R. I. 4358 — October 1948

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

BUREAU OF MINES
JAMES BOYD, DIRECTOR

REPORT OF INVESTIGATIONS

INVESTIGATION OF THE SALT CHUCK COPPER MINE KASAAN PENINSULA, PRINCE OF WALES ISLAND SOUTHEASTERN ALASKA

BY

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By S. P. Holt,[2] J. G. Shepard,[3] R. L. Thorne,[4] A. W. Tolonen,[4] and E. L. Fosse[5]

CONTENTS

INTRODUCTION AND SUMMARY

The Salt Chuck mine is on the east bank of the Salt Chuck, a salt-water inlet at the head of Kasaan Bay, Prince Edward Island, Southeastern Alaska.

The deposit was worked at intervals from 1905 until 1941. Early shipments of hand-sorted ore are reported to have assayed about 4 percent copper, 0.15 ounce gold, and 0.15 ounce silver. The total mine production up to 1941 is reported to have been 326,000 tons containing 6,200,000 pounds of copper.

During December 1942 the Bureau of Mines cut a 15-foot channel sample on the surface and 7 channel samples from headings on the 300-foot level. In July 1943 a development project was started. Thirteen diamond-drill holes totaling 1,550 linear feet were drilled from underground stations on the 200-foot and 300-foot levels.

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 4358."
2/ Mining engineer, Rolla, Mo.
3/ Senior mining engineer, Juneau, Alaska.
4/ Associate mining engineer, Juneau, Alaska.
5/ Assistant mining engineer, Juneau, Alaska.

Sample analyses, drill-hole logs, and results of beneficiation tests are presented in this report.

ACKNOWLEDGMENTS

Field investigations were under the general direction of R. S. Sanford, acting chief, Alaska Branch, Mining Division. Preliminary examinations of the deposit were made by the following members of the Bureau of Mines' staff: R. L. Thorne, J. G. Shepard, and S. P. Holt. The investigative project of the Bureau of Mines was supervised by S. P. Holt, assisted by A. W. Tolonen and E. L. Fosse.

Special mention is made of the cooperation and assistance received from John C. Reed, E. N. Goddard, H. R. Gault, Clyde Wahrhaftig, L. A. Warner, and C. D. Bressler, members of the United States Geological Survey, who were assigned to the area at various times during this project.

The many courtesies received from the owner, A. L. Howard, are also acknowledged.

LOCATION AND ACCESSIBILITY

The Salt Chuck mine is situated at 55° 38' north latitude, 132° 33' 30" west longitude, on the east bank of the Salt Chuck, a salt-water inlet at the head of Kasaan Bay, Prince of Wales Island, Southeastern Alaska. It is 10-1/2 miles northwest of the village of Kasaan, by Forest Service trail, and 43 miles northwest, by water, from Ketchikan. The general location is shown on figure 1.

Kasaan has a store, a post office, an elementary school, and a cannery. Except when the cannery is operating during the salmon-fishing season in July and August, the community consists of fewer than 50 persons, mostly native Indians.

Ketchikan, a city of about 6,000 people, is a seaport on the Inside Passage waterway 750 miles north of Seattle and has regular steamer service at frequent intervals supplied by the Alaska Steamship Co., Northland Transportation Co., Canadian Pacific Railway Co. Steamship Service, and Canadian National Lines.

Ocean-freight rate quoted by steamship companies on ore or concentrate from Ketchikan or Kasaan Bay to points on Puget Sound is $4.50 a ton plus longshoring charges for loading and unloading. It is reported that marble and limestone were shipped from Dall Island to Seattle for $0.90 a ton in barges, and that copper ore and concentrate were shipped from Salt Chuck to Tacoma in small motor ships for $1.50 a ton, the ships bringing mill reagents, grinding balls, mine supplies, and food on the return trips. To allow for increased labor and other costs, the figure of $2.50 per ton for freight is used for the purpose of estimates in this report.

Ketchikan is the best local source for food and mining supplies, lumber, and labor.

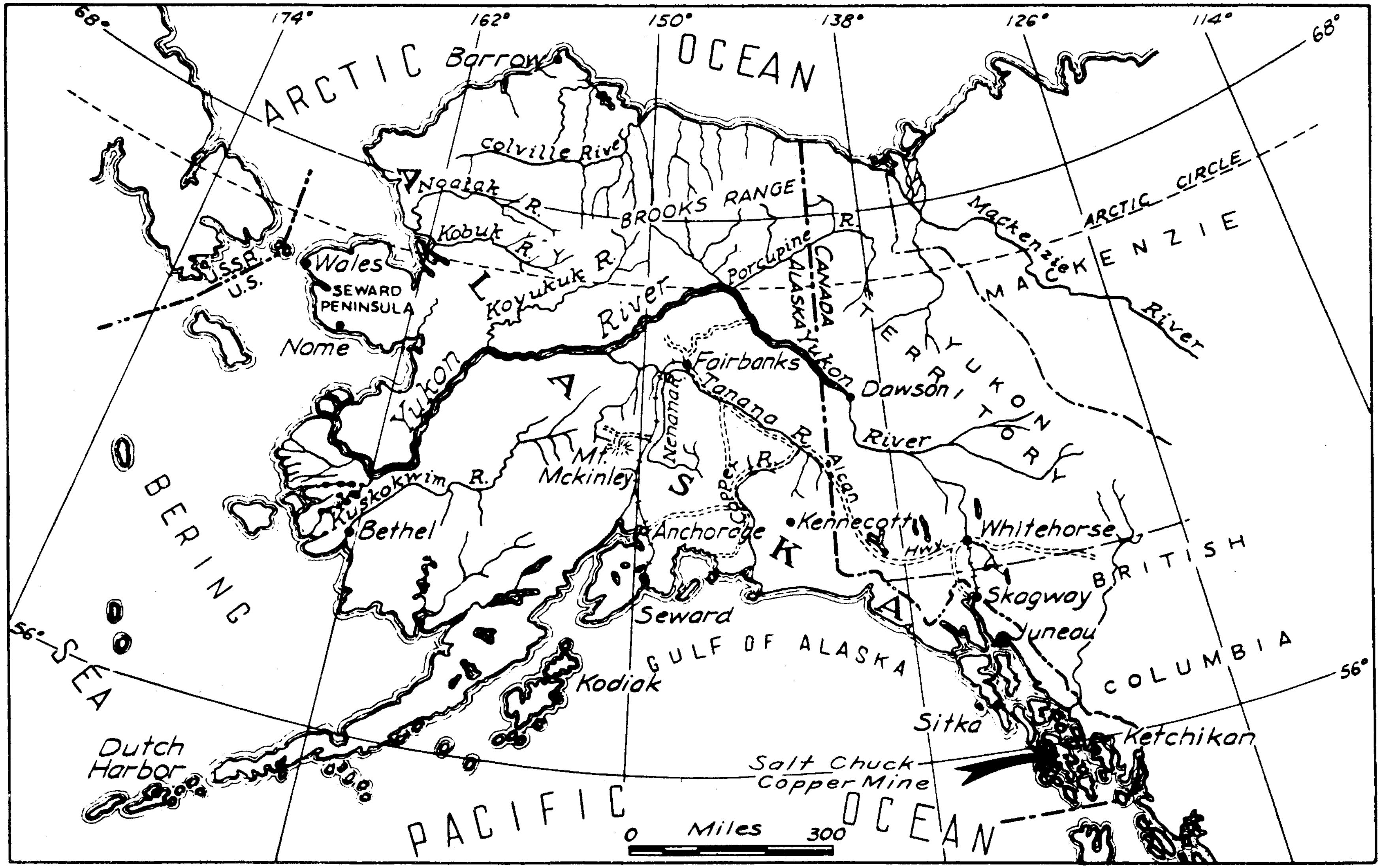

Figure I. - Index map showing location of Salt Chuck copper mine.

PHYSICAL FEATURES AND CLIMATE

The ore deposit lies on a wooded knoll at 400 feet above sea level, about 1/2 mile north of the mill and camp buildings, which are at sea level along the shore of the Salt Chuck. Surrounding terrain is low, covered with dense underbrush, and partly wooded with spruce, hemlock, and a little cedar suitable for mining purposes.

The climate is typical of southeastern Alaska, with mild temperatures, rarely dropping below 0° F. in winter or rising above 90° F. in summer. Precipitation is heavy, reported to average about 150 inches a year. Most precipitation is in the form of rain, snowfall not often amounting to more than 6 to 8 inches a year. During the winter of 1942, said to have been unusually severe, 24 inches of snow was measured at an altitude of 400 feet in December, and the temperature remained below 0° F. for 10-day periods.

Mining operations have been conducted at Salt Chuck throughout the year, with men properly housed. Shipping to and from Seattle continues the year around by vessels moving along the ice-free Inside Passage.

HISTORY AND PRODUCTION

The deposit, then known as the Goodro or Joker prospect, was located in 1905 by Charles Goodro, who operated it at intervals from 1905 until 1915, shipping small quantities of ore during this period. This ore, sorted by hand, is reported to have contained 4 percent copper, 0.15 ounce gold, and 0.15 ounce silver a ton. That the ore contained palladium was not known at that time.

J. A. Chilberg bought the property in 1915 and formed the Salt Chuck Mining Co. A mill with a capacity of 30 tons of ore a day was built, and an adit tunnel 1,200 feet long at an altitude of 105 feet was driven to intersect the ore body 300 feet below its outcrop. Capacity of the mill was increased in 1923 to 130 tons a day.

In 1923 the company was reorganized by Mr. Chilbert under the name of Alaska Palladium Mining Co., and the capacity of the mill was again increased, to 300 tons a day. This company suspended operations in 1926.

The property was then purchased at a marshall's sale by John Koel, of Ketchikan, and was optioned in 1929 to the Solar Development Co., a subsidiary of Colsolidated Mining & Smelting Co. of Canada, Ltd.

The Solar Development Co. diamond-drilled seven holes for a total length of 985 feet from underground locations in the Salt Chuck mine. Results of drilling was not encouraging and the company dropped its option in 1931.

Present owners of the property, the Alaska Gold & Metals Co., operated the mine from 1934 to 1941, inclusive. From early 1941 to January 1946 it has been idle.

Total production of ore from this deposit from the beginning of mining to the spring of 1941 has been, according to the unusually complete records kept during the period:

Total tons ore produced	326,000
Total pounds copper produced	6,200,000

Average analysis of this ore was:

0.95 percent copper a ton.
0.036 ounce gold a ton.
0.17 ounce silver a ton.
0.063 ounce palladium a ton.

