, 260 ppm zinc, and 2 ppm silver, but it probably represents contamination from dumps on the steep slope to the north.

The Alpine district seems to offer little promise for the presence of substantial ore bodies. Though small occurrences of lead, zinc, and silver were discovered and explored many years ago, the workings have failed to disclose any significant deposits. Further exploration probably would disclose other occurrences of lead-zinc mineralization similar to those found in the past, but the finding of very few anomalous sediment samples and the lack of any other evidence of widespread circulation of ore solutions are discouraging. The mineral potential of the area is judged to be very small.

SILVER LAKE MINING DISTRICT

In the 1870's a wave of propectors, in the first flush of exploration and discovery of important silver-lead ore deposits in the central Wasatch Range, spread westward from the American Fork mining district into the area drained by Deer Creek and both forks of Silver Creek, along the east boundary of the Lone Peak study area (pl. 1). The miners early found small showings of silver and lead, and in 1871 organized the Silver Lake mining district (Huntley, 1885). Though shallow workings scattered throughout the district give evidence of their activity (see section on mines and prospects), no substantial ore bodies were found. Desultory prospecting continued for many years; no recent signs of prospecting were detected.

Geologically, the Silver Lake mining district lies north of the Deer Creek fault along and near the east and southeast margin of the Little Cottonwood stock. A thin skin of sedimentary rocks ranging in age from late Precambrian to Mississippian overlies the stock and dips southeast and south away from the stock contact (pl. 1 and section A-A'). Within the boundary of the study area, the upper Precambrian Big Cottonwood Formation is overlain by Cambrian Tintic Quartzite, Ophir, and Mississippian Doughnut Formations. Formations normally present between the Ophir and Doughnut Formations are presumably cut out by a thrust fault that is largely concealed under alluvium in the valley of Silver Creek, below Silver Lake Flat (pl. 1), outside the study area boundary. Near the stock, the Doughnut Formation is partially bleached parallel to the bedding (fig. 17) and in part completely converted by contact metamorphism to calc-silicate minerals such as tremolite, wollastonite, and garnet. The Deer Creek fault, which crosses the divide at the head of Deer Creek, brings the Oquirrh Formation, on the south or hanging wall, against the Little Cottonwood stock, on the north. Farther east in its course along Deer Creek, it faults Oquirrh against the Doughnut Formation. The major movement on the fault was apparently post-stock emplacement, and the Oquirrh south of the fault is not affected by contact metamorphism, nor have any prospects been found south of the fault in the Silver Creek-Deer Creek area.

As in the American Forks district to the northeast, the only lead-silver deposits that have been developed occur in sedimentary rocks as fissure and replacement deposits. Though iron-stained joints in the Little Cottonwood stock have been prospected to a slight extent near Silver Glance Lake, no fissures in the igneous rocks have yielded any metal.

FIGURE 17.—Contact-metamorphosed Upper Mississippian Doughnut Formation west of Silver Lake. Carbonate rocks are bleached and banded and, in part, converted to calc-silicate minerals near Little Cottonwood stock which forms lower light-colored jointed outcrop.

The lead-silver fissure deposits that have been developed are found principally in the spur between the forks of Silver Creek above Silver Lake Flat and just outside the study area (pl. 1). The fissures, which strike northeast and in general dip 65°–85° NW, cut Cambrian Tintic Quartzite and the underlying quartzites of the Big Cottonwood Formation. A small but unrecorded silver and lead production has come from fissures cutting the Tintic in the Milkmaid mine on the west side of the east fork of Silver Creek and from the Ontario mine just south of the Milkmaid, both just outside the study area. According to Burge (1959, p. 42), the lower adit of the Milkmaid entered quartz monzonite of the Little Cottonwood stock at about 600 feet (180 m) from the portal.

As judged from material on dumps and from limited observation in accessible open adits, the fissure veins of the Milkmaid and Ontario mines contain pyrite, argentiferous galena, and some sphalerite in a gangue of quartz and barite. The ore evidently occurs discontinuously in scattered bunches or small shoots along the vein. Two adits with accessible stopes had a width of as much as 4 feet (1.5 m) and a maximum stope length of 30-40 feet (9-12 m). Selected samples of best looking ore specimens from the dump (RM030-032, RM156-158, RM160, table 5) and screened fines from the dump (SC286-287, table 5) show high content of silver, together with lead, some zinc, but scant gold. Two adits, one above the other, the lower caved, explore weak fissures or joints in rusty Tintic Quartzite on or just within the study area boundary about half a mile (800 m) northeast of Silver Lake. No ore minerals were found. Samples of the most highly iron-stained quartzite from the dump (RM158, table 5) showed 700 ppm lead, 3 ppm silver, 200 ppm copper, and 15 ppm molybdenum.

Southwest of Silver Creek, carbonate rocks of the Mississippian Doughnut Formation underlie the steep terrain on the north side of Deer Creek. Quartz monzonite of the Little Cottonwood stock crops out in the headwaters of the creek, and probably underlies the carbonate rocks in the upper part of the drainage at shallow depth. Prospectors have dug several prospect pits and short adits exploring iron-stained limestone in search of replacement deposits with little success. The best of these occurrences is in the Deer Creek drainage on the west side of the ridge just west of Silver Lake Flat. The dark-gray limestone of the Doughnut Formation in this area strikes N. 70° E. and dips about 45° S. A 2- to 4-foot-thick (0.5-1.2 m) oxidized zone consisting of soft earthy yellowish-brown gossan parallels the bedding in the limestone and has been followed downward on an incline. (See section on mines and prospects and fig. 32.) A grab sample (RM154, table 5) from the soft limonitic bedded zone is high in lead and zinc, but contained less than an ounce of silver (20 ppm) and only 0.1 ppm of gold. The gossan probably contains lead and zinc carbonates, and perhaps plumbojarosite, a common mineral in the oxidized ores of the Cottonwood-American Forks districts to the east.

Sample RM154 also contains 50 ppm tin, which amount is considerably above its crustal-abundance of 2-4 ppm in common rocks. Four other samples in the Silver Lake district (and one in White Pine Fork) contain tin in amounts ranging from 10 to 50 ppm (RM001, 156, 157, 160, and RM110). All these samples contain abundant sulfide minerals, and the slightly anomalous tin content may reflect the common occurrence of trace amounts of tin in sulfide minerals and thus would not indicate a potential for tin deposits (Sainsbury and Reed, 1973, p. 650).

Scheelite, an ore mineral of tungsten, commonly occurs in metamorphosed carbonate rocks near contacts with granitic intrusives. Close to the intrusive the carbonate rocks are typically replaced by various calc-silicate minerals in zones or irregular masses called tactites or skarns. Such is the geologic setting of scheelite occurrences in the Deer Creek part of the Silver Lake district.

In this area, carbonate rocks of the Doughnut Formation underlie the steep brush-covered slopes on the north side of the creek. The beds dip southwest at moderate angles away from the Little Cottonwood stock, and as geologic mapping (pl. 1) shows the stock to have a relatively flat dip to the southwest, the carbonate rocks apparently overlie the stock as a comparatively thin blanket (fig. 18; pl. 1). Near the stock, the carbonate rocks are in part bleached and marbleized and converted by contact metamorphism to a variety of calc-silicate minerals such as wollastonite, brown and green garnet, idocrase, pyroxene, and tremolite. A specimen of dense black hornfels, probably a metamorphosed shale, was observed in this section to have abundant andalusite of the variety chiastolite. Scheelite has been found as disseminations in garnet-pyroxene tactite in several places in the area.

South of the Deer Creek fault (pl. 1), the carbonate beds of the Oquirrh Formation are not metamorphosed, and no scheelite has been found.

Scheelite occurs in a tactite deposit about 600 feet (200 m) north of Deer Creek at an elevation of about 7,640 feet (2,500 m). This scheelite is believed to be on the Mayday Extension claim and, according to Crawford and Buranek (1957, p. 53), a small shipment of tungsten ore from the Deer Creek area came from this locality. (See section on "Mining Claims, Prospects, and Mineral Deposits.") The workings are caved and are inaccessible, and the vicinity is thickly overgrown with brush; however, the small dump does not suggest any extensive development. As judged from the dump and a very small outcrop in the caved entrance, the workings explored an occurrence of scheelite associated with a skarn consisting of brown garnet, a dark-green silicate, possibly idocrase or diopside, white quartz, and a little sericite and calcite. Sparse pyrite, chalcopyrite, and molybdenite were also observed. Selected specimens from the dump (RM001-003, table 5) contain 300-1,000 ppm tungsten, and 200-500 ppm molybdenum. The country rock exposed in a gully within 100 feet (30 m) of the dump is dark-gray limestone with a strike of N. 65° E. and a dip of 40° SE. No tactite was seen.

Calkins and Butler (1943, p. 93), apparently visited a tungsten occurrence on Deer Creek. The location given by him is very general but is believed to be marked by a 120-foot (35-m) adit on the north side of Deer Creek about 1,400 feet (400 m) west of the workings on the Mayday Extension claim. At that locality, Calkins observed metamorphosed limestone cut by a diorite dike and in part replaced by pyrrhotite and chalcopyrite. The best showings of scheelite were seen in the dike. Some scheelite was seen in tactite composed of garnet, wollastonite, idocrase, and diopside. Sample RM006 (table 5) collected from the dump at this site contained only sparse pyrite. No pyrrhotite or chalcopyrite was observed. Analysis showed no detectable tungsten and only trace amounts of copper and molybdenum. A sample of gossan (RM096) collected from a small pit at about 8,900 feet (2,700 m) contained 200 ppm tungsten and 500 ppm of lead and copper (pl. 2; table 5). Garnet-bearing tactite outcrops have been prospected by small pits on the slope about 300 feet north of the adit. Outcrops are poor but the country rock is chiefly limestone. Some quartzite and olive drab micaceous siltstone were seen in the cut and on the dump. No gossan was observed in place. To the north, quartz monzonite crops out within a few hundred feet.

A hundred years of prospecting in the Silver Lake district has failed to develop profitable ore bodies of even moderate size. Two silver-lead veins, just east of the boundary, have yielded a small but unrecorded production, and one small carbonate replacement deposit just inside the boundary may have had a few tons shipped from it . Continued prospecting would undoubtedly find similar small silver-lead ore shoots, but the finding of large deposits seems unlikely. The silver-lead potential of the Silver Lake district must be considered slight.

Further intensive search, especially in the upper basin of Deer Creek (north of the Deer Creek fault) and on the west side of Silver Creek (along and near the contact of the carbonate rocks with the Little Cottonwood stock) might disclose other scheelite-bearing tactite lenses or layers similar to the ones already discovered. Nevertheless, few of our samples were anomalous in tungsten, and these contained so little as to suggest that the probability of finding considerably larger tactite deposits is slight.

HOGUM FORK-BELLS CANYON AREA

The area in general north and west of Lone Peak, extending from Hogum Fork west to the boundary of the study area, here called the Hogum Fork-Bells Canyon area, is barren of significant mineralization. Nearly the entire area is underlain by the quartz monzonite of the Little Cottonwood stock save for a small part near the northwest corner of the study area which is underlain by upper Precambrian quartzite and a small Tertiary intrusive mass of diorite (pl. 1).

A small adit on the north side of Bells Canyon near its mouth was driven in quartzites of the Big Cottonwood Formation and in diorite. The iron-stained and altered diorite contains abundant calcite and chlorite. Of four selected samples of iron-stained chips from this area, one contained 100 ppm copper (RM073, table 5); the others were not anomalous.

Most of the analytical results from stream-sediment samples were negative. A few scattered samples showed a small but anomalous content in silver, molybdenum, and zinc, chiefly in Hogum Fork; and in Bells Canyon several samples showed anomalous lead (fig. 12), and a few showed copper (fig. 8). The few anomalous samples in Hogum Fork seem most readily explained as coming from a marginal halo of mineralization on the fringes of the strong anomaly in the White Pine Fork area (figs. 7-10). The anomalous lead and copper samples in Bells Canyon are from an area that is underlain by apparently fresh unaltered quartz monzonite. No veins or other signs of mineralization were seen. Relatively high lead values for some stream sediments probably reflect the higher than average lead content of the quartz monzonite stock, its potassium feldspar phenocrysts (table 6), and many of the joints that cut the stock (table 7). Similarly, some joints contain anomalous copper (table 7), and weathering of the stock may locally increase copper content of some stream sediments to above background amounts.

The geochemically anomalous samples scattered through the area from Hogum Fork west to the study area boundary are far fewer and weaker than those in the Silver Creek or Alpine mining districts, which themselves contain only small deposits and marginal prospects with no recorded production. Little likelihood exists that significant ore deposits occur in the Hogum Fork-Bells Canyon area.

DRY CREEK CANYON AREA

The Dry Creek Canyon area comprises the drainage area of Dry Creek, Chipman Canyon, and the small drainages south of the ridge above which Lone Peak rises (pl. 2). The terrain is rugged. Most of the area is underlain by the quartz monzonite of the Little Cottonwood stock except for a small part south of Dry Creek which is underlain by Paleozoic sedimentary rocks.

The area contains no signs of any significant mineral potential, and any signs of mineralization are scarce. One small stub adit and a pit were found in the upper Fort Canyon area; the adit (RM051, pl. 2) is just south of and outside the Lone Pine area boundary; the pit, 1,600 feet (488 m) west is just inside. Both the adit and pit are in sheared granite which is partially altered to chlorite and epidote in this area. The adit, about 20 feet (6 m) long, explores a shear zone 6 inches to 1 foot (15-30 cm) in width with a strike of N. 60° E. and a dip of 75° NW. Sparse pyrite and a trace of malachite stain were the only indications of mineralization. A sample taken from the shear zone (RM051, table 5) contained 200 ppm copper but no other anomalous metals. The sample of iron-stained sheared quartz monzonite from the pit (RM050, table 5) was barren. Similar iron-strained, crushed, sheared quartz monzonite with abundant chlorite and epidote is common along the boundary in this area between Chipman Canyon and Jacobs Ladder and possibly reflects the nearness of the Wasatch fault, a short distance south (pl. 1). None of the rock samples taken were anomalous.

Most stream-sediment samples from the Dry Creek Canyon area have no anomalous metal content. The most notable exceptions are a few anomalous molybdenum samples along and near Dry Creek at its mouth and a few near the headwaters of the drainage. A few stream sediments with trace amounts of gold also were found in the headwaters of Dry Creek.

The low-level molybdenum anomaly in a few samples in upper Dry Creek probably was derived from leaching of joint planes containing meager molybdenum. A sample from an iron-stained joint in this area (RM014, table 5) contained 300 ppm molybdenum. The few stream-sediment samples slightly anomalous in molybdenum along Dry Creek near its mouth (fig. 7) are mainly from small side drainages entering Dry Creek from the south, which all cross the Deer Creek fault zone. Possibly they indicate minor mineralization associated with the Deer Creek fault. The area is brushy, and outcrops are poor; but nowhere were any altered or mineralized outcrops seen, or any float, to suggest such outcrops. The molybdenum anomaly is too small and weak to suggest the presence of economic deposits.

Four scattered stream sediments in the upper Dry Creek drainage contain very small amounts of gold (SA40, 41, 62, and 73 table 4) at levels from 0.05 to 0.6 ppm (pl. 2; fig. 13). These apparently are marginal to a cluster of slightly anomalous gold samples in the Silver Lake mining district where a few of the narrow quartz veins contain minor gold (0.05-0.6 ppm), much too low to be commercially significant.

None of several other scattered samples, anomalous in a few metals, seem to be of much significance. Zinc and silver are present in slightly anomalous amounts in three sediment samples collected from minor steep drainages on the west flank of Box Elder Peak (SA68, 71, and 72, table 4). These samples were taken from mechanically weathered sediments derived directly from either the underlying dark shale of the Manning Canyon Shale or the dark limestones of the lower member of the Oquirrh Formation. A sample of black shale from the Manning Canyon contained 180 ppm zinc, 150 ppm lead, and 5 ppm molybdenum. Such values are well within the normal range for these elements in black shales (Vine and Tourtelot, 1970).

Slightly anomalous lead occurs in stream sediments in the area underlain by the quartz monzonite (fig. 12), and three samples show very minor copper content (fig. 8). As discussed in the section on Hogum Fork-Bells Canyon, the anomalous lead values probably reflect the high-lead background of the stock and its numerous joints. Similarly, the very few scattered anomalous copper values may represent a local, but minor, enrichment of some joints with copper (table 7).

A few samples collected in the Dry Creek area contain weakly anomalous metal values. The lack of any consistent consequential or sizable anomalies and of other evidence to suggest the presence of worthwhile concentrations of metals suggests that the mineral resource potential of this area is negligible.

BOX ELDER-AMERICAN FORK CANYON AREA

The picturesque area between Box Elder Peak on the north and American Fork Canyon on the south of the study area is extremely rugged and difficult of access, especially along the southern part adjacent to American Fork Canyon. In contrast to the Dry Creek Canyon area to the north, the terrain is underlain entirely by sedimentary rocks of late Precambrian and Paleozoic age.

No known mineral production has come from the area. The only workings seen were several shallow adits and a pit at an elevation of about 9,600 feet (2,900 m) on a spur running westward on the south side of upper Box Elder Canyon. In that area, prospecting was apparently done on a bedded iron-stained zone in the Humbug Formation. The Humbug Formation near the prospects consists of dark-gray medium-bedded dolomite which strikes slightly north of west and dips 45° N. The zone is less than a foot (30 cm) thick. A small highly selected dump sample of gossan (RM054, table 5) showed 11,000 ppm zinc, no detectable silver or gold, and only trace amounts of lead or copper. A second sample (RM055, table 5) of iron-stained dolomite from the zone contained only 380 ppm zinc, no detectable silver or gold, and only trace amounts of lead or copper. The zinc probably occurs in part as smithsonite and small crystalline crusts of hemimorphite; the associated minerals are iron oxides, probably limonite and goethite, and probably the sulfate jarosite. No sulfides were observed. Other samples from these workings are given in the section on mines and prospects.

