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THE PIOCHE DISTRICT

By
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ABSTRACT

The main production of lead-zinc ore in the Pioche district comes from sulphide replacements of the C.M. limestone, the lowest limestone of the Pioche Shale formation, of Cambrian age. They occur in channels localized by fracture zones. One such channel has been followed for nearly 10,000 feet, the deposits along it being up to 40 feet thick and 250 feet wide. Other types of deposit include veins in quartzite (formerly yielding rich silver-values in the oxidation-zone, which extended to a depth of 1,200 feet); replacement veins in limestone and fissure veins in the Yuba granite-porphyry dike. Both normal and thrust-faulting occurs in the district, splitting it up into many fault-blocks tipped to various angles. Much of the faulting is later than the late Mesozoic or early Tertiary lavas of the district, but most of it preceded the mineralization.

HISTORY AND PRODUCTION

THE Pioche district in Lincoln County in the south-eastern part of Nevada, while not one of the world's major producers of metal, is worthy of inclusion in a symposium on Ores of Lead and Zinc. In the first place, according to data compiled by various governmental agencies, the production of the area over nearly 80 years is in excess of five million short tons, with a gross recovered value approximating a hundred million dollars. Incomplete early records make exact data unavailable. In the second place, it is one of the outstanding examples of successful development of zinc-lead ore bodies by the combined use of geological theory, geological mapping, and churn and diamond drilling.

The area involved is shown on the accompanying map, which is reproduced, in part, from U.S. Geological Survey, Prof. Paper 171.

Production.—From 1869 to 1946, inclusive, Lincoln county produced approximately 517,250 ounces of gold, 43,000,000 ounces of silver, 12,700 short tons of copper, 194,000 short tons of lead, and since 1902 about 210,000 short tons of zinc, over two-thirds coming from the Pioche district. From 1912 to 1946, nearly 1,200,000 short tons of manganese oxide ore, which assayed approximately: gold, 0·013 ozs.; silver, 2·75 ozs.; lead, 3·0 per cent; zinc, 4·0 per cent; iron, 31·0 per cent, and manganese, 12·3 per cent was shipped from the Prince-Virginia Louise Mines.

The Combined Metals Reduction Company shipped, from 1923 to 1947, inclusive, 1,599,575 short tons with an average assay of gold, 0·0407 ozs.; silver, 5·528 ozs.; lead, 5·385 per cent; and zinc, 13·71 per cent.

Copper production has come largely from the Bristol Silver Mine in the northern part of the area. A substantial part of the gold production came from the Delamar District, which is not a part of this report.

History.—Pioche, named after F. L. A. Pioche, who became interested in the area in 1868, had the usual colourful beginning which was so characteristic of western bonanza mining camps. In 1869, William H. Raymons and John Ely came to Pioche and started their spectacular operations. The rich outcrops, discovered in fissures in quartzite, led to activities that within six years produced over $17,000,000. The ores of the early days were largely silver chloride with lead carbonate and some galena in a silicious gangue. Treatment of these ores in local mills by the Washoe process was said to have recovered 75 to 85 per cent of the value in the ore. Tailings were treated in later years. The Meadow Valley Mining Company, from 1869 to July 31, 1874, produced 93,690 tons of crude ore, with bullion yield of $52·94 per ton, or a total of nearly five million dollars.

Water level, reached near the 1,200 level, and decline in metal prices slowed down production until in 1886 a low of seven tons was reported. Leasing and scattered mining ventures continued

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for many years. About 1905, John Janney entered the district and formed a consolidation of many of the old-time mines and is to-day producing 200–300 tons daily of zinc sulphide ore from his Ely Valley mine. During the years 1914–18 inclusive, the Prince Mine produced over 565,000 tons of manganese oxide ore.

Mr. Edward H. Snyder entered the district about 1911, and organized the Combined Metals, Inc., in 1915. This company, later merged with the Combined Metals Reduction Company, expanded the productive area by obtaining its ores from replacement deposits in favourable Cambrian limestone beds, the largest production coming from a fifty foot bed locally designated as the CM bed.

In 1937, electric power was brought to the district from Hoover Dam, a distance of 156 miles at 69,000 volts. Approximately 70 miles of branch lines distribute the power over the area. In 1941 the Combined Metals Reduction Company completed its 600 ton custom mill for selective flotation of mixed sulphide ores. This mill has recently been enlarged to 1,200 tons daily capacity to handle the increased production from the area. During the years an aggressive exploration and development policy has been followed with gratifying results.

SURFACE FEATURES

While the Pioche Hills contain the principal deposits discussed in this paper, the north-south Bristol and Highland ranges to the west are so closely connected by rock relations, types of deposits and by inter-connection of mine ownership and management that these ranges should be included in the general discussion. The total area is about 22 miles in a north-south direction from Bristol Pass to Bennett Pass by 12 miles in an east-west direction.

