GEOLOGY AND METALLIFEROUS RESOURCES
OF THE REGION ABOUT SILVER CITY, IDAHO

by

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PREFACE

Silver City is the most important quartz mining district in Idaho, so far as gold and silver are concerned, over twenty million dollars worth of each of these metals having been produced in the aggregate from the three areas of War Eagle Mountain and Florida Mountain and De Lamar.

While on a professional visit to the area in 1905, and still more during a second visit in 1919, I was impressed with the improbability of certain of the ore bodies having been exhausted, and, on the second occasion, the conclusion was reached that Silver City should be included in the program of field work of the Idaho Bureau of Mines and Geology at the earliest possible date.

The present report by Messrs. Piper and Laney represents, therefore, not only the fulfillment of a determination made several years ago, but it serves to confirm in detail earlier impressions of the likelihood of future profitable production. This report, which represents in many ways the most laboriously detailed work yet done by the Bureau staff, carefully analyzes not only the areal geology, but also the nature of the fissuring and the deposition of the ores. It shows that both structurally and genetically, there are excellent reasons for believing that careful, intelligent prospecting, laterally and at depth, of the extensions of formerly productive ore bodies, is fully justified, and that in certain instances at least, such a program presents less than the usual mining risk.

FRANCIS A. THOMSON.

INTRODUCTION

PURPOSE AND SCOPE OF THE REPORT

The decline of the Silver City region as an abundant producer of the precious metals was a serious blow to the mining industry of southern Idaho. More than twenty-five years having passed since a geologic examination of the region had been made, the Idaho Bureau of Mines and Geology undertook a re-examination to analyze geologic conditions in the light of recent developments and to ascertain whether or no further search for ore bodies would be justified. This report presents the findings of that re-examination.

In the case of several geologic conditions which limit the occurrence of ore bodies, ample evidence has been secured to modify the conclusions reached by earlier investigators, and to alter thereby their estimate of the future of mining activity in the region. A rather complex fault system, not fully recognized heretofore, has been analyzed as completely as the dearth of accessible mine workings permits, and the relation of the several sets of fractures to the ore deposits has been established. The problem of the genesis and localization of the ore bodies has been attacked anew in order to predict the conditions that are to be expected at depths greater than those attained by past mining operations. It is regrettable that the inaccessibility of many old mine openings has made it impossible to determine the critical factors with the degree of quantitative precision that is desirable in every instance, but their qualitative effects are definitely established. The report presents ample justification for the conclusion that further search for ore bodies promises success, if carried on intelligently within certain restrictions that are formulated below, and under competent geologic guidance.
Inasmuch as the revival of mining activity depends more directly upon the downward persistence of the ore bodies than upon any other single factor, attention was concentrated upon those properties in which the most extensive exploratory programs had been carried out, because in them could be obtained the most information of critical value. The length of the discussion of a given property is not a measure of its promise, and failure to mention all is in no sense a condemnation of any one. Rather, the endeavor has been made to establish the fundamental geologic conditions for each of the units into which the region is logically divided. This treatment of the problem is, indeed, the only one possible in the time that could be granted to its study.

FIELD WORK AND AUTHORSHIP

The field investigation was carried on during the period from July 6 to October 15, 1925, with one interruption of ten days’ duration. General responsibility for the progress of the work was assigned to Dr. Francis B. Laney, who spent eleven days in the field during July in a preliminary reconnaissance of the region with Arthur M. Piper. Upon Mr. Piper devolved the greater part of the mapping. In the absence of a satisfactory base for the compilation of geologic data, it was necessary to prepare large scale topographic maps covering 14 square miles in three separated areas. Upon these maps as a base, detailed geologic studies were made and expanded by stadia traverse over a total area of 21 square miles. Incidentally rather cursory attention was given to the encompassing region, an area about 10 miles square. During August and September, Dr. Laney devoted seven days with Mr. Piper to an intensive study of the fault problem at De Lamar, and an additional five days to inaugurating the geologic mapping in the vicinity of Silver City. Technical assistance was rendered by M. H. Archibald until September 5, and by the late Delos Frye for the period September 7-11, 1925. Both these men were students at the University of Idaho.

The laboratory studies of the petrography of the Silver City rocks, the analysis of the geologic structures, and the compilation of the various maps and sections have been executed by Mr. Piper. Dr. Laney has studied the mineralogy and paragenesis of the vein matter and ores. All inter-related and obscure phenomena have been freely discussed by both investigators and the conclusions presented herein are a consensus of opinions. The report, with the exception of those sections dealing with the mineralogy, genesis, and depth persistence of the veins and ore bodies was written by Mr. Piper.

ACKNOWLEDGMENTS

It is obvious that the success or failure of an investigation such as this depends in large measure upon the freedom with which those who are familiar with the district give of their store of knowledge acquired through the stern experience of mine operation. Space does not permit individual mention of all those who have contributed in this way, although the writers’ debt to them is large. Messrs. W. R. Helm of Jordan Valley, Oregon, and H. H. Bonnell of Silver City gave material assistance by granting unrestricted access to the property and records at De Lamar. E. V. Orford of Boise, for many years manager at the property of the De Lamar Mining Co., devoted many hours to invaluable discussion of conditions that exist in underground workings that are now inaccessible. Mr. Peter Steele of Silver City was especially courteous in throwing open his files of data pertaining to the mines on Eagle Mountain, at a time when the properties were involved in litigation. To Mr. Ray Duncan, manager of the Never Sweat Mining Company’s property on War Eagle Mountain, commendation is due for keeping the lowest level of the mine pumped out for two days in order that access might be had to that ground. Mr. J. W. Stoddard very kindly loaned a valuable collection of high-grade ores, thus facilitating greatly the study of the mineralogy of the district.

Technical assistance has been rendered in the preparation of thin sections by L. G. Morrell of the University of Idaho and by A. L. Anderson of the Idaho Technical Institute; in the preparation of specimens and the study of ores by Rollin Farmin and R. E. Sorsen, also of the University of Idaho; and in making assays and chemical analyses by G. V. Larsen, formerly analyst on the staff of the Idaho Bureau of Mines and Geology, and also by A. L. Anderson. To these and many others who have been contributors, the writers express appreciation of the courtesies extended.

LITERATURE

Although the Silver City region is one of the famous old mining camps of the west, the literature describing it is neither plentiful nor in any sense complete. The earliest reference to the geology
of the region is found in notes by G. F. Becker (2: pp. 52-59) contained in the report of the Tenth Census. Mr. Becker notes the occurrence of silver and gold-bearing veins in the granite, and that these veins are usually parallel to the axes of the mountain ranges in which they are found. G. H. Eldridge conducted a reconnaissance across central Idaho in 1894 and made a cursory examination of the Silver City District (15: pp. 271-272). In 1897 Waldemar Lindgren, assisted by F. C. Schrader and N. F. Drake, studied the gold and silver deposits of western central Idaho and reported on them in some detail (24a; 24b: pp. 107-188; 18c). Historical notes and data of production are to be found in the reports of J. Ross Browne (9b: pp. 522-530) and of R. W. Raymond (29a: pp. 161-166; 29b: pp. 235-247; 29c: 29d: pp. 250-254; 29e: pp. 189-197; 29f: 29g: p. 804; 29h: pp. 235-247), in the annual reports of the Director of the Mint (106a: p. 125; 106b: pp. 205-207; 106c: pp. 227-230; 106d: pp. 467-471; 106e: pp. 278-280), in the volumes of Mineral Resources of the United States, and in the annual reports of the Idaho Inspector of Mines. Notes on the mineralogy of the district have been published from time to time by E. V. Shannon (31a: 31b; 31c; 31d) and recently have been summarized (31e). These published technical data have been freely consulted, together with the many unpublished reports by consulting engineers and mine operators which have come to the attention of the writers.

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GEOGRAPHY

LOCATION AND SUBDIVISIONS OF THE REGION

The Silver City region embraces an area about 10 miles square in parts of six townships of Owyhee County, in the southwestern part of the State of Idaho. It is bisected by parallel 43° north latitude and lies between meridians 116° 40’ and 116° 55’ west longitude. The location of the region with respect to the boundaries of the State is shown by the insert which forms a part of the accompanying index map (fig. 1).

To facilitate field examination and discussion, the region may be subdivided into three parts: the De Lamar district, the Florida-War Eagle Mountain district, and the Flint district. Each of these has been mapped as a unit (See Pls. I, II, and III respectively). The relative positions and extent of the several districts is also shown by the index map (fig. 1).

TRANSPORTATION

The Silver City region is served by a branch of the Oregon Short Line railroad, which leaves the main line at Nampa and extends southward to and across the Snake River, a distance of nearly 30 miles. The terminus of this branch line is at Murphy. From Murphy a stage road extends southward and westward 25 miles to Silver City, the county seat and business center of the district. From Silver City the stage road continues down Jordan Creek three miles to Dewey and an additional four miles to De Lamar. A wagon road courses southwestward from Silver City, ascends Sawpit Gulch, crosses a divide 7,500 feet above sea level, skirts the head of Louse Creek, and descends Flint Creek to Flint, a distance of 10 miles. Access to the region may also be had from the town of Jordan Valley, Oregon, the terminus of a 50-mile highway which leaves the railroad at Homedale, Idaho. From Jordan Valley, a wagon road leads eastward 20 miles to Flint and nearly the same distance to De Lamar.

None of these routes of travel is at present feasible for the heavy duty truck service which would be a prerequisite for an extensive revival of mining activity in the region. The stage road from Murphy ascends and descends several low ridges and then gains Silver City by a grade which averages 15 per cent for three miles.

FIGURE 1—Index map of northwestern Owyhee County, Idaho, showing subdivisions of the Silver City region, and (by insert) the portion of the State covered by this index map.
of its length, and in many places exceeds 20 per cent. It crosses a divide at an elevation of 6,700 feet which is snowbound for at least four months of the year and is usually closed to heavy vehicles for six months. The other roads of the region are no better and many are worse. The cost of transporting supplies from Murphy to Silver City is at present one cent per pound, on account of the small permissible loads that can be hauled. Mine timber laid down at Murphy for $55 per thousand feet in 1919, cost $85 per thousand feet delivered to the De Lamar mine 30 miles distant. It is obvious that this condition places a great handicap on mining activity, and that low cost of transportation is indispensable for mine operation at reasonable cost.

Happily the weaknesses of the present routes of transportation can be in large part removed, if future exploratory work justifies the resumption of mining on a large scale. A road whose grade would not exceed five per cent and whose length would approximately equal that of the present Murphy-Silver City stage road, could be built from Murphy up Rabbit Creek, skirting Black Mountain and the ridge which extends southward from it, and crossing either Democrat Saddle or the 6,500-foot pass about 2½ miles farther east. If winter snow conditions should make its development feasible, the eastern route would be several miles shorter. Portions of the proposed route are roadways at present and the amount of new construction would not exceed the re-location that would be necessary to make the present road suited to heavy duty trucking. This proposed route could be kept open at least eight months of the twelve.

The Flint district could be most directly reached by extending this route southeastward from Dewey through the 6,300-foot pass east of De Lamar Mountain, thence around the head of Louse Creek and down Flint Creek. This extension would place Flint only 10 miles from Dewey and 35 miles from Murphy over a road of easy grade; it would eliminate the 7,500-foot pass at the head of Sawpit Gulch on the present road from Silver City or the 70-mile haul from Homedale through Jordan Valley. Moreover, the 20 miles from Jordan Valley to Flint are traversed by an abominable road which would need to be entirely re-located if this means of approach were developed. Furthermore, if the approach should be by way of Dewey, the entire Silver City region would be tied together by a single route and the lowest attainable ton-mile cost of transportation gained thereby.

POWER

Each of the three districts which make up the Silver City region is reached by electric transmission lines and is served with power by the Idaho Power Company from its Swan Falls plant on Snake River. It is exceedingly fortunate that this hydro-electric power is available, in view of the lack of local wood supply and the prohibitive cost of hauling coal to operate steam-driven plants. Moreover, the high-water flow of Jordan Creek generated sufficient power to operate the mill at De Lamar for many years and it is not unlikely that a similar development would be found feasible at present for both Dewey and De Lamar.

CLIMATE

The Silver City region has a mean annual precipitation of 23.14 inches, of which only 1.95 inches falls during the summer months of July, August, and September. Usually only these three months are without snow and the annual snowfall is 129 inches. Almost incessant winds drift the snow badly and add greatly to the rigor of the winter climate. The summer days are warm and usually clear, the nights cool; rain falls occasionally during this season in brief showers, some of which are torrential downpours. On account of the moderately heavy snowfall, the surface water supply is usually ample for the needs of mining and milling operations, the larger streams maintaining their flow through the dry summer months.
The regional relief is, therefore, about 5,500 feet. From Long Gulch and Sawpit (PI. II), whose respective elevations are 7,785, 8,065, and 8,406 feet. The regional relief, therefore, about 5,500 feet. From the summit of Cinnabar Mountain, about 4½ miles southeast of Silver City, the range descends sharply southward.

As shown by the topographic maps (Pls. I, II, and III, in pocket) the region is deeply incised by steeply graded streams, and yet sharp pinnacled peaks and precipitous slopes are uncommon. Along the axis of the Owyhee Range, shown by the map of Florida and War Eagle Mountains, the topographic prominences are characterized by dome-like or flattish summits bounded by steep smooth slopes. Similar but smaller forms are characteristic of the granite area of the Flint district (Pl. III). These steep slopes make the task of reaching many of the mining properties an arduous one, but they present excellent sites from which adit-tunnels may tap the veins as much as 2,000 feet below their outcrops. From the western faces of Florida Mountain and Sawpit Peak (Pl. II) the terrane slopes westward to a lava-covered region in which terraced slopes descend gently from flat-topped summits nearly to the streams, then plunge sharply into the waterways. Unfortunately none of these characteristic forms is shown by the topographic maps. As one progresses westward toward the flank of the range, the relief steadily decreases and the topographic forms become more and more subdued until they merge into a maze of low rounded hills and ridges.

Alpine glaciation has been effective to a limited extent in the development of the topographic details of the more elevated portions of the terrane that immediately surrounds Silver City (Pl. II). A small typical cirque remains on the eastern face of Florida Mountain, and the open head of Coffee Gulch on the southeastern face suggests a similar origin. Long Gulch and Sawpit creeks head in flat-bottomed basins of roughly semi-circular contour, the floors of which are made up of glacial debris now undergoing dissection by the streams. Glaciation has been the primary factor in carving the amphitheatre-like basin at the head of the South Fork of Sinker Creek in the vicinity of the Afterthought Mine (Pl. II, No. 68), and the precipitous northern face of Cinnabar Mountain is the result of sapping and plucking by ice. All of the summit areas about War Eagle and Florida mountains have been subjected to the scouring action of an ice cap, and much of the characteristic roundness of form is probably traceable to this cause. Many other minor topographic features not specifically mentioned are likewise the result of ice scour. Stream erosion, however, is everywhere removing the effects of glacial action and has been by far the dominant agent in the sculpture of the Silver City terrane.

In a following description of the regional geologic structure, it is shown that the Silver City terrane has been subjected to repeated diastrophic activity, part of which is of post-mineral age. The displacement in some instances may exceed 1,000 feet. Glacial scour and erosion by sub-aerial agents has reduced the surface until most of the direct topographic expression of even the latest displacement has disappeared. Consequently, the topographic surface has been lowered at least several hundred feet and possibly thousands of feet since the period of mineral deposition. It is impossible, therefore, to postulate the relation of the present ore bodies to the surface that existed at the time of their formation.

The region about Silver City is tributary to Snake River, the master stream which drains southern and central Idaho and eastern Oregon into the Pacific Ocean by way of the Columbia River. The indefinite ridge which extends northwestward through Cinnabar and War Eagle mountains forms a local divide from which water flows northeastward directly to Snake River and southwestward to the Owyhee River, a major tributary which drains the southwestern corner of Owyhee County and adjacent parts of eastern Oregon. Castle Creek, Sinker Creek, and Rabbit Creek carry the northeastward drainage, and Reynolds Creek flows northward to Snake River from the divide north of De Lamar. These tributaries are shown by the index map (fig. 1). The greater part of the mining districts, however, is drained by Jordan Creek, a tortuous waterway which flows northward through Silver City, thence westward about six miles through De Lamar to the site of the former Wagontown (Pl. I), turns southward in a precipitous-walled canyon for ten miles, and then, after uniting with Boulder Creek, courses west-
ward and northward to its confluence with the Owyhee River.
Sawpit Creek and Long Gulch Creek are important branches of
Jordan Creek from the region south of Florida Mountain, Louse
Creek drains most of the territory between De Lamar and Flint,
and Flint Creek serves the district of the same name.

The geologic maps (Pls. I, II and III) show that the pattern of
the waterways is in part in very close agreement with the surface
traces of major earth fractures. Moreover, the regional pattern of
drainage ways shown on the index map (fig. 1) is in close harmony
with that of the smaller areas, and suggests that a correlation be-
tween it and the regional structure could be readily made. These
relations will be discussed further in the section on structure.

GEOLOGY

STRATIGRAPHY

GENERAL CHARACTER AND SUCCESSION OF THE ROCKS

The rocks of the Silver City region include both igneous and
metamorphosed sedimentary species. The sediments, of possible
Carboniferous age, occur in very limited amount as remnants of
pendant blocks held in the peripheral zone of a granitic intrusive.
The whole is overlain by extrusive basalt and that in turn by a
thick series of rhyolite flows. With these Tertiary extrusives are
associated dikes of similar material which represent some of the
sources from which the lava flows were poured out.

The study of the metalliferous resources of the region involves
only the relative ages of the several rock types, their absolute ages
being of secondary interest. Recent work by Chaney (12) and
Buwalda (22: p. 19) has revised Lindgren’s correlation of the Pay-
ette formation (24b: pp. 97-99; 24c: p. 3) upon which the age of
the Silver City extrusives depends, and the writers believe that
Umpleby’s assignment of the Idaho granitic batholith to the late
Cretaceous (34: pp. 42-43) is open to question. However, only
passing attention could be given in the field to questions of correla-
tion, and a complete review of the problem at the present time is
not justified.

METAMORPHOSED SEDIMENTS

DISTRIBUTION AND AGE

Along the western border of the area of granitic rocks in the
Flint district (Pl. III), in what is clearly a contact aureole of the
intrusive, occur a few scattered blocks of highly metamorphosed
sediments. These are too small to be distinguished on the geologic
map, and may be recognized only in a few scattered outcrops and
in the debris from mine workings. Such rocks do not occur else-
where in the region covered by this investigation. At South Moun-
tain, 20 miles southwest of Silver City, garnetiferous schists and
crystalline limestones are intruded by diorite (24b: pp. 188-189:)
these sediments are mapped by Lindgren as possible Carboniferous
(24b: Pl. VIII, p. 76), although the evidence favoring this correla-
tion is not stated. It is probable that the sediments of the Flint
district are an extension of the South Mountain series and may be correlated with them. They show unquestionably the effects of intrusion by granitic magma and of contact metamorphism; they are, therefore, undoubtedly older than the intrusive.

