R. I. 4399

February 1949

UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. Krug, Secretary

BUREAU OF MINES
James Boyd, Director

REPORT OF INVESTIGATIONS

CORE-DRILL TESTING FOR BASE-METAL MINERALIZATION BELOW THE HOPE SILVER MINE, GRANITE COUNTY, MONT.

BY

John W. Cole

R. I. 4399,
February 1949.

REPORT OF INVESTIGATIONS

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

CORE DRILL TESTING FOR BASE METAL MINERALIZATION BELOW THE HOPE SILVER MINE, GRANITE COUNTY, MONT.[1]

By John W. Cole[2]

CONTENTS

INTRODUCTION AND SUMMARY

Ore deposits in the vicinity of Philipsburg, Mont., have been mined continuously since discovery of the Hope mine in 1865. Although originally famed chiefly for its silver production, since about 1917 the district has been the only important producer of battery-grade manganese ore in the United States. Also, it has produced substantial quantities of zinc ore and during World War I and World War II contributed notable amounts of manganese for metallurgical consumption. Nearly the entire production of base metal ores has been mined from the outcrop area of a dolomitic limestone bed that plunges beneath overlying beds of limestone and shale northward from the outcrop area. The Hope silver mine, with a production record of over $4,000,000, was in one of the overlying limestone beds about 3,000 feet north of the base-metal producing area and about 1,000 feet vertically above the projected downward position of the dolomitic bed that has produced the base-metal ores. Furthermore, the Hope ore bodies were controlled, in part at least, by east-west fractures similar to those that controlled the deposition of the base-metal ores.

In 1946 the Bureau of Mines drilled two diamond-drill holes to intersect the dolomitic limestone bed immediately below the Hope mine in an effort to prove the continuance of base-metal mineralization northward from the productive area and thereby greatly to enlarge the potential productive area of the

1/ The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Report of Investigations 4399."

2/ Mining engineer, Bureau of Mines, Mining Division, Albany Branch.

district. Although neither hole penetrated ore bodies of commercial size and grade, both holes disclosed the presence of a wide zone of iron-copper mineralization at the upper contact of the dolomitic limestone. In hole 2, this zone was mineralized continuously throughout a width of over 100 feet. Hole 1 encountered a 2-inch seam of 12-percent tungsten ore at a depth of 457 feet.

The project was performed under the general supervision of S. H. Lorain,3/ G. C. Reed4/ and J. A. Herdlick4/ were successively in direct charge of drilling operations. This report presents the factual data obtained during the progress of the preliminary investigations and the project work.

LOCATION AND ACCESSIBILITY

The Hope mine is in the Flint Creek mining district, Granite County, Mont., 1 mile northeast of Philipsburg (fig. 1). It is accessible from Philipsburg by mile of county road. Philipsburg is a mining and ranching village with a population of 1,300. It is on U. S. Highway 10 S., 31 miles by highway northwest of Anaconda, Mont., and is the terminus of a branch line of the Northern Pacific Railroad, which joins the main line at Drummond, Mont., 26 miles to the north.

PHYSICAL FEATURES AND CLIMATE

The Hope mine is in Hope Hill, a part of the western foothills of the Flint Creek Mountain range. Rounded grass-covered hills rise with moderate slopes from Flint Creek Valley (altitude 5,100 feet) to an altitude of 6,300 feet at the top of Hope Hill (fig. 2). The cover of second-growth pine and fir trees on the higher hills to the east extends down the deeper draws to Flint Creek Valley.

The climate is typical of areas of the same altitude in western Montana. Temperatures range from minus 35 in winter to plus 90 in summer. Precipitation is moderate; it falls chiefly as snow in late winter and early spring and continues as occasional rains until midsummer. Summers are warm and pleasant. The winters are long and moderately severe but do not seriously handicap mining.

HISTORY AND PRODUCTION

Ore was discovered on Hope Hill in 1865, when the Hope claim and several adjoining claims were located. The following year the claims were acquired by the St. Louis Mining Co., which erected a mill to treat the ore by the pan amalgamation process. This was the first mill built in Montana. After a reorganization in 1867, the company was known as the Hope Mining Co. This company operated the Hope mine as a subsidiary of the Granite Bimetallic Mining Co. until 1920, when formal company operations ceased. Sporadic leasing continued until 1938, when all mining was terminated. Ownership of the Hope mine passed from the Granite Bimetallic Mining Co. to the Philipsburg Mining Co. and recently to J. C. and Juanita Yob of Philipsburg, Mont., the present owners.

3/ Chief, Mining Division, Albany Branch, Bureau of Mines.
4/ Mining engineer, Mining Division, Albany Branch, Bureau of Mines.