The Bristol and Highland ranges are typical north-south mountains, extending along the western half of the area, with fairly steep sides—usually steeper on the west slopes—often delineated by strong north-south normal faults and with sedimentary rocks dipping eastwardly at moderate angles. In marked contrast, the Pioche Hills are an elongated mass extending about N. 20° W. from Panaca, then curving gradually to a N. 60° W. trend. The total length is about 13 miles with a width varying from a few hundred yards to about three miles.

This mountain forming anomaly is due to a great system of north-west faults which controlled the uplift, and which may be largely responsible for the unusual concentration of mineral deposits in the Pioche Hills. These three ranges, which reach altitudes of 7,500 to 9,000 feet are surrounded by plains which slope gradually from the mountains and stand from 4,700 to 6,000 feet above sea level. The north-west fault system of the Pioche Hills projects to intersect the Bristol-Highland ranges in an area known as Stampede Gap (elevation 7,300) which serves as a dividing point for the two ranges.

Pioche, situated in the foothills on the north-east slope of the Pioche Hills, is the county seat of Lincoln County, on a branch of the Union Pacific Railroad, on U.S. Highway 93, and equipped with the usual facilities of a modern mining centre while retaining much of the romance of the early days. Branch railroad lines lead to the Caselton, Prince, and Jack Rabbit (Bristol) mines.

The rocks of these ranges are almost entirely Paleozoic sediments, although patches of lava and small areas of intrusives indicate the presence of magmatic influence. Some 9,000 feet of Cambrian rocks, mostly limestones and dolomites, give a greyish cast to the mountain sides, which is modified in the south central part of the Pioche Hills by a great thickness of pink to red basal quartzite and in scattered areas by green or brown patches of Lower Cambrian shales. In proportion to the total mass of the mountains, the exposed igneous rocks are so nearly negligible that one wonders at the mineral wealth contained underground.

GEOLOGICAL INVESTIGATION

The first systematic attempt to study and map the area was made by Lewis G. Westgate and Adolph Knopf of the U.S. Geological Survey during the summers of 1922, 1923, 1924, and 1926. The results of their work appeared in 1932 as Prof. Paper 171. " Geology and Ore Deposits of the Pioche District, Nevada." From about 1925, Mr. E. H. Snyder, after nearly 15 years of personal observations,

began the employment of engineers and geologists to study and map in detail the complex faulting and to determine the correct structure of the producing areas. This work has been continued under his inspiration and direction to the present time.

From 1936 to 1942, Dr. Harry E. Wheeler, and associates and students of the Mackay School of Mines, Reno, Nevada, made detailed studies in various parts of the area and published several bulletins containing much new detail of the Cambrian log and correlation with sediments of a much larger area.

Based on these various studies, the following general succession of geological events is assumed:

1. Sedimentation during most of Paleozoic time from Cambrian to Pennsylvanian. We are concerned chiefly with the Cambrian sediments.
2. Uplift, slight warping, and erosion.
3. Volcanism of perhaps late Mesozoic or early Tertiary, producing lavas and tuffs.
4. Tilting and early normal faulting.
5. Thrust faulting.
6. Quartz-monzonite intrusion at Blind Mountain and dikes in the Pioche Hill, at Bristol, Stampede Gap, and Comet.
7. Normal faulting of several different periods.
8. Mineralization.
9. Late normal faulting.
10. Erosion of the faulted blocks to the essential topography of to-day.

STRATIGRAPHY

Geological Section.—This area is particularly favourable for the study of Cambrian sediments. Great tilted areas are almost bare of vegetation and available for research. The Cambrian sea extended from the Rocky Mountains to the Sierras in California with the deepest point of the geosyncline not far west of Pioche. We will confine our discussion to the Pioche area with such comments as are pertinent to the problems of ore finding.

Basal Pioche Quartzite.—Some 2,000 feet of this rock is exposed in this area, and it is known that this thickness increases to perhaps 9,000 feet in areas to the south-west near the Nevada-California line. On the surface this quartzite is found principally forming the south central portion of the Pioche Hills and along the western foothills of the Highland and Bristol ranges. In colour it ranges from white through buff to red, weathering having a tendency to darken the rocks. Sand grains are often visible with a hand lens, but the rock breaks across the grains, cementing material being silica. Difference in grain size may produce laminations and at times show cross-bedding. True bedding is often quite distinct. Some of the quartzite is micaceous, and in places there is an interbedding of micaceous shale which emphasizes the bedding. Interbedding of shale and quartzite is particularly noticeable at the top of the formation where transition is made to the Pioche shale. The bonanza mines of the early days were in nearly vertical fissures in this quartzite.

