STATE OF MONTANA
Tim Babcock, *Governor*

BUREAU OF MINES AND GEOLOGY
E. G. Koch, *Director*

BULLETIN 54

October, 1966

SOME HIGH-PURITY QUARTZ DEPOSITS IN MONTANA

by

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MONTANA COLLEGE OF MINERAL SCIENCE AND TECHNOLOGY
Butte, Montana
October 1966

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Montana Bureau of Mines and Geology

Room 203-B, Main Hall

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Butte, Montana

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J. M. Chelini

INTRODUCTION

Increasing production in the silicon-alloy industry in the West Coast area and diminishing reserves of high-purity quartz in the areas near the plants have resulted in an increased demand for high-purity "quartz pebble" in the entire Pacific Northwest. Consequently, the Bureau began a survey of high-purity quartz deposits in Montana in the summer of 1964, for the purpose of aiding consumers in their search for this commodity.

This bulletin should not be construed as an exhaustive and complete report of high-purity quartz deposits in Montana. In scope the survey entailed the gathering of geologic data on known or reported high-purity deposits chiefly of magmatic origin in Montana. No concerted effort was made to find new unrecorded deposits, though reconnaissance surveys were made in some favorable areas.

Quartz deposits of sedimentary origin (sandstone and quartzite) were not studied, although they are widespread in Montana, because of their generally heterogeneous composition. It is known, however, that the Quadrant Sandstone (Quartzite) in southwestern Montana is locally very pure, as is illustrated by the Daly Spur (page 22). If glass sand, which must be pure, is ever produced in Montana its source will more than likely be a locally pure zone in the Quadrant Formation.

Crushed and graded quartz is used for the abrasive backing of "flint" sandpapers. Chalk flint from England is more desirable, but almost any massive white quartz is suitable. Powdered quartz from similar sources is used for scouring compounds and for the harsher metal polishers. Other silica products, such as tripoli, are used for lighter scouring compounds and polishers.

Silicon carbide, a silicon compound used both as an abrasive and as a refractory, demands high-purity silica for its manufacture. "Green grit" silicon carbide requires a product containing 99.5 to 99.7 percent silica. Dark silicon carbide, "black grit", can be produced using a raw product having 99.3 to 99.5 percent silica. Alumina, which is the coloring impurity, must not exceed 0.04 percent in material used for manufacture of "green grit", and 0.20 percent for "black grit". Ferric iron, lime, and magnesia are each limited to a maximum of 0.10 percent for both products. A particle size range of $\frac{1}{4}$ to 1 inch is usually specified.

REFRACTORIES

High-purity quartz is used to produce three classes of silica brick. The most restrictive specifications are for "super duty" acid brick, which demands careful control of alumina during its production. Maximum alumina tolerance in the silica raw material is about 0.4 percent. Lime should be less than 1 percent, total alkalies not greater than 0.5 percent, and titania (TiO_2) should not be present in greater than trace amounts. Ignition loss, which is a measure of the molecular water in the raw material (high in opal), should not exceed 0.5 percent.

The second brick, termed "conventional class", and a third-class brick are produced under greater tolerances. The final product of the former can contain as much as 1.0 percent total of alumina, titania, and alkalies--the latter about 1.4 percent to 2.5 percent total of alumina, titania, and alkalies.

METALLURGICAL

High-purity "quartz pebble" for metallurgical use requires a clean graded silica in gravel sizes. To qualify as a raw material for the production of silicon alloys, it must meet rigorous specifications. Such alloys as calcium-silicon, ferrosilicon, silicon-chrome, silicon-copper, silico-manganese, and silicon-titanium are the principal products prepared from metallurgical-grade silica.

Chemically, alumina is undesirable because it promotes a sticky unmanageable slag that contaminates the finished product. For this reason alumina in the raw product must not exceed 0.4 percent. Total iron can be as much as 0.2 percent, combined alkalies should be kept below 0.3 percent,

Table 1.--General chemical and particle size specifications for important uses of silica raw materials.

	SiO_2%	Maximum permissible percentage										Particle size
		Fe_2O_3	Al_2O_3	CaO	MgO	Total alk.	TiO_2	Ign. loss	CO_2	P_2O_5	As	
Abrasives												
Sandblasting and sandpaper	Almost any massive white quartz is suitable.											
Silicon carbide												
Green grit	99.5 - 99.7	0.10	0.04	0.10	0.10	t	t	t	t	t	t	$\frac{1}{4}$-1 inch
Black grit	99.3 - 99.5	.1	.2	.1	.1	t	t	t	t	t	t	
Refractories												
Superduty acid brick	97.0 - 97.2	.4	.4	1.0	t	0.5	*tr	0.5	t	t	t	+$\frac{1}{2}$-8 in.
Metallurgical alloys												
Calcium-silicon	98.0 - 98.8	.2	.4	t	t	.3	tr	.3	t	none	none	+$\frac{1}{2}$-8 in.
Ferrosilicon	98.0 - 98.8	.2	.4	t	t	.3	tr	.3	t	none	none	+$\frac{1}{2}$-8 in.
Silicon-chrome	98.0 - 98.8	.2	.4	t	t	.3	tr	.3	t	none	none	+$\frac{1}{2}$-8 in.
Silicon-copper	98.0 - 98.8	.2	.4	t	t	.3	tr	.3	t	none	none	+$\frac{1}{2}$-8 in.
Silicomanganese	98.0 - 98.8	.2	.4	t	t	.3	tr	.3	t	none	none	+$\frac{1}{2}$-8 in.
Silicon-titanium	98.0 - 98.8	.2	.4	t	t	.3	tr	.3	t	none	none	+$\frac{1}{2}$-8 in.
Flux												
Elemental phosphorus	90.0	t	t	.2	t	t	t	t	1.5	t	t	+$\frac{1}{4}$-4 in.**
Base metals	70.0	t	t	t	t	t	t	t	t	t	t	
Glass												
Flint quality	98.0 - 99.7	.025	.2	t	t	.01	t	t	t	t	t	+140-30 mesh
Amber (container)	98.0 - 99.6	.05 - 0.08	.2	t	t	.01	t	t	t	t	t	+140-30 mesh

----

*tr, Trace.
**Not more than 5 percent can be $\frac{1}{4}$ inch.
t, Not reported as being critical, but no impurities are tolerated in large amounts.

and titania held to a minimum. Phosphorus and arsenic are dangerous because of their toxic qualities and should be held to an absolute minimum. Opaline silica, an amorphous form of silica, is detrimental because of its contained molecular water, which causes the material to spall in the furnace and seal the furnace charge against free circulation of the desired reducing atmosphere. High ignition loss in a chemical analysis of the raw material is a measure of the amount of contained molecular water and should not exceed 0.3 percent. Size of silica raw material utilized for silicon-alloy production is plus $\frac{1}{2}$ inch minus 8 inch and no fines.

Silica used as metallurgical flux in the manufacture of elemental phosphorus by the electrical furnace method (process used by Victor Chemical Company in their plant 12 miles west of Butte) has specifications that are more tolerant. Ferric iron, alumina, and carbon dioxide (CO_2) may be as much as 1.5 percent each, but calcium oxide should be less than 0.2 percent. Silica content must exceed 90 percent. Where silica is used in the base-metal smelters as a flux, the silica content generally need not exceed 70 percent; but the higher the silica content, the less tonnage is required for fluxing. For fluxing material the size specification is generally plus $\frac{1}{4}$ inch minus 4 inch.

GLASS

No silica sand deposit is known in Montana that can meet the stringent physical and chemical specifications for manufacture of glass. It is, however, one of the more important uses of high-purity silica sand. Source materials of this commodity are more restricted geographically than for any other industrially used silica. The product must be of superlative purity and is difficult and expensive to prepare. Raw material for glass production commands high prices and can be economically shipped long distances.

To qualify for glass manufacture the product must be a chemically pure quartz sand essentially free of inclusions, coatings, stains, and detrital minerals. Delivery to a customer in this highly refined state must be guaranteed and uniformity maintained.

Different chemical specifications are generally given for manufacture of flint-quality glass and for amber glass (container glass). Alumina and iron are the most common impurities and must be kept to extremely low limits. Flint-quality glass sand should not contain more than 0.025 percent ferric iron and 0.2 percent alumina. In both, the maximum allowable for lime and magnesia is about 0.05 percent, and for alkalies 0.01 percent. All impurities must be held to absolute uniformity in all shipments.

Particle-size distribution of the sand is also an important factor. Midwestern and eastern glass producers demand that quartz sand must all pass through a 30-mesh sieve, and that a maximum of roughly 2 percent pass a 140-mesh sieve. West coast and mid-continent glass makers have adapted to generally finer grained sand by lowering the threshold at the fine end of the distribution scale to 2 percent passing a 200-mesh sieve.

CONSUMERS

Marketing is both a science and an art; it follows established principles, but a great deal of practical skill and effort is required of the person doing the marketing. He must remember that the most important buying motives of purchasers of silica are assurance that the product being purchased will be uniform in its physical and chemical properties and assurance that the product will be delivered to the buyer on schedule.

High-value products can be transported greater distances to market. Some glass sand is imported from Belgium. Marketing of abrasive sand is restricted by transportation cost to areas close to consumers. Consequently, the market area depends a great deal upon the value of the product; and the feasibility of production depends upon the value and quantity of the product consumed in its market area. Finding a market is an important first step before starting production.

The following list of consumers of "quartz pebble" used for metallurgical purposes, and quartz sand used for sandblasting, foundry sand, and glass sand has been extracted from information obtained by canvassing industrial mineral consumers in Oregon, Washington, Idaho, and Montana. Users in other states can be located by using the new Consumers' Industrial Minerals Classification proposed by Chelini (in press).

QUARTZ PEBBLE

Oregon Metallurgical Corp.
120 W. 34th Avenue
Albany, Oregon

Union Carbide Corp.
Metals Division
11920 N. Burgard Road
Portland, Oregon

National Metallurgical Corp.
1801 South A Street
Springfield, Oregon

Hanna Nickel Smelting Co.
Riddle, Oregon

The Anaconda Co.
Great Falls, Montana

QUARTZ SAND

Western Kraft Corp.
Beaverton Plant
900 Western Avenue
Beaverton, Oregon

Rasmussen and Co.
318 N.W. Canyon Road
Beaverton, Oregon

Astoria Foundry
18th and Franklin
Astoria, Oregon

Eugene Aluminum & Brass Foundry
1285 W. Second Avenue
Eugene, Oregon

General Foods Corp.
Birdseye Division
239 West Baseline
Hillsboro, Oregon

Cascade Paint Co.
9650 E. Burnside Street
Portland, Oregon

Century Industries, Inc.
1355 River Road
Eugene, Oregon

Precision Castparts Corp.
4600 S.E. Harney Drive
Portland, Oregon

Frontier Leather Co.
P. O. Box 116
Sherwood, Oregon

Pendleton Woolen Mills
8500 S.E. McLaughlin Boulevard
Portland, Oregon

W. W. Rosebraugh Co.
Salem, Oregon

Publishers Paper Co.
P. O. Box 551
Oregon City, Oregon

Portland Paint and Lacquer Products
7835 S.W. 37th
Portland, Oregon

Pacific Steel Foundry Co.
1979 N.W. Vaughn Street
Portland, Oregon

Columbia Steel Casting Co.
10425 N. Bloss Street
Portland, Oregon

Pennsalt Chemicals Corp.
6400 N.W. Front Street
Portland, Oregon

Reliance Varnish Co., Inc.
16th and Cross Streets
Salem, Oregon

Crawford and Doherty Foundry
4604 S.E. 17th Avenue
Portland, Oregon

Macadam Aluminum and Bronze
2427 N.W. 30th Avenue
Portland, Oregon

Rich Manufacturing Company of California
866 N. Columbia Boulevard
Portland, Oregon

Paulsen and Roles Laboratories
1836 N.E. 7th Avenue
Portland, Oregon

Walter N. Boysen Co.
2100 N.W. 22d
Portland, Oregon

Quartz sand--contd.