The latest operating company, Alaska Gold & Metals Co., reports the following record of production from 1934 to 1941:

Ore mined	80,000 tons
Smelter return	1,356,381 pounds copper
	1,861 ounces gold
	8,756 ounces silver
	3,115 ounces palladium
Percent mill recovery	Copper, 85
	Gold, 68
	Silver, 72
	Palladium, 65
Ratio of concentration	45 to 1.

PROPERTY AND OWNERSHIP

The property consists of 23 lode-mining claims and two unpatented mill sites. These claims were surveyed for patent in 1920 by H. P. Crowther, U. S. Deputy Mineral Surveyor, but patent proceedings were not carried to a conclusion.

The Alaska Gold & Metals Co., A. L. Howard, president, holds title to the property subject to a mortgage held by John Koel of Ketchikan, Alaska.

GEOLOGY AND ORE DEPOSITS

The geology and ore deposits at the Salt Chuck mine have been described by Gault,6/ of the Federal Geological Survey, as follows:

> The ore deposits are in pyroxenite and gabbro, which form part of a large body of intrusive rocks at the head of Kasaan Bay * * *. The pyroxenite and gabbro are large irregular masses * * *.

6/ Gault, H. Richard, The Salt Chuck Copper-Palladium Mine, Prince of Wales Island, Southeastern Alaska: U. S. Geol. Surv. mimeographed report, 1945, 88 pp.

In the mine and the area immediately adjacent to it, the upper surface of the gabbro forms a steep southeast-pitching trough, which is filled with pyroxenite. The walls of the trough are nearly vertical and in places are overturned. Fingers and lobes of gabbro jut into pyroxenite, and pyroxenite lobes jut into gabbro. Such projections of pyroxenite and gabbro are more abundant, and the trough is narrower away from its bottom in the southern part of the ground opened by the mine near the start of the 311 drift. In this part of the mine gabbroic pyroxenite rock and alternating zones of gabbro and pyroxenite 1 foot to 5 feet thick occur between massive pyroxenite and massive gabbro so that the location of the boundary * * * is approximate. In general, elsewhere in the mine the boundary between gabbro and pyroxenite is placed within a zone not more than 1 foot wide.

The portal of the 300 level tunnel is in gabbro. At about 40 feet in from the portal pyroxenite is exposed, and the 300 drift continues in pyroxenite for 620 feet to a point where gabbro is again exposed. This gabbro is part of the same gabbro body as that at the southern limit of the 300 drift * * *.

North of the glory hole, across a muskeg area * * *, is a group of knolls and hills underlain by greenstone. Greenstone also crops out near the north and east sides of the lake east of the glory hole. The contact of the greenstone and gabbro is concealed.

Small fine-grained basaltic dikes and thin, light-colored dikes, possibly aplite, cut the other rocks. Basic dikes are exposed in the western part of the mine at intervals from the surface to the 300 level. These may be parts of a single dike.

The pyroxenite is dark-green and coarse-grained and contains a pyroxene, probably augite, as the principal constituent. The pyroxenite also contains minor amounts of feldspar. Magnetite is a common accessory mineral, locally making up almost 10 percent of the rock. Chlorite and epidote are common alteration minerals in the pyroxenite. The typical gabbro is dark-gray and coarse-grained, containing feldspar and pyroxene in about equal proportions. The gabbroic pyroxenite contains more feldspar than the normal pyroxenite but less than the typical gabbro. South and west of the glory hole the gabbro apparently grades into a lighter and finer-grained rock, which for the purpose of mapping is called diorite * * *. An altered gabbro, lighter-colored than the typical gabbro and containing appreciable amounts of pyrite, is exposed in the northern 140 feet of the 300 drift, at the north end of the north drift on the 200 level, and in several drill holes * * *.

The greenstone is a fine-grained dark-green or brown rock locally containing phenocrysts of augite and fragments of porphyry. Throughout the mine and vicinity are bodies of altered pyroxenite and gabbro, and gabbro and pyroxenite pegmatite.

Many faults with small displacements can be traced through the mine. Some of these faults are 4 inches to 24 inches thick and in the area of the mine workings contain considerable carbonate and chalcopyrite in addition to fault gouge.

These faults appear to fan out northwestward from the narrow part of the pyroxenite body, which fills the gabbro trough in the vicinity of the south end of the main workings. Other small faults and many fractures are present throughout the mine, and some contain carbonate veins, aplite, or very thin basic dikes. All faults that cut the gabbro-pyroxenite contact displace it for short distances.

The gabbro and pyroxenite appear to be almost contemporaneous differentiates of the same magma. The gabbro is considered to be slightly younger and to have intruded the pyroxenite.

The principal ore mineral at the Salt Chuck mine is bornite. Small amounts of chalcopyrite are locally associated with the bornite. Chalcopyrite is the principal sulfide mineral in the mineralized fault zones. Small flakes of native copper are widespread throughout the mines but are too few to be economically important. Chalcocite and covellite have been reported as alteration products,* * * and copper carbonates stain some weathered surfaces and fractures. Associated with the copper sulfides are recoverable amounts of gold, silver, and palladium as well as a little platinum.

Pyroxenite ore and gabbro ore are recognized. In the higher-grade pyroxenite ore the rock is cut by many small fractures extending in all directions, some of which are slickensided but show little displacement. The bornite is irregularly distributed as disseminated grains and patches along the fractures and in the rock between the fractures. In the lower-grade pyroxenite ore the rock is more massive and the bornite commonly occurs on fracture surfaces without penetrating far into the pyroxenite.

The gabbro ore is generally of lower grade than the pyroxenite ore, and the sulfide minerals are finer grained and more uniformly distributed through it. The gabbro ore is less fractured than the pyroxenite ore, and the sulfide minerals are not restricted to fracture surfaces.

The drill holes and the mine exposures indicate that the bornite within the ore bodies is very irregularly distributed. The ore is in small shoots randomly arranged in the ore bodies with lean and barren rock between them.

The glory holes and stopes * * * probably represent the general positions and shapes of the ore bodies which have been mined. In detail the ore bodies probably were smaller than these openings suggest and contained ore shoots and barren zones. Several small patches of ore in stope walls and small pillars represent remnants of these shoots.

The ore bodies were more or less pod-shaped, generally with their longest dimensions pitching steeply southeastward. The ore bodies are smaller and more irregular in the southern part of the main workings. Descriptions of the ore which has been mined suggest that the ore was richest near the center of each shoot.

The gabbro that crops out northwest of glory hole No. 1 * * * contains disseminated bornite and some chalcopyrite and is known as the north ore body. The ore is leaner toward the edges of the outcrop, and barren gabbro is exposed in the ore chute connecting the north ore body with the 200 level.

Low-grade ore is exposed in portions of the raise leading to the surface between the north ore body and the glory hole from the 200 level. The downward continuation of the gabbro of the north ore body is exposed in the north drift of the 200 level. Bornite occurs as scattered grains in the otherwise typical gabbro and in gabbro containing disseminated pyrite only near their contact at the north end of this drift. Normal gabbro and gabbro containing pyrite are also exposed in the northern part of the 300 drift below the north ore body but no bornite is recognized there. These exposures on the 200 and 300 levels suggest that the north ore body extends only to about the 200 level.

The ore exposed between the 300, 313, and 314 drifts * * *, here called the middle ore body, apparently is the continuation of the ore mined from stopes No. 3 and No. 4.

The gabbro ore in the southeast or 311 drift just east of the pyroxenite-gabbro contact * * * designated as the southeast ore body, appears to be the continuation of the gabbro ore exposed on the south side of the 308 stope.

At the southwest end of the glory hole * * *, in parts of the No. 1 stope and in a raise in the roof of the 201 stope at its west end, bornite is disseminated through the gabbro. The pyroxenite at the upper end of the ore chute connecting the west end of the 201 stope with the No. 1 stope * * * also contains scattered bornite grains. These bornite occurrences are near the contact and may represent lean portions of the ore body mined out in the western part of the 201 stope.

The deposition of bornite in the ore bodies apparently was controlled by the gabbro-pyroxenite boundary and by fractures and faults in the steeply pitching, pyroxenite-filled gabbro trough. The pyroxenite in the mine and immediate vicinity may represent a local center of differentiation. The bornite was deposited from rising thermal fluids, which presumably were differentiates of the same parent magma. The bornite was deposited in the pyroxenite after it was fractured.

The ore-bearing fluids followed the contact and spread into the fractured pyroxenite and into less-fractured gabbro. The more prominent fault zones, which are now metallized principally with chalcopyrite, seem to have been the main channels for the dispersion of the copper-bearing fluids to the smaller faults and fractures and thence to the microscopic fractures reported by Mertie * * *. The ore shoots are not bounded by the main fault zones but instead seem to lie near them.

SAMPLING AND ANALYSIS

During 1930, the Solar Development Co., while it held the property under lease and option, drilled 7 diamond-drill holes with a total length of 988.5 feet. These are shown on figure 4 and table 1.

TABLE 1. - Sample analyses, Salt Chuck mine

Sample No.	Location	Ore body	Length of sample, feet	Cu, percent	Au, oz/ton	Ag, oz/ton	Pt group, oz/ton
B-T[1]	Surface	North	15	1.25	0.01	0.15	
B-1[2]	300 level	Southeast	10	trace	0.01	0.10	none
B-2	do.	do.	10	0.33	0.015	0.12	none
B-3	do.	do.	10	0.56	0.015	0.14	0.015
B-4	do.	do.	10	0.84	0.01	0.10	0.03
B-5	do.	Middle	6	2.31	0.15	0.93	0.11
B-6	do.	do.	15	0.30	0.01	0.10	trace
B-7	do.	do.	6	0.64	0.05	0.25	0.05
B-8	Mill heads		-	0.77	0.02	0.18	0.015
B-9	Concentrates		-	35.45	0.88	5.64	1.22
B-10	Tailings		-	0.13	0.01	0.11	trace
S-1[3]	Hole S.D. 2	Middle	3	0.24	trace	trace	
S-2	do.	do.	5	1.14	0.03	0.25	
S-3	do.	do.	5	0.39	0.02	0.12	
S-4	do.	do.	5	nil	trace	trace	
S-5	do.	do.	5	0.49	trace	0.12	
S-6	do.	do.	5	0.90	0.04	0.24	
S-7	do.	do.	5	0.28	trace	trace	
S-8	Hole S.D. 2	Middle	1	5.50	0.06	1.30	
S-9	do.	do.	0.5	1.04	0.04	0.48	
S-10	do.	do.	5	1.02	trace	0.10	
S-11	do.	do.	5	0.22	trace	0.10	
S-12	do.	do.	5	0.79	trace	0.20	
S-13	do.	do.	2.5	0.60	0.01	0.17	
S-14	Hole S.D. 3	do.	5	0.32	trace	trace	
S-15	do.	do.	5	0.38	trace	0.10	
S-16	Hole S.D. 4	Northwest	5	none	trace	trace	
S-17	Hole S.D. 5	Middle	5	trace	trace	trace	
S-18	Hole S.D. 6	East gabbro	5	none	trace	trace	

See footnotes on page 9.

