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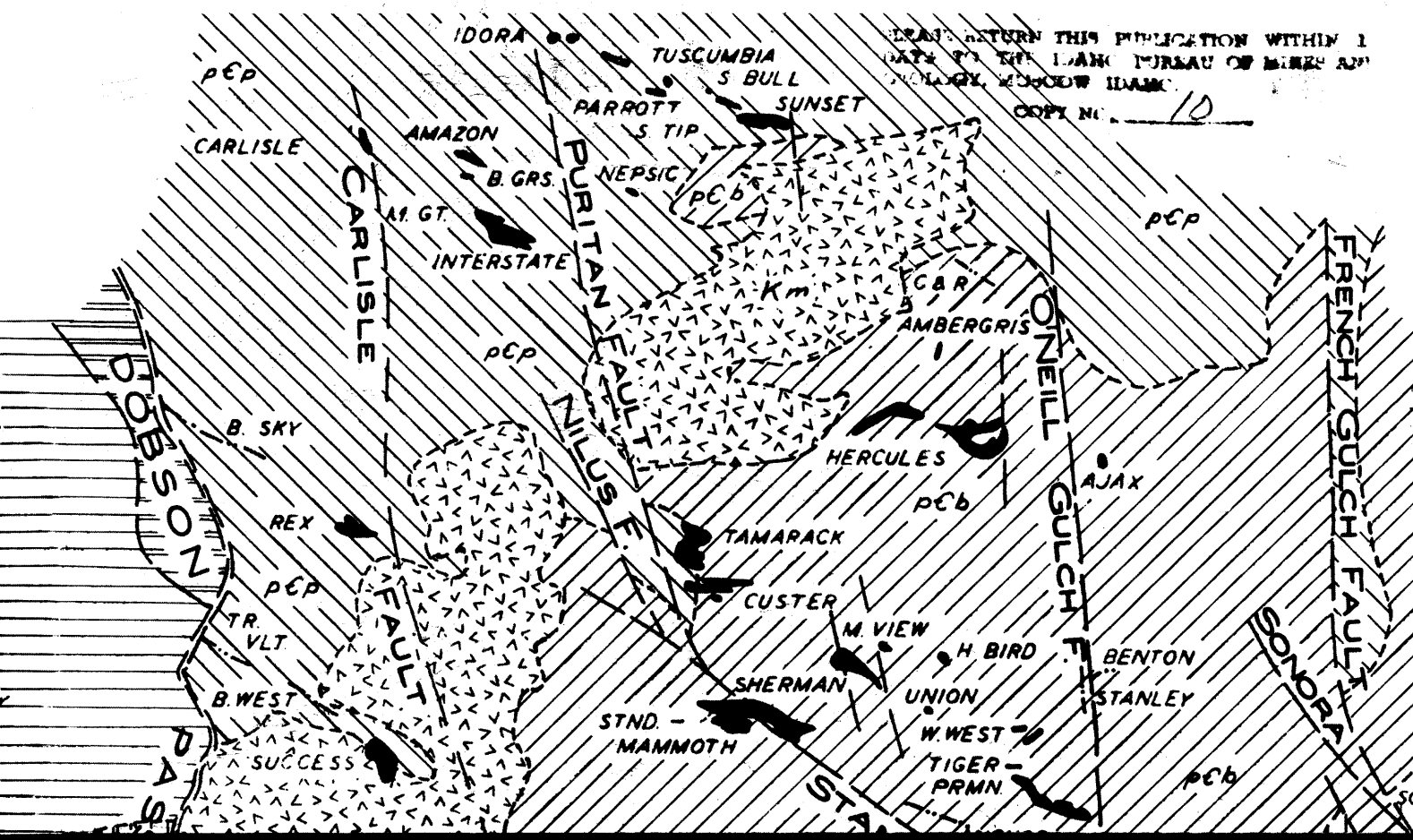
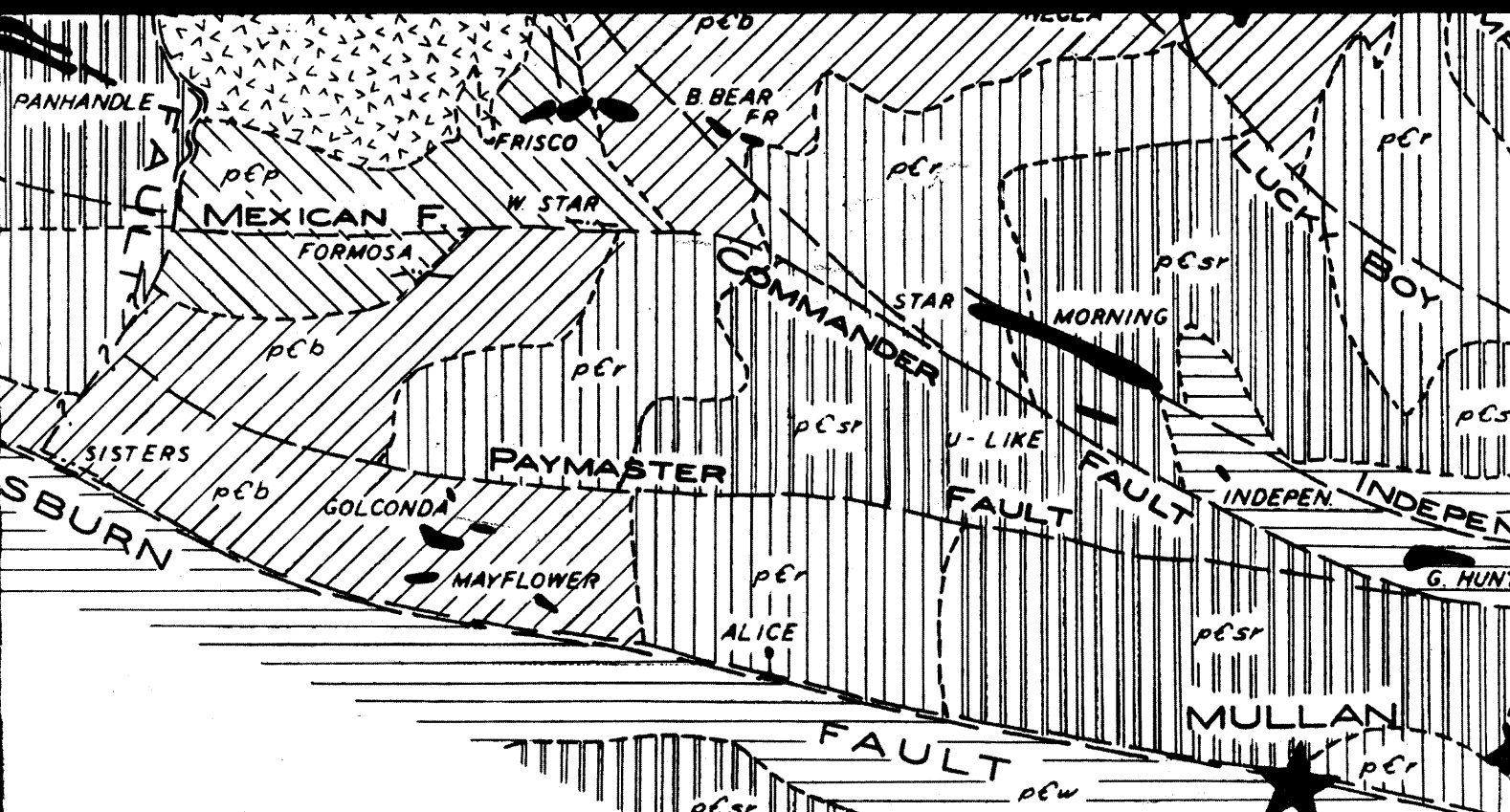


GUIDEBOOK TO THE GEOLOGY OF THE COEUR D'ALENE MINING DISTRICT



BULLETIN NO. 16 APRIL, 1961

GUIDEBOOK TO THE GEOLOGY OF THE COEUR D'ALENE MINING DISTRICT

by

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IDAHO BUREAU OF MINES AND GEOLOGY

Moscow, Idaho

FOREWORD

This guidebook was prepared initially for use during a Coeur d'Alene district field trip held in conjunction with the April, 1961 meetings of the Association of American State Geologists, sponsored by the Idaho Bureau of Mines and Geology on the University of Idaho campus. Beyond this rather transitory use, the material contained herein provides a brief but useful source of information on the Coeur d'Alene district. For this reason it has been published by the Idaho Bureau of Mines and Geology.

Aspects of district history and general geology are treated in the first papers. Brief articles on the detailed geology of five mines, representative of the district visited during the field trip, complete the bulletin.

A number of busy people kindly took time to prepare the various articles that follow. Their contributions, as well as the cooperation of the organizations they represent, are gratefully acknowledged.

Rolland R. Reid
Guidebook Editor

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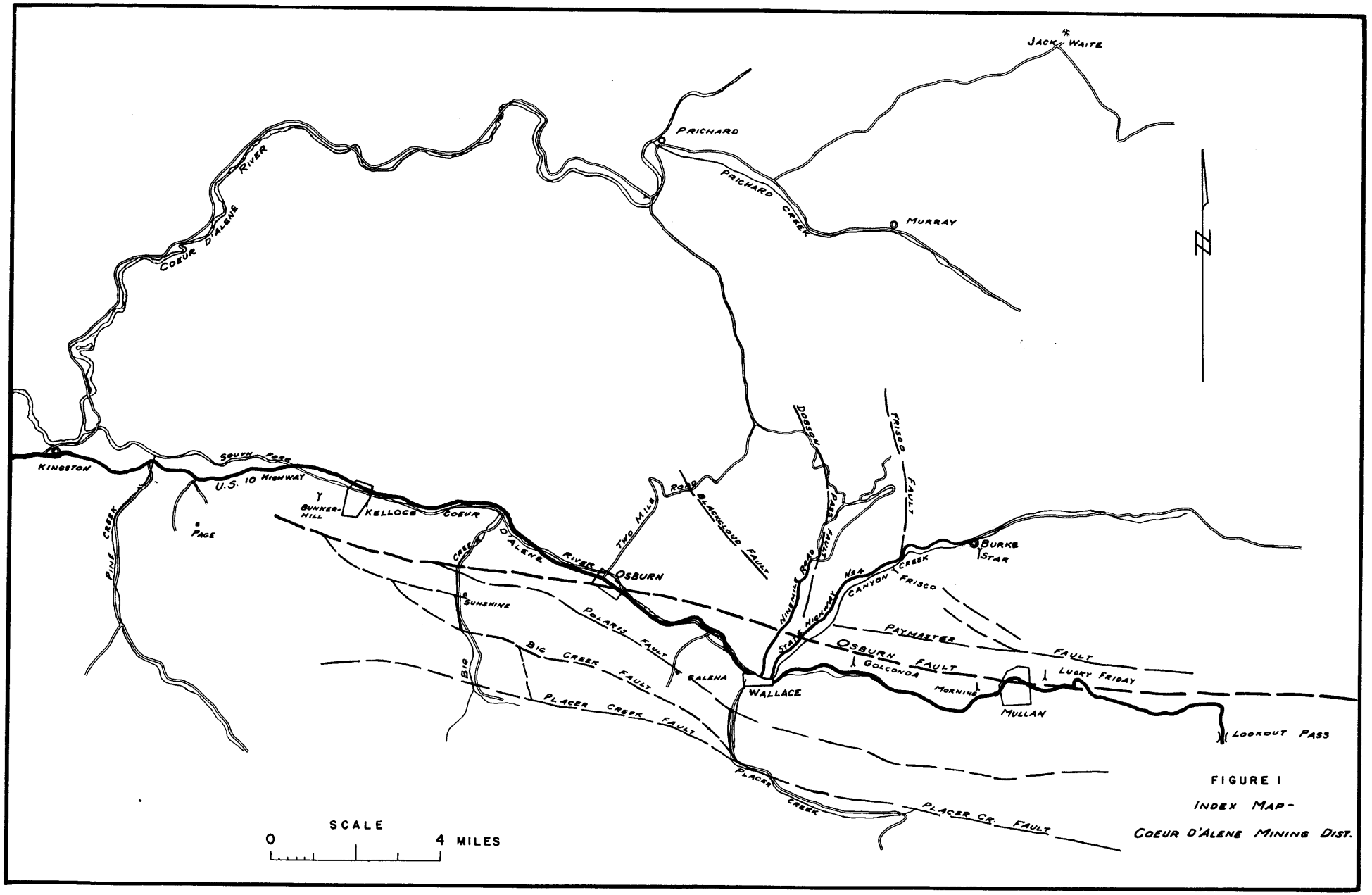

FIGURE I

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COEUR D'ALENE MINING DIST.

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THE COEUR D'ALENE MINING DISTRICT

by

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The Coeur d'Alene District, located in the "Panhandle" of northern Idaho, includes a number of mining districts, and many mines, scattered over an area 25 miles in an east-west direction and 15 miles in a north-south direction. This area over the past eighty years has produced 439,000 fine ounces of gold, 619,737,400 fine ounces of silver, 6,546,000 tons of lead, 2,156,400 tons of zinc, and 93,000 tons of copper, not to mention by-products in considerable amounts.* This metal production is valued at $1,853,000,000 and from it dividends totaling $272,500,000 have been paid.

The Coeur d'Alene district numbers among its mines some of the world's greatest - the Bunker Hill and the Page mine, on the west side, the Morning and Star, on the east, the Sunshine at the south, and the Hercules, Hecla, Tamarack, Standard-Mammoth, and other mines in the north-central area. Some of the mines are now closed but others, including the Lucky Friday near Mullan and the Vulcan near Wallace, have recently grown into the great-mine category.

The mining history of the Coeur d'Alene district began with the discovery of placer gold on Prichard Creek, near Murray, in 1879. Active mining, however, did not begin until 1883. The placers were very rich and with the news of the discovery miners rushed to the district. Gold-bearing lodes were found shortly after the placer discoveries and by 1885 several arrastras and stamp mills were in operation and Murray, with a population of 1500, had become the county seat of Shoshone County.

As early as 1884 lead-silver deposits were known in the vicinity of Burke and Mullan and rich silver veins had been found in Polaris Gulch west of the Sunshine mine. Also, by this time Col. W. R. Wallace had built a cabin and store at the site of the town that now bears his name. However, access to the mines was difficult and tedious. Passengers and supplies were brought up the Coeur d'Alene River in small steamers, to the vicinity of Cataldo, where they were transferred to wagons or horses and thence carried over the old Mullan military road, or up the North Fork to Murray.

In 1885 the Bunker Hill and Sullivan mines were found and by that time large, rich ore bodies had been discovered at the Tiger, Poorman, Granite, Frisco, and Morning mines. In 1886 the first smelter was built near the town of Wardner and by 1890 two railroads had reached the Coeur d'Alenes, which greatly stimulated mining activity. In this year the value of the metals produced passed the four million dollar

*Production figures by courtesy of A. J. Teske, Secretary of the Idaho Mining Association

mark and by 1917 the annual production had exceeded fifty million dollars. During the three years the United States participated in the second World War the Coeur d'Alene district produced 6,491,332 tons of ore and treated 3,666,161 tons of old tailings and slag. At that time thirty-three concentrating mills were in operation. In 1959 the Coeur d'Alene production had fallen to 1,262,620 tons of ore valued at $37,452,821.00. In 1960, due to low metal prices and unsettled labor conditions, the production was at a level considerably below even that of 1959.

Over the years since gold was found near Murray, the mining history of the Coeur d'Alene district has been one of recurrent discoveries and, as more and more is learned about the complex geology that has controlled the formation of the great ore bodies, additional discoveries can be expected. Great faith and courage were required to search for the deep ore bodies at the Bunker Hill mine when the early ore bodies appeared to have bottomed. The same sort of faith and courage were required to find the great Hercules ore body and to develop the deep levels at the Sunshine mine where the fabulously rich silver veins were found. In more recent years no other word than courage can describe the commitment required to sink the 3000-foot shaft and explore the deep levels of the Vulcan mine, largely on the promise of what appeared to be favorable geological conditions. The same sort of courage has recently developed the Lucky Friday into a great mine and in the future, when economic conditions justify the necessary exploration costs, we can expect that other great mines will be found in the Coeur d'Alene district.

TECTONIC SETTING OF THE COEUR D'ALENE DISTRICT, IDAHO*

by

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In gross structural pattern the Coeur d'Alene district lies at the intersection of the Lewis and Clark line (Billingsley and Locke, 1939, p. 36), represented by the Osburn and related faults, and a broad arch that extends north at least to Kimberly, British Columbia. The rocks of the district have been intensely deformed in a complex pattern that shows a marked discordance of structural elements on opposite sides of the Osburn fault and which well might be referred to as a structural knot (fig. 2.C).

Dominating this structural knot is the Osburn fault which strikes about N. 80° W. across the area. Strike slip is indicated on the Osburn fault by: (a) the offset of large upwarped blocks more or less delineated by areas of outcrop of the Prichard formation, the oldest unit of the Belt series; (b) the offset of major folds and faults, and the dissimilarity of structural features adjacent to one another on opposite sides of the fault; (c) large-scale drag features; (d) offset of the same sense along parallel or subparallel faults; and (e) the position of major mining areas on opposite sides of the Osburn fault and the pattern of ore and gangue-mineral distribution within the areas. A maximum of about 16 miles of right-lateral strike slip is indicated on the segment of the Osburn fault east of the Dobson Pass fault and about 12 miles displacement in the same sense is indicated west of the Dobson Pass fault. The difference in displacement on these two segments is believed to be principally the result of contemporaneous dip slip on the Dobson Pass fault, which has effectively lengthened the block north of the Osburn fault relative to the block south. A few miles east of the area shown in figure 2, in the vicinity of Superior, Mont., the cumulative lateral movement in the Osburn and the related Boyd Mountain fault, as shown by stratigraphic displacement, appears to be approximately 16 miles, which strongly corroborates the suggested displacement on the Osburn fault in the Coeur d'Alene district.

The age of the Osburn fault is known only within broad limits. It cuts rocks of the Belt Series of Precambrian age and is capped by flows of Columbia River basalt of middle Miocene age. The probably contemporaneous Dobson Pass fault cuts the Gem stocks, which have been dated as about 100 million years old (Jaffe and others, 1959, p. 95-96). Other geologic evidence indicates that a lineament in the general position of the Lewis and Clark line may have been in existence since early Precambrian time.