Willemese Stained & Commercial Glass Studio
105 S.W. Alder
Portland, Oregon

Columbia Steel Casting Co.
10425 N. Bloss Street
Portland, Oregon

Herbert Malarkey Paper Co.
3131 N. Columbia Boulevard
Portland, Oregon

Rodda Paint Co.
6932 S.W. Macadam Avenue
Portland, Oregon

Pacific Stoneware, Inc.
9217 N. Peninsular
Portland, Oregon

Central Brass and Aluminum Foundry
P. O. Box 5688
Portland, Oregon

Sather Manufacturing Co., Inc.
3330 McDougall Avenue
Everett, Washington

Coolidge Propeller, Inc.
1608 Fairview Avenue N.
Seattle, Washington

Martin Ceramic Supply
510 A Street, S.E.
Auburn, Washington

Northwestern Glass Co.
5801 E. Marginal Way
Seattle, Washington

Ohio Ferro Alloys Corp.
3002 Taylor Way
Tacoma, Washington

Arabol Manufacturing Co.
Division of Borden Chemical Co.
10915 N. Lombard
Portland, Oregon

Swanson Manufacturing Co.
5012 N.E. 42d
Portland, Oregon

Spaulding Pulp & Paper Co.
P. O. Box 70
Newberg, Oregon

Norris Paint & Varnish Co.
1710 Front Street, N.E.
Salem, Oregon

Esco Corp.
2141 N.W. 25th Avenue
Portland, Oregon

The Flintkote Co.
P. O. Box 2744
Portland, Oregon

Yakima Machinery Foundry Co.
712 S. First Street
Yakima, Washington

Pennsalt Chemicals Corp.
2901 Taylor Way
Tacoma, Washington

Liquid Coatings, Inc.
23305 Highway 99
Edmonds, Washington

Pacific Car & Foundry Co.
4th and Factory Streets
Renton, Washington

Cascade Casting Co.
P. O. Box 1605
Yakima, Washington

Quartz sand--contd.

Star Foundry & South Seattle
Foundry
3901 Ninth Avenue South
Seattle, Washington

Protective Paint Products, Inc.
7315 Eighth Avenue S.
Seattle, Washington

Shell Oil Co.
Anacortes Refinery
P. O. Box 700
Anacortes, Washington

Keokuk Electro-Metals
Wenatchee Plant
Division of Vanadium Corp.
Wenatchee, Washington

Long Foundry Co.
P. O. Box 296
Hoquiam, Washington

Seattle Foundry Company, Inc.
3444 - 13th S.W.
Seattle, Washington

The Chemithon Corp.
5430 W. Marginal Way
Seattle, Washington

Certain Teed Products Corp.
1718 Thorne Road
Tacoma, Washington

Washington Stove Works, Inc.
3402 Smith Avenue
Everett, Washington

S & M Foundry
P. O. Box 785
Wenatchee, Washington

Salmon Bay Foundry Co.
5320 - 24th Avenue N.W.
Seattle, Washington

Spokane Steel Foundry Co.
Terminal Box 3305
Spokane, Washington

Jones & Porter Paint
Manufacturing Co.
P. O. Box 1258
Spokane, Washington

Crown Zellerbach Corp.
Port Angeles, Washington

Acme Foundry, Inc.
2240 Taylor
Tacoma, Washington

Roslyn Foundry
P. O. Box 199
Roslyn, Washington

Scoot Paper Co.
West Coast Division
Everett, Washington

Parker Paint Manufacturing
Co.
3302 S. Junett Street
Tacoma, Washington

National Lead Co.
1128 W. Spokane
Seattle, Washington

Swanson Stone and Marble
1516 W. Second Avenue
Spokane, Washington

Philadelphia Quartz Company
of California
1212 Taylor Way
Tacoma, Washington

Roemer Electric Steel &
Iron Foundry
1327 California Way
Longview, Washington

Quartz sand--contd.

Rudd Paint & Varnish Co.
1608 - 15th Avenue W.
Seattle, Washington

Duwamish Manufacturing
Company, Inc.
8700 Dallas Avenue
Seattle, Washington

Glacier Trail Creamery
7 W. Second Street
Havre, Montana

General Mills, Inc.
511 Ford Building
Great Falls, Montana

Humble Oil & Refining Co.
P. O. Box 1163
Billings, Montana

Langs Cemetery Service
1322 Avenue F
Billings, Montana

Columbia Paint Co.
P. O. Box 1704
Helena, Montana

Jellison Brothers
510 Main Street
Boise, Idaho

Idaho Potato Starch Co.
P. O. Box 231
Blackfoot, Idaho

Preservative Paint Co.
5410 Airport Way
Seattle, Washington

Vancouver Iron & Steel
Foundry Company, Inc.
P. O. Box 265
Vancouver, Washington

Montana Flour Mills Co.
900 - 16th Street N.
Great Falls, Montana

Pacific Vegetable Oil Corp.
P. O. Box 98
Culbertson, Montana

Big West Oil Co.
Kevin, Montana

Western Montana Marble
& Granite
305 S. Fourth East
Missoula, Montana

Bozeman Granite Works
428 N. 7th Avenue
Bozeman, Montana

Birdseye, Division of General
Foods Corp.
City Acres
Nampa, Idaho

Monsanto Chemical Co.
Soda Springs, Idaho

DESCRIPTIONS OF QUARTZ DEPOSITS

Sixteen quartz deposits in Montana are described herein (Fig. 1). Twelve (1 through 6, 8, 9, 13, 14, and 16) are quartz-core pegmatites intruding granitic rocks of either the Boulder or Idaho batholith or apophysis therefrom. Number 7 is a sandstone (Quadrant Formation) of sedimentary origin; 11 is a series of quartz dikes cutting Precambrian gneiss and schist; 10 and 12 are quartz dikes intruding Precambrian Belt sediments; and 15 is of questionable origin--either igneous or metamorphic.

For purposes of prospecting, the most likely areas for outcrops of massive, high-purity quartz are the granitic rocks of the Boulder and Idaho batholiths. Sandstone of high purity is most likely to be found locally in the Quadrant Formation, which crops out prominently in western Montana. Foundry sand and sand for sandblasting and abrasives are best sought in old and recent river channels that have cut through large areas underlain by acid igneous rocks.

1. AMBROSE CREEK

The Ambrose Creek quartz deposit is on private land in the NW$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 13, T. 9 N., R. 19 W., Ravalli County, in the foothills of the Sapphire Mountains (Fig. 2). Access is by the highway east out of Florence (20 miles south of Missoula) to the sign "Ambrose Creek Road", 7 miles distant, then along the Ambrose Creek road. The quartz deposit is 2.5 miles beyond the first cattle guard over a road that turns south at an old corral. The corral turnoff is midway between the third and fourth steel cattle guards. Tree Farmers, Inc., were extending the main road farther east in August 1964.

The deposit is 15 miles from Florence. The product could be loaded on the Northern Pacific Railway branch that serves the Bitterroot Valley from Missoula to Darby. Nine miles of the distance would be paved road and 6 miles improved dirt road.

The quartz outcropping marked A on Figure 3 is on grass-covered range land owned by V. G. Brechbill of Stevensville. Outcrops B through J are on land owned by Percy Pentz, whose home is on Ambrose Creek about 1$\frac{1}{2}$ miles south of the deposit.

Quartz from outcrops B and C was quarried by M & S Ready Mix Company of Missoula for use in the "tree columns" and the floor-to-ceiling panels on the east lobby wall of the First National Bank Building at Missoula. The white quartz chips were precast into columns and ceiling panels, then etched with acid to expose the quartz on the surface to the texture

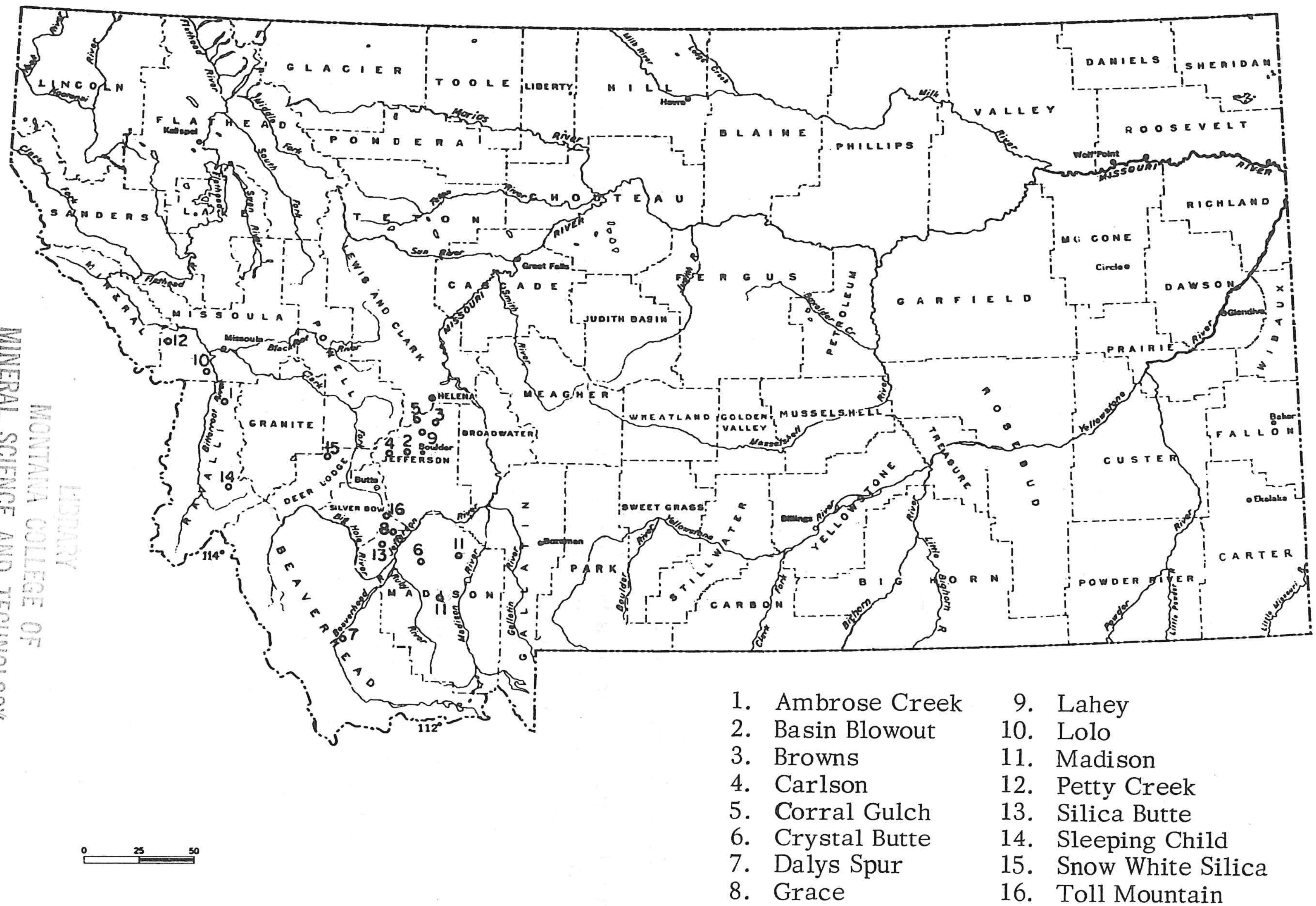

Figure 1. --Quartz deposits in Montana discussed in this report.