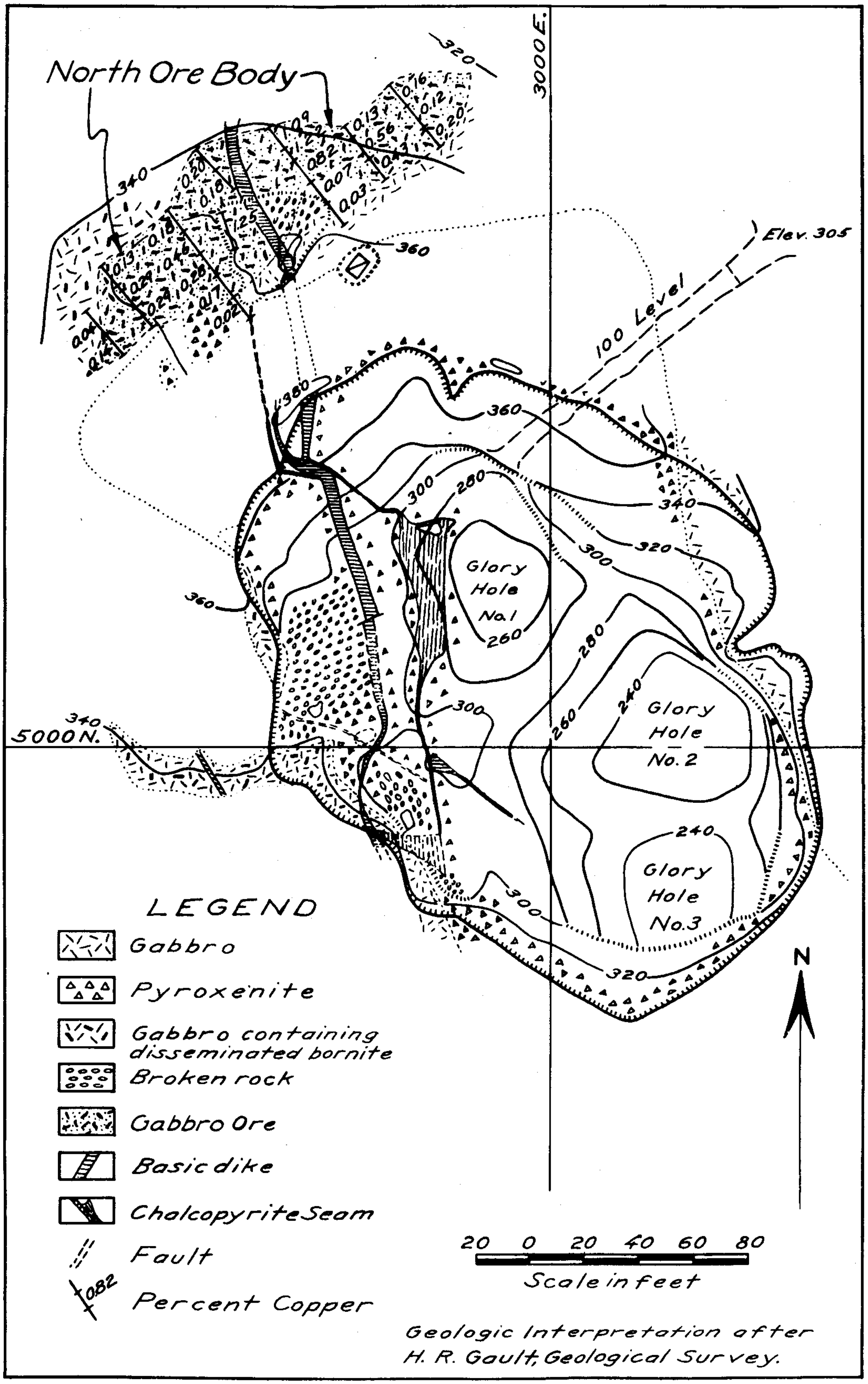

Figure 2. - Glory hole and north ore body.

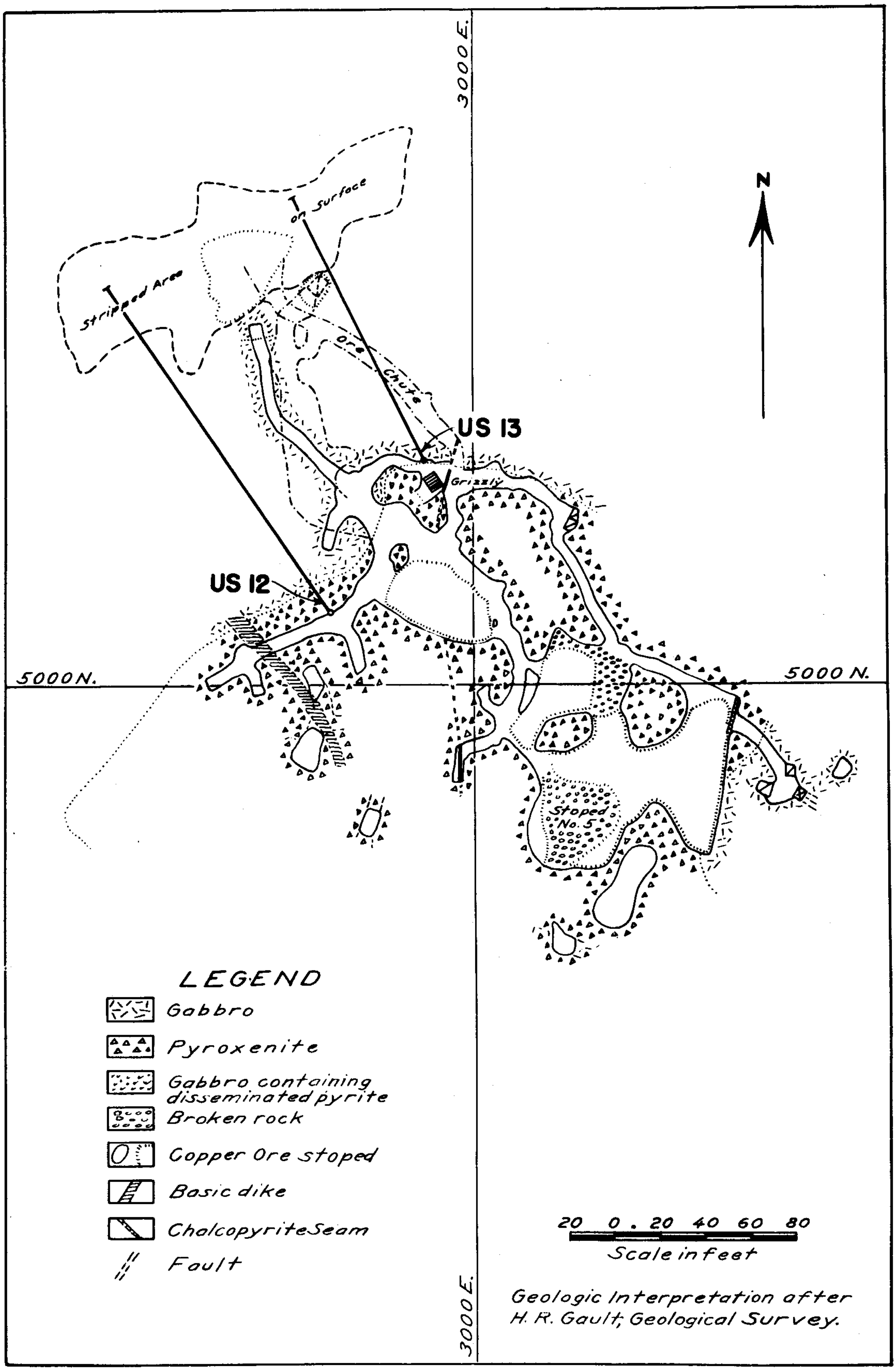

Figure 3. - 200 level, Salt Chuck mine.

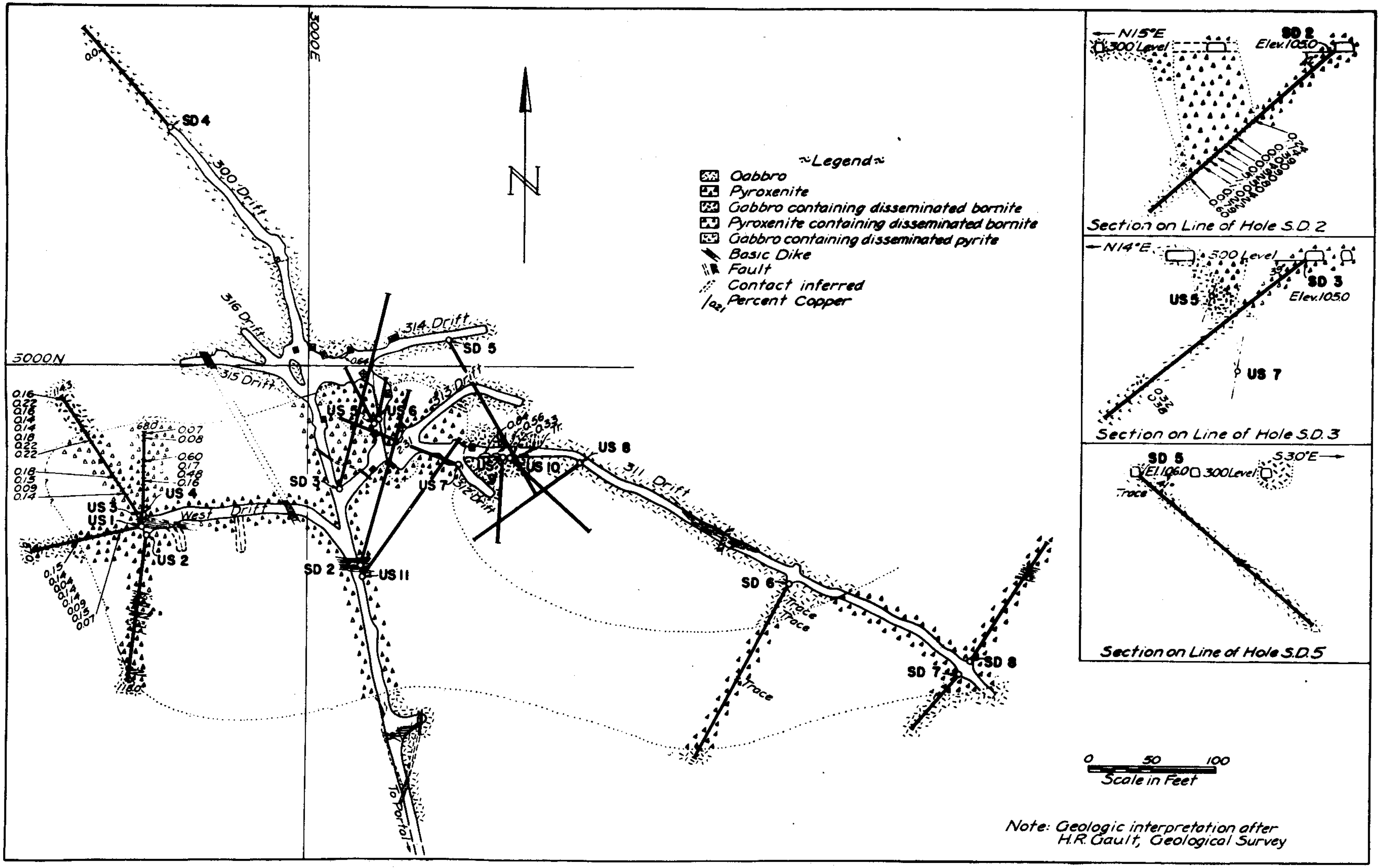

Figure 4. - 300 level, Salt Chuck mine.