Ages obtained from uraninite from the Sunshine mine (L. R. Stieff and T. W. Stern, written communication, 1957; Eckelmann and Kulp, 1957, p. 1130) indicate that uranium mineralization occurred about 1,250 million years ago. Thus tight folds such

*Reprinted from "Short papers in The Geological Sciences,"
U.S. Geological Survey Professional Paper 400-B, 1960.

as the Big Creek anticline (fig. 2), that are cut by the uraninite veins, must have been developed before that time. In contrast, the principal ore-bearing veins are younger than the Gem stocks of about 100-million-year age.

The overall history of development of the structural knot must have been complex; the following summary of a possible sequence of events is suggested. During an early stage of deformation (fig. 2.A), the principal folds were developed and overturned to the northeast and reverse faults that strike northwest and dip southwest were formed. A large domelike structure, the Moon Creek-Pine Creek upwarp, was formed west of the reverse faults.

Accompanying a major reorientation of the stress system, the axes of the folds began to bow (fig. 2.B), the southern part of the region moved relatively westward, and incipient strike-slip faults developed. The Mill Creek and Deadman syncline was separated from the Granite Peak syncline and wrapped around the truncated end of the Granite Peak syncline. The northern flank of the Lookout-Boyd Mountain anticline was sliced off by one of the antecedent fractures of the Osburn fault.

Monzonite stocks intruded the structural knot thus produced (fig. 2.C), and the principal period of ore deposition followed. Most of the veins are included in spatial groups that define distinct linear belts trending slightly more northwesterly than the Osburn fault system. The concentration in such belts of veins, which are subparallel but differ in size and orientation, suggest that linear feeders for the mineralizing solutions existed at depth, although no through-going structural elements reflect these feeders in the upper crust.

After the principal period of ore deposition, strike-slip movement along the ancestral Osburn zone of weakness became more through-going than previously, and apparently deep-seated stresses were accommodated at this time by displacement on relatively few faults, most of which were in or parallel to this zone. The Osburn fault offset the major folds and early reverse faults, and separated the northern segment of the ore-bearing area from that to the south. The Thompson Pass fault also offset the major folds, and the Placer Creek fault offset the Pine Creek anticline and vein system. The Dobson Pass fault came into existence concurrently with the Osburn fault. The small stocks a few miles west of the Dobson Pass fault may represent cupolas displaced from the main part of the Gem stocks by dip slip on the Dobson Pass fault.

Some of the early-formed tight folds and strike-slip faults were flexed as later rotational stresses were accommodated along newly developed slip planes. Thus, the east end of the Savenac syncline and the adjacent north branch of the Osburn fault were sharply bent and later movement was "short-circuited" along the south segment of the fault. Likewise, the Polaris fault may have accomodated strike-slip deformation after the Placer Creek fault buckled.

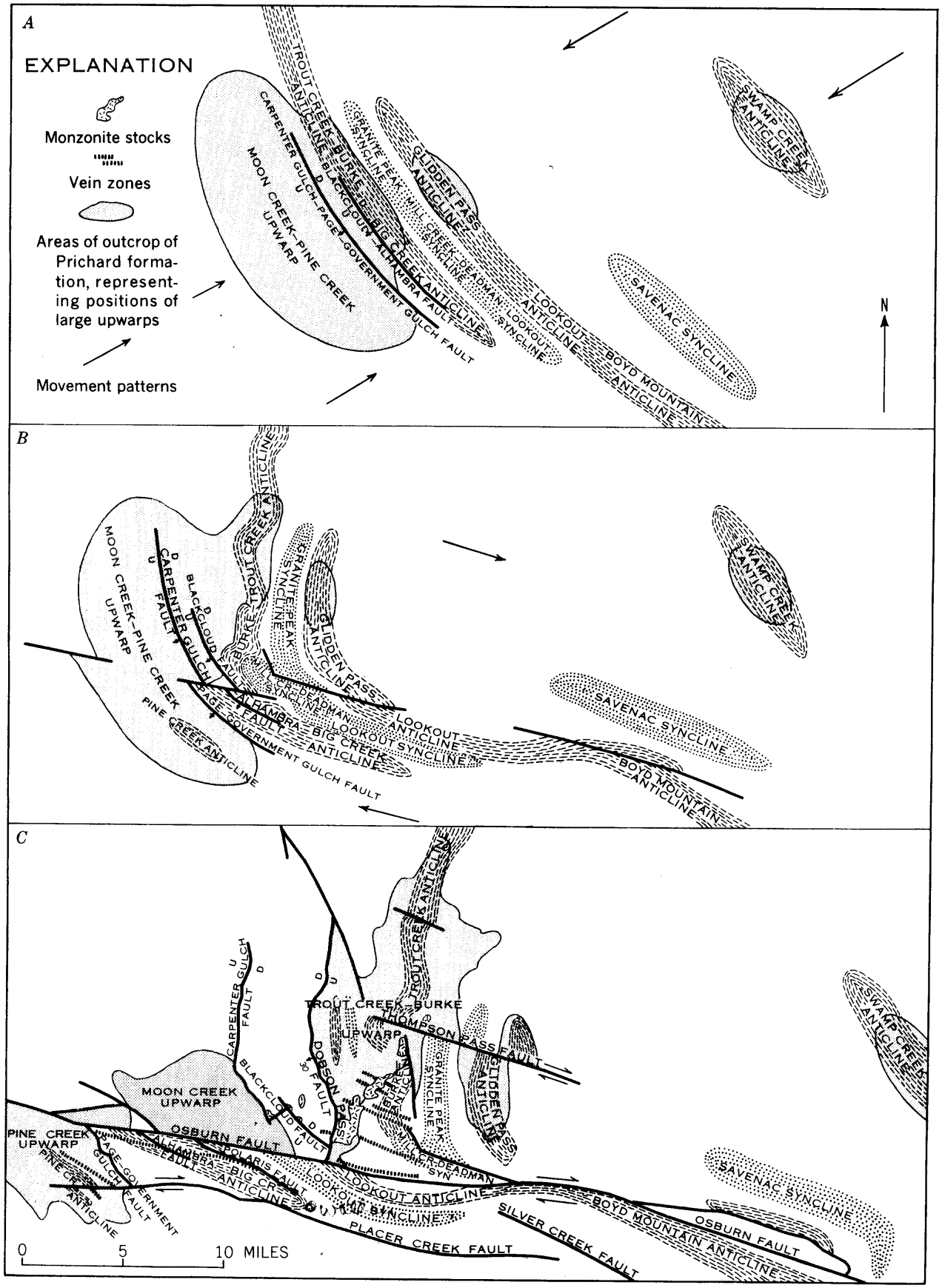

Figure 2 - Three stages (A to C) in the development of the tectonic setting of the Coeur d'Alene district, Idaho.

Late normal faults, some resulting from the final stages of strike-slip deformation, and others possibly of Quaternary age (Pardee, 1950), have affected the area.

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GENERAL FEATURES OF THE ORE DEPOSITS OF THE COEUR D'ALENE DISTRICT, IDAHO*

by

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The ore deposits of the Coeur d'Alene district are replacement veins that appear to be characterized by simple structural controls, and, though the list of hypogene vein minerals is reasonably long, individual veins have simple mineral makeup. Six periods of mineralization are recognized, of which one, here designated the Main period, was responsible for the major ore deposits of the district. The earliest two are believed to be Precambrian, the Main period Cretaceous, and three less important ones to be Tertiary in age.

The oldest mineralization of the district consists of zones of disseminated arsenopyrite that are older than the uraninite veins (Kerr and Robinson, 1953, p. 507). The oldest veins of the district contain uraninite of Precambrian age (Kerr and Kulp, 1952, p. 86; Eckelmann and Kulp, 1957, p. 1130). It seems that the main period of bleaching antedates the uraninite veins.

The productive veins of galena, sphalerite, and tetrahedrite, all considered to belong to the same period of mineralization, are younger than monzonitic stocks that have been dated as Late Cretaceous (Larsen and others, 1958, p. 51). These Main period veins lie in 12 mineral belts and sub-belts which cut the country rock without regard for fold attitudes or lithology. They appear to have originated as zones of fracturing and shearing that extended to great depths, although the individual fractures probably had only slight to moderate movement. These fractures have served as the channels from which replacement of the country rock started.

The Main period of mineralization was accomplished in several episodes or stages. "It would seem, therefore, that movement concurrent with deposition, so that lodes of different systems were reopened at different times, is a sufficient explanation of preponderant galena and siderite in the Bunker Hill area, quartz and galena in the Jersey area, a mixture of the four predominant minerals of the region in the Blue Bird lodes, quartz and galena in the Hecla, sphalerite, quartz, and siderite in the Interstate-Callahan, and quartz and pyrite in the gold area near Murray" (Umpleby and Jones, 1923, p. 132).

The distribution of ore and gangue minerals which resulted from the fractures being open and accessible during part of the Main period of mineralization and closed during other parts appears at first sight to be chaotic. However, if the distribution patterns of minerals formed during the different stages are considered separately, a fairly orderly zoning of concentric, linear, and planar patterns can be demonstrated. Furthermore, the distribution of minerals in the veins of the Main period suggests derivation from three different sources: (1) the roots of the monzonitic stocks; (2) a

*Publication authorized by the Director, U.S. Geological Survey.

deep linear source, more than 95 miles long, that may have tapped the top of a cooling batholith; and (3) a deep point source that may have been nonmagmatic in nature. As the oldest source (the monzonite) appears to be Late Cretaceous in age, the Main period veins are also considered to be of that age.

Most of the Main period veins strike N. 60°-70° W. and dip 65°-85° S., but there are many exceptions. Many of the ore shoots are of considerable size. The largest ore shoot is in the Morning Star vein, where a nearly vertical ore shoot is known to have a vertical length of 6,700 feet, a horizontal length of 4,000 feet, and a maximum width of 50 feet. Most are much smaller, but strike lengths and vertical extents of 1,000 feet are common. Stope widths vary considerably but are commonly 6 to 10 feet. These veins have been formed by a series of replacements of quartzose slate and quartzite that started from quite unimportant-appearing fractures. Initial replacement of the country rock was commonly incomplete, as was the replacement of older by younger ore and gangue minerals. Some veins consist of lenses, stringers, and disseminations of galena and sphalerite in country rock with virtually no introduced gangue minerals. In other veins the ore sulfides more or less completely replaced earlier amphibole, siderite, or pyrrhotite that contain a few remnants of country rock.

Several groups of veins, probably younger than the Main period veins, are considered to be of Tertiary age. Veins of what are called the First Tertiary period contain galena, yellow sphalerite, and nonargentiferous tetrahedrite. The existence of these veins was first recognized by Shannon (1926, p. 167). Only two of these veins are known to cut a Main period vein. Veins of what is called the Second Tertiary period have been mined for stibnite, and one also contained mineable quantities of scheelite. The gold-scheelite veins of the Murray district, recognized by Shenon (1938, p. 23) as being younger than the base metal veins of that area, also are probably of this age. Veins of what is called the Third Tertiary period have been recognized only where they cut diabase dikes; they contain dolomite, quartz, arsenopyrite, and a small amount of gold. A group of large, essentially barren quartz veins, the only large quartz veins in the district, have been explored for gold with little success. These veins may also be of Tertiary age, but there is no evidence for grouping them with any of the other Tertiary veins. Calcite-pyrite veins that cut Main period veins in the area surrounding the stocks are probably also Tertiary in age.

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MINERAL BELTS NORTH OF OSBURN FAULT
COEUR D'ALENE DISTRICT
SHOSHONE COUNTY, IDAHO

Abstract of an unpublished thesis by

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The caption area has contributed about one-half the district production with an average grade of 4.2 ounces of silver per ton, 7.3 percent lead and 3.1 percent zinc.

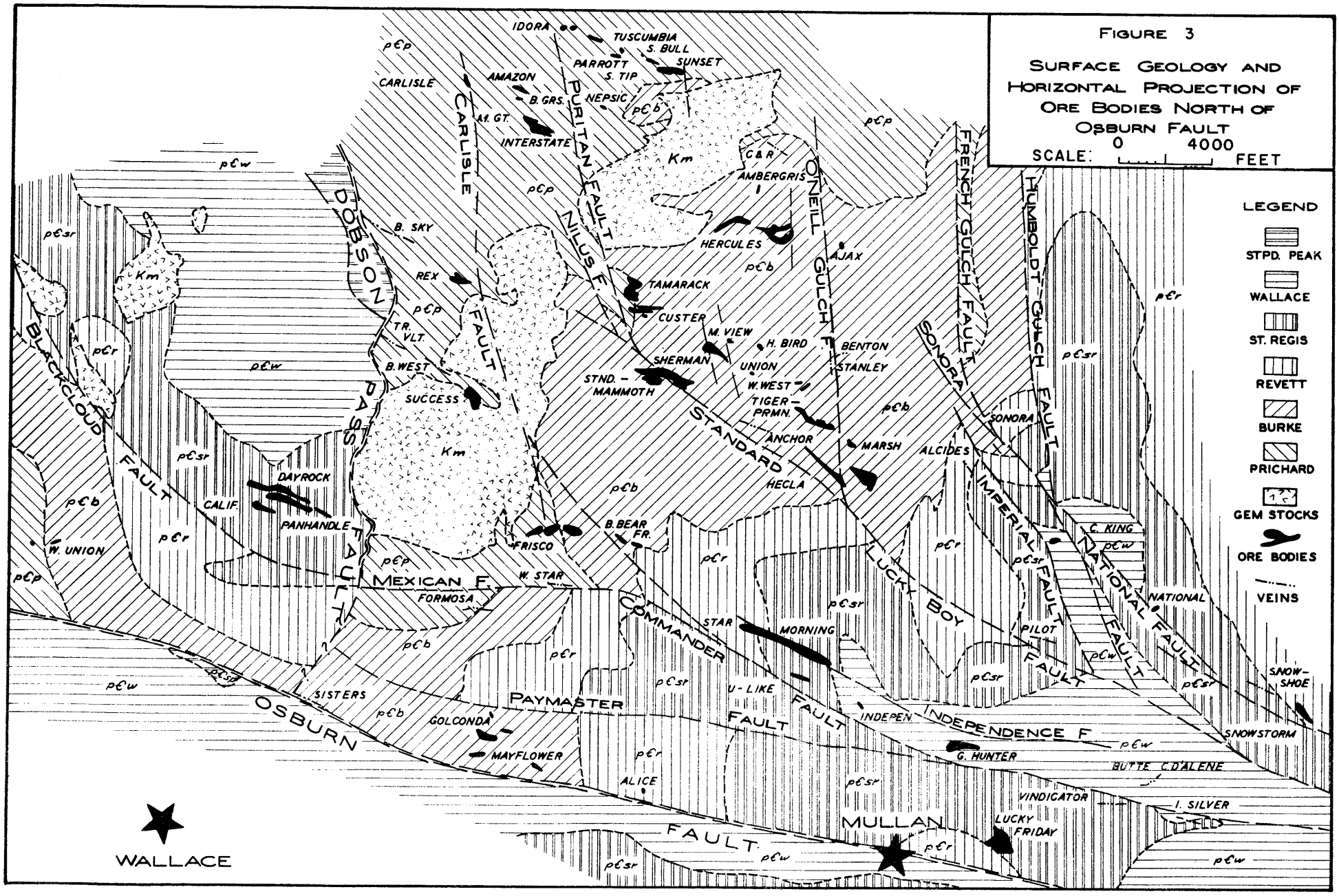
The Coeur d'Alene district is underlain by complexly folded and faulted siliceous Precambrian Belt rocks intruded by Late Cretaceous granitic stocks (see Figure 3). The dominant structure is the great Osburn fault with right-lateral strike slip of 16 miles. R. E. Wallace and associates suggest early folding and up-warping followed by major faulting partly concurrent with stock emplacement and district mineralization. The result is a 16-mile separation of this from the other area which lies south of the fault.

East-southeastward-trending faults converge on the Osburn fault. Toward the west they junction with north-striking faults which appear to be "working their way around" the stocks. The vicinity of these junctions have been the sites of profuse base metal vein mineralization. Horizontal projections of ore bodies are shown in Figure 3.

Ore deposits occur in mineral belts which follow the trends of east-southeast faulting. While adjacent ore bodies may lie along crude projections of each other they are not connected by vein fractures. Rather, they are mutually allied to district structures in the belt relationship. Figure 4 shows the mineral belt pattern.