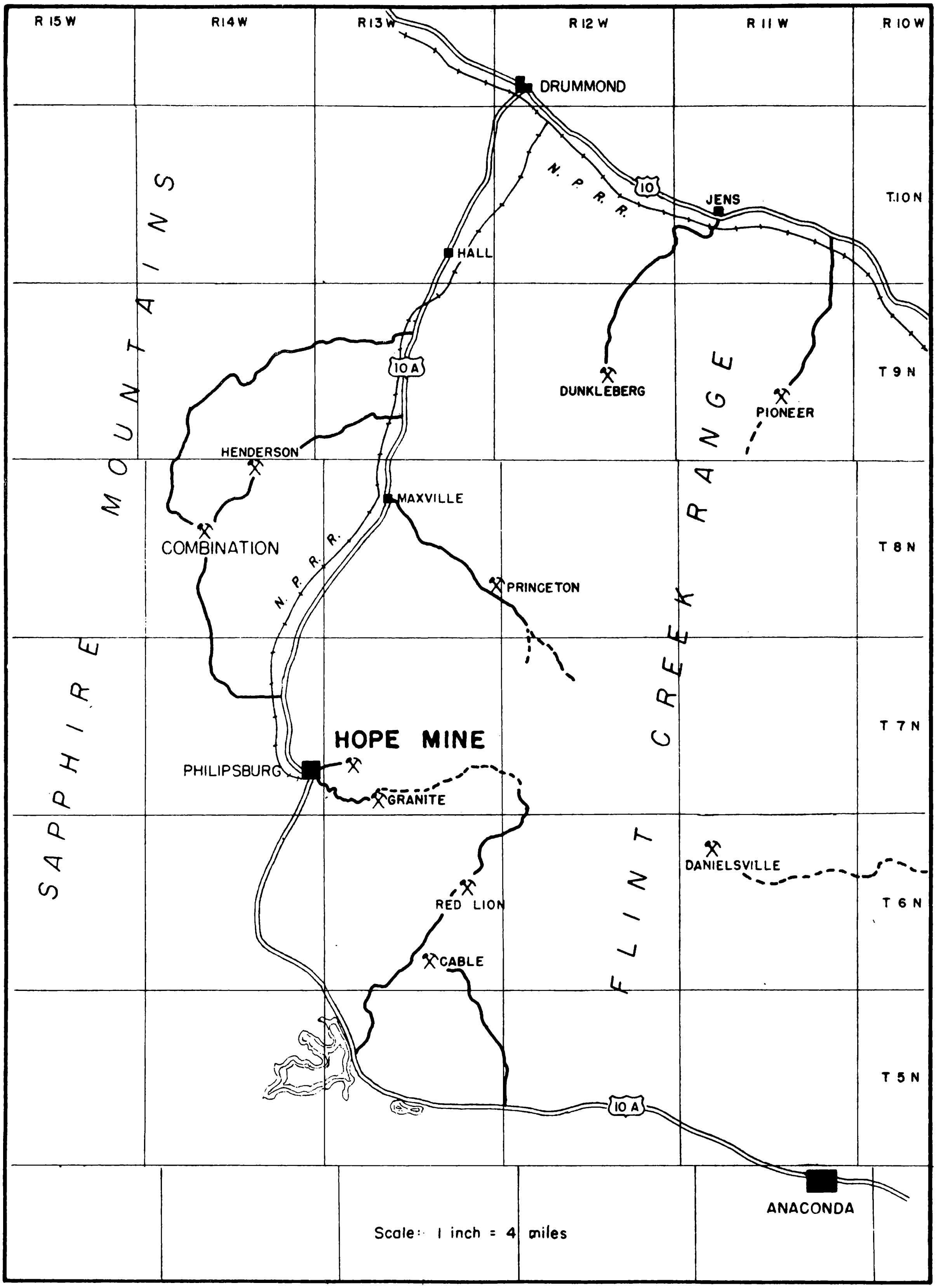

Figure 1. - Index map showing location of the Hope mine, Granite County, Mont.