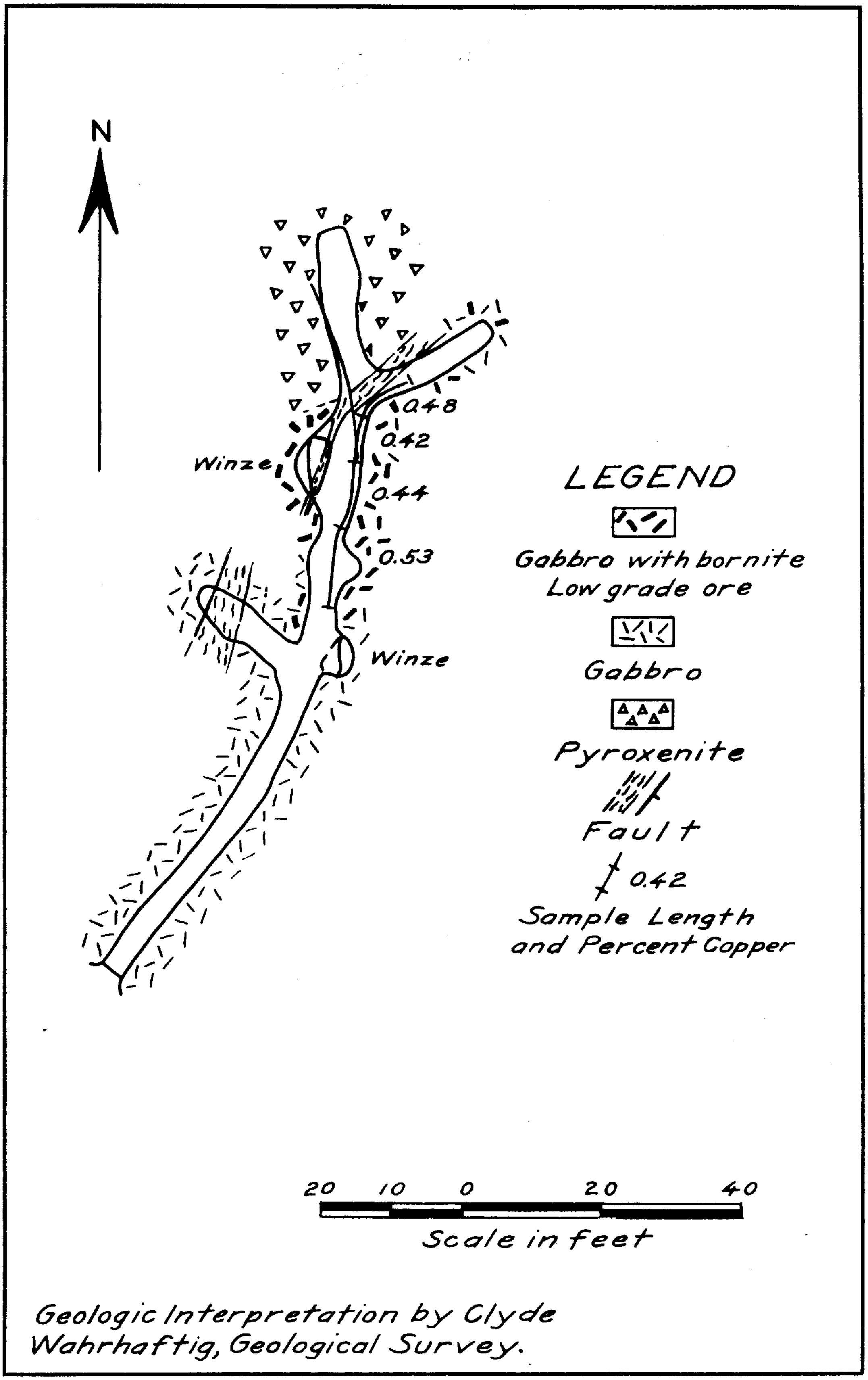

Figure 5. - Lower adit west of Salt Chuck mine.

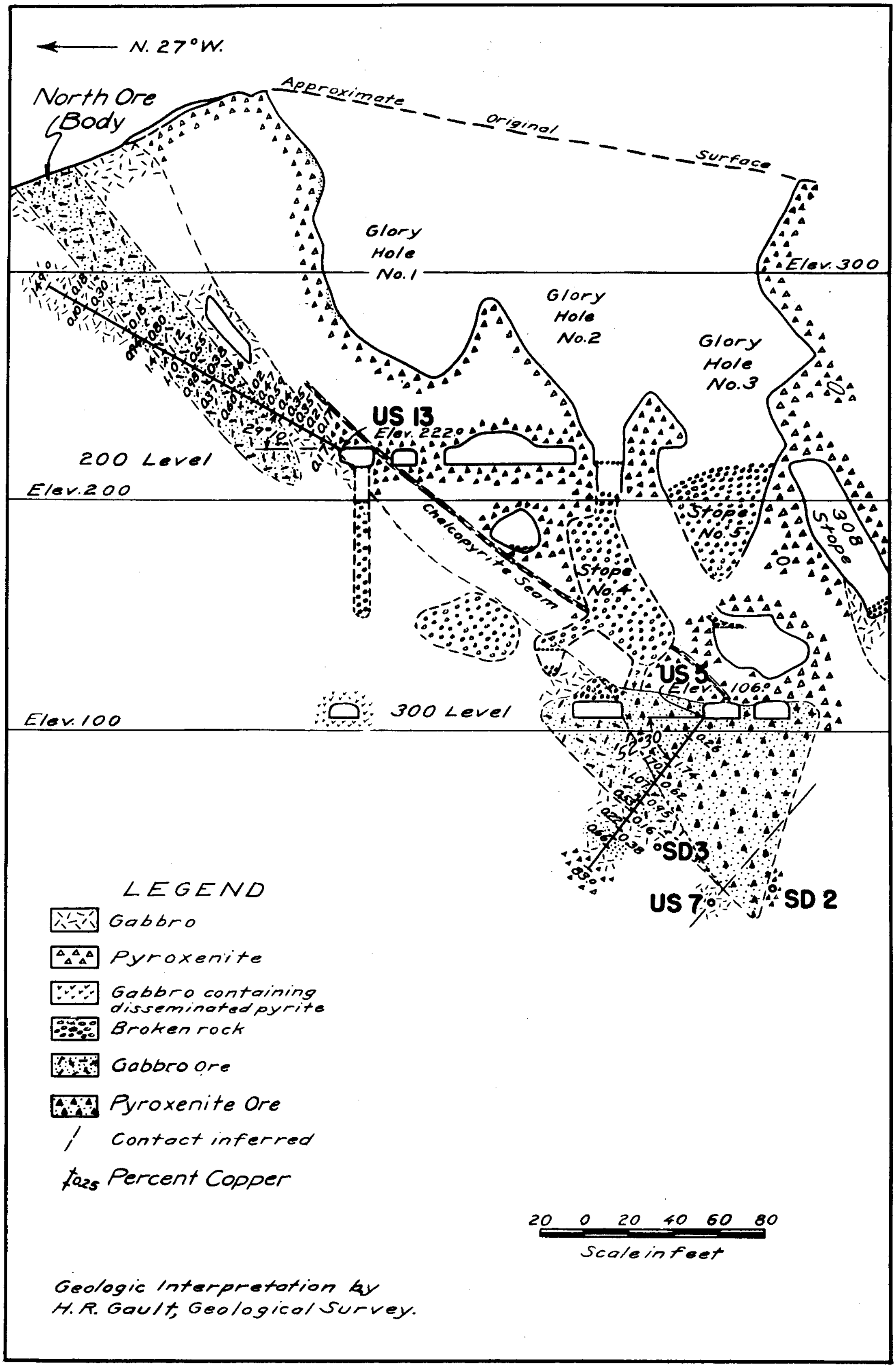

Figure 6. - Section on line of holes U.S. 5 and 13.