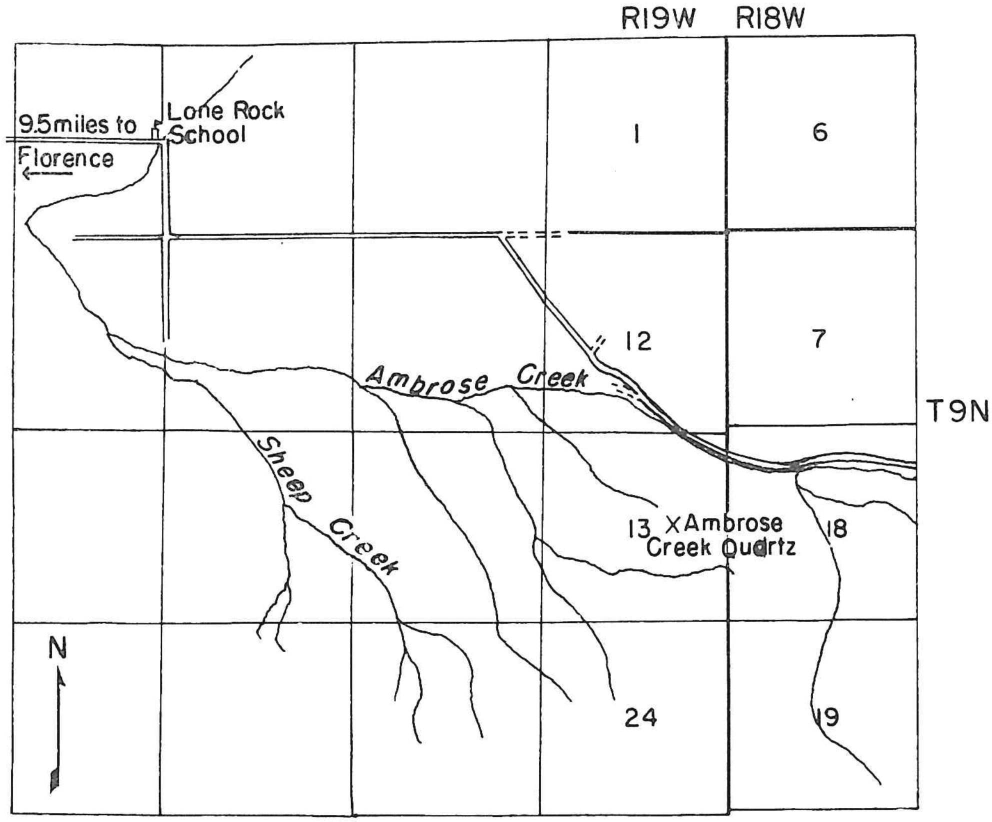

Figure 2.--Map showing location of Ambrose Creek quartz deposit.

desired. The material has been used for the same purpose in buildings constructed at the University of Montana at Missoula. About 600 tons has been quarried for this purpose.

Previous (late 1950's) to the above work, the property was reported to have been drilled by Keokuk Electro-Metals Company of Wenatchee, Washington. Neither maps nor assays of this work are available.

The Ambrose Creek quartz bodies are in part quartz-core pegmatites intruding granitic rock of the Idaho batholith, and in part iron-stained quartz veins intruding a metamorphic zone in the northern part of the area (Fig. 3). In the exposed pegmatite outcrop, a quartz-muscovite zone is found encircling the quartz core. Such a zone is not present around the quartz veins that intrude the metamorphic rocks.

Substantiating a pegmatitic origin are the several large (longest dimension 8 feet) poorly formed quartz crystals exhibiting horizontally striated prism faces. These large crystals were bulldozed from outcrop A.

Outcrops of ten quartz deposits are mapped (A through J, Fig. 3). Three are quartz veins and seven are quartz-core pegmatites. Quartz has been quarried only from deposits B and C. Only deposits A and B contain significant tonnages. Possible reserves calculated for deposits A and B on

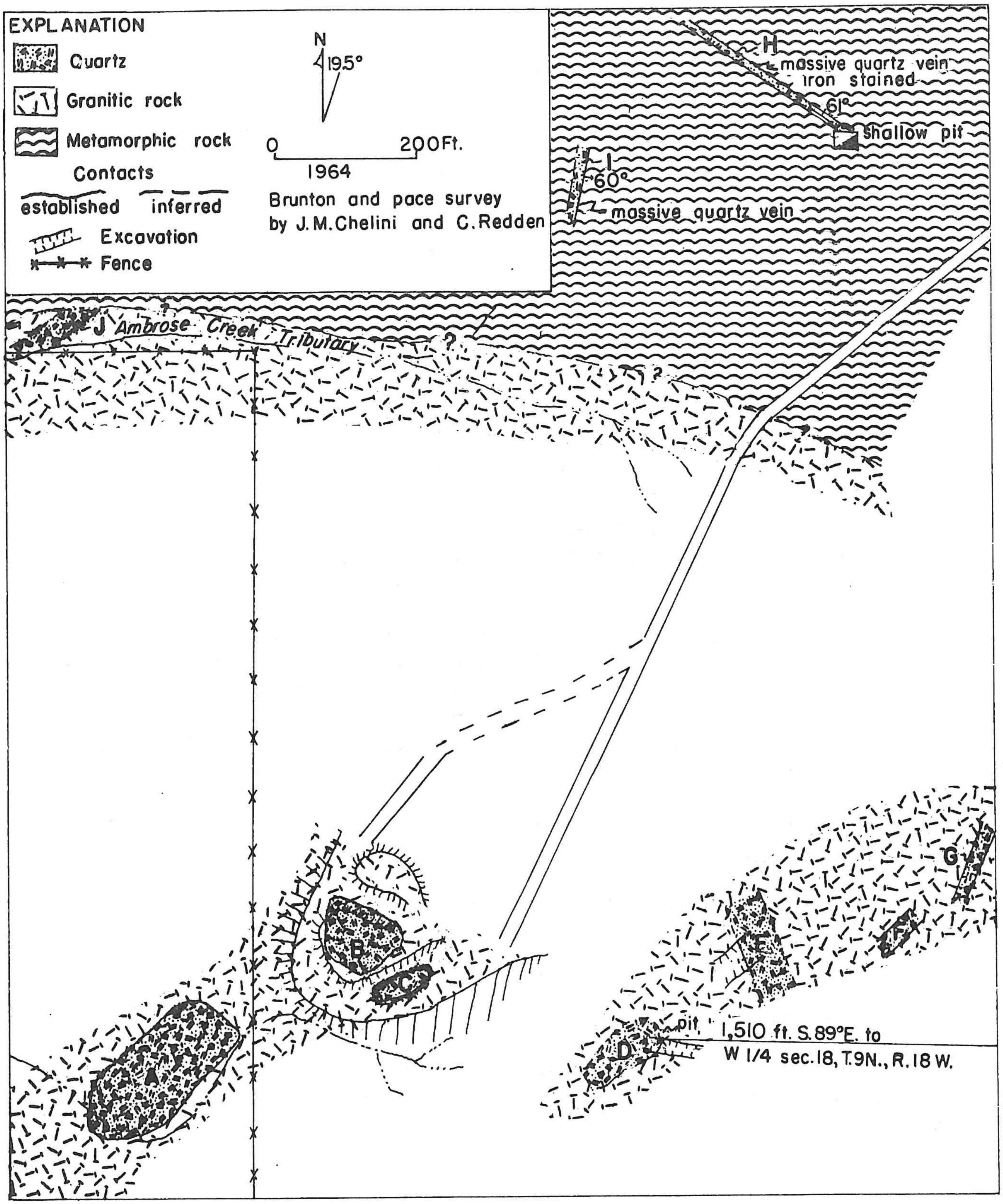

Figure 3. --Geologic sketch map of Ambrose Creek quartz deposit.

the assumption that the quartz continues to a depth equal to one-fourth of the outcrop length are 156,000 tons (weight factor, 170 pounds per cubic foot).

Analysis of the material, in percent:

	Outcrop A	Outcrop B
SiO_2	99.51	99.65
Al_2O_3	.213	.290
Fe_2O_3	.107	.063
Fe	.075	.044
CaO	.011	.009
MgO	.008	.009
Ign. loss	.175	.035
Total	100.099	100.10

2. BASIN BLOWOUT

The Basin Blowout deposit is in Jefferson County, about 2 miles east of Basin along U. S. Highway 91, in the SE$\frac{1}{4}$ sec. 16, T. 6 N., R. 5 W. (Carter and others, 1962, p. 23).

A lens or plug-shaped outcrop of massive white quartz rising approximately 300 feet above the railroad forms the deposit. The exposure of light-pink feldspar in the back of abandoned quarry workings indicates that the quartz is probably of pegmatitic origin. The quarry floor is 125 feet above the road. Past production, which was used as a metallurgical flux, was estimated to be greater than 200,000 tons.

Broken rock and ledge outcrops were sampled across 400 feet of the quarry opening.

The main line of the Great Northern Railway runs along the base of the deposit, and a loading spur track accommodates empty cars for loading.

The angular fragments produced by crushing the massive quartz were clear and fresh in appearance. Inclusions of iron minerals with staining halos and surface iron staining were noted on the fragments. Because crushing did not release the inclusions, beneficiation tests were not effective.

Component	Sample analysis, percent A*	B*
Glass button analysis		
Head sample, Fe_2O_3	0.04	---
Nonmagnetic product, Fe_2O_3	.04	---
Chemical analysis, head sample		
Fe_2O_3	.029	0.036
SiO_2	98.9	99.2
Al_2O_3	.29	.31
CaO	<.05	<.05
MgO	<.05	<.05

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*Duplicate chemical analyses.

3. BROWNS

The Browns quartz deposit is on private land in the center of sec. 31, T. 8 N., R. 3 W., Jefferson County (Fig. 4). The outcrop is accessible over a poorly defined field road that leaves U. S. Highway 91 about a quarter of a mile north of Browns ranch. Since the author's visit, a new road supposedly has been cut to the deposit.

A loading dock at Corbin on the Great Northern Railway is about $5\frac{1}{2}$ miles distant. The haul would be partly over U. S. Highway 91 (about 1 mile) and partly over unimproved dirt road. No steep grades are encountered.

The quartz crops out on land owned by Edgar G. Brown, P. O. Box 15, Jefferson City, Montana. According to Mr. Brown, there has been periodic interest shown in the deposit by International Stone and by W. F. Criswell. A representative of Pacific Silica at Basin has also looked at the exposure. The author recently has been told that quartz is being quarried from the deposit and shipped to Keokuk Electro-Metals at Wenatchee, Washington.

The outcrop is crescent shaped, and the deposit is composed of massive white quartz. It is 905 feet long, averages 20 feet wide, and protrudes 35 feet above the enclosing grantic rock of the Boulder batholith (Fig. 5). On its north end two 5-foot quartz feeder dikes strike northwest. Measured reserves, calculated on the basis of the above dimensions (weight factor, 170 pounds per cubic foot), are 54,000 tons. Probable reserves are double this figure.