Pioche Shale Formation.—The designation " Pioche Shale " covers a formation about 900 feet thick, in the Pioche area, but which thins in every direction from this centre. It is composed, for the most part, of shales, often micaceous, with various physical characteristics, interbedded limestones and one sandstone layer. Fossils have been found which place this formation in the Lower and Middle Cambrian. Economically considered, for the past 25 years, this shale formation with its interbedded limestones has been the most important formation in the area and warrants rather detailed discussion.

Locally, these shales are designated A, B, C, and D, the various letters indicating particular sections of the log, beginning at the top. Because of its economic importance, much churn and diamond drilling has been done, insoluble residues have been studied under the microscope, and numberless geological sections drawn in an attempt to secure greater familiarity with this section.

Shale A.—This portion is 335 feet thick. The upper portion is often limy containing several limestone beds from five to 25 feet thick. These limestones occur as lenses in the shales, making close

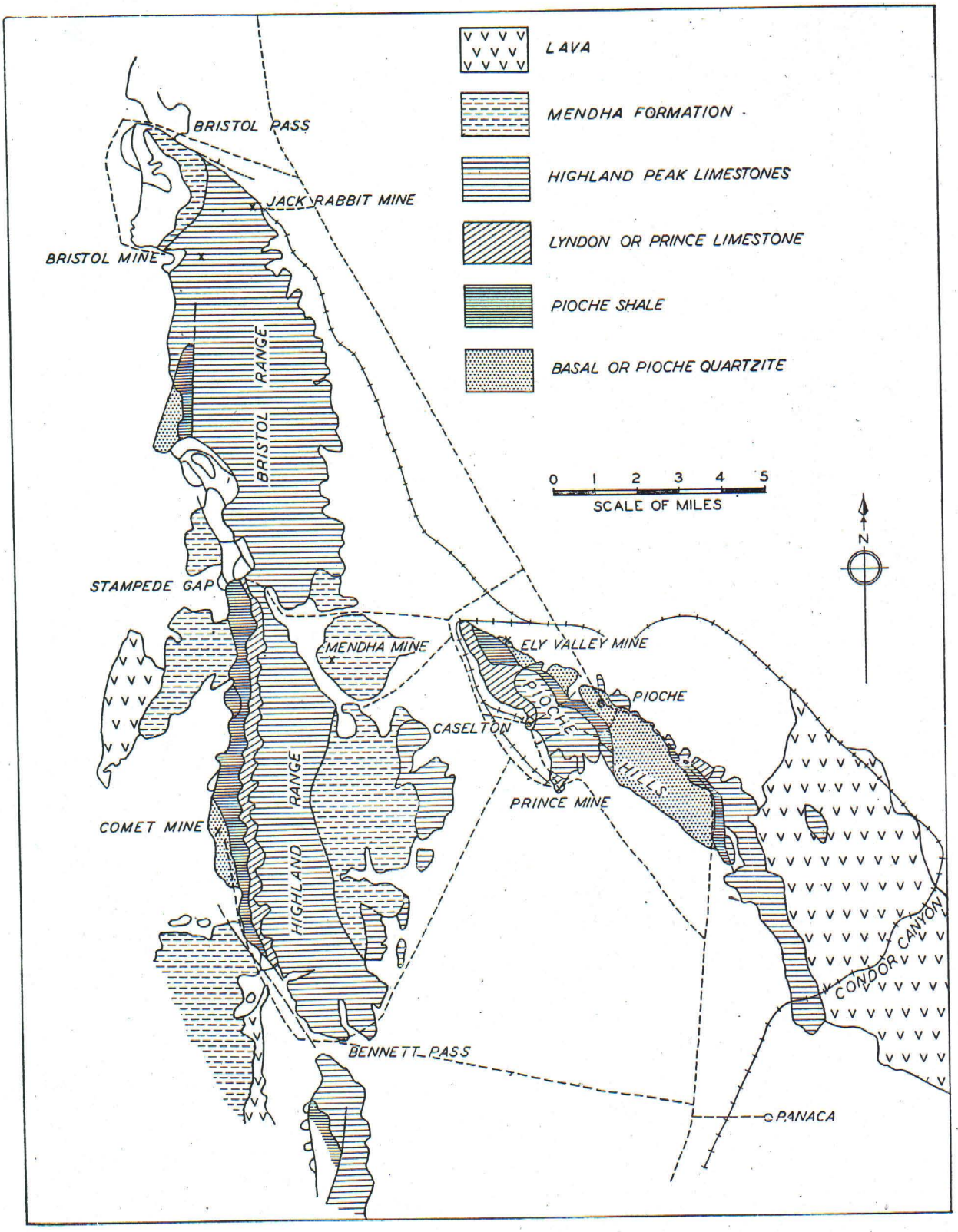

FIG. 31.—*Geological map of the Pioche district.*

correlation difficult or impossible. These limestones often contain valuable deposits of lead, zinc, and silver. Portions of shale A are argillaceous while other portions are sandy with much micaceous material. Colours vary from greenish-yellow to buff to brown, but are not diagnostic.