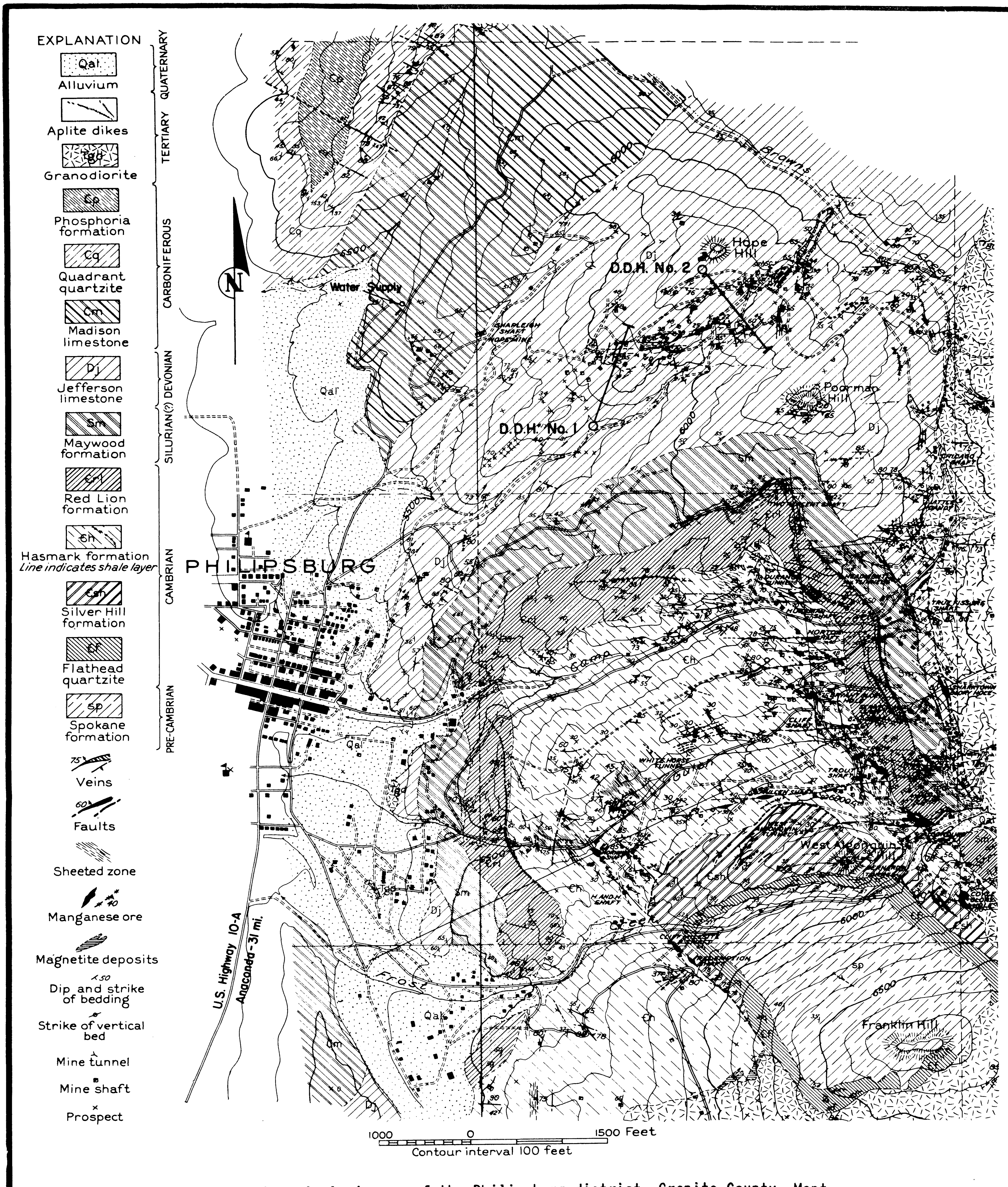

Figure 2. - Geologic map of the Philipsburg district, Granite County, Mont.

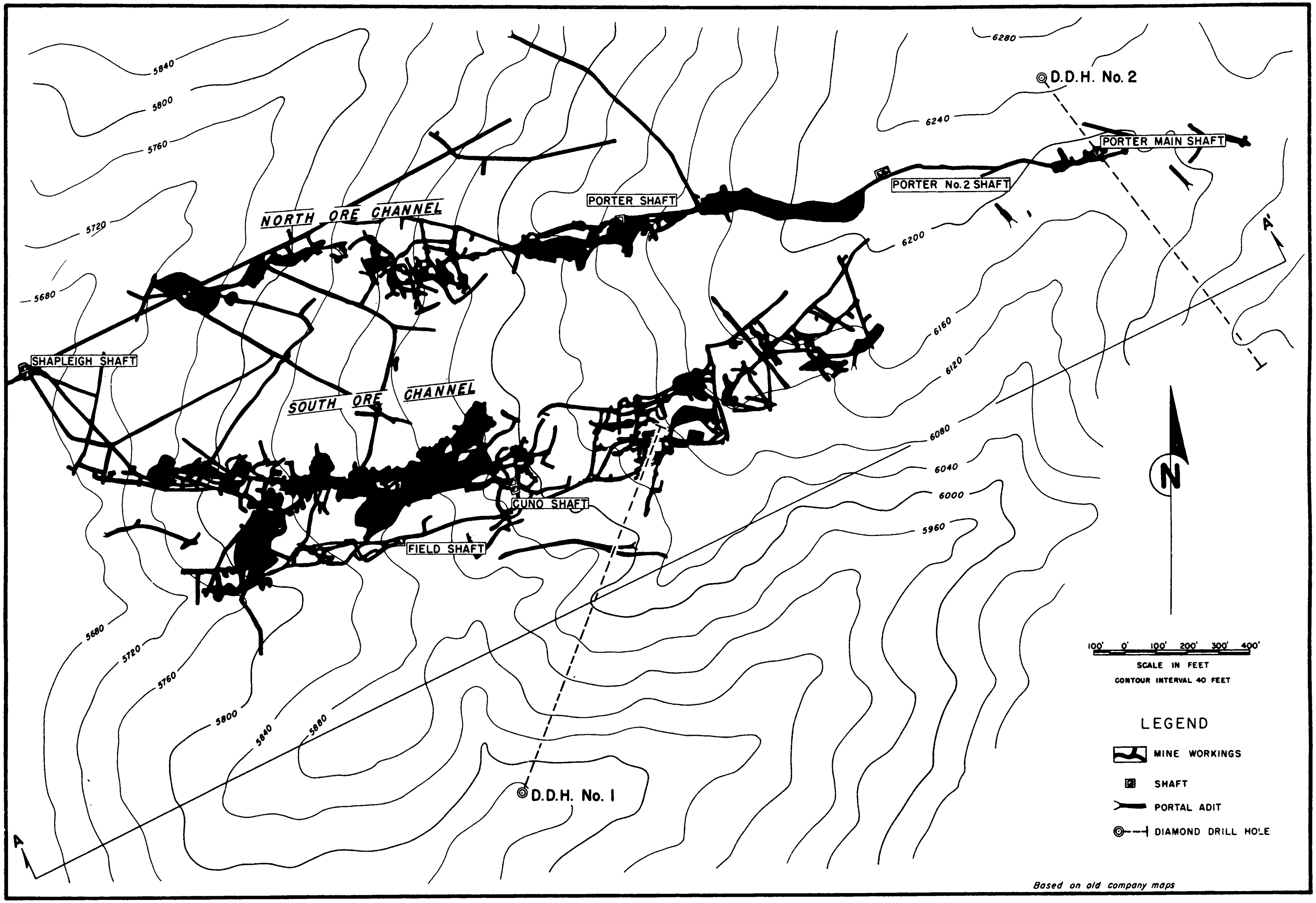

Figure 3. - Mine workings and drill holes, Hope mine, Granite County, Mont.

Production of silver from the Hope mine exceeded $4,000,000 prior to 1913. No record is available of base-metal production prior to 1908. Table 1 gives production data of the Hope and other mines in the Philipsburg area, 1901 to 1944.