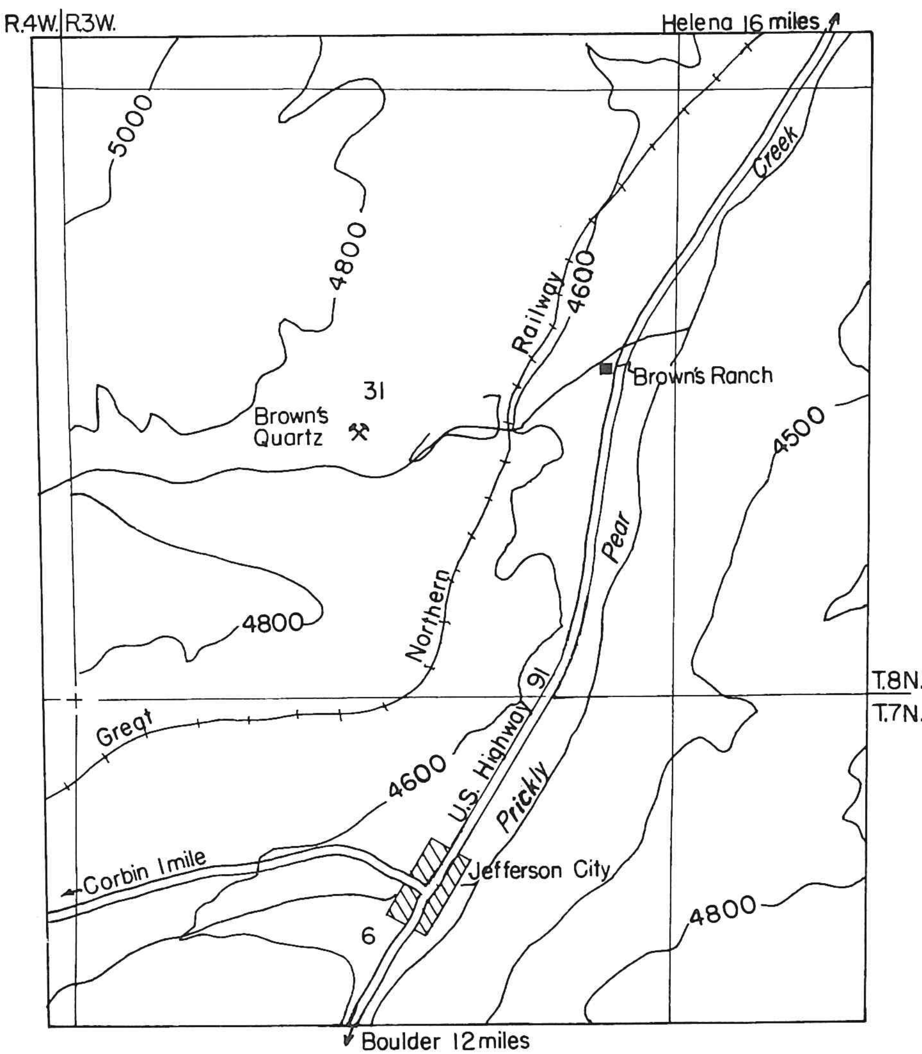

Figure 4. --Map showing location of Browns quartz deposit.

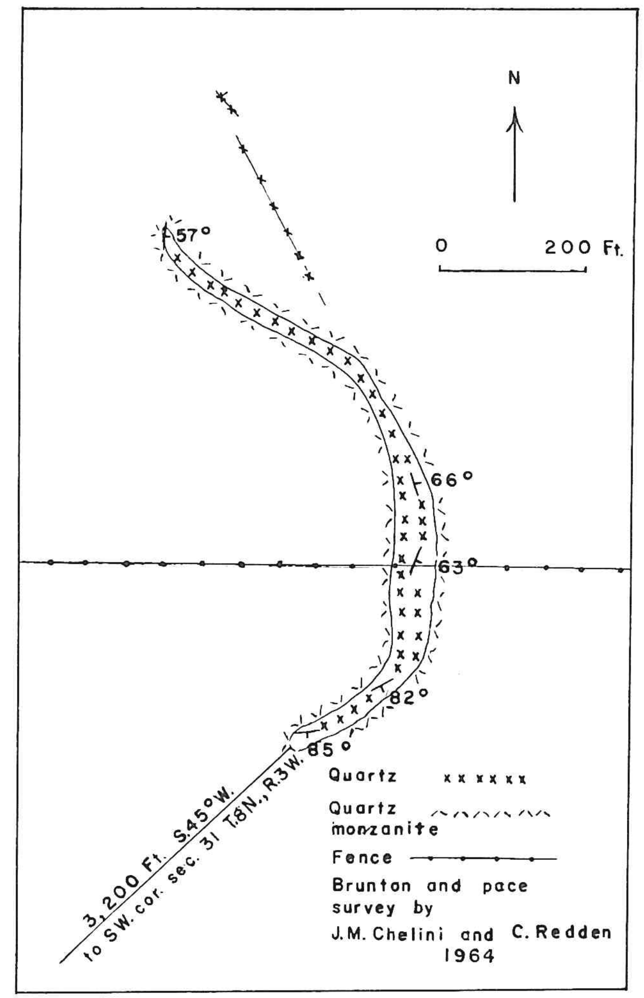

Figure 5. --Geologic sketch map of Browns quartz deposit.

Analysis of material that was collected randomly the full length of the outcrop, in percent:

SiO_2	99.70
Al_2O_3	.249
Fe_2O_3	.036
Fe	.025
CaO	.019
MgO	.015
Ign. loss	.470
Total	100.514

4. CARLSON

The Carlson quartz deposit is on National Forest land in the NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 18, T. 6 N., R. 6 W., Jefferson County. The deposit is accessible over improved to fair dirt road, which leaves U. S. Highway 91 at the Carlson ranch 2.5 miles west of Basin. The improved section of dirt road is traversed on the north side of South Boulder River for 3.5 miles to Trophy Gulch. The quartz crops out on a timber-covered slope on the west side of the road 1 mile up Trophy Gulch.

The quartz outcrop has been located by Frank Carlson, who in the summer months resides in a cabin three-fourths of a mile south of the deposit in Trophy Gulch.

Outcropping white quartz is found intruding granitic rocks of the Boulder batholith. The outcrop measures only 110 feet by 50 feet in area. Depth is assumed to equal one-fourth the length, and on this basis the measured reserves are 10,000 tons.

Analysis of the material, in percent:

SiO_2	99.74
Al_2O_3	.202
Fe_2O_3	.018
Fe	.013
CaO	.006
MgO	.003
Ign. loss	.330
Total	100.312

5. CORRAL GULCH

The Corral Gulch quartz deposit is on National Forest land in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 5, T. 8 N., R. 4 W., Jefferson County (Fig. 6). Access to the deposit is via Lump Gulch road, which leaves U. S. Highway 91 three-fourths of a mile north of Clancy. The Lump Gulch road is traversed to the sign "Corral Gulch road", a distance of 8.3 miles. The white quartz crops out high on the north side of the road one-tenth of a mile past the National Forest boundary.

The Great Northern Railway is located at Clancy 8.5 miles distant.

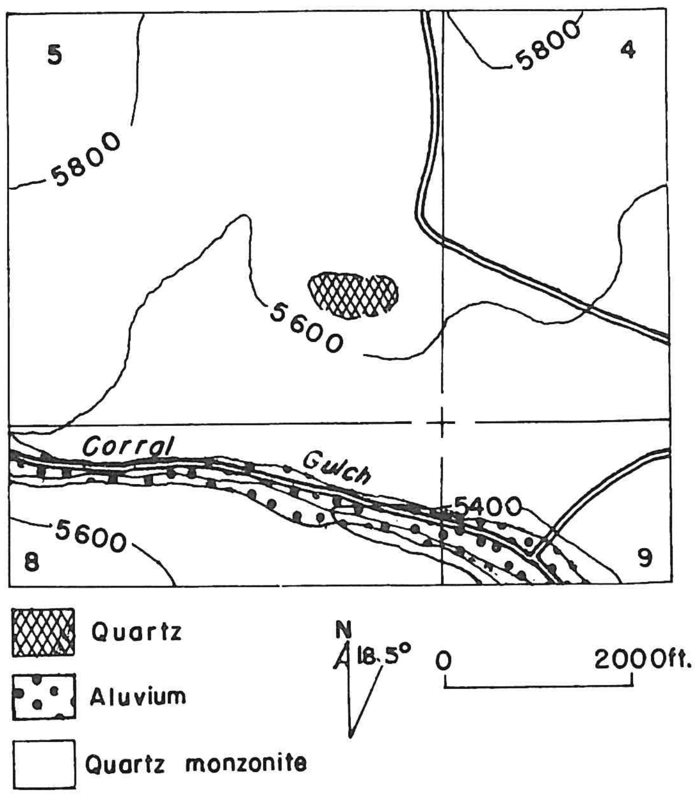

Figure 6.--Geologic map of Corral Gulch quartz deposit.

The property is supposedly under claim to A. Anderson of Clancy. J. F. Williams from Pullman, Washington, leased the property in 1957. Present status is unknown.

The Corral Gulch deposit is a near-vertical lichen-covered white quartz body intruding quartz monzonite of the Boulder batholith (Fig. 6). It crops out over a paced length of 375 feet and a paced width of 180 feet. The quartz protrudes above the quartz monzonite about 50 feet. A measured reserve of 275,000 tons is calculated. Feldspar stringers and inclusions within the body will reduce the mineable tonnage.

Analysis of the material, in percent:

SiO_2	99.65
Al_2O_3	.211
Fe_2O_3	.054
Fe	.038
CaO	.006
MgO	.005
Ign. loss	.410
Total	100.374

6. CRYSTAL BUTTE

The Crystal Butte silica deposit is in Madison County, 8.9 miles west of Twin Bridges and half a mile north of the road, in sec. 4, T. 3 S., R. 4 W. (Carter and others, 1962, p. 26).

A massive, lenticular quartz body of pegmatitic origin intruded into altered granitic rock to form the Crystal Butte deposit. The long axis of the lens trends northeast. The quartz is white but has a pinkish cast, and some surface iron staining was noted along joint and fracture planes.

The sample was taken at random from the outcrop that forms the top of a rounded hill.

A new, easily constructed road, 1 mile in length, would provide access to the deposit. Quarried rock would have to be trucked 10 miles to the Northern Pacific Railway siding at Twin Bridges.

The clear, angular fragments of quartz had some iron-stained surfaces and contained inclusions of iron minerals enveloped by staining halos. Electromagnetic beneficiation decreased the estimated iron content from 0.04 to 0.02 percent Fe_2O_3, and recovery was 96.7 percent. Low-intensity electrostatic beneficiation produced a concentrate testing 0.02 percent Fe_2O_3, and permitted recovery of 95.5 percent of the feed.

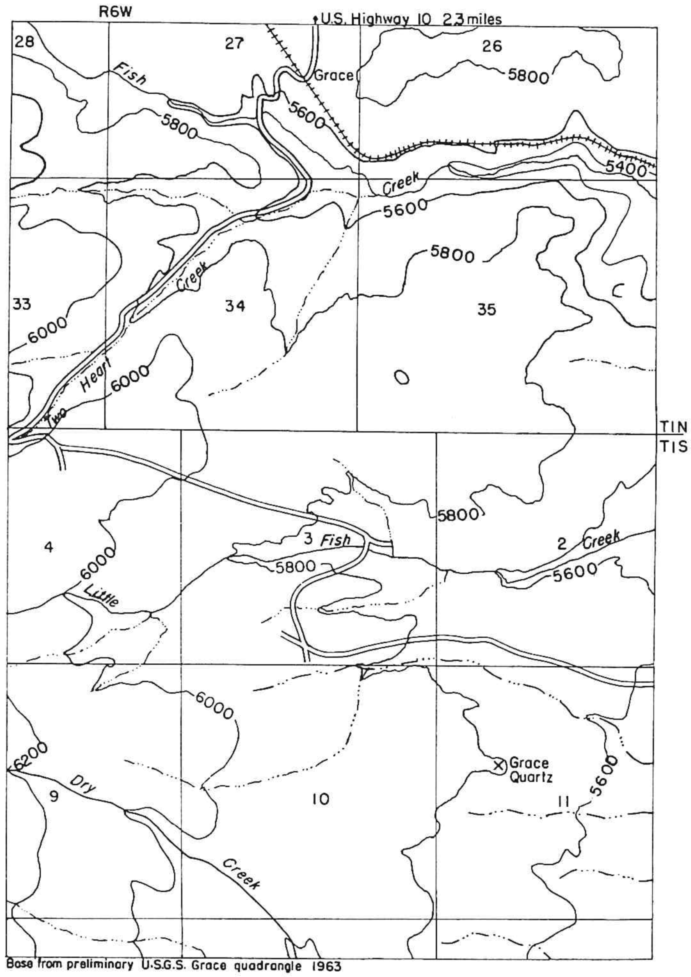

Figure 7.--Map showing location of Grace quartz occurrence.