**PETROGRAPHY**

The metamorphosed sediments of the Flint district are graphitic and biotite schists derived from a fine-grained argillite. The crystalline limestones of South Mountain are not represented. A fine-grained light gray fissile rock from the west wall of No. 1 vein, Precious Metals Mines Company, is 65 per cent equigranular quartz grains of irregular outline embedded in shred mica accompanied by dendritic and compact masses of graphite derived from the carbonaceous content of the unaltered rock. Graphite amounts to 5 per cent of the whole. In the coarser-grained phases biotite and muscovite are the dominant metamorphic minerals. One specimen from the Doughboy claim is corrugated in an extremely regular fashion as a result of the compression accompanying regional diastrophism. Invariably the small blocks of schist are traversed by small apophyses from the granite and by veinlets of quartz associated with the precious metal-bearing veins.

**INTRUSIVE ROCKS**

The granitic intrusive of the Silver City region is possibly a small peripheral outlier of the Idaho batholith, which covers an area of more than 20,000 square miles in the central part of the state. Once covered by a mantle of Carboniferous (?) sediments, it had been exposed over most of the region by erosion before the outpouring of the Tertiary lavas. The normal type of the intrusive rock resembles a true granite when examined in the hand specimen, but under the microscope is seen to be an intermediate type which is close to a granodiorite in composition and takes the latter name. As is usual in such outliers, the rock varies from its typical mode from place to place, and is also accompanied by both acidic and basic differentiates. In the case of Silver City, these differentiates are aplite, and dacite or diorite porphyry respectively.

**GRANODIORITE OR SILVER CITY GRANITE**

**OCCURRENCE**

Granite and its allied igneous types crop out over an extensive region about Silver City. The area of intrusives traced on the map of War Eagle and Florida mountains (Pl. II) is the southern tip of a mass of granitoid rocks, 25 miles long and 10 miles wide, which trends northward beneath an interrupted cover of basalt and rhyolite (24c: areal geology map), and finally plunges beneath the Snake River plains. In the basin of Cottonwood Creek, about five miles southwest of Silver City, a prolongation of this mass appears at the surface and extends southward about five miles to and slightly beyond the Flint district (Pl. III). Dioritic granite again pierces the Tertiary lavas at South Mountain (24b: p. 117) and covers an area about eight miles long and four miles wide.

Outcrops of the granodiorite are invariably parted into regular polygonal blocks by persistent sets of intersecting fractures resulting from the diastrophism to which the region has been subjected. Usually one or another of these fracture sets is more perfectly developed than the others, so that a marked and unusually perfect sheeting results. Locally, where a topographic slope cuts across the strike of the sheeting, the effect is that of a truncated sedimentary series. Erosion, working rapidly along the fracture planes, produces here and there serrated ridges and castellated and buttressed topographic forms which, although somewhat unusual, are quite characteristic of the region. Over most of the granodiorite area, however, rapid disintegration of the coarse-grained rocks has smoothed the slopes with a mantle of sandy debris.

**PETROGRAPHIC CHARACTERISTICS**

*Normal phase.*—The typical unaltered granitoid rock is medium-to coarse-grained, light gray, and wholly crystalline. The individual grains are of unequal size, but average 0.15 to 0.20 inch in diameter. The hand specimen is characterized by a great abundance of quartz, and small amounts of biotite (black mica) and muscovite (white mica). There is a decided tendency toward porphyritic texture, phenocrysts of potassic feldspar attaining here and there a maximum dimension of 1½ inches. Purely megascopic examination would probably classify the type as a true granite.

The microscope shows, however, that the rock differs markedly from a typical granite. The essential minerals, in the order of their crystallization, are muscovite and biotite, plagioclase, potassic feld-
spars, and quartz. Biotite, usually the more abundant of the two types of mica, occurs in scattered tabular forms, partly resorbed during the crystallization of the plagioclase. Muscovite forms individual foils or is interlaminated with biotite. The dominant feldspar is oligoclase-andesine (Ab, An), which occurs in stout and elongate euhedral prisms and mutually interfering forms and constitutes fully 45 per cent of the whole. The larger sections are characterized by zonal extinction, and in many cases enclose small crystals of quartz and mica. Carlsbad twinning combined with the usual albite or polysynthetic type is common, and one crystal was noted in which twinning according to both the Carlsbad and Baveno laws is combined with the polysynthetic. The potassic feldspars, microcline and orthoclase occur as large pseudo-phenocrysts whose outline is controlled by the arrangement of the older oligoclase crystals; frequently, however, they approach true crystal form. In the aggregate these minerals amount to about 15 per cent of the rock, although their habit makes any estimate of relative abundance uncertain; microcline is the more abundant of the two. They are invariably micropoikilitic, that is they enclose microscopic crystals of quartz and oligoclase, many of which are partly resorbed. Quartz, fully 35 per cent of the average granitoid type, makes up anhedral masses of interlocking grains. Undulatory extinction and fracturing are always present, and speak of the diastrophism which the rocks have suffered. Frequently the potassic feldspar and nearby oligoclase are partly bordered by micropegmatite, a phenomenon which indicates that the potassic feldspar and quartz crystallized, at least in part, at the same time. Magnetite and apatite are invariably present and are usually accompanied by zircon with or without rutile, octahedral (?) or titanite. Of these accessory minerals, all but magnetite are characteristic of the more acid igneous rocks.

Rigorous adherence to the classification of igneous rocks formulated by Iddings (20: pp. 357-358) demands that this typical rock be classified as a granodiorite, on account of the dominance of the oligoclase-andesine feldspar. It differs from typical granodiorite, however, in that it is unusually high in quartz and is completely lacking in amphiboles and pyroxenes. It is a somewhat unusual type, being more acidic than most true granites and at the same time dominantly sodic. The term “soda granite” would be properly descriptive if it had the prestige of standard usage.

Lindgren (24b: p. 84) calls the less acidic rock from the region north of Snake River a quartz-monzonite, although he recognizes it as an intermediate type and states that it also resembles certain rocks from the Sierra Nevada which have been called granite by H. W. Turner (33: p. 142).

Facies.—Local departures from the normal granite are quite numerous, the most common being the development of a coarse-grained porphyritic phase. True phenocrysts of potassic feldspar, usually microcline, reach a length of two inches and may constitute 30 per cent or more of the rock. In many instances they are colored deep brownish-red by the presence of iron oxide, or are intergrown with oligoclase-andesine in the form of microperthite, and usually enclose small euhedral crystals of oligoclase, quartz, biotite, and muscovite. These inclusions may amount to as much as 10 per cent of the host crystal. Primary gneissic or laminated texture in this coarse-grained phase is well exposed along the Silver City-De Lamar stage road about a mile and a half north of Silver City, the potash feldspar phenocrysts having been turned parallel to one another by movement of the magma during crystallization. In many cases the potassic feldspar is far more abundant than plagioclase, and the rock is a calcic-alkalic granite.

Pegmatite is found here and there. Potassic feldspar, the dominant constituent, forms subhedra of which many attain a length of four to six inches, a few being even larger. These subhedra are ordinarily graphically intergrown with quartz. In the mass of the rock, quartz forms anhedral and ramifying interrupted veinlets. Muscovite and subordinate biotite may or may not be present in foils not more than half an inch in diameter. Almandite (a species of garnet) is an abundant accessory. Fine-grained aplite, with the composition of highly quartzose calcic-alkalic granite, frequently accompanies the pegmatite as a complementary differentiate.

Schlieren are numerous in the contact zone of the intrusive in the Flint district. These segregations form small lenticular masses and irregular bands of fine-grained rock rich in biotite, which alternate with coarse-grained mica-free phases. The fine-grained basic segregate consists of 8 to 10 per cent minute biotite foils, 60 to 65 per cent andesine (Ab, An) in stout and elongate subhedral and mutually interfering prisms, and 25 per cent quartz in small interlocking anhedra. Its composition is that of a typical quartz-biotite diorite.

Alterations

Under the influence of the weather the granodiorite assumes a dull reddish-brown color from the oxidation of the iron-bearing...
biotite, and, as hydration of the feldspar progresses, it crumbles into a coarse sandy debris which mantles the less rugged slopes. Specimens of fresh rock are obtainable only from the waste of mining operations.

Specimens collected anywhere within the zone of the mineral deposits invariably show chemical changes brought about by circulating heated solutions. Biotite is largely if not completely altered to chlorite (usually penninite). The sodic feldspar reveals secondary mica (paragonite?) and cloudy kaolin developed along cleavage planes. In the more intensely altered phases abundant kaolin and zoisite, locally accompanied by a subordinate amount of calcite, have expanded from cleavage and twinning planes until the primary mineral has been entirely destroyed. Only in the areas of more intense alteration have kaolinization and sericitization of the potassic feldspar taken place. Chlorite and zoisite, when abundantly developed, give the rock a light bluish-green tint which characterizes the waste of many a mine dump.

Locally, the alterations which accompanied the formation of the metalliferous deposits have given the quartz crystals a brilliant rose hue in the hand specimen. A study of thin sections shows that the phenomenon is due to flocculent films, spongy dendrites, and dense nuclei of a highly-tinted substance which occupy fractures. These pigment-filled fractures traverse the crystals of quartz, follow the contacts between quartz and feldspar crystals, and in a few instances penetrate the feldspar. The fracture filling resembles titanite, some of the denser nuclei approaching quadratic outline, but precise identification proved to be unattainable.

**APLITE**

Typical aplite occurs only in the peripheral zone of the granodiorite in the Flint district, where it forms a few dikes three to eight feet wide. It is generally a white fine-grained rock with an average grain size of 0.05 inch. Quartz is 30 or 35 per cent of the whole, with dull milky feldspar and a very small quantity of muscovite making up the remainder. Specimens of fresh rock for microscopic study were not obtainable from the few outcrops, so that the species of feldspar is unknown. The rock weathers easily to a sandy debris which conceals the outcrops almost completely, so that the dikes are not traceable for more than a few yards.

**DIORITE PORPHYRY AND DACITE PORPHYRY**

**OCCURRENCE**

The granodiorite of War Eagle Mountain, southeast and south of Silver City, is traversed by several dikes of diorite and dacite porphyry. Their continuity has been interrupted by a complex system of faults, which will be discussed on a later page, so that their pattern on the geologic map (Pl. II) seems at first glance to lack regularity. The dikes, for the greater part of their length, are between 25 and 50 feet thick but widen locally to as much as 200 feet. They strike N. 20-65° E. and dip 45-70° SE., in some instances following sheeting planes in the granodiorite. Some of the smaller of these dikes are not plotted on the geologic map, but an effort was made to trace all those which were of diagnostic value in tracing the geologic structures.

The diorite porphyry is somewhat older than the dacite porphyry, but both undoubtedly represent the same general period of igneous activity. Field relations show conclusively that these dikes do not penetrate the rhyolite which overlies the granite, although they fail to show the relative age of the basalt. Moreover, the granodiorite and the dacite dikes are dominantly sodic rocks which are very similar to one another but are markedly different, both mineralogically and chemically, from the two other igneous types of the region, basalt and rhyolite. There can be little doubt that the dacite and diorite porphries are differentiate from the granodiorite magma, differentiates which are slightly more basic than the normal.

**PETROGRAPHIC NATURE**

Specimens of unweathered diorite porphyry are difficult to obtain and an accurate conception of the fresh rock is not gained from a study of a casually gathered hand specimen. Its ordinary appearance shows a motiled light greenish-gray ground-mass with a very few slightly rounded quartz phenocrysts 0.10 to 0.15 inch in diameter; microscopic examination shows, however, that this ground-mass is crystalline and fine- to medium-grained. Andesine (Ab, An), in mutually interfering prisms, is the dominant constituent; biotite forms a few foils and irregular shreds; and quartz is present as a few small, scattered anhedra. Intersertal hornblende or other amphibole is doubtfully known from alteration products. Orthoclase is probably present but was not determinable. Magnetite is the most plentiful accessory, but apatite is also present.
The dacite porphyry is typically a grayish-green rock, of which as much as 25 per cent is comprised of phenocrysts. These are, in order of abundance, andesine, quartz, biotite, and hornblende (?). Andesine (Ab$_3$An$_1$) forms elongate mutually interfering prisms usually less than 0.2 by 0.4 inch, although a few are as large as $\frac{3}{4}$ by 1 inch; basal sections show zonal banding. It makes up 15 to 20 per cent of the rock. Quartz phenocrysts, which attain a maximum diameter of 0.2 inch and amount to less than five per cent of the rock, are rounded and embayed by magmatic resorption and are usually surrounded by a fringe of radiating microlites. The average index of this microlitic fringe is somewhat higher than quartz and approximately that of oligoclase, a feldspar which is more acid than the species which dominates the rock. Biotite is always present and may or may not be accompanied by a smaller quantity of amphibole (hornblende (?)); these two generally constitute two or three per cent of the whole. A very few intratelluric crystals of sanidine, almost wholly resorbed, represent the only determinable potassic feldspar. The ground-mass is microcrystalline but too fine-grained to be fully resolved by the microscope. It is in large part composed of microlites of soda-lime feldspar, but probably contains orthoclase and quartz as well. Chemically and mineralogically these rocks are approximately equivalent to the diorite porphyry already described, but the large portion of microcrystalline ground-mass demands the name biotite dacite porphyry.

**ALTERATION**

Alteration, in part by heated solutions, has progressed so far in many specimens that the character of the fresh rock is almost wholly obscured. Biotite and amphibole are represented by feebly pleochroic remnants accompanied by chlorite (usually penninite) and iron oxides. Andesine is transformed into zoisite, mica (paragonite (?)), calcite, and kaolin. Tale, secondary quartz, and questionable sillimanite may be recognized in the more intensely altered phases. Pyrite has been deposited in the rocks, and much of the alteration can be traced directly to the solutions which effected the pyritization.

**EXTRUSIVE ROCKS**

**BASALT**

**GENERAL CHARACTER AND DISTRIBUTION**

After its intrusion, the granodiorite was denuded by the ensuing erosion. By early Tertiary (Miocene ?) time its surface had been reduced at least to a state of maturity, with rounded hills and moderate relief. Over this mature surface a vast quantity of basalt lava was poured out during Miocene (?) time, the succession of rocks being unquestionably proven by the frequent occurrence along their contact of arkosic debris cemented by infiltrated basalt. This phenomenon is particularly well exposed on the flat east of the Afterthought mine, about three-quarters of a mile southeast of War Eagle Mountain (Pl. II, No. 46).

Partly on account of the irregularities of the underlying granite surface and partly on account of unequal subsequent erosion, the thickness of the basalt varies greatly from place to place, its maximum exposed thickness being nearly 2,000 feet. The oldest of the exposed extruded material is basaltic agglomerate or tuff which has its best exposure in the Flint district. Angular to sub-angular fragments of dense fine-grained basalt, usually not more than a foot in maximum dimension, are held in a glassy or pumiceous matrix, the whole being rather well bedded. Thin interrupted flows of dense basalt are intercalated here and there in the series. Similar material was penetrated for 377 feet in the bottom of a 925-foot well drilled for water near the west end of the De Lamar mill (Pl. I, No. 16), nearly 10 miles north of the Flint district. This basaltic agglomerate has a known thickness of 1,500 feet in the heads of Cottonwood and Twilight creeks, northeast of the Flint district, and the base is not exposed.

Overlying the agglomerate are dense fine-grained and porphyritic basalts, the product of quiet extrusion which contrasts sharply with the violent igneous activity which must have accumulated the fragmental material. Several small areas of very fine-grained basalt occupy the summit of War Eagle Mountain and the flows have a thickness of 850 feet on the southeastern face of Florida Mountain (Pl. II). The same thickness is exposed in the De Lamar district (Pl. I), although the total thickness exposed and penetrated by the drilled well is approximately 1,000 feet. Inasmuch as the upper surface of the basalt has been protected from erosion by a cover of rhyolite, this figure represents approximately the original thickness of the dense basaltic flows. In the Flint district about 150 feet of basalt is exposed beneath the rhyolite in the head of Flint Creek, and 175 feet of dense almost glassy basalt overlies the agglomerate on the summit of Black Warrior Mountain (Pl. III). It is impossible to trace separate flows on the surface, but the gently terraced ridges of the basaltic terrane north of De Lamar and Dewey suggest that these lavas were accumulated by successive outpourings. The
areas of basalt plotted on the geologic maps are portions of scattered separate exposures along the southern margin of a basalt-covered area which extends northward 25 miles and has a width of 13 miles, an area which coincides approximately with the principal mass of intruded granodiorite (18c: areal geology map).

An adequate source of the extrusion for the great volume of basaltic lavas cannot be satisfactorily established. Basalt dikes, usually from three to ten feet wide and traceable for 1,500 feet or more in some instances, abound in the granite adjacent to the crystalline flow rocks, and especially in the tuffs of the Flint district. Some of these dikes are directly connected with the bodies of lava and are the obvious loci of some of the extrusion. In view of the great extent and uniform character of the flows, however, it is almost inconceivable that comparatively small known dikes could be the only source. The wide distribution and great thickness of the coarse-bedded tuff demand, moreover, a vent or vents of a higher order of magnitude than these dikes. It is the writers’ belief that the basaltic tuffs and flows were extruded from major vents located in the region about Silver City but now concealed by younger rocks, and that the dikes are minor if not inconsequential sources.

PETROGRAPHY

The mineralogical composition and texture of the basalts present no unusual features. The most abundant of the flow rocks are porphyritic with recognizable lath-like and tabular feldspar phenocrysts as much as 0.6 inch long, held in a fine-grained dark gray matrix. Thin sections identify the phenocrysts as laths of andesine-labradorite or labradorite (\(\text{Ab}_{50}\text{An}_{50}\)), usually with slight marginal resorption. The ground mass has typical ophitic texture with andesine-labradorite (\(\text{Ab}_{50}\text{An}_{50}\)) microlites interlacing through a matrix of diallage accompanied by hexagonal euhedra and acicular or tabular grains of ilmenite. Olivine may or may not be present but is lacking in the majority of slides. The fine-grained phase does not differ markedly in composition and texture from the groundmass of the porphyritic type. A very small amount of dark colored glass occurs in a few slides and the texture leans toward the intersertal. The rocks from the narrow basalt dikes are often fine-grained and cannot be distinguished in the thin section from the flow rocks of similar megascopic appearance.

HYDROTHERMAL ALTERATION

The basaltic rocks, at a distance from the ore deposits, are fresh and unaltered in the outcrop. Hydrothermal alteration, however, is quite marked in the vicinity of the metalliferous veins but at the same time quite erratic in occurrence. Fresh rock may be found within a few feet of a vein and intensely altered phases several hundred feet away. The first effect of the heated solutions on the basalt is detected in the hand specimen by a dull, earthy luster, greenish-gray color, and loss of conchoidal fracture; in the porphyritic varieties a dull motting may be recognized on freshly broken surfaces and is frequently accentuated by weathering. The corresponding mineralogical changes include the development of chlorite or calcite and serpentine from the pyroxene, accompanied by a minor amount of magnetite. Flocculent kaolin is abundant in some specimens, but is strikingly absent from others in which calcite is most abundant; it is on the whole subordinate. In one moderately altered porphyritic basalt from No. 16 adit of the De Lamar mine (Pl. I, No. 17), the total acid-soluble carbonates, calculated as calcite, amounted to 10.7 per cent of the whole.