TABLE 1. - Production data, Philipsburg area, 1901-1944 1/

	Hope mine 2/	Granite-bimetallic mine	All other mines	District total
Ore mined, tons 3/	12,706	599,299	444,484	1,056,489
Gold, oz.	182	35,477	12,975	48,634
Silver, oz.	335,179	13,359,837	8,049,355	21,744,371
Copper, tons	230	79.7	841.7	1,141.4
Lead, tons	25.3	280.5	6,801.1	7,106.9
Zinc, tons 4/	-	28.9	24,480.3	24,509.2
Manganese, tons 5/	-	-	567,600	567,600

1/ Based upon data compiled by the Economics and Statistics Division, Bureau of mines, Salt Lake City, Utah.
2/ Production for the Hope mine is for the period 1908 to 1920 only.
3/ Exclusive of manganese ores.
4/ About 93 percent of the district's total recorded zinc production was mined from two properties during the period 1928-1939.
5/ The approximate total of high-grade crude ore, metallurgical ore, and battery-grade concentrates ranging from 24 to 46 percent contained manganese. Large shipments of mill tailings containing 20 percent manganese are excluded.

PROPERTY AND OWNERSHIP

The investigation was confined to the following patented mining claims: Check, Wabus, Field, Cross, Fraction, Take All, Comanche Lot, Hope Lot, Potosi, Porter, Little Emma, Homestead No. 2, Broadhead, Prince Imperial, Cross, Constant, Shapleigh, and Nellen. The claims are owned by J. C. and Juanita Yob, Philipsburg, Mont.

MINE WORKINGS

The Hope mine workings consist of several miles of interconnected drifts, shafts, raises, inclines, and stopes, ranging in altitude from 5,100 feet to 6,300 feet. In lateral extent they cover an area 3,600 feet long in an east-west direction by 1,300 feet wide (fig. 3). Ore bodies have been mined from at least six shafts ranging in depth from 100 to 570 feet and two adits.

The mine workings have been entirely inaccessible since 1941, when the Shapleigh shaft house, head frame, and part of the shaft timbers were destroyed by fire.

The Shapleigh shaft is a vertical two-compartment shaft 570 feet deep. The Jubilee adit was driven from the west slope of Hope hill 540 feet to intersect the Shapleigh shaft at a depth of 100 feet below the collar. The

Jubilee level consists of about 6,000 feet of drifts and crosscuts. Levels from the Shapleigh shaft have been turned at 100, 300, and 470 feet below the Jubilee level. The water level is reported to be about 200 feet below the Jubilee level.

GEOLOGY

Geology of the Philipsburg area and the Hope mine has been recorded by Emmons and Calkins.6/ Pardee7/ and, later, Goddard8/ described the geology in relation to manganese ore deposits. The following description of the geology and ore deposits has been abstracted from those publications.

The ore deposits of the Philipsburg area are in a series of sedimentary rocks ranging in age from Cambrian to Devonian; also in Tertiary granodiorite of the Philipsburg batholith. Table 2 describes the sedimentary formations.

The sedimentary rocks have been folded into a broad, symmetrical anticline, which plunges 10° to 35° in a northerly direction. Granodiorite cuts across the axis of the anticline on the south and also forms the border of the east limb (fig. 2). Small sills and tongues of granodiorite extend into the sedimentary formations. The sedimentary rocks along the contact with granodiorite have been metamorphosed and contain garnet and other silicate minerals.

Three distinct but closely related types of ore deposits have been mined from the sedimentary formations: 1. Silver-zinc-lead ores in quartz veins that strike across the axis of the anticline and dip steeply to the south. Similar veins are found in the granodiorite east and southeast of the contact. 2. Manganese ores associated with the silver-zinc-lead veins as irregular replacement deposits in the wall rock or as replacement of favorable dolomitic beds. 3. Silver-copper ores in limestone replacements along east-west fractures at the Hope mine.

DESCRIPTION OF THE DEPOSITS

Although the Granite Bimetallic mine was on a vein-type deposit in the granodiorite and the Hope mine was in the Jefferson limestone, nearly all other mines that have made a notable production (including all current and recent operations) were in the Hasmark limestone or very close to it (fig. 2). As noted above, the ore shoots generally are in or are closely associated with east-west fractures. These east-west fractures, when in the Hasmark formation, have been most productive near the contact with the overlying Red Lion formation or the underlying Silver Hill formation. Nevertheless, they are much more strongly developed throughout the entire thickness of the Hasmark formation than in any other formation except the relatively thin Flathead quartzite. Replacement deposits have not been found in the quartzite. Inasmuch as most of the upper contact of the Hasmark has been removed by erosion from the area in which it crops out, it may be assumed that a large part of the original ore deposits

---

6/ Emmons, W. H., and Calkins, F. C., Geology and ore deposits of the Philipsburg quadrangle, Mont.: U. S. Geol. Surv. Prof. Paper 78, 1913, 271 pp.

7/ Pardee, J. T., Deposits of manganese ore in Montana, Utah, Oregon, and Washington: U. S. Geol. Surv. Bull. 725 (c), 1921, pp. 141-243.

8/ Goddard, E. N., Manganese deposits at Philipsburg, Granite County, Mont.: U. S. Geol. Surv. Bull. 922 (g), 1940, pp. 157-204.

of the district have been eroded. The Hasmark never has been explored down the plunge of the anticline below the overlying formations to the north.

TABLE 2. - Sedimentary rocks of a part of the Philipsburg quadrangle[1/]

Age	Formation	Thickness, feet	Characteristics: Philipsburg quadrangle in general	Characteristics: Philipsburg area
Devonian	Jefferson limestone	1,000	Pale-gray to dull-black, thick-bedded, somewhat magnesian limestone, locally slabby near base.	Near the granodiorite contact, a medium-grained, blue-gray to cream-white marble.
Silurian (?)	Maywood formation	250	Thin-bedded gray and light-green to purple or red magnesian limestones and calcareous shale, commonly stained yellow. Some calcareous sandstone near the base.	Chiefly green hornstone.
Cambrian	Red Lion formation	280	Chiefly limestone with wavy siliceous laminae. Black to olive-green shale at base.	Partly green to brown hornstone and garnet rock.
Cambrian	Hasmark formation	1,000	Chiefly magnesian limestone with dark shale of variable thickness near the middle. Limestone above the shale mostly cream-white; that below mostly blue-gray	Almost everywhere a medium-grained cream-white marble. The shale appears to be absent.
Cambrian	Silver Hill formation	100-600	Banded green and brown calcareous shale interbedded with gray limestone having thin siliceous laminae.	An irregular, commonly coarse-textured rock made up chiefly of brown garnet and other complex silicates, locally rich in magnetite.
Cambrian	Flathead Quartzite	0-200	Thick-bedded vitreous white to pale-gray quartzite.	Mostly brownish-gray quartzite.
Algonkian	Spokane formation	9,000	Shale and sandstone, prevailing red.	Mostly reddish-gray quartzite showing pale-gray spots.