Each belt is characterized by an assemblage of deposits having similar metal combinations; the belts are classified as follows:

LEAD BELTS	PRODUCTION (tons)	% LEAD	% ZINC
Hecla Belt	14,741,397	9.8	1.5
Hercules Belt	3,520,407	11.0	1.3
Lucky Friday Belt	689,962	6.5	2.4
C & R Belt	(no record)		
ZINC BELTS			
Interstate Belt	1,597,801	3.9	12.6
Success Belt	784,475	2.0	7.4



From an unpublished thesis by Garth M. Crosby

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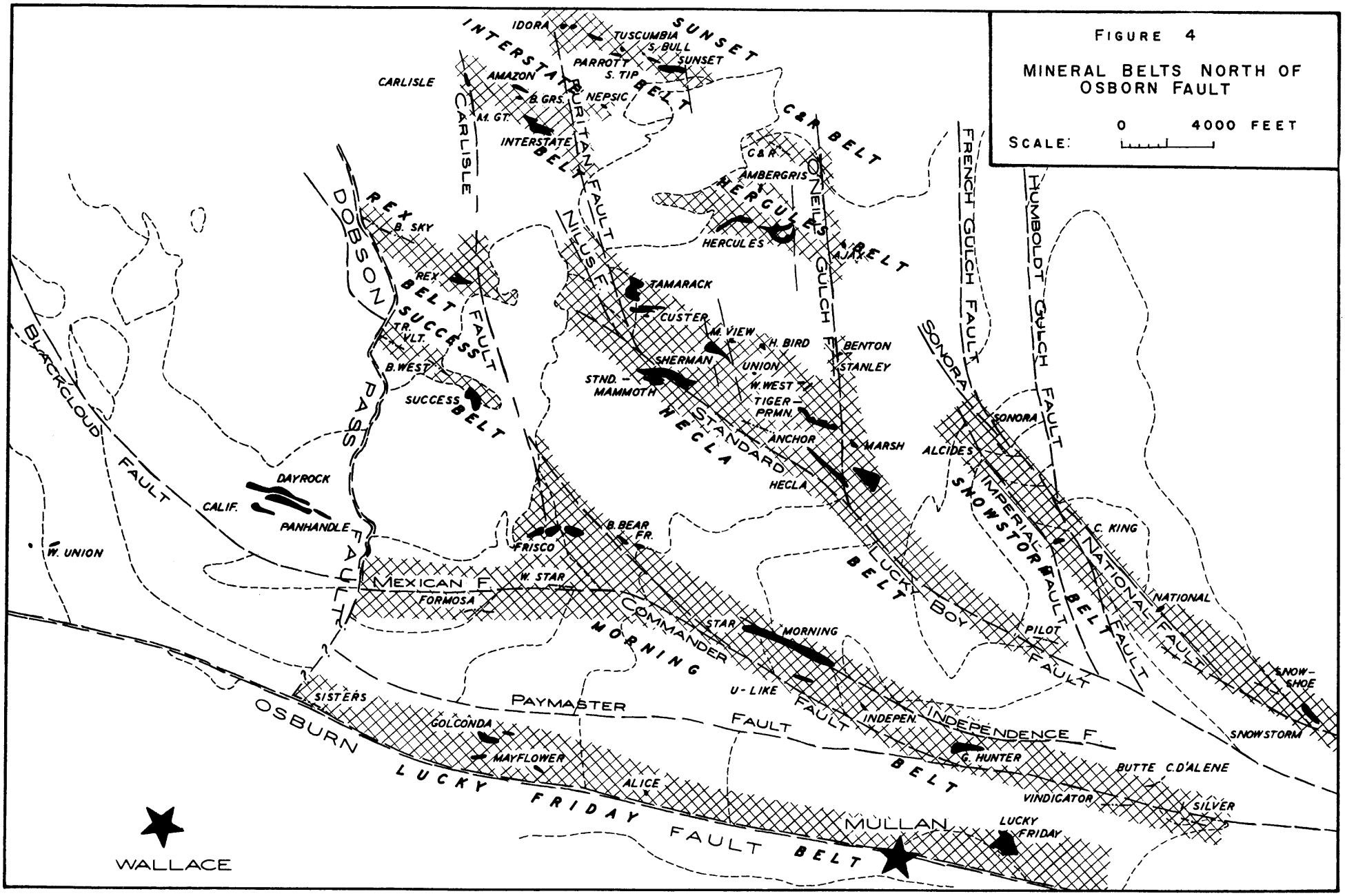

From an unpublished thesis by Garth M. Crosby

LEAD-ZINC BELTS

Morning Belt	24,281,944	6.0	3.7
Rex Belt	169,762	3.2	3.2
Sunset Belt	431,319	4.0	5.7

COPPER BELT

Snowstorm Belt	820,008	(1.5 -6.5	% Copper)
Total	47,923,159	7.3	3.1

Metal zoning around the stocks is absent, but individual ore bodies display increasing zinc/lead ratios with increasing depth.

Of unexplained significance is the fact that ore bodies are situated near either the St. Regis - Revett or Burke - Prichard contacts. Further emphasis is given the observation by the lack of any occurrence near the intervening Revett - Burke contact. The one exception is an occurrence in Wallace formation. A tabulation of production from each stratigraphic "Band" is given below:

STRATIGRAPHIC "BAND"	NO. MINES	PRODUCTION (tons)	OZ AG	% PB	% ZN
St. Regis - Revett	6	21,120,706	2.6	6.0	3.9
Burke - Prichard	37	23,642,532	5.6	8.7	2.6
Wallace	1	3,159,921	3.8	3.6	
Total	44	47,923,159	4.2	7.3	3.1

BLEACHING IN THE COEUR D'ALENE DISTRICT, IDAHO*

by

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A striking feature of the Coeur d'Alene district is the presence of large elongated masses of what is commonly called bleached rock, though its color is pale yellowish green rather than white; many of these masses are associated with ore deposits. Not all of the bleached rock contains ore, nor do all ore deposits occur in bleached rock, but the association is sufficiently frequent so that the bleached rock has been recognized and used as a general guide to prospecting for 20 years or more. Geologists who have worked in the district have generally regarded bleached zones as being of hydrothermal origin and related in some way to the ore deposits. The cause of the bleaching, however, is in dispute. Two views have been expressed: (a) A number of workers, among them Shenon and McConnel (1939), believe that the bleached rocks have been sericitized--that is, that they have undergone hydrothermal alteration that converted pre-existing minerals to sericite. (b) Others, notably Mitcham (1952), believe that the bleached zones are places where certain of the pigmenting minerals have been replaced or removed. The present investigation is principally an effort to decide between these views.

The rocks involved in the bleaching are a part of the Belt series, of late Precambrian age. All are thin-bedded, fine-grained, slightly metamorphosed, quartz-rich rocks. They include quartzites, phyllites, slates, and all the many intermediate types. Adjacent beds may differ widely in composition, mainly because they contain different proportions of the two principal minerals, quartz and sericite. Quartz content ranges from about 10 percent to 90 percent, and the sericite varies essentially inversely through about the same range. The rocks also contain about 5 to 10 percent of other material--rock fragments, carbonates (including calcite, dolomite, ferrodolomite, ankerite, and siderite), plagioclase and potassium feldspar, chlorite, hematite, magnetite, pyrite, zircon, tourmaline, rutile, carbonaceous(?) material, and probably leucoxene and goethite. The bleached rocks contain the same minerals, except that hematite, chlorite, carbonaceous(?) material and in places pyrite are absent.

One way to approach the problem of the nature of the bleaching is to consider what characteristics the bleached rocks should have if they were sericitized. Those that come to mind are as follows:

1. Sericitized rocks should contain more sericite than unbleached rocks--which should be apparent both in thin sections and in chemical analyses.

2. Sericitized rock should contain veinlets of sericite and pseudomorphs of sericite after other minerals, especially detrital feldspar; it should show replacement textures where the process was incomplete.

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*Publication authorized by the Director, U. S. Geological Survey.

3. Introduced sericite should have random orientation, in contrast to sericite formed under stress during metamorphism. Some pre-existing flakes of sericite might be enlarged.

4. Progressive, systematic differences in sericite content from place to place should be recognizable, especially where such differences are related to structural features.

5. Ore deposits and zones of sericite-rich rock should bear some recognizable relation to each other as well as to structural features.

If sericitization were responsible for the color changes that define the bleached zones, then one or more of these features should be readily identified in strongly bleached rock. Not one of these features was found, however, in the bleached rocks of the Coeur d'Alene district.

Specimens that contained both bleached and unbleached parts of the same bed were studied with particular care. Without exception, these specimens showed no difference between altered and unaltered rock in content of sericite, carbonates, and detrital feldspars. Other evidences of sericitization are similarly lacking in the bleached rocks. The conclusion is inescapable; the bleached rocks do not owe their color to sericitization.

The mineralogical changes that accompanied the bleaching are simple. Hematite, carbonaceous(?) material, and green chlorite, the principal pigmenting minerals, are absent from the bleached rocks; otherwise the mineralogy of bleached and unbleached rocks is identical. It should be emphasized that the proportion of sericite has not been increased by bleaching.

The intimate association of bleached zones to faults and areas of more disturbed rocks, and their generally close relation to ore deposits, suggests a hydrothermal origin. The problem, then, is to define the probable range in temperature and chemical composition of a solution that will attack hematite, carbonaceous material, and green chlorite without attaching such relatively susceptible minerals as carbonates and feldspars. The solutions cannot have been strongly acid, or they would have attacked the carbonates. Nor can they have been strongly alkaline, for feldspars, especially plagioclases, are attacked by strongly alkaline solutions and hematite is not. It appears that their temperature range can also be roughly bracketed, within the limits 110° and 150° C, for although hematite can be hydrolized to goethite in nearly neutral solutions within that approximate range (Smith and Kidd, 1949, p. 411), it is stable at higher and lower temperatures. The effect of such a solution on chlorite and carbonaceous material is unknown; one can only assume that because in the bleached rock the supposedly carbonaceous material is absent and the chlorite is altered to a colorless though apparently sheeted mineral, the effect of the bleaching solution on them was similar to its effect on hematite.

Although the precise chemical composition of the bleaching solution is not known, the solution apparently need not have contained anything other than nearly neutral warm water. It may have contained a little CO_2 or H_2S, but these evidently were not essential. The solution may have removed the pigmenting minerals, or have caused them to recombine with other minerals in the rock, or have aggregated some of them into such large grains that they were no longer effective as coloring agents; in some places the rock may have been affected by any one of these changes or by two or three of them. The final result, at any rate, was the destruction of disseminated dark-colored pigmenting minerals, apparently without any other change.

Hydrothermal solutions consisting merely of warm water are a far cry from the solutions that many geologists envision as agents that deposited the ores. Such apparently great differences between the two solutions indicate that they must have been separated both in time and in source, but further work will be necessary to provide the details of origin and age of the bleaching solutions, and their relations, if any, to the ore solutions.

One of the few places in the district where both bleached and unbleached rocks are well exposed and readily accessible is at the Rock Creek Tunnel, on the south side of U.S. Highway 10, approximately 3 miles east of Wallace, Idaho. The portal of the tunnel is on the east line of sec. 31, T. 48 N., R. 5 E., and lies about 150 feet south of the highway. Good specimens can be found on the dump; exposures exist in the tunnel, but bad air prevents exploration of the working for more than a few hundred feet.

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COEUR D'ALENE HIGHLIGHTS

by

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Although the discovery in 1860 by E. D. Pierce and associates of gold in the Pierce area led to the first mining in Idaho just a century ago and to the formation of Idaho Territory in 1863, gold had been discovered in north Idaho prior to 1860. A French-Canadian is believed to have found gold on the Pend Oreille River in 1852; both Father DeSmet and Captain John Mullan knew of the presence of gold in north Idaho as early as 1854.

The Coeur d'Alene district, destined to far outstrip all other Idaho mining camps, was a relative latecomer. It was a placer discovery that started the district. In 1881 and 1882 A. J. Prichard found gold on several creeks near what is now Murray; his finds caused a stampede to the new gold belt in the summer of 1883. A town named Eagle City materialized almost out of thin air. T. A. Rickard (A History of American Mining, 1932, p. 319-320) described the new camp:

> "The buildings were made of logs and shingles. Shoveling of the snow in front left a mound between the houses and street. From big tents with gaudy signs came sounds of barbaric music, the click of poker chips, the clink of coin over the bar. At the corner stood groups of men talking about mines and mining, some of them examining specimens as they were passed from hand to hand. The stores exhibited lumps of gold-spattered quartz. A pistol shot would cause a transient flutter and the saloons momentarily disgorged a motley crowd. Pack trains arrived weather-worn and delapidated from hard travel and after them came the poor fellows that had dragged their belongings on sleds and toboggans over the snow-covered trail from Thompson Falls, their ardor having been excited by the flamboyant advertisements issued to boost the newly constructed Northern Pacific Railroad. An air of expectation pervaded the community, the town was full of life and hope, a transitory gleam."

The first silver-lead lode in the district was the Tiger, discovered in May, 1884. Within a few months followed the discovery of many of the richest and most productive mines in the district--the Poorman, the Gold Hunter, the Morning, and many others. In the fall of 1885 the biggest mine of them all--the Bunker Hill--was found by Noah Kellogg and/or his jackass. As Rickard (1932, p. 321-322) repeats the story:

> "Kellogg's yarn was that the donkey went astray and that he found the animal mesmerized by a brilliant mass of ore. In the memoirs of Jim Wardner...the tale of Kellogg is given thus: 'Looking across the

creek we saw the jack standing upon the side of the hill and apparently gazing intently at some object which attracted his attention. We went up the slope after him expecting that as usual he would give us a hard chase but he never moved as we approached. His ears were set forward, his eyes were fixed upon some object, he seemed wholly absorbed. Reaching his side we were astounded to see the jackass standing upon a great outcropping of mineralized vein matter and looking in apparent amazement at the marvelous ore shoot across the canyon which...was reflecting the sun's rays like a mirror.' This is a mere concoction and it may seem frivolous to quote it but the story of Kellogg and his burro is as much a part of mining tradition in the northwest as was that of Jason and the Golden Fleece among the Greeks in the dawn of mining adventure. Neither Wardner nor Kellogg nor the gentle jackass, nor even the keenest of observers ever saw a glistening mass of galena outcropping there or anywhere else in nature.... Portions of the Bunker Hill outcrop can still be seen near the place of discovery. They consist of iron-stained quartzite containing specks of lead material."

By 1891 the value of Shoshone County's mineral production exceeded the combined production of the rest of Idaho. Around the turn of the century two other big lead mines, the Hecla and the Hercules, were brought into production. By 1903 annual lead output of the district was up to 100,000 tons.

Labor disturbances in 1892 and 1899 gave a sinister fame to the Coeur d'Alene district. In 1892, growing bitterness between members of the miners union and the mine owners protective association exploded into violence during the long day of July 11. About daybreak a pitched battle broke out between union strikers and nonunion men at the Frisco mine; after the strikers had wrecked the Frisco mill by sending giant powder down the flume into the waterwheel, the fight was continued at the Gem mine. The union forces prevailed. Five men were killed and a considerable number wounded. After their victory at the Frisco and the Gem, the strikers proceeded to Wardner, took possession of the Bunker Hill mill, placed a ton of powder under it, and by threatening to blow it up, forced the management to discharge their nonunion workers. But martial law was promptly declared and many of the nonunion men returned. The strikers had won a battle but not the campaign.

In 1899 another strike was called against the Bunker Hill.

"On April 29th of that year a group of masked men took possession of a train at Burke, compelled the engineer to back the train to the powderhouse at the Frisco mine, where 70 boxes of dynamite were loaded on a box car. By the time the train got to Wallace there were about a thousand men on board, of whom 300 were masked and armed. They left the train near Wardner and went to the Bunker Hill mill which was

then completely destroyed by dynamite.... Again United States troops were sent into the district...and about 500 men suspected of complicity in the destruction of the mill were rounded up and imprisoned all summer in a bullpen at Kellogg. The troublemakers were scattered effectively and normal conditions of production were restored by the end of the year." (Rickard, 1932, p. 333-335)

Spurred by World War I demand, Idaho's lead production reached its all-time peak of 187,768 tons in 1917. Since then it has fluctuated widely, according to economic conditions.

Zinc in the lead ores of the Coeur d'Alenes was known from the earliest days, but it was regarded as a nuisance. The first big spurt in zinc output came during World War I, reaching a high of 48,960 tons in 1916. But by 1921 production had dropped to a mere 909 tons, despite steady improvement in metallurgy that was making possible the successful separation of zinc and lead in complex ores. Although there was an upsurge in the late 1920's zinc continued in the role of byproduct until World War II when mines with zinc ore bodies finally came into their own. In 1944 zinc output topped lead for the first time. During the 1941-1950 decade the total value of zinc produced exceeded that of lead, $191,000,000 to $186,000,000.

Silver likewise was a byproduct in most Coeur d'Alene mines until the Sunshine mine got into profitable production late in the 1920's. By 1931 when the first real bonanza ore was opened on the 1700 level, the Sunshine was the second largest silver producer in the nation. In recent years the Galena and the Lucky Friday mines have come into prominence as silver producers.

THE BUNKER HILL MINE

by

Roger H. McConnel
Chief Geologist
The Bunker Hill Company, Kellogg, Idaho

The purpose of these notes is to present some very brief remarks on The Bunker Hill Company's Coeur d'Alene District operations and the geologic features of the Bunker Hill mine.

Production

Production, 1885 through 1960, is approximately as follows:

25,270,000 tons of ore
2,078,000 tons of lead
286,000 tons of zinc
93,082,000 ounces of silver

The gross value of this production at present metal prices (11¢ lead, 11-1/2¢ zinc, and 93-1/2¢ silver) is approximately $608,000,000.

In recent years the annual rate of production from the mine has varied as follows:

350,000 to 530,000 tons of ore
26,000 to 35,000 tons of lead
9,500 to 12,500 tons of zinc
1,750,000 to 2,200,000 ounces of silver

The Bunker Hill mine contains well over 100 miles of underground workings, and at present extends for nearly a mile in depth, from 3600 feet above sea level to 1350 feet below sea level.

In addition to the Bunker Hill mine, the company owns and operates the Crescent silver-copper mine near Kellogg and owns the Star zinc-lead mine between Burke and Mullan, Idaho, which is operated by Hecla Mining Company.

The company operates a lead smelter having a capacity of about 100,000 tons of lead per year and an electrolytic zinc plant producing about 60,000 tons of super-high grade zinc per year. These plants also produce cadmium, silver, gold, leaded-zinc oxide, zinc die cast alloys, copper matte and speiss. In addition the company operates a sulfuric acid plant producing about 100,000 tons of acid per year, and has just started a phosphoric acid plant having a capacity of 47,000 tons of 54% P_2O_5 acid per year.

The ore bodies occupy a diverse group of fractures within the steep to overturned north limb of a major anticline involving quartzites and argillites of the Precambrian series.

Rock units

The only formations exposed in the mine workings are the Revett and St. Regis formations. In general, the Revett formation is made up of rather massive quartzites, with relatively minor amounts of argillaceous rocks. The St. Regis formation is made up of argillites and argillaceous quartzites, and its upper portion is quite argillaceous. The base of the St. Regis formation grades downward into nearly pure quartzites. There is no sharp line of demarcation between the Revett and the St. Regis formations, and there are no well defined "marker" beds within them.

The bulk of the metal that has been mined has come from the zone of somewhat argillaceous and moderately thin-bedded rocks of the lower St. Regis formation. These rocks are apparently of the proper hardness and consistency to maintain openings for ingress and deposition of ore, being neither too soft and "muddy" nor too hard and brittle.

Rock alteration

Rock alteration consists of "bleaching", most of the St. Regis formation in the mine being gray and greenish gray in color. Unbleached St. Regis formation is characteristically purple. Bleaching cannot be recognized in the normally white and gray rocks of the Revett formation.