In some intensely altered basalt from the same adit the pyroxene is altered to weakly pleochroic amphibole and epidote with a variable amount of magnetite and hematite. Hematite may be in sufficient abundance to give the rock a deep reddish-brown color. The feldspar may or may not be affected, chlorite and calcite being formed along cleavage fractures. These scattered products are usually accompanied by nodular segregations of other minerals. Calcite, which may or may not surround a core of greenish chlorite, is usually the most abundant segregate, although chlorite may be predominant. Analcite accompanies the calcite in some instances, drusy quartz generally forms a narrow peripheral shell, and an outer selvage of pistachio-green earth-like substance separates the whole from the ground-mass. Determinations of its index of refraction by immersion media identified the material of this selvage as prehnite. These nodular masses are usually nearly spherical and not more than half an inch in diameter, although sizes as large as 2\(\frac{1}{2}\) inches are occasionally found. In extreme cases they constitute as much as 30 per cent of the rock. They are not filled cavities, for not any of the unaltered basalts are vesicular and the pattern of the feldspar microlites in the surrounding ground-mass bears no relation to the outline of the nodule. Lindgren notes similar bodies formed in a holocrystalline diabasic dike (24b: p. 175). Moreover, the micro-
texture of the marginal portion of the nodule results from successive botryoidal crusts of calcite separated by magnetite, hematite or prehnite. It is clear that these amygdaloid masses are the result of hydrothermal agencies, and that they have grown by outward attack on the normal basaltic rock with consequent destruction of its component minerals and segregation of the alteration products.

A further stage of alteration of the basalt is well shown by the Nugget vein, which crosses the main adit of the Idawa Gold Mining and Milling Company's property (Pl. II, No. 22) 340 feet from the portal. This vein is enclosed by basalt and varies from a single stringer one to four inches wide to a vein breccia 18 inches wide. The vein filling consists of a band of comb quartz at either wall separated by a plastic white material known to the miners as talc; in places this plastic material forms the entire vein filling, especially in the stringers of the vein breccia. Usually it contains a trace of gold and silver. It is quite an abundant constituent of the vein matter of the Florida Mountain ore deposits and, as will be further discussed on a later page, accompanies quartz, calcite, and the potassic feldspar valencianite. Without doubt this plastic material is an alteration product of the wall rocks, effected by the solutions from which the accompanying gangue minerals were formed. A portion of the material taken from the Nugget vein was air dried preparatory to identification. Under the binocular microscope it is revealed as an extremely finely felted mass, apparently homogeneous. When fused with sodium bicarbonate and dissolved in dilute hydrochloric acid, it gives a positive flame test for potassium. Examination in immersion media established its homogeneity and showed it to be made up of minute scaly and cleavable aggregates with low birefringence and minimum and maximum indices of refraction of 1.545 and 1.558, respectively. These indices, coupled with its other properties, place the mineral as intermediate between sericite and the unusual hydrous aluminous silicate, leverrierite (beidellite) on the basis of Larsen's tables (23: pp. 245 and 252). Shannon (31d) points out that sericite varies from a hydrogen-free potash silicate on the one hand to a potash-free hydrogen silicate on the other, that the presence of sericite, therefore, does not imply an abundance of potash. Furthermore, he shows that leverrierite differs from the muscovite molecule only in that it has a large portion of combined water which it liberates below 110° C. He cites a gouge clay from the Garfield tunnel (Pl. II, No. 2) which was determined by Lindgren (24b: p. 171) as a mixture of sericite and kaolinite and shows it to be a single homogeneous substance close to leverrierite, with minimum and maximum indices of 1.547 and 1.556, respectively. This agrees closely with the indices of the Nugget vein matter and tends to confirm the writers' identification of that material.

From the study of material collected in the Black Jack mine (Pl. II, No. 7), Lindgren concluded that sericite and carbonates are almost wholly absent from the alteration products of the basalt and that the circulating waters were very poor in carbon dioxide (24b: p. 176). However, these two minerals are by no means absent from the region as a whole, and some modification of this conclusion becomes inevitable. The alteration of pyroxene to amphibole occurs typically under deep-seated conditions and involves the substitution of magnesia and iron for the calcium radicle; neither hydration nor dehydration occurs. The alteration to chlorite, serpentine, and epidote is a process of hydration which liberates the calcium and iron radicles. A portion of the calcium radicle forms the hydrous calcium-aluminum silicate, prehnite, but in the areas of most intense alteration it separates as calcite. This demands a carbonated solution as the agent of alteration. The formation of sericite and analcite requires the presence of the alkalies, which are probably derived from feldspar, although these minerals are on the whole very free from alteration. The iron oxides are liberated as magnetite and hematite. The excess of the silica molecule, beyond the requirements of the reactions, separates as quartz. The large amount of calcite present in some specimens of the altered basalt requires the addition of the calcium radicle at the site of alteration, probably during the first stage of vein formation in which the cellular calcite of certain veins was deposited. The conclusion is inescapable that calcite and sericite are characteristic products of the alteration, which is effected under deep seated conditions by heated solutions rich in carbon dioxide.

RHYOLITE

**OCURRENCE AND AREAL EXTENT**

Overlying both granite and basalt along the flanks of the Owyhee Range and flooring large parts of the bounding valleys, is a thick column of rhyolite of probable Miocene age. This extrusive rock advanced over the basalt and those granite summits which had not been submerged by the outpourings of basalt until, at the close of this igneous activity, it formed an unbroken cover over the entire region. Erosion subsequent to diastrophic events which will be
discussed on a later page, has removed the rhyolite over wide areas and exposed the underlying basalt and granite along the axis of the range. These underlying rocks, however, are not exposed in the highest peak, Cinnabar Mountain. The rhyolite-covered areas shown on the geologic maps (Pls. I, II, and III) are portions of a continuous exposure of irregular outline which extends northward nearly twenty miles from De Lamar, eastward to the margin of the Snake River plains, and westward and southward to Jordan Valley and beyond (fig. 1).

That the rhyolite flowed over an older granite surface is particularly well shown along the contact west of the Miller and Walters (Metallic) adit portal (Pl. II, No. 25), where arkosic debris and weathered round boulders of granite as large as a foot in diameter are bound together by a matrix of chilled rhyolite. The normal surface that separates the rhyolite from the underlying basalt, as exposed in Long Gulch and Sawpit Creek southwest of Silver City (Pl. II) and elsewhere in the region, is nearly plane and parallel to the flow banding of each rock type. It is clear, therefore, that erosion had not been long at work on the basalt and that the periods of extrusion for the two lava types were separated by only a brief interval. The period of rhyolite extrusion was not unbroken, however, for at least one break of sufficient duration for the establishment of vigorous vegetation is attested by the occurrence of natural charcoal in the Lobe prospect (Pl. II, No. 11) and elsewhere on Florida Mountain and of large fragments of silicified wood in the vicinity of the Henrietta shaft, De Lamar district (Pl. I, No. 7). In addition, much of the rhyolite float from the latter locality displays a pumiceous to glassy matrix which encloses sub-angular and partly rounded fragments of an older banded rhyolite. Obviously this float represents an exhumed agglomerate formed by rhyolitic lava inundating a terrane covered by erosional debris. Another break in the period of accumulation may exist near the top of the rhyolite column, but it is probably not exposed within any of the areas that were studied in detail and was not examined critically. Actual relations are probably best conceived by picturing a cycle of extrusion opening with basic basalt and closing with acidic rhyolite, a cycle interrupted by several brief periods of quiescence and erosion.

The column of rhyolites includes well banded porphyritic rocks, agglomerates or breccias, massive spherulitic flows, vitrophyres or porphyritic glasses, and locally, tuff beds. The complications of faulting and of very intense alteration made it impossible, in the time available, to ascertain the detailed sequence and thickness of the several flows, but general relations can be stated. The lower part of the column predominates in the thin-banded porphyritic rocks, and the breccias and spherulitic flows occur for the most part above them. The uppermost part of the series, which may be separated from the earlier flows by an unconformity, consists of coarse, massive breccias and spherulitic flows containing scattered lenticular masses of black vitrophyre and capped by a heavy flow of the same rock. Approximately 1,000 feet of rhyolite is exposed in Florida Mountain (Pl. II), more than 500 feet in the Flint district (Pl. III), and nearly 2,000 feet at Cinnabar Mountain. The maximum thickness may have been much more.

When unaffected by hydrothermal agencies, the rhyolites are extremely dense and weather-resistant and form bold, rugged cliffs and ridges as in the Flint district, the canyon of Jordan Creek below De Lamar, and elsewhere. Over Florida and De Lamar mountains, however, the rocks have been greatly softened by alteration, and the easy-erosion has produced smooth slopes deeply mantled with fine debris.

The only known sources for the acidic flows are the numerous rhyolite dikes which strike through granite and basalt alike. Their width is usually from 10 to 45 feet and occasionally one may be traced along its strike for more than a mile. One of these dikes, shown on the map of the Flint district (Pl. III) has a central portion of light drab gray felsophyric rock with some porphyritic facies and well marked bands of black rhyolitic glass at either wall, clearly due to chilling of the magma against the walls of the fissures through which it was extruded. About one mile northwest of Silver City and just west of Jordan Creek there crops out a block of rhyolite about 2,000 feet long and 1,400 feet wide, with rough quadrangular outline (Pl. II). This occurrence has been described by Lindgren (24b: p. 121) as a neck marking a major vent through which the rhyolites of Florida Mountain were extruded. The rock within this mass is a porphyritic rhyolite identical with known surface flows elsewhere and it has a marked fluidal banding which dips steeply at various angles, although the dips are not a function of the shape of the block. Moreover, the block is bounded on three sides by sharp approximately vertical surfaces which are nearly true planes. It is inconceivable that a neck of this size could be developed without extensive disruption of the enclosing rock and a consequent
formation of numerous irregular apophyses by filling of the fractures. The writers believe, therefore, that this is not a neck, but rather a product of faulting. This being true, the known dikes are scarcely adequate sources for the volume of rhyolitic magma extruded, but other vents can be found only in the realm of speculation rather than of description.

**Petrographic Descriptions**

The Silver City rhyolites are strikingly similar to the acidic lavas of Yellowstone National Park, so well described by Iddings (20: pp. 383-425). The banded porphyritic rhyolites, when least altered, are dark bluish-gray rocks which weather purplish and reddish brown. The groundmass is typically lithoidal and may or may not show flow banding; the megascopically discernible phenocrysts are vitreous prismatic feldspar and sub-hexagonal and rounded quartz individuals, whose maximum dimension is 0.1 inch. Quantitative estimates from thin sections show that quartz phenocrysts constitute about 5 per cent of the average rhyolite, the potassic feldspar sanidine makes up perhaps 3 per cent, and andesine-labradorite (Ab,An1) about one per cent. Ilmenite or titaniferous magnetite occurs in small quantity and alteration products suggest the presence of a ferromagnesian mineral, not strictly identified; these minerals, although not of megascopic size, belong to the same period of crystallization as the phenocrysts. Quartz crystals show wavy extinction and fracturing, probably caused by the internal stresses of solidification, and are always rounded or embayed by magmatic resorption. Usually they are surrounded by an aureole of radiating microlitic intergrowth of quartz and feldspar, of which the quartz has the same optical orientation as the phenocryst. Sanidine occurs in well formed crystals and is slightly resorbed; in a few instances it has been fractured by the stresses of cooling and cemented by groundmass. It is not usually accompanied by a peripheral microlitic band. The plagioclase is but slightly resorbed. The groundmass is usually not resolvable under the microscope, although an aggregate polarization indicates crystallinity. In some specimens micro-spherulitic and micro-granular intergrowths of quartz and feldspar may be recognized. The fluidal banding of the hand specimen is reflected under the microscope by an alternation of micro-granular and micro-spherulitic bands, or by a similar alternation of micro-spherulitic bands and others in which crystallinity is known only by an aggregate polarization. The variegated coloring is due to variable intensity of alteration controlled by the degree of crystallinity rather than to a difference in primary pigmentation. The fact that the flow banding curves about the phenocrysts indicates that these crystals are intratelluric.

Spherulitic rhyolites accompany the banded porphyritic rocks, although they are best developed in the massive flows of the upper portion of the lava series. The spherulites of the banded flows vary from microscopic size to globules five inches in diameter, but by far the greater portion of them do not exceed two inches. The smaller of the spherulites are made up of concentric crusts of radiating microlites of quartz and feldspar (sanidine?). In many instances central voids are lined with chalcedonic or drusy quartz which may be intergrown with prisms and microlitic fans of one of the zeolites (heulandite?). Lithophysal parting is common. Many of the larger spherulites, especially those on De Lamar Mountain above the Golden Cycle prospect, are little more than mere shells of porphyritic rhyolite into the hollow center of which project plates of typical lamellar or pseudomorphic quartz similar in all respects to the pseudomorphic quartz vein fillings. This filling is believed to be a secondary development after a calcite filling that came into the spherulites during the alteration of the adjacent basalt long after the rhyolites were extruded. In facies of the upper massive flows, spherulites may constitute two-thirds or more of the rock, and form botryoidal clusters and aggregates which are brought into prominent relief upon weathered surfaces.

Rhyolitic agglomerate or breccia is well developed in the flat-topped ridge which deflects the head of Henrietta gulch northeastward (Pl. II). A specimen of the typical rock is purplish gray with fragments constituting 65 per cent of the whole and ranging up to 1½ by 2½ inches. These are sub-angular and composed of typical, porphyritic, banded rock quite similar in both megascopic and microscopic characteristics to the types just described. The matrix is lithoidal and non-porphyritic, and similar to the groundmass of the normal rock. It is probable that this breccia or a similar rock is a fresh phase of the altered greenish tuff that is exposed on the No. 16 level of the De Lamar mine (Pl. II, No. 17, Pl. XII) and in the lower Chatauqua adit (Pl. II, No. 15, Pl. X).

A specimen from Sawpit Peak (Pl. II), representative of the upper massive flows, does not differ greatly from the porphyritic banded rocks of the lower part of the series. Phenocrysts constitute 3 to 5 per cent of the rock, quartz being dominant in some slides.
and andesine-labradorite (Ab,An) in others. Sanidine is somewhat less plentiful than quartz, and biotite and apatite occur in small quantity as new constituents. The groundmass is microcryptocrystalline, with variegated purple banding caused by minute discrete globules of red, yellow, and green pigment intermingling with irresolvable microlites.

At several localities in the Flint district small lenticular bodies of tuff are intercalated with the rhyolite of the upper division of the series. This material is a light olive-green friable mass which contains tabular, needle-like, and irregular fragments of dark-colored glass scattered through a dull earthy matrix.

The vitrophyre, or porphyritic glass, comprises 5 to 7 per cent of phenocrysts held in a matrix of black glass irregularly streaked and banded in pearl gray and reddish-brown tones. As in the other members of the rhyolite series, quartz is the dominant phenocryst. It has invariably been crushed by the stresses of cooling and in some instances the crystals are cemented by infiltrated glass. Slight rounding of the crystal forms by resorption is characteristic. Sanidine is second in point of abundance, and is somewhat rounded and embayed. Plagioclase occurs sparsely, but diagnostic sections for precise identification were lacking in the slides. The groundmass is usually brownish, its color being due to diffuse pigment. Pearlitic parting is characteristic. Microlitic crystallization has begun about the peripheries of phenocrysts and to a smaller extent throughout the groundmass, but is not sufficiently advanced to produce an aggregate polarization.

**HYDROTHERMAL ALTERATION**

The rhyolite has been intensely altered by hydrothermal activity throughout the areas which enclose the ore deposits, so that a specimen of fresh rock is practically unobtainable. The usual change involves a more or less complete silicification so that even in its most intensely altered phases the rock has a deceptively fresh appearance, although its color is ordinarily very light gray or white. Aureoles of secondary micro-granular quartz surrounding the phenocrysts, accompanied by sericitization of the sanidine and development of flocculent films of probable sericite throughout the groundmass, characterize the least altered rocks. In one field the quartz mosaic replaces sericite derived from the potassic feldspar; in another secondary quartz is undergoing replacement by sericite. The two processes are, therefore, essentially contemporaneous, but either one may dominate locally under the variable conditions of chemical activity.

A silicified rhyolite from the “28” crosscut from the Blaine tunnel (Pl. II, No. 20) is an opaque flinty rock known to the miners as quarizite. To the eye it bears no suggestion of fluidal banding or crystalline structure. The microscope, however, shows remnants of primary phenocrysts of quartz and sanidine, the latter being in large part replaced by micro-granular quartz embedded in fine shreddy sericite. In the groundmass, alternating fluidal bands have been replaced and fractures have been filled by fine quartz mosaic and the whole is suffused with a shreddy translucent chalky-white product, which is probably sericite. Cubic crystals of pyrite are scattered through the secondary quartz, indicating the contemporaneity of pyritization and silicification. The end product of the silicification is a dense sub-vitreous mass, scarcely distinguishable from normal chaledonic quartz. Such material is exposed on the flat-topped ridge north and west of the Alta tunnel, De Lamar district (Pl. I, No. 18).

In contrast to the intense silicification which represents one extreme of the alteration cycle, there is a complementary sericitization, usually developed farther from the vein. Along the east drift from the No. 16 adit of the De Lamar mine (Pl. I, No. 17) the rhyolite displays an earthy banded groundmass in brownish drab tones mottled by chalky feldspar phenocrysts. The thin section shows quartz and sanidine remnants in a blotchy aggregate of sericite and diffuse sub-translucent products which were not determinable, differential alteration having accentuated the fluidal banding of the fresh rhyolite. Secondary pyrite accompanies the alteration as in the case of the more silicified rocks. The sericitization is most complete in the clay-like “talc” which frequently forms a part of the vein matter in rhyolite. As in the case of the Nugget vein in basalt, described above, this material fills the space between comb quartz at the walls of the veins. In the De Lamar mine, it also occurs as small masses entirely surrounded by the chaledonic phase of the quartz vein matter and evidently a product of the metasomatic replacement of the enclosing rhyolite. This is particularly well developed in the “Silver Talc” vein of the Sommercamp section of the mine. Shannon has recently re-examined some of Lindgren’s original specimens and shown (31d) that this clay-like material is a homogeneous gouge clay which ranges between the variable mineral sericite and the more hydrous allied species, leuvierrite.
Lindgren (24b: pp. 185-186) describes a further phase of the alteration of the rhyolite along its contact with the basalt in the Black Jack and Trade Dollar mines, in which the rhyolite is chloritized by interaction between the two rocks and the hydrothermal agents. The mine workings in which this phase is exposed are no longer accessible and the locality was not visited by the writers. There is no reason, however, to delve more deeply into the matter.

It has been shown by the preceding paragraphs that the normal alteration of the rhyolite is sericitization accompanied by silicification. Evidence indicates that this alteration is contemporaneous, at least in part, with the deposition of quartz vein-filling. The chemical changes involved are hydration of the aluminous silicates and the removal of bases other than magnesia as soluble carbonates or other salts; the formation of a great abundance of secondary quartz requires silica-bearing solutions. Analyses of two altered rhyolites from the De Lamar mine as presented by Lindgren (24b: pp. 179-180), may be used to test the correctness of the microscopic determinations. These analyses have been re-calculated to 100 per cent without considering FeS$_2$ (pyrite) and TiO$_2$, of which the first is introduced into the rock extraneously and the second does not enter into the reactions, and are compared in the following table with the analysis of an average rhyolite:

**Comparison of altered rhyolites from the De Lamar Mine with an average unaltered rhyolite**


<table>
<thead>
<tr>
<th>Constituent</th>
<th>I</th>
<th>II</th>
<th>Average Rhyolite$^5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO$_2$</td>
<td>88.83</td>
<td>74.61</td>
<td>74.68</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>7.51</td>
<td>12.47</td>
<td>13.48</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>0.69</td>
<td>6.00</td>
<td>1.01</td>
</tr>
<tr>
<td>FeO</td>
<td>1.48</td>
<td>0.99</td>
<td>0.97</td>
</tr>
<tr>
<td>MgO</td>
<td>1.62</td>
<td>0.42</td>
<td>0.31</td>
</tr>
<tr>
<td>CaO</td>
<td>1.00</td>
<td>0.16</td>
<td>0.73</td>
</tr>
<tr>
<td>Na$_2$O</td>
<td>1.14</td>
<td>1.20</td>
<td>3.46</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>1.81</td>
<td>2.02</td>
<td>4.00</td>
</tr>
<tr>
<td>H$_2$O</td>
<td>1.91</td>
<td>3.38</td>
<td>2.33</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>99.99</td>
<td>100.00</td>
<td>99.99</td>
</tr>
</tbody>
</table>

---

1. Specimen from No. 14 level, De Lamar mine, adjoining the Seventy-seven vein in the hanging wall.
2. Specimen from No. 14 level, De Lamar mine, 20 feet from the Seventy-seven vein in the hanging wall.