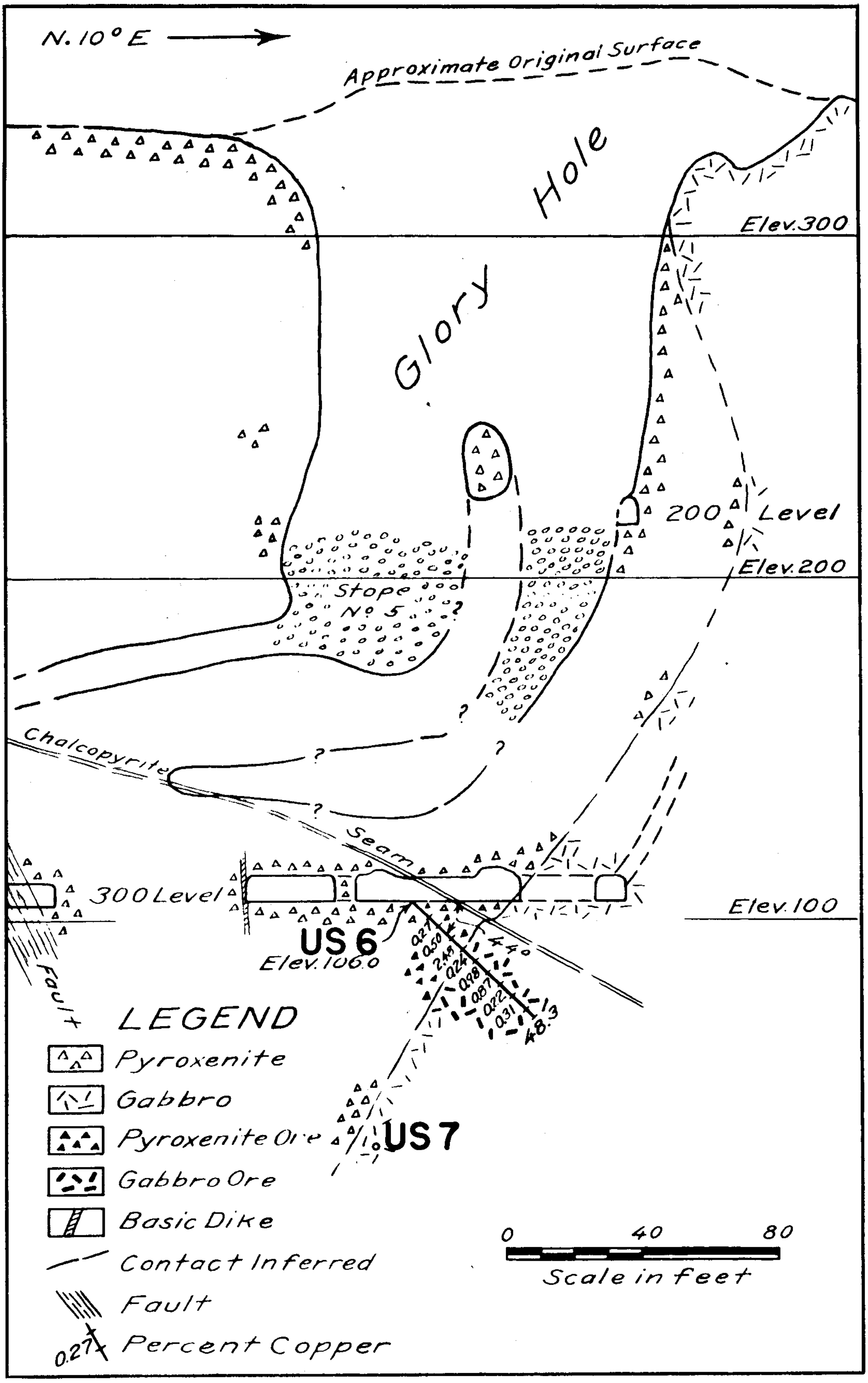

Figure 7. - Section on line of hole U.S. 6.

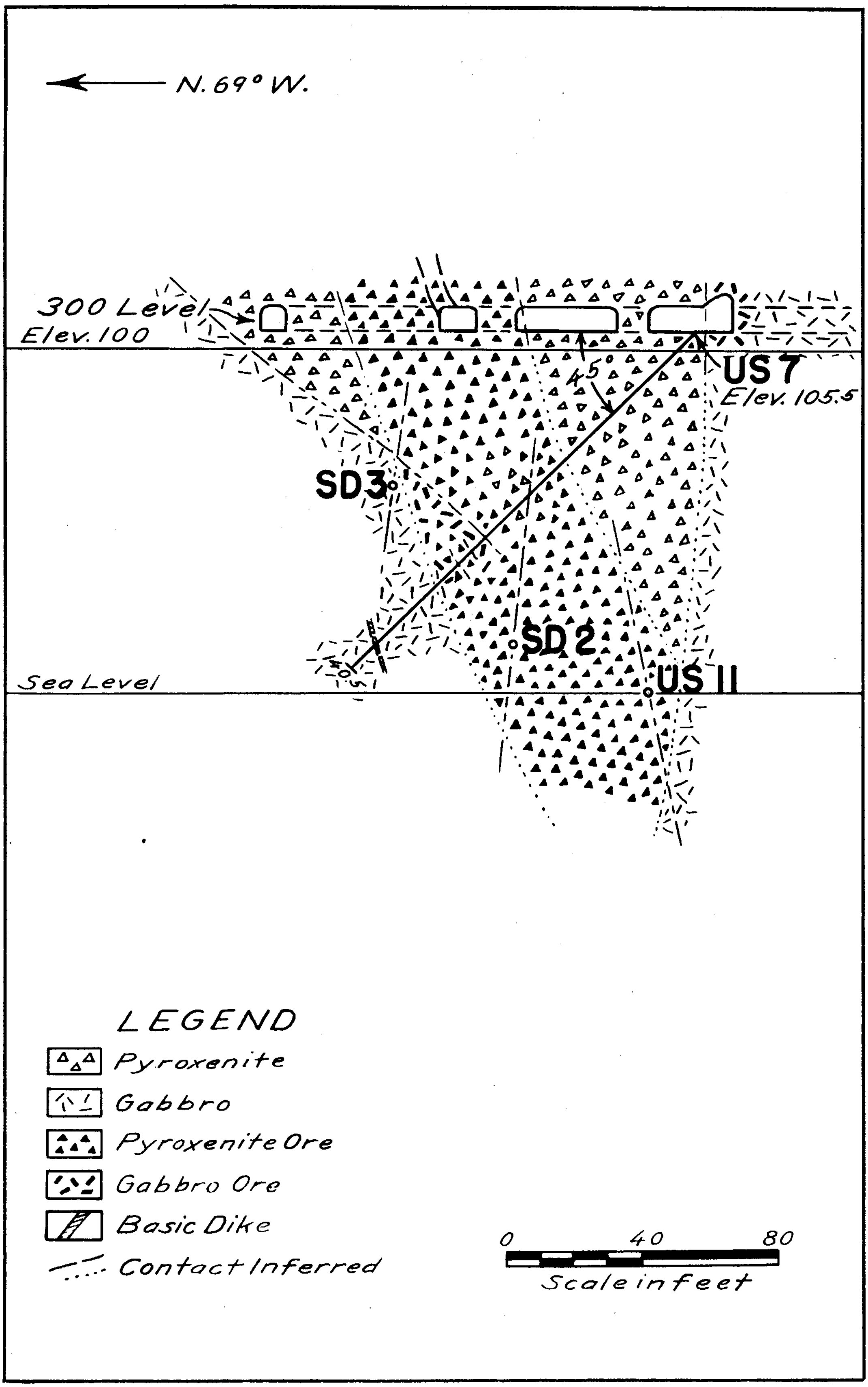

Figure 8. - Section on line of hole U.S. 7.

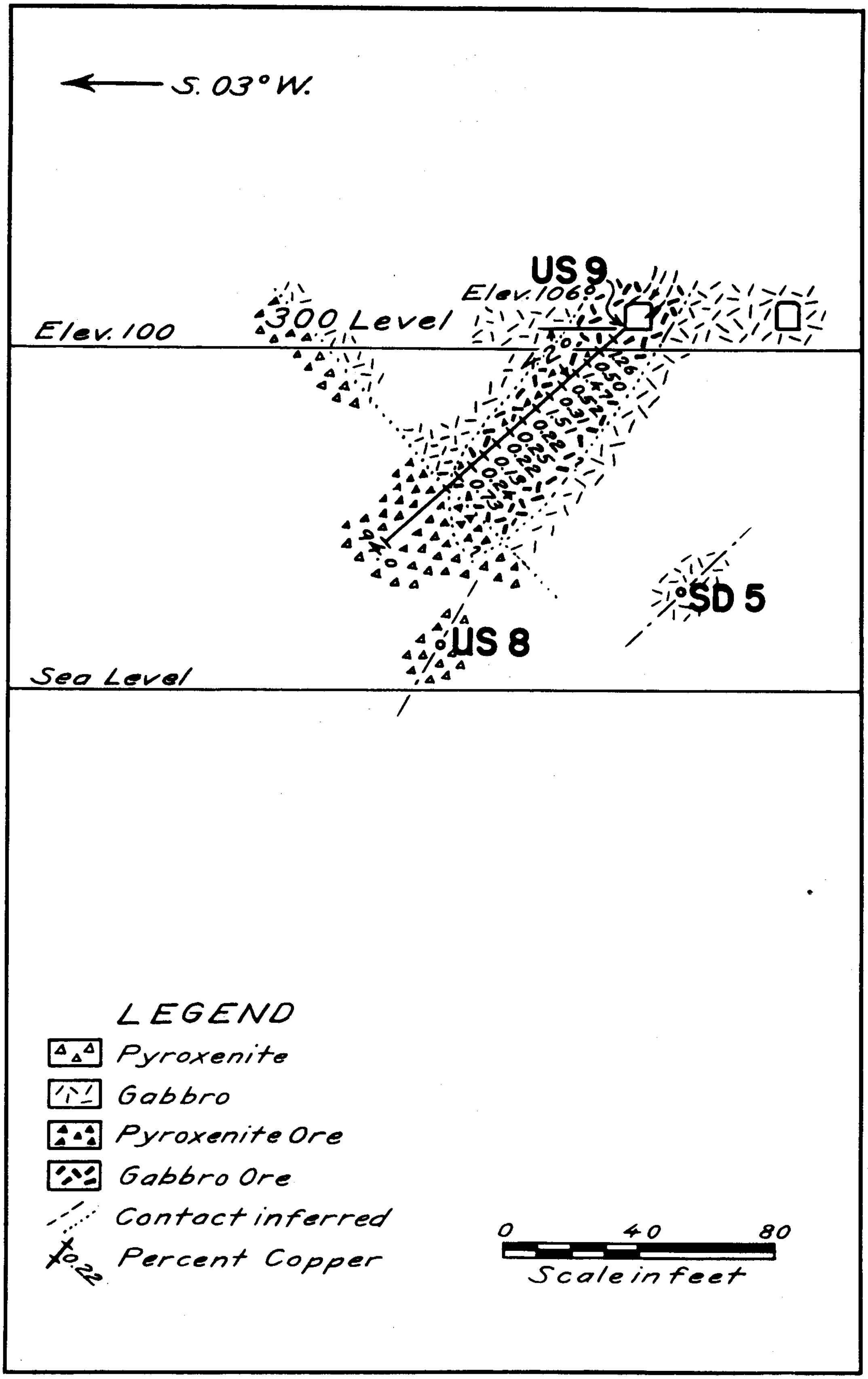

Figure 9. - Section on line of hole U.S. 9.