The quartz crops out on land owned by Edward Kyler of Boulder. The deposit in 1964 had been under lease to Ed Lahey of Corbin. In 1965 the property was subleased to Arthur Benson and Frank Bissell, both of whom reside in Butte. Present status is unknown.

Lahey operated the property sporadically for about two years and shipped plus $\frac{3}{4}$-inch minus 4-inch material to Keokuk Electro-Metals Company at Wenatchee, Washington. He shipped about 3,500 tons before ceasing operations.

The area in which the deposit lies is mountainous but the topography is not rugged; most of the ridges are smoothly rounded. Vegetation consists of grasses except for local areas of timber, generally perched on the higher ridges.

The deposit is a pegmatite having a milky white quartz core, which, because of its greater resistance, protrudes (locally more than 20

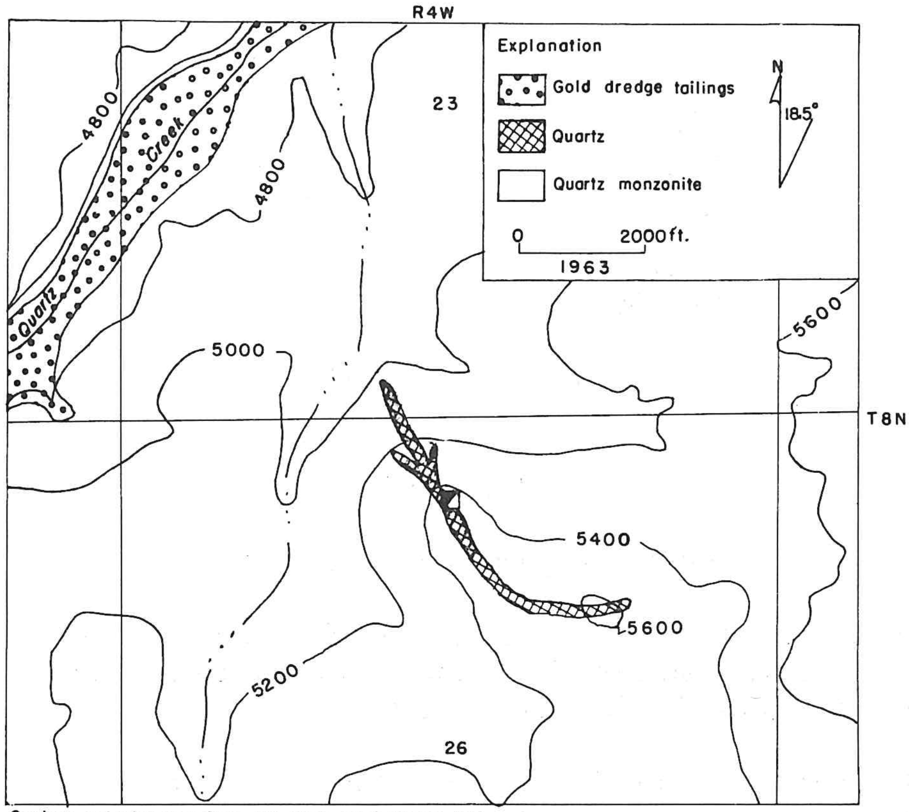

Figure 8.--Geologic map of Lahey quartz deposit.

feet) above the surrounding quartz-feldspar outer zone. The quartz-feldspar zone is in contact with fine-grained light-gray porphyritic quartz monzonite that has an aplitic groundmass. In outcrop the quartz body is crescent shaped. Strike ranges from west to northwest, and dip is almost vertical (Fig. 8).

In the central part of the northwest-striking section is a mineralized zone showing copper carbonates at the surface. This zone, which is small relative to the total volume of material present, would not meet grade requirements for use in silicon alloys. There are other small zones within the quartz body that will not meet grade because of feldspar inclusions.

The quartz in outcrop is 3,885 feet long (paced distance) and 188 feet wide. It is exposed over a vertical range of 440 feet plus. This could not be, at present-day prices, its mineable depth, because the ratio of waste to ore would become too great. Measured reserves, after allowance for waste zones and the limitation on depth to which the quartz could be quarried, are about 500,000 tons. Probable reserves may be 1,000,000 tons, and possible reserves might run as much as 12,000,000 tons.

Analysis of material collected from quarried stockpile at Corbin, in percent:

SiO_2	99.75
Al_2O_3	.184
Fe_2O_3	.018
Fe	.013
CaO	.013
MgO	.013
Ign. loss	.195
Total	100.186

10. LOLO

by W. M. Johns and R. D. Geach

Two bodies of high-grade silica, the Schroeder and the Maclay deposits, are on the west side of Bitterroot Valley approximately 1½ airline miles southwest of Lolo in Missoula County.

The Schroeder deposit in the SW¼ sec. 10, T. 11 N., R. 20 W., is on deeded land owned by John Schroeder, whose ranch headquarters is on the west side of U. S. Highway 93, 2.2 miles south of Lolo. An access road from the Schroeder ranch cuts diagonally across section 10 to the southwest section corner, then north for about a quarter of a mile to the deposit.

A lenslike body of milky white massive quartz, whose long axis trends eastward, crops out for a distance of about 125 feet, and ranges in width from a few feet to an estimated width of 40 feet. A few small outcrops west of the main body indicate a much narrower extension of the quartz deposit westward. The south contact strikes nearly east; the north contact is convex northward and is difficult to establish with certainty. The quartz is weakly fractured and shows very sparse iron oxide on broken surfaces. Quartz outcrops are on a moderate east-dipping grass-covered slope. About 250 feet southeast of the main quartz body is a smaller lenslike body of milky quartz 76 feet long and having a maximum width of 15 feet. This quartz deposit is elongated northwest and aligned with two much smaller northeast-elongated outcrops (Fig. 9). The silica deposits are in Belt (Precambrian) quartzite, containing octahedral magnetite and probably forming a part of the Ravalli Formation.

Computation of ore reserves is based on the assumption that the quartz lenses persist to a depth equal to one-fourth of their strike length (to a depth of 31 feet for the main body and 18 feet for the smaller deposit). Reserves amount to 8,000 tons and 900 tons respectively, a total reserve of 8,900 tons of high-grade silica.

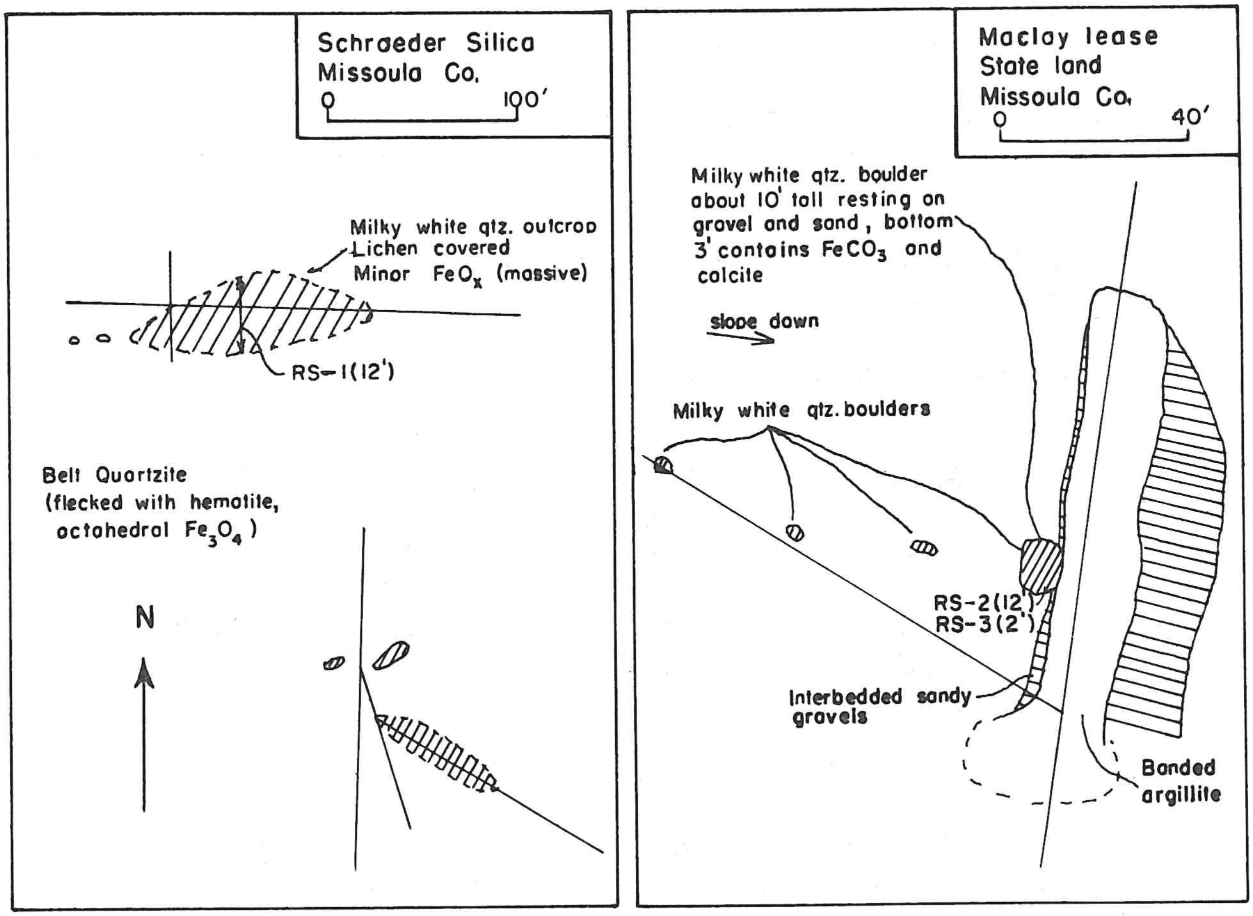

Figure 9.--Sketch map of Lolo quartz deposit.

Chip sample RS-1 was taken across the main quartz body near its widest part.

The Maclay deposit is in the SE$\frac{1}{4}$ sec. 16, T. 11 N., R. 20 W., on ground leased by Mr. Maclay for mining purposes from the State of Montana. The deposit is easily reached by a side road leading off from the McClain Creek road.

The deposit consists of four milky white quartz boulders in a small grassy park. It is not known with certainty whether these boulders are float derived from an unknown source or represent outcroppings of a larger quartz mass, the greater extent of which is concealed by overburden. The boulders, however, are more or less aligned in an east-west direction.

Development work consists of a bulldozer trench dug along the east side of the largest boulder. The bedrock exposed at the bottom of the cut is layered gray argillite. Along the cut the boulder seems to rest on gravel and intermixed gravel and sand. The height of the boulder is about 10 feet; the uppermost 7 feet is massive milky white quartz, but the lower 3 feet is composed of crystalline and massive tan ankerite, interlaced by white calcite stringers and quartz. This vertical section suggests that a zonal arrangement of minerals is present.

Chip sample RS-2 was taken across the upper portion of the boulder, which is about 12 feet wide. Chip sample RS-3 represents a 2-foot zone of carbonate.

The deposit at present is insufficiently developed to permit an estimate of reserves.

Analyses of samples, in percent:

	RS-1	RS-2	RS-3
SiO_2	99.54	98.009	26.70
Al_2O_3	.086	.123	1.68
Fe_2O_3	.059	.275	1.83
Fe	.184	.315	3.20
CaO	.072	1.181	21.90
MgO	.042	.318	12.21
Ign. loss	1.57	1.85	33.2
Total	101.553	102.071	100.72

Sample RS-3, assayed also for metals, contained 0.001 ounce gold, 0.20 ounce silver, 0.01 percent copper, but no lead or zinc.