Sandstone member.—Shale A is separated from shale B by a sandstone member from 25 to 35 feet thick. The sandstone is usually coarse grained and cemented by silica. It weathers to a dark brown. It may be the base of the Middle Cambrian.

Shale B.—This portion is 125 feet thick, is greenish-grey when fresh, micaceous, with the partings usually wavy, is not ore bearing.

Susan Duster Limestone.—This limestone, 15 to 20 feet thick is the dividing member between shale B and shale C. It is thin bedded, often somewhat nodular, fossiliferous, and sometimes ore-bearing.

Shale C.—This shale bed is 100 feet thick, very fine-grained, somewhat micaceous, and characterized by partings that are parallel and often very thin.

C.M. Limestone.—This 50 foot limestone bed has produced at least 90 per cent of the Pioche ores during the past 25 years. It lies above the shale D and below shale C, which may account in part for its selection by the mineralizing solutions. Physically and chemically the bed has many variations, which have led to designation of the footwall bed, the silicious rib, the low bed, the micaceous rib, the lower part of the upper bed (L.P.U.B.), and upper bed. Ore may occur in any or all of these various portions with the better ores usually found in the lower half of the series. The ores are all of the limestone replacement type and are an intimate mixture of galena, sphalerite, pyrite containing some silver and gold in a gangue of limestone, shale, and graphite. A striking characteristic of the ore bearing limestone is the high amount of carbonaceous material.

Shale D.—This, the lowest member of the formation, is from 200 to 250 feet thick. It is often micaceous and grey-green when fresh. It may be mineralized in the vicinity of fissures, usually containing scattered pyrite with some sphalerite. It lies conformably on the basal quartzite and frequently merges through a 30 to 40 foot transition zone into the quartzite.

Lyndon or Prince Limestone.—This limestone is from 350 to 400 feet thick and lies conformably on the Pioche shale A. At the top of the formation a 25–30 foot bed of dark grey to black, thin-bedded limestone has been ore bearing in some places. Below this there are about 140 feet of dark grey layers which pass into a limestone locally called " White Prince." This consists of about 70 to 90 feet of light grey to white, fine-grained to dense limestone, often with a pinkish cast. This is underlain by about 200 feet of dark grey to blue limestone called the " Blue Prince." The bottom 20 to 30 feet may be interbedded with some shale A, thus making the end point difficult to determine. These bottom layers may be ore bearing. No diagnostic fossils have been found in the Lyndon. Best mineralization is the " Big Bed " in the Prince Mine, which produced a large tonnage of manganese oxide during World War I.

Chisholm Shale.—This is a yellow, buff to brown, fine-grained shale with two or three small intercalated limestone beds. Its measured thickness varies from 75 to 150 feet. It is easily identified because it weathers to a red, brown flat debris. It is minutely micaceous under the microscope. It is the most fossiliferous of all the Cambrian formations and is placed in the Middle Cambrian. The Half-Moon bed is a small limestone in this shale about 20 feet from its top. This bed produced silver-lead-gold bedded ore and was explored in many parts of the range in the early years.

Peasley Limestone.—The Peasley or Davidson blue limestone is the lowest of a thick series of limestones and dolomites that compose the Highland Peak formation. It is named from its occurrence in the Davidson Mine and also in Peasley Canyon. It varies from 100 to 150 feet in thickness, lies conformably on the Chisholm shale and is characterised by dark grey, thick-bedded limestones with calcite stringers. It contains oolites and sponge spicules which are not diagnostic. It contained the silver-manganese-lead-zinc bedded replacement ores at the Davidson Mine.

Burrows Limestone or Davidson Dolomite.—This limestone, much of which shows extensive secondary crystallization and dolomitization varies from 230 to 400 feet in thickness. The upper 200–250 feet is usually coarsely grained, white to dark grey, and massively bedded dolomite. The

lower 50 to 75 feet is often mottled grey and dark blue (the zebra dolomite) which shows clearly the secondary alterations. It was originally " a light grey, fine-grained to dense massively bedded limestone " such as is found to-day in some localities. The Burrows, which is Middle Cambrian, is separated both above and below from adjacent limestones by unconformities. It has not been an ore producer.

Black Davidson Limestone.—This limestone, also known as Type C, rests unconformably on the Burrows. It is almost black, thinly-bedded, and with partings in the lower portion, showing pink to red iron stains. It is about 200 feet thick and has been productive on the 1,700 level of the Bristol Mine.