Assuming that the first two altered rocks were derived from the average unaltered rhyolite by the addition of water and silica without loss of other constituents, we may re-calculate theoretical altered types in which the alumina content is the same as in the actual types. We may then adjust these theoretical types by replacing the bases which have apparently been lost as soluble salts by an equivalent amount of silica. This has been done in the following table:

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Theoretical altered rocks</th>
<th>Adjusted theoretical rocks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>SiO$_2$</td>
<td>88.83</td>
<td>74.61</td>
</tr>
<tr>
<td>Al$_2$O$_3$</td>
<td>7.51</td>
<td>12.47</td>
</tr>
<tr>
<td>Fe$_2$O$_3$</td>
<td>0.56</td>
<td>0.93</td>
</tr>
<tr>
<td>FeO</td>
<td>0.44</td>
<td>0.73</td>
</tr>
<tr>
<td>MgO</td>
<td>1.17</td>
<td>2.29</td>
</tr>
<tr>
<td>CaO</td>
<td>4.11</td>
<td>6.88</td>
</tr>
<tr>
<td>Na$_2$O</td>
<td>1.93</td>
<td>3.20</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>2.23</td>
<td>3.71</td>
</tr>
<tr>
<td>H$_2$O</td>
<td>1.91</td>
<td>3.38</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>99.99</td>
<td>100.00</td>
</tr>
</tbody>
</table>

The agreement between the actual and the theoretical types is remarkably close and well within the range of the uncertainty that results from the lack of an analysis of the true unaltered rhyolite of the district. It serves to show conclusively that the alteration of the rhyolite at De Lamar was possibly effected by a dual process of contemporaneous sericitization and silicification, a process which was most complete adjacent to the veins. As explained elsewhere (p. 84) the vein filling has, in part at least, been formed by quartz replacing cellular calcite. Moreover, the presence of calcium-bearing solutions is demanded by certain of the altered basalts. It seems likely, therefore, that during the first stage of hydrothermal alteration solutions rich in the calcium and carbon dioxide radicles deposited the cellular calcite of the veins, calcitized the basalts locally, and possibly sericitized the rhyolite more or less completely. Later, the cellular calcite of the veins was replaced by quartz and the rhyolite was simultaneously silicified. Sericitization could have been effected by this siliceous solution if it were also relatively rich in carbon dioxide. Sericitization may have been carried to completion by the calcite-bearing solutions on the one hand, or the rhyolite may have been wholly unaltered during the first stage of hydrothermal activity and later simultaneously sericitized and silicified.
by a siliceous solution relatively rich in carbon dioxide and at not more than moderate temperature.

This analysis is somewhat different from that of Lindgren, who postulates two types of alteration as essential to the chemical and mineralogical changes that have taken place in the rhyolites (24b: pp. 179-182): first, ordinary sericitization effected by waters containing alkaline carbonates; second, leaching of alumina from the sericitized rock by siliceous waters bearing sulphuric acid. The writers' explanation is wholly in accord with all observed facts, however, and is preferable because of its simplicity. Lindgren notes that marcasite occurs locally in the De Lamar district in very limited amount, although it was not positively detected in any of the material available to the writers for laboratory study. Its presence does not necessarily demand conditions of formation differing from those postulated above, and is, therefore, of little significance.

It remains to describe the result of alteration processes acting upon finely crushed rhyolite fault gouge to form the "iron dikes" that are encountered in the mine workings at De Lamar and somewhat less frequently on Florida Mountain. These "iron dikes" are sheets of plastic clay, usually pistachio-green in color, abundantly pyritized, and separated from the enclosing rhyolite by a distinct fault plane at the footwall and sometimes at the hanging wall also. One of these "dikes," the Sommercamp fault, is penetrated by No. 4 Sommercamp crosscut (Pl. X). At this point the "dike" is sharply defined at either wall and about six feet thick, although the rhyolite of the hanging wall is intensely altered across a distance of 250 feet in a zone of intersecting fractures. On the eighth level of the De Lamar mine (Pl. XI), however, a crosscut driven through the "dike" revealed a sharply defined footwall but no hanging wall, the "dike" material passing into the usual rhyolite by insensible gradation extending across a distance of 120 feet. As a consequence of this gradation, it is necessary to guard zealously against assuming the width of the zone of alteration to be the same as that of the zone of crushing.

Specimens collected from No. 4 Sommercamp crosscut reveal the "dike" filling as an end product of hydrothermal alteration acting upon a finely crushed rhyolite. Small patches of grayish-green clay-like material, denser than the mass of the specimen and scattered irregularly through it, are clearly fragments. Similar irregular streaks are probably fragments elongated by flowage or shearing. Minute quartz grains of subhedral form represent phenocrysts preserved from the original rhyolite. The mass of the material seems to be clay-like rather than chloritic. Grains of pyrite, usually perfectly developed pyritohedra or groups of such crystals, are scattered irregularly through the mass after the fashion of a typical disseminated sulphide. It was deposited, in its present form at least, after the crushing of the rhyolite. Some of the sulphide resembles marcasite. It is probable that pyritization was contemporaneous with much of the hydrothermal alteration, and that the green color of the altered mass is due to silicates of ferrous iron. This assumption is in harmony with the occurrence, at a distance of 100 to 250 feet from this locality but in the same zone of intersecting fractures, of a non-pyritized rhyolite which has been altered to a creamy-white textureless mass of sericite.

In the lower Chatauqua adit (Pl. I, No. 15; Pl. X) a banded porphyritic rhyolite is interbedded with an intensely altered breccia of creamy fragments as large as two inches in dimension held in a green matrix. This breccia or tuff grades into a typical pyritized clay-like "iron dike" in a distance of 100 feet. Examination with the microscope shows that the material at a distance from the "dike" is an end product of hydrothermal alteration, probably sericitization, acting on a tuff which is shown to be rhyolitic by quartz phenocrysts in the fragments. The random orientation of the fragments and the absence of flowage in the clayey products of alteration indicate that the rock is true tuff. The filling of the "dike" on the other hand, is the result of a similar alteration of finely crushed tuff mingled with fragments of the banded rhyolite, the whole showing the results of mashing and shearing. The fresh phase of the altered tuff, and of the similar material which is so abundant in the east drift from No. 16 adit of the De Lamar mine (Pl. XV), is probably similar to the rhyolite breccia or agglomerate which has been described on a preceding page, although it cannot be said that the occurrences cited are parts of the same bed.

A chemical analysis of typical "iron dike" filling is compared in the following table with that of an average rhyolite and with that of the leverrierite clay from Garfield tunnel which is described by Shannon (31d: p. 375). As in the case of the altered rhyolites from the hanging wall of the Seventy-seven vein, the analyses have been re-calculated to show the changes undergone by the essential rock constituents alone.
Comparison of "iron dike" filling with an average rhyolite and with a gouge clay from Garfield tunnel

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Average Rhyolite</th>
<th>&quot;Iron Dike&quot; Filling</th>
<th>Leverrierite Clay</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>74.68</td>
<td>72.23</td>
<td>45.94</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>13.48</td>
<td>16.68</td>
<td>34.14</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>4.91</td>
<td>1.99</td>
<td>1.98</td>
</tr>
<tr>
<td>MgO</td>
<td>0.79</td>
<td>0.92</td>
<td>0.18</td>
</tr>
<tr>
<td>K₂O</td>
<td>3.13</td>
<td>1.0</td>
<td>8.4</td>
</tr>
<tr>
<td>Na₂O</td>
<td>3.46</td>
<td>0.17</td>
<td>18</td>
</tr>
<tr>
<td>K₂O</td>
<td>4.00</td>
<td>3.79</td>
<td>6.52</td>
</tr>
<tr>
<td>H₂O</td>
<td>1.53</td>
<td>4.12</td>
<td>9.70</td>
</tr>
</tbody>
</table>

1 Re-calculated from the average of analyses of eight typical rhyolites cited by Clarke (13: p. 499).
2 At beginning of "iron dike", east end Wilson drift, No. 4 level, De Lamar mine.
3 Iron content reported as Fe₂O₃, although most of it is in the form of FeO.

It is seen that the alteration which produced the "iron dike" filling involves hydration, desilicification, and removal of the metallic bases in varying proportions. There is an apparent increase in magnesia, but this radicle is not more abundant than in some unaltered rhyolites. In the absence of an analysis of the fresh rhyolite of the De Lamar district, it is not necessary to postulate addition of this radicle from an extraneous source. The alteration is typically that of sericitization of the potassic feldspar, which, if carried to completion in the same direction, would yield the homogeneous leverrierite. This is essentially the explanation advanced by Lindgren (24b: pp. 182-184). The loss of silica indicates that at least a part of that radicle, liberate from the sanidine molecule by hydration, is removed from the site of the alteration in soluble form. The reagent of alteration must have been a non-siliceous aqueous solution relatively concentrated in carbon dioxide, and at 'moderate temperature. If, as seems probable, pyritization and sericitization progressed simultaneously, then this reagent must also have been iron-bearing. Whether this agent attacked a strictly normal rhyolite or one partly sericitized during the period of vein formation, the end product would be the same. It is likely that the "iron dikes" of the De Lamar district were developed by such a dual process.

Assays of heavily pyritized filling from the "iron dikes", in the Chatauqua adit and No. 4 Sommercamp crosscut, De Lamar mine, as well as of the pyritized altered rhyolite breccia from No. 16 level, De Lamar mine, show a trace of gold and from a trace to 0.6 ounce of silver per ton. This heavily pyritized material does not constitute ore, therefore, although the presence of precious metals therein suggests that the alteration and pyritization was effected by agents from the same source as those which deposited the ore, but probably at a time long after the ore shoots were formed.

The effect of this non-siliceous solution acting on a rhyolite previously silicified during the vein-forming period, is shown by the "Big Reef," near the summit of De Lamar Mountain. This bold outcrop lies in the zone of ore deposition and is at the same time in the footwall of the "iron dike." It has therefore been subjected to alteration during each of the two periods of hydrothermal activity. The rock is a greenish-gray porphyrite with dust groundmass which a thin section shows to be composed of secondary micro-granular quartz, a product of the first period of alteration, embedded between shreds and fibrous bands of a finely-felted light olive-green material. This material, which is probably that which gives the filling of the "iron dike" its characteristic color, has medium birefringence and refraction, but its other optical properties are indeterminate. Lindgren (24b: p. 179) believes that this material is a magnesian silicate carried up from the underlying basalt, but notes that the rocks on which it was abundantly present failed to yield a chemical test for acid-soluble magnesium, so that the mineral is not a chlorite. Besides, its birefringence is much too high for a chlorite. The chemical reactions involved in the alteration of the basalt did not release an excess of magnesia, so that it seems inadmissible to postulate the presence of a mineral which demands the migration of a relatively large amount of magnesia or of a magnesium silicate several hundred feet upward from the basalt. The habit of the mineral and its optical properties suggest one of the mica group. This, coupled with the abundance of ferrous iron known to be in the "iron dike" filling, points to a species allied to thuringite, a magnesia-free hydrous silicate of iron and aluminum. It is probably derived in part from sericite formed during the period of vein formation and may be accompanied by a variable portion of sericite. The iron content of such a mineral could have been derived from primary limenite, which is represented by grains of iron-stained leucocrene, or from the later hydrothermal agent itself, which is known to be abundantly iron-bearing.

STRUCTURE

The geologic structure of the Silver City region involves a rather complex system of block faulting, not recognized heretofore, which
has been analyzed as completely as the dearth of accessible mine workings permits. The relation of the several sets of earth fractures to the ore deposits has also been established. Three major periods of diastrophism, each represented by a distinct system of fractures, are involved in the geologic structure of the region. As would be expected, however, the earlier fracture system has controlled in large measure the resolving of subsequent diastrophic forces so that the three systems are closely related. They may be classified as fractures genetically related to the granodiorite intrusive, fractures which followed the extrusion of the rhyolites but preceded the latest period of ore deposition, and fractures which followed the ore deposition.

**PRE-MINERAL EARTH FRAC TURES**

**FRAC TURES GENERALLY RELATED TO THE GRANODIORITE**

The earliest known period of diastrophism has produced a system of high-angle or medium-angle fractures of which the most apparent are the conspicuous joints which subdivide the granodiorite into rhomboidal blocks. This blocking has been described already under the discussion of granodiorite. The dominant fracture-set strikes northward with a deviation of not more than 10 degrees, either to east or west, and dips steeply eastward; it is represented on the map of the Flint district (Pl. III) by the surface traces of the silver-bearing veins. The conjugate fractures strike N. 85° W., and are developed only locally, as would be expected of the inactive shear. Secondary fractures, which result from stresses set up within the blocks outlined by the dominant conjugate planes of maximum shear are usually more apparent because much more plentifully developed. These secondary fractures are those which cause the well developed sheeting and blocking of the granodiorite. Prominent among them are sheeting planes which strike northeastward and dip 30-60° SE., with complementary fractures trending northwestward; these are caused by shear stresses resulting from a marked horizontal component in the principal deforming force. Other fractures strike northward and dip westward at moderate angles; they are induced by a component of stress normal to the dominant northward-trending shear.

The strain rhomb which depicts the regional deformation is plotted in its relative orientation on the map of the Flint district (Pl. III), where the fracture set may be studied to best advantage. This rhomb calls for maximum crustal shortening in a northeast and southwest direction. This being true, reverse faulting or thrusting must be the usual displacement along the northward trending high-angle fractures. Moreover, the arrangement of the fractures in space, when considered in projection upon both the horizontal and vertical planes, requires that the deforming stress be rotational or shearing rather than a pure compression. This theoretical conclusion is fully substantiated by the frequent occurrence of fracture planes marked by nearly horizontal striations and grooves, which indicate that above, or longitudinal movement along the plane of the fracture, is the dominant component of the displacement. The total displacements, although unknown, are probably small.

This earliest diastrophism affected only the granodiorite intrusive, but not the overlying basalts and rhyolites. Clearly, therefore, the intrusive had gained sufficient rigidity to resist fracture before the deformation occurred. Aplite dikes are intruded along several of the northward trending fractures of the Flint district, however, and diorite porphyry and dacite porphyry dikes follow the north-south sheeting of War Eagle Mountain (Pl. II). The preceding discussion of the igneous rocks has shown that these types are, respectively, acidic and basic differentiates of the granodiorite magma segregated during the closing stage of the magmatic activity. The obvious inference is that the deformation occurred during the later part of the period of intrusion. If the primary gneissic texture which is developed in the porphyritic granodiorite along Jordan Creek about a mile and a half north of Silver City (as described on a preceding page) is a result of the deformation then the stresses were active before crystallization within the granodiorite was complete. It is conceivable that these stresses were due merely to contraction of the cooling intrusive, but more probably the deformation was of regional magnitude.

**FRAC TURES YOUNGER THAN THE RHYOLITE**

The second class of fractures includes those which followed the extrusion of the rhyolites but preceded the later period of ore deposition, to which later period the deposits of De Lamar, Florida, and War Eagle mountains are due. These constitute by far the greater part of the earth fractures traceable on the surface. On War Eagle mountain, where this system may be most readily analyzed, the dominant regional shear strikes N. 75° W. and dips 70-80° S., and is represented by the fracture trace which crosses the tip of the basalt outcrop a quarter of a mile southwest of Silver City (Pl. II).
and passes slightly north of the old Ida-Elmore shaft (Pl. II, No. 58) on the eastern face of the mountain. Another parallel fracture intersects the extension of the Golden Chariot vein in the workings of the Great Western Mines Co. about 1,600 feet south of the adit (Pl. II, No. 55). Less evident fractures may be interpolated between these two, in harmony with observed displacements of the dacite dikes. Together these fractures constitute a very perfect parallel slicing which is probably even more extensively developed than can be traced at the surface. A similar nearly parallel slicing exists in the Flint district (Pl. III) about the property of the Precious Metals Mine Co. At De Lamar, this dominant fracture set is represented by the Seventy-seven vein (Pl. X) and by quartz veins which crop out about 300 feet north of the portal of the old Stoddard tunnel (Pl. I, No. 26). These veins strike N. 62° W., thus indicating that the De Lamar block has undergone a rotation of 12° eastward with respect to War Eagle mountain, a rotation which is, however, an effect of the third and last period of major diastrophism. The dip of the Seventy-seven vein has been distorted in the upper levels of the mine by the late faulting, but on the lower levels this vein dips 65-70°S. The less active shear which is complementary to the dominant set just described is represented by the Golden Chariot-Oró Fino, Poorman, Deluge, and Potosi veins (Pl. II, Nos. 59, 40, 36, and 26, respectively). The average strike of these fractures is N. 2° E., and the dip nearly vertical.

Accompanying these major fractures are four sets of secondary fractures. Of these the most important strikes N. 25-40° W. and dips 75-90°, usually eastward. This set is represented by the Illinois Central, San Juan, Red Jacket (Pl. II, Nos. 42, 45, 47, and 45, respectively), and other parallel veins of War Eagle Mountain, and by the Black Jack-Trade Dollar and associated veins of Florida Mountain (Pl. II, No. 20). At De Lamar, the Wilson and No. 9 veins (Pl. X) fall into this class, as do also veins “A” to “J” of the Sommercamp section. These two groups of veins, however, have been rotated eastward 13° and 20° with respect to those of War Eagle Mountain by post-mineral faulting. Only locally, however, has this fracture-set been the site of vein formation, although it is extensively developed throughout the region. A prominent compound fracture of this set strikes obliquely across Jordan Creek in the vicinity of Silver City and two others trend across the axis of Florida Mountain, accounting for some of the irregular distribution of the extrusive rocks in that vicinity (Pl. II). The more east-
The major component of displacement in the first set, however, may be shove (longitudinal movement parallel to the trace of the fault plane) as in the case of the northernmost of the three westerly trending fractures shown on the map of the Flint district (Pl. III). A steeply dipping rhyolite dike has been parted and the northern block shoved westward 1,350 feet, although it was uplifted relatively only 210 feet. The amount of displacement along these fractures on Florida Mountain is not known but it is in the same direction and probably of similar magnitude. Movement along the second set of fractures involves the tilting of large blocks and the vertical component of displacement is large. The few scattered patches of basalt on the summit of War Eagle Mountain are 1,000 feet above the most elevated of that rock on Florida Mountain west of Silver City (Pl. II). The lower outcrop has preserved the original upper surface of the flows, but those on War Eagle Mountain are but remnants of flows or are the underlying sources of extrusion. It seems likely, therefore, that 1,000 feet is a minimum estimate of the vertical displacement. The Flint district has suffered relative uplift of about 2,000 feet along the fault which marks its western border, and has been tilted northeastward about 12°, although the amount of displacement is rendered somewhat uncertain by the presence of secondary displacements. Because criteria for measuring the longitudinal component are lacking, its possible magnitude can only be conjectured. Pivotal or hinge movement along the fault plane is shown by the fracture which bisects Florida Mountain, passing 150 feet east of the Banner mill (Pl. II, No. 19). At the Banner mill and at its intersection with the “28” crosscut from the Blaine tunnel (Pl. II, No. 20), this is a normal fault with a basalt footwall in contact with a rhyolite hanging wall: near the northern end of its trace, however, the fracture is a reverse fault. Along the fractures of this set the eastern block is generally uplifted. It is to be expected that the displacement along the northeastward trending secondary fractures would be normal.