As a guide to ore, bleaching is only of the most general use, as most of the St. Regis formation within the mine is bleached, and ore bodies may occur anywhere within these bleached rocks.

Major faults

The major faults of the mine (and these make up the skeleton with which the ore bodies are associated) are the Cate fault, the Sullivan, Dull, and Kruger faults.

The Cate fault is the major structure in the mine. It strikes northwesterly and dips southwest at about 40 to 60 degrees. It is pre-mineral in age, but movement has taken place on it subsequent to mineralization.

The Sullivan, Dull, and Kruger faults lie northeast of the Cate fault and strike somewhat more westerly than the Cate fault, so that on all except the deeper levels each of them intersects the Cate fault at the north and west. They dip 50 to 80 degrees southwest.

Ore bodies

Many ore bodies occupy the Cate fault and fractures in either wall of the Cate fault, often, but not always, at locations where the attitude of the fault changes. The vicinity of the Cate fault, therefore, has been the site of some of the largest ore bodies in the mine (the March ore shoot for instance).

Ore bodies in the vicinity of the Cate fault have diverse trends, and individual fractures comprising those ore bodies may have the following attitudes.

North striking and west dipping.
Northeast striking and northwest dipping.
Northwest striking and southwest dipping.

Within a single ore body, stringers and lenses of ore usually occupy only one of these trends, but in some ore bodies lenses of more than one trend are evident, and in others lenses and pods of ore are so completely coalesced that individual trends are lost.

In addition to occupying the above trends, there are a number of major veins striking northeasterly and dipping southeasterly. These are found in both the footwall and the hanging wall of the Cate fault. Those in the footwall form links between the Cate fault and the Sullivan, Dull, and Kruger faults. Such veins in the hanging wall of the Cate fault are the Jersey, "N", and Sierra Nevada veins. Those in the footwall are the Motor, Frances, Barr, Mac, Emery, and Truman-Ike veins.

Mineralogy

Mineralogically the ores are relatively simple. The gangue minerals are siderite, quartz, and "ankerite". The sulfide minerals are galena, sphalerite, tetrahedrite, pyrite, a little chalcopyrite, and quite minor amounts of bournonite and boulangerite.

The major northeasterly veins (Jersey, Emery, etc. named above) have a predominantly quartz gangue, whereas the northwesterly and northerly striking ore bodies more closely associated with the Cate fault commonly have a dominantly siderite gangue.

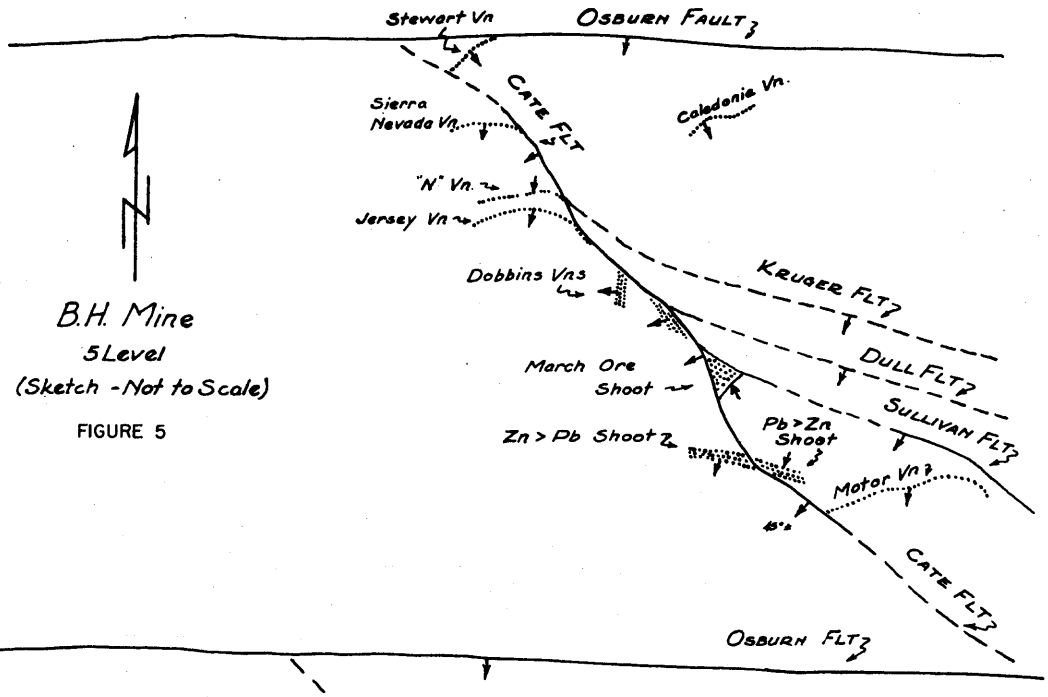
In the hanging wall of the Cate fault there are a series of ore bodies that contain abundant zinc and pyrite. These bodies have been found from the surface down to the deeper levels of the mine.

There does not appear to be any consistent zoning of minerals within the mine as a whole. In fact there are marked contrasts in relative quantities of the various minerals between certain ore bodies. It is therefore thought that differences in mineralogy between ore bodies has been much influenced by recurrent fault movements during the period of mineral deposition, thus from time to time altering the "plumbing system" through which the ore fluids were travelling, and consequently resulting in differences

in mineral content in different ore bodies.

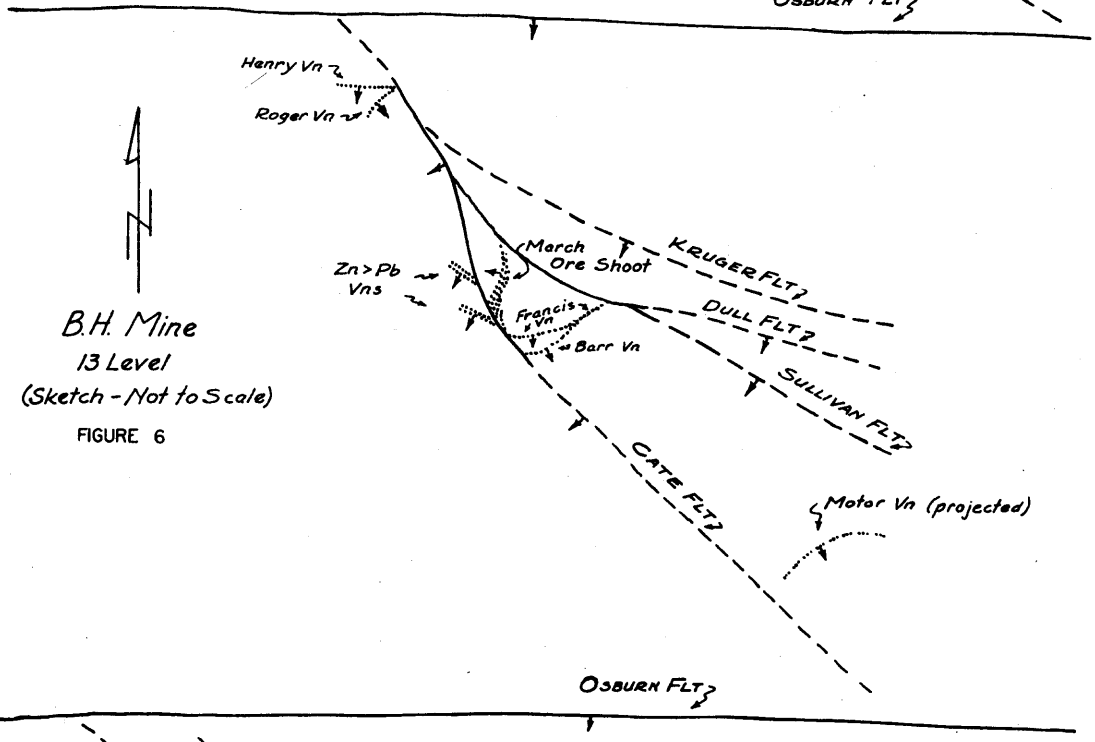
Sketches

There are attached three very generalized sketches to illustrate the structure pattern of the mine. These sketches are not to scale, and are intended only to show the generalized pattern of faults and veins on three levels of the mine, without regard to precise mutual relations in space (Figs. 5, 6, 7).



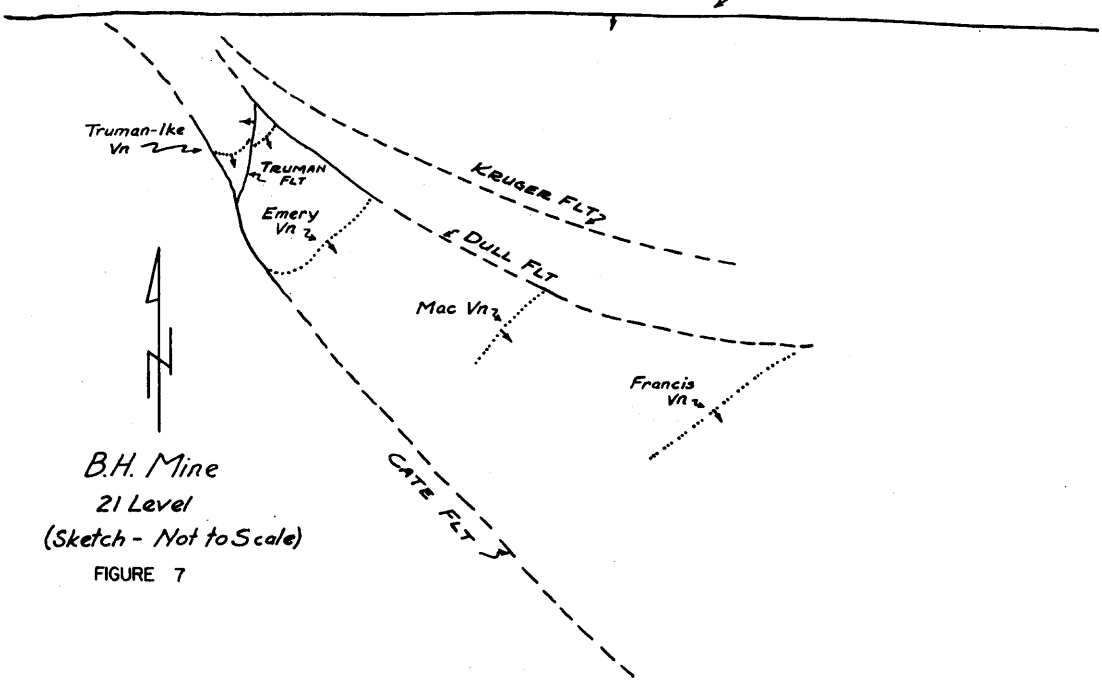
B.H. Mine
5 Level
(Sketch - Not to Scale)

FIGURE 5



B.H. Mine
13 Level
(Sketch - Not to Scale)

FIGURE 6



B.H. Mine
21 Level
(Sketch - Not to Scale)

FIGURE 7

GEOLOGY OF THE DAYROCK MINE

by

Rollin Farmin
Manager of Mines
Day Mines, Inc., Wallace, Idaho

The Dayrock mine lies three miles north of Wallace, Idaho, at elevation 3,200 feet on Ninemile Creek. (See Figure 3 of G. M. Crosby for this series.) Although mineral claims covered the property in 1888, commercial ore was not discovered until 1923. Since that year Dayrock has remained under the present management and has produced about 900,000 tons of lead-silver ore.

Mineralogy

The ore is mainly argentiferous galena, associated with minor pyrite, sphalerite and tetrahedrite. Nonsulphide gangue minerals include quartz, calcite, ankerite, and siderite but the volume of the gangue is subordinate, commonly comprising less than half of the vein. The ore occurs in lenses, stringers and disseminations, rarely marked by banding or other minor structures.

Host rocks

The host rocks for the Dayrock ores are the argillites and quartzites of the central members of the Belt Series, of Algonkian age. Argillites of the St. Regis formation are host through the upper three-quarters of the mine; the lower quarter is in the underlying Revett quartzite. The Revett is harder and more thickly bedded than the St. Regis. Shearing and mineral alteration have softened and "bleached" the argillites, which now contain abundant clay minerals and sericite. Consequently, most of the mine openings must be timbered or rock-bolted to minimize caving.

Immediately east of the mine lies the Gem stock of monzonitic granite but its juxtaposition is the result of miles of movements on the intervening Dobson Pass fault, so no genetic significance should be assumed. A few igneous dikes are found in the mine. All seem to be post-ore: one on the 1100-foot level splits the ore longitudinally for a length of 100 feet. The dikes are altered and softened now but appear to have been intermediate-to-basic types.

Structural geology

The Belt rocks in the Dayrock mine generally strike northwesterly and dip northeasterly at 45-80°. This tilted block of argillite and quartzite is bounded on the east by the Dobson Pass fault and on the south by the Blackcloud fault, followed by the Osburn fault. The principal veins parallel the beds in strike but dip opposite, from 45-80° southwesterly (see Figure 8). The veins have been named Panhandle, Dayrock,

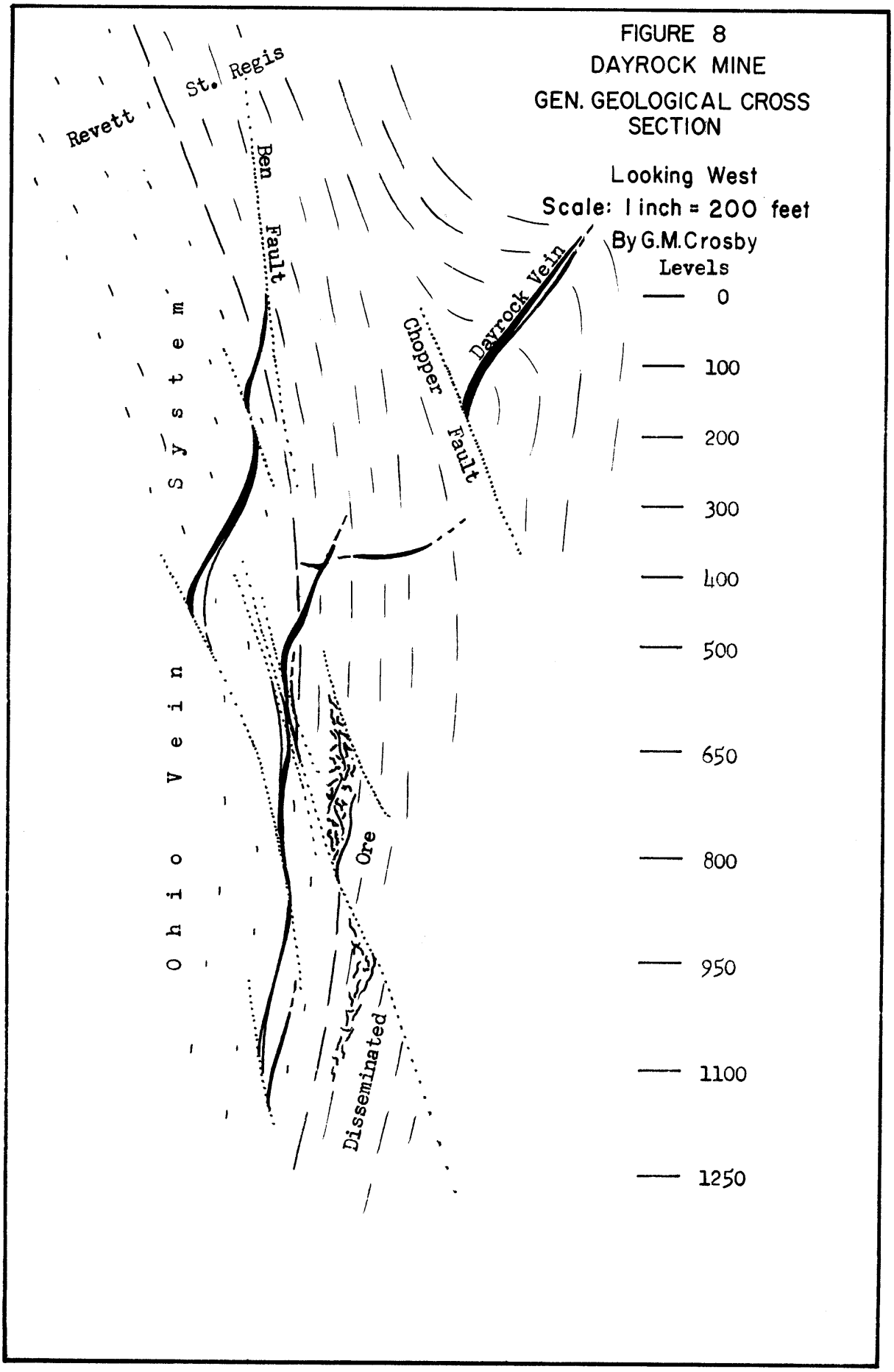


FIGURE 8
DAYROCK MINE
GEN. GEOLOGICAL CROSS SECTION
Looking West
Scale: 1 inch = 200 feet
By G.M.Crosby
Levels
0
100
200
300
400
500
650
800
950
1100
1250
Revett
St. Regis
Ben
Fault
Ohio Vein System
Chopper
Fault
Dayrock Vein
Ore
Disseminated

Ohio, Dora, Bonanza and Hornet, in order of their discovery. In addition, several small ore bodies have been mined on horizontal spur veins; a third type is the steeply-dipping Freeman vein which strikes at right angles to the main veins.

The veins occupy fractures or shears in the host rocks. Additional movements along the fractures after ore deposition has caused some attenuation and over-lapping of vein matter from place to place. Numerous stringers, pods and disseminated bodies of ore minerals scattered between the veins are evidence that the mine block was greatly fractured before mineralization, a condition which facilitated mineral replacement in certain favorable beds. Several veins may be traced for hundreds of feet, mainly as weakly mineralized fractures, with ore shoots where the vein width is greater and the galena content is richer.

A system of transverse normal faults cuts the veins and drops them progressively to the west. The largest, the Murray and the Monarch, have movements of several hundred feet. Another system of faults strikes parallel to the veins but dips opposite, parallel to bedding planes of the host rock. These have post-ore, reverse movements which range up to one hundred feet and they seriously complicate the mine development.

The host rocks, and to some extent the veins, are considerably drag-folded, especially near faults, in an intimate manner not shown in Figure 8 because of its small scale.