Highland Peak Formation.—From the top of the Chisholm shale to the top of the Middle Cambrian a total thickness of 4,000 feet of variable limestones and dolomites has been logged by Wheeler and others and divided into 17 lithological units. These units are practically devoid of recognisable fossils and have been designated by the letters from A to Q, beginning at the bottom or oldest beds, the Peasley limestone being Type A. In the Pioche Hills no ore has been found above Unit A. At Bristol, the ore occurrence is more widespread, but with the bulk of the ore having come from Unit G (the Bristol Line), which is a dark grey, medium grained, carbonaceous limestone about 430 feet thick.

Mendha Formation.—This discussion would not be complete without mention of the Mendha formation, which occurs principally in the Arizona Peak area about six miles west of Pioche. Some 2,100 feet of limestones and dolomites with one shale bed have been incompletely logged and assigned to the Upper Cambrian. Due to extensive faulting, both thrust and normal, the complete log has not been determined, nor has the relation to the overlying Ordovician formations been decided. Replacement ore bodies in some of the limestone beds, adjacent to mineralizing fissures have been mined in a small way.

Igneous Rocks.—Great thicknesses of surface lavas and tuffs, covering large areas, occur in this part of Nevada, but are of little importance in the production of non-ferrous ores, as the mountain ranges which contain the ore deposits are composed of sedimentary rocks. Intrusive rocks, while of limited extent, are considered of great importance as guides to ore. Dikes and sills of quartz-monzonite, monzonitic and dioritic porphyry are found over a wide range. The best known is the Yuba Dike found in the Pioche Hills. Because of its association with one of the major ore channels of the district, it has been mapped and traced with great care. Its general direction is east-west to N. 70° W. with a steep dip and a width ranging from say 10 feet to 100 feet.

At the Bristol, a number of dioritic dikes of east-west trend and 70° southerly dip seem to be a part of one great system which parallels the east-west mineralization in the mine. An east-west dike in the newly organized Idamic property in the northerly part of the Bristol district is believed to have important bearing on ore deposition. It must be pointed out that the porphyry dikes are not ore bearing, except in one mine in the quartzite in the Pioche Hills where later mineralization filled fissures in the Yuba Dike. However, their occurrence compels the belief that their intrusion is a geological phenomenon closely related to the intrusion of ore-bearing emanations and solutions.

STRUCTURE

While intensive study was being made of the rock sequences, an equally important research was concerned with the structure. Everywhere, the sediments are faulted. Hence, the structural problems centre in the faulting. A few generalizations can be made.

1. Faulting occurred over a long time interval and is both normal and thrust.
2. All faulting was post-Pennsylvanian.
3. All the faulting was completed before the formation of the Pliocene sedimentary tuffs.
4. Faulting probably preceded, and surely followed the eruption of the lavas. The flows, which may have extended from late Mesozoic to the Miocene, have a thickness of over 6,000 feet in Condor Canyon, a few miles south-east of Pioche.
5. Most of the faulting is pre-mineral, some post-mineral and some indeterminate.

The earliest faulting was normal and is known only from old faults that disappear under the thrusts. Paul Gemmill points out " The May Day," the great footwall fault of the Bristol Mine is older than the thrusts, for it did not shift the outcrop of the thrust.

Thrust faulting was mapped by Westgate and Knopf during their studies in the northern and western parts of the district. In recent years it has been determined by Wheeler, Paul Gemmill, and