It is seemingly anomalous that the veins should be slightly offset along the fractures which strike N. 75° W. and N. 45° E., because these fractures and veins are, according to this analysis, contemporaneous. It is possible that the secondary shear fractures now occupied by veins tended to form in alinement in the opposing walls of a transverse master fracture, because the homogeneity of the rock would demand equal spacing of fractures to relieve the opposing secondary strains. Strict continuity of the vein fissures would not be necessary to the fracture system which is postulated. Moreover, the region has been subjected to major diastrophism since the vein-forming period, a diastrophism which would re-open the older master fractures and effect a limited adjustment by secondary movements along them. It is to be expected from the direction of the later stresses that the direction of these secondary movements would be in each case the same as the primary displacement described above. However, since the vein fissures may not have been formed in strict alinement, the apparent displacements may not agree with the actual movement; hence a general rule cannot be expected to solve these problems. The problem of each offset vein requires an individual solution which can be attained only by detailed geologic mapping in each case. Fortunately, however, the offset is small and recovery of the vein should not be difficult.

The alternative analysis of the fracture system of War Eagle Mountain would be to consider the vein fissures as a distinct set older than those which offset them. This analysis, however, entails several weaknesses. First, vein fissures merge into barren fractures which would necessarily be classified as part of the younger set. Second, the strain rhombs of the two sets would show more extreme crustal distortion than seems justified, together with a changing direction of maximum stress. Third, the veins would intersect the younger fractures with a small offset or none at all, although the displacement of dikes and strata along the same fracture would be considerable. The first analysis constitutes a wholly logical explanation of the observed facts without the weaknesses of the second.

POST-MINERAL EARTH FRAC TURES

The latest period of major crustal adjustment is apparently that which produced the “iron dikes” of the De Lamar district, although its effect is much more widespread than has been realized hitherto. The material of these “dikes,” the end product of repeated hydrothermal alteration acting upon finely crushed rhyolite, has already been described. The repeated occurrence of this material in the various workings of the district was recognized early by the miners and prospectors, but their dread of the underground hazards it introduced seemed to inhibit a dispassionate analysis of the phenomenon. A fundamental error was made in correlating all occurrences as parts of a single feature rather than as several distinct
features. The “iron dike” became in imagination a most fantastic creature replete with close folds and complex curves.

The fractures of the “iron dike” system are low angle faults which, although being somewhat undulatory as they strike obliquely across hard and soft strata, are quite uniform in average strike and dip. The fracture against which the veins of the eastern portion of the De Lamar mine terminated, shown on the level plans (Pls. X, XI and XII) as the De Lamar fault, has an average strike through the mine of N. 75° W. with minor undulations. Unfortunately this portion of the mine was entirely inaccessible during 1925, and the trace of the fracture is known only from maps and reports of the De Lamar Mining Co., Ltd. (28b; 19b; 27). Some of its irregularities probably would disappear, if one could visit the ground and discriminate between the true fracture and the zone of hydrothermal alteration which accompanies it. It dips 23-31° between the fourth and tenth levels of the mine, the average dip being 27° 10’. Projected westward, this fracture passes directly through another “iron dike” which is penetrated by the lower Chatauqua adit (Pl. I, No. 15; Pl. X) about 1,250 feet from the portal. At this place the fracture strikes approximately westward and dips southward about 30°, although caving of the drift makes exact determination impossible. The agreement between the projection and an actual fracture seems too close to be a mere coincidence, and correlation of the two appears fully justified. Moreover, this fracture may be projected to the surface and traced thereon, passing south of the portal of the Stoddard tunnel and the Big Reef, cropping in a prospect trench near the summit of the ridge southwest of the Chatauqua adit, then descending the south face of the ridge obliquely. A parallel fracture, indicated on the maps as the Chatauqua fault, crosses the Chatauqua adit just within its portal; it crosses also the No. 16 adit of the De Lamar mine (Pl. I, No. 17) about 300 feet north of the east drift, at which place it forms the contact (a crushed zone 70 feet wide) between a footwall of basalt and a hanging (south) wall of rhyolite. On the surface it also marks a contact between basalt and rhyolite which passes westward close to the Webfoot adit (Pl. I, No. 6) and then swings southwestward to the foot of the ridge. Still a third fracture of the set follows the creek eastward from the Henrietta shaft (Pl. I, No. 7), ascends the ridge obliquely, is exposed by the surface trenching 500 feet north of the portal of the No. 4 Sommercamp adit (Pl. II, No. 24), crosses the summit of De Lamar Mountain and skirts the southern edge of the low ridge that runs eastward from it. Fractures of the same set strike across the southern part of the region close to Silver City (Pl. II), although they are distributed across a wide zone of shearing that is not readily traceable. One of these is exposed in the Venus adit (Pl. II, No. 15) and its surface trace bears southeastward into the head of Long Gulch. Another crosses Jordan Creek and ascends Silver Cord Gulch, crosses Stormy Hill saddle south of the old shaft of that name (Pl. II, No. 49), and is encountered in the south drift of the Afterthought mine (Pl. II, No. 68). A parallel shearing also strikes through the main adit of the Never Sweat Mining Co. (Pl. II, No. 54). The dominant complementary fracture induced by secondary strain in the walls of the master fault is represented by the “iron dike” against which the veins of the Sommercamp section of the De Lamar mine abut (Pl. X). This fracture strikes N. 57° E. and dips 26° SE., and has been considered heretofore as an extension of the “dike” which has been re-named the De Lamar fault. Another fracture of the same set strikes across the Daisy adit (Pl. I, No. 11) near its portal. Theoretical considerations call for other complementary fractures, several of which are shown developed on the No. 16 level (Pl. XII).

Satisfactory criteria upon which a precise measurement of the displacement along these fractures may be based were not found during the course of the field studies, but the direction of displacement is accurately known. The Chatauqua fault is indubitably normal, since it brings basalt in the footwall into juxtaposition to rhyolite in the hanging (south) wall. Since the direction of displacement probably would be the same for each of the parallel slicings, the south block may be regarded as the one which is relatively downthrown. The greatest component of the displacement, however, is shove parallel to the strike of the fault plane. The combined shove along the De Lamar and Henrietta faults, from a measurement based upon a somewhat uncertain correlation of an older displaced fracture, is 2,400 feet, the southern blocks having been displaced eastward. If the two faults are equal in magnitude, the shove along each would be 1,200 feet, although this figure is a merely approximate estimate. The pattern of secondary fractures and the reported drag at the ends of terminated veins give ample support to the postulated directions of movement. The argument might be advanced that the amount of crushing along the walls is far too great to have been produced by a normal fault of such low angle, but there has been an intense subsequent hydrothermal alteration...
which makes it very difficult to distinguish the amount of actual crushing that has taken place, and might readily lead to gross over-estimation of this feature. Moreover, movements of the magnitude that has been described could readily produce much attrition along the walls of even a low-angle fracture. The displacements that have been postulated are in strict harmony with those theoretically required by the strain diagram, which shows that the greatest shortening has taken place in a northeast and southwest direction with crustal extension normal thereto. This diagram also shows that the low angle deformations have been caused by continued activity of the regional stresses of the older diastrophism.

Much discussion of the relation between the “iron dike” fault system and the veins pervades the literature. D. B. Huntley, manager of the De Lamar Mining Co., Ltd., from 1897 to 1901, reported to the company in 1898 that “as the ore shoots abut against the dike on one side there is a chance that they have been faulted, and will be found on the other side” (19b). Later in the same year Lindgren concluded that the “dike” was older than the veins and that “when the fissures which were to receive the mineral-bearing solutions were broken open, the force which readily shattered the brittle rocks spent itself in vain against the tough clayey ‘iron dike’ and thus the veins are apparently cut off by the latter” (2b: p. 159). E. V. Orford, manager of the mine from 1901 until 1914, believed that the “dike” was a post-vein fracture, although his instructions forbade any underground search for the continuations of the veins. R. N. Bell confirmed the belief in 1920 (3n); in the same year J. W. Gwinn noted Bell’s contention, although he failed to comment upon its probability (18). Thus it seems that the question is still an open one, and that a review of the problem is justified.

The conclusion reached by Lindgren appears to be based upon the fact that “in examining the Chatauqua tunnel a small vein of the normal laminated quartz was found in the clayey ‘iron dike,’ showing that the vein fissures succeeded the early crushing and clayey alteration.” This conclusion is weakened, however, by the fact that none of the fifteen veins developed in the De Lamar mine penetrates the “dike” filling in the least, although the micro-texture of this filling shows it to be replete with small fissures and therefore rigid enough to deform by fracture. The occurrence cited by Lindgren was inaccessible in 1925, although it has been described by Mr. Orford1 as a vein about four inches wide which protruded into the clayey “dike” less than one foot. In view of the difficulty of discriminating between the intensely altered fault gouge and the equally altered wall rocks, this occurrence, if correctly described, seems a doubtful criterion upon which to postulate an age relationship. Furthermore the “L” vein of the Sommercamp group, on the fourth level of the De Lamar mine (Pl. X), is intensely brecciated at its termination against the footwall of the “dike” and has suffered minor displacement along fractures induced by the secondary strain. Mr. Orford describes the terminations of other veins in a similar manner. That vein-forming activity was not confined to the footwall block of the De Lamar and Sommercamp faults is unquestionably proven by the “M” vein, which lies in the hanging wall (upper) block of the Henrietta fault and was stoped from below the fourth level (Pl. X) to the surface (Pl. I, No. 23), also by the Hope (Pl. I, No. 22) and Cash (Pl. I, No. 25) prospects which lie in the hanging wall blocks of the De Lamar and Henrietta faults, respectively. That the stress which formed the vein fissures “spent itself in vain against the tough clayey ‘iron dike’,” seems rather doubtful. The reports of the managers of the De Lamar mine (19b; 27; 28) make frequent reference to the fact that each vein, at its contact with the “dike,” was broken and drawn out into a feather edge which was turned eastward in the direction of the postulated shove of the footwall block. At this feather edge and extending eastward from it along the fault for a variable distance there occurred bunches and “nuggets” of argentite, of which many were rounded as though by attrition. Such a phenomenon is most easily explained as ore dragged along the fault plane as the vein was displaced. Each of these physical relationships is more in harmony with post-vein age of the “iron dike” faulting.

A critical review of the alteration processes that have been active in the De Lamar district also yields diagnostic facts. The wide zone of alteration that constitutes each of the “iron dikes” is incontrovertible proof that the fractured zone was readily permeable by the agents of hydrothermal alteration. Since the walls of vein and “dike” fissures are of the same type of rock it is a logical assumption that a given hydrothermal agent would produce the same type of alteration in each. The preceding discussion of alteration of the rhyolite has brought out the fact that the alteration which accompanied the vein formation and ore deposition was sericitization accompanied by silicification. The material of the “dike,” on the other hand, is the result of a very different process of alteration

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1 Oral discussion with the writer.
accompanied by heavy pyritization. The two must, therefore, have
dissimilar histories. If the vein fissures had been permeable at the
same time as the "dike" faults they would have been the site of
similar alteration and pyritization. Since the alteration is wholly
lacking and pyrite occurs very sparsely in the veins, it is clear that
the two sets of fractures were not open at the same time. If the
"dike" were the older fracture it would have been accompanied by
complementary fissures which would have allowed widespread circu-
ation of solutions and consequent widespread alteration of the dike
type. Moreover, the vein-forming solutions, which replaced the
rhodochrosites with great facility, would have formed identical veins
within the "dike" filling and deposited ore minerals therein. Neither
is the case. Lindgren has concluded (18b: p. 184) that the alteration
of the "dike" filling was effected by an alkaline hydrothermal
agent low in carbonic acid during a period in which the veins were
filled with calcite or barite gangue. This opposes his own conclusion
that alteration had rendered the dikes thoroughly plastic before the
vein fissures were opened, unless there was a period of alteration
before the opening of these fissures, an alteration of which there is
no record anywhere else in the region. He concludes further that
the alteration along the veins results from action of acid solutions
on rhyolite previously altered by the alkaline solutions. This would
entail the development of the same type of alteration in the "dike"
as along the veins, at least at the zone of intersection; such, however,
is not the case. The alternative decision is that the veins were in
existence before the De Lamar fault and its associated fractures
were opened. This decision is substantiated by the preceding dem-
Onstration that the "iron dike" fault system is younger than the veins and that it
has fractured and displaced them. Speculation suggests that this
diastrophism occurred shortly after the previous fractures had been
thoroughly closed locally by vein formation and ore deposition;
that it re-opened the sources from which the vein-forming agents
were discharged; and that subsequent hydrothermal activity was
by solutions, largely depleted in silica and the precious metals, but
relatively more concentrated in pyrite-forming constituents.

The subsequent description of the De Lamar mine brings out the
fact that the ore shoots pitch southeastward in the veins about 30°,
especially parallel to the De Lamar fault. This fact may or
may not indicate that the fault was present before the deposition of
the ore and that the ore bodies were localized beneath it. However,
the ore shoot in the "M" vein, which lies in the upper block of the
Henrietta fault, also pitches southeastward. It becomes necessary,
therefore, to postulate an explanation which will satisfy the known
conditions of ore shoots pitching southeastward in both the upper
and lower blocks of the "iron dike" faults. Theoretical analysis
establishes a thoroughly logical explanation of this parallelism even
though the faulting is later. Secondary strain, induced by compres-
sion of the walls of the Seventy-seven vein at the time that fissure
was opened, would find relief in secondary fractures, striking nearly
eastward and dipping southward 25° to 45°. Such fractures un-
doubtedly formed. The discussion of localization of ore bodies, which
follows on a later page, shows they are probably in large part con-
trolled by the position of intersecting fractures, creating shattered
zones in which the ore-bearing agent can circulate freely. If the loci
of ore deposition in the Seventy-seven vein and those associated with
it were controlled by the intersection of the main fissures with the
secondary fractures postulated above, the resulting ore shoots would
pitch southeastward slightly less than 25°. The regional earth
stresses, when subsequently re-activated, would be resolved into
components controlled by the dominant pre-existing fracture-set,
which strikes N. 62°-75° W. and dips 70° south and is represented
by the Seventy-seven vein. This would give a tendency to shear
in the direction of the secondary fractures of the earlier period of
diastrophism. This tendency, if relieved, would cause the resulting
fracture to be strictly parallel to the pitch of the ore shoots in the
vein. This may be the true explanation of the phenomenon ob-
erved in the De Lamar mine.

Thus, the weight of evidence appears to the writers to show that the
"iron dike" fault system is younger than the veins and that it
has fractured and displaced them. Speculation suggests that this
diastrophism occurred shortly after the previous fractures had been
thoroughly closed locally by vein formation and ore deposition;
that it re-opened the sources from which the vein-forming agents
were discharged; and that subsequent hydrothermal activity was
by solutions, largely depleted in silica and the precious metals, but
relatively more concentrated in pyrite-forming constituents.

EPOCHS OF DIASTROPHISM

The preceding discussion of the several systems of earth fracture
points to three successive periods of diastrophism, in each of which
maximum crustal shortening took place in a northeast and south-
west direction. The tendency is toward westward rotation, so that
the master force must have acted in a general easterly direction
against the southern part of the region, in opposition to an equal
force acting westerly at the north, or else in opposition to the passive
resistance offered by the positive crustal segment of central Idaho.
The first of these periods is contemporaneous with the closing stages
of granodiorite intrusion, and, on the basis of the generally accepted
age of the intrusive, occurred during the interval between late Cre-
taceous and early Eocene. The second and third periods are later
than the rhyolites which, in view of recent correlation by Chaney
(12) and Buwalda. (22: p. 19), are probably of lower Miocene age.
There is some evidence for concluding that the ore deposits of War
Eagle, Florida and De Lamar mountains are genetically related to
the latest of the rhyolites, so that the second period is probably pre-
middle Miocene. Glacial topography developed after the latest
diastrophism indicates that crustal adjustment has not extended
later than the Pleistocene. This tentative correlation of deforma-
tional epochs, and the stresses involved, agrees closely with Mans-
field's analysis of the diastrophic history of southeastern Idaho
(25a: pp. 63-66; 25b: p. 465; 25: pp. 704-705). It is a logical assump-
tion, therefore, that the stresses were regional rather than local and
that a similar history must obtain over much of the encompassing
region.

RELATION TO MINING DEVELOPMENT

Inasmuch as the fault systems which have been described will
constitute the critical problem to be met in any future search for
ore bodies, it is essential that the problem be clearly recognized.
With the exception of the De Lamar and other parallel faults, the
displacements to be expected on War Eagle, Florida, and De Lamar
mountains are small and their directions may usually be predicted.
Not all the fractures that exist have been detected, of course, but
others can probably be classified in one of the sets already described.
Along the faults of the "iron dike" system the displacements are
probably as great as 1,200 feet or more, and carefui search is required
before the extension of the vein systems will be found. The problem
is quite different in the Flint district, inasmuch as the ore deposits
are genetically related to the first period of diastrophism and have
been deformed in each of the two succeeding periods. The displace-
ments are, therefore, relatively large. Moreover, several parallel
veins may be displaced so that the two segments most nearly in
alinement in the opposing walls of a fault may not be portions of
the same vein or ore body. The analysis of the fault problem be-
comes, therefore, of critical importance. Competent geologic guid-
ance accompanied by detailed geologic mapping, which attains its
greatest value only when it keeps ahead of the timberman, becomes
an essential part of the exploratory program of any magnitude.

RELATION TO TOPOGRAPHY AND DRAINAGE

In each of the three periods of diastrophism the maximum
crustal shortening has been in a northeast and southwest direction,
and the greatest extension normal thereto. This direction of max-
imum shortening is at right angles to the axis of the Owyhee Range,
which trends northwestward. The latter is, therefore, a structural
range produced by block faulting: and the bounding topographic
depressions, at least in part, must have been similarly formed.

It has been shown that the pattern of the waterways, in part,
agrees very closely with the surface traces of major earth fractures.
Perhaps the best example of this agreement may be seen in the
western branch of Flint Creek (Pl. III), which follows almost ex-
actly the major fault which bounds the western edge of the grano-
diorite. Moreover, Louse Creek (fig. 1) follows the extension of
this earth fracture northward and westward nearly to the De Lamar
district; suggesting that the fracture is similarly extended. Other
streams of the region follow the extensions of known fractures, or
are parallel to them, so that close harmony exists between the
regional patterns of major drainage lines, and of fractures. It is
not inconceivable, especially in view of the structural origin of the
Owyhee Range, that geologic structure exerts a similar control over
the drainage of a large part of southwestern Idaho.