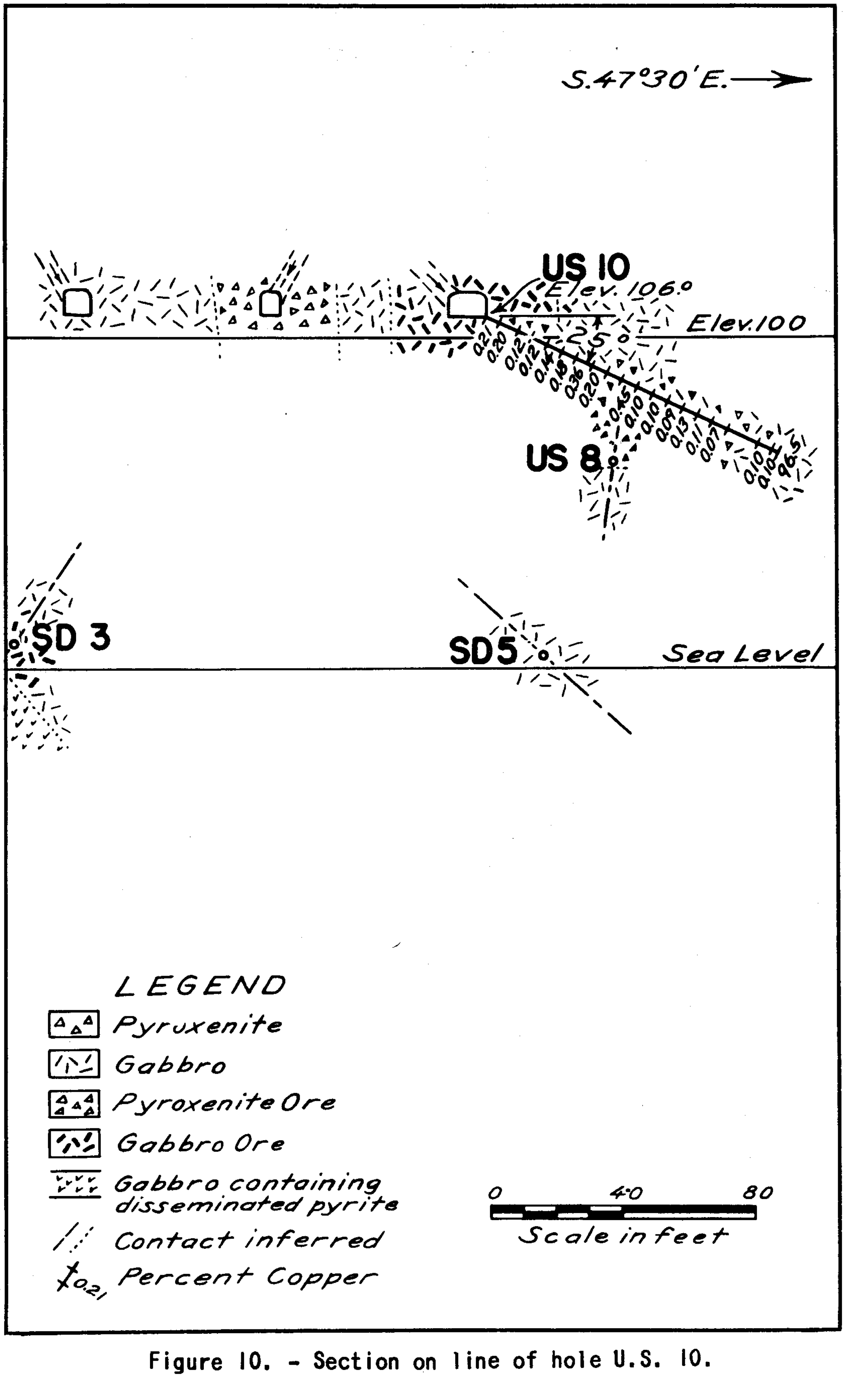

Figure 10. - Section on line of hole U.S. 10.

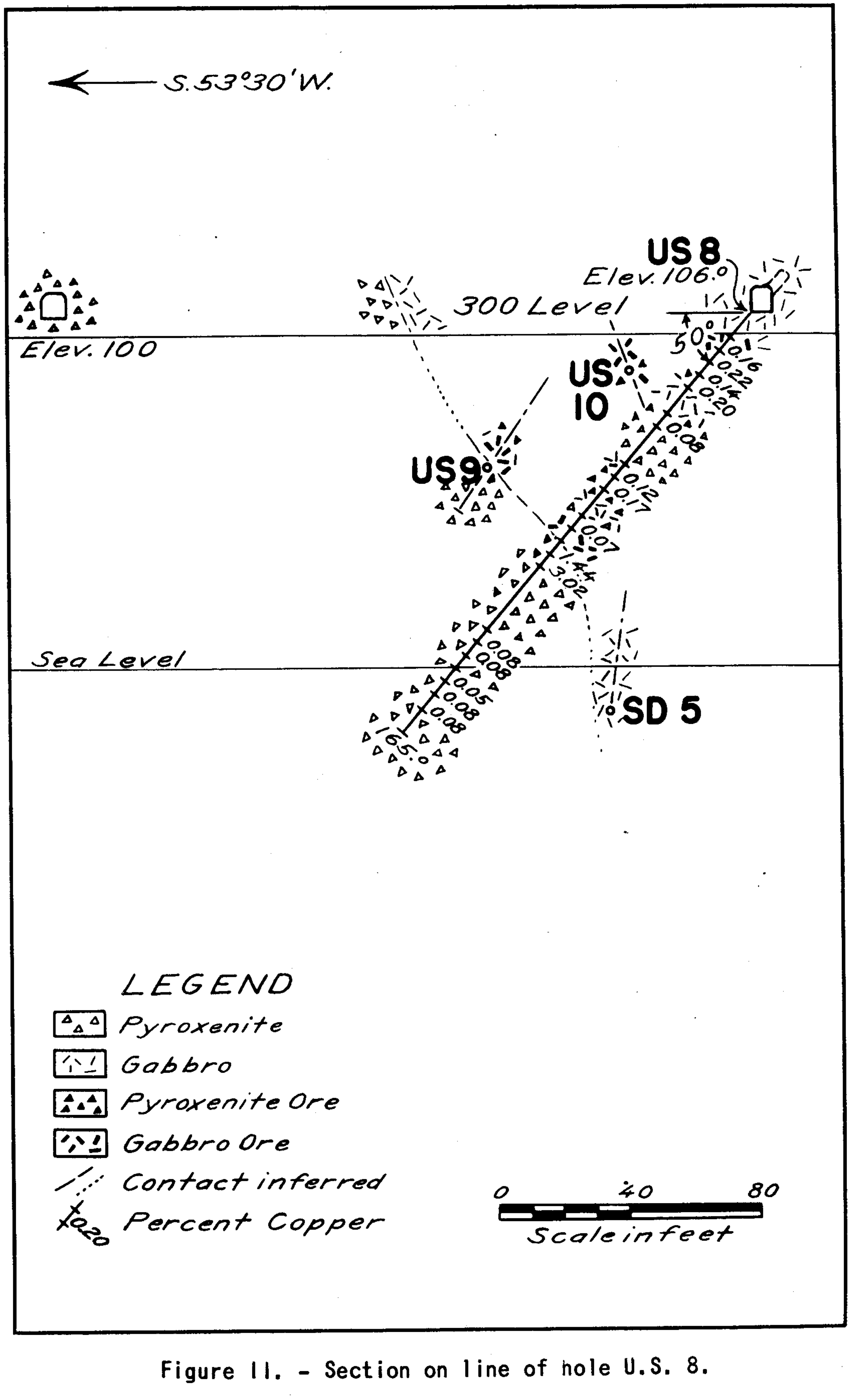

Figure 11. - Section on line of hole U.S. 8.

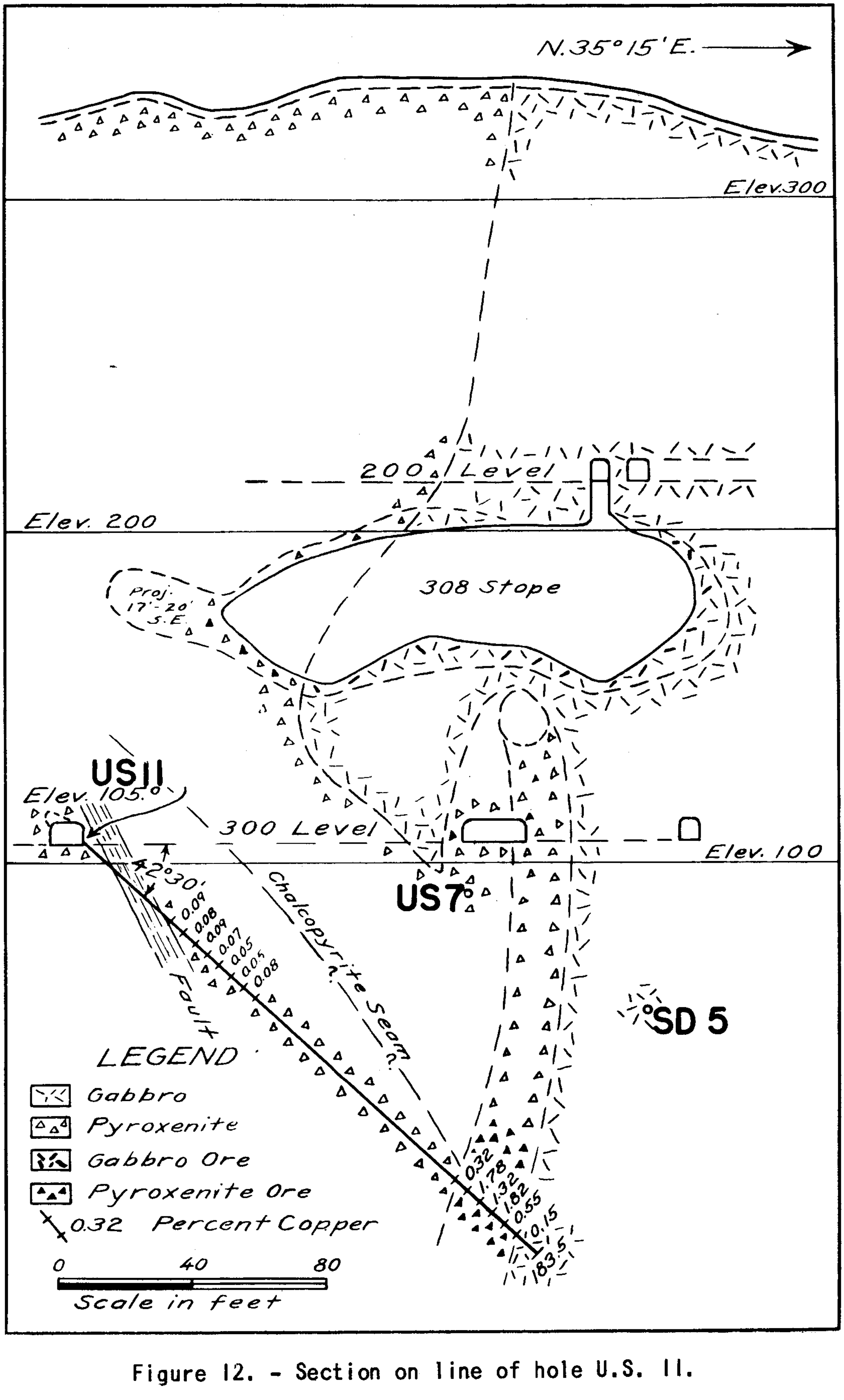

Figure 12. - Section on line of hole U.S. 11.