A few samples of stream sediments, anomalous at low levels in molybdenum and zinc, were collected from steep drainages on the flanks of Box Elder Peak (figs. 7, 10). Two of three samples of black shale and shaly limestone collected southwest of the Peak were slightly anomalous in lead and the third was anomalous in zinc. These are not believed to be significantly anomalous but rather are well within the limits for typical black shales (Vine and Tourtelot, 1970). Such shales are common in both the Mississippian Great Blue Limestone and Manning Canyon Shale which crop out on the slopes of Box Elder Peak.

COAL, OIL, AND GAS POTENTIAL

No possibility for coal exists in the Lone Peak area. No coal beds occur in any rocks of the Paleozoic sequence in the Lone Peak area, nor are they known in this part of the stratigraphic column anywhere in Utah. Most of the coal in Utah is of Cretaceous age, some of early Tertiary age; but no rocks of these ages occur in the area. No surface indications for oil and gas were seen in the Lone Peak area. Almost all the oil and gas production and major sedimentary basins in Utah are in the eastern part of the State. Much of the production has come from Mesozoic and Cenozoic sedimentary rocks. Rocks of this age have been stripped by erosion from the Lone Peak area. Though some significant production has come from upper Paleozoic rocks, as at Ashley Valley near Vernal or at the Aneth Field in the southeastern part of the State (Stowe, 1972), the Paleozoic rocks, such as underlie the Lone Peak area, remain little tested over much of the State. No significant finds have yet been made in Paleozoic rocks in the structurally complex Basin and Range province in the western half of Utah.

Though existence of oil is a hypothetical possibility in the Lone Peak area, the region in which the area lies is considered to be unfavorable for oil and gas accumulation (Crawford, 1963, p. 329-330). The rocks were folded and thrustfaulted in Laramide time, then were faulted and intruded by igneous rocks in mid-Tertiary time, and the range was subsequently uplifted and deeply eroded. Virtually no possibility for petroleum or gas exists in the mid-Tertiary quartz monzonite of the Little Cottonwood stock that makes up the northern part of the area. The Paleozoic sedimentary rocks in the southern part of the area, folded into a dome and faulted into a complex mosaic, are breached deeply by erosion, exposing younger Precambrian clastics at the core of the dome. Despite the numerous faults and deep erosion there are no surface indications of petroleum—no known seeps or bituminous sandstones. However, Baker, Huddle, and Kinney (1949, p. 1196-1197) noted that thrust faulting may be a significant factor in interpretation of subsurface conditions under the southern half of the Lone Peak study area. The Charleston-Nebo thrust passes under the area at depth, though the depth to the fault surface, and the stratigraphy and the structure of the overridden rocks are moot. Nevertheless, possible favorable structural conditions in the overridden block and, in addition, the transition from a thick to a thin section of dominantly marine rocks may offer potential stratigraphic traps. Other than this tenuous possibility, the lack of any surface indications for the presence of oil and gas, the structural complexity, the occurrence of igneous intrusive rocks, and the deep erosion strongly argue that there is little if any oil and gas potential that can be postulated.

OTHER RESOURCES

Structural stone has been quarried from the Little Cottonwood stock on the north side of Little Cottonwood Canyon, near its mouth, and outside the boundaries of the Lone Peak study area. From this quarry came the stone from which the Mormon Temple in Salt Lake City was erected. Though abundant within the study area, such stone is readily available and more accessible north of the area.

Small deposits of sand and gravel, though present in scattered glacial moraine within the Lone Peak area, are more readily and abundantly obtainable closer to the market in Salt Lake valley.

There are no known thermal springs in the Lone Peak area and no young igneous rocks are present; therefore, no geothermal resources can be implied.

MINING CLAIMS, PROSPECTS, AND MINERAL DEPOSITS

By Lowell L. Patten, U.S. Bureau of Mines

Locations of patented and unpatented mining claims are shown in figure 18. Many unpatented mining claims could not be plotted because of changes in the names of landmarks, vagueness, and other uncertainties in the recorded descriptions. Some information on the unpatented claims shown was taken from the claim map of

Calkins and Butler (1943, pl. 30); other information was taken from Weed's (1920, p. 1,386) report. Information on 12 patented claims was taken from the U.S. Bureau of Land Management plats.

Ninety-four samples were taken from 13 localities in the study area. For easy reference, the localities discussed in the text are lettered, A through H, on figure 18. Assay results are shown in table 8.

WHITE PINE FORK (LOCALITY A)

White Pine Fork is a tributary of Little Cottonwood Creek in the northeastern part of the study area. The central part of the drainage (loc. A in fig. 18) has been prospected for possibly 75 years by mining companies and individuals drilling, trenching, and developing underground workings as shown in figure 19. Locations of recent mining claims are shown on plate 4. The chief commodities of interest are molybdenum, copper, and tungsten.

Previous work in the White Pine Fork area includes a study by Sharp (1958) and exploration diamond drilling by Bear Creek Mining Co. and Midwest Oil Corp. Holes drilled by the two companies ranged from 236 to 3,000 feet (70 to 900 m) deep. Most of the holes are near the bottom of White Pine Fork canyon and are oriented as indicated in figure 19.

Molybdenum mineralization of submarginal grade was found in several drill holes and in geochemical sampling. Copper was found in drill hole and surface samples, mostly in concentrations of less than 0.1 percent. Tungsten was identified in surface and drill hole samples, mostly in trace amounts.

Drilling data made available to the writer by Bear Creek Mining Co. show intervals as much as 10 feet thick that contain molybdenum mineralization ranging from 0.3 to 0.5 percent MoS_2. Drill holes 2, 7, and 9 intercepted a zone about 130 feet (40 m) thick that contained approximately 0.1 percent MoS_2 starting at depths of 300 to 400 feet (90 to 120 m).

Assuming a continuous zone between holes and assigning an equal area of influence to each hole, there are about 16 million tons (15 million t) of material having an average grade of about 0.1 percent MoS_2. The drill holes surrounding these three holes contained little MoS_2, indicating that the mineralization might be phasing out towards the other holes.

Drilling results indicate that molybdenum mineralization is strongly anomalous in the White Pine Fork area and that further exploration might locate a deposit of economic importance. Areas that are favorable for further drilling are north of hole 4 and east of holes 12-15, west of hole 6, and at depth below most of the existing holes. Geochemical samples collected along Bear Creek near holes 3 and 5 (fig. 19) contained a mean of 284 ppm MoS_2.

The present study included investigation of dumps, prospect pits, and talus, all of which contained minor amounts of molybdenum, copper, lead, zinc and bismuth. Tungsten mineralization was investigated at night by checking road banks and chip samples by ultraviolet light.

An obvious area of earlier mineral investigation is a knoll of quartz-cemented quartz monzonite breccia containing visible molybdenite that has been prospected by an 8-foot-deep (2.4-m) pit, several smaller pits, and two drill holes. Sample 1 (figs. 19 and 20), a random sample of quartz breccia from the large pit, contained 0.05 percent molybdenum, 0.01 percent copper, 0.04 percent lead, and traces of bismuth and zinc. Drill-hole data and information were not found.

Scheelite and powellite are widely scattered as fillings in minute fractures, and although no large tungsten concentration was detected, crystals as much as a quarter of an inch (0.6 cm) long were found. Scheelite grades into powellite in the vicinity of the Alta Superior tunnel (site of sample 2).

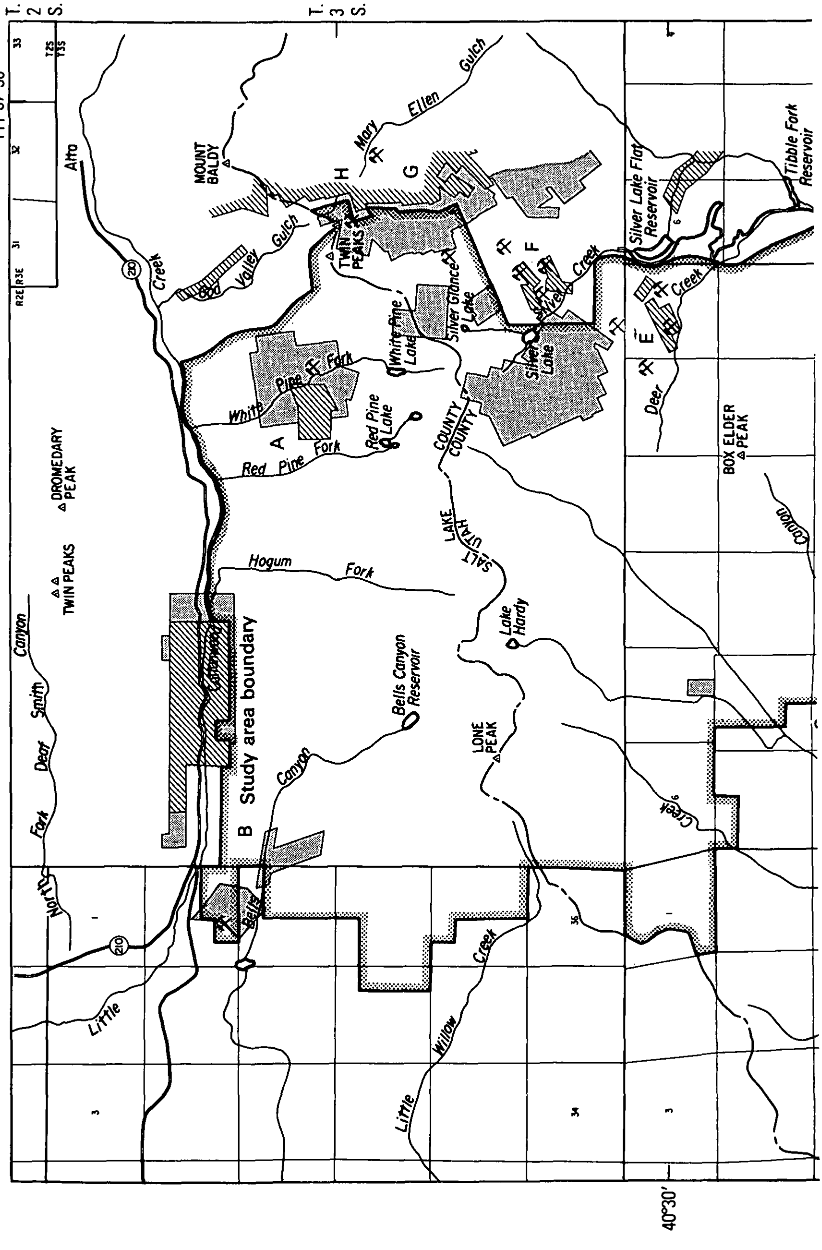
Random chip samples 3-9 (fig. 19) were taken over intervals of 400 to 700 feet (120 to 210 m) across talus slopes to test for disseminated minerals. All samples contained molybdenum ranging from less than 0.002 percent to 0.016 percent with one exception that contained 0.03 percent. In addition, all samples contained about 0.003 percent copper and 0.01 percent lead. Although no tungsten showed in the analyses, all samples except 3 and 8 contained trace amounts of fluorescent tungsten minerals.

MOUTH OF LITTLE COTTONWOOD CANYON

(LOCALITY B)

Placer and lode mining claims were filed at various times near the mouth of Little Cottonwood Canyon (pl. 4). Samples collected in this area are shown in figure 21. Evidence of past exploration includes three caved adits, two open adits, and one 12-foot shaft with a 40-foot drift.

Dumps of the caved adits contained traces of copper, lead, and zinc in micaceous shales and quartzite as indicated by samples 12, 14, and 15. A fault zone exposed at the collar of the 12-foot shaft contained traces of copper and lead (sample 13). A 500-foot exploration adit driven in barren quartz monzonite was not sampled.


T. 2 S.
T. 3 S.
111°37'30"
40°30'
Alta
MOUNT BALDY
Mary Ellen Gulch
TWIN PEAKS
Silver Lake Flat Reservoir
Tibble Fork Reservoir
Silver Glance Lake
Silver Lake
White Pine Lake
White Pine Fork
Red Pine Lake
Red Pine Fork
SALT LAKE COUNTY
UTAH COUNTY
Deer Creek
BOX ELDER PEAK
DROMEDARY PEAK
TWIN PEAKS
Hogum Fork
Lake Hardy
Bells Canyon Reservoir
LONE PEAK
Study area boundary
Bells Canyon
Little Willow Creek
Deaf Smith Canyon
North Fork
Little Cottonwood Creek
Gad Valley Gulch
Canyon
Creek
A
B
E
F
G
H

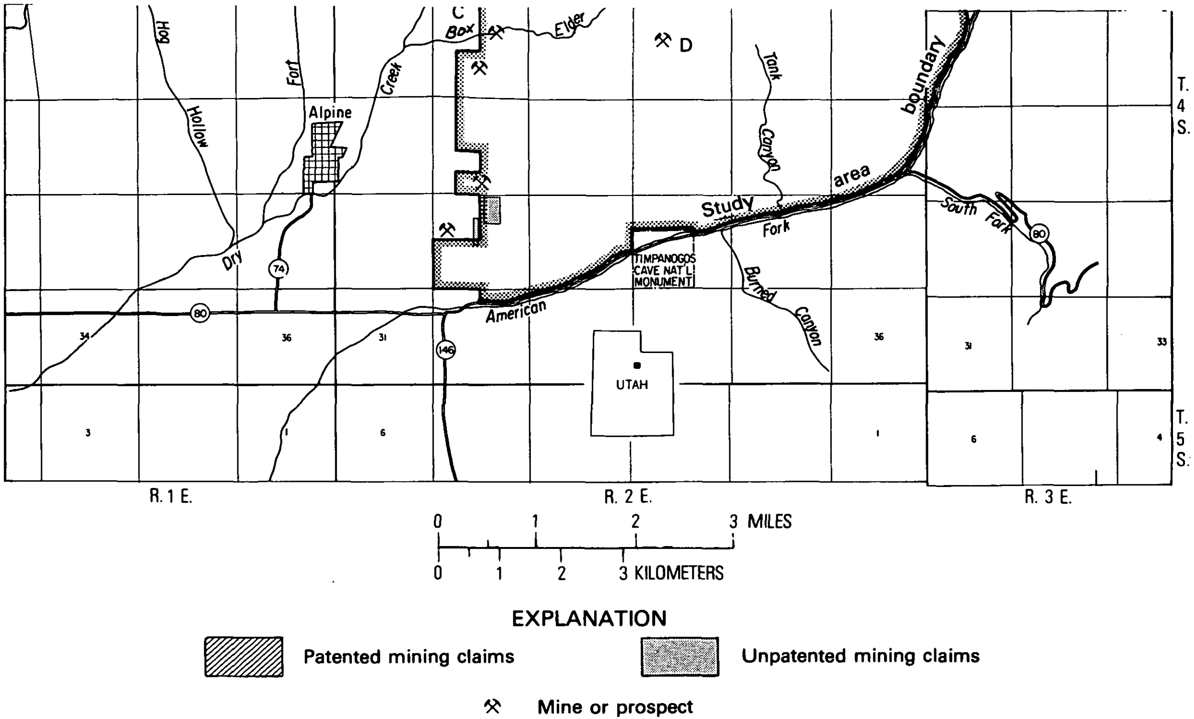


FIGURE 18.—Mining claims, prospects, and mineral deposits (labelled A-H) examined in the Lone Peak wilderness study area.

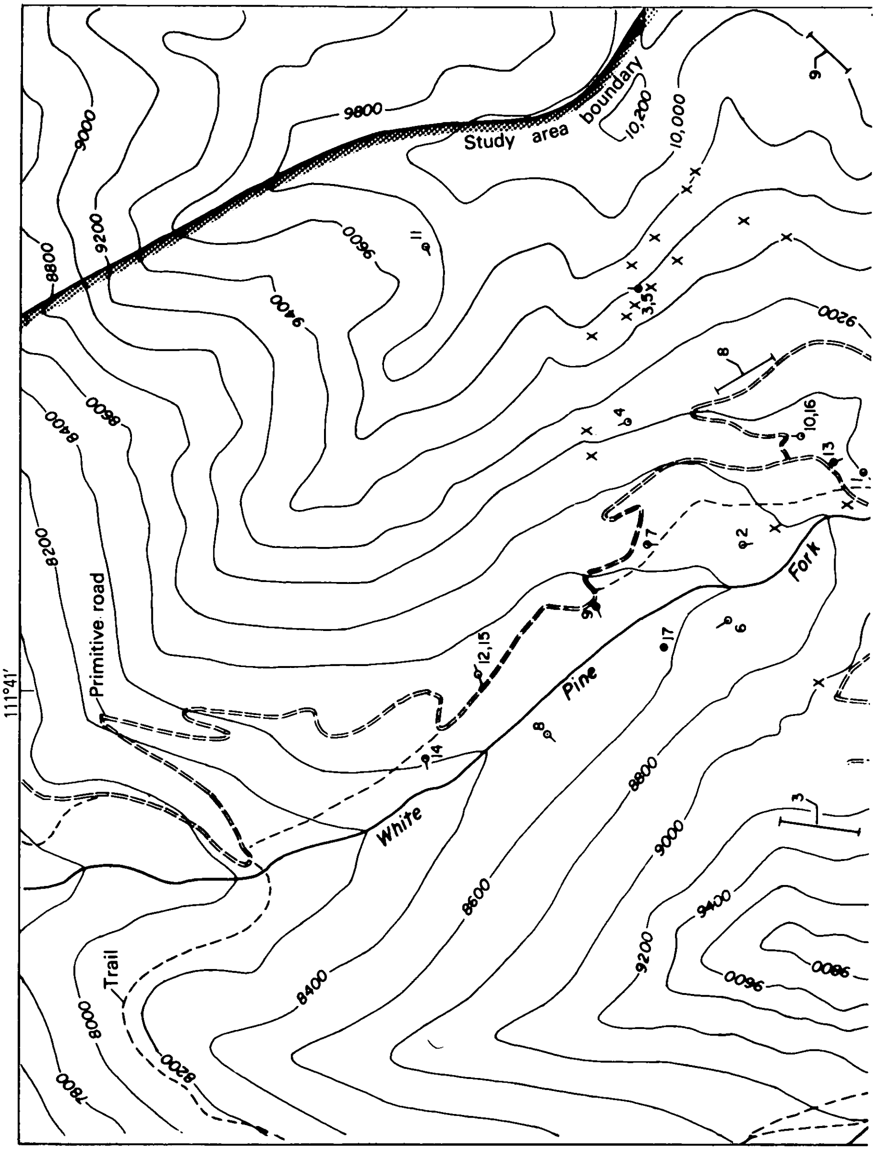
TABLE 8.—*Analyses of samples taken by the Bureau of Mines in the Lone Peak study area*