11. MADISON

The Madison quartz deposits A, B, and C are in Madison County, in the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 29, T. 5 S., R. 2 W.; SE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 5, T. 6 S., R. 2 W. (Fig. 10); and NW$\frac{1}{4}$ sec. 28, T. 2 S., R. 1 W. (Fig. 11), respectively. Access to A and B is over dirt road that branches north from State Highway 287 at a point 2$\frac{1}{2}$ miles east of Virginia City. Madison quartz A is 6.6 miles and Madison quartz B is 5 miles from this junction. Outcrops of Madison quartz C are visible to the east from U. S. Highway 287, four miles south of Harrison.

Nearest railroad loading dock to quartz deposits A and B is on the Northern Pacific Railway at Alder. The same railroad would serve quartz deposit C at Norris or Harrison (Fig. 11).

The Madison quartz deposits are a related group of quartz dikes that commonly are found intruding Precambrain gneiss and schist. Madison quartz A consists of three milky-white quartz dikes, the largest of which measures 90 feet by 25 feet.

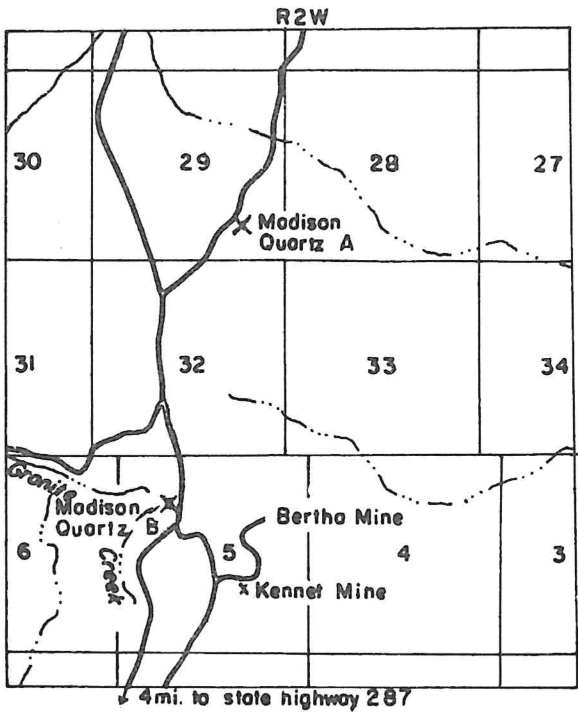

Figure 10. --Map showing location of Madison quartz deposits A and B.

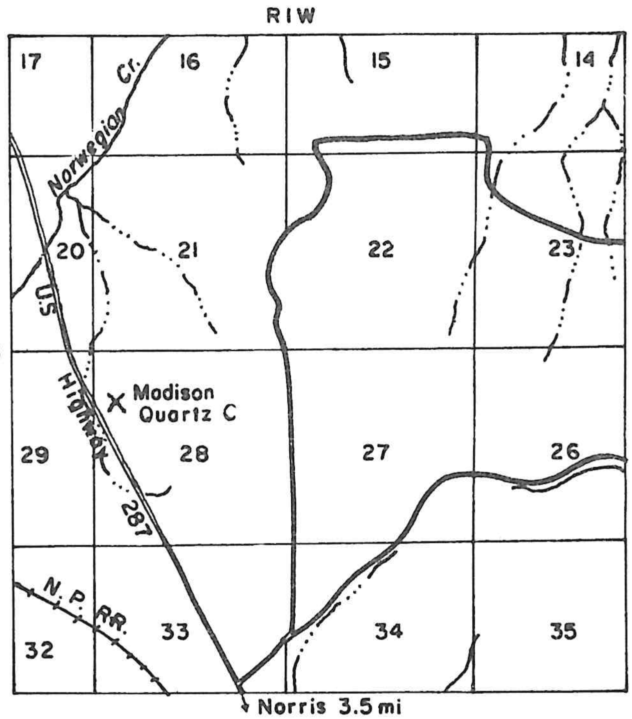

Figure 11. --Map showing location of Madison quartz deposit C.

Analysis of material collected from this outcrop, in percent:

SiO_2	99.43
Al_2O_3	.261
Fe_2O_3	.072
Fe	.050
CaO	.025
MgO	.025
Mn	.029
Ign. loss	.454
Total	100.346

Madison quartz B consists of one milky-white quartz dike that measures 180 feet by 20 feet. This material was not analyzed.

Madison quartz C consists of nineteen separate quartz dikes, the largest of which is 90 feet by 15 feet and the smallest 15 feet by 2 feet. These crop out in an area of about a quarter of a square mile.

Reserves were not calculated, as no one outcrop is of sufficient size to warrant development, nor are their positions relative to each other amenable to mining a combination of deposits.

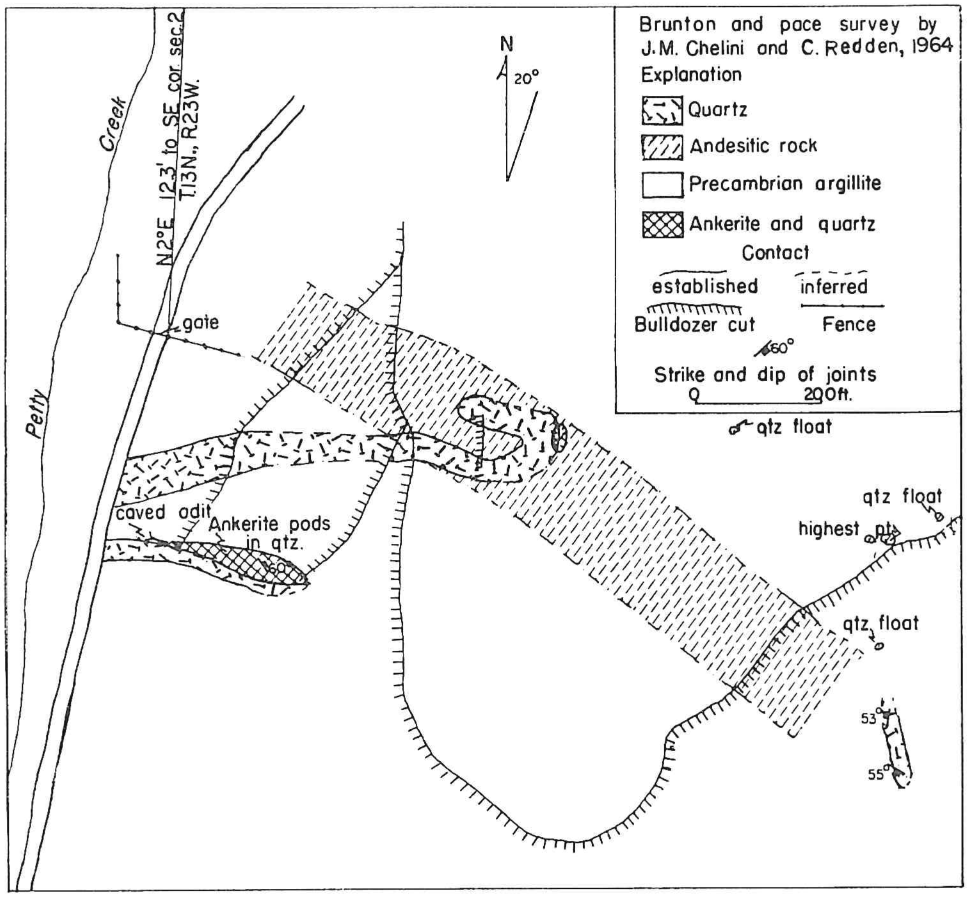

Figure 13.--Geologic sketch map of Petty Creek quartz deposit.

13. SILICA BUTTE

The Silica Butte quartz deposit is on National Forest land in the NW$\frac{1}{4}$ sec. 1, T. 2 S., R. 7 W., Madison County. The deposit is accessible over 14 miles of fair to poor dirt road, which leaves State Highway 287 three and one-half miles south of Silver Star at the Iron Rod Bridge. This road, which parallels the Jefferson River, is traversed for 2 miles to the Hells Canyon turnoff. From this point the quartz deposit is 12.1 miles northwest. A forest service boundary is crossed 7.8 miles from Hells Canyon turnoff.

A spur of the Northern Pacific Railway serves the valley area, from Whitehall to Alder. Nearest loading dock to the Silica Butte deposit would be Silver Star, 3$\frac{3}{4}$ miles north of the Iron Rod Bridge or a total distance of about 18 miles from the deposit.

The Silica Butte quartz deposit was located as the Rose Quartz lode on July 16, 1965, by J. McLaughlin, M. Nyhart, and N.C. Smith (addresses unknown).

The Silica Butte deposit is a quartz-core pegmatite intruding granodiorite of the Boulder batholith. The white high-purity quartz is surrounded by a graphic-textured quartz-feldspar zone (Fig. 14); this, in turn, is in contact with the granitic rock of the batholith. A discovery pit on the north end bares the contact of the quartz-feldspar zone with the granodiorite.

The quartz core, which protrudes about 20 feet above the surrounding quartz-feldspar zone, is 117 feet long and 37 feet wide (maximum dimensions). The quartz-feldspar zone protrudes about 70 feet above the enclosing granodiorite. The "butte" has a total relief of about 90 feet.

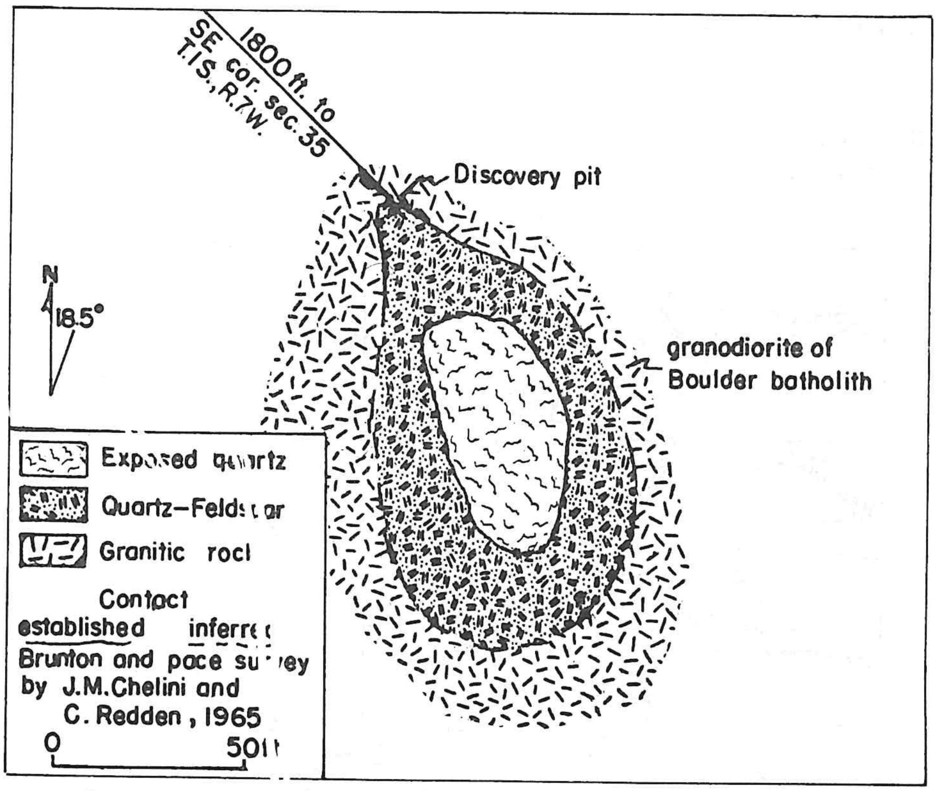

Figure 14.--Geologic sketch map of Silica Butte quartz deposit.