HISTORY AND PRODUCTION

The following history of the Silver City district has been gleaned
from several sources. Lindgren has summarized the events preced-
ing 1898 (24b: pp. 108-110), gathering much of his data from Ray-
mond's reports for the years 1867-1875, and from the reports of
the director of the Mint for the period 1880-1884. Many items
have been taken from a file of clippings from The Owyhee Avalanche,
Silver City's newspaper, which file was kindly contributed by Mr.
R. H. Leonard. These sources of published information have been
freely drawn upon.

The mining industry of the Silver City district dates from 1863,
in which year placer gold was discovered near the site of the later
settlement of Wagontown, by a party led by a prospector named Michael Jordan. In honor of the discoverer the stream was given the name Jordan Creek. The report of fabulously rich deposits spread rapidly, and a veritable horde of eager gold seekers soon gathered in search of the yellow metal. During 1863 the placer gravels were traced up Jordan Creek, and its tributaries, to the rich lode deposits at their heads on War Eagle Mountain. For two years the stream beds were extensively washed, the notable production coming from Jordan Creek, Blue Gulch and Coffee Gulch on Florida Mountain, and the tributaries draining from the eastern face of War Eagle Mountain. The bullion produced contained a large proportion of silver, and had an average value of $10 per ounce; this is equivalent to a ratio between gold and silver of approximately 1:1 by weight. By 1865 the major deposits had been worked over and placer mining was virtually abandoned by the white gold-seekers; the more provident Chinese, however, continuing operations on a small scale for many years.

Although several of the lode deposits had been discovered in the first few months of the camp's history and the first reduction plant had been erected at the Morning Star mine in 1864, the mines were worked at first in a somewhat desultory fashion by men of small means. By 1865, however, fabulously rich bodies of surface ore had been opened in the Poorman (Pl. II, No. 40) and Oro Fino (Pl. II, No. 57) mines, and lode mining entered on a period of impetuous, and almost frenzied, development. Guerrilla warfare was carried on openly between contendents for desirable ground, and, on one occasion, Federal troops were called in to restore order. Until 1869 supplies were brought by ocean and river steamer from San Francisco to Umatilla, on the Columbia River, thence overland to Silver City, at a total cost of seven cents per pound. Even after 1869, when the Central Pacific railroad had been built as far as Winnemucca, Nevada, freighting from the railhead was 4½ cents per pound. Heavy machinery had to be hauled on skids over the winter snow. Ruby City and Silver City were built on Jordan Creek by opposing factions. Silver City rapidly gained ascendency over its rival and grew to 4,000 people, and became the proud possessor of one of the first telegraph offices and daily newspapers. Fairview, situated close to the mines on War Eagle Mountain, became a town of 2,500 inhabitants. Other settlements were Booneville, at the mouth of Blue Gulch; Wagontown, below the site of the present De Lamar; and Flint.

In spite of the serious handicaps the mines were vigorously worked, at first by individual enterprise, and, later, by corporate companies. The Poorman mine, with its surface stopes in bonanza silver chloride and ruby silver ore which yielded shipments worth $4,000 a ton, and milling ore returning $300 in bullion per ton of ore, and the Oro Fino mine with its $160 gold ore, offered stimulus enough to prospector and miner. In 1866 these mines, and the Ida Elmore, Golden Chariot, Mahogany, Minnesota, Morning Star, and other properties, were producing ore; and 12 reduction plants, with a total of 132 stamps, were in operation. The Oro Fino—Golden Chariot vein was opened up for a total length of 3,350 feet and worked, through shafts, to depths of 300 to 1,100 feet. The daily output averaged 40 or 50 tons of ore per mine and from half a ton to one ton per man. In 1869 the cost of mining varied between $17.50 and $30.00 per ton at depths less than 500 feet, and the average was about $20 per ton. The cost of reduction by wet crushing and amalgamation averaged $12 per ton, and a maximum of $40 is recorded for roasting, chloridizing, and amalgamation combined. Complete operating costs were from $40 to $50 per ton. In the Oro Fino mine the upper levels yielded $150 per ton of ore, with gold and silver contents nearly equal; the ore mined at a depth of 220 feet was worth $40 or $45 a ton; and the silver content was six times as large, by weight, as the gold content. The Golden Chariot found $21 ore on its sixth and seventh levels and then entered $30 ore on the eighth. The experience was the same in other mines as the zone of primary ore was developed. In the face of the extravagant and reckless management which was the order of the day, and the steadily mounting cost of raising ore and water, the margin of profit on the operations became smaller and smaller. Too often, also, speculation took precedence over careful mining. Finally, in 1876, after the mines had been actively worked for 11 years, the financial support for the enterprises was swept away by the failure of the Bank of California. The crash was complete, property after property was closed and abandoned to sheriff's sale, many of them never to be reopened. With a production of precious metals valued at nearly $12,500,000, the first period of activity terminated.

One significant occurrence of the time, before the history of this first period is brought to a close, may be mentioned. The plan of a deep tunnel under War Eagle Mountain, to open its entire vein system, was proposed in 1868 by a group of mine operators, and
the organization of a company to execute the plan was undertaken by Mr. George C. Robbins, then superintendent of the Owyhee Mining Co. Organization plans were never completed and the plan slumbered for three decades before it again crystallized.

For the 12 years following 1876, the mining industry of the region was in the doldrums. The mines on War Eagle Mountain were operated by private enterprise and new properties were developed, but capital was lacking and activity was sporadic. Only the upper levels of the old properties were entered, and deep prospecting was not even attempted, although the aggregate amount of work done was moderately large. In spite of the gloomy outlook, however, enterprise was not lacking, as attested by the use of the diamond drill for prospecting in 1878, one of the earliest uses of this device in the Northwest. Most of the miners soon deserted the district, and production fell steadily. In 1880 Silver City held but 800 people; Fairview had shrunk to a mere hundred and was later abandoned.

Even while the activity on War Eagle Mountain was steadily waning, attention began to turn to other districts which were afterwards to write into the regional history a chapter of brilliant achievement. Rich gold-bearing float had been found on Florida mountain in 1871, but subsequent prospecting was disappointing. In 1881, we heard of production from the Seventy-nine ledge and in 1883 from this property and from the Empire State, Black Jack, Starlight, and others. Ore had also been discovered on the Silver Vault claim south of De Lamar Mountain in 1870. In 1883 the Mint report speaks of production from the Garfield, Webfoot, Crown Point, Idaho, St. Clair, Stoddard, and other claims of that district, and the Henrietta and Silver Vault properties were quite active. Curiously enough the Wilson and Ohio claims, later to be the backbone of the famous De Lamar group, are spoken of only as interesting prospects. In spite of these developments, however, production declined steadily and reached its minimum in 1887.

In 1889 the Silver City district entered upon a second era of prosperity which was to surpass by far that attained at any preceding time. Almost simultaneously in that year the ore bodies of the Black Jack mine on Florida Mountain and of the De Lamar mine at Wagontown were found underground and developed. Two years later the Trade Dollar mine encountered rich ore on the southern extension of the Black Jack vein. Production grew rapidly. By 1890 it had passed $1,000,000 annually, a figure which it equaled each year for more than a decade. One by one these enterprises were acquired by well capitalized incorporated companies, and development and mining were inaugurated on a scale which was large for that day. The De Lamar Mining Company, Ltd., of London, acquired the property which had been developed by Capt. J. R. De Lamar, a property which soon became famous under that name. Though not in bonanza, its ore bodies were large and carried a higher proportion of gold than any mine hitherto developed in the region; for five years they yielded the greater part of the regional production. On Florida Mountain, the Black Jack and Trade Dollar mines found bonanza ore and developed their holdings rapidly. These bitter competitors were consolidated later, and, in 1903, were reorganized by Eastern capital. Forcing rapidly ahead they surpassed the output of the De Lamar mine in 1897, and established a supremacy in production which they maintained for eleven years. Further stimulus to these operations was derived from the completion, in 1898, of a branch line railroad from Nampa to Murphy, which reduced the distance to railhead to 25 miles.

Other activities were by no means wanting. On War Eagle Mountain, the Poorman mine was reopened in 1895 by the Poorman Gold Mines, Ltd., the second London company to enter the field, and it operated with reported financial success until 1903. The Cumberland mine, close to the old Golden Chariot, operated for a brief period during 1898, but the properties which had been famous in the seventies remained idle. At De Lamar, the Henrietta mine was reopened and worked during 1896 and 1897. In the Flint district, the old Rising Star mine was acquired in 1909 by a third English corporate organization, the Perseverance Mining Co., and considerable development work was carried on until 1914.

During this period also the question of depth persistence of the ore bodies came to the fore, and courageous prospecting was undertaken in the search for an answer. At De Lamar and in Florida Mountain, exploratory work was carried to depths of 950 and 1700 feet, respectively, beneath the vein outcrops. A deep tunnel was started from Sinker Creek in 1899, driven beneath the Oro Fino-Golden Chariot workings of War Eagle Mountain, and tapped the veins more than 2,000 feet below the outcrops. Each of these major explorations failed for causes that will be discussed later, and did not encounter workable ore bodies.

Shortly after the opening of the twentieth century, production began to overtake development throughout the Silver City region
and the exhaustion of known ore bodies forced a gradual decline in the total output. In 1910, the consolidated Black Jack and Trade Dollar mines had been stripped of workable ore and were shut down by the operating company. Four years later the De Lamar Company, Ltd., worked the last of its ore reserve and ceased operations. Lacking the stimulus afforded by these two major enterprises, the mining industry suffered a second almost complete collapse after 25 years of most vigorous activity during which the total production of precious metals had been nearly $28,000,000.

Since 1914, the condition existing throughout the region has duplicated that of the years 1876-1889. Individuals and small corporate groups have striven zealously, but capital has been limited and the odds against them great. Several new developments have been begun on War Eagle Mountain and attempts have been made to reopen the mines at De Lamar, at Flint, and on Florida Mountain. Production, however, declined steadily until 1920, in which year gold and silver valued at $19,173 were recovered. This was the lowest point yet reached on the curve of annual production. Since 1920 the output has increased steadily if slightly, but only the future will tell whether this increase is a promise of future repetition of past production.

MINING DISTRICTS

For purposes of administration, during those early days when a mining community was a veritable republic unto itself, the Silver City region was organized into four districts. The Carson district embraced the drainage area of Jordan Creek above the mouth of Louse Creek, and included the western half of War Eagle Mountain and the properties of Florida Mountain and of De Lamar. The French district, bounded by the divide of Sinker Creek, was dominated by the Oro Fino-Golden Chariot group of mines. The drainage area of Boulder Creek constituted the Steele district; and the Flint district included the watershed of that stream and also that of Cottonwood Creek. Each of these districts is now completely disorganized and their names are disappearing from local literature. Reference to them is made, however, in many old reports and records, so that a re-statement of their bounds is not amiss in the present paper.

OUTPUT OF THE PRECIOUS METALS

PRODUCTION BY YEARS

The gross output of gold and silver from Owyhee County may be ascertained with reasonable accuracy, and, since the Silver City region embraces all the important producers, its output is essentially that of the county. The available data have been tabulated below. The figures for the years prior to 1890 are based upon the reported production from some of the mines, and, in part or in whole, upon estimates; they are, therefore, subject to some uncertainty. Gerry (17: p. 395) has recently estimated that Owyhee County during the period of 1863-1923, produced gold valued at $21,674,700 (1,048,515 fine ounces) and 24,529,712 ounces of silver. These estimates differ slightly from the totals reached by the writer, but it is impossible to reconcile this difference without knowledge of the source of Gerry's data. It will be noted that the ratio of silver to gold varies greatly from year to year, reaching a minimum of 1.3 in 1887 and a maximum of 143.9 in 1920. This extreme variation is due to the great annual range of production from a large number of ore bodies, whose maximum and minimum gold-silver ratios are even more unequal than the extremes of the annual ratios. In the absence of complete tonnage and production records for each individual mine, it is useless to attempt to prove or disprove that the gold to silver ratio varies systematically from place to place over the region, or from one level to another, in any given mine.
# Geology and Metalliferous Resources of Silver City Region

## Production by Mines and Districts

Complete segregation of the data of precious metal output to show the production of each individual mine is not possible, on account of the incompleteness of the record. The data which can be segregated, however, constitute the following table. The estimates for the mines on War Eagle Mountain are based upon Lindgren's published figures (24b: pp. 143-157).

### Approximate value of gold and silver produced by individual mines of Owyhee County

<table>
<thead>
<tr>
<th>District and Mine</th>
<th>Period</th>
<th>Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>War Eagle Mountain</td>
<td>1863-1890</td>
<td>$15,000,000</td>
</tr>
<tr>
<td>Golden Chariot mine</td>
<td>1863-1878</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Elmore mine</td>
<td>1863-1878</td>
<td>1,000,000</td>
</tr>
<tr>
<td>Morning Star mine</td>
<td>1863-1880</td>
<td>2,000,000</td>
</tr>
<tr>
<td>Oro Fino mine</td>
<td>1865-1890</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Oro Fino group</td>
<td>1865-1890</td>
<td>3,000,000</td>
</tr>
<tr>
<td>Poorman group</td>
<td>1865-1890</td>
<td>3,000,000</td>
</tr>
<tr>
<td>De Lamar district</td>
<td>1868-1914</td>
<td>12,485,797</td>
</tr>
<tr>
<td>De Lamar mine</td>
<td>1868-1914</td>
<td>12,485,797</td>
</tr>
<tr>
<td>Florida Mountain</td>
<td>1883-1898</td>
<td>2,885,000</td>
</tr>
<tr>
<td>Black Jack mine</td>
<td>1883-1898</td>
<td>2,885,000</td>
</tr>
<tr>
<td>Trade Dollar mine</td>
<td>1888-1888</td>
<td>2,885,000</td>
</tr>
<tr>
<td>Trade Dollar Mining and Milling Co</td>
<td>1899-1908</td>
<td>2,885,000</td>
</tr>
<tr>
<td>Trade Dollar Consolidated Mining Co</td>
<td>1903-1910</td>
<td>4,245,000</td>
</tr>
<tr>
<td>Flat district</td>
<td>Rising Star-Perserverance mine</td>
<td>1865-1924</td>
</tr>
</tbody>
</table>

### Metallurgical Treatment

In the effort to obtain the highest possible recovery of precious metals from the Silver City ores, many metallurgical processes and devices have been employed. In the early days of the camp, the free-milling oxidized ores were successfully worked by wet crushing with stamps, followed by plate amalgamation. Several arrastras operated successfully on these ores for many years. As the silver content of the mill feed increased, with increased depth, modifications became necessary. In some mills, various concentrating devices were used to treat the tailings from the amalgamating plates, while others, the ore was subjected to a preliminary roast, either with or without chloridization. These modifications were not fully effective, and the plate amalgamation process gradually came into disuse.

During the eighties and early nineties, pan amalgamation, preceded by concentration, was used to the virtual exclusion of all other methods throughout the Silver City region. In the Dewey mill of the Trade Dollar Consolidated Mining and Milling
Co. (Pl. II, No. 1) the ore was crushed in four 5-stamp batteries to pass a 30-mesh screen, classified, and concentrated by Frue vanners. Under normal operating conditions 63 per cent of the silver content and 83 per cent of the gold content of the ore was recovered in the concentrate. The tailings from the vanners then passed to thickening cones, thence to the amalgamating pans in which they were regrounded with mercury in the presence of copper sulphate, salt, and a small amount of lye. It is interesting to note that this order of vanner and amalgamating pan is the reverse of the usual installation. The bullion ultimately recovered from the amalgam was equivalent to 29.5 per cent of the silver content of the mill feed and 11.5 per cent of the gold content. The ore treated contained 0.15 to 0.5 ounce of native gold per ton, and 20 to 50 ounces silver as native metal or argentite and naumannite, accompanied by less than one per cent of chalcopyrite in a quartz gangue. The total recovery from this ore was 91.5 per cent of the silver and 94.5 per cent of the gold. At De Lamar prior to 1897, crushing by stamps was followed by pan amalgamation without concentration. The process recovered from 71 to 83 per cent of the value of the precious metals from quartzose ore whose average content was 0.85 ounces native gold and 16.5 ounces silver, chiefly as argentite and naumannite, per ton. It was not effective for ores with clayey gangue. At the mill of the Addie Consolidated Mining Co. (Pl. II, No. 31) the metallurgical process differed somewhat from that at Dewey. A small amount of concentrate was recovered from Frue vanners. The tailings from the vanners passed to Wheeler pans for regrinding and thence to a settling tank. The sands from the settler were then re-concentrated by a Deister slime table. The recovery effected is not known.

Cyanidation was first employed in the Silver City region in 1897. In that year a small experimental plant was operated by the Poorman Gold Mines, Ltd., but the process did not replace pan amalgamation in their mill. The same year the Pelatan-Clerici cyanidation process was installed in the mill at De Lamar, and, after considerable modification, operated successfully. Repeated modification was necessary and the installation soon lost most of its resemblance to the original patented process. In 1905 the mill was wholly rebuilt, and its flow sheet again revised. The ore was received by a 1½-inch size by crushers and rolls, then ground with cyanide solution in Chilean mills, and separated into sand and slime products by classifiers. These two products were leached separately in tanks equipped with mechanical agitators. Filtration of the pulp, and precipitation of the precious metals with zinc dust followed in the usual manner. Although working upon the clayey ores which earlier operators had classed as impossible to treat, the mill attained an extraction of 91.0 to 98.3 per cent of the gold, and as high as 89.7 per cent of the silver. A cyanide plant was also installed about 1915 at the mill of the Idaho Gold Mining & Milling Co. (formerly the Silver City Mining & Milling Co.) on Florida mountain (Pl. II, No. 21). At this plant the ore is crushed to 2-inch size by Blake crushe, is reduced to 12-mesh by a 5-stamp battery, and is ground in cyanide solution by a pebble mill operating in closed circuit with an Ovoca classifier. The overflow from the classifier passes in turn to a Dorr thickener, Pachuca agitating tanks, a second thickener, and, finally, to an Oliver continuous filter. The pregnant cyanide solution is clarified by filter press, is treated with zinc dust, and passes to a precipitate filter press, from which the precipitate is melted for bullion and the barren cyanide solution is returned to the mill storage tank. This installation approaches the standards of present practice and should have effected a high recovery of the precious metals. The actual recovery, however, is not known.

Efforts to recover the precious metal content of the ores by mechanical concentration alone have been made only during the past decade. The Banner mill (Pl. II, No. 19), handling ore from the Alpine vein of the old Trade Dollar mine, crushes the mill feed to 1½-inch size, reduces it to 40-mesh with four Nissen stamps, separates a first and a second class concentrate on a Simplex table, and treats the reject from the Simplex table on one of the Wilfley type. Second-class concentrate is recovered and a tailing is rejected from this second table. At the Never Sweat mill (Pl. II, No. 54), the ore is broken to 1-inch size, then passes to a rod mill for fine grinding. The rod mill discharge is concentrated on two Wilfley tables; of these, the first yields a middling which is added to the feed of the second, and the latter produces a concentrate. The tailing from the two tables is elevated to a cone classifier from which the sands are returned to the ball mill for further grinding. This practice makes the tables serve as a classifier operating in closed circuit with the rod mill. The classifier overflow passes to a Callow pneumatic flotation machine which wastes a clean tailing and sends a low grade concentrate to a second Callow machine for cleaning. The cleaner separates a concentrate for shipment and returns a middling to the cone classifier. One lot of concentrate shipped dur-
ing August, 1925, assayed 58.88 ounces gold and 1,573 ounces silver per ton and the operators claim high recovery, although precise data are not available.