1/ Adapted from U. S. Geol. Survey.

Practically all base-metal ores (lead, zinc, and manganese) produced in the district have been obtained from the deposits in the Hasmark formation. The lead-zinc ores were in quartz veins whose average width was about 3-1/2 to 4 feet. The strike length of individual shoots commonly was 300 to 600 feet or more.

Although some manganese ore has been mined from disseminated ore along individual beds, by far the greatest part has been mined from large, irregular replacement deposits in the Hasmark dolomite adjacent to the east-west fractures. Most of the manganese mined has been in the form of oxides, but it is apparent that the oxides were formed by the oxidation of rhodochrosite.

The ore bodies at the Hope mine are different from any others in the district. Their manner of occurrence is well-illustrated in figures 3 and 4.

WORK BY THE BUREAU OF MINES

The Bureau of Mines drilled two diamond-core drill holes from surface stations. Some necessary road repairs were made. The positions of the drill hole sites were located in relation to the Hope mine workings by a transit survey. The drill holes were directed to the objective of crosscutting the downward projection of the Hope fissure system and, particularly, to penetrate the upper part of the Hasmark formation immediately below the Hope mine to determine whether or not base metal deposits similar to those that have been mined from the Hasmark outcrop area could be discovered. A large amount of low-grade sulfide mineralization was found near the top of the Hasmark, but no ore of minable grade was cut by the two holes drilled.

Hole 1 was started October 1, 1946, drilled to a depth of 1,745 feet, and completed February 8, 1947. Hole 2 was started February 24, 1947, drilled to a depth of 1,800 feet, and completed June 7, 1947. Caving formation was encountered at 404 feet in hole 2. A deflection wedge was placed at 279.7 feet, at which point the hole was deflected downward 2°.

Four hundred eighty-eight core samples and 94 sludge samples were collected. Twenty-three core samples and 36 sludge samples were analyzed.

The positions of the holes are shown on figures 2 and 3. A composite projected section showing the two drill holes in relation to the Hope mine workings and the rock formations is shown in figure 4. Sections of each hole are shown in figures 5 and 6.

Pertinent drilling data on the two holes are given in table 3.

TABLE 3. - Drilling data

	Hole 1	Hole 2
Altitude at collar	5,755.0 ft.	6,264.0 ft.
Bearing	N. 20 - 30' E.	S. 37 E.
Inclination at collar	-50-1/4	-60
Depth	1,745 ft.	1,800 ft.
Core recovery	77 percent	54.1 percent