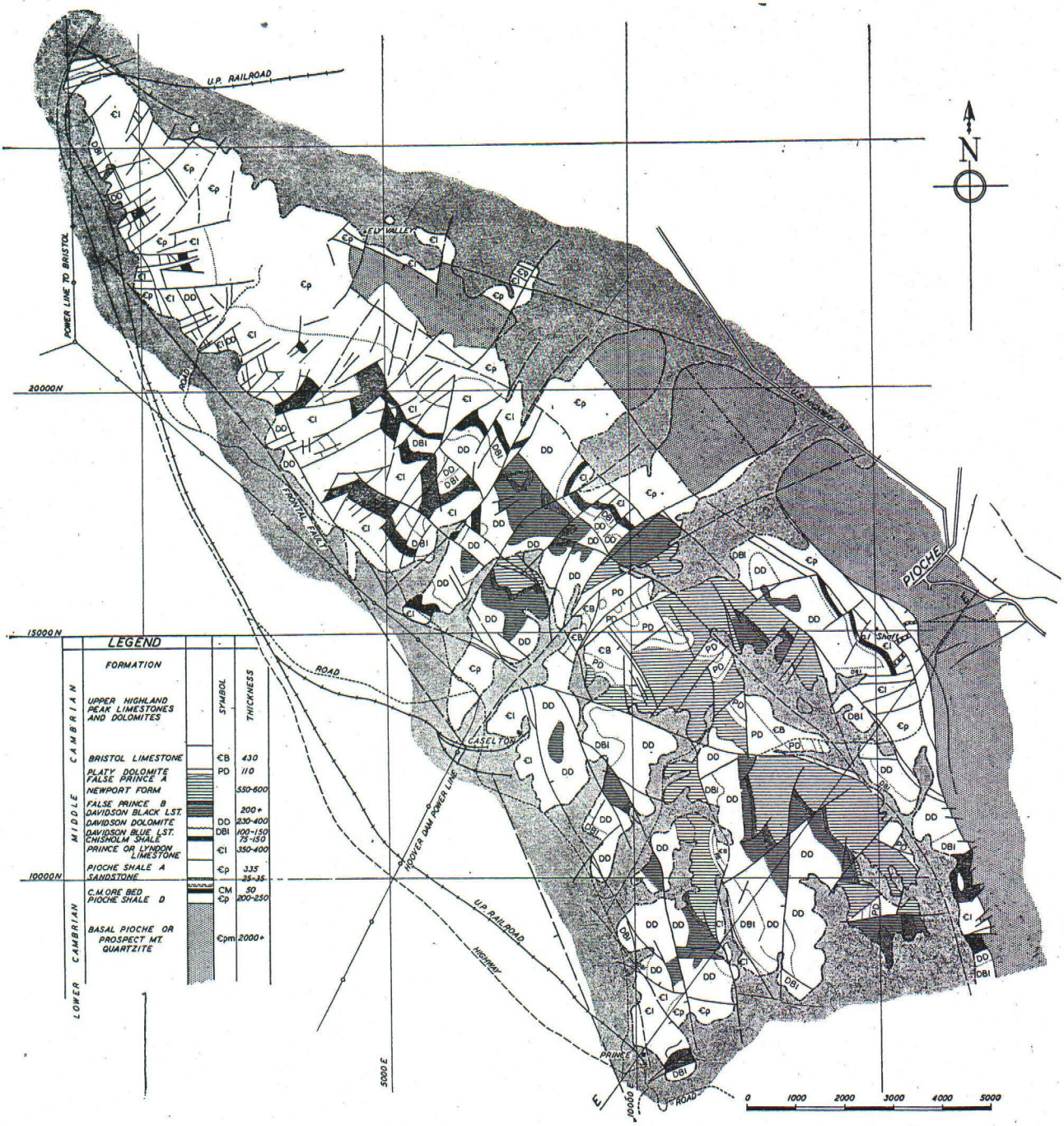

FIG. 32.—*Geological map of the producing area of the Pioche Hills.*

others that thrust faulting is rather widespread. In the Stampede Gap area, numerous branches of the thrusts have been mapped, some of which bound steep-dipping or overturned strata and furnish definite proof of being pre-quartz-porphyry dikes. The thrusting is later than most of the lava, but earlier than the great series of normal faults which have, to a great extent, shaped the ranges and controlled the present topography. The dips of the thrusts are usually of low angle and may be either

easterly or westerly. Some geologists have suggested that the over-riding blocks may have come from the south-west. Before and after the thrust faulting, there was a long series of normal faults. In the Bristol Mine, the May Day, a strong east-west, south-dipping fault cuts and displaces for a thousand feet the great Iron Vein, a north-south, east-dipping fracture with a throw of many hundreds of feet. In turn, the May Day is displaced by the No. 1 and the No. 10 faults which, again, are north-south in strike. No. 10 is pre-mineral and No. 1 may be. In the Stampede Gap area, the normal north-south and north-west faults displace the thrusts hundreds of feet and add much to the complexity of the structure. The frontal fault west of the Caselton and the N. 65°–70° W. fault at the Lucky Star Mine cut and displaced the main thrust faults.

But it is in the Pioche Hills that the fault pattern becomes involved. The outstanding faults are a great system of north-west, south-west dipping breaks, sometimes with a displacement of over a thousand feet which have outlined the range. These faults intersect, but only slightly displace a very extensive system of north 50° east, south-east dipping faults, which also have movements from a few feet to many hundreds of feet. Some of these north-east faults have served also as mineralizers. The surface geological map shows the complexity of the faulting and suggests the difficulties encountered in solving the ore-finding problems.

There are hundreds of small slips and faults with an east-west strike. In certain zones, these have become so numerous that they have determined ore channels. In some places, faults dipping at low angles have complicated the structure still more.

The results of this criss-cross faulting is that the district is divided into many fault blocks, tipped, over the long adjustment period, to various angles. Fortunately these angles are seldom over 30° to the horizontal. But, unfortunately, the block structure was so complicated that only small portions of the log were exposed in any one block. Careful surface mapping, supplemented by over 160 churn drill holes, has solved the problem. An east-west section across the Pioche Hills is submitted to show the complicated nature of the faulting. This particular section also shows the structural anticline which is characteristic of this part of the range. A north-east section also shows the large displacements characteristic of the Pioche Hills.