[Samples were analyzed by semiquantitative spectrographic methods and standard fire assay at the U.S. Bureau of Mines laboratory in Reno, Nev. The spectrographic analyses were made by use of a 3.4-meter Wadsworth spectrograph with a 30-inch plate holder. A margin of error of plus 100 percent and minus 50 percent is assumed. The following elements, normally detectable by this process, were found to be absent: Co, Ga, Hf, In, La, Li, Nb, Pt, Re, Sc, Ta, Te, Tl, and Y. Small, probably insignificant, quantities of barium, boron, chromium, nickel, strontium, vanadium, and zirconium were detected in some samples but are not reported in the table; also omitted are values for aluminum, calcium, iron, magnesium, manganese, silicon, sodium, and titanium. Selected samples were rerun by chemical methods. Symbols used are: <, less than amount shown; -, looked for but not found; Tr, Trace; M, major constituent; *, results of rerun by chemical methods]

	Fire assay ounces/ton		Semiquantitative spectrographic analyses (percent)					
Sample	Au	Ag	Bi	Cu	Mo	Pb	Zn	Sample description
				White Pine Fork (loc. A)				
1	-	-	0.005	*0.014	*0.05	0.04	<0.1	Random, quartz breccia.
2	Tr	Tr	-	.003	*.010	<.01	-	Dump, quartz monzonite.
3	-	-	-	.003	*.027	.02	-	600-ft random chip, quartz monzonite.
4	-	-	-	.003	<.002	.01	-	400-ft random chip, quartz monzonite.
5	-	-	-	.003	<.002	.02	-	700-ft random chip, quartz monzonite.
6	-	-	-	.004	*.009	.01	-	400-ft random chip, quartz monzonite.
7	-	-	-	.002	<.002	.01	-	500-ft random chip, quartz monzonite.
8	-	-	-	.003	*.016	.01	-	Do.
9	-	-	-	.003	<.002	<.01	-	400-ft random chip, quartz monzonite.
10	-	0.1	*<.01	.003	*.003	.07	-	Dump, quartz and quartz monzonite.
11	-	-	-	.002	<.002	.02	*.01	Random, quartz monzonite.
				Mouth of Little Cottonwood Canyon (loc. B)				
12	-	-	0.02	0.002	<0.002	0.01	-	Dump, schist.
13	-	-	-	.06	<.002	.01	-	1.1-ft chip, quartzite.
14	-	-	-	.016	<.002	*.16	-	Dump, quartzite.
15	-	-	-	.003	-	-	-	Dump, schist.
16	-	-	-	.004	.002	.07	-	1.0-ft chip, gneiss.
				Alpine mining district (loc. C)				
17	Tr	0.2	-	<0.006	*0.009	<0.01	-	Dump, limestone.
18	-	-	-	.002	-	<.01	-	2.0-ft chip, quartzite.
19	Tr	.2	-	<.002	*<.003	.04	-	Grab, limestone.
20	-	Tr	-	<.002	*<.003	.02	-	1.0-ft chip, limestone.
21	-	-	-	<.002	-	-	-	Dump, limestone.
22	-	-	-	.002	<.002	-	-	Do.
23	-	-	-	<.002	-	*.21	*0.45	Do.
24	-	-	-	<.002	-	*.21	*.18	Do.
25	-	-	-	<.002	*<.003	.04	-	1.2-ft chip, limestone.
26	-	Tr	-	<.002	*<.003	.04	-	2.0-ft chip, limestone.
27	-	.8	-	<.002	-	*4.15	*2.49	Do.
28	-	Tr	-	<.002	-	*.69	*.77	Do.
29	-	-	-	<.006	-	.04	-	1.5-ft chip, limestone.
30	-	Tr	-	<.002	-	<.01	-	Dump, limestone.
31	-	.3	-	<.002	-	-	-	3.0-ft chip, limestone.
32	Tr	.1	-	.003	*.008	<.01	-	Dump, quartzite.
				Upper Box Elder Canyon (loc. D)				
33	-	-	-	0.002	<0.002	0.03	*0.064	0.8-ft chip, dolomite.
34	-	0.1	-	<.002	<.002	.04	*35.5	Grab, hemimorphite.
35	-	-	-	<.002	<.002	.03	-	1.3-ft chip, dolomite.
36	-	-	-	<.002	<.002	.02	-	Selected, dolomite.
				Deer Creek (loc. E)				
37	-	-	-	0.002	<0.002	-	-	Dump, limestone and sandstone.
38	-	-	-	.003	<.002	<0.01	-	1.7-ft chip, limestone.
39	-	-	-	.004	*.021	-	-	Random chip, limestone.
40	-	-	-	.03	*.042	-	-	2.0-ft chip, quartz vein.
41	-	-	-	.06	*.049	-	-	Grab, quartz and tactite.
42	-	Tr	-	<.002	*.008	-	-	1.2-ft chip, limestone.
43	-	0.1	-	<.002	<.002	.04	-	2.0-ft chip, limestone and sandstone.
44	Tr	.4	-	.004	<.002	*7.39	*0.51	2.5-ft chip, limestone.
45	Tr	.5	-	.004	<.002	*5.30	*5.43	0.8-ft chip, limestone.
46	-	-	-	.003	<.002	<.01	-	0.8-ft chip, quartz monzonite.

TABLE 8.—*Analyses of samples taken by the Bureau of Mines in the Lone Peak study area*—Continued

Sample	Fire assay ounces/ton		Semiquantitative spectrographic analyses (percent)					Sample description
	Au	Ag	Bi	Cu	Mo	Pb	Zn	
Deer Creek (loc. E)--Continued								
47	-	-	-	0.016	<0.002	-	-	1.0-ft chip, limestone.
48	-	Tr	-	.016	<.002	0.02	-	Dump, schist.
49	-	-	-	.008	<.002	-	-	2.0-ft chip, calcium silicate.
50	-	-	-	.002	<.002	.01	-	1.5-ft chip, limestone.
51	-	-	*<0.01	.003	-	.04	-	Dump, limestone.
52	-	-	-	.002	<.002	.02	-	Grab, quartz.
53	-	0.1	*.016	.003	*.041	.07	-	Dump, limestone.
54	Tr	.3	-	.003	*.034	.01	-	1.0-ft chip, quartz and pyrite.
55	-	Tr	-	.002	<.002	-	-	1.3-ft chip, limestone.
56	-	-	-	.002	-	-	-	0.25-ft chip, gouge.
57	-	-	-	.004	*.024	.01	-	Dump, limestone and calcium silicate.
58	-	.1	*.013	.003	*.017	*.12	-	Dump, limestone and sandstone.
59	-	-	-	.004	<.002	-	-	2.5-ft chip, quartzite.
60	-	-	-	.003	<.002	-	-	3.0-ft chip, quartzite.
Silver Lake (loc. F)								
61	-	4.6	-	*0.17	<0.002	*14.3	*0.82	1.0-ft chip, galena.
62	-	2.5	-	.008	<.002	*2.62	-	Dump, quartzite.
63	0.02	2.0	*0.01	*.051	<.002	*4.74	*.07	Do.
64	Tr	5.7	-	.05	<.002	*10.7	-	1.4-ft chip, quartzite.
65	Tr	2.2	-	.05	<.002	*8.07	-	1.0-ft chip, gouge.
66	Tr	.7	-	.008	<.002	*.098	-	1.3-ft chip, quartz.
67	-	-	-	.016	<.002	*.067	-	Dump, quartzite.
68	-	-	-	.004	<.002	.02	-	1.0-ft chip, quartzite.
69	-	Tr	-	.016	<.002	-	-	1.5-ft chip, quartz and quartzite.
70	-	-	-	.003	<.002	*.02	-	1.2-ft chip, quartzite.
71	-	Tr	-	.004	*<.003	.01	-	0.8-ft chip, quartzite.
72	-	.1	-	.004	*.01	*.023	-	2.0-ft chip, quartzite.
73	-	-	-	.004	-	.02	-	0.7-ft chip, gouge.
74	-	-	*<.01	.003	<.002	.07	-	Dump, quartzite.
75	-	Tr	-	.008	<.002	.01	-	Do.
76	-	-	-	.008	<.002	.15	-	Dump, quartz monzonite.
77	.03	.1	*<.01	.004	<.002	*.096	-	0.3-ft chip, quartz.
78	-	.1	-	.002	<.002	.02	-	2.3-ft chip, quartzite.
79	Tr	1.7	*.011	.002	<.002	*2.2	-	0.2-ft chip, quartzite.
80	-	.7	-	.003	.002	*.48	.09	0.9-ft chip, quartzite.
81	Tr	2.9	-	.004	-	*9.15	*.10	0.3-ft chip, quartzite.
82	-	.1	<.005	.003	<.002	.6	-	Dump, quartzite.
83	-	-	-	.003	<.002	.04	-	Do.
84	-	-	*<.01	*.027	<.002	*.014	*.033	0.4-ft chip, quartz.
85	-	.2	<.005	*.021	<.002	.15	-	Dump, quartzite
86	-	-	-	.003	<.002	*.10	-	Do.
87	Tr	Tr	-	*.22	<.002	.01	-	Do.
Merril Flat (loc. H)								
88	-	0.1	*<0.01	0.002	<0.002	0.04	-	2.0-ft chip, quartzite.
89	-	Tr	-	.004	*.009	.01	-	Do.
90	Tr	.2	-	.003	<.002	.01	-	2.5-ft chip, quartzite.
91	-	-	-	.002	<.002	.01	-	300-ft random chip, quartz monzonite.
92	-	.1	-	.002	<.002	.01	-	Do.
93	-	Tr	-	.002	<.002	.01	*.07	Do.
94	-	.1	-	.002	<.002	.01	*.006	400-ft random chip, quartz monzonite.


Study area boundary
9800
9000
9200
8800
9600
9400
10,200
10,000
9200
8600
8400
8200
Primitive road
111°41'
White
Pine
Fork
8800
9000
8600
9200
9400
9600
9800
8400
8000
Trail
7800
8200
11
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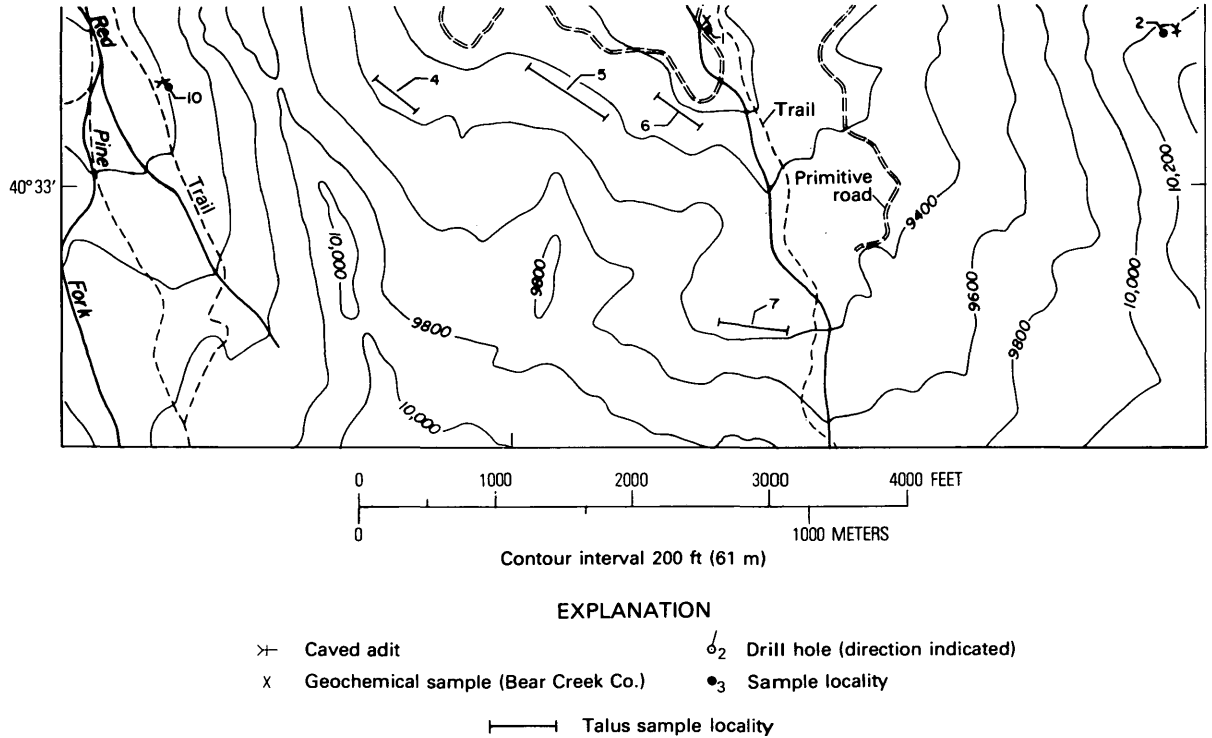


FIGURE 19.—Prospect workings and drill-hole and sample localities in the White Pine area (*A* in fig. 18).

FIGURE 20.—Outcrop of quartz monzonite breccia near White Pine Fork.

Massive quartz monzonite found just outside the study area on the north side of the canyon has been quarried for building stone. About three-fourths of a mile (1 km) north of the quarry area is the Big Mitt mine, which reportedly yielded a small gold production from metamorphosed dikes. The dikes do not extend into the study area.

About 2 miles (3 km) southwest of the mouth of Rocky Mouth Canyon, an adit was driven 92 feet (28 m) in gneiss on a steeply dipping fault N. 30° E. A 30-foot (9-m) winze is 30 feet (9 m) from the portal. Chip sample 16 taken across the back of the adit in the fault 15 feet (4.6 m) in from the portal contained traces of copper, molybdenum, and lead.

The limited and weak occurrences of base and precious metals near the mouth of Little Cottonwood Canyon indicate a low potential for the discovery of significant ore deposits.

ALPINE MINING DISTRICT
(LOCALITY C)

The Alpine mining district includes prospects and claims near the front of the Wasatch Range mostly east and southeast of the town of Alpine (fig. 18). Others lie about 2 miles (3 km) north of Alpine in upper Fort Canyon. The principal prospects and sample localities are shown in figure 22.

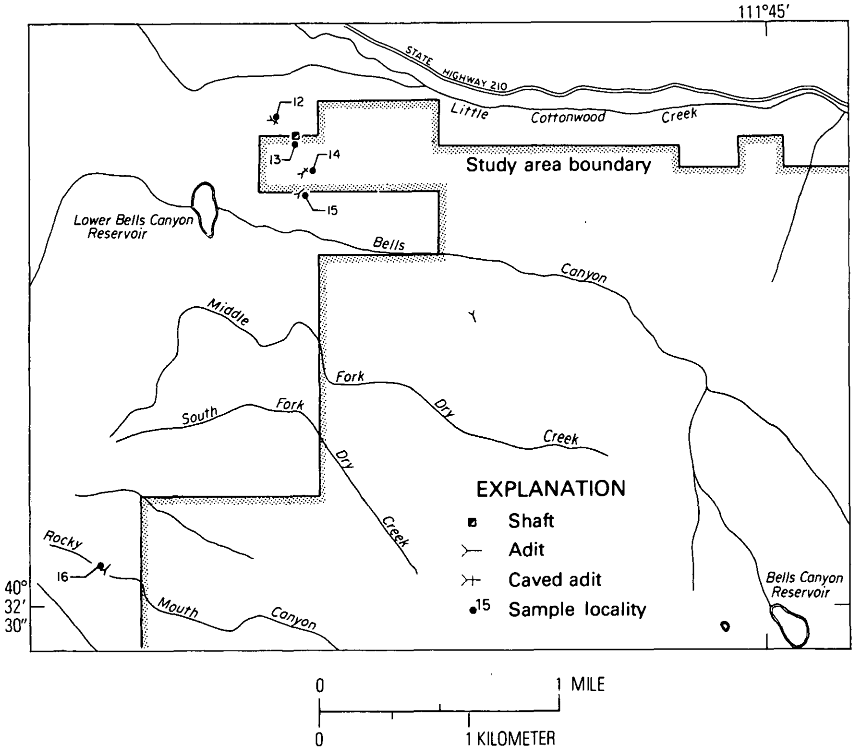


FIGURE 21.—Prospect workings and sample localities near the mouth of Little Cottonwood Canyon (*B* in fig. 18).

The Alpine-Galena mine is at the mouth of Box Elder Canyon (fig. 22) in a fault zone in the Gardison Limestone. According to G. F. Loughlin (in Butler and others, 1920, p. 284), this mine produced a little lead-silver ore. A dump of black limestone is all that remains of the working. Dump sample 17 (table 8) contained 0.2 ounce silver per ton.

About half a mile (800 m) south of the Alpine-Galena dump is a group of workings just inside the study-area boundary on the ridge between Box Elder and Wadsworth Canyons (figs. 22, 23). The area has been the site of numerous mining claims, but no record of production from this locality was found. A conspicuous bulldozer road on the western slope postdates the original workings and connects the three lower adits (fig. 24). Several more adits and opencuts (some probably caved stopes) are at the top of the steep slope above the road at about 6,000 feet (1,800 m) (fig. 25) on the north slope of Wadsworth Canyon.