GEOLOGY OF THE GALENA MINE

by

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Introduction

The Galena Unit of American Smelting and Refining Company's Northwestern Mining Department is situated in the Coeur d'Alene mining district in northern Idaho, about 85 miles east of Spokane, Washington, and 1-1/2 miles west of Wallace, Idaho, immediately south of U.S. Highway No. 10. The property is owned by the Callahan Mining Company and is leased jointly by Day Mines, Inc., and ASARCO, with the latter having operating control.

The various groups comprising the present property were located in the 1880's but serious mining did not begin until 1917. Between that time and 1946, about 137,000 tons of ore were extracted having an average grade of about 4 oz. Ag per ton and 5% Pb. This mining was done through the Galena shaft, then down to 800 feet, and later through the Callahan winze from the 600 to 1600-foot horizon. By 1946 the ore possibilities above the 1600 level were presumed to have been exhausted. At that time the present operators undertook to sink to the 3000 level and to do a certain amount of crosscutting, drifting and diamond drilling at that elevation. Shaft sinking difficulties slowed the project, but by 1952 the shaft had been completed to the required depth, the Lead Zone had been found on the 3000 level and intensive exploration could be undertaken. During the next year the Lead Zone was explored on both the 3000 and 2800 levels and in February 1953 a crosscut to the south exposed the Silver Vein. Thereafter, attention was concentrated on the latter vein, and in January 1955 the mine embarked on the production stage and a rate of 400 tons per day has been maintained ever since, except for two periods of strikes aggregating more than 12 months.

General geology

The mine is located about 1.5 miles south of the Osburn fault. This is a major strike slip, or zone of strike slips, which has been traced from the vicinity of Coeur d"Alene Lake in Idaho, to Superior, Montana, a distance of about 90 miles. The general strike of the structure is N. 75° W., and the dip is very steep to the south. Horizontal component of movement in the Coeur d'Alene district is said to be about 14 miles, and the vertical component relatively minor, possibly 2,000 feet. The Osburn fault crosses structures--folding and faulting--having a north to northwesterly trend, which pre-existed, or the early elements of which pre-existed, the latest large movement in the Osburn fault zone.

The area is underlain principally by rocks of the Belt series, which are late Precambrian in age. These rocks are sediments of shallow water origin and are made up of quartz and argillaceous material in varying proportions. Those rocks which are principally quartz have now become quartzites, for the most part, while those which were originally shales have been metamorphosed to argillites, phyllites and slates, although the term "argillite" is applied loosely to all the metamorphosed shales. Alteration is widespread in the district and consists of "bleaching", sericitization, and chloritization, with the first two the most common. Almost all veins are within an envelope of bleached and sericitic rock, but this type of alteration is also present for considerable widths in the walls of almost all major faults.

These rocks are intruded by a number of small monzonite stocks in the area north of the Osburn fault. The intrusion is believed to have taken place in Cretaceous time, and mineralization took place during and after the intrusion. Mineral deposits were localized in fractures related to faults which pre-existed the main movement on the Osburn fault, although there may be many exceptions to this generalization.

Several zones of mineralization might be delineated, but for a discussion of the Galena mine, the zone of particular interest is the Silver Belt. This zone lies immediately south of the Osburn fault and extends from just west of Wallace to just east of Kellogg, a length of about 10 miles. It is characterized by deposits of galena, containing some silver, near surface and, at depth, both galena and argentiferous tetrahedrite, the latter predominating. The Galena mine is in the Silver Belt.

Local geology

The present discussion will occupy itself with the geologic setting of the mine and with a description of the veins on the lower and currently active levels.

The rocks in the mine area are argillites and quartzites of the late Precambrian Belt series. Three formations are present:

Wallace formation:	Thinly laminated argillite, argillaceous quartzite and quartzite, all of which are more or less calcareous.
St. Regis formation:	Thinly-bedded purple and gray interbedded quartzite and argillite.
Revett formation:	Thickly-bedded to massive, relatively pure quartzite.

The mine is situated on the north limb of the Big Creek anticline, the axis of which strikes west-northwesterly. The axial plane dips steeply to the south. The north limb of the fold is cut by the Polaris fault, which has an over-all strike of

N. 65° W. and a dip of 60° to 65° to the southwest. The rocks in the footwall of the Polaris fault are overturned steeply to the south near surface but apparently steepen and attain a north dip at sea level.

In the vicinity of the mine the Polaris fault splits into three or four strands. Immediately east of the mine two of the splits are formed which are 250 feet apart at surface at the Galena shaft and 500 feet at the Callahan shaft. The strands are believed to come together west of the mine area and at depth. Coincident with the splitting of the fault into two strands, the strike changes from N. 65° W. to N. 75° to 80° W. and the dip from 65° SW to 80° S. or steeper.

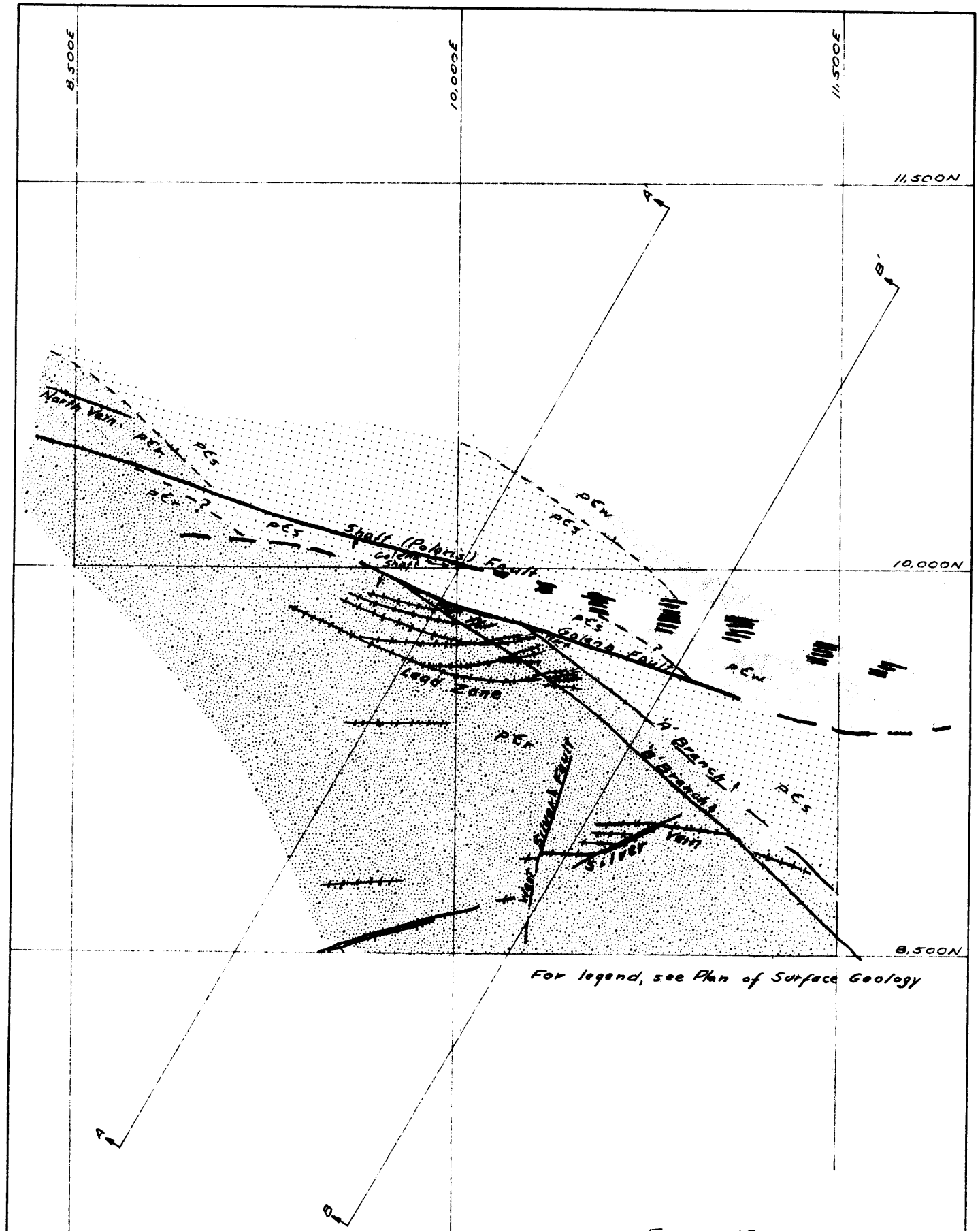
The more southerly of the two strands of the Polaris fault has been named the Galena fault, the more northerly the Shaft fault. In the hanging wall of the Galena fault a series of lesser faults has formed along bedding planes, striking N. 50° to 60° W. and dipping 65° to 75° NE. The members of this series, which are 100 to 200 feet apart, have the appearance of branches of the Galena fault, and have been named 'A' Branch, 'B' Branch, etc. 'B' Branch appears to be the strongest of the lesser faults and to have had the greatest effect upon the veins.

The Lead Zone

This is a zone of fracturing 600 to 1,000 feet long in an east-west direction, 100 to 200 feet wide, and extending a vertical distance of about 1,000 feet. The zone as a whole has a rake of about 45° to the east, but its dip is essentially vertical. It is made up of a series of vein-filled fractures which generally parallel the long axis of the zone but which dip at about 60° S. At some distance from the 'B' Branch, in its footwall, both in dip and strike, the fractures form strong, discreet veins, but near 'B' Branch and between 'B' and 'A' Branches, the rock is much more shattered and the mineralization is spread over a wide zone. The vein material is quartz and siderite holding argentiferous galena. Sphalerite is locally present in very minor amounts, and other, rarer minerals have been observed. The metallic content of the veins decreases as distance from the 'B' Branch increases. In addition to the filled fractures there are disseminations of fine-grained galena in apparently unshattered quartzite.

The Silver Vein

This vein is one of a large number of siderite-filled fractures within a zone about 300 feet wide, but it is the only one of the group with extensive vertical and horizontal persistence, and the only one with persistent values. Where first encountered, on the 3000 level, the vein has an east-west strike, except where it follows a minor fault for a short distance, and a dip of 65° to 70° S. Above this level the strike gradually swings to the northeast, pivoting on the west end, and below it swings towards the southeast, again pivoting on the west end. Furthermore, above the 3000 level, the dip gradually steepens to vertical on the 2400 level and then becomes a north dip above the 2200 level. It also steepens below the 3000 level, but not as markedly.



For legend, see Plan of Surface Geology

FIGURE 10
AMERICAN SMELTING & REFINING CO.
GALENA MINE
PLAN OF GEOLOGY ON 3000 LEVEL (El. +100')
1" = 500' SNK FEB 1, 1961

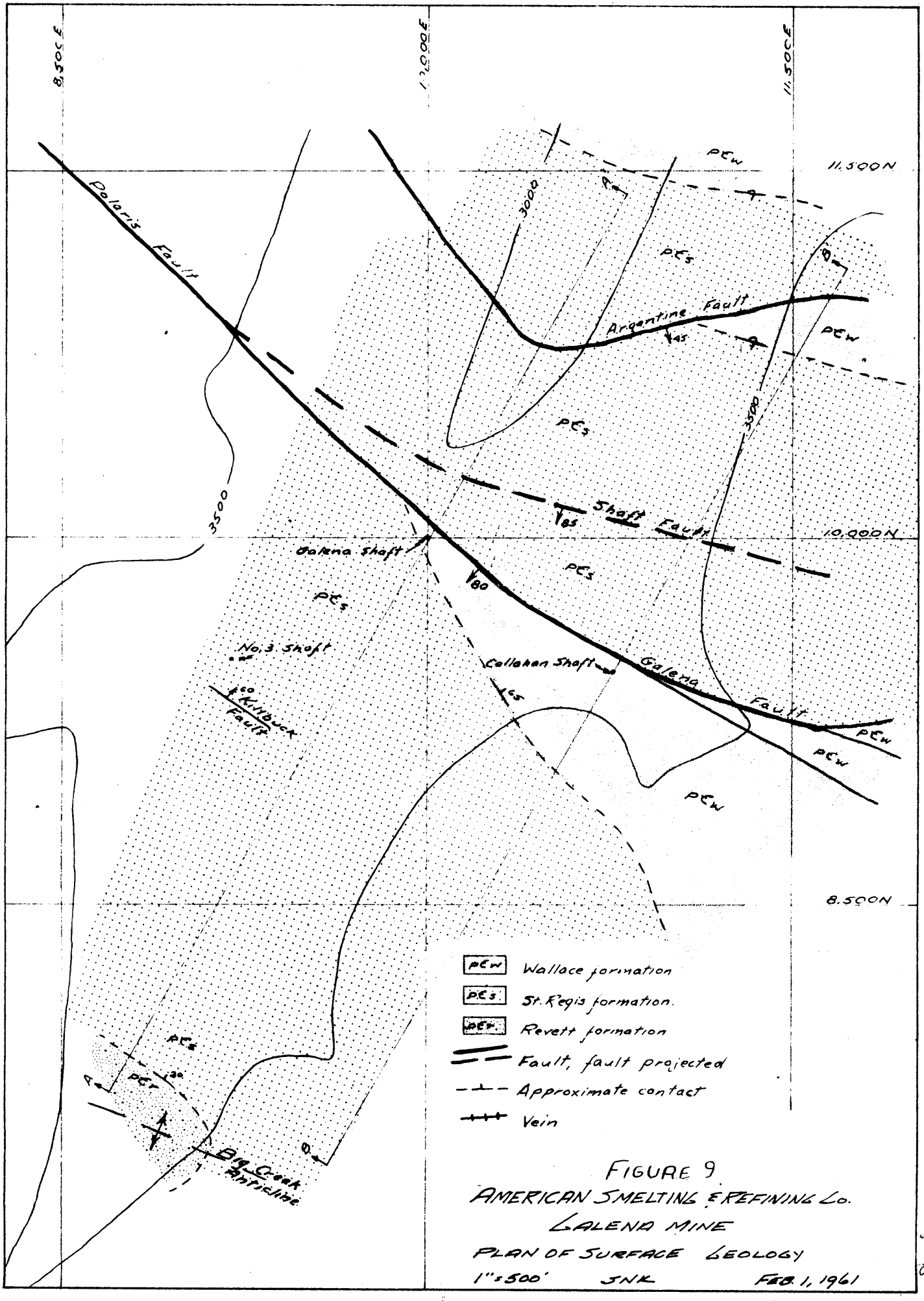


FIGURE 9
AMERICAN SMELTING & REFINING CO.
GALENA MINE
PLAN OF SURFACE GEOLOGY
1" = 500' JNK FEB. 1, 1961

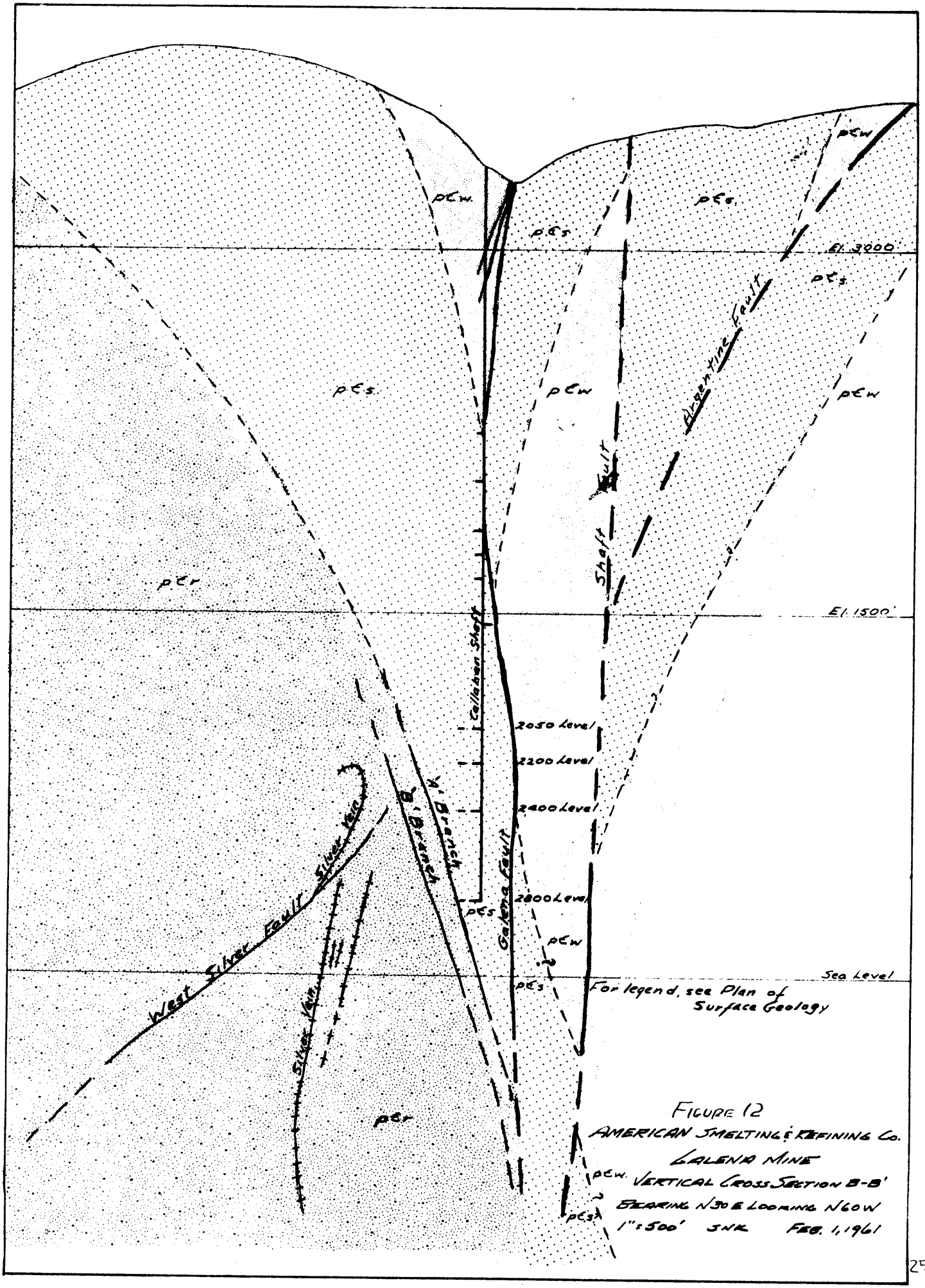


FIGURE 12
AMERICAN SMELTING & REFINING CO.
GALENA MINE
VERTICAL CROSS SECTION B-B'
BEARING N30E LOOKING N60W
1" = 500' JNK FEB. 1, 1961