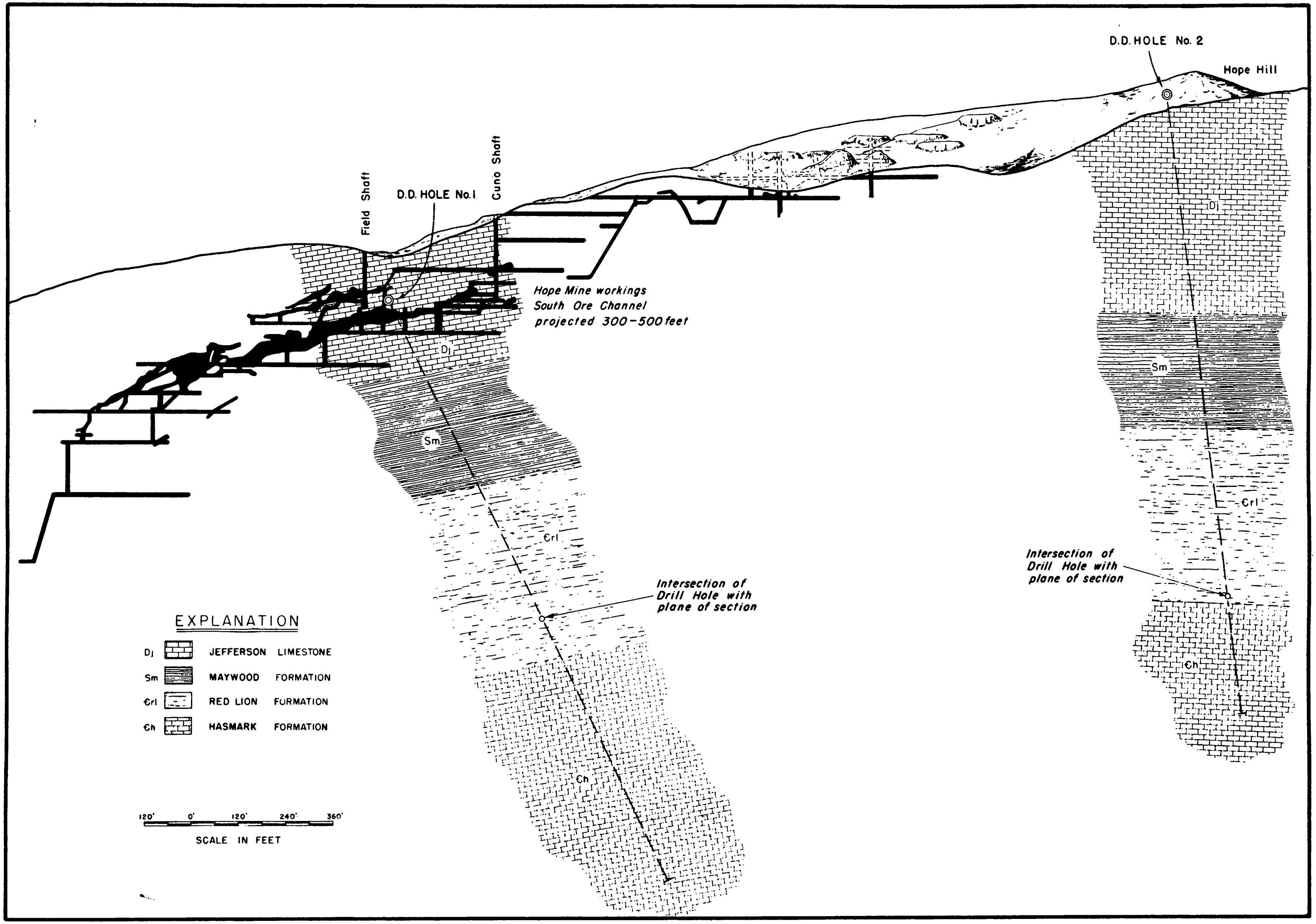

Figure 4. - Section A-A' through drill holes 1 and 2.

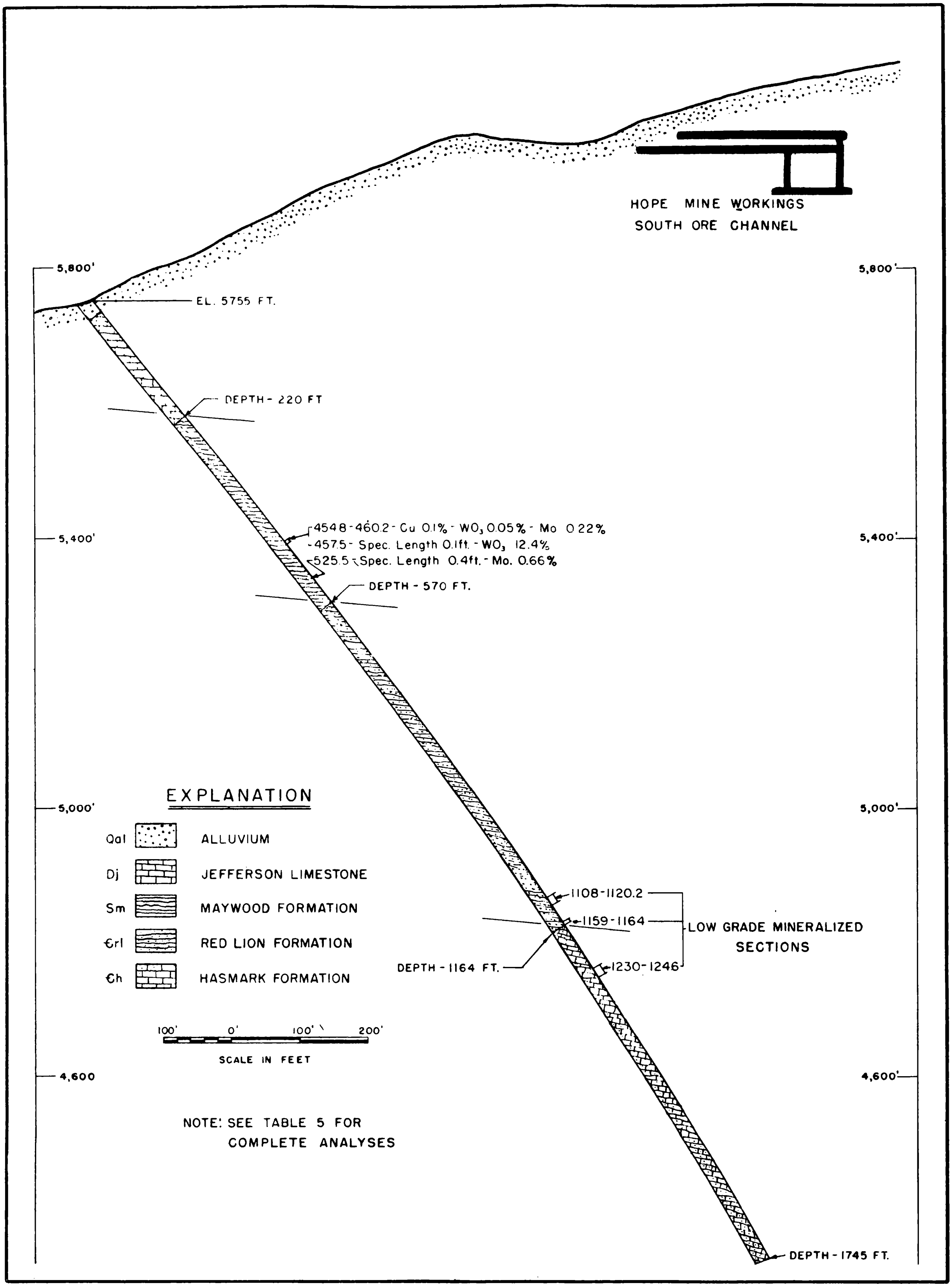

Figure 5. - Geologic section, hole 1.