The workings seem to converge toward the ground beneath the opencuts (fig. 23), but all are caved. The lower workings have a

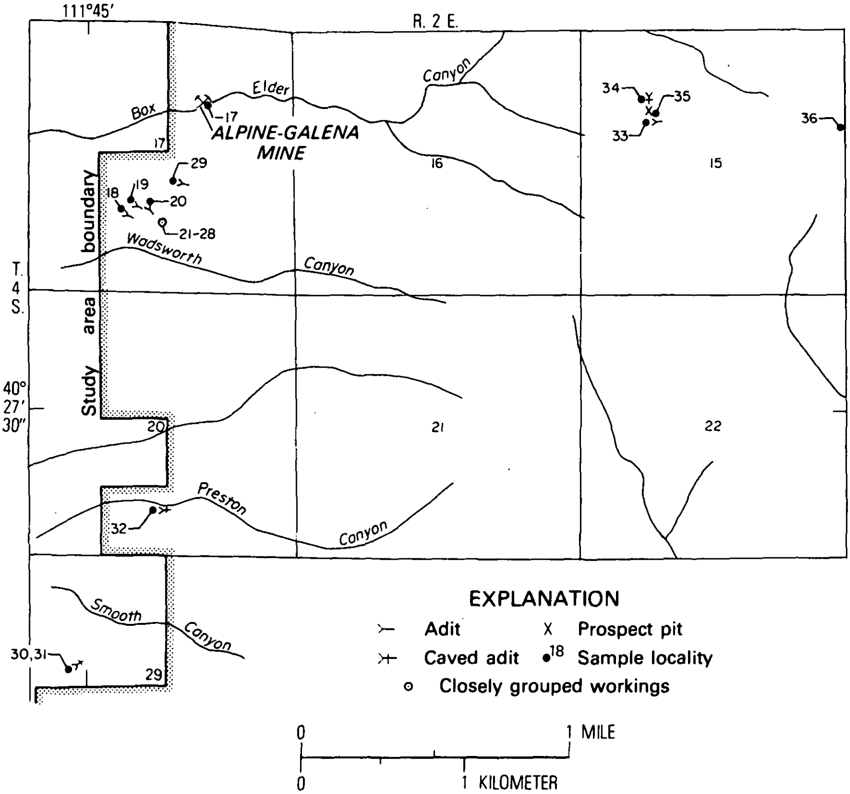


FIGURE 22.—Prospect workings and sample localities east of Alpine.

circulation of air indicating that an opening connects to the surface. There are no records of production and only a little information was obtained for this group of workings. One local resident referred to the workings as the "M" mine; another said the property was never more than a prospect, although there are definite signs of past mining.

The workings are all in the Gardison Limestone in a heavily crushed zone (fig. 23). There is no clearly defined structure exposed in the workings. The workings are labeled A through H in figures 23, 24, and 25 for easy reference. Sample localities are shown on figure 22.

The lower adit, A, at the largest dump shown in figure 24, bears S. 70° E. in limestone, shale, and quartzite and is caved at 250 feet (76 m). The original timber is rotted and nearly covered by loose slough. Sample 18, a chip sample taken across the back of the adit near the caved zone, contained a trace of lead.

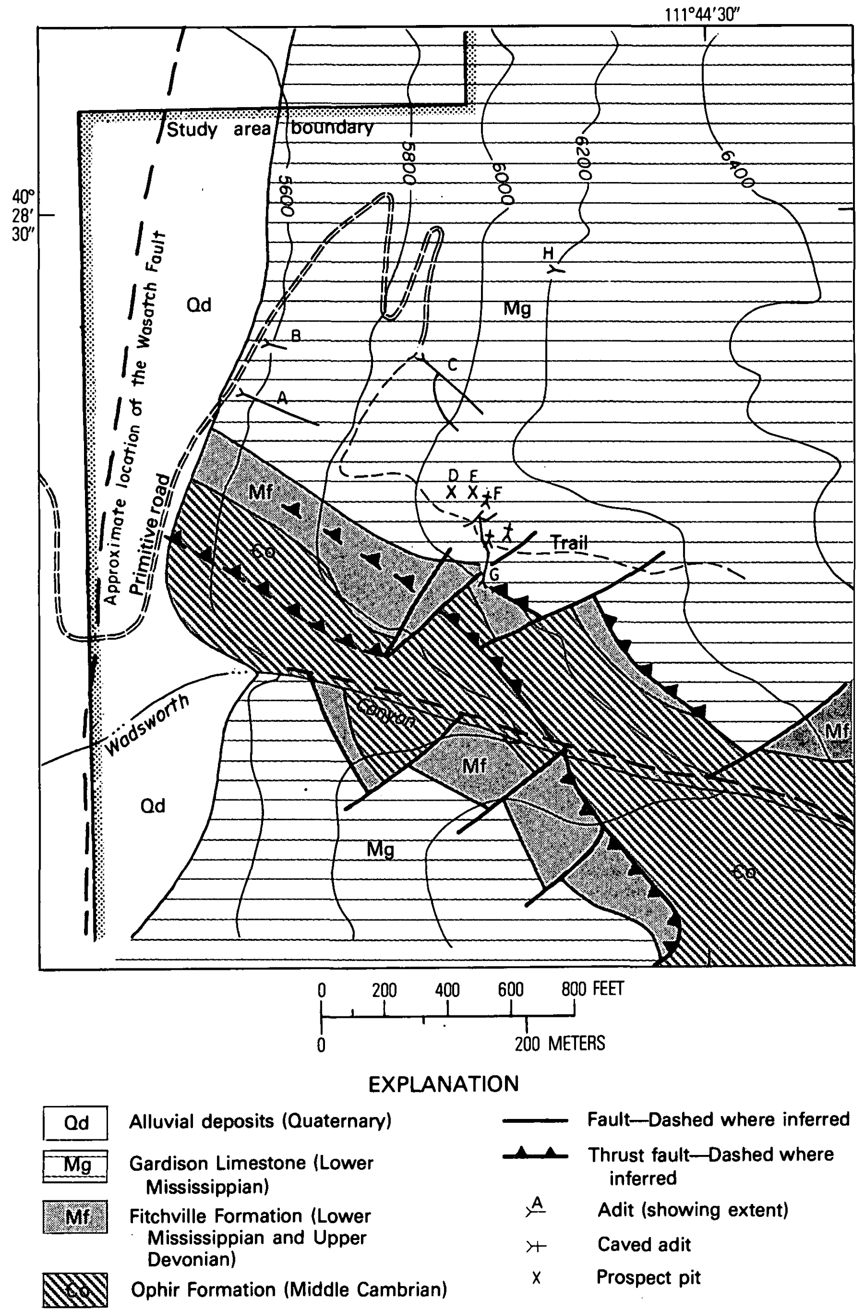


FIGURE 23.—Generalized geology, and prospect and mine workings of the Wadsworth Canyon area. Geology modified from Baker and Crittenden (1961).

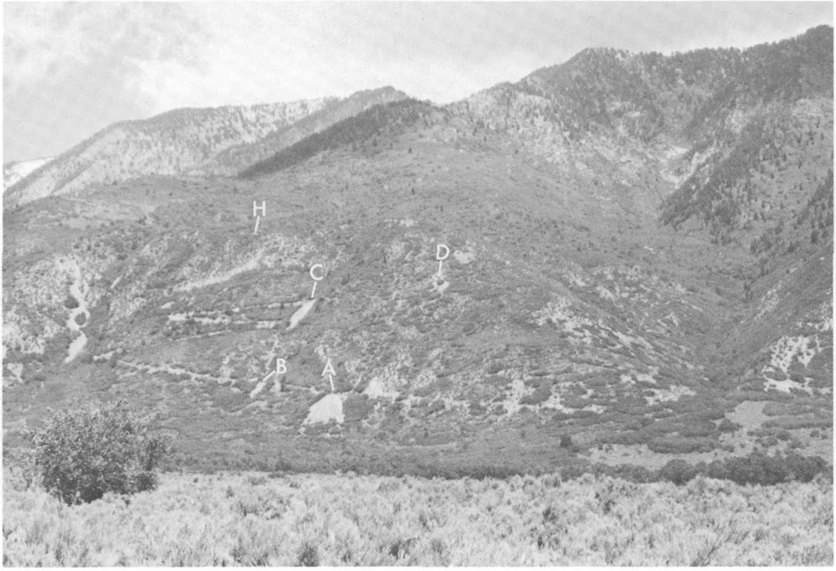


FIGURE 24.—View toward the east showing prospect workings north of Wadsworth Canyon. Letters refer to localities discussed in text and shown in figure 23.

FIGURE 25.—View toward north showing prospect workings on north slope of Wadsworth Canyon. Letters refer to localities discussed in text and shown in figure 23.

The second adit, B, up the road (just left of the first in the photograph) bears S. 80° E. and is caved at 50 feet (15 m). Sample 19 of caved material contained 0.2 ounce silver per ton and a trace of lead.

Adit C (fig. 26) was driven in dark limestone at an elevation of about 5,900 feet. Sample 20, a 1-foot (30-cm) chip sample, was taken from near a possible caved stope across an irregular iron-stained vein or replacement that dips about 10° W. and that may have followed a bedding plane in the limestone. The sample contained a trace of silver and a little lead and zinc.

Near the top of the steep slope (center of figure 24 and left-center of figure 25) are two pits that are possibly caved, surfaced slopes. The lower, D, is about 10 feet (3 m) deep; the upper, E, is somewhat shallower. Both are in black limestone. Neither dump sample 21 from the lower pit nor sample 22 from the upper pit contained significant quantities of metals. Sample 23 was iron-stained limestone from the dump of caved adit (or stope) F above the pits. It contained nothing significant.

Adit G (fig. 27) is about 75 feet (23 m) below the upper workings on the south slope and is also in limestone. Dump sample 24 contained 0.21 percent lead and 0.18 percent zinc. Four chip samples (25–28) from adit G were from iron-stained veins in fractured limestone. No well-defined structure was seen; the veins, however, were probably formed by replacement along bedding planes or faults. Samples 25 and 26 contained 0.04 percent lead. Sample 27 contained 0.8 ounce silver per ton, 4.15 percent lead, and 2.49 percent zinc. This is near ore-grade material and may be part of a small ore shoot. Sample 28, taken from near a caved stope(?), contained 0.69 percent lead and 0.77 percent zinc.

About 150 yards (140 m) north of the upper workings, at about the same elevation, is a 10-foot (3-m) adit driven S. 80° E. in crushed, iron-stained Gardison Limestone.

Two workings were found just south of Smooth Canyon, about 1.5 miles (2 km) south of the workings discussed above. They are in the NW¼ sec. 29 and about a quarter of a mile (400 m) outside the study area (fig. 22). Several mining claims were located in this area; some are shown on plate 4. The lower of the two workings is a caved adit in iron-stained limestone. Sample 30 (fig. 22) from the dump showed no significant mineralization. About 200 feet (60 m) above the lower working is a partly caved adit, driven N. 35° E. 20 feet (6 m) in iron-stained limestone. A 3-foot (1-m) chip sample (31) taken from above the portal contained 0.3 ounce silver per ton.

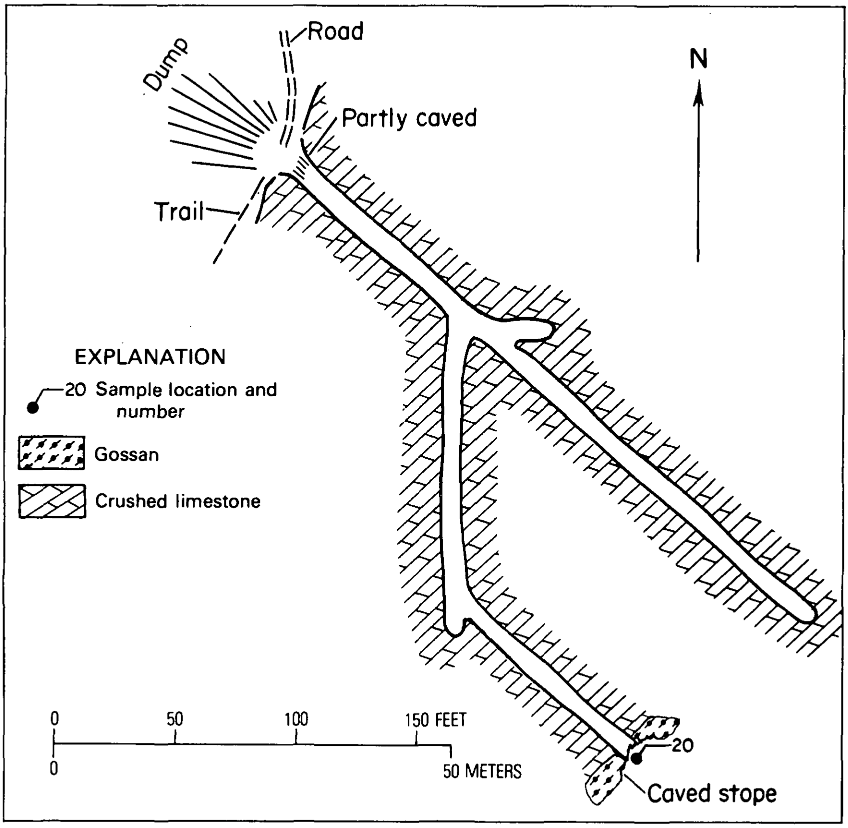


FIGURE 26.—Underground workings at location C (fig. 23), north of Wadsworth Canyon.

The dump of a caved adit in rusty quartzite is about half a mile (800 m) northeast of sample site 31 in the mouth of Preston Canyon (fig. 22); it is just inside the study area. Sample 32 from the dump contained 0.1 ounce silver per ton.

Upper Fort Creek, about 2 miles (3 km) north of the town of Alpine (fig. 18), has been the site of several mining claims. The claims were not plotted because of vague descriptions, but they are probably south of the area boundary. Although G. F. Loughlin (in Butler and others, 1920, p. 283) reported that the Lucky Chance mine had some production of gold, silver, and lead from that area,

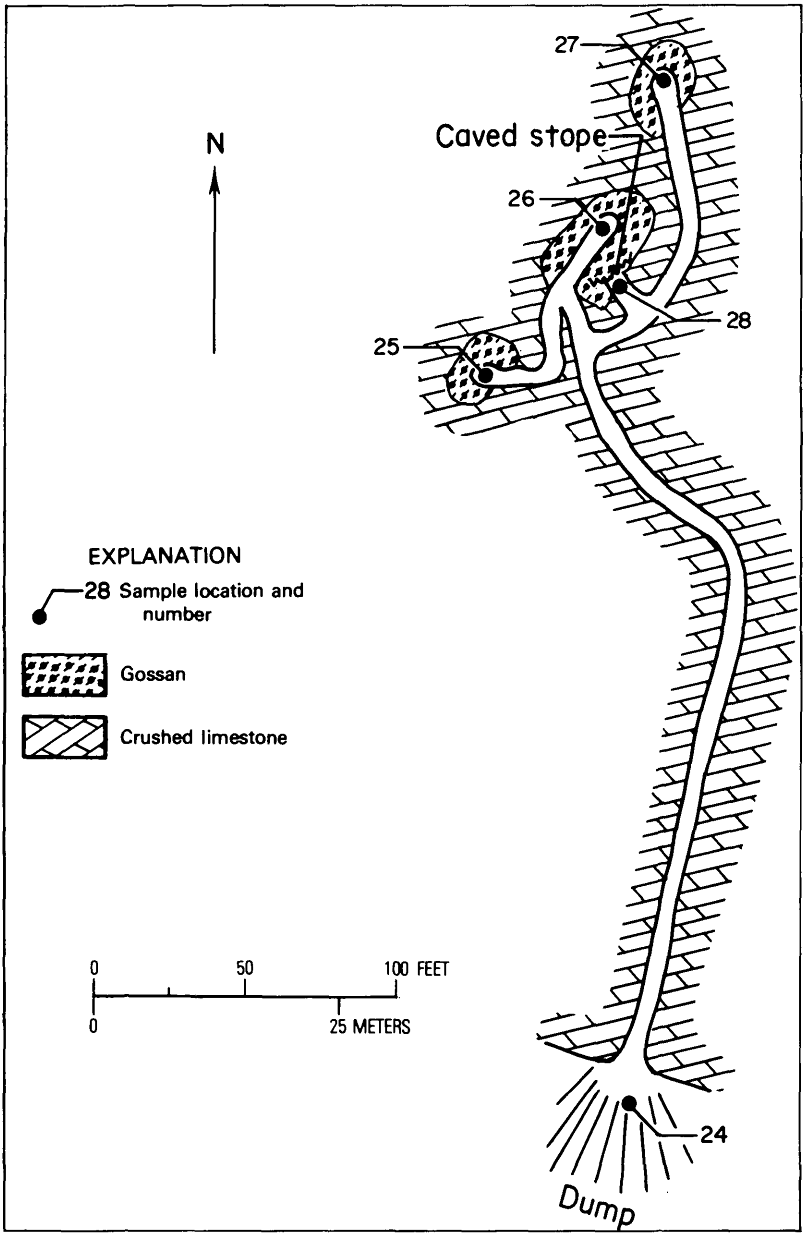


FIGURE 27.—Underground workings of adit G, north of Wadsworth Canyon (fig. 23).

no trace of this working was found during the investigation, and inquiry of local residents produced no additional information.

UPPER BOX ELDER CANYON
(LOCALITY D)

Several old workings are in the upper drainage of Box Elder Canyon on a ridge in the NW¼ sec. 15, T. 4 S., R. 2 E. (fig. 22). These workings are in dolomite of the Humbug Formation in which folding is complex, but no major faulting was detected (fig. 28). The south adit, on the south slope of the ridge, was driven 30 feet (9 m) east in gray dolomite along an iron-stained replacement zone. This zone was sampled at the face of the working, where it is 0.8 foot (24 cm) thick, dips 45° N., and strikes east approximately parallel to bedding. Chip sample 33 (fig. 28) contained nothing significant. A 30-foot (9-m) trench runs west from the portal. A 10-foot (3-m) trench 50 feet (15 m) east of the adit was not sampled. Three more workings are in a line down the mountainside on the north slope of the same ridge at a little lower elevation. They have explored similar, narrow, iron-stained zones. The projection of the first zone does not coincide with those downslope to the north, but the dip could be erratic. Surface cover prevents determination of this. The vein in the northern workings also dips 45° N.

The lowest working is a caved adit. Sample 34, heavily iron-stained material from a quarter-ton ore pile, was identified as mostly hemimorphite, a zinc silicate. The sample contained 35 percent zinc. The ore pile from which this sample was taken was evidently hand sorted from a narrow vein in the workings. The outcrop of the vein was not found, and the significance of the occurrence was not determined. Chip sample 35, collected across a vein in the highest working (stope?), contained 0.3 percent lead. The middle working, a prospect pit, was not sampled.