Measured reserves (tonnage factor, 170 pounds per cubic foot) are 7, 400 tons.

Analysis of material, in percent:

SiO_2	99.55
Fe_2O_3	.161
Al_2O_3	.104
CaO	.030
MgO	.101
TiO_2	.002
Ign. loss	.428
Total	100.376

14. SLEEPING CHILD

The Sleeping Child quartz deposits A and B are on National Forest land, in the SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 16, T. 3 N., R. 18 W., and the SE$\frac{1}{4}$ SE$\frac{1}{4}$ sec. 34, T. 3 N., R. 18 W. respectively (Fig. 15). Both are in the area covered by the Sleeping Child forest fire of 1961, in the south end of the Sapphire Mountains, Ravalli County.

The deposits can be reached from Sula, a small community on U. S. 93 about 18 miles south of Darby, by following the East Fork Bitterroot road for 13 miles northeast from Sula to the Tepee Creek road, thence on the Tepee Creek road 11 miles to deposit B and 18 miles to deposit A.

A branch line of the Northern Pacific Railway serves the Bitterroot Valley as far south as Darby.

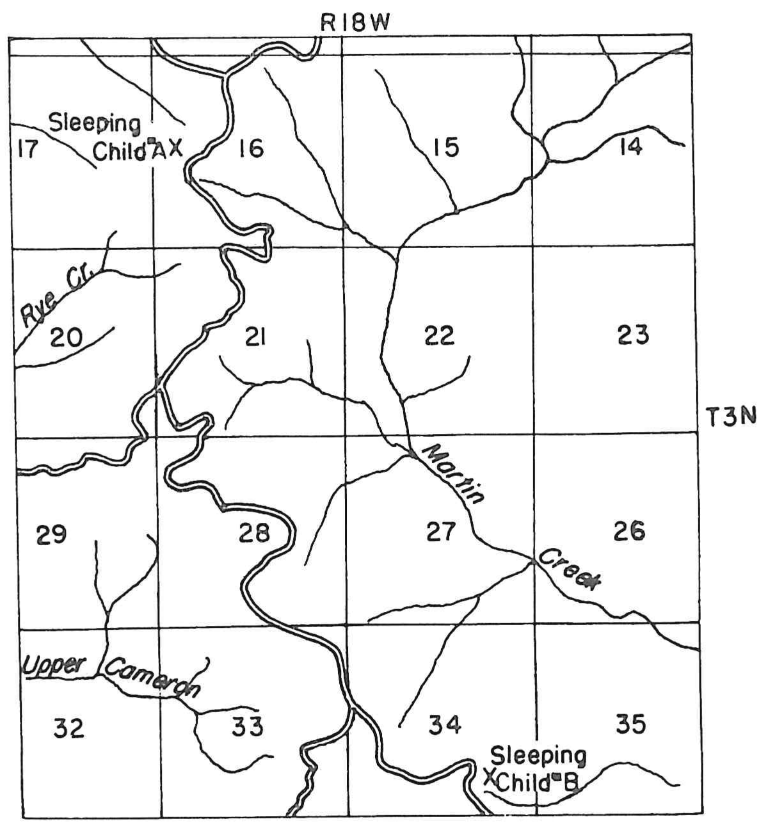

Figure 15.--Sketch map showing location of Sleeping Child quartz deposits A and B.

The two deposits are under lode claim to Walter E. Wilson, Hamilton, Montana.

Both deposits consist of a series of quartz-core pegmatite bodies of small extent that intrude granitic rocks of the Idaho batholith (Fig. 16A and B). The milky white quartz in the larger bodies are associated with a narrow quartz-feldspar border zone. Crystals of actinolite were found in a pit in the contact zone of the largest quartz deposit in Sleeping Child deposit A. About 200 feet northwest of this outcrop is a ridge of limestone believed to be a xenolith in the granitic rock.

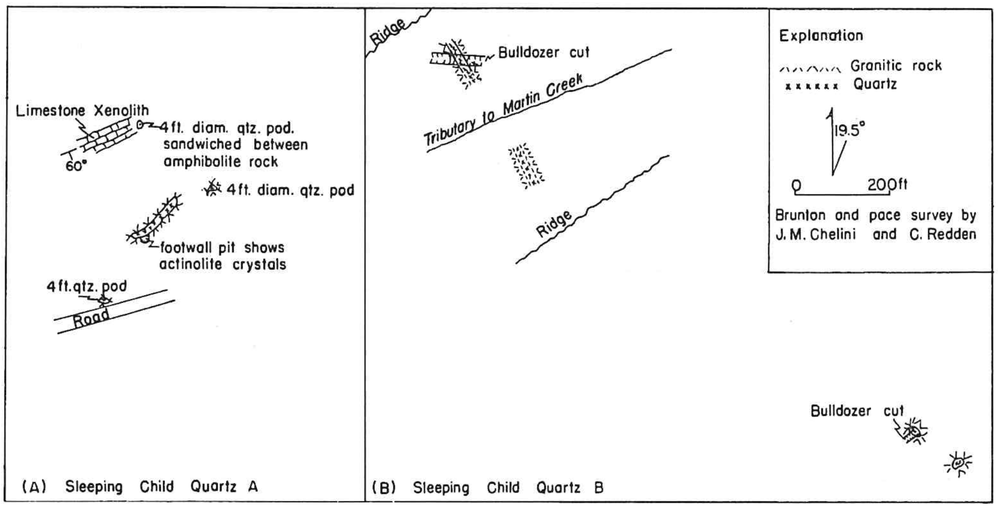

Figure 16.--Geologic sketch map of Sleeping Child quartz deposits A and B.

As outcrops are sporadic and small, reserves are not estimated.

Analysis of material collected from the major outcrop in Sleeping Child B, in percent:

SiO_2	99.76
Al_2O_3	.117
Fe_2O_3	.036
Fe	.025
CaO	.006
MgO	.004
Ign. loss	.095
Total	100.043

15. SNOW WHITE SILICA

by R. N. Roby, mining engineer
U. S. Bureau of Mines, Spokane, Washington

The Snow White silica deposit in Deer Lodge County was examined July 10 and 11, 1963. The property consists of two claims, the Snow White 2 and the Snow White 3, located on June 15, 1963, by John J. Meloy, Anaconda, Montana.

No recent exploratory work has been done on the claims. An existing adit follows an iron-stained fracture for a short distance. No doubt the adit was driven in search of gold or silver.

This silica deposit is in the NW$\frac{1}{4}$ sec. 28, T. 6 N., R. 11 W., Deer Lodge County. It is within the Deer Lodge National Forest, on the southeast slope of the Flint Creek Range. Altitude of the deposit ranges from 7,300 to 7,400 feet. Topography is well rounded and mature. The western border of Deer Lodge Valley, 8 miles east of the deposit, is at an altitude of 5,000 feet. Hill slopes are generally treeless and grass covered although the deposit is in a forested area. Bedrock exposures are rare.

The present jeep road from the country roads in the valley to the deposit is steep and rough; it would be unsatisfactory for truck haulage. The construction of a new access road from the valley to the deposit would be relatively easy. (Author's note: New access road completed in 1965.)

The nearest rail shipping point is near Galen, Montana, about 12 miles east of the deposit. Both the Northern Pacific Railway and the Chicago, Milwaukee, St. Paul, and Pacific Railroad serve Deer Lodge Valley.

The road distance from the deposit to Anaconda is about 13 miles. The Anaconda Company-owned Butte, Anaconda, and Pacific Railway serves Anaconda.

The Snow White silica deposit is about half a mile east of the east border of the Philipsburg quadrangle. By projecting the geologic formations eastward from the quadrangle, it would seem that the deposit is in either lower Cambrian or upper Precambrian (Belt Series) rocks.

There are no rock outcrops other than the quartz in the vicinity of the deposit. Bedrock formations are concealed by soil cover, but rock contacts can be traced by float. Gray granular limestone composes all the float contiguously southeast of the principal quartz outcrop. An old trench in this area was excavated entirely in limestone. The walls are now caved, and the attitude of the beds could not be determined.

A contact between limestone and gray quartzite is indicated in a road cut about 200 feet northwest of the deposit. The contact can be traced by means of float in a N. 60° E. direction for a distance of about 900 feet.

About 190 feet east of the outcrop C (Fig. 17), an old pit was excavated in iron-stained quartz, green tactite, and dark granitic rock. The granite seems to be a dike with irregular walls and seems to trend in a northerly direction. Tactite-quartz-granite breccia float was noted north of the pit.

Thin sections of the quartz show its origin to be quartzite.

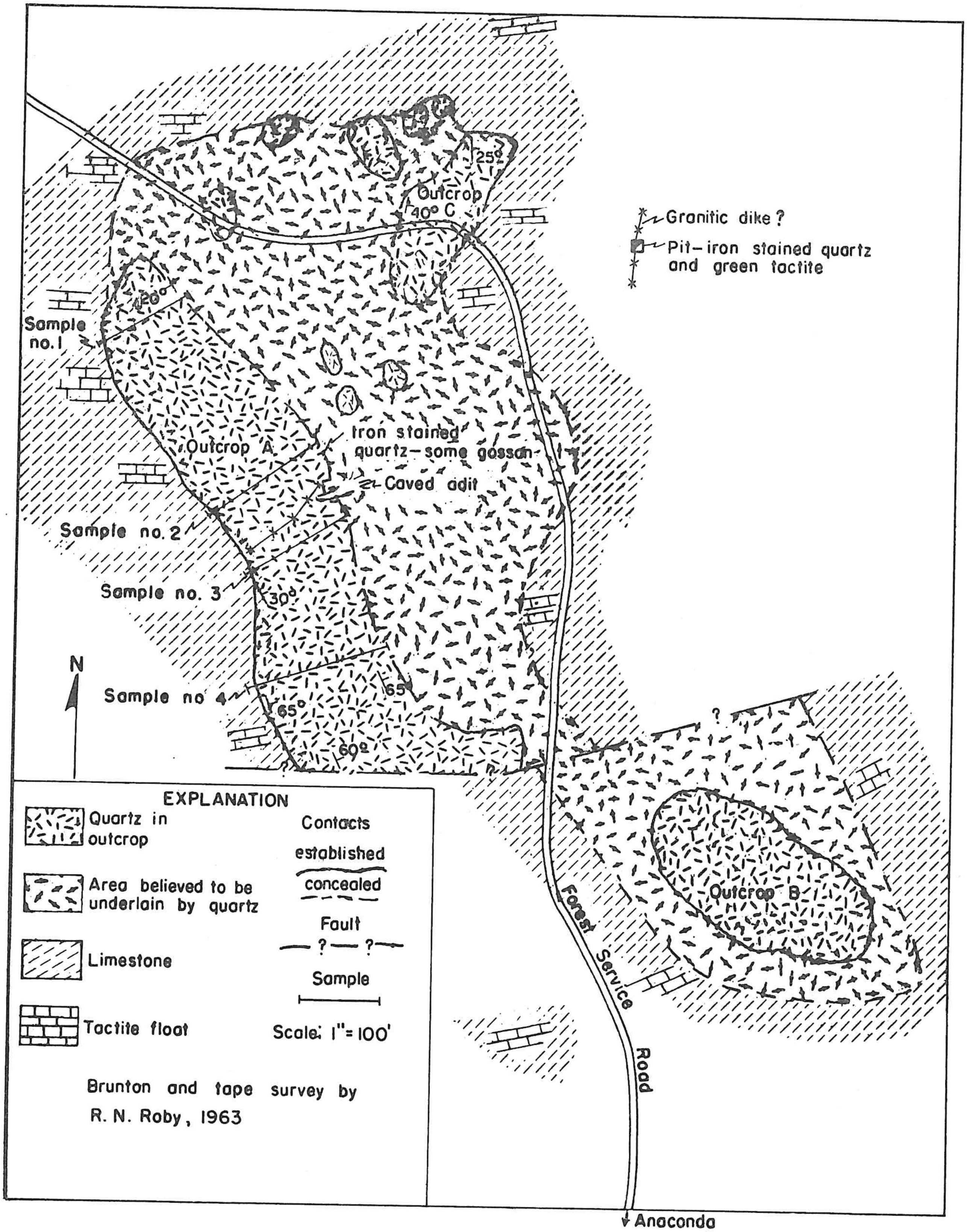

Figure 17. --Geologic map of Snow White silica deposit.