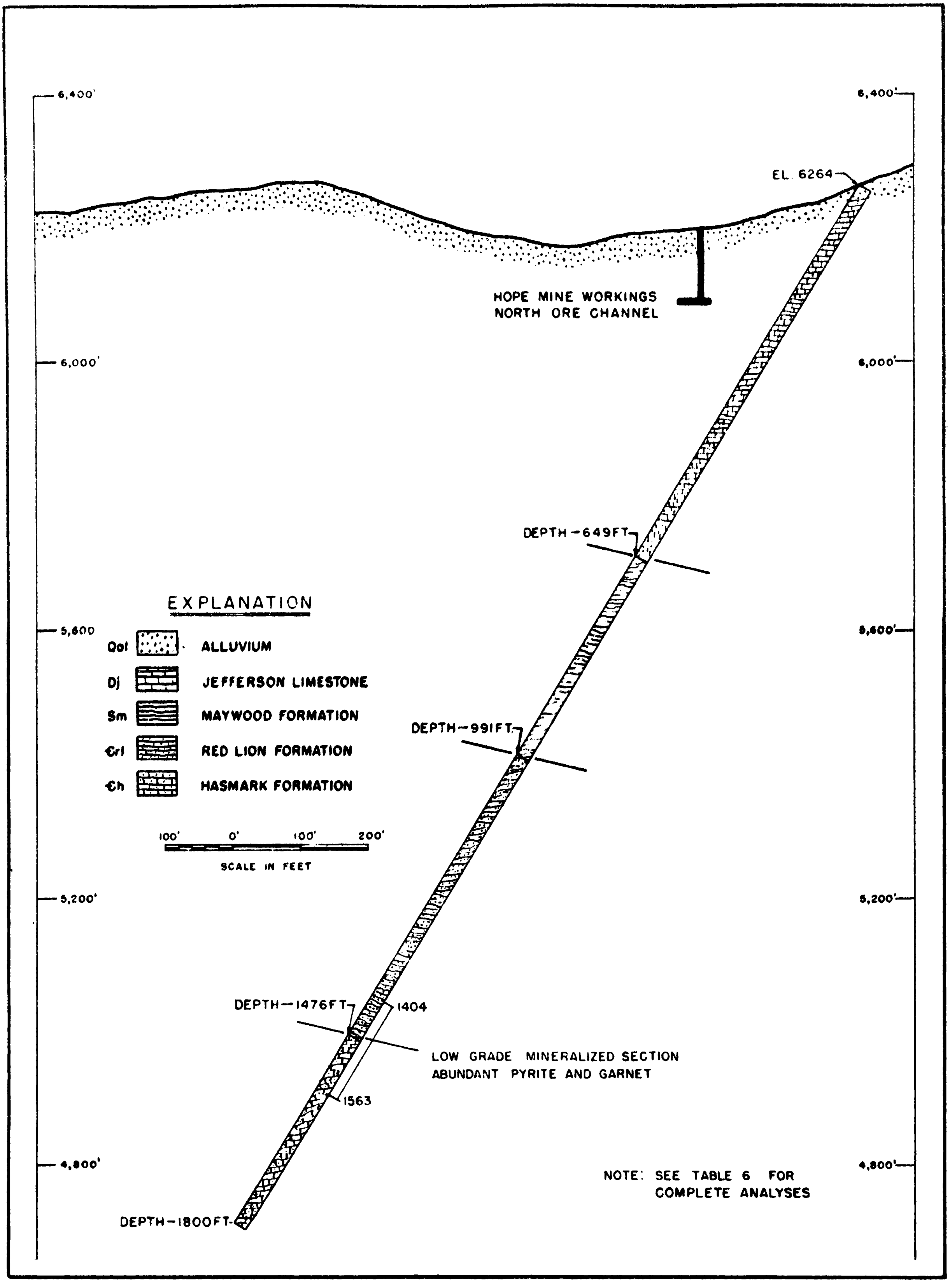

Figure 6. - Geologic section, hole 2.

Both holes were started with NX bits and were reduced, successively, to BX, AX, and EX. The holes were surveyed by acid etch tube at 200-foot intervals. Hole 1 steepened gradually to an inclination of 61° at 1,700 feet; hole 2 flattened to 57° at 350 feet. After the deflection of hole 2 at 279.7 feet, it maintained an inclination of 59° to 60° from there to the bottom. The bearing of the holes was checked by Carlson compass; the maximum deviation from original bearing was 2°.

Sparsely disseminated pyrite, iron and manganese oxides and occasional narrow veinlets of rhodochrosite occur in most of the formations encountered in the drill holes. Some sections that are more heavily mineralized with pyrite and garnet contain copper and zinc, probably as chalcopyrite and sphalerite. Traces of scheelite were observed in the core at numerous intervals. Molybdenite was observed in assayable quantity at two intervals in hole 1. The most highly mineralized section of hole 2 (1436.8-1446.7) assayed 0.24 percent copper and 1.8 percent zinc. A 2-inch length of core from interval 454.8-460.2 (hole 1) assayed 12.4 percent tungsten trioxide. This same interval contained a stringer of molybdenite, and the entire interval assayed 0.22 percent molybdenum. A 0.4-foot length of core from depth 525.5 feet in hole 1 assayed 0.66 percent molybdenum.

Sample data and analyses of drill samples are given in table 4 and 5.