The gold and silver content of the Silver City ores is in the form of native metals or of minerals in which the proportion of silver is large; usually the amount of accompanying sulphide minerals, chiefly chalcopryite, is not more than two per cent of the whole. Such an ore is in general far more amenable to hydro-metallurgical treatment than to any method of concentration, for complete separation of such a small amount of mineral from its gangue requires a very closely adjusted and closely watched concentrator. Moreover, the high ratio of concentration that must be effected to produce a marketable product demands either duplication of equipment in order that a low grade middling may be further concentrated or else the use of large units operated far below their maximum efficiency. These ores are, on the other hand, particularly amenable to the cyanidation process. This mode of treatment was wholly successful at De Lamar for a long period. A representative lot of medium-grade ore taken from the old stopes of the Trade Dollar mine by the Florida Mountain Mines Co. was tested at the metallurgical laboratory of the University of Idaho to determine its amenability to cyanidation (16). This lot of ore analyzed as follows:

<table>
<thead>
<tr>
<th>Metal</th>
<th>Amount (oz per ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>0.06</td>
</tr>
<tr>
<td>Silver</td>
<td>14.2</td>
</tr>
<tr>
<td>Lead</td>
<td>None</td>
</tr>
<tr>
<td>Zinc</td>
<td>None</td>
</tr>
<tr>
<td>Iron</td>
<td>1.1%</td>
</tr>
<tr>
<td>Copper</td>
<td>Trace</td>
</tr>
<tr>
<td>Antimony</td>
<td>Trace</td>
</tr>
<tr>
<td>Arsenic</td>
<td>None</td>
</tr>
</tbody>
</table>

Laboratory tests indicated a recovery of 91.7 per cent of the gold and 94.0 per cent of the silver by fine grinding in cyanide solution followed by agitation. Fineness of grinding and length of the period of agitation were found to be the factors most directly controlling the extraction, strength of cyanide solution being less important. Obviously, laboratory tests do not furnish complete data upon which a milling plant can be designed, but they are a sound basis for selecting a process to be elaborated by plant tests. The greater efficiency attainable in practice suggests that the cyanidation process, especially counter-current decantation or other continuous systems, should return 95 per cent of the gold and silver content of the Silver City ores. If the future brings about a rejuvenation of the mining industry, it cannot be too strongly recom-

The following discussion of the mineralogy of the ores brings out the fact that the dominant silver mineral of the Silver City region is the selenide, naumannite. This mineral, fortunately, dissolves in cyanide solution without much difficulty, especially if the ore is finely crushed. The presence of more than a trace of selenium renders the bullion brittle, but this difficulty can be eliminated by a suitable treatment with acid at the zinc precipitation boxes. There is no reason to believe that the cyanide process would not be wholly successful with the ores of the Silver City region.

THE VEINS AND THE ORES

The veins as structural features are described and discussed on pages 40 to 43. In this place they will be considered as ore deposits, that is, from the point of view of economic geology.

TYPES OF VEINS

Although all the veins of the region are in one way or another fissures, they are seen, when studied in detail, to belong in four different groups or classes. The classification is based both on the kind of fissuring and the kind or type of filling. The types are: 1) Fissures filled with massive ore-bearing white or milky quartz with varying amounts of crystallized quartz, those of the Flint district being typical of this class; (2) Fissures filled with lamellar, pseudomorphic quartz, the characteristic veins of De Lamar district being typical of this class: (3) Silicified and mineralized shear-zones, of which the Poorman vein appears to be a typical example; (4) Cemented breccias, the cementing material being either massive and crystallized quartz, or pseudomorphic quartz, the Oro Fino-Golden Chariot vein, and portions of the Seventy-seven vein at De Lamar are examples respectively of this class. It must be borne in mind that, although broadly and generally this classification holds, there are veins which show the characteristics of more than one type, as, for example, certain portions of the Seventy-seven vein consist of a fissure filled with ore-bearing pseudomorphic quartz, whereas other portions consist of a breccia cemented with similar material. The recognition of the differences upon which the veins

1 Dr. Francis A. Thomson, private communication.
are grouped or classified does not preclude an equal recognition of their similarities. In fact, the similarities are probably more striking to the casual observer than the differences. The similarities are brought out in the lists of gangue and ore minerals accompanying the descriptions of the mines of the different districts and in the discussions which follow them. By way of summary it may be stated that with the exception of a few minerals which occur so sparingly that they may be regarded as mere accessories, the gangue and the ore minerals of the four districts are almost identical. The only notable difference is the relative abundance of a certain mineral or group of minerals. In other words, the minerals are practically identical but the relative abundance of one or another varies from district to district. These facts are believed by the writers to indicate that the mineralization of the Silver City region came from a common source. The question is discussed in some detail under genesis of the ores (p. 88).

The veins might be logically classified, as was done by Lindgren (24b: p. 158) into silver veins and gold-silver veins, but a genetic classification seemed to be more suitable to the present report. Besides, since all the veins produce both the precious metals, they are in reality all either gold-silver or silver-gold veins, and one place in an ore shoot may produce dominantly silver-gold ore whereas in another place from the same shoot the order of the metals on the basis of value may be reversed. However, on the basis of weight or mass of the respective metals they are all silver-gold veins, the average ratio being approximately one ounce of gold to thirty ounces of silver for the total recorded production from the region.

The veins in which massive mineralized quartz predominates, that is, those of the first type, have two clearly defined walls and appear to be true fissures which perhaps were widened both by replacement and by the pressure against the walls produced by the force of the crystallizing quartz. The vein matter breaks free from the walls and so far as observations have extended, there is little or no mineralization of the wall rock. Except for superficial changes such as always occur in the upper portions of mineral veins, the vein matter and the gold and silver-bearing minerals appear clearly to be of contemporaneous deposition. It is evident that there were periods in which the deposition of vein matter was pronounced, while the deposition of the ore minerals was at a minimum. Although massive white or milky quartz is by far the dominant occurrence, it is by no means the only form of the mineral in this type of vein, and in vugs and other open spaces well developed and perfectly terminated quartz crystals project from the walls of the openings. Frequently among such crystals in the Rising Star vein in the Flint district there are bunches and crystalized masses of pyrrargyrite, polybasite, and other silver minerals. In the Banner and the Alpine veins, at the south end of Florida Mountain similar cavities are lined with both quartz and valencianite in fine crystals, and in a few instances in the Banner vein the quartz crystals are coated and covered with lamellar calcite. Veins of this type are persistent both in length and depth so far as developments have gone. They vary in thickness or width, but are remarkably uniform. The ores are apparently confined to definite but extensive ore shoots.

The second type of vein, which is characteristic of the deposits in De Lamar Mountain, was developed in fissures apparently similar in all respects to that in which the massive quartz veins developed. The difference lies in the filling, which consists of lamellar or pseudomorphic quartz, the ore minerals occurring in and upon the lamellar quartz and on fragments of the wall rock included within it. There is also this further difference (if we accept the assumption that the lamellar quartz is pseudomorphous after lamellar calcite) that the fissure must first have been filled with calcite and that later the calcite was replaced by quartz. If any ore or value-carrying minerals were deposited with the calcite they were either taken into solution and redeposited, or were removed. So far as the writers have been able to interpret the situation there is no other evidence of this calcite deposition than the form and structure of the lamellar quartz. They fully realize that the theory is clumsy and possibly that the assumption is of considerable magnitude, but at the present they cannot find a simpler or more satisfactory theory. In addition to the veins in De Lamar Mountain which are typical of the class, similar characteristics are found abundantly in the Owyhee, the Stormy Hill veins, and to a less extent in the Oro Fino vein, all in War Eagle Mountain. In these veins the laminae of pseudomorphic quartz are generally coated thickly with small perfectly formed quartz crystals which give the whole mass a decided drusy appearance. There was little opportunity to study the relation between ore and gangue minerals in the War Eagle veins of this type, but from reports and from such material as was available it appears to be much the same as in the other places.

The breccia veins consist of fragments of the country rock cemented by vein matter. There are two types of such veins, one
in which the breccia is cemented by massive and crystallized quartz of which the Oro Fino-Golden Chariot vein, in part, is an example, and another in which the fragments are cemented by pseudomorphic quartz, of which portions of Seventy-seven vein and of the Oro Fino-Golden Chariot, respectively, are examples. The ore minerals, except those of superficial origin, are all apparently contemporaneous with the gangue matter, there having been periods during the long process of mineralization when little but gangue was deposited, and others when the deposition of the ore minerals was important. That this type of vein is persistent is evident when one realizes that the Oro Fino-Golden Chariot vein has been actually mined for more than 3000 feet in length, and that where intersected by the Sinker tunnel, some 2500 feet below the surface, it is as strong as in the upper levels.

The silicified shear-zone type consists of a narrow zone of the country rock which has been fissured and to a certain extent shattered and mashed, and then silicified and mineralized. It appears that in some places the forces operating to produce the openings or fissures in which the veins later developed, formed a single clear-cut fracture or fissure; in others they formed many closely spaced minor fissures and to a certain extent crushed the intervening rock, or in other words, developed shear zones. The process of mineralization silicified these, depositing at the same time the gold and silver-bearing minerals, and produced the silicified shear-zone type of vein, of which the Poorman is the best example in the district. This type of vein is not nearly so common as the quartz-filled fissure, and so far as known the Poorman is the only vein of the type in the district. There are, however, in the De Lamar district silicified, pyritized, and otherwise mineralized areas or veins in the rhyolite which, in some places carry more than $20 per ton in silver and gold. There has not been sufficient development to determine their characteristics, however, and they are, therefore, tentatively placed in the group of silicified and mineralized shear-zones. These ores are found on the dump at the Golden Cycle claims near the west end of De Lamar mountain and in the end of the “K” crosscut, eighth level, Sommercamp section of the De Lamar mine. It is stated upon reliable authority that in Florida Mountain many of the veins which were true fissure deposits in the granite and in the basalt became silicified shear-zones in the rhyolite.
SIZE AND EXTENT OF VEINS

The size, characteristics, extent, and probable persistence of the veins have been discussed in the descriptions of the individual mines. However, since this question is the factor upon which the entire future of the district depends, it is desirable that a brief summary be given here.

All of the larger veins, such as the Black Jack-Trade Dollar on Florida mountain, as well as the Oro Fino-Golden Chariot, the Poorman, and others on War Eagle mountain, are remarkable for their continuity along both strike and dip so far as developments have gone. The Black Jack-Trade Dollar vein has been developed for 6000 feet along its strike and for 1800 feet in depth without notable decrease in strength. The Oro Fino-Golden Chariot vein has a development along its strike of nearly 4000 feet, and is strong and well developed where the Sinker tunnel cut it, 2500 feet below the outcrop. While not so long, probably because they were cut off by the De Lamar fault ("iron dike") the veins in De Lamar mountain are equally strong and persistent. The same is true of the veins in the Flint district, so far as limited development has furnished information. These facts seem to preclude any adverse conclusions as to the persistence of the main veins in the direction of strike and dip. The fissuring and fracturing which made possible the development of the veins are discussed on pages 40-43, and it is there shown that the principal faults and fractures are certainly continuous for long distances. Further evidence in support of this conclusion is afforded by the geologic maps of the respective districts upon which the veins are plotted from actual stadia surveys. On War Eagle Mountain are many minor cross veins of much lesser magnitude, but even these, though in many instances very small, are surprisingly persistent.

ORIGIN OF VEINS

The veins consist of gangue and ore minerals which were deposited by aqueous solutions rising in and along previously formed fractures, which in many instances are faults of different magnitudes. The main questions involved in the origin of the veins are: the origin of the fractures; the source of the vein-forming solutions; and the factors involved in the precipitation or deposition of the material carried by the solutions. The question of formation of the fractures, the fissuring and faulting, is discussed in the portion of the report which deals with the structure of the region, pages 37-51,
where it is shown that during periods of earth movements in the geologic past the whole region was extensively fissured and faulted. The fissures in which the veins developed were formed during those periods of diastrophism. The question as to source of the vein-forming solutions, is both problematical and theoretical. Certain facts are known. The veins consist almost wholly of highly siliceous minerals, quartz and feldspars, and of metal-carrying minerals in small amounts in comparison with the mass of the vein. The source, therefore must have been one which could furnish such material from somewhere within the earth—most probably a mass or reservoir of siliceous magma from deep within the earth. Similar ores are frequently found associated with the Tertiary lavas of the Great Basin area of which the Silver City region is a part. Since the veins extend into the rhyolite, the magma from which they were derived must be younger than this rhyolite. The rock to which the veins are genetically related is not known. Possibly the vein-filling and the younger tuffaceous, glassy rhyolite, the youngest igneous rock in the whole region, may have been derived from the same magma.

The causes producing deposition of materials from solution are many and complicated: such as loss of heat; decrease in pressure; influence of wall rock; and mingling of solutions. There is no way of knowing what were the dominating factors; any one or all of them may have been active.

ORE SHOOTS

Certain portions of the veins in all mining districts are practically barren of valuable metals, and these metals are concentrated, as it were, in certain other portions of the veins, which are technically known as "ore shoots." The causes which lead to the formation of ore shoots are numerous, and it is difficult if not impossible to designate the determining factors in any particular case. Most of the physical and chemical factors mentioned above as concerned in the precipitation of substances from solution are probably active in the formation of ore shoots. There are also additional factors, such as fractures and planes or zones of shearing which exert a controlling influence upon the courses of circulating solutions, the complexity of the ions involved in the chemical reactions, the acidity or the alkalinity, and also the concentration of the solutions, the distribution and concentration of the metals in or about the parent magma, and many others. Be the causes what they may, the valuable metals are localized within limited areas in all veins and are rarely if ever diffused uniformly throughout their whole extent. There may be one or more ore shoots in a vein, the extent of which may be a few or many feet, but in every case the ore shoot is limited and can be followed both horizontally and vertically until the ore is exhausted or until its value falls below the limits of profitable mining. When this has happened, does it invariably mean that the deposit is exhausted and that it must be abandoned? Not necessarily. The ore minerals were formed by solutions which, according to modern theories of ore deposition, came from unknown depths and made their way upward within the vein and deposited the various minerals in accordance with chemical and physical laws of solution and precipitation.

When all the causal factors are considered, it appears that local influences, such as cross-fractures, porosity of vein matter, and perhaps others determined the localization of the ore shoots. Of these, cross-fracturing, since it would permit the mingling of solutions of different composition and possibly from different sources, is believed to have been the most important. Influence of wall rock, which in many ore deposits seems to have been the determining factor in precipitation of the ore minerals, does not appear to have been of great importance in the Silver City region, in which the ore shoots extend from granite into basalt, and upward into rhyolite without material changes in richness.

Unless the deposit be at a contact, the intersecting fracture is most likely to furnish a channel or conduit for the mineralizing solutions, and to be responsible for the precipitation, and thus determine the pitch of the ore shoot and to a great extent its richness. This line of reasoning appears to the writers to lead to the conclusion that one ore shoot may in the direction of its pitch be followed by another, and yet others, and that no mine should be abandoned as exhausted until such possibilities have been tested by actual exploratory work.

Before leaving the more or less theoretical consideration of ore shoots, some thought should be given to the removal of portions or all of an ore shoot by erosion. It is evident at once that two factors are important in determining the amount so removed: the depth at which the ore shoots were formed, and the thickness of the sheet of material carried away by erosion. If the present theories as to the zonal arrangement of ores with respect to their source be accepted, and if it also be accepted that peculiar combinations of minerals indicate the temperature and roughly the depth at which
they were deposited, then by a careful study of the minerals of an ore shoot it should be possible to determine whether much or little of the vein has been removed, and consequently some idea may be gained as to the possible vertical extent of ore shoots.

The ores in all veins of the Silver City region occur in well defined shoots, one or more in each of the developed and partly developed veins, only two or three veins, however, showing more than one. The workings of the Trade Dollar vein, the one most extensively developed in the region (see stope sheet of this mine, Pl. XIII), show what may be interpreted as a single ore shoot about 5000 feet long. If, however, the stope sheet be studied in connection with the assays from different parts of this great mineralized zone, it appears that the situation is better explained by the assumption of four ore shoots pitching to the south about 45°, and so closely spaced that the outer zone of one reaches nearly to that of another. The workings were not accessible at the time of the field studies, consequently there was no way of proving or disproving this assumption. There is in the district a set of fractures, or planes of maximum shearing which intersect the Trade Dollar vein, and the dip of which is the same as the assumed pitch of the ore shoots. It is reasonably certain that similar fractures or planes of shearing determined the pitch of the ore shoots in the De Lamar veins. It is also reported, that the richest ores in the Oro Fino-Golden Chariot, the Poorman and other veins in War Eagle mountain were found at and near places where small cross-fractures intersected the respective veins. It is, therefore, probable that cross-fracturing, or shearing, was a dominant factor in determining both the location and the pitch of ore shoots in all the veins of the region. These questions are discussed in the descriptions of the individual mines, and are only summarized in this place. If this reasoning is correct, the apparently insignificant cross-shears and cross-fractures which in many instances are not distinguishable except by very carefully made observations, will prove to be of great value in further exploratory work and should be given most careful attention in all prospecting and development.

So far as could be learned from such records as were available, only one ore shoot was developed in each vein of the De Lamar mine. The early annual reports made to the directors of the company mention three ore bodies on the fourth level of the Seventy-seven vein, but it seems probable that these were only richer portions in one continuous ore shoot, inasmuch as the term "ore" at that time meant gold and silver in excess of $30.00 per ton. If this assumption is correct, the ore shoot on this vein ranged from 100 to some 800 feet in length with the depth not determined.

In general, the ore shoots in the region vary from 100 to some 400 or 500 feet in the horizontal direction or stope length, probably averaging somewhere between 100 and 300 feet. They extend to the greatest depths attained by the workings. The richest ore was found in the upper levels, probably not deeper than 500 feet. This is to be expected, since this depth would in most cases comprise the portions of the deposits most intensively affected by the processes of supergene or secondary enrichment. There is prevalent in the region a belief that the veins in general become barren at depths varying from a few hundred to 1,000 or 1,500 feet, and it is true that in some instances, the deeper portions of good ore shoots were found to be lean where they are supposed to have been cut by the mine workings. There are a number of causes, other than exhaustion of the ore, however, that could account for this condition: the fact that ore shoots are invariably irregular as to distribution of metal values and it is possible therefore that the particular development work intersected a leaner portion of a by no means exhausted ore shoot. (It must be borne in mind also that material carrying less than $15.00 to $30.00 per ton was not regarded as ore). In many instances such development work as was done indicates clearly that the operators had little or no conception of the geological features of the deposits, especially the pitch of the ore shoots. It seems probable that in many instances the work was done in the most unpromising places in the vein. As a case in point, it may be stated that the development work below the tenth level of the De Lamar mine was evidently based on an erroneous assumption as to the projected position of the ore shoots, which pitch some 30 or 35 degrees to the east. At any rate, practically all the deeper development work is far to the west of the projected pitch of the stoped ore shoots.

It must also be remembered that the operators carried on very little exploratory work ahead of the demand for increased ore supply. The maps of the mines and such of the old workings as were accessible very clearly indicated that many of the operators took out such ore as could be obtained with a minimum of development work, and when it was gone, they announced that the ore was exhausted and closed the mine. In fact, it is believed that never before nor since has so little real exploratory work been done in so
important a mining district. This being the case, it appears to the writers that the facts do not at all justify the current beliefs as to the exhaustion of the mines.

The ore shoots are discussed in detail in the description of the individual mines and the reader is referred thereto for further data.