An 8-foot-deep (2.4-m) trench in limestone near the eastern boundary of section 15 cuts an east-west-striking gossan zone. Selected sample 36 (fig. 22) of heavily iron-stained material contained nothing of economic significance.

DEER CREEK
(LOCALITY E)

Several old workings were found north of Deer Creek in the east-central part of the study area (fig. 29). Several are along the north bank of the Creek. A caved adit bearing N. 25° W., in the Doughnut Formation and having a large dump containing tactite and limestone with pyrite, is just below the Deer Creek–Alpine trail at

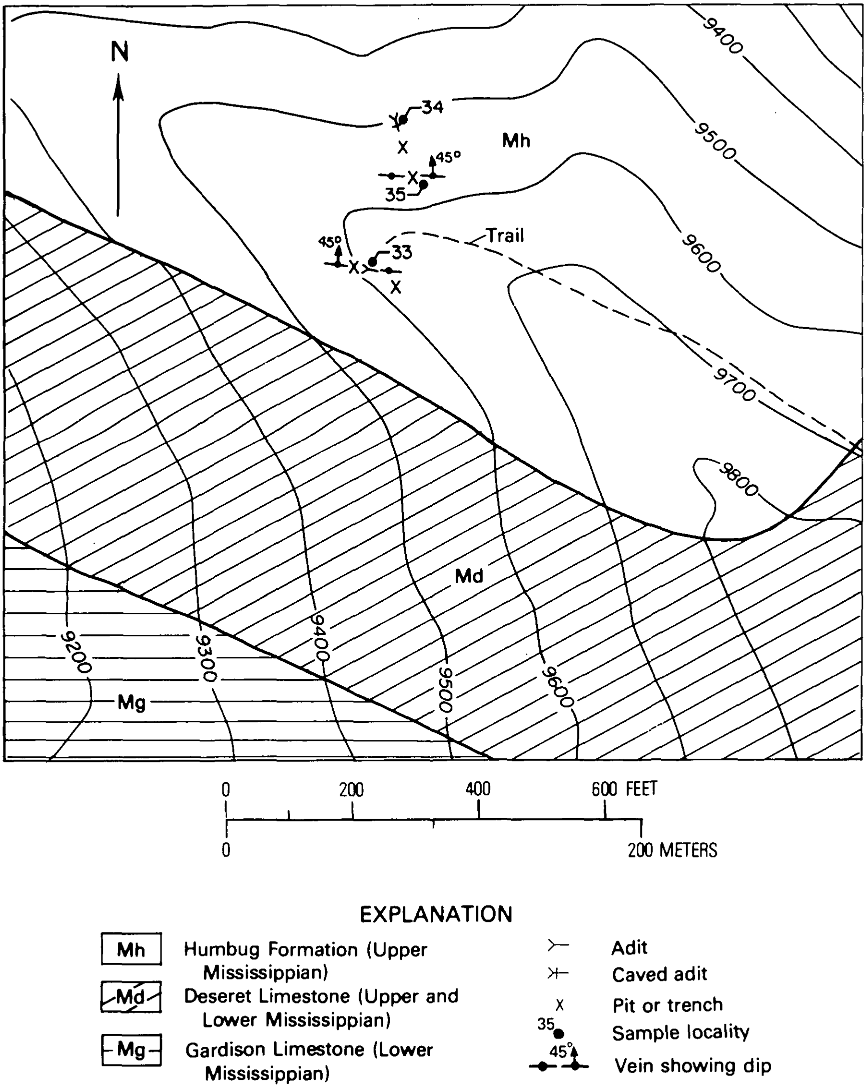
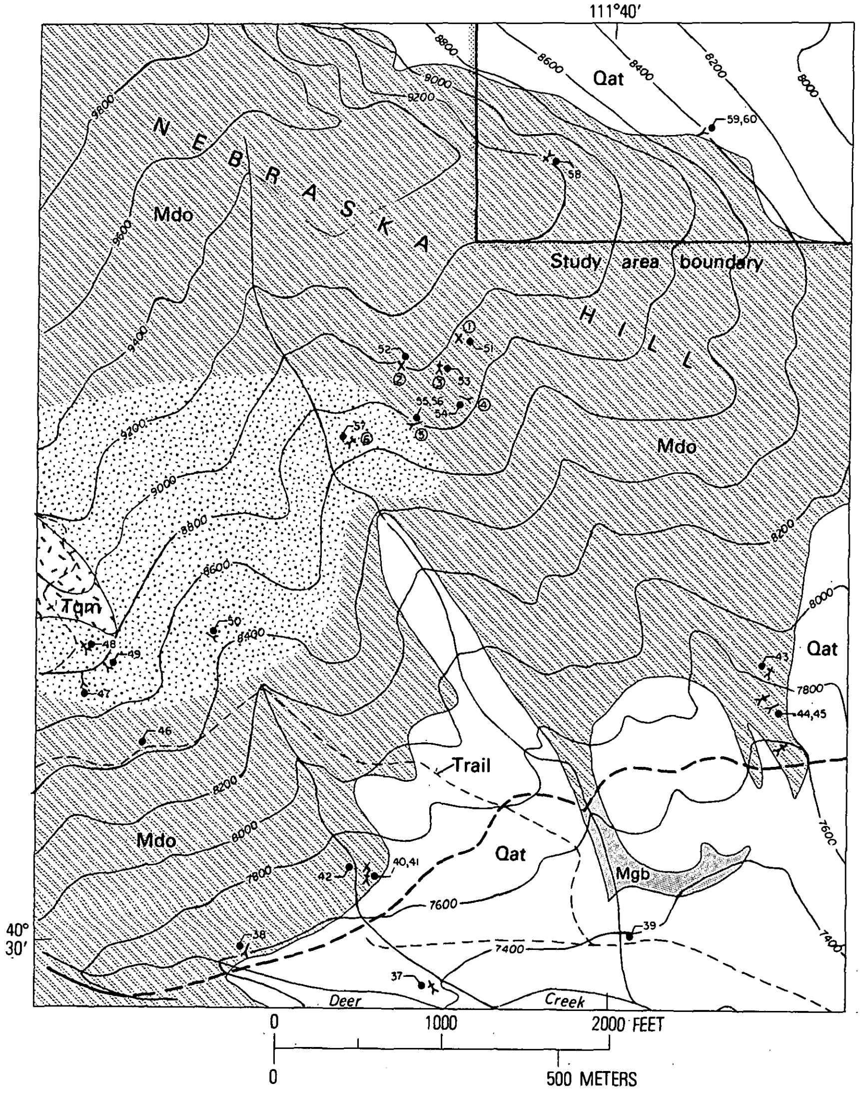


FIGURE 28.—Prospect workings in NW ¼ sec. 15, T. 4 S., R. 2 E. Geology modified from Baker and Crittenden (1961).

an altitude of about 7,400 feet (2,200 m). Sample 37 (fig. 29) from the dump contained a trace of copper (table 8). About a quarter of a mile (400 m) to the west in iron-stained limestone is an adit that bears N. 10° E. 75 feet (23 m), then N. 20° E. 48 feet (15 m). Chip sample 38, of iron-stained limestone (the most heavily altered material observed in the working) from right of the face, contained only a trace of copper.



EXPLANATION

Qat	Alluvium and talus (Quaternary)		Area of calc-silicate alteration
Tqm	Quartz monzonite of Little Cottonwood stock (Tertiary)	——	Fault
		≻—	Adit
Mdo	Doughnut Formation (Upper Mississippian)	≻+	Caved adit
		×	Pit or trench
Mgb	Great Blue Limestone (Upper Mississippian)	•52	Sample locality
		③	Nebraska Hill workings

FIGURE 29.—Prospect workings in the Deer Creek locality. Geology modified from Crittenden (1965a, b).

A small stream, tributary to Deer Creek from the north, crosses the trail at the site of sample 39 (fig. 29). Random chip sample 39 from iron-stained, sulfide-bearing limestone boulders in the creek bed contained a trace of copper and 0.02 percent molybdenum (table 8).

Two workings were found in heavy underbrush at the mouth of a draw about 800 feet (150 m) east of the open adit that provided sample 38 (fig. 29). About 77 tons (70 t) of tungsten ore were produced from these workings (Crawford and Buranek, 1957, p. 53). The workings consist of a caved adit with a pit above. Both workings are in limestone of the Doughnut Formation. No bedrock is exposed at the mouth of the caved adit. The pit, about 50 feet (15 m) above, is open for about 20 feet (6 m) and follows a heavily iron-stained quartz vein that dips 45° N. and strikes east. A 2-foot (60-cm) chip sample (sample 40) across the vein in the west wall contained 0.41 percent WO_3. Sample 41 from a half-ton ore pile on the dump contained 0.34 percent WO_3. The heavy undergrowth and soil mantle prevented further investigation of the deposit; no significant amount of tungsten minerals was found in the surrounding area with an ultraviolet lamp.

Chip sample 42 of iron-stained limestone from the bottom of the draw about 100 feet (30 m) northwest of the adit contained nothing of economic interest.

Along the east-central margin of the area of figure 29, several workings, possibly connected underground, were found in a northward-trending line. These workings are approximately where the U.S. mine should be, as described in several notices.

All workings are in impure limestone of the Doughnut Formation. The upper working, a caved adit at about 7,900 feet (2,400 m), was driven in a flat-dipping zone that strikes about N. 20° E. Chip sample 43, taken across the zone west of the portal, contained 0.1 ounce silver per ton. About 200 feet (60 m) below this working is another, possibly stoped, shown in figure 30. The first part of the lower working is a meandering incline that follows a heavily iron-stained zone down its 25° easterly dip. The zone seems to be a replacement of limestone along bedding and may be controlled by a fissure.

Chip sample 44, taken across the vein at the west side of the portal, contained about 7 percent lead, 0.4 ounce silver per ton, and traces of gold and tin. Another chip sample (45), taken across the vein on the second level, contained 5 percent lead, 5 percent zinc, 0.5 ounce silver per ton, and traces of gold and tin.

A caved adit west of the portal was not sampled. Below the adit, at about 7,600 feet (2,300 m), a concrete foundation near the portal

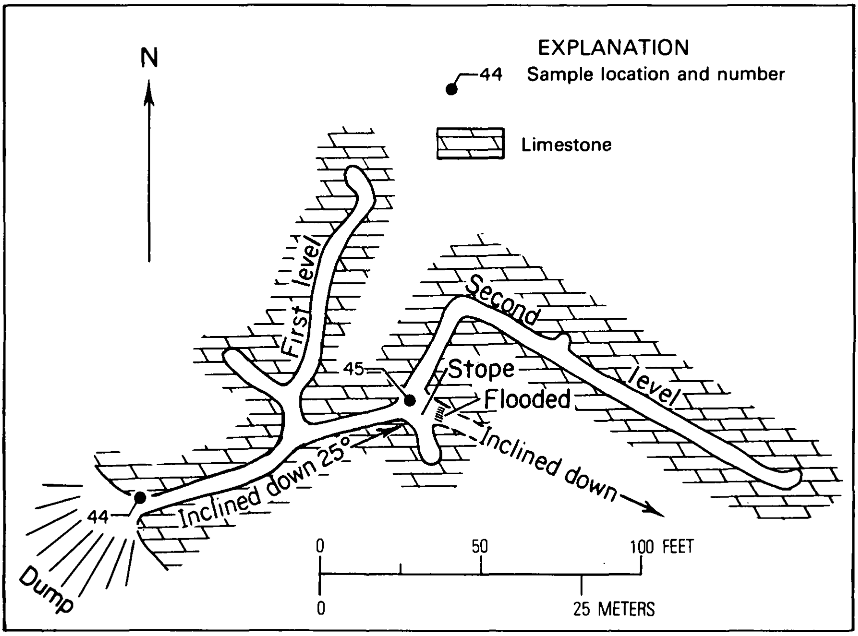


FIGURE 30.—Underground workings in NE¼ sec. 1, T. 4 S., R. 2 E.

of a caved adit apparently supported heavy machinery. Although some ore may have been produced from the workings, no records of production were found.

Several samples, mostly from shallow pits and adits were taken in and near the west-central part of the area of figure 29. Samples 46-50 (fig. 29) taken from these workings contained traces only of copper and lead. The workings are in a heavily altered zone in the Doughnut Formation near the quartz monzonite intrusive.

A group of workings, long abandoned, is about 4,000 feet (1,200 m) south of Silver Lake on the mountain spur between Deer Creek and Silver Creek. This locality, called Nebraska Hill in old location notices, was the site of several claim locations mentioned in the records. Butler and others (1920, p. 248) listed a Nebraska mine as having produced 10 tons (9 t) of lead-silver ore before 1880. The workings, mostly on the south slope, are numbered in figure 31 for easy reference. The area is underlain by dark, impure limestone of the Doughnut Formation and by a light-colored rock that is altered as a result of the intrusion of the Little Cottonwood stock. These appear in the lower part of figure 31.

Ten samples (51-60) (fig. 29) were taken from nine localities on

FIGURE 31.—Workings on Nebraska Hill. Numbers refer to claim locations discussed in text.

Nebraska Hill. Sample 51 was a dump sample of material removed from a trench 30 by 8 feet (9 by 2 m) bearing N. 30° W. in limestone (fig. 29; location 1, fig. 31). The sample contained 0.02 percent bismuth, 0.04 percent molybdenum, and 0.07 percent lead. Sample 52, a random grab of quartz (vein?) from a shallow trench west of sample site 51 (location 2, fig. 31), contained traces of copper, molybdenum, and lead. Sample 53, from the dump of a caved adit in limestone between the two trenches (location 3, fig. 31) contained 0.1 ounce silver per ton, traces of bismuth and copper, and 0.04 percent lead. A 50-foot (15-m) adit in the Doughnut Formation is below and a little east of the caved adit (location 4, fig. 31; fig. 32*A*). Chip sample 54 was taken in the back of the adit in a vein (?) containing quartz and pyrite; the sample showed 0.3 ounces silver per ton and 0.03 percent molybdenum. A prospect adit, also in the Doughnut Formation, is on the steep hillside; it is shown in figure 31 (location 5) and in the plan view in figure 32*B*. Chip sample 55, taken across an iron-stained limestone bed, contained traces of silver, copper, and molybdenum. Sample 56, chipped across a low-angle fault to the left of the face in iron-stained gouge, contained only a trace of copper. The adit (no. 6) with the light-colored dump in the lower left of the photograph (fig. 31) is caved. It was driven eastward in limestone of the Doughnut Formation and in altered calcium-silicate rock. Sample 57, from the dump, contained 0.02

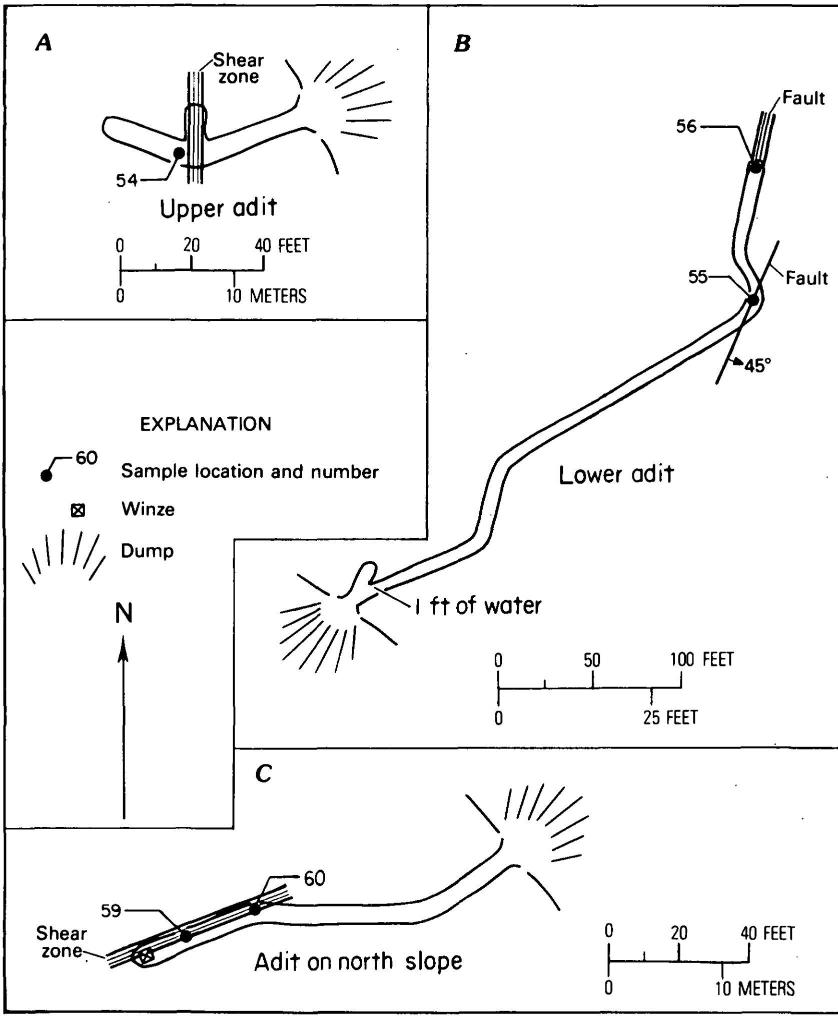


FIGURE 32.—Underground workings of the upper (*A*) and lower (*B*) (*C*) adits on Nebraska Hill (fig. 31).

percent molybdenum. Two more excavations are northeast of these workings on the north slope of the hill. The uppermost, just over the ridge, is a caved, inclined (about 30° downward) adit driven in limestone of the Doughnut Formation on a bearing of S. 40° W. It is open for about 25 feet (8 m). Sample 58 taken from the dump of this adit contained 0.1 ounce silver per ton, 0.01 percent bismuth, and 0.02 percent molybdenum. Below this adit, at the base of the cliff, is the adit shown in figure 32*C*. It is driven in limestone and quartzite near a concealed thrust fault at the Doughnut-Fitchville contact (not shown). It explores a steeply dipping fault zone that is crushed and iron-stained. Sample 59 was a vertical chip in the north wall in crushed quartzite. It contained a trace of copper. Sample 60 consisted of crushed, iron-stained quartzite; it was a 3-foot (90-cm) vertical chip. It contained a trace of copper.