MINERALIZATION

Ore Bodies.—The long series of faultings had prepared the area for the admission and trapping of mineralizing solutions. There are many favourable structural locations and consequently many places to hunt for ore. The total probable flow of metal into the various channels either in gaseous or liquid solutions cannot be estimated, but it was surely many millions of tons.

The ore bodies may be classed as: (1) veins in quartzite; (2) replacement in fissures in limestones; (3) replacement in limestone and dolomite beds; and (4) fissures in the Yuba Dike.

(1) The veins in the quartzite caused the sensational production of the '70's. These veins are of modest width—up to 9 feet and quite steep. The filling of the veins is largely fragments of quartzite with the valuable minerals deposited between the fragments. The ore was oxidized to the water level —1,200 feet—and was somewhat porous due to removal of pyrite and sphalerite. The ore contained lead carbonate, silver chloride, gold, and many oxidation products, and some galena. Black sphalerite occurred below the water level along with pyrite and galena.

(2) The replacement in fissures in limestones was developed most completely in the Prince, Mendha, and Bristol groups of mines. The ores in the Bristol group were highly oxidised down to the water level below the 1,700, and contained silver, lead, copper, and zinc. Several ages of mineralization have been recognised—the iron copper mineralization characteristic of the east-west fracture; the silver-lead mineralization which predominated in the north-south fissures and the lead-zinc mineralization, found in the north-westerly fissures. It is believed that the primary ores were deposited from ascending solutions, but that some re-arrangement was caused during the processes of oxidation, although the limestone host rock retarded migration in most instances. Replacement veins and replacement bedded deposits frequently merge and are mined in the same stopes.

"In the Prince Mine, the fissure veins have a quartz gangue with primary sulphides of lead, zinc, and silver, and represent a type of mineralization associated with a somewhat higher temperature than the manganese-iron replacement deposits. In some places the veins cut iron-manganese beds with no apparent alteration of the bedded ore, and a striking contrast is formed by the light coloured fissure filling adjacent to the now oxidized black manganese ore. In other places, the fissure ve. have caused varying amounts of replacement of iron-manganese ore by the silicious vein type. In such cases, most of the iron contained in the original replacement remains, but most of the manganese is replaced."—Report by Paul Gemmill, 1941.

(3) Bedding Replacements.—The unoxidized ore bodies are highly carbonaceous silver-bearing limestone masses containing pyrite, galena, and sphalerite, often in so intimate a mixture that much research was required to perfect the separation by milling. In this research, Combined Metals was a pioneer and led the way in selective flotation. Near the edges of the ore bodies the manganese content increases, usually in the form of manganosiderite. Deposits of iron and manganese oxides containing small amounts of silver, lead, and zinc are abundant and are estimated to contain several million tons of ore. The manganese is usually pyrolusite, braunite or wad, the iron as goethite, limonite, or hematite. The silver, lead, and zinc content is variable, and is frequently high enough to add materially to the value of the ore.

At the Prince Mine the large manganese replacements are in the Prince and Davidson limestones and were mined largely during World War I. Since 1924, the production of the Pioche area has come largely from the sulphide replacements in the C.M. limestone. As the solutions ascended through the sediments, the C.M. was the first limestone to be encountered. This location, together with its enclosure within the thick shale beds, its nodular, thin-bedded structure, and its graphitic content, gave it a highly preferential position with several favourable factors. The Susan Duster bed, which lies about 100 feet above the C.M. bed and several of the limestones in the upper part of the A shale have also been productive locally.

These replacement ore bodies in the C.M. limestone occur in channels which are localized by fracture zones. In the Prince Mine, the channel runs about N. 25° W. and is from 100 to 300 feet wide. In the No. 1 mine of the Combined Metals, the channel trends east-west to N. 70° W., being localized by east-west fractures. A few hundred feet south of the channel is the largest granite porphyry dike in the area. The parallelism of the channel with the dike suggests a genetic connection. In this