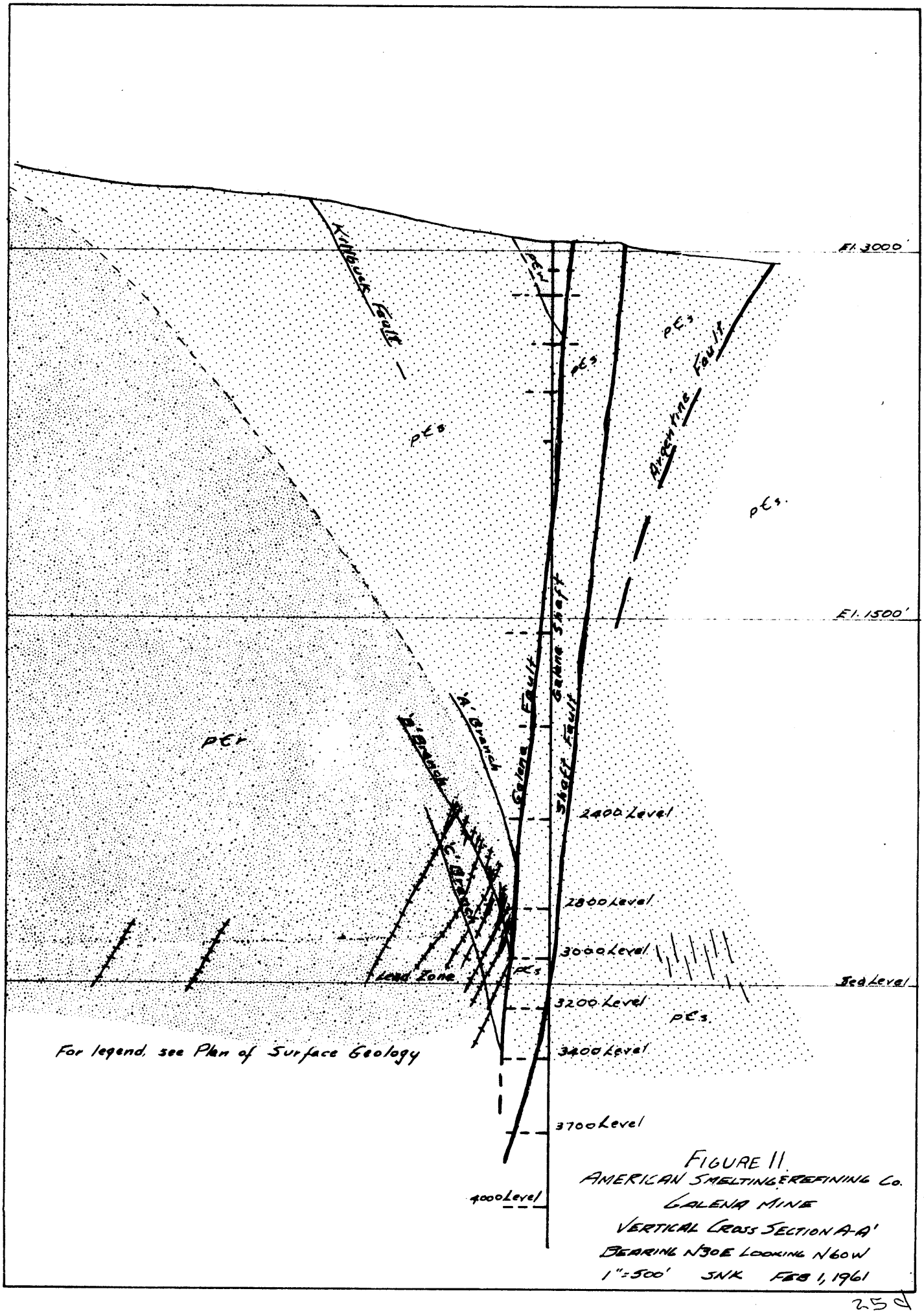


FIGURE 11
AMERICAN SMELTING & REFINING CO.
GALENA MINE
VERTICAL CROSS SECTION A-A'
BEARING N30E LOOKING N60W
1" = 500' SNK FEB 1, 1961

25d

The vein material is predominantly siderite, which holds varying concentrations of tetrahedrite, much less chalcopyrite, and very rarely, some galena. The tetrahedrite is argentiferous and the silver-copper ratio averages about 20:1.

Drawings

Attached are two plans (Figs. 9, 10) and two sections (Figs. 11, 12) to illustrate the mine geology.

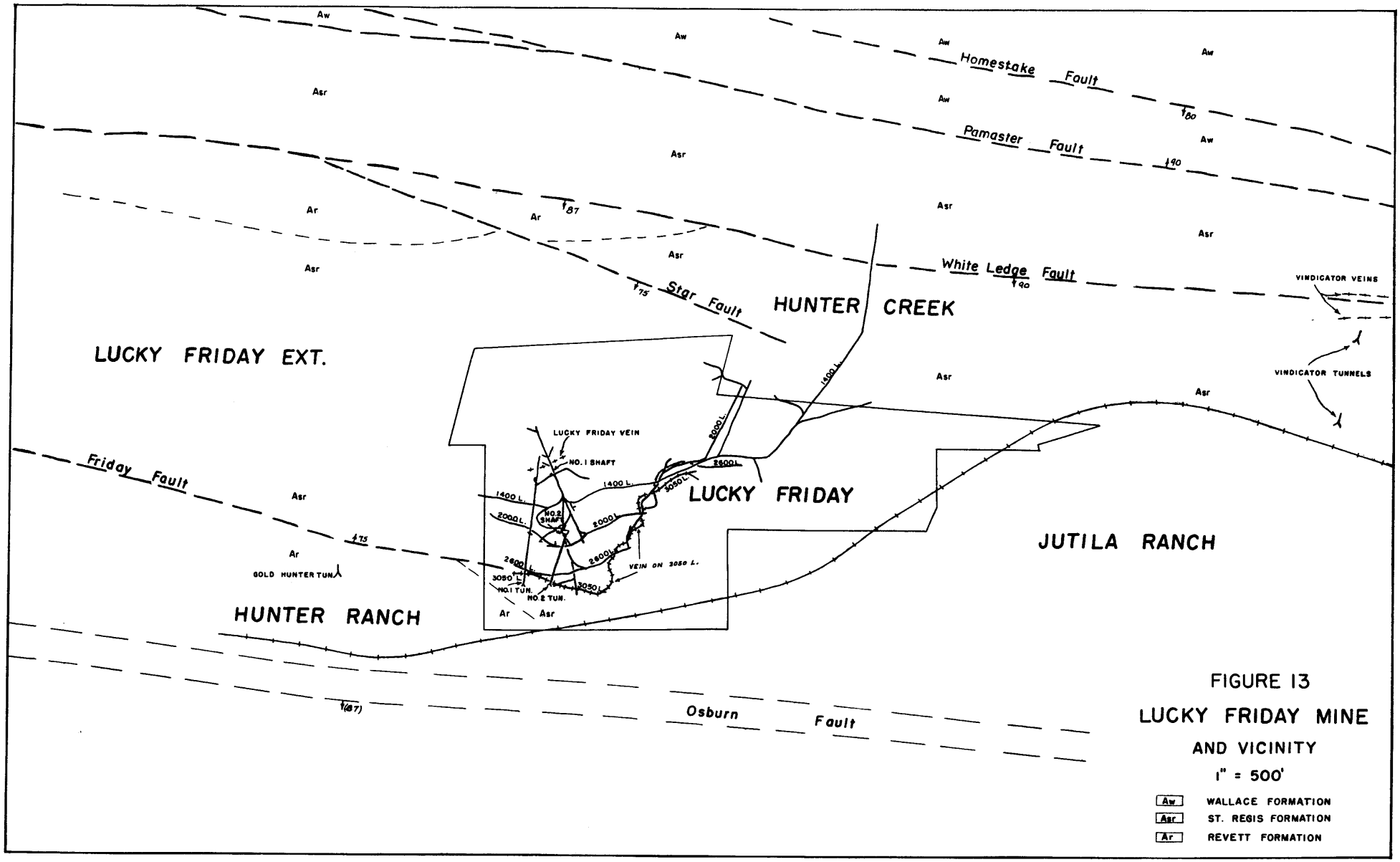


FIGURE 13

LUCKY FRIDAY MINE

AND VICINITY

1" = 500'

Aw WALLACE FORMATION

Asr ST. REGIS FORMATION

Ar REVETT FORMATION

269

GEOLOGY OF THE LUCKY FRIDAY MINE

by

M. W. Hutchinson
Geologist
Hecla Mining Company, Wallace, Idaho

The Lucky Friday mine is an outstanding example of a Coeur d'Alene district property where a small and insignificant appearing silver-lead-zinc vein at the surface has changed with depth into a large and important ore body. The vein has little if any surface expression and above the 1200 level, the veins are small and discontinuous. Between the 1200 level and the 3050 level, the lowest developed level, the vein has shown remarkable improvement so that the Lucky Friday is now one of the major lead-silver producers in the Coeur d'Alene district.

The property is comprised of six claims located about one mile east of the town of Mullan. In addition, Lucky Friday owns a one-half interest in the Hunter Creek property adjoining the Lucky Friday group on the north; a 90 percent interest in the mineral rights of the Jutila ranch adjoining the Lucky Friday on the east; and a 60 percent interest in the Lucky Friday extension group to the northwest. The company also has a long-term mining lease on the Hunter ranch to the west.

Development

The mine is now operated by Hecla Mining Company. It is developed through two vertical shafts. The original shaft was sunk from the tunnel level at an elevation of about 3,365 feet to the 2000 level and was used to explore the vein at 200 foot intervals to that depth. The new shaft, 325 feet south of the original one, extends from the surface to a depth of 3,332 feet and is used as the main hoisting shaft. Below the 2000 level the vein is developed by crosscutting and drifting from the new shaft at 150 foot intervals except for the 2800 level which is half way between the 2600 and 3050 levels. The latter level is currently being developed by crosscuts from a lateral in the north and northeast wall. First floor drifts will be driven on the vein to complete the development on this level and to better facilitate the use of the recently installed sand fill system. Levels below 3050 level will probably be driven at 200 foot intervals with development by laterals and crosscuts for best adaptation to the use of the sand fill system.

The ore is milled in the recently constructed 500 - t.p.d. mill with the ore being transported approximately 600 feet by conveyor belt from the new shaft to the coarse ore bin.

Geology

Stratigraphy

The Coeur d'Alene district is principally underlain by metamorphosed sedimentary rocks of the Precambrian Belt series. The Belt series, aggregating more than 20,000 feet in thickness, has been divided into six formations by the U. S. Geological Survey. These are, in ascending order, the Prichard, Burke, Revett,

St. Regis, Wallace, and Striped Peak formations.

Most of these sedimentary rocks are of shallow water origin and have been regionally metamorphosed so that the prevailing rocks of the district are quartzites, argillite, slates, calcareous shales and rocks of intermediate composition. Because of the common origin and similarity in composition, the contacts between formations are generally poorly defined and in-faulted, folded and especially in bleached areas the division between formations is even less certain.

Rocks in the Lucky Friday mine are St. Regis in the upper part of the mine and Revett in the lower portion, with the vein entering the older Revett formation at about the 1,800 level. They are predominately quartzitic in the vicinity of the main ore body, but vary from argillaceous beds in some areas to beds of intermediate composition in others. The transitional zone from St. Regis to Revett and the upper portion of the Revett are for the most part more quartzitic than the rocks higher in the St. Regis or lower in the Revett.

Folding

The rocks of the district have been intimately folded into a complex system of anticlines and synclines. In many folds the beds are sharply contorted and crumpled and many folds are overturned so that throughout much of the district the strata are inclined at steep angles and in many places are vertical.

In the Lucky Friday, a system of several small folds combined with a larger anticline and syncline strike generally east-west to southeasterly through the mine and are at least in part responsible for the rather unique shape of the ore body (Fig. 13).

Faulting

Faulting in the district is as pronounced and as complex as the folding, the dominant structure being the Osburn fault. This fault crosses the district in a west-northwesterly direction and has been traced for many miles east and west of the district. The apparent vertical displacement along the Osburn fault is as much as 10,000 feet and the horizontal displacement is thought to be as much as 12 to 15 miles, with the south block having been shifted west relative to the north block. North of the Osburn fault many of the major faults trend northwesterly or northerly, while in the southerly part of the district the larger faults trend more nearly parallel to the Osburn fault. Most of the east-west faults are normal with steep southerly dips, but some are reverse faults with considerable displacement.

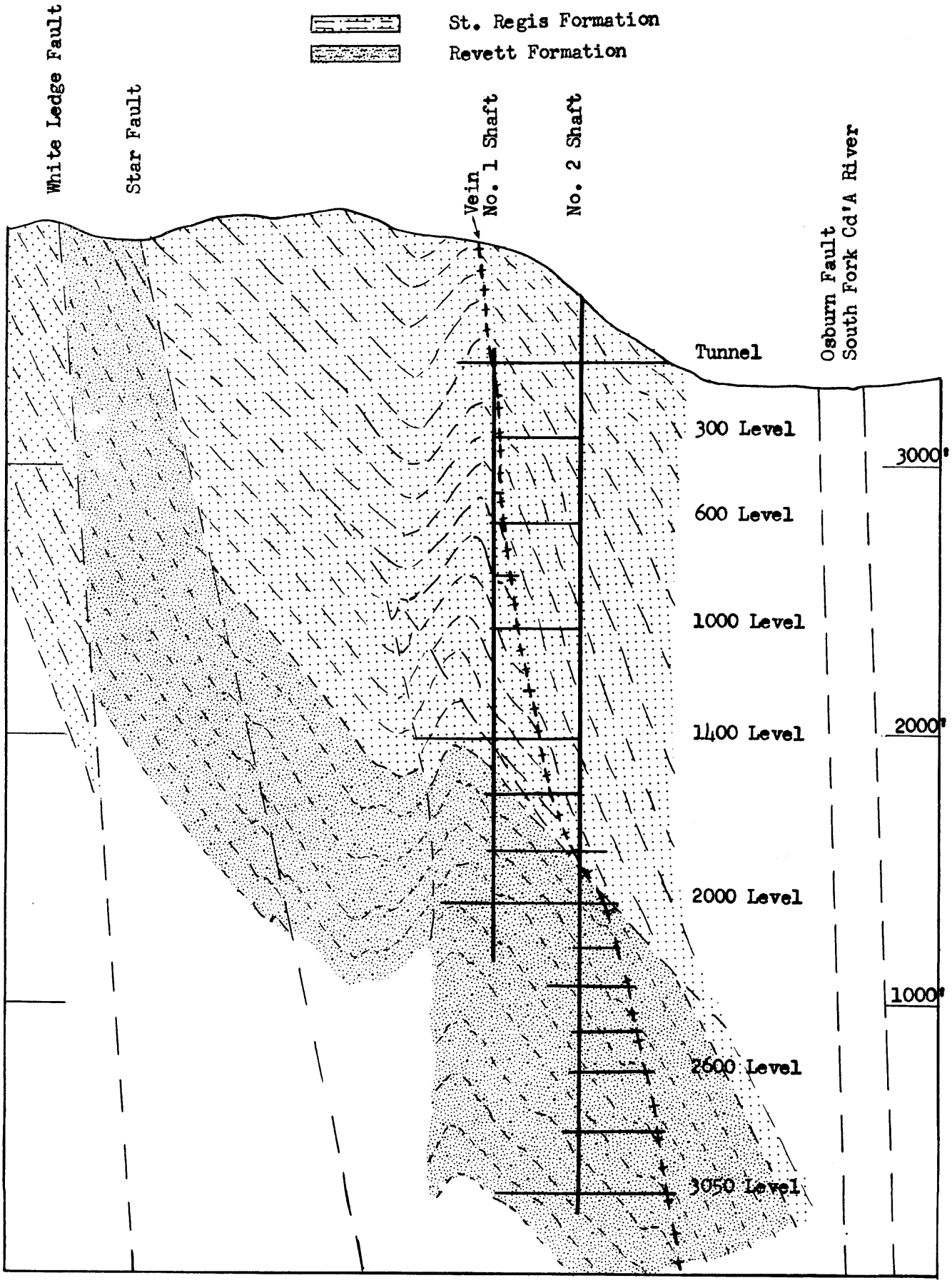
The Lucky Friday mine area is within a block of ground bounded on the south by the Osburn fault and on the north by nearly parallel structure known as the White Ledge fault. About 800 feet farther north is the Paymaster fault which is also roughly

Figure 14

LUCKY FRIDAY MINE

Generalized Section Looking Easterly

1" = 500'



parallel in strike.

The vein

The Lucky Friday vein (Fig. 14) has been followed on the 2,000 level and lower levels for about 1,400 feet and has been developed over a vertical range of 3,300 feet from the surface to the 3,050 level. The main portion of the vein has an average strike of N. 65° E. that is remarkably constant from the tunnel level to the lowest levels of the mine. Between the 1,600 level and the 2,600 level the vein lengthens easterly and westerly with these extensions deviating from the general strike. The westerly portion strikes about N. 65° W. and the easterly extension, although locally very irregular in strike, averages N. 30° E. Below the 2,600 level the N. 65° W. and the N. 65° E. sections of the vein shorten markedly but this shortening is compensated for by the lengthening of the northeasterly-striking portion. The northeasterly section of the vein is particularly irregular in strike where it is offset by the numerous southeasterly trending cross faults. The horizontal displacement of the vein by these faults is generally less than 5 feet but is as much as 100 feet on one fault near the easterly end of the vein on the 1,800 level. Much less displacement was noted on this same fault on lower levels, however.