Records, old workings, and sample results indicate that the Deer Creek area has some potential for the discovery of small deposits of tungsten and lead.

SILVER LAKE
(LOCALITY F)

A few workings are found just outside the east boundary of the study area on the ridge east of Silver Lake in part of the old Silver Lake district. Location of the workings and samples taken in this area are shown in figure 33. The ridge just east of Silver Lake, informally named Milkmaid Hill, contains workings of the Milkmaid and Ontario mines (fig. 33). Figure 34, a photograph of the Milkmaid Hill area taken toward the west, shows these workings. in the area near the right center of the picture, there were evidently three openings (according to descriptions in claim patents of the Milkmaid mine), two of which are now obliterated. These openings are marked "A" in figure 33. Timber at the portal of one of these was visible in the summer of 1973 but is now completely covered. The workings of the Ontario mine (also on patented claims) are in the left-center area of the photograph (fig. 34) south of the Milkmaid mine.

Butler and others (1920, p. 284) reported an output from the Milkmaid mine worth $13,000 before 1880. U.S. Bureau of Mines production records for 1902, 1903, 1953, 1954, 1956, and 1958 show that a total of 61 tons (55 t) of ore containing lead and silver were mined during that period. Milling machinery now scattered down the hillside below the Milkmaid workings indicate that some ore may have been milled on the property, although no fine tailings were seen. The chief ore mineral was argentiferous galena; cerussite and anglesite were also mined.

The Milkmaid ore body was in a northeast-striking fissure vein. The accessible working follows minor fractures in the Tintic Quartzite.

South of the Milkmaid mine, several workings of the Ontario (marked "B" in fig. 33) mine explore a fissure vein that strikes northeast and in general dips steeply northwest, nearly parallel to the vein in the Milkmaid workings. The southernmost of these workings is an adit that crosscuts to the vein. Uphill and to the

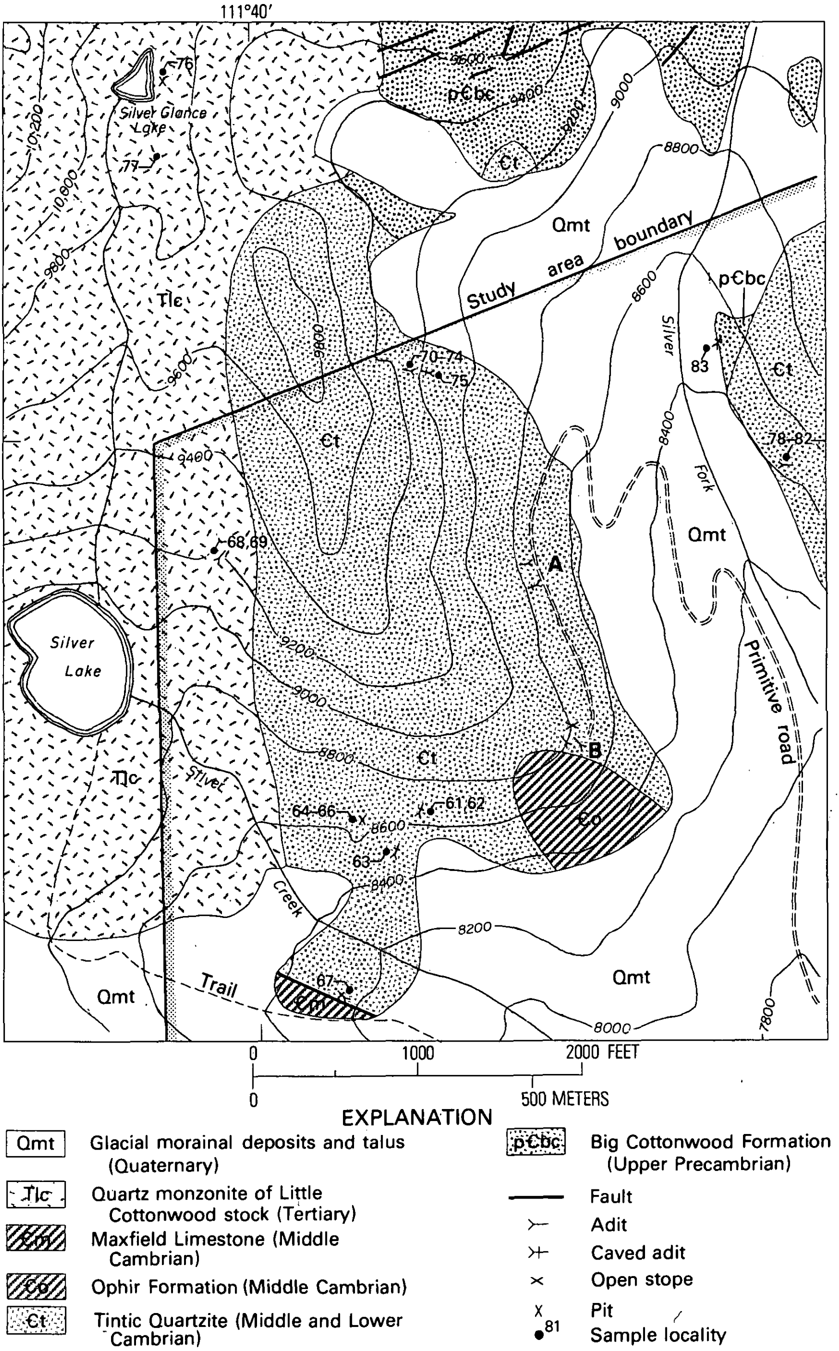


FIGURE 33.—Mine and prospect workings in the Silver Lake area. Geology modified from Crittenden (1965a). A, Milkmaid mine; B, Ontario mine.

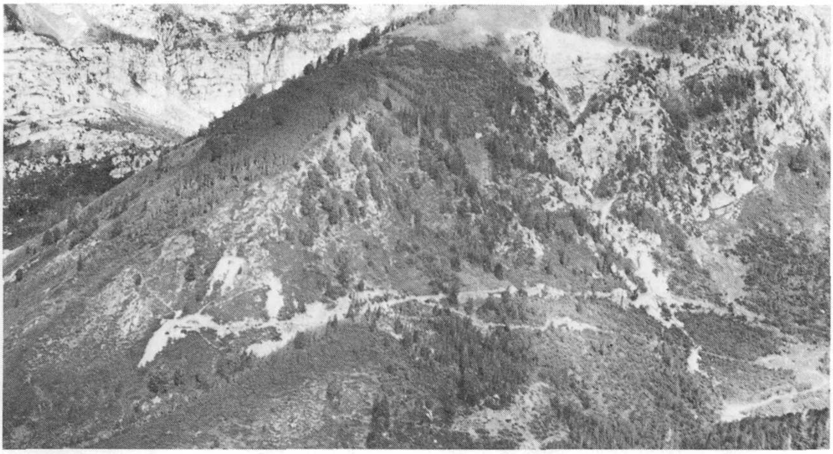


FIGURE 34.—View toward the west across the east fork of Silver Creek showing workings on Milkmaid Hill. Dumps on the north (right center) are of the Milkmaid mine. Workings on the south (left center) are of the Ontario mine. Hill underlain chiefly by Lower and Middle Cambrian Tintic Quartzite dipping southeast.

north are two other workings on the vein. The ore shoot in the southernmost adit evidently did not extend to the two upper workings. In this adit the vein strikes about N. 55° E. and dips about 45°–75° NW. Another adit, about 100 feet (30 m) above, provides access to a stope that is evidently on the same vein. An incline near the portal leads to a two-compartment stope below, which has surfaced on the eastern slope. Small quantities of galena remain exposed in these workings.

Three more workings, two caved adits and a trench, are on the southern slope southeast of Silver Lake (fig. 33, 35). All three are in white Tintic Quartzite. An exposed vein (northeast strike and steep dip) above the portal of the upper adit contains two 0.5-foot (15-cm) veinlets of galena about 2 feet (60 cm) apart. A composite sample of the veinlets (61, fig. 33) contained 4.6 ounces per ton silver, 14.3 percent lead, and 0.82 percent zinc. Sample 62 from a dump containing about 1,000 tons (900 t) of material contained 2.5 ounces silver per ton and 2.62 percent lead. The dump by the lower adit contained about 1,500 tons (1,300 t) of material. Sample 63, from this dump, showed 0.02 ounce gold per ton, 2.0 ounces silver per ton, 0.01 percent bismuth, and 4.74 percent lead. A 20-foot-long (6-m) trench is at the top of a rocky ridge above the lower adit (left center figure 35). The trench follows a 3-foot-wide (90-cm) shear zone in Tintic Quartzite. The zone contains quartz and sporadic galena. A 1.4-foot (43-cm) chip sample 64 in iron-stained quartzite, taken

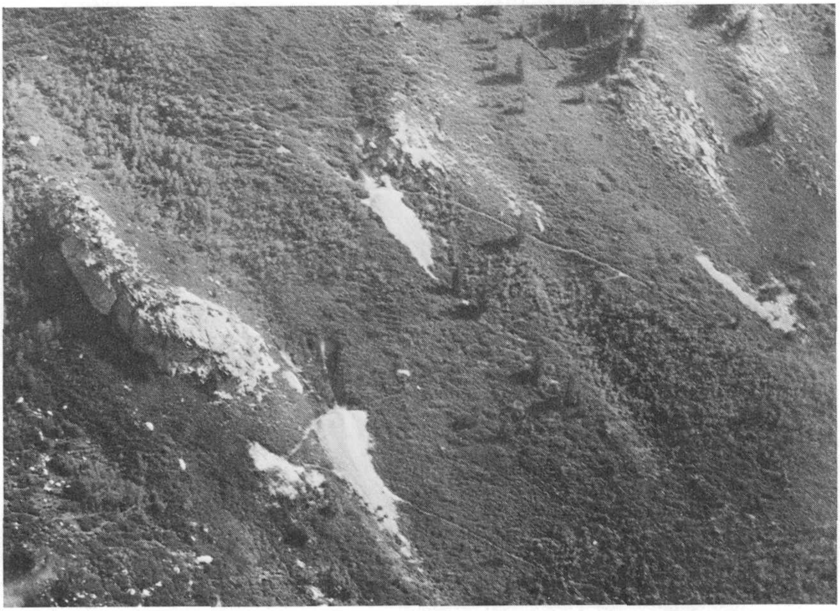


FIGURE 35.—View toward northeast of prospect workings southeast of Silver Lake.

across part of the zone in the southeast wall of the trench, contained 5.7 ounces silver per ton and 10.7 percent lead. Sample 65 was a 1-foot (30-cm) chip taken across fault gouge in the southwest end of the trench and contained 2.2 ounces silver per ton, 0.05 percent copper, and 8.1 percent lead. A third sample (66) from the trench, chipped across a brecciated zone in the northwest wall, contained 0.7 ounce silver per ton. These workings are on the general southwest trend of the vein in the Ontario workings, but surface cover prevents tracing of the vein. The size of the dumps indicates that the two underground workings were substantial (possibly 1,200 ft; 360 m) and that they represent a considerable effort at underground prospecting. Dump samples 62 and 63 suggest that ore was discovered, but no record of production is known.

In the bottom of the draw below these workings is a caved adit, driven northwestward in Tintic Quartzite. Sample 67 from the dump of this adit contained 0.02 percent copper and 0.07 percent lead.

A 60-foot (18-m) adit in a steeply dipping fault zone was driven N. 35° E. in the quartzite near its contact with the stock about 1,000 feet (300 m) northeast of Silver Lake. Chip sample 68 (fig. 33), of sheared, rusty quartzite taken at the face contained traces of copper, molybdenum, and lead. Sample 69, a chip taken in the back at the midpoint of the adit in quartz and quartzite containing iron oxide, showed only traces of silver and copper.

A 473-foot (144-m) adit about 2,000 feet (600 m) southeast of Silver Glance Lake at an altitude of about 9,400 feet (2,900 m, fig. 36), explores ill-defined fractures in Tintic Quartzite. A chip sample (70, fig. 33) in white quartzite at the face contained traces of copper and lead. Sample 71, an 0.8-foot (25-cm) chip taken across a speckled layer consisting of oxidized pyrite in quartzite, contained traces of silver, copper, molybdenum, and lead. Sample 72, a vertical chip taken across a rusty zone in quartzite, contained nothing significant. Sample 73, a chip of clayey gouge from a low-angle fault, contained traces of copper and lead. Sample 74, from the adit dump, contained traces of copper, bismuth, molybdenum, and lead. Sample 75, from the dump of a caved adit about 100 yards (90 m) below, also in Tintic Quartzite, contained little of economic interest.

On the east bank of Silver Glance Lake, a 4-foot (1.2-m) pit penetrates an iron-stained zone in quartz monzonite. Dump sample 76 contained traces of copper, molybdenum, and lead. A 0.3-foot (10-cm) quartz veinlet crops out south of Silver Glance Lake. Sample 77 taken across the vein contained 0.03 ounce gold per ton.

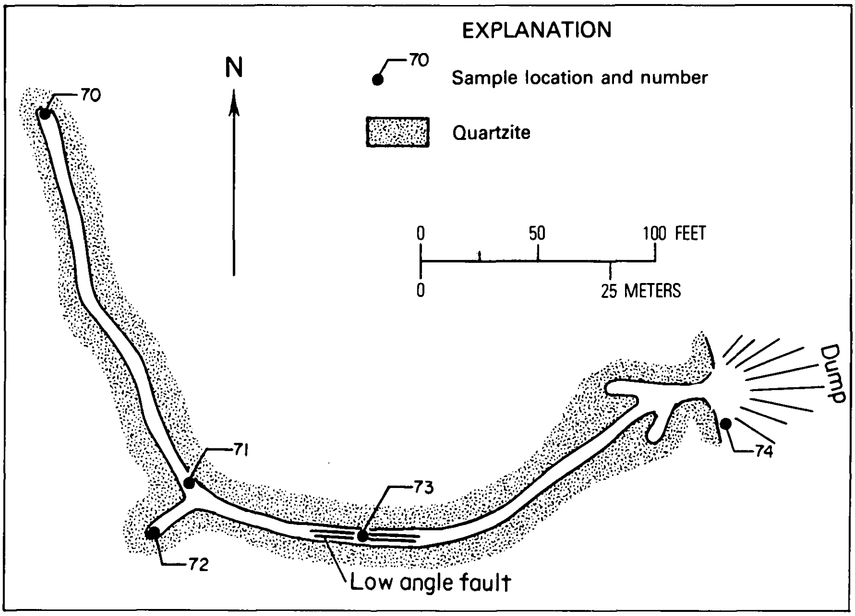


FIGURE 36.—Underground workings of the adit southeast of Silver Glance Lake.

About 1,500 feet (450 m) east of the Milkmaid mine on the east side of the canyon at an elevation of about 8,500 feet, two adits, one about 30 feet (9 m) above the other, explore a vein that has a steep northwestward dip in Tintic Quartzite. This may be the same vein found in the Milkmaid. The upper adit is 30 feet (9 m) long and bears N. 55° E. Near the face, an inclined winze connects to the adit below. Sample 78, a chip taken across the back in white quartzite from near the winze, contained no significant mineralization. Sample 79, taken across a rusty zone containing a little galena in the footwall (south) side of the adit near the winze, contained 1.7 ounces silver per ton, 0.01 percent bismuth, and 2.2 percent lead.

Three samples were taken from the lower adit (fig. 37) east of the Milkmaid mine. Sample 80, a chip taken in the right wall in rusty quartzite, contained 0.7 ounce silver per ton and 0.48 percent lead. Sample 81, a chip taken across a rusty zone in the right wall 20 feet

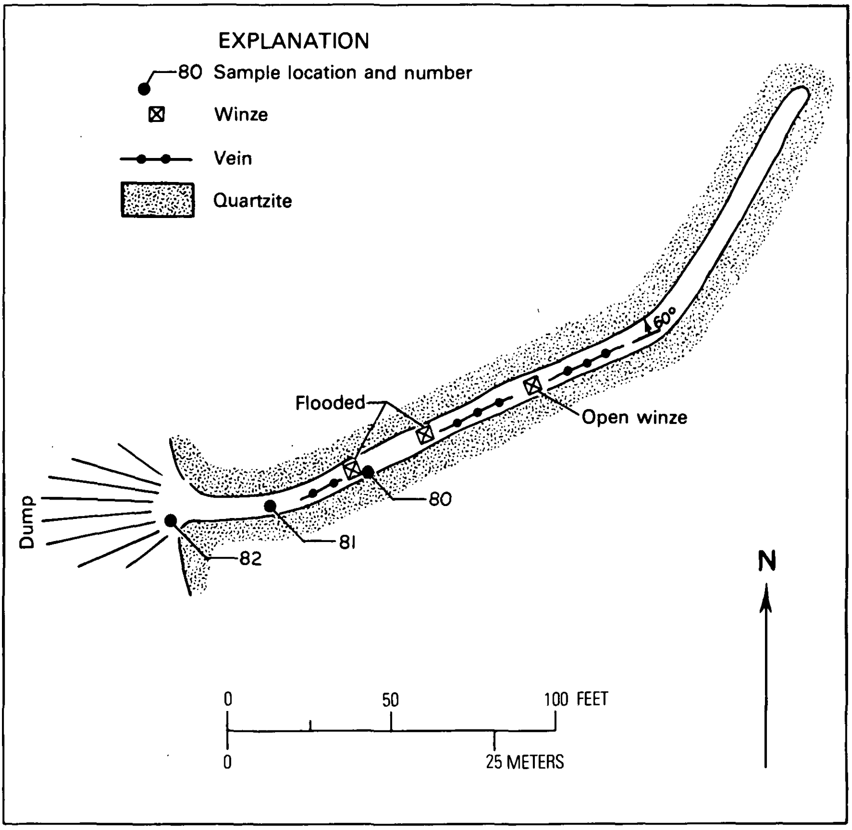


FIGURE 37. — Underground workings of the lower adit, east of the Milkmaid mine.