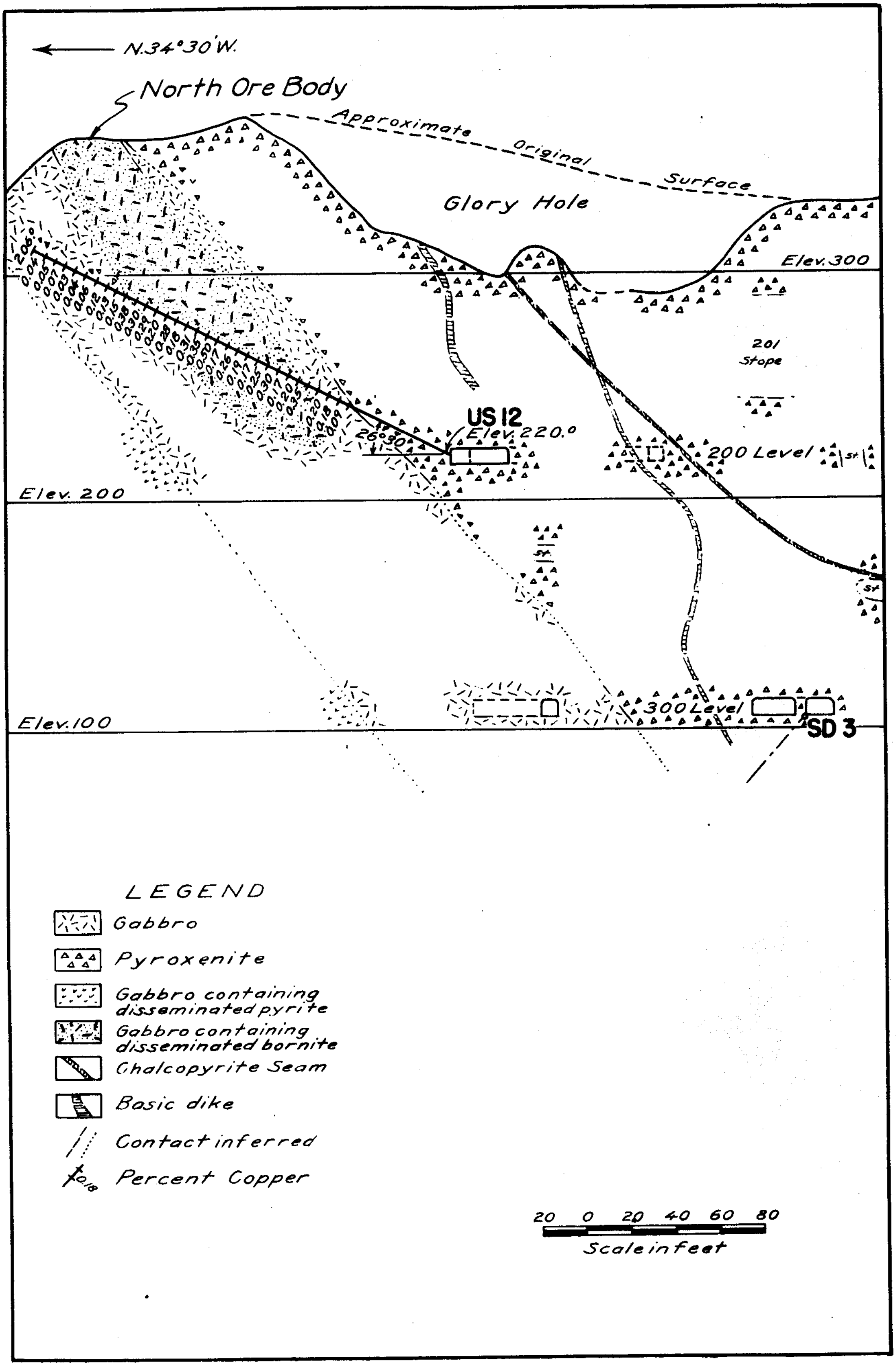

Figure 13. - Section on line of hole U.S. 12.

TABLE 1. - Sample analyses, Salt Chuck mine (continued)

Sample No.	Location	Ore body	Length of sample, feet	Cu, percent	Au, oz/ton	Ag, oz/ton	Pt group, oz/ton
S-19	Hole S.D. 6	East pyrox.	5	trace	trace	trace	
S-20	do.	do.	5	trace	trace	trace	
Composite	Hole US 5	20-45	25	1.15	trace	0.20	0.013
-	Hole US 1	50-55	5	0.15	0.005	0.09	0.015
-	Hole US 3	35-40	5	0.18	trace	0.09	0.018
Do.	Hole US 4	25-45	20	0.65	0.035	0.61	4/ 0.052
Do.	Hole US 6	5-35	30	0.86	0.025	0.46	none
Do.	Hole US 8	90-95-105-110	10	2.28	0.040	0.41	4/ none
Do.	Hole US 9	5-20	15	1.26	0.020	0.03	0.013
Do.	Hole US 10	0-35	35	0.16	0.005	0.62	trace
Do.	Hole US 10	35-75	40	0.18	trace	0.05	0.005
Do.	Hole US 11	35-70	35	0.07	trace	0.04	0.015
Do.	Hole US 11	150-175	25	1.39	0.050	0.20	4/ none
Do.	Hole US 12	50-65	15	0.23	none	none	none
Do.	Hole US 12	70-110	40	0.28	none	none	none
Do.	Hole US 12	110-150	40	0.33	trace	0.13	none
Do.	Hole US 12	150-170	20	0.25	none	trace	trace
Do.	Hole US 13	4-60	56	0.43	0.010	0.03	none
Do.	Hole US 13	65-100	35	0.91	0.010	0.19	4/ none
Do.	Hole US 13	125-140	15	0.19	trace	0.25	none

1/ Sample taken by R. L. Thorne, Bureau of Mines, 1942.
2/ Samples B-1 to B-10 taken by Bureau of Mines, 1942.
3/ S-1 to S-20, analytical results of samples from Solar Development Co. diamond drill cores, 1930.
4/ Palladium indicated.

A sample was taken in August 1942 by an engineer of the Bureau of Mines across 15 feet of the north (gabbro) ore body at the surface. In December 1942 the Bureau of Mines cut 7 channel samples on the 300 level, at the same time taking a general mill-head sample from ore in mill bins, a sample from concentrate sacked in storage, and a general sample from the tailing pond. The analyses of these samples are shown in table 1.

In June and July 1943, the Bureau of Mines diamond drilled 13 holes with a total length of 1,553.5 feet from underground stations on the 200 and 300 levels of the Salt Chuck mine. Results of the drilling are shown graphically on figures 3 to 13, inclusive.

Sludge from core drilling was carefully collected, dried, and split. Sludge samples were analyzed by the Territorial Assay Office at Ketchikan, Alaska. Cores were split and analyzed by a private concern in the States.

The analyses for copper of sludge and core samples from holes drilled by the Bureau of Mines were adjusted by the Longyear method, and the results are shown on figures 3 to 13. Method of adjustment, if any, of analyses shown for solar development (S.D.) holes is not known. It is probable that the results shown for those holes are of cores only.

Cores from Bureau of Mines drill holes were composited, and composite samples were analyzed for copper, gold, silver, and platinum group metals. The results are shown in table 1.

The so-called "North ore body" was sampled by means of channel samples cut 2 by 4 inches in cross section. Twenty-three samples with a total length of 222 feet were cut from the outcrop of this deposit. The results of analyses of these samples are shown on figure 2.

Two short adits 1,400 feet southwest of the glory hole have been driven to develop an outcrop of gabbro containing disseminated bornite. Four channel samples 2 by 4 inches in cross section, with a total length of 34 feet, were cut along the east wall of the lower of these adits. The results of analyses of these samples are shown on figure 5.

Average analyses of the three ore bodies and weighted average of all ore is as follows:

Average analyses of all ore bodies

Ore body	Copper, percent	Gold, oz/ton	Silver, oz/ton	Platinum group, oz/ton
North	0.452	0.01	0.08	0.02
Middle	0.946	0.024	0.269	0.015
Southeast	1.043	0.025	0.130	0.005
Weighted average all ore	0.61	0.014	0.11	0.017

Because of the low content of platinum-group metals in the samples analyzed, accurate determinations could not be made of the relative percentages of palladium and platinum, but previous experience of the operating company, as given by A. L. Howard, manager, was that the palladium-platinum ratio in the ore was generally about 10 to 1.7/

DEVELOPMENT

An adit 1,225 feet long taps the mine workings on the 300-foot level. Drifts have been driven on this level beyond the mined section, both to the southeast and the northwest. Spiral raises wind up through large stopes into the glory hole at the surface. Mining has left only remnants of the 100- and 200-foot levels. No workings extend below the 300-foot level.

From the initial operation until the property was taken over by the Alaska Gold & Metals Co., mining was confined principally to the glory hole. As large horses of waste occur within the ore shoots, the method resulted in serious dilution of the ore. Shrinkage stoping has been carried on from the sill of the 300-foot up to the 200-foot level. This method was much better

7/ Howard, A. L., The Salt Chuck Mine, Kasaan Bay, Prince of Wales Island, Alaska: Unpublished report, Jan. 7, 1935.

than the old glory hole, as pillars of waste could be left in place. Walls and roof stood remarkably well, and no timber was needed. The empty stopes are still in good condition and can be traversed readily. In late years all ore, which breaks rather blockily, was pulled from the stopes over grizzlies and transferred by chute raises to the 300-foot level, where it was drawn and trammed to the mill. Owing to the nature of the ground and the relatively large size of the ore shoots, mining costs were comparatively low.

Workings are in fair to good condition. Track and air lines on 300 level were repaired where necessary and used during the core-drilling program of the Bureau of Mines in July 1943. The air line to the 200 level was also repaired and used at that time.

Timbering, mostly around chutes and raises, was nearly all standing in July 1943 but would have to be replaced before the mine could be operated again.