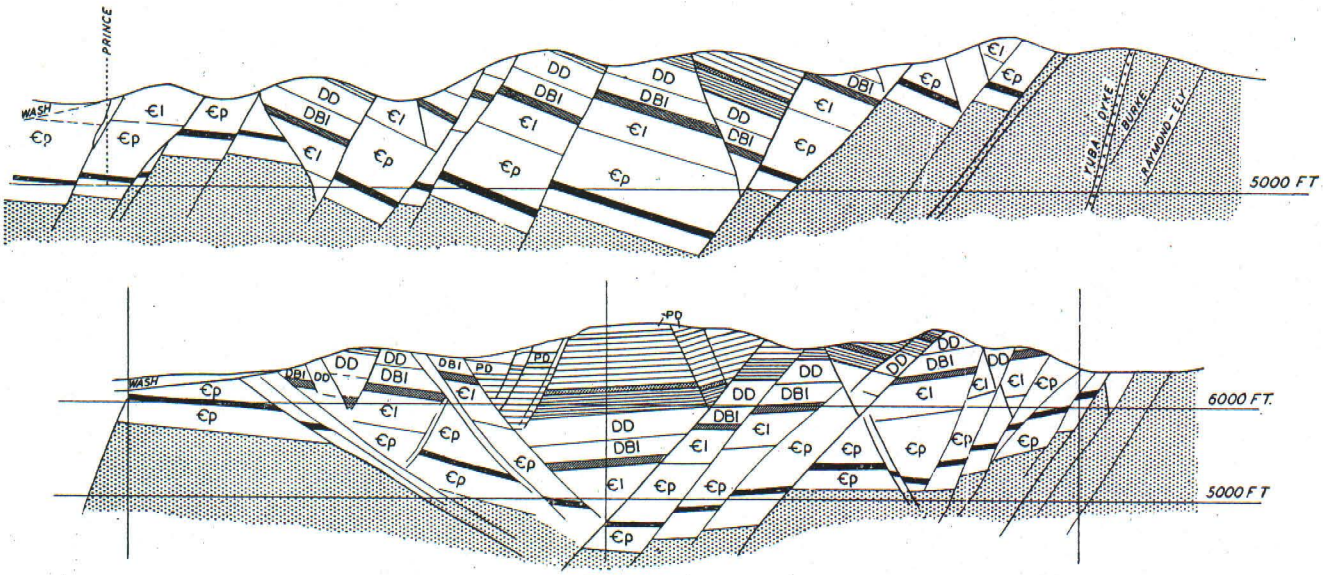

FIG. 33.—*Vertical sections through the Pioche Hills.*

Upper section on line E–E of Fig. 32, looking north-west; lower section on co-ordinate 15,000 N., looking north.

channel the C.M. bed has been replaced to such an extent that stopes may extend completely across the bed, 40 feet or more, and with a width along the bedding of 250 up to 400 feet. It has been followed nearly 10,000 feet through the Pioche Hills and to date has produced over one-and-half million tons of lead-zinc sulphide ore. One of the peculiarities of this channel is the fact that, although the C.M. bed is faulted many times by north-west and north-east faults, often with hundreds of feet of displacement, the ore blocks, as mined, line up nearly east-westerly across the range.

(4) Fissure veins in the Yuba Dike, a granite-porphyry, are of interest principally as showing an intimate connection between the dike and the sulphide mineralization. " The dike contains shoots or pods of ore distributed irregularly through it; they occur sporadically at both contacts or anywhere in the interior of the dike. The dike is 40 feet thick, trends east, and dips 80° south. It cuts through the quartzite, which dips 25° north. . . . It is highly sericitized. . . . Where unoxidized the porphyry contains finely disseminated pyrite, which was manifestly put into the porphyry at the time it was sericitized. . . . Genetically it is clear that the Yuba Dike was shattered after it solidified and that it served as a channel-way along which hot solutions ascended. These solutions deposited galena, sphalerite, pyrite, and a silver-bearing mineral in the dike and altered all its feldspars and biotite to white silky mica (sericite)."*

Ore Reserves.—The managements of the Combined Metals Reduction Company and of associated companies have adopted an ore reserve policy which may be said to have three phases. The first is to maintain a positive mineable ore reserve sufficient for two to three years of production. The second phase, consisting of exploration and development, is carried on by geological mapping and churn drilling followed by preparatory mining activities such as the driving of main haulage ways. This phase of the work should indicate and prepare for mining of ore for at least an additional five years. The third phase is represented by a much broader programme of careful geological surface mapping, acquisition of lands, and an occasional churn drill hole with the purpose of locating new ore channels which should provide ore for many years. To date, this policy has yielded excellent results with the conviction that the district will have a long life of profitable operation. One phase of the long range prospecting will be exploration at depth in the quartzite below productive zones for fissure ore which may recall the fabulous days of the '70's.

ACKNOWLEDGMENTS

I wish to express appreciation to Mr. Edward H. Snyder, President and Manager of the Combined Metals Reduction Company, for his inspiration and for his permission to assemble these notes for publication. To him should be given the credit for a lifetime devotion to the development of the district, and for an unusual perseverance in the face of many discouraging problems. I wish also to acknowledge frequent reference to U.S.G.S. Prof. Paper 171, published in 1932, and to the several bulletins published by the Mackay School of Mines, Reno, Nevada, on the Cambrian rocks of the Pioche area. It also is appropriate to acknowledge the loyal co-operation of the Pioche staff, which, over the years, has laboured over the complexities of the district. Leaders in this work were: S. S. Arentz, Jr., Kenneth Cochrane, Paul Gemmill, C. R. Hagen, George Heikes, and L. G. Thomas. The successful development of the district reflects credit on the management and on all who have participated in the work.

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