(6 m) in from the portal, contained 2.9 ounces silver per ton, and 9.15 percent lead. Sample 82 from the adit dump contained trace amounts of silver, copper, molybdenum, and lead.

A partly caved adit and a long trench are about 800 feet (250 m) north of the two adits on the east bank of Silver Fork. Sample 83 (fig. 33), from the adit dump, contained traces of copper, molybdenum, and lead. At the base of a cliff about 1,300 feet (400 m) northeast of this adit, at an elevation of about 9,500 feet (2,900 m) is another adit that explores a fault zone in Tintic Quartzite. It bears N. 65° E. for 190 feet (58 m), then S. 65° E. for 45 feet (14 m). Sample 84 (fig. 38) was a chip taken 23 feet (7 m) from the face on the northeast wall in a crushed quartz vein that has a low northeastward dip. It was essentially barren. Sample 85 from the adit dump contained 0.2 ounce silver per ton.

Two caved workings driven westward, which were found at about 9,300 feet (2,800 m) on the west side of the cirque near the head of Silver Fork, may have been the Austin mine referred to by Butler and others (1920, p. 284). The lower adit is in purplish quartzite of the Big Cottonwood Formation. The upper adit is about 70 feet (20 m) higher in rusty quartzite of the same formation. Dump samples 86 and 87 from these adits contained little of economic interest.

The Silver Lake district has been the site of considerable prospecting and some mining, mostly involving silver-lead deposits that occur in the Tintic Quartzite in small but occasionally high-grade shoots. Similar deposits may occur in the small part of the study area that is underlain by the Tintic Quartzite.

UPPER MAJOR EVANS GULCH (LOCALITY G)

The working known as the Earl-Eagle mine (fig. 39), at the head of Major Evans Gulch near the eastern boundary but outside the study area, is an adit in Maxfield Limestone, originally about 1,500 feet (460 m) long (Calkins and Butler, 1943, p. 142). At the time of this investigation, the adit, which never struck ore, was reported to be caved at about 900 feet (270 m). In 1974, an exploration raise was being driven about 70 feet (20 m) from the portal. On the steep hillside above the adit, a series of trenches has been bulldozed in loose material sloughed down from above. Another series of trenches is about 1,500 feet (460 m) down the draw. This activity was evidently triggered by the presence of galena float, high in silver, that reportedly is common along most of the length of Major Evans Gulch (Calkins and Butler, 1943, p. 141). The source of this

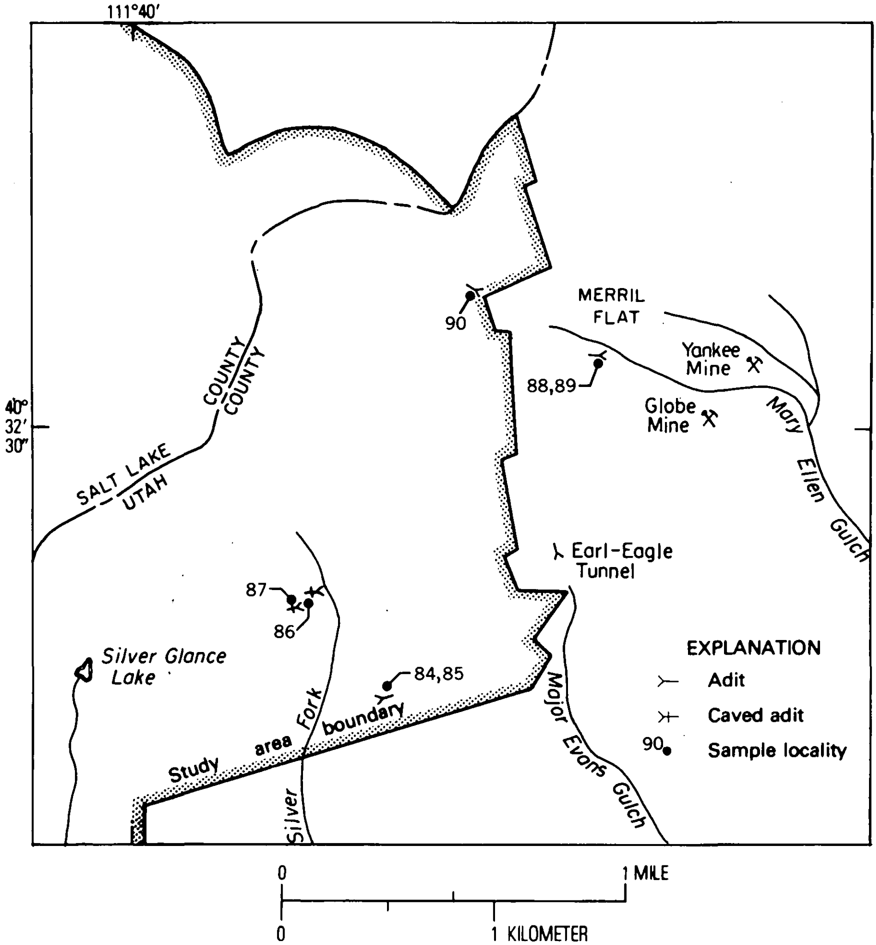


FIGURE 38.— Prospects, mine workings, and sample localities in the Silver Fork-Major Evans-Merril Flat area.

material has been sought unsuccessfully for many years and may have been removed by erosion. No samples were taken in the area.

MERRIL FLAT
(LOCALITY H)

Merril Flat, just east of the eastern boundary of the study area and north of Major Evans Gulch (fig. 38), has been the site of significant mining activity. The Yankee mine, about three-fourths of a mile east of the boundary, is discussed by Calkins and Butler

FIGURE 39.—View toward the north showing prospect workings in upper Major Evans Gulch. The Earl-Eagle mine is marked by the dump in the center of the picture.

(1943, p. 143). The nearby Globe mine has also been a significant producer. U.S. Bureau of Mines records show production from the two mines as follows:

Mine	Period	Gold (ounces)	Silver (ounces)	Copper (pounds)	Lead (pounds)	Zinc (pounds)
Yankee	1902-1959	11,467	1,529,888	56,607	29,014,029	3,109,346
Globe	1925-1947	84	25,588	16,257	330,303	665,227

On the mountain slope west of Merril Flat, two workings in Tintic Quartzite were examined. The lower is an adit at an altitude of about 10,000 feet (3,000 m) that explores minor faults. Sample 88 taken from this adit in iron-stained quartzite at the face, contained nothing of economic interest. A chip sample (89) taken in the left wall in quartzite containing pyrite showed traces of silver, copper, molybdenum, and lead. The upper adit is west of the lower at an altitude of about 10,800 feet (3,300 m). A chip sample (90) taken in quartzite across the face of the upper adit contained nothing of economic interest.

TALUS SAMPLES

In addition to the talus samples discussed under the White Pine Fork locality, four random chip samples (91-94) were taken in talus slopes at localities shown in figure 40. All were from quartz monzonite of the Little Cottonwood stock. Sample 91 was from the upper drainage of Bells Canyon; sample 92 was from the east fork of the upper drainage of Hogum Fork; sample 93 was from the upper drainage of Dry Creek; and sample 94 was from the draw below Lake Hardy in the Dry Creek drainage. These were taken for general information on the igneous rocks of the Little Cottonwood stock. All four samples contained trace amounts of copper and molybdenum, as did the talus samples from White Pine Fork. All samples also contained 0.01 percent lead. Samples 92 and 94 contained 0.1 ounce silver per ton, and sample 93 contained 0.07 percent zinc.

CONCLUSIONS

The Lone Peak study area has little potential for production under present economic conditions. Nevertheless, three areas merit further prospecting. First, the White Pine Fork area contains

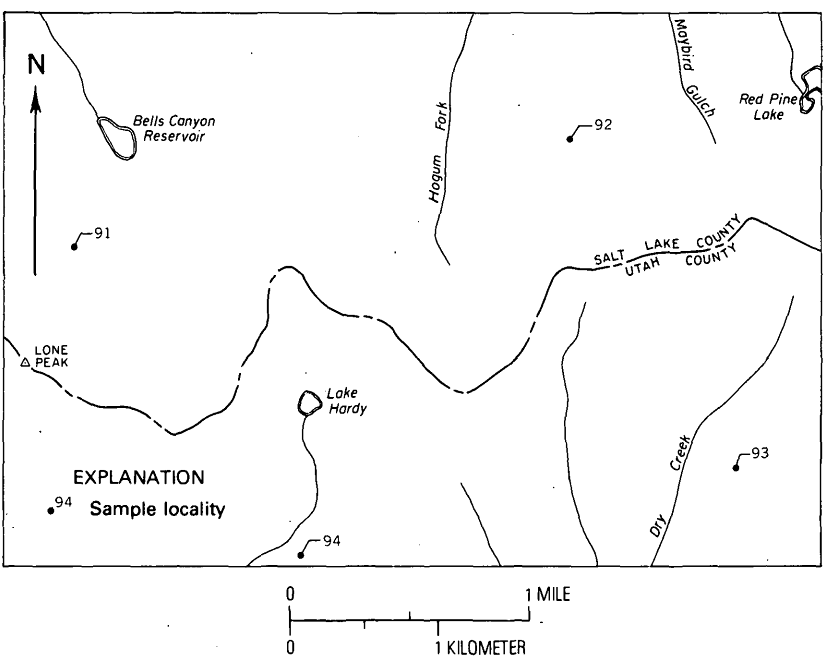


FIGURE 40.—Talus (Quaternary) sample localities in the Lone Peak wilderness study area.

widespread molybdenum mineralization where further drilling may delineate bodies of low-grade molybdenite that may be a future resource. Second, small amounts of high-grade lead-silver ore may exist near Silver Lake, chiefly just east of the study area boundary. Third, widely scattered trace amounts of tungsten minerals in the White Pine Fork and Deer Creek areas offer some encouragement for further prospecting.

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TABLES 4 AND 5

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*

[For sample localities see plate 2. Number in parentheses at head of each column indicates sensitivity limit of method used. <, element detected at concentration less than value shown; N, element looked for but not detected. Results of semiquantitative determinations are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.15, and 0.1, which represents the approximate midpoints of group data on a geometric scale. Semiquantitative analyses for 18 other elements were reported. Most of these were either not detected or were not present in anomalous amounts, although a few anomalous concentrations of these elements are reported in footnotes. Complete analytical tables are available (Whittington and others, 1975). Analysts: C. F. Whittington and E. F. Cooley, assisted by R. N. Babcock]

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses[1]	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Silver Lake area							
SB014	N	200	200	10	50	N	110
SB015	N	15	30	N	N	N	40
SB016	N	20	50	N	N	N	55
SB017	N	15	20	15	N	N	30
SB018	N	15	30	<5	N	N	40
SB019	N	10	20	N	N	N	50
SB020	N	70	50	5	N	N	160
SB021	N	50	50	N	N	N	45
SB044	N	30	100	<5	N	N	140
SB050	N	30	70	N	N	<.05	130
SB051	N	20	50	<5	N	N	80
SB052	N	10	20	<5	N	N	110
SB053	N	20	30	<5	N	N	140
SB054	N	20	70	<5	N	.10	100
SB055	N	30	30	<5	N	N	160
SB056	N	50	70	<5	N	N	100
SB083	N	50	100	N	N	N	95
SB282	N	10	30	N	N	N	60
SB285	.5	100	100	N	N	N	85
SB294	N	50	15	N	N	N	75
SB295	N	100	15	N	N	N	50
SB296	2.0	50	300	N	N	<.05	100
SC022	5.0	50	1,000	10	N	N	130
SC023	N	50	200	<5	N	N	160
SC024	N	50	150	<5	50	N	120
SC025	N	30	150	N	N	N	120
SC026	N	30	300	N	N	N	110
SC027	N	30	100	N	N	N	65
SC028	N	50	100	10	N	N	260
SC029	1.5	50	100	5	N	.05	350

[1]Partial digestion.

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*—Continued

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Silver Lake area--Continued							
SC030	0.5	70	200	5	N	N	260
SC058	<.5	15	300	N	N	.05	130
[2]SC059	7.0	70	1,500	<5	N	.05	830
SC179	N	70	200	20	N	N	100
SC180	N	20	100	100	N	N	60
Stream sediment from White Pine area							
SD080	1.5	70	100	5	N	N	400
SD081	N	50	100	N	N	N	220
SD106	1.0	500	100	100	70	N	370
[2]SD107	2.0	1,000	200	100	150	N	460
SD108	.5	70	150	7	N	N	95
SD109	.5	200	100	100	50	N	40
SD110	<.5	100	100	7	<50	N	110
SD111	N	50	150	10	N	N	80
SD112	<.5	70	200	<5	N	<.05	300
SD113	<.5	700	150	50	N	N	700
[2]SD114	<.5	200	100	100	200	N	120
SD115	1.0	1,500	30	50	N	N	330
SD116	<.5	100	150	15	N	N	180
SD117	<.5	150	150	30	<50	N	280
SD118	2.0	200	200	20	70	N	250
SD119	N	100	150	<5	50	N	190
SD120	N	50	100	<5	N	N	120
SD121	N	20	50	5	50	N	100
SD122	N	20	100	N	N	N	150
SD123	N	20	100	N	N	N	100
SD124	N	20	100	N	N	N	100
SD230	N	20	30	N	N	N	180
SD231	N	300	100	50	N	<.05	800
SD232	N	200	200	150	70	N	70
SD233	1.5	150	70	50	<50	N	180
SD234	1.0	70	100	N	N	N	160
SD254	1.0	700	150	100	100	N	550
SD255	1.0	700	150	70	50	N	850
SD257	1.0	150	100	30	<50	N	340
SD258	<.5	50	50	10	N	N	120
SE075	2.0	150	200	30	70	N	230
SE235	N	150	100	N	N	N	390
SE236	2.0	300	100	50	N	N	420
[3]SE237	2.0	70	200	300	N	N	130
SE238	3.0	20	50	70	N	N	95

[2]10 ppm Bi.
[3]20 ppm Bi.

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*—Continued

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from White Pine area--Continued							
SE239	N	50	100	<5	N	N	110
SE240	N	50	100	N	N	N	100
SE241	2.0	200	200	50	100	N	300
[3]SE242	2.0	200	150	70	<50	N	140
SE243	3.0	150	200	100	<50	N	390
SE247	N	50	100	N	N	N	240
SE259	<.5	150	200	20	70	N	160
SE260	1.0	150	200	20	50	N	320
SE261	<.5	100	100	20	<50	N	250
SE262	1.0	100	200	15	<50	N	120
SE263	<.5	100	150	10	70	N	270
SE289	N	50	150	N	N	<.05	180
SF244	2.0	100	150	20	<50	N	150
SF288	<.5	50	100	<5	N	N	150
SF290	1.0	15	20	N	N	<.05	130
SF291	.5	70	150	N	N	N	130
SF292	<.5	50	150	N	N	N	90
SF293	1.0	50	150	N	N	N	90
Stream sediment from Hogum Fork-Bells Canyon area							
SG245	N	50	100	N	N	N	90
SG275	N	50	70	N	<50	N	70
SG276	N	20	70	N	N	N	170
SG277	N	20	150	N	N	N	90
SG278	N	20	150	N	N	N	110
SG279	N	20	50	N	N	N	90
SG280	1.5	50	100	15	N	N	120
SG281	3.0	100	100	100	N	N	170
SH198	N	15	50	N	N	N	60
SH199	N	15	100	N	N	N	70
SH228	N	70	200	N	N	<.05	85
SH229	N	70	200	N	N	N	120
SH248	<.5	150	500	10	N	N	140
SH249	<.5	100	300	N	N	N	80
SH250	N	30	150	N	N	N	45
SH251	N	20	150	N	N	N	60
SH252	N	50	200	N	N	N	85
SH253	N	20	70	N	N	N	80
SH264	N	100	300	N	N	N	110
SH265	N	100	200	N	N	N	85
SH266	N	15	150	N	N	N	55
SH267	N	30	150	N	N	N	60
SH268	N	20	100	N	N	N	90
SH297	N	50	300	N	N	N	130
SH298	N	20	150	N	N	N	80

[3]20 ppm Bi.