The rock is hard and stands well, so that very little timbering is needed to support ground. Several faults, generally small, with 4 to 24 inches of gouge, were noted in the glory hole and stopes. A larger fault at the end of the west drift on the 300 level strikes easterly and is probably the same as that cut by the 300 main adit at the collar of drill hole SD 2 and in drill hole US 11. This fault has 10 feet of gouge and breccia, but the ground is firm and requires no timbering.

The mine is wet, water coming mostly from the heavy rainfall, which seeps down from the glory hole and other workings open to surface. No large, open watercourses were noted in the mine, and only a small amount of water flows from drill holes. Trouble from water is not to be expected if winzes are sunk short distances below the 300 level, although pumps will have to be provided to take care of normal flows.

EQUIPMENT

Power-plant equipment consists of 5 semi-Diesel and full-Diesel engines having a total capacity of 635 horsepower. Of this total, 220 horsepower is electrically connected, and the remainder is belted to ball mills and flotation units. A Pelton wheel driven by water from Goodro Lake under 180-foot head develops 60 horsepower for about 9 months each year.

Diesel-oil storage is provided by four steel tanks with a total capacity 16,000 gallons. There are two air compressors, one a single-stage, class E. R. 1, 14 by 12 inches, the other a converted steam compressor of similar size and type. Both have been belted to Pleton wheels, and one of them is so set that it can, by changing the belt, be driven by an electric motor.

Ore was transported from the 300 level of the mine and over 1,200 feet of surface tram in 40-cubic-foot, gable-bottom, side-dumping ore cars, of which there are 11 on the property, besides a number of smaller cars. Haulage was by a Mancha storage-battery locomotive of 4-1/2 tons capacity.

A blacksmith shop near the portal of the 300-level adit contains a forge, drill sharpener, and all necessary hand tools. Drifter, stoper, and jackhammer drills, though in fair to good condition, are most obsolete types.

Other shop equipment, including a blacksmith forge, lathe, and drill press, are set up in the mill building.

There is a small but well-equipped assay office. Sample crusher and pulverizer are set up in the mill. Much of the assay equipment, especially the furnaces and glassware, are now in poor condition. Milling equipment includes:

1 7-foot by 36-inch Hardinge ball mill.
1 8-foot by 48-inch Hardinge ball mill.
3 Wilfley sand pumps.
2 3-inch Krogh sand pumps.
1 4-inch Krogh sand pump.
6 K. & K. flotation machines.
1 15-foot by 7-foot Dorr thickener.
1 9- by 15-inch Blake-type jaw crusher.
1 Symons disc crusher.
1 14- by 55-inch Traylor gyratory crusher.
3 Allen sand cones.
Conveying, feeding, and screening equipment.
Mill buildings, in fair condition, adequate to house above equipment.

Most of the power-plant and mill machinery is in fair to good condition, except such articles as rubber hose and belting, which must be replaced before mill operation is possible. The Blake crusher is broken and too small for the job. The flotation machines are obsolete. A new Britannia-type deep-column flotation machine, nearly completed, was intended to replace the three old K. & K. machines.

Camp buildings include cook house, several dwellings, superintendent's residence, office building, warehouse, and about 15 cabins. Nearly all of these buildings are usable but require extensive repairs.

RESULTS OF ORE TESTING BY THE BUREAU OF MINES

During the investigation of the Salt Chuck mine herein reported, it became apparent that additional information on the factors controlling successful concentration of the ore to marketable products was desirable.

Accordingly, one sample of mine ore and four samples of mill tailing were obtained and shipped to the Bureau of Mines' laboratory at Rolla, Mo. for testing.

Mine Ore

The mine ore consisted of magnetite, bornite, sparing amounts of chalcopyrite and malachite, and a very small amount of pyrite in a pyroxenite gangue.

The bornite and chalcopyrite were fairly well liberated by 48-mesh grinding. Considerable magnetite was locked at 65-mesh and some at 100-mesh, but very little remained locked at 150-mesh.

The pyroxenite gangue of the mine ore and mill tailing consisted of augite, talc, biotite, epidote, calcite, and fine veinlets of quartz.

Vanadium, which was detected chemically in both the mine ore and the mill tailing, was concentrated in the magnetite, but the vanadium mineral was not identified.

Analysis of the mine ore sample is 0.68 percent Cu, 8.6 percent Fe, and 0.06 percent V_2O_5.

No gold, platinum, or palladium was detected spectroscopically in the samples, but a trace of silver was found. Fire-assay fusions were made on the mine ore and later on the composite mill tailing. Silver was inquarted in the charges, but the gold was not determined. The dore beads were analyzed spectrographically; a trace of platinum and a high palladium content were noted. The spectrographic analysis, however, does not indicate a high amount of palladium, as it was not noted in a spectrographic analysis of the ore or tailing.

The treatment procedure involved tests on the flotation of the copper minerals and magnetic separation of the iron minerals.

A portion of the ore was crushed to minus 10-mesh in a jaw crusher and rolls. A charge of minus 10-mesh ore was stage-ground in a pebble mill to minus 80-mesh. The pulp density was adjusted to 25 percent with grind water, and the charge was conditioned and floated in a mechanical-type, subaerated flotation cell. The rougher concentrate was cleaned twice. Zeolite-softened water was used for grinding and flotation.

The flotation tailing was treated in a Davis tube to remove the magnetite. One ampere of current for a 15-minute period was used. The combined results of flotation and magnetic separation were as follows:

Flotation and magnetic-separation results

Product	Weight, percent	Analysis, percent						Percent of total	
		Cu	Fe	V_2O_5	Insol.	P	S	Cu	Fe
Copper concentrate..	1.21	45.7	9.3	1/0.05				83.8	1.3
Copper middling	2.44	1.79	8.8	1/0.05				6.6	2.6
Copper tailing									
Magnetic portion ...	8.50	0.02	61.7	0.52	9.4	0.036	0.03	0.3	62.6
Nonmagnetic portion.	87.85	0.07	3.2	1/0.05		0.078	0.10	9.3	33.5
Calculated head	100.00	0.66	8.4	-	-	-	-	100.0	100.0

1/ Less than.

Flotation operating data

Reagents	Pounds per ton of ore			
	Conditioner	Rougher	Cleaner 1	Cleaner 2
Potassium amyl xanthate	0.175			
Methyl amyl alcohol	0.08			
pH		7.9		
Time, minutes	3		4	3

The iron in the nonmagnetic portion was largely in the ferro-magnesian minerals.

Spectrographic analyses of the copper concentrate and the magnetic and the nonmagnetic portion of the tailing were made for silver, platinum, and palladium. The results were as follows:

Product	Ag	Pt	Pd
Copper concentrate	Low	Negative	Trace
Magnetic portion	Negative	do.	Negative
Nonmagnetic portion	do.	do.	do.

This shows a silver and palladium concentration in the copper concentrate.

Using the same treatment procedure, but grinding to minus 65-mesh, recovered a copper concentrate containing 50.7 percent, an iron concentrate containing 62.7 percent, and a reject containing 0.08 percent copper and 3.4 percent iron. Thus, the 65-mesh grind gave slightly lower recoveries of copper and iron but slightly higher-grade copper and iron concentrates.

A supplemental test was made to study the possibility of preparing an iron product suitable for the production of sponge iron by magnetic concentration.

The sample was ground to minus 200-mesh, which is the size necessary for liberation of the iron.

The copper was floated from the mine ore previous to magnetic separation. The results of the tests are as follows:

Magnetic concentration of mine ore (flotation tailing)

Product	Weight, percent	Analysis, percent			Percent of total	
		Fe	Insol.	SiO_2	Fe	Insol.
Magnetic	7.32	68.7	4.2	1.14	60.1	0.4
Nonmagnetic	92.68	3.6	73.5	-	39.9	99.6
Heads, calculated.	100.00	8.4	68.4	-	100.0	100.0
Heads, analyzed ..		8.6	-	-		

The grade of the magnetic portions was improved by 200-mesh grinding, but open-hearth sponge-iron specifications as to insoluble were not met. Iron recoveries also were lower.

Mill Tailing

Four mill-tailing samples were obtained for metallurgical testing. The samples were analyzed separately and composited for metallurgical testing. Analysis of each sample and the composite are as follows:

Analysis, percent

Sample designation	Cu	Fe	V_2O_5
Tailing 1	0.13	9.1	0.05
Tailing 2	0.20	8.3	0.05
Tailing 3	0.08	9.1	0.05
Tailing 4	0.10	9.0	0.05
Composite tailing	0.13	8.9	0.05

The mill tailing had been treated by flotation for the recovery of copper and was largely minus 35-mesh. Mineralogically, the composite tailing and the mine ore were the same. Most of the bornite remaining in the tailing was partly coated with malachite, and much of the residual chalcopyrite was locked with gangue. Locking of the magnetite was noted in sizes as coarse as 65-mesh.

Equal weights of the mill-tailing samples were composited for magnetic separation tests. The material, as received, was treated in a Davis tube to remove the magnetite. The product so separated contained only 56.8 percent iron. A microscopic examination of the magnetic portion showed that much gangue was locked with the magnetite at this size, approximately 35-mesh.

Another portion of the composite tailing was stage-ground wet in a pebble mill to minus 65-mesh and separated in a Davis tube by 2 amperes of current for 5 minutes, followed by 1 ampere for 10 minutes. The vanadium concentrated in the magnetic portion. Most of the iron in the nonmagnetic portion was in the form of ferro-magnesian minerals. A little recoverable copper was released by the grinding. Results were as follows:

Magnetic-separations results

Product	Weight, percent	Analysis, percent						Percent of total		
		Fe	Insol.	P	S	Cu	V_2O_5	Fe	Insol.	P
Magnetic portion..	10.0	66.0	5.5	0.028	0.05	0.05	0.56	74.6	0.7	2.6
Nonmagnetic portion	90.0	2.5	82.1	0.115	0.08	0.13	0.05	25.4	99.3	97.4
Calculated feed	100.0	8.8	74.4	0.106	-	-	-	100.0	100.0	100.0

Supplemental tests to study the possibility of preparing a product suitable for the production of sponge iron were undertaken on the mill tailing as they were on the mine ore, previously described.

The sample was ground to minus 200-mesh, which was the size necessary for liberation of the iron. The results of the magnetic concentration tests are as follows:

Magnetic concentration of mill tailing

Product	Weight, percent	Analysis, percent			Percent of total	
		Fe	Insol.	SiO_2	Fe	Insol.
Magnetic	9.18	67.3	4.3	1.60	69.4	0.5
Nonmagnetic	90.82	3.0	81.3	-	30.6	99.5
Heads, calculated	100.00	8.9	74.2	-	100.0	100.0
Heads, analyzed		8.9	-	-		