The deposit includes three principal quartz outcrops labeled A, B, and C on the map (Fig. 17). The principal outcrop A is about 440 feet long and averages 80 feet in width. It projects 20 to 40 feet above the surrounding surface. Outcrops B and C are smaller and extend only a few feet above the ground surface. Smaller outcrops or possibly blocks of breccia from the larger outcrops (several tons) are found north of outcrop A and northeast of outcrop C.

A striking feature of the deposit is the pronounced jointing that trends about N. 30° W., and dips consistently to the northeast. There is some evidence of faulting between outcrops A and B, predicated mostly on the offset appearance of the outcrops. Outcrop B is probably the downdropped block, because it does not stand out as prominently as A.

Most of the quartz is pure white except for a few iron-stained fractures. An old adit, now caved, was driven into outcrop A on the east side. This adit followed an iron-stained fracture containing iron-stained cellular green material. No sulfides were noted in the dump. In the vicinity of Sample 4, the quartz is somewhat iron stained. Much of it is "rose quartz".

The quartz deposit may be considerably larger than indicated by the three outcrops. The possible outcrop area shown on Figure 17 was traced by quartz float.

Four chip samples were taken across outcrop A averaging about 95 feet in length. It is believed that the samples represent the deposit as a whole. Outcrops B and C seem to be similar rock, but they would be much more difficult to sample in a preliminary examination, because they do not stand above the surrounding ground as does A, and would be contaminated by soil.

All samples were scrubbed with a fiber brush and water to remove lichen and extraneous material. The samples were split into two parts, and one part sent for analysis without being being crushed in a metal crusher to prevent contamination from crusher plates. Samples were submitted to Sharp-Schurtz Laboratory, Lancaster, Ohio, for analysis.

Chemical analyses of samples collected by U. S. Bureau of Mines, in percent:

Sample	1	2	3	4
SiO_2	99.76	99.80	99.82	99.86
Al_2O_3	.13	.04	.06	.03
Fe_2O_3	.007	.017	.01	.028
CaO	<.01	.01	.07	<.01
MgO	<.01	<.01	<.01	<.01
TiO_2	.002	.001	.002	.001
Ign. loss	.06	.05	.10	<.01
Total	99.979	99.928	100.72	99.949

Preliminary ore-reserve estimates are based on the area of the three exposures and on the possible outcrop area shown on the map. A tonnage factor of 12 cu. ft. per ton is used, based on the specific gravity of 2.65 for quartz:

Block	Outcrop area, sq. ft.	Tonnage per ft. of depth
A	38,800	3,200
B	13,900	1,100
C	6,100	500
Possible outcrop area	163,800	13,500

The assured tonnage is based on outcrop A that extends above the ground surface. This would be the very minimum of assured ore. Probable ore would be the three exposed areas projected to a depth one-half of their surface length. Possible ore would be that based on the possible outcrop area projected to one-half its length. These tonnages follow:

Assured ore	75,000 tons
Probable ore	900,000 tons
Possible ore	5,800,000 tons

Author's note: Since the property was visited by Roby, quartz pebble has been produced from outcrop A. The author visited the property after quarrying began and collected three random grab samples from outcrop A. Samples 1 and 2 were collected from quarried debris, and sample 3 from the weathered surface. Results of analyses are shown below:

Chemical analyses of samples collected and analyzed by Montana Bureau of Mines and Geology, in percent:

Sample	1	2	3
SiO_2	99.68	99.75	99.76
Al_2O_3	.164	.069	.152
Fe_2O_3	.072	.036	.018
Fe	.05	.025	.013
CaO	.025	.025	.013
MgO	.009	.011	.013
Ign. loss	.195	.165	.240
Total	100.195	100.081	100.209

16. TOLL MOUNTAIN

The Toll Mountain quartz deposit is on National Forest land, in the SW$\frac{1}{4}$ sec. 5, T. 1 N., R. 6 W., Jefferson County (Fig. 18). The deposit is reached by turning north from U. S. Highway 10 on the Toll Mountain dirt road, about 19 miles east of Butte, following the Toll Mountain road past the Toll Mountain campground to the Moose Creek road, a distance of 2 miles, then on the Moose Creek road about 0. 2 mile to a left turn across a creek, thence following a poorly defined jeep road to the draw where the quartz outcrop (about half a mile down the draw) is visible at the confluence of the draw with North Fork Little Pipestone Creek. A 4-wheel-drive vehicle is needed after turning left from the Moose Creek road.

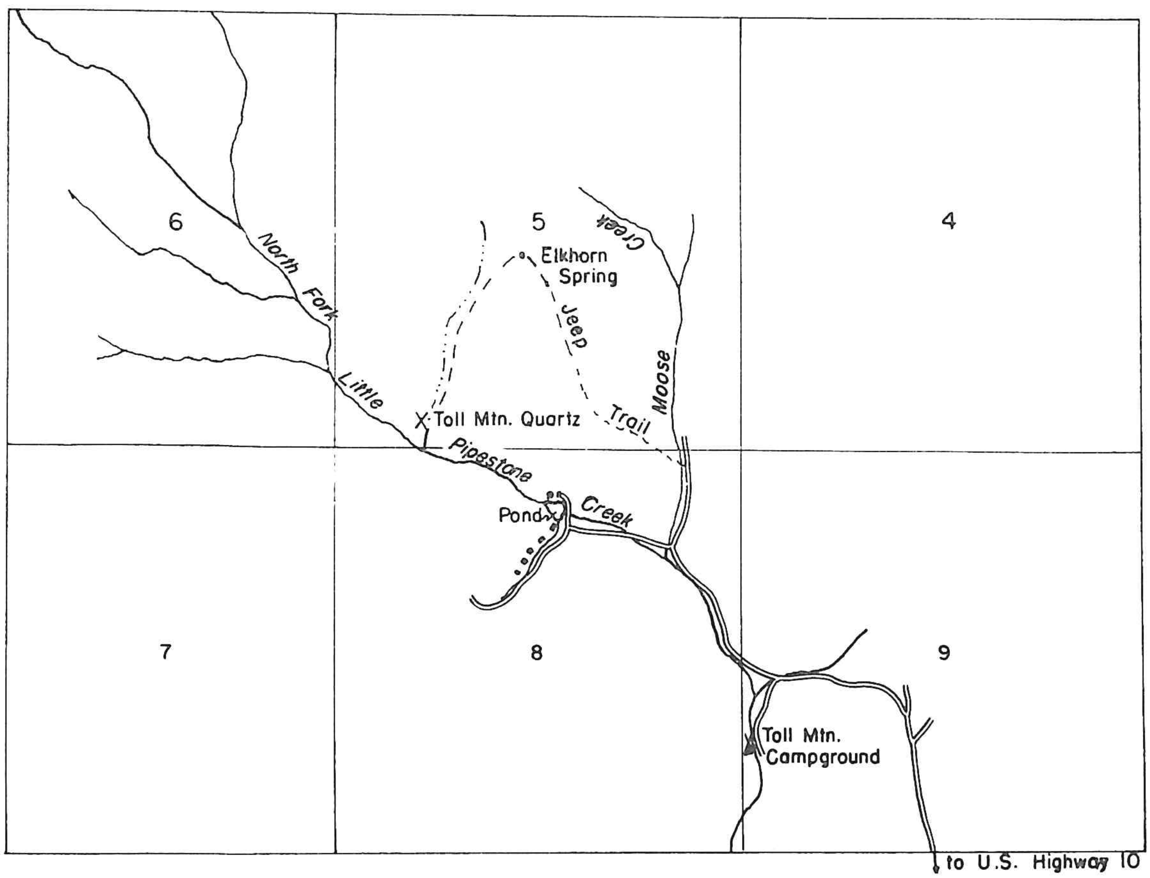

Figure 18. --Map showing location of Toll Mountain quartz deposit.

The quartz deposit is more easily reached by walking up the North Fork Little Pipestone Creek from a summer home (with pond) in the NE$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 8, T. 1 N., R. 6 W. From this point, the outcrop is about 2, 000 feet distant on the north side of the creek.

Nearest railhead is 10 miles distant over good to fair dirt road at Grace, on the Chicago, Milwaukee, St. Paul, and Pacific Railroad. Whitehall, which is also served by the Northern Pacific Railway, is about 20 miles east.

The Toll Mountain quartz deposit was located as the "Big Quartz Lode" on June 9, 1965, by Dan Price of Butte.

The milky white quartz protrudes 15 feet above the surrounding granitic rock of the Boulder batholith (Fig. 19). A knoll having a relief of 100 feet is formed by the more resistant quartz. The exposed quartz is 190 feet long and 60 feet wide (maximum dimensions).

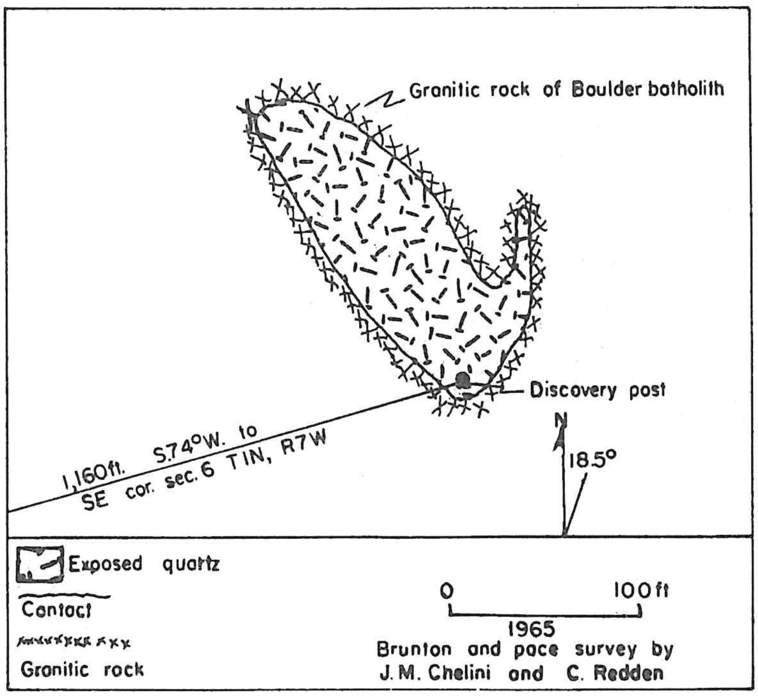

Figure 19. --Geologic sketch map of Toll Mountain quartz deposit.

Measured reserves are 14, 500 tons; probable reserves, based on 47 feet as estimated depth (one-fourth the outcrop length), are 45, 500 tons.

Analysis of material, in percent:

SiO_2	99.76
Fe_2O_3	.053
Al_2O_3	.170
CaO	.010
MgO	.030
TiO_2	.010
Ign. loss	.126
Total	100.159

OTHER DEPOSITS

After field work was completed the following quartz deposits were reported:

Rochester Basin, Madison County
Wallis Banning
Dillon, Montana
Phone 683-2047

Spar Lake, Lincoln County
Sec. 16 and 26, T. 19 N., R. 34 W.
E. Williams
Troy, Montana

Northwestern Montana
Chester Johnson, Secy.-Treas.
Spar Mining Company
P. O. Box 554
Polson, Montana

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