The vein dips southerly over most of its length with the dips ranging from vertical to as flat as 45° but averaging about 75°. In the easterly portion of the mine, however, the vein reverses dip in the north and northwesterly striking sections. It is characterized by a persistent fault fissure that has been variably replaced by galena and quartz with subordinate amounts of tetrahedrite, sphalerite, pyrite and chalcopyrite. Small amounts of jamesonite and pyrargyrite have been noted. The main strand of the vein, usually high-grade galena, varies in width from less than an inch to more than 10 feet with occasional pods 12 to 14 feet in width. Irregular stringers of galena and other sulfides usually accompany the main strand in one or sometimes both walls. In places of intense fracturing and silicification fine grained galena and tetrahedrite are disseminated in the wallrock for several feet on either side of the vein. Similar disseminations are present as a replacement of certain favorable quartzite beds for distances of several tens of feet away from the vein.

Development work below the 2,000 level has shown a great improvement in the width and grade as well as the length of the ore body as compared with the shorter shoots in the upper part of the mine. The average stoping width in the main portion of the vein below the 2,000 level is 7 to 8 feet, while narrower widths of 5 to 6 feet are maintained in most of the easterly and westerly extensions of the vein. The ore shoots in the levels above the 1,200 were generally less than 100 feet long but on 2,600 level, the lowest level where any stoping has been done, a continuous length of over 1,250 feet is now being mined.

The improvement of the vein in the lower levels, favorable rock types and structural conditions plus the fact that the major ore bodies of Coeur d'Alene district are noted for their great vertical extent all point to a promising future for the Lucky Friday mine.

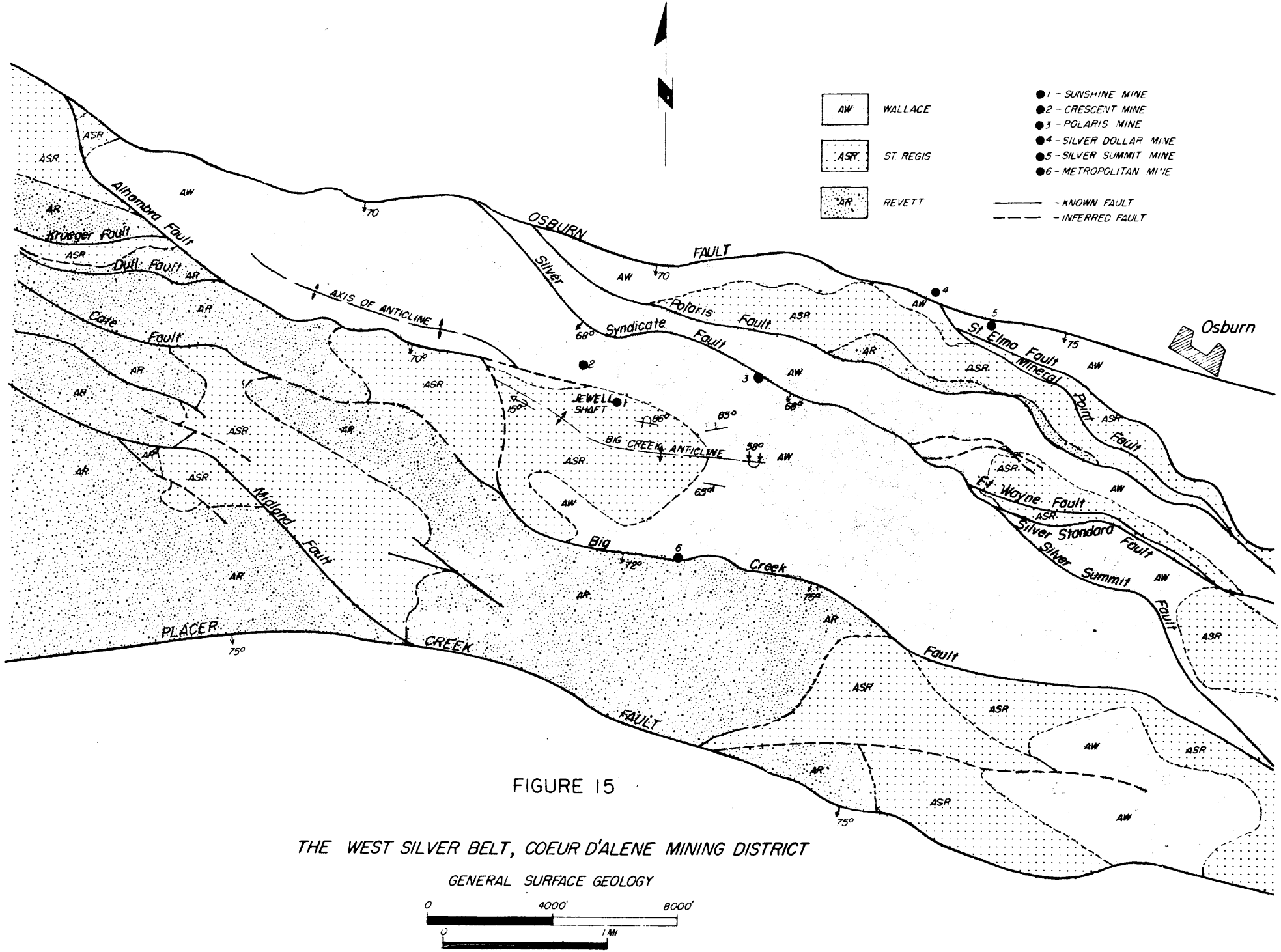


FIGURE 15

THE WEST SILVER BELT, COEUR D'ALENE MINING DISTRICT

GENERAL SURFACE GEOLOGY

THE GEOLOGY OF THE SUNSHINE MINE

by

James B. Colson
Chief Geologist
Sunshine Mine, Kellogg, Idaho

Introduction

The Sunshine Mine of northern Idaho lies in the Coeur d'Alene Mountains about half way between the towns of Kellogg and Wallace, on the west end of the "Silver Belt" which is a structural and mineralogical subdivision of the Coeur d'Alene mining district. The predominance of argentian tetrahedrite over other ore minerals helps set off the "Silver Belt" as a distinct unit.

The "Silver Belt" of the Coeur d'Alene district is a structural depression bounded by uplifted, older sedimentary rocks to the north and south. The Osburn fault on the north, with normal displacement of 14,000 feet, and the Placer Creek fault on the south with normal displacement of 8,500 to 9,000 feet, form the limits. Within this great east-trending slice of rock are several approximately parallel or slightly divergent faults which cut the strip into narrow blocks, or wedges. (Fig. 15) In these, the Precambrian Belt sediments are tilted and folded into steep, or overturned structures. The main structural blocks of this area are to some extend expressed by the topographic forms, or high ridges being developed on the blocks of more resistant rocks. Some of the stream courses locally follow zones of weaker rocks, but in conspicuous instances they cut directly across the structure, and the drainage system seems to have developed independently of the structure, and the relative resistance of the formations. Where major faults have brought together rocks of markedly differing characters, there is a recognizable effect on relief, but in most cases, this is not so strongly shown as might be expected. (Fig. 16)

Geologic setting

The Sunshine Mine is enclosed in Wallace, St. Regis, and Revett argillites and quartzites - the middle of the Precambrian Belt Series rocks. The Wallace and St. Regis formations are the most prevalent on the surface, and these continue downward to near the 3,100 level where the Revett quartzite is encountered.

The geologic sequence exposed in the mine from the surface downward is as follows:

Wallace formation	Calcareous argillites and quartzites (4000' - 5000')
St. Regis formation	Argillites and Quartzites (1600' - 2000')
Revett Quartzite	Quartzite (2100' - 3400')

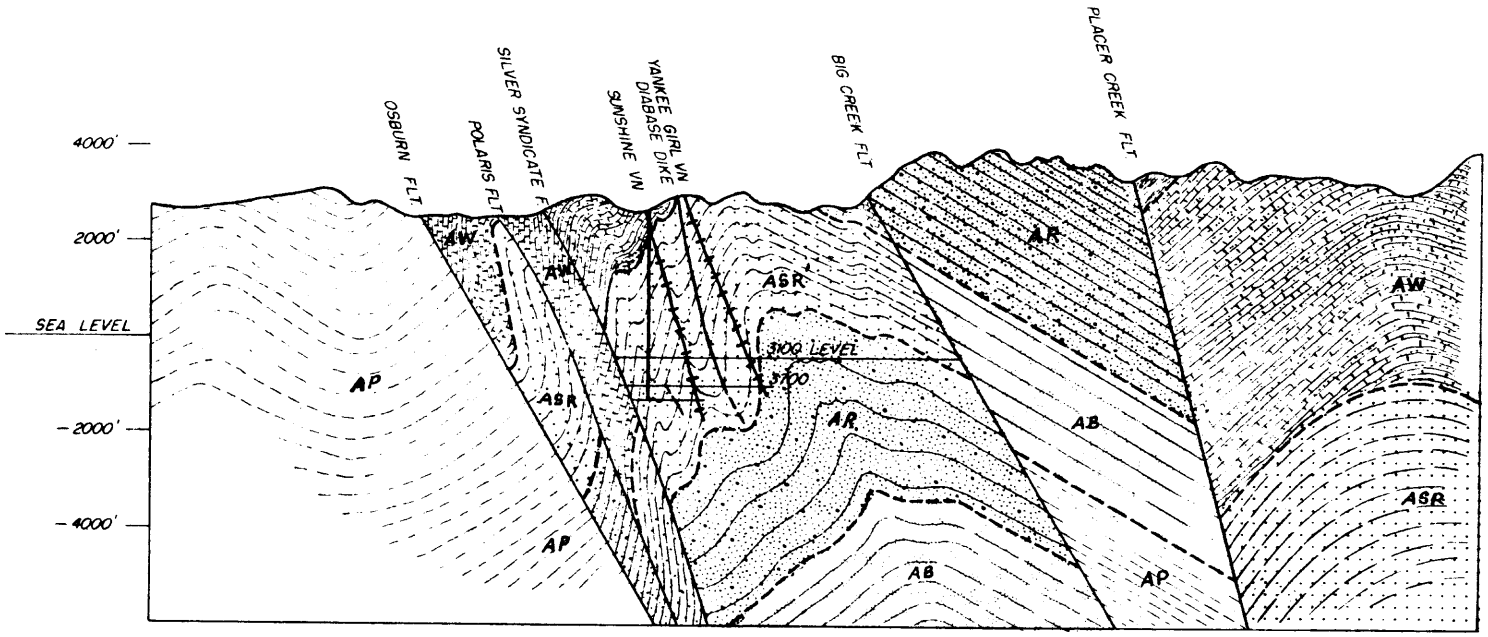


FIGURE 16

GENERALIZED SECTION - SUNSHINE MINE

LOOKING EAST THROUGH THE JEWELL SHAFT

0 4000' 8000'

ASP STRIPED PEAK (1500'-2000')

AW WALLACE (4000'-5000')

ASR ST REGIS (2000'+)

AR REVETT (2100'-3400')

AB BURKE (1800'-2400')

AP PRICHARD (12000 +)

309

These formations are made up of interbedded and gradational mixtures of quartzite and argillite, except the Wallace formation which contains calcareous beds. These sediments are typically deltaic with cross bedding, ripple marks, and mud cracks.

Mineralization at the Sunshine Mine is localized entirely within the confines of a large asymmetrical anticline, known as the Big Creek anticline. (Fig. 16) This fold is overturned to the north, with its axial plane inclined 58° south. The north and south limits of this fold are the Silver Syndicate fault and the Big Creek fault, respectively. The trace of the fold becomes obscured to the west because the Big Creek fault is thought to swing northerly and connect with the Alhambra fault. (Fig. 15) The Big Creek Anticline is interlaced with numerous south dipping faults which trend generally northwest, and coupled with a persistent series of north-south cross faults, have considerable importance in ore localization.

An important fault, in the Silver Syndicate fault, is especially prominent at this mine as an ore-bearing structure. This fault strikes N. 70° -80° W., and dips 65° - 70° South. Massive, silver-bearing galena with large blebs of tetrahedrite is prevalent at various places along the fault. Control of ore shoots along the fault lie in areas where the main fault vein splits and branches. Along these splits and branches considerable replacement of the intervening rock has taken place. Where only the main fault gouge is present, little ore occurs. This feature, which localizes ore shoots along the fault, delineates the limits of mineralization horizontally and between levels.

Ore-bearing structures

Ore occurrences of the Sunshine Mine may be divided into four general groups of ore zones shown collectively in Figure 17:

Sunshine - Polaris Vein System
Chester Vein
Silver Syndicate Fault
Yankee Girl Vein

The Sunshine-Polaris vein system was the first discovered, and had the greatest vertical range. It extends from the surface to approximately 1,350 feet below sea level, which is a total of about 5,500 feet along the dip of the vein. It is essentially a silver-copper-antimony bearing system. Siderite, quartz, tetrahedrite, pyrite, arsenopyrite, minor chalcopyrite, sphalerite and galena are the principal vein minerals.

It is an east-west striking group of mineralized fractures dipping 60° - 75° to the south. The Sunshine group consists of the main Sunshine vein, and several branches as parallel veins, the most important of which are the "D" and "06" veins. The main Sunshine vein in reality was two separate veins from the upper working to a point about 50 feet above the 2,700 level. Below that point, the two veins merged and continuous mining was carried on throughout its length.

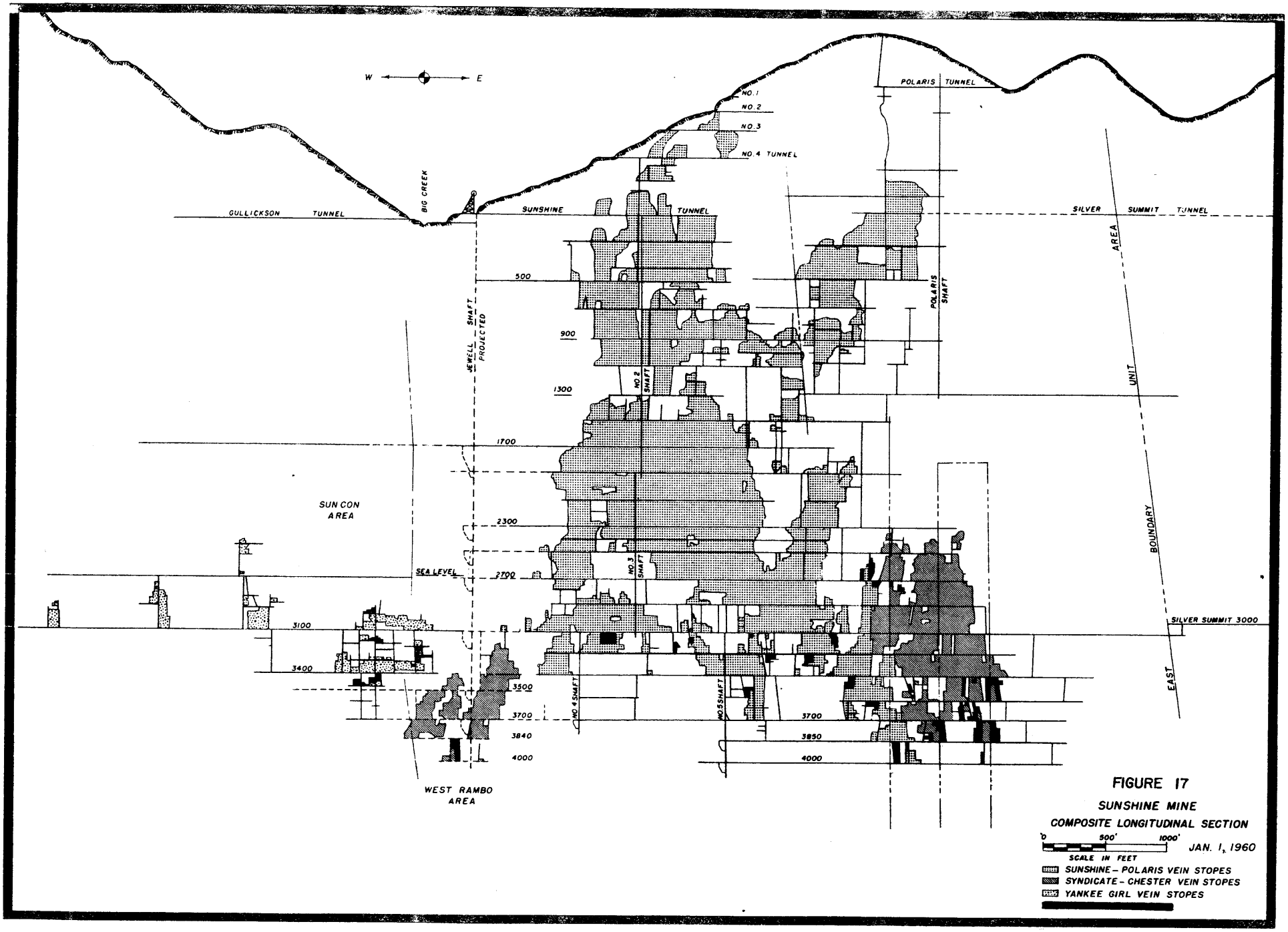


FIGURE 17

SUNSHINE MINE

COMPOSITE LONGITUDINAL SECTION

The Polaris veins which in reality are not directly connected to the Sunshine vein, have been worked from the 2,500 level to the 4,000 level. The persistent system here, is much like the Sunshine vein in mineralogic and structural character. This group of veins strike about east-west and dip 60° - 75° South. These veins do not have the stope width of the Sunshine vein, nor do they have the strike length. The three main veins are designated as the footwall 08, the 09, and the hanging wall 09. The 08 vein has been mined from the 2,500 level to the 4,000 level. Strike length and relative position has changed little between levels though mining progress shows a well-defined easterly rake to the ore shoot. The hanging wall 09 vein is much like the 08 vein mineralogically and structurally, though along its easterly strike the vein takes a sudden turn to the north and is cut off by the Silver Syndicate fault. (Fig. 18) At the point where the vein diverges from its easterly strike to near north, values increase and an ore shoot is developed.