TABLE 4. - Analyses of samples from hole 1

Sample intervals	Length, feet	Core recovery, percent	Percent					Oz. per ton	
			Cu	Pb	Zn	WO_3	Mo	Au	Ag
Core samples:									
454.8 - 460.2	5.4	92.0	0.1	*0.05	*0.05	0.05	0.22	Nil	Tr
- 457.5	.1			-		12.4	-	Tr	
- 525.5	.4	-	-		-	-	0.66	-	
688.7 - 694.0	5.3	75.0	0.15	*0.05	*0.05	-	-	Nil	
752.4 - 758.0	5.6	75.0	.07	* .05	* .05			Nil	Tr
1059.4 - 1069.5	10.1	96.0	.1	* .05	* .05			Nil	Tr
1108.0 - 1113.1	5.1	100.0	.35	* .05	* .05		-	Nil	Tr
1113.1 - 1120.2	7.1	24.0	.35	* .05	* .05	-	-	Nil	Tr
1323.0 - 1328.7	5.7	98.0	* .05	* .05	* .05			Nil	Tr
1328.7 - 1329.8	1.1	87.0	.2	* .05	* .05	-		Nil	Tr
Sludge samples:									
444.5 - 449.6	5.1		* .05	* .05	* .05			Nil	Tr
449.6 - 454.8	5.2		* .05	* .05	* .05	-	-	Nil	Tr
454.8 - 460.2	5.4	-	* .05	* .05	* .05	0.15	0.23	Nil	0.1
460.2 465.3	5.1		* .05	* .05	* .05			Nil	Tr
465.3 - 470.6	5.3		* .05	* .05	* .05	-		Nil	Tr
541.7 551.0	9.3		* .05	* .05	* .05	-		Nil	Tr
551.3 - 553.0	3.0		* .05	* .05	* .05	-	-	Nil	Tr
587.8 - 593.1	5.3		* .05	* .05	* .05	-	-	Nil	Tr
624.9 - 634.3	9.4		* .05	* .05	* .05	-		Nil	Tr
634.3 - 644.7	10.3		* .05	* .05	* .05			Nil	Tr

TABLE 4. - Analyses of samples from hole 1 (Cont'd.)

Sample intervals	Length, feet	Core recovery, percent	Percent					Oz. per ton	
			Cu	Pb	Zn	WO_3	Mo	Au	Ag
Sludge samples: (cont'd.)									
644.7 - 654.9	10.2		*0.05	*0.05	*0.05		-	Nil	Tr
654.9 - 664.7	9.8	-	* .05	* .05	* .05			Tr	2.8
688.7 699.2	10.5		* .05	* .05	* .05	-		Nil	Tr
699.2 709.7	10.5	-	* .05	* .05	* .05	-	-	Nil	0.6
709.7 - 713.5	3.8	-	* .05	* .05	* .05	-	-	Nil	Tr
713.5 - 723.7	10.2		* .05	* .05	* .05	-	-	Nil	Tr
1159.7 - 1164.2	4.5	-	.35	* .05	.7	-		Nil	0.2
1164.2 - 1165.7	1.5	-	.35	.05	.5	-		Nil	.2
1210.0 - 1220.0	10.0		.07	* .05	* .05			Nil	.2
1220.0 - 1230.5	10.5		.07	* .05	* .05		-	Nil	.2
1230.5 - 1240.8	10.3		.15	* .05	* .05	-	-	Nil	.2
1240.8 - 1246.7	5.9	-	.15	* .05	* .05	-	-	Nil	.2

* Less than.

TABLE 5. - Analyses of samples from hole 2

Sample intervals	Length, feet	Core recovery, percent	Percent					Oz. per ton	
			Cu	Pb	Zn	WO_3	Mo	Au	Ag
Core samples:									
1199.9 - 1210.3	10.4	64	0.05	*0.05	0.5			0.01	1.2
1291.4 - 1301.4	10.0	23	.07	* .05	.8			Tr	Tr,
1301.4 - 1306.7	5.3	47	* .05	* .05	.4		-	Tr	Tr
1306.7 - 1311.8	5.1	14	* .05	* .05	* .05	-		Tr	Tr
1404.0 - 1414.0	10.0	23	.08	* .05	* .05			Tr	Tr
1414.0 - 1421.3	7.3	52	.1	* .05	* .05	-		Tr	Tr
1421.3 1426.4	5.1	48	.24	* .05	* .05	-	-	Tr	Tr
1426.4 - 1431.7	5.3	52	.05	* .05	* .05		-	Tr	Tr
1431.7 - 1436.8	5.1	21	* .05	* .05	* .05			Tr	Tr
1436.8 1446.7	9.9	26	.24	* .05	1.8			Tr	0.1
1446.7 - 1456.9	10.2	99	.2	* .05	.2			Tr	Tr
1456.9 - 1466.7	9.8	30	.3	* .05	* .05			Tr	0.1
1466.7 - 1474.7	8.0	58	.3	* .05	* .05			Tr	.2
1498.6 - 1500.2	1.6	100	.14	* .05	* .05			Tr	Tr
1558.2 - 1563.8	5.6	92	.24	* .05	* .05	-		Tr	Tr

TABLE 5. - Analyses of samples from hole 2 (Cont'd.)

Sample intervals	Length, feet	Core recovery, percent	Percent					Oz. per ton	
			Cu	Pb	Zn	WO_3	Mo	Au	Ag
Sludge samples:									
214.2 - 217.7	3.5	-	* .05	* .05	* .05	-	-	Tr	0.1
222.2 - 227.5	5.0	-	* .05	* .05	* .08	-	-	Tr	Tr
291.3 - 296.3	5.0	-	* .05	* .05	* .05	-	-	0.01	0.2
600.6 - 606.3	5.7	-	* .05	* .05	* .05	-	-	Tr	.1
606.3 - 611.4	5.1	-	* .05	* .05	* .05	-	-	Tr	Tr
611.4 - 616.6	5.2	-	* .05	* .05	* .05	-	-	Tr	Tr
616.6 - 621.8	5.2	-	* .05	* .05	* .05	-	-	Tr	Tr
637.7 - 643.8	6.1	-	* .05	* .05	* .05	-	-	Tr	0.1
643.8 - 649.4	5.6	-	* .05	* .05	* .05	-	-	Tr	Tr
1178.2 - 1183.3	5.1	-	* .05	* .05	* .05	-	-	Tr	0.1
1183.3 - 1188.5	5.2	-	* .05	* .05	* .05	-	-	Tr	Tr
1188.5 - 1193.7	5.2	-	* .05	* .05	* .05	-	-	0.01	0.3
1193.7 - 1198.7	5.2	-	* .05	* .05	* .05	-	-	.01	.2

* Less than