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah,*—Continued

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Hogum Fork-Bells Canyon area--Continued							
SH299	N	20	150	N	N	N	110
SH300	N	30	300	N	N	N	90
SH308	1.0	70	300	<5	N	N	140
SH309	.5	70	500	<5	N	N	120
SH310	.5	70	300	<5	N	N	100
SH311	.5	70	300	<5	N	<.05	100
SI194	<.5	50	150	N	N	N	95
SI196	N	20	150	N	N	N	65
SI197	N	100	150	N	N	N	75
SI223	N	20	100	N	N	N	70
SI224	N	50	100	N	N	N	90
SI225	N	50	100	N	N	N	100
SI226	N	50	150	N	N	N	120
SI227	N	50	100	N	N	N	90
SI269	<.5	100	300	N	N	N	140
SI270	N	50	200	N	N	N	120
ST057	N	20	70	N	N	N	110
ST246	N	20	100	N	N	N	45
Stream sediment from Dry Canyon area							
SA001	N	15	30	15	N	N	110
SA002	N	15	30	10	N	N	95
SA003	N	10	30	5	N	N	75
SA004	N	15	30	N	N	N	70
SA005	N	30	100	<5	N	N	80
SA006	N	20	100	N	N	N	65
SA007	N	20	100	10	N	--	75
SA008	N	20	100	5	N	N	70
SA010	N	20	50	N	N	N	110
SA011	N	50	150	N	N	<.05	120
SA012	N	15	70	<5	N	N	130
SA031	N	30	200	<5	N	N	75
SA032	N	10	50	5	N	N	70
SA033	N	20	100	5	N	N	90
SA034	N	30	200	7	<50	N	75
SA035	N	30	150	5	N	N	85
SA036	N	30	150	N	N	N	100
SA037	N	15	30	N	N	N	85
SA038	N	50	50	N	N	N	120
SA039	N	70	150	N	N	<.05	100
SA040	N	30	100	<5	N	.15	120
SA041	N	30	50	<5	N	.60	110
SA042	N	30	150	<5	N	N	110
SA043	N	30	150	<5	N	<.05	95
SA045	N	20	30	<5	N	N	95

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*—Continued

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Dry Canyon area--Continued							
SA046	N	10	50	<5	N	N	120
SA060	N	50	100	<5	N	N	95
SA061	N	70	50	N	N	N	95
SA062	N	50	300	5	N	.05	130
SA063	N	20	50	<5	N	N	75
SA064	N	20	200	N	N	--	100
SA067	N	20	30	<5	N	N	100
SA068	2.0	50	30	50	N	N	310
SA069	N	30	30	<5	N	N	130
SA070	N	30	50	<5	N	N	130
SA071	1.5	30	70	<5	N	N	170
SA072	N	30	70	<5	N	N	160
SA073	N	20	30	<5	N	.05	85
SA074	N	15	70	<5	N	N	100
SA181	N	10	70	N	N	N	45
SA182	N	15	100	N	N	N	70
SA271	N	15	10	N	N	N	75
SA272	N	15	20	N	N	N	95
SA273	N	30	150	N	N	N	95
SA274	N	15	10	N	N	N	45
SJ091	N	20	100	<5	N	N	70
SJ092	N	20	100	<5	N	N	70
SJ093	N	20	30	<5	N	N	90
SJ094	N	30	100	<5	N	N	85
SJ153	N	10	20	N	N	N	80
SJ161	N	15	100	N	N	N	80
SJ162	N	50	150	N	N	N	100
SJ163	N	15	70	N	N	N	85
SJ164	N	15	100	N	N	N	50
SJ165	N	15	100	N	N	N	75
SJ166	N	30	150	N	N	N	130
SJ167	N	20	100	N	N	N	90
SJ168	N	20	70	N	N	N	100
SJ169	N	15	20	20	N	N	100
SJ170	N	20	70	N	N	N	50
SJ171	N	20	150	20	N	N	85
SJ188	N	100	200	<5	N	N	70
SJ189	N	50	150	N	N	N	100
SJ190	N	50	150	N	N	N	90
SJ191	N	50	200	N	N	N	90
SJ192	N	30	100	N	N	N	60
SJ193	N	70	200	10	N	N	60
SJ201	N	20	100	N	N	N	70
SJ202	N	15	20	N	N	N	90
SJ203	N	50	100	N	N	N	110

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*—Continued

Sample No.	Sémiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Dry Canyon area--Continued							
SJ204	N	30	150	N	N	N	95
SJ205	N	20	100	N	N	N	55
SJ206	N	50	150	N	N	N	120
SJ207	N	20	100	N	N	N	65
SJ208	N	20	70	N	N	N	70
SJ209	N	20	150	N	N	<.05	60
[4]SJ210	N	30	100	N	N	N	40
[5]SJ211	N	50	150	N	N	N	50
SJ215	N	30	150	N	N	N	80
SJ216	N	50	200	N	N	N	100
SJ217	N	50	150	N	N	N	60
SJ218	N	50	200	N	N	N	100
SJ219	N	50	200	N	N	N	130
SJ220	N	20	100	N	N	N	80
SJ221	N	50	150	<5	N	N	60
SJ222	N	15	70	N	N	N	55
SK154	N	30	150	<5	N	N	80
SK155	N	20	70	N	N	N	75
SK156	N	15	70	N	N	N	75
SK157	N	20	150	N	N	N	65
SK158	N	20	100	N	N	N	95
SK159	N	30	150	N	N	N	95
SK160	N	20	70	N	N	N	75
SK183	<.5	100	300	10	N	<.05	130
SK184	N	100	300	N	N	N	120
SK185	N	100	150	N	N	N	95
SK186	N	30	100	N	N	N	75
SK187	N	15	20	N	N	N	80
Stream sediment from Alpine area							
SM084	1.0	15	50	<5	N	N	130
SM086	N	15	200	<5	N	N	150
SM141	2.0	50	700	<5	N	N	260
SM142	N	15	20	<5	N	N	85
SM143	N	15	50	<5	N	N	95
SM144	N	15	15	<5	N	N	75
SM145	N	15	150	<5	N	N	110
SM148	N	15	20	N	N	N	100
SM149	N	20	50	N	N	N	75
SM150	N	20	50	N	N	N	80
SM151	N	100	50	N	N	N	25
SM152	N	15	50	N	N	N	70

[4]8 ppm U.
[5]12 ppm U.

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*—Continued

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Box Elder-American Fork area							
SL065	N	20	100	5	N	N	110
SL066	N	20	30	<5	N	N	90
SL089	N	10	20	<5	N	<.05	45
SL090	N	15	20	<5	N	N	50
SL146	N	15	20	<5	N	N	85
SL212	N	15	50	70	N	N	140
SL213	N	30	70	10	N	N	150
SL214	N	20	50	<5	N	N	100
SN047	N	20	100	N	N	N	50
SN048	N	30	70	N	N	N	85
SN105	N	15	150	N	N	N	95
SN301	N	15	100	N	N	N	60
SO049	N	50	200	N	N	N	90
SO136	N	15	20	N	N	<.05	35
SO137	N	20	15	N	N	N	30
SO138	N	30	100	N	N	N	65
SO139	N	20	150	N	N	N	65
SP100	N	20	30	N	N	N	40
SP125	N	10	15	N	N	N	40
SP126	N	10	20	N	N	N	40
SP127	N	15	20	N	N	N	40
SP128	N	20	50	N	N	N	60
SP129	N	20	100	N	N	N	65
SP130	N	10	50	N	N	N	60
SP131	N	30	100	N	N	N	100
SP132	N	20	100	N	N	N	180
SP133	N	15	70	N	N	N	75
SP134	N	15	50	N	N	N	85
SP135	N	10	50	N	N	N	75
SP140	N	15	20	N	N	N	40
SP172	N	20	50	N	N	N	130
SP173	N	20	100	N	N	N	180
SQ009	N	20	100	N	N	N	180
SQ013	N	20	100	5	N	<.05	80
SQ082	N	10	20	N	N	N	130
SQ101	N	20	70	N	N	N	70
SQ102	N	20	150	N	N	N	70
SQ103	N	10	20	N	N	N	75
SQ104	N	20	20	N	N	N	120
SR095	N	10	20	<5	N	N	120

TABLE 4.—*Analyses (in parts per million) of stream-sediment samples from the Lone Peak study area, Utah*—Continued

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Stream sediment from Box Elder-American Fork area--Continued							
SR096	N	10	10	<5	N	N	110
SR097	N	15	30	<5	N	N	75
SR098	N	10	15	N	N	N	85
SR099	N	5	10	N	N	N	80
SR174	N	15	50	N	N	N	95
SR175	N	20	70	N	N	N	80
SR176	<.5	70	150	10	N	N	140
SR177	N	15	30	<5	N	N	85
SR178	N	15	50	N	N	N	100
SR200	N	10	10	N	N	<.05	85

TABLE 5.—*Analyses (in parts per million) of rocks from the Lone Peak study area, Utah*

[For sample localities see plate 2. Indications of mineralization range from meager iron staining to the presence of visible ore minerals. Number in parentheses at head of each column indicates sensitivity limit of method used. <, element detected at concentration less than value shown; >, element concentration greater than value shown; N, element looked for but not detected. Results of semiquantitative determinations are reported to the nearest number in the series 1, 0.7, 0.5, 0.3, 0.15, and 0.1, which represents the approximate midpoints of group data on a geometric scale. Semiquantitative analyses for 18 other elements were reported. Most of these were either not detected or were not present in anomalous amounts, although a few anomalous concentrations of these elements are reported in footnotes. Complete analytical tables are available (Whittington and others, 1975). Analysts: C. F. Whittington and E. F. Cooley, assisted by R. N. Babcock]

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses[1]	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Samples showing some indication of mineralization							
[2]RM001	N	20	<10	200	500	N	65
[3]RM002	N	70	15	200	300	N	25
RM003	N	70	15	500	1,000	N	80
RM004	3.0	2,000	20	<5	N	<.05	65
[4]RM005	N	20	N	<5	N	N	5
RM006	N	50	N	<5	N	N	25
RM007	N	5	N	<5	N	N	15
RM008	2.0	700	300	15	N	N	260
RM009	N	100	20	10	N	N	10
[5]RM010	20.0	1,000	150	N	N	.20	5
[6]RM011	2.0	1,000	<10	1,000	N	<.05	60
[6]RM012	10.0	2,000	200	10	N	.10	45
RM013	N	30	30	10	100	N	65
RM014	2.0	20	1,000	300	70	N	15
RM015	N	7	50	N	N	N	65
RM016	N	<5	N	5	N	N	15
RM017	1.5	150	100	>2,000	N	.25	30
RM022	N	15	10	N	N	N	15
RM025	N	50	70	10	N	N	20
RM026	N	20	<10	<5	N	N	30
[7]RM030	100.0	50	>20,000	5	N	N	110
[8]RM031	300.0	1,000	>20,000	100	N	.05	1,100
[9]RM032	300.0	100	>20,000	N	N	<.05	280
RM033	<.5	5	500	N	N	N	50
RM034	N	5	200	N	N	N	10
RM035	N	15	150	5	N	<.05	180
RM036	N	100	100	200	N	N	25
[10]RM037	<.5	150	10	7	N	N	<5
[11]RM038	N	150	<10	1,000	N	N	20
[12]RM039	5.0	10	3,000	N	N	<.05	65,000
RM040	2.0	50	1,500	N	N	<.05	6,000
RM041	N	15	700	N	N	N	6,500
RM042	N	5	1,000	<5	N	<.05	12,000
RM043	N	<5	N	N	N	N	75
RM046	N	5	20	N	N	N	50

See footnotes at end of table.

TABLE 5.—*Analyses (in parts per million) of rocks from the Lone Peak study area, Utah— Continued*

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses[1]	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Samples showing some indication of mineralization--Continued							
RM047	N	<5	10	N	N	N	50
RM048	N	<5	20	N	N	N	60
RM049	N	<5	50	N	N	N	50
RM050	N	5	30	N	N	N	45
RM051	N	200	20	N	N	N	35
RM053	N	<5	100	N	N	N	35
RM054	N	5	15	N	N	N	11,000
RM055	N	<5	10	N	N	N	380
RM056	<.5	700	10	10	N	N	30
RM057	2.0	100	150	N	N	N	25
RM058	N	10	70	N	<50	N	10
RM059	5.0	50	200	100	<50	N	<5
RM061	N	N	N	N	N	N	35
RM062	N	<5	N	N	N	N	35
RM065	N	<5	<10	N	N	N	95
[3]RM069	7.0	20	300	N	N	<.05	50
[13]RM070	N	300	N	N	N	N	35
RM071	N	5	20	N	N	N	30
RM072	N	<5	N	N	N	N	10
RM073	N	100	<10	N	N	N	45
RM074	N	<5	<10	N	<50	N	45
RM075	N	<5	<10	N	<50	N	35
RM076	N	<5	30	N	N	N	70
RM077	N	10	10	N	N	N	20
RM079	<.5	500	50	10	N	N	30
RM080	N	20	50	N	N	N	60
RM081	N	50	50	20	N	N	30
RM082	<.5	150	100	700	N	N	35
RM083	N	20	100	500	N	N	10
RM084	N	<5	50	N	N	N	35
RM087	N	20	70	<5	N	N	65
RM088	<.5	50	100	N	N	N	95
RM092	1.0	50	150	N	N	N	45
RM094	.5	20	150	5	N	N	5
RM095	N	50	30	5	N	N	20
[14]RM096	3.0	500	500	N	200	N	35
RM101	N	100	N	N	N	.05	20
RM106	N	<5	<10	N	N	N	25
RM107	N	200	50	150	N	N	20
RM108	N	1,000	10	30	100	N	15
RM109	<.5	200	50	200	N	N	5
[2]RM110	2.0	100	100	700	N	N	20
RM111	<.5	50	100	300	70	N	10
RM112	N	70	70	20	N	N	30
RM113	N	10	70	N	N	N	45
RM114	1.5	100	200	N	N	N	150
RM115	N	100	15	N	N	N	55
[15]RM117	5.0	100	200	70	70	N	75
[3]RM118	5.0	70	200	20	N	N	95
RM119	<.5	20	70	20	<50	N	20

See footnotes at end of table.

TABLE 5.—*Analyses (in parts per million) of rocks from the Lone Peak study area, Utah—Continued*

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses[1]	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Samples showing some indication of mineralization--Continued							
RM120	N	50	50	20	N	N	80
RM121	5.0	15	500	200	N	N	15
RM122	5.0	30	200	100	N	N	20
RM123	N	15	30	20	N	N	25
RM124	N	50	10	70	100	N	20
RM126	N	N	20	N	50	N	60
RM129	N	20	50	<5	N	N	35
RM133	N	5	30	N	N	N	55
RM134	2.0	20	150	30	N	N	50
RM135	N	5	100	200	N	N	25
RM136	N	15	10	<5	N	N	15
RM137	N	<5	100	70	N	N	5
RM138	N	150	50	N	N	N	35
RM139	1.0	20	100	100	N	N	50
[16]RM150	5.0	15	200	30	100	N	20
[16]RM151	2.0	50	500	100	70	N	25
[17]RM154	20.0	300	20,000	20	N	.10	11,000
[18]RM156	3,000.0	2,000	>20,000	N	N	.60	7,000
[19]RM157	500.0	700	>20,000	15	N	.20	700
RM158	3.0	200	700	15	N	N	110
[20]RM160	500.0	300	>20,000	7	200	.40	200
RM162	N	10	30	N	N	N	40
RM163	N	70	50	200	N	N	30
RM165	2.0	50	150	50	N	N	20
RM166	N	70	50	100	N	N	30
RM167	2.0	100	50	70	N	N	20
RM168	1.0	70	70	70	1,000	N	10
[3]RM169	15.0	100	300	20	N	N	120
RM172	2.0	70	150	200	N	N	10
RM174	N	<5	20	N	N	N	45
Samples showing no indication of mineralization							
RS018	N	<5	10	N	N	N	15
RS019	N	5	<10	N	N	N	15
RS020	N	<5	<10	N	N	N	10
RS021	N	<5	30	10	N	N	40
RS023	N	150	15	N	N	N	50
RS024	N	<5	N	N	N	N	5
RS027	N	10	70	N	N	N	50
RS028	N	<5	50	N	N	N	50
RS029	N	10	20	N	N	N	45
RS044	N	<5	10	N	N	N	110
RS045	N	<5	N	N	N	N	40
RS052	N	<5	150	N	N	N	10
RS060	N	N	N	N	N	<.05	10
RS063	N	5	70	10	N	N	50
RS064	N	100	100	N	N	N	75
RS066	N	<5	N	N	N	N	30
RS067	N	<5	N	N	N	N	20
RS068	N	<5	N	N	N	<.05	55
RS078	N	5	70	N	N	N	35
RS085	N	20	50	N	N	N	50

See footnotes at end of table.

TABLE 5.—*Analyses (in parts per million) of rocks from the Lone Peak study area, Utah—Continued*

Sample No.	Semiquantitative spectrographic analyses					Atomic absorption analyses[1]	
	Ag (0.5)	Cu (5)	Pb (10)	Mo (5)	W (50)	Au (0.05)	Zn (5)
Samples showing no indication of mineralization--Continued							
RS086	N	<5	100	30	N	N	60
RS089	N	<5	70	N	N	N	55
RS090	N	7	70	N	N	N	55
RS091	N	<5	N	N	N	N	20
[16]RS097	2.0	7	300	10	N	N	55
RS098	1.5	<5	300	N	N	N	10
RS100	N	<5	50	N	N	N	40
RS102	N	5	50	200	N	N	50
RS103	N	<5	100	N	N	N	15
RS104	N	<5	15	50	N	N	<5
RS105	N	30	30	100	N	N	70
RS116	N	20	20	N	N	N	55
RS128	N	<5	20	N	N	N	100
RS130	N	<5	20	N	N	N	35
RS131	N	15	20	N	N	N	140
RS132	N	5	20	10	N	N	15
RS140	2.0	<5	70	N	N	N	5
RS141	N	N	N	N	N	N	<5
RS142	N	5	100	N	N	N	15
RS143	N	<5	N	N	N	N	20
RS144	N	<5	N	N	N	N	15
RS145	N	N	N	N	N	N	10
RS146	N	N	N	N	N	N	10
RS147	N	N	N	N	N	N	10
RS148	N	N	N	N	N	N	10
RS152	N	20	150	N	N	N	75
RS153	N	<5	100	N	N	N	60
RS170	.5	70	100	15	N	N	35
RS171	N	10	30	N	N	N	55
RS173	N	<5	70	N	N	N	10
RS175	N	<5	70	N	N	N	15
RS176	N	<5	100	N	N	N	10
Fine-grained samples from prospect dumps							
SB283	N	100	10	N	N	N	75
SB284	15.0	50	1,000	<5	N	N	370
SC286	150.0	300	15,000	10	N	.05	1,700
SC287	200.0	300	>20,000	15	N	.20	800
SD256	10.0	700	500	700	70	N	130
SL147	N	50	200	<5	N	N	330
SM085	5.0	10	20,000	<5	N	N	13,000
SM087	N	15	150	<5	N	N	130
SM088	N	15	150	<5	N	N	95

[1] Partial digestion.
[2] 10 ppm Sn.
[3] 20 ppm Bi.
[4] 200 ppm B.
[5] 200 ppm Bi.
[6] 1000 ppm As.
[7] 500 ppm Sb.
[8] 1500 ppm Sb.
[9] 100 ppm Sb and 500 ppm Bi.
[10] 500 ppm B.
[11] 150 ppm B.
[12] 100 ppm Cd.
[13] 100 ppm Bi.
[14] 30 ppm Bi.
[15] 50 ppm Bi.
[16] 10 ppm Bi.
[17] 3000 ppm As, 100 ppm Sb, and 50 ppm Sn.
[18] >1000 ppm Bi, 150 ppm Sb, and 20 ppm Sn.
[19] 1000 ppm Sb, and 20 ppm Sn.
[20] >1000 ppm Bi, and 30 ppm Sn.

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