The Chester Vein, like the Sunshine vein lies on the north limb of the Big Creek anticline, but is north of the Silver Syndicate fault. This vein is so named because the original work on it was done in Chester Mining Company's ground on what was designated as the Chester fault. Rather than being a distinct and unrelated vein to other vein systems in the Sunshine mine, area boundaries designate its location and name as "The Chester Vein". The Chester vein is part of the Silver Syndicate fault for a considerable distance, but, diverges finally from it, takes a north hook, and connects with the Chester fault, and continues on an easterly strike for 7,800 feet. Commercial mineralization has not been found along its entire length. It is a replacement vein along the Silver Syndicate fault and Chester fault, but becomes a mineral-filled tension fracture along the "North hook". Siderite, quartz, pyrite, tetrahedrite, and galena are the most conspicuous minerals. Tetrahedrite replaced galena in abundance at lower extremities of the vein. The Chester ore shoot does not reach the surface, although the Silver Syndicate and Chester faults do. The vein strikes east-west and dips 65° - 70° South. The "North Hook" area is characterized by a mineral sequence of siderite, quartz, galena, and abundant tetrahedrite. The Chester ore shoot apexes a little above the 2,300 level and has a vertical range to date of about 2,000 feet.

The Silver Syndicate Vein is located along the Silver Syndicate fault and consists of three major ore shoots. (Fig. 19) It is a replacement vein and is characterized by the predominance of tetrahedrite-bearing galena over the gangue of quartz, siderite and pyrite. The fault has a vertical range of 5,600 feet from the surface to the 4,000 level. It strikes N. 70° - 80° W., and dips 65° - 70° South. The vein, where first intersected on the 3,700 level, consists of massive, silver-bearing galena with remnants of unreplaced tetrahedrite. The ore shoot does not apex at the surface and thus far extends from 125 feet above the 3,100 level to the 4,000 level, or about 1,025 vertical feet.

The Yankee Girl Vein is in reality a complex, irregular and braided, but persistent system of tension veins which have been developed along the southern extremities of overturning on the north limb of the Big Creek anticline. The vein system

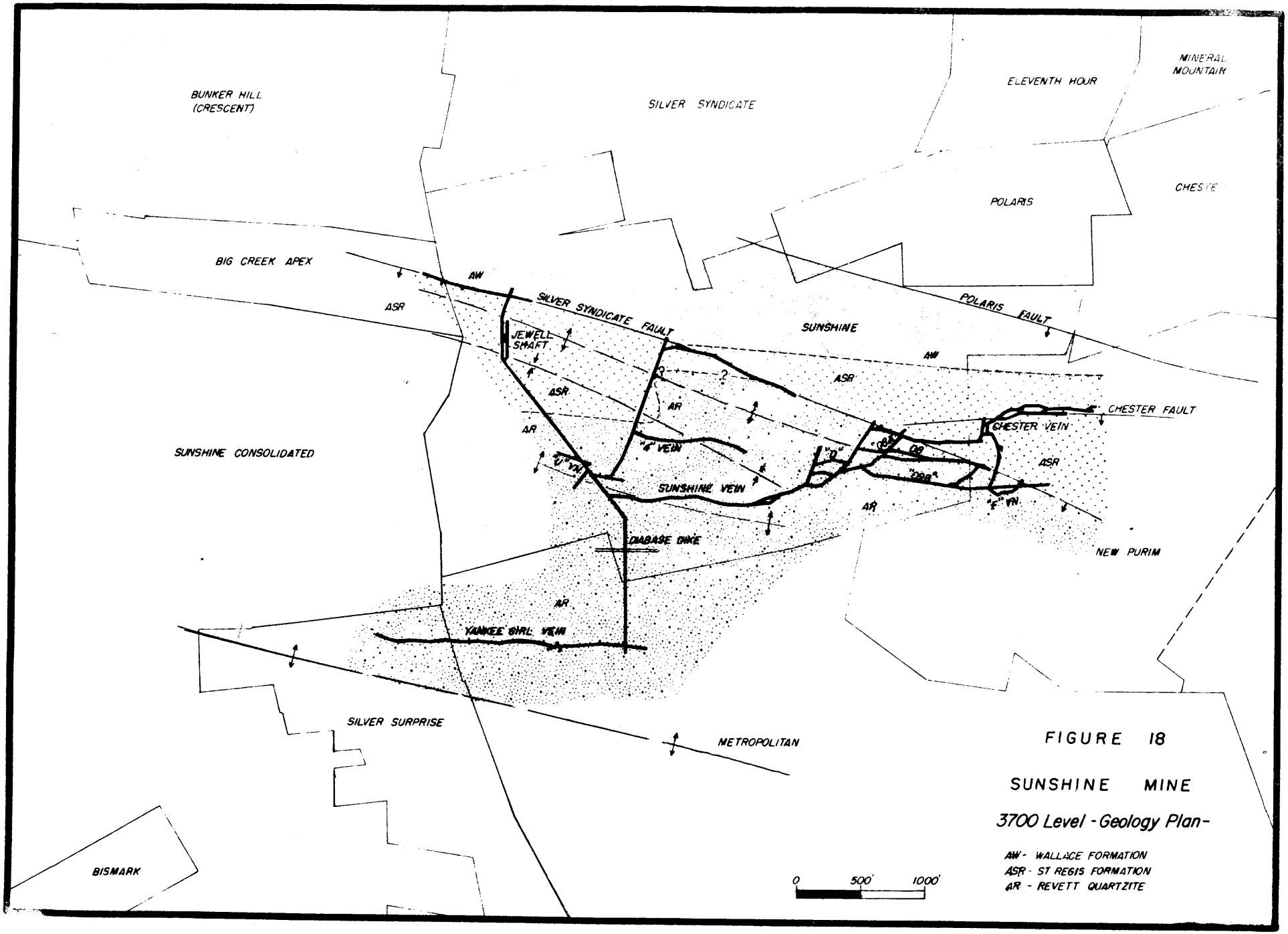


FIGURE 18

SUNSHINE MINE

3700 Level - Geology Plan -

AW - WALLACE FORMATION
ASR - ST REGIS FORMATION
AR - REVETT QUARTZITE

strikes east-west and dips 65° - 70° South. In contrast to the other vein systems mentioned above, the zone occupied by the Yankee Girl vein is not as widely sheared or secondarily folded. The vein consists of several narrow interlaced veins within a shear averaging from three to six feet wide. Mineralization consists of siderite, ankerite, quartz, pyrite, tetrahedrite, chalcopyrite, and rarely galena. These veins have been formed mainly by fracture filling.

Ore shoots and their behavior

Veins in the Sunshine mine consist of quartz and carbonates (siderite and ankerite) associated with various sulphides and other minerals. The more common sulphide minerals are tetrahedrite, galena, sphalerite, chalcopyrite and pyrite. Gersdorffite, bournonite, boulangerite, proustite, and pyrargyrite are some of the minor minerals. Freibergite, the silver-bearing variety of tetrahedrite, is the most important mineral in the Silver Belt, but its silver content varies considerably. In the Sunshine zone, ore from the footwall vein contained 60 to 75 ounces of silver to each percent of copper, whereas the hanging wall vein carried about 50 to 60 ounces to each percent of copper.

Silver-copper ratios vary with each vein in the Sunshine mine:

Vein	Oz. of Silver per % of copper
Sunshine - Polaris	50 - 75
Chester	75
Yankee Girl	40

With increasing depth in the Sunshine mine, there is a progressive change in certain metal ratios. The copper tenor has remained relatively stable, but there is a decrease in silver and antimony content. Quartz, pyrite, and chalcopyrite become more abundant near the bottom of the veins.

It is evident, from the splitting and branching pattern of the Sunshine vein on both west and east extremities, that the vein character does change where it passes through minor fold axes. If the vein passes out of steep beds of approximately parallel strike into beds of moderate dip and divergent strike, there is some evidence to indicate that the vein will branch and become less productive, regardless of whether the host rock is quartzite or argillite. There are a number of localities with several approximately parallel veins, but parallel ore shoots are less common. Ore usually appears in one branch or the other, but only rarely are both branches of commercial value directly opposite each other. There is a tendency for a single line of shoots with irregular en echelon arrangement.

Production (1904-1959)

The following resume is a grand total of production from all the vein systems mined by the Sunshine Mining Company from the Sunshine mine on Big Creek:

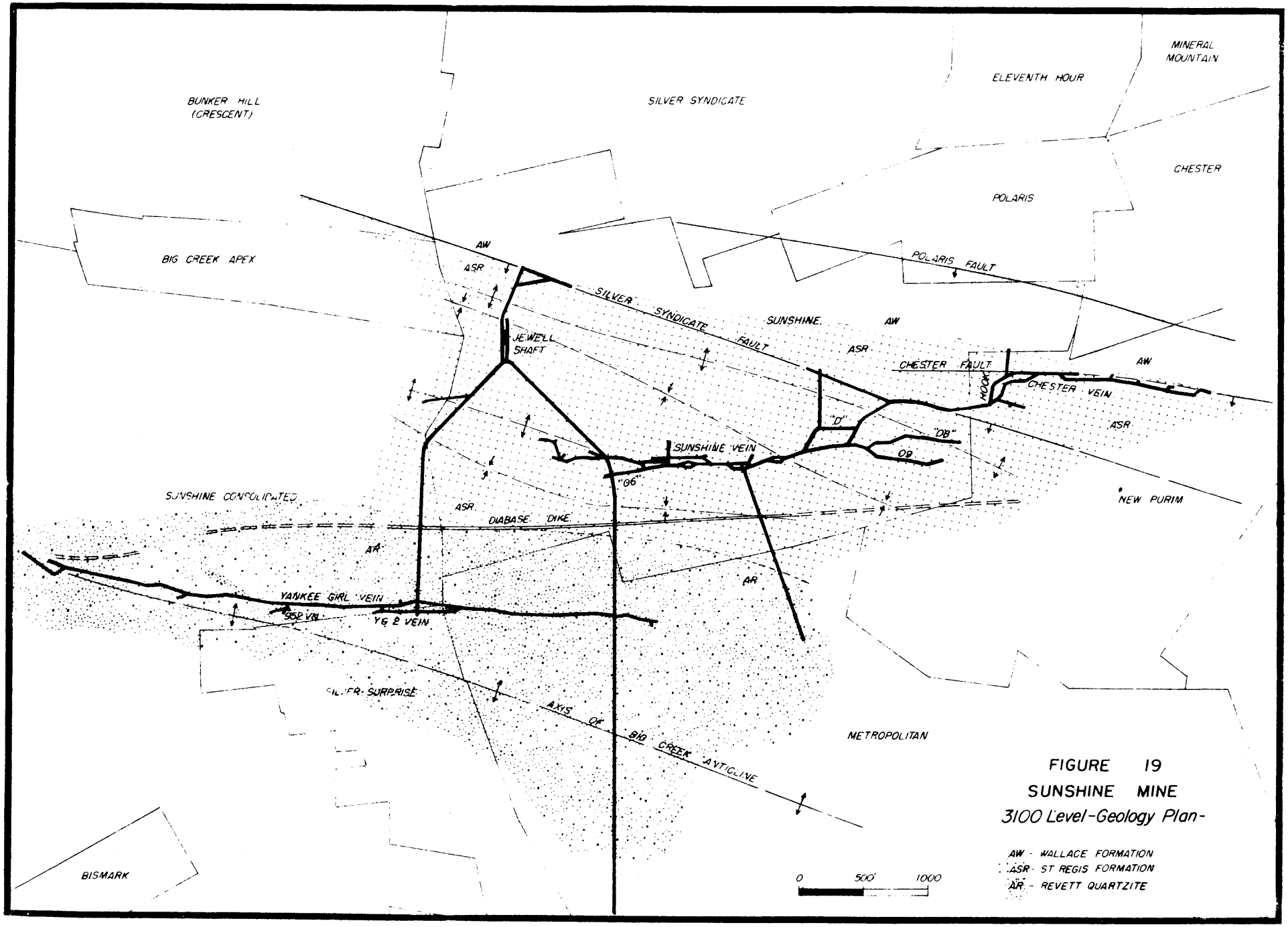


FIGURE 19
SUNSHINE MINE
3100 Level-Geology Plan-

Tons Crude Ore	6,143,467
Ounces Silver Recovered	187,500,311
Pounds Lead Recovered	123,186,726
Pounds Copper Recovered	52,856,877
Pounds Antimony Contained	41,502,062
Ounces Gold Paid	1,922
Net Smelter Returns	$151,601,237

TABLE 1

Production of Gold, Silver, Lead, Copper and Zinc
In the Coeur D'Alene Mining District
Shoshone County, Idaho 1884-1960 Incl.
Compiled by Idaho Mining Association

	GOLD	SILVER	LEAD	COPPER	ZINC	
Year	Fine Ounces	Fine Ounces	Tons of 2000 Pounds	Tons of 2000 Pounds	Tons of 2000 Pounds	Value of Total Metallic Product
1884	12,500					$ 258,375
1885	18,220					376,607
1886	8,823	116,246	1,500			436,335
1887	7,367	340,000	5,980			1,022,996
1888	10,250	554,000	8,000			1,438,227
1889	8,433	1,095,265	17,500			2,532,978
1890	8,000	1,499,663	27,500			4,132,506
1891	10,000	1,825,765	33,000			4,868,356
1892	11,000	1,195,904	27,839			3,538,684
1893	14,748	1,963,561	29,563			4,258,621
1894	17,531	2,343,314	30,000			3,816,026
1895	18,439	2,471,300	31,000			4,016,049
1896	17,369	3,163,657	37,250			4,703,971
1897	16,404	3,756,212	57,777			6,764,010
1898	13,011	3,521,982	56,339			6,565,287
1899	8,602	2,737,218	50,006			6,263,404
1900	5,754	5,261,417	81,535			10,588,707
1901	4,915	4,339,296	68,953			8,731,662
1902	4,761	5,033,928	74,739			8,847,552
1903	7,651	5,471,620	103,691			11,885,078
1904	2,226	6,141,426	107,561			12,830,582
1905	1,886	6,690,000	123,830			15,759,907
1906	3,244	7,903,487	125,825	3,428	700	20,891,688
1907	3,435	7,317,962	114,965	3,567	4,536	19,084,434
1908	4,105	6,531,890	102,753	4,495	910	13,439,796
1909	7,155	6,203,715	107,792	3,834	800	13,723,104
1910	3,110	7,262,271	114,975	2,502	2,998	15,275,024
1911	3,054	7,784,417	127,216	973	5,044	16,375,258
1912	4,446	7,364,581	136,674	2,100	7,972	18,492,338
1913	3,510	9,510,868	147,851	2,263	14,127	21,115,808
1914	4,052	13,409,095	169,304	1,638	24,136	23,607,602
1915	4,500	12,199,000	175,528	500	46,155	35,568,987
1916	2,600	11,454,680	173,073	823	48,960	44,265,554
1917	4,753	11,715,000	187,768	1,002	46,312	51,392,348
1918	14,628	8,234,389	136,530	725	24,828	32,908,188
1919	10,191	4,598,072	84,745	477	10,207	16,742,607

Production in Coeur d'Alene District, Continued

	GOLD	SILVER	LEAD	COPPER	ZINC	
Year	Fine Ounces	Fine Ounces	Tons of 2000 Pounds	Tons of 2000 Pounds	Tons of 2000 Pounds	Value of Total Metallic Product
1920	9,000	6,639,000	128,367	54	10,966	$ 30,365,160
1921	7,217	5,132,320	101,088	80	909	14,594,399
1922	6,049	4,697,517	95,503	47	2,798	16,182,008
1923	11,873	6,109,522	120,490	315	17,345	25,032,974
1924	8,026	6,684,504	123,740	427	10,647	26,130,395
1925	6,259	6,691,658	126,664	283	18,537	30,502,217
1926	5,060	6,930,126	133,706	496	26,956	31,008,972
1927	436	8,236,341	146,864	664	31,321	28,574,888
1928	440	8,472,560	144,770	788	33,612	27,474,740
1929	637	8,786,525	148,273	918	51,952	32,030,868
1930	810	8,438,208	127,089	827	32,528	20,438,084
1931	672	7,029,130	101,569	739	20,951	12,295,656
1932	398	6,559,394	74,487	713	11,406	7,310,478
1933	1,000	6,766,162	80,107	845	22,993	10,544,975
1934	3,965	7,062,640	70,331	736	24,799	12,159,340
1935	2,740	9,894,300	78,314	988	31,054	16,369,235
1936	2,454	13,740,222	86,634	1,315	44,310	23,370,963
1937	3,659	18,457,726	96,505	1,944	47,070	32,382,311
1938	4,053	17,325,379	82,274	1,883	31,937	22,346,313
1939	5,550	15,165,000	81,438	2,050	39,750	22,805,024
1940	6,866	15,616,852	95,609	2,680	62,948	29,444,265
1941	4,800	14,600,000	94,400	3,150	67,300	35,931,860
1942	2,688	12,977,287	106,474	2,993	78,313	38,880,253
1943	2,250	10,302,840	89,813	1,987	79,634	38,594,728
1944	2,075	8,669,371	76,813	1,289	85,227	38,307,297
1945	1,898	7,115,646	63,430	1,018	78,025	34,258,050
1946	1,758	5,655,672	56,548	810	67,429	33,673,731
1947	2,808	9,234,906	73,060	1,312	79,251	49,226,932
1948	3,362	10,598,338	82,587	1,388	83,801	62,168,955
1949	2,438	9,146,146	74,152	1,171	74,370	50,699,924
1950	3,416	15,056,131	94,197	1,895	86,102	64,555,947
1951	2,684	13,639,808	70,570	1,874	74,989	65,058,887
1952	2,476	13,752,081	67,330	1,862	70,316	58,459,368
1953	2,376	13,636,680	69,885	2,100	68,650	47,729,814
1954	2,047	14,898,699	64,812	2,566	58,736	45,515,124
1955	1,777	12,984,323	59,820	2,637	50,527	44,036,867
1956	2,782	12,663,214	60,221	2,889	46,738	45,729,474
1957	2,225	14,464,108	66,569	3,763	55,919	47,459,665

Production in Coeur d'Alene Mining District, Continued

	GOLD	SILVER	LEAD	COPPER	ZINC	
Year	Fine Ounces	Fine Ounces	Tons of 2000 Pounds	Tons of 2000 Pounds	Tons of 2000 Pounds	Value of Total Metallic Product
1958	2,363	15,615,220	52,488	3,884	49,532	38,645,000
1959	2,349	16,460,825	61,155	3,678	55,454	44,058,000
1960*	3,433	12,886,000	39,599	3,955	34,698	32,453,000
TOTALS	439,842	619,803,582	6,546,307	93,340	2,157,485	$1,853,374,797

*Preliminary figures