Tradition seems to have it that the ore bodies in the large mines were fabulously rich. It is true that certain small portions of most of the ore shoots did produce very rich ore, which, as has been stated above, invariably came from the upper levels, rarely exceeding 400 or 500 feet in depth, and represented a primary body that had been enriched by supergene processes. Such records of past productions, and such additional information as appear to be reliable indicate that, exclusive of the enriched bonanzas, the ore shoots were of consistently good rather than fabulously high grade, the value of the ore as mined ranging from $15.00 to perhaps $50.00, and averaging about $25.00 per ton. This question is discussed in some detail in the paragraphs on enrichment and persistence of the ore shoots, and in the descriptions of the individual mines, and therefore need not be continued further in this place.

MINERALOGY

The gangue minerals, so far as identified, are few and of simple composition. The ore minerals, however, are of many species and are often complex chemically, the most important being sulphides, selenides, and sulphantimonides. The following list represents only such minerals as have been described previously and those that were recognized in a hurried examination of material collected from the mine dumps, from such places in the mines as were accessible, and some material contributed from private collections which were made while the mines were in operation. It is probable that a few species were and are present which were not seen by the writers. Few quantitative chemical analyses were made, and although the identifications made by the writers are believed to be correct, there may be inaccuracies.

For more complete descriptions of the different minerals, the reader is referred to the various publications of Shannon, especially his *Minerals of Idaho* (31e), and to the work of Lindgren (24b). In some instances the descriptions are in part condensed from these writers.

ORE MINERALS

The ore minerals are as follows:

**Argentite (Silver Glance).—**Argentite, the black silver sulphide, Ag2S, was found in each of the districts except Flint and it is probable that it occurs there. In the mines on Florida and De Lamar mountains it is reported to have been very abundant and to have formed one of the most important ore minerals. Except in the Poorman and a few other mines, argentite was probably not so abundant in War Eagle Mountain as in the other two localities. As noted by Shannon 31b and 31e, argentite has almost exactly the same physical properties as the naumannite of the same mines. With these facts in mind the writers very carefully examined numerous specimens of supposed argentite and found them to contain much more naumannite than argentite. Some of the material examined proved to be intergrowths of naumannite and argentite, and much of it appeared to be wholly naumannite. The two minerals as they occur in the Silver City district have identically the same physical properties, both are black, sectile, and somewhat malleable. Both form isometric crystals which show the same dominant forms, and both occur as crusts and films, and as irregularly distributed specks in the gangue minerals. It is therefore necessary to resort to chemical and microscopic means to distinguish one from the other. Naumannite dissolves in hot concentrated sulphuric acid and produces a beautiful dark green color which changes to reddish brown upon further boiling, due to the presence of selenium. If the solution is allowed to cool and then a few drops are poured into cold water, a brownish red or brown precipitate of metallic selenium forms. It may also be distinguished if heated in an open tube when the characteristic odor of selenium, tha. of decayed horseradish, is emitted. In polished surface naumannite may be distinguished from argentite by the fact that argentite is quickly etched by potassium cyanide, whereas naumannite is attacked slowly. It is probable that of the two, naumannite was and is by far the more abundant. It is also probable that the greater part of the silver produced from War Eagle, Florida and De Lamar mountains was derived from these two minerals.

**Arsenopyrite.**—Arsenopyrite (FeAsS), is probably present in small amount in the leaner and pyritic ores of the Flint district. A few of the polished surfaces of these ores contained small idiomorphic crystals that answered qualitative tests for arsenopyrite.
Azurite.—Azurite, a basic copper carbonate, occurs as blue stains on surface ores from a few of the veins, notably the Morning Star vein. It is of no commercial value in any of the Silver City ores.

Cassiterite.—Cassiterite, the oxide of tin (SnO₂) in small water-worn pebbles up to one-half inch in diameter, is reported to have been found in the placer mining on Jordan Creek (31a: p. 294). A few small pebbles of the mineral showing beautiful concentric banding were donated to the University of Idaho, by Mr. Bills, who stated that he obtained them in placer work on Jordan Creek near Dewey. None of the mineral was seen in place, and the source of the material in the placers is not known.

Cerargyrite.—Horn silver, or cerargyrite (AgCl), according to statements (31e: p. 174) and reports was abundant in the oxidized portions of probably most, if not all of the mines of the district. Traditions of the bonanza days of Silver City tell of large and finely crystallized masses of cerargyrite from some of the mines, notably the Poorman vein, from which masses weighing many pounds were obtained (31e: p. 174; 9b: p. 524). Most of this material was used as ore and hence is not available for study. Fine specimens (31e: p. 174) are preserved in mineralogical collections of Yale University.

It occurs as coatings, as platy fillings in fractures and as small more or less crystallized masses among the oxidation products in the upper portions of the veins.

Chalcopyrite.—Small amounts of chalcopyrite, a copper-iron sulphide (CuFeS₂), is found in the veins on Florida and War Eagle mountains, and very sparingly in the Flint and De Lamar districts. It appears, in some instances at least, to have been one of the last of the hypogene minerals. This is especially true of the ore from the Banner mine, in which chalcopyrite forms a thin coating over drusy naumannite. The mineral is of no commercial value in the Silver City district.

Clausthalite.—The rare lead selenide (PbSe) was tentatively identified, by qualitative chemical tests and microscopic study of polished surfaces, in a single specimen reported to have come from the Trade Dollar vein on Florida Mountain. The mineral in most respects resembles galena, but is softer and has a resplendent metallic luster. In polished surface it also closely resembles galena, even to the triangular pits—indicative of its prominent cubic cleavage. It is distinguished from galena by its not being readily tarnished by warm H₂O.

Carefully selected material gave strong qualitative tests for both lead and selenium and failed to react for sulphur, antimony, arsenic, or silver. Lead is present in small amount in the ores from Florida mountain, and it is probable that clausthalite was one of the minor accessory minerals in some of the large ore bodies of the Trade Dollar-Black Jack vein.

Electrum.—The natural alloy of gold and silver (AuAg) forms one of the important silver-gold minerals of all the districts except Flint, and it is probable that the material was present in the portions of the lodes that were operated in this district years ago.

Almost all of the native gold, even that from the placers, contained large but variable amounts of silver; all the native gold seen by the writers in any of the mines was decidedly light or silver-like in color, and would probably contain only from §8 to $15 per ounce in gold, the rest being silver. Native silver free from gold and native gold free from silver are both rare in the Silver City district. It is believed that most of the electrum is a primary or hypogene mineral.

Galena.—Galena, the lead sulphide (PbS), the commonest ore of lead, occurs only as an unimportant accessory mineral in the Silver City ores. It is more abundant in Florida Mountain than elsewhere in the district, and, if present at all in De Lamar, it is only in minute amounts. It is known also in the Flint and the War Eagle Mountain districts.

Gold.—Gold has formed one of the most important products from all the mines in the Silver City district, but metallic gold reasonably free from silver is rare in any of the deposits. Practically all the native gold in the region occurs as the natural alloy of gold and silver which is known as electrum.

Jamesonite.—The lead-iron sulphantimonide, jamesonite (4PbS Fe₃Sb₂S₄), is found in specimens of ore from the Black Jack-Trade Dollar vein, and in small amount from the 800-foot level of the De Lamar mine, where it was found as radiating fibers in a cavity (31b: p. 162). It is abundant in the ores from the Flint district where it is massive and is intergrown with silver-bearing tetrahedrite, cerargyrite and other silver minerals. Jamesonite makes up the greater part of the low-grade silver ores of the Flint district, but is by no means limited to this type of ore. It is present in all and only relatively more abundant in the low-grade ores.
It should be stated that the mineral was determined by qualitative tests only, and that some, or all of it, may be owyheeite or boulangerite.

Malachite.—The green copper carbonate, malachite, occurs as a product of weathering in the oxidized portions of the veins that contain any of the copper-bearing sulphides or sulphantimonides. It was seen in larger amount in the surface workings along the Morning Star vein than elsewhere in the region. It is present only in small amount, and is therefore of no commercial value in the district.

Marcasite.—The “white iron pyrites,” marcasite (FeS₂), is sparingly present in many of the mines. Very little marcasite was found by the writers. Lindgren (24b: p. 169) reports it as occurring in quartz in the Chautauqua tunnel, in the De Lamar and the Trade Dollar mines, and in kaolin in the Garfield tunnel.

Miargyrite.—The monoclinic dark ruby silver, miargyrite (Ag₃S₂Sb₂S₄) was found for the first time in the United States by Penfield in material collected from the Henrietta mine by Lindgren (24b: p. 168). It appears from the present study of the district that miargyrite is rather plentifully present in the ores from a number of the mines, especially those from Flint and the Trade Dollar, Black Jack veins on Florida mountain, in which it is intergrown massively with pyrargyrite. The identification of the massive material was only by qualitative tests and microscopic examination of polished surfaces, but it is reasonably certain that much of the “ruby silver” of the mines is neither pyrargyrite nor proustite, and its characteristics so far as determined agree with those of miargyrite. It also occurs in unmistakable crystals in the ores from the Flint district and from Florida mountain. It is therefore probable that in the Silver City district miargyrite is a comparatively abundant mineral.

Naumannite.—The heretofore supposedly rare silver selenide, naumannite (Ag₂Se), is one of the most abundant of the silver-bearing minerals in the Silver City district, probably more abundant than argentite. Naumannite, as it occurs in this district, has almost identically the same physical properties as argentite; that is, the minerals are both black in color, decidedly sectile, and slightly malleable, and both crystallize in the isometric system and present the same forms. They also both occur identically as inclusions as fracture fillings, and as small specks in the quartz and feldspar.

It seems certain that much of the mineral previously called argentite was in reality naumannite. It appears for the most part to be a primary or hypogene mineral, but probably was deposited rather late in an extensive period of mineralization. In a few instances its relation to other minerals indicates that it is of supergene origin and that it has replaced other minerals. If this be true it means that both selenide and sulphide enrichment of silver ores may occur.

The mineral is abundant in ores from De Lamar, Trade Dollar, Alpine, Banner, and Poorman veins. It was not recognized in ores from the Flint district, but qualitative tests on some of the ores from Rising Star vein gave reactions for selenium. Tests for naumannite and its relations to argentite are discussed under that mineral.

Owyheeite.—The lead-silver sulphantimonide, owyheeite (SPbS₂Ag₃S₅), a new mineral, was found by Shannon (31e; p. 160) in 1920 in ores from the Poorman mine. As described by him the mineral could be called a silver-bearing jamesonite, which mineral it closely resembles, and from which it is distinguished only by means of a quantitative analysis. None of the mineral was recognized during the studies upon which this report is based. Some of the jamesonite from Flint gave reactions for silver, and may upon quantitative determinations prove to be owyheeite. The writers assumed that the silver present was carried by one of the associated silver minerals or was present as a solid solution of silver sulphantimonide in the jamesonite.

Proustite.—The silver sulpharsenide, proustite (3Ag₂S₂As₂S₇), the light ruby silver, was recognized in ores said to have come from Florida Mountain and from War Eagle Mountain, probably from the Trade Dollar and the Poorman veins respectively. Neither of these veins were accessible at the time of the field work, and consequently the writers did not see any of the mineral in place. Browne (9b: p. 522) states that at a depth of about 100 feet from the surface in the Poorman mine a body of light ruby silver weighing some 500 pounds, showing partially the planes and angles of a crystal, was found. A portion of this mass was exhibited at the Paris Exposition of 1867 and was awarded a gold medal (31e: p. 159; 24b: p. 153).

In the few specimens examined, proustite appears to be intimately associated with pyrargyrite and polybasite, one or both. It was not found in the Flint district, where the ore contains pyra-
gyrite and miargyrite, but may be present. Shannon (31e: p. 151) reports it from the Henrietta mine in the De Lamar district.

**Polybasite.**—The silver sulphantimonide, polybasite (9Ag_2S_3Sb_2S_3), is one of the most abundant silver minerals of the Silver City district. It is either reported upon reliable authority as present in, or was found in ore from almost every important mine in the whole district. It is therefore probable that much of the silver produced in this district came from polybasite. Polybasite from the Silver City region appears to have a dark or a cherry red streak somewhat darker than pyrargyrite, and not the black streak attributed to it by the different textbooks on mineralogy. This fact caused some difficulty in determining the mineral. It occurs in two forms: massive and intergrown with pyrargyrite, miargyrite, stephanite and tetrahedrite, in the Flint district; and as crystals and tabular plates in fractures in ore and gange minerals. Shannon (31e: p. 171) gives drawings of and describes typical crystals of polybasite from one of the prospects in Rich Gulch on Florida mountain.

**Pyrargyrite.**—Another of the abundant and important silver minerals of the Silver City region is the “dark ruby silver,” pyrargyrite (3Ag_2S_3Sb_2S_3). It is probably the most widely distributed of any of the silver-bearing minerals of the district, and was found in ore from all the important mines. It occurs in two forms, massive and intergrown with the other silver-bearing minerals, except naumannite and argentite, and with jamesonite, and in well developed crystals in vugs and upon other minerals. Shannon (31e: pp. 155 and 157) presents drawings of some of the characteristic pyrargyrite crystals of the region.

**Pyrite.**—The common isometric iron sulphide (FeS_2), while not an important mineral in any of the mines, is present in varying amounts in all of them. In the ore bodies it appears as one of the earliest deposited minerals, and also as coatings on some of the younger minerals, and consequently one of the latest of all.

The pyrite itself, in the silver veins, carries little or no gold or silver—when a pyrite concentrate shows commercial amounts of silver or gold or both, microscopic examination always shows the usual gold-silver minerals.

Two other interesting occurrences of pyrite should be noted: In a “silicified” or siliceous vein at the end of the “K” vein crosscut, on the eighth level of the New Vein, Sommercamp section of De Lamar mine, and the Golden Cycle prospects on De Lamar Mountain west of the Chatauqua adit tunnel in a similar silicified zone or vein, there is heavy pyritic mineralization which apparently carries commercial amounts of the precious metals, principally silver; assays ranging from $19.00 to $30.00 per ton were obtained from selected ore from these places. Microscopic examination of the ores shows considerable supergene alteration of both rock and pyrite; the pyrite altered into a soft, black, finely granular, non-descript material. In addition there are here and there through the ore very small drusy cavities in which are minute crystals and specks of a black sectile mineral, either argentite or naumannite. It is therefore probable that in these deposits the pyrite is barren. The other deposit of the mineral is found in the De Lamar fault (“iron dike”) of the De Lamar mine proper, and in a wide zone of hydrothermally altered rhyolitic tuff on the sixteenth level of the same mine. In these places the fault gouge and the altered tuff respectively are heavily impregnated with pyrite in small crystals and masses. So far as material could be obtained for study, although it contains small amounts of gold and silver, it is certainly of no value as an ore. The relation of this pyritic mineralization to the veins and structure of the DeLamar mine is discussed on page 36.

**Pyrostilpnite.**—The silver sulphantimonide, pyrostilpnite, or “fire blende,” as it is called, has the same chemical composition as pyrargyrite but crystallizes in the monoclinic instead of the hexagonal system. Lindgren reports (24b: p. 169) that S. L. Penfield found pyrostilpnite associated with miargyrite in ore from the Henrietta mine.

**Silver.**—Much of the silver produced by the Silver City district, especially in the early days, came from native silver, or more properly electrum, since practically all the native silver is alloyed naturally with gold. Native silver other than as electrum was found in most of the mines, especially the TRADE Dollar-Black Jack and the De Lamar, but was not abundant. (See “Electrum.”) It is probably of supergene origin.

**Sphalerite.**—Zinc sulphide (ZnS), or sphalerite, popularly known as “zinc blende,” occurs as an accessory mineral in practically all the mines of the district, but not in sufficient quantity to be of any commercial value. For the most part, it occurs in grains and small masses generally more or less isolated from the other ore minerals, but occasionally intimately associated with them. The grains and
masses all show the characteristic dodecahedral cleavage, and in color range from nearly white or colorless, through light, to dark resinous. Its general relationship to the other ore minerals suggests that for the most part sphalerite was one of the early formed hypogene minerals.

Stephanite.—The black “antimonial silver,” or silver sulphantimonide, stephanite (5Ag₂S.Sb₂S₃), occurs in the high grade silver ores from the Flint district, intergrown with the other silver minerals, but probably only in small amount. It was not found in the ores available from Florida and War Eagle mountains, nor in those from De Lamar. This, however, must not be taken as evidence that it does not occur in these localities, for none of the important mines were operating at the time of the field study and little material was available for study.

Stibnite.—The antimony sulphide, stibnite (Sb₂S₅), was found in abundance in practically all the ores from the Flint district, where it occurs massive in the lower grade silver ores, and rarely in quartz-lined vugs in the form of blades and needles. Some of the ore from the Rising Star vein consists almost wholly of stibnite. About four miles north north-west from Silver City, in the head of a gulch that leads north and east into Sinker Creek, is a deposit of stibnite known as the Nugent antimony mine. The ore consists of bladder and massive stibnite in a pegmatitic phase of the Silver City granite.

Stromeyerite.—The silver-copper sulphide, stromeyerite (Ag₅Cu₃S), is reported by Shannon (31e: p. 106) as probably occurring as small grains in ore from the Rising Star vein in the Flint district. Grains, in reality small, well-formed crystals, the physical properties of which in so far as they could be determined from the small amount of material available appear to be similar to the grains which Shannon describes, were found by the writers in the high-grade silver ores from the same vein. There was not enough of the mineral for satisfactory determination, and until more is available the statement must be that the mineral is probably stromeyerite. It was not found elsewhere.

Tetrahedrite.—The copper-sulphantimonide, tetrahedrite (4Cu₃S.Sb₂S₅), is a common mineral in the ores of the Flint district where it is intergrown with jamesonite, pyrargyrite and other silver-bearing minerals. It was also found in ore reported to have come from the Trade Dollar mine. Although this mineral when pure has the composition stated above, it almost invariably carries other metals, such as iron, zinc, and silver. The tetrahedrite of the Silver City region all carries silver and has the dark cherry red streak characteristic of the silver-bearing variety of the mineral.

Xanthoconite.—The silver sulpharsenide, xanthoconite (3Ag₂S. As₂S₅), is reported by Browne (2b: p. 528) as being one of the silver minerals of the rich silver ore in the Flint district. It was not found in any of the material available to the writers.

Unidentified Ore Minerals.—Two silver-bearing minerals were found as minute crystals on corroded rich silver ore from the Flint district. They were found on pyrargyrite and polybasite, but may occur on other minerals. One of them nearly always shows tarnished faces, as though a film of chalcopyrite, covellite, or bornite, had been formed on the surface of the mineral. The coloration seems to be only a tarnish for the slightest scratch reveals an iron black mineral. The other mineral crystallizes in a different form, is softer, and shows no tarnish. Neither of these minerals was identified.

Gangue Minerals

The term “gangue” as here employed includes the non-metallic minerals, which commonly occur in and as a part of the vein-filling; it does not include either the country rock or its constituent minerals where such are present.

Barite.—Barium sulphate, barite (BaSO₄), is reported by both Lindgren (24b: p. 170) and Shannon (31e: p. 144) as occurring sparingly in the De Lamar mine. Shannon describes a small cavity lined with minute tabular crystals of barite. None of the mineral was found by the writers, who looked very carefully for it in such of the workings as were accessible; in the material on the various mine dumps, and in all the ores they examined. It is therefore believed to be very sparingly present.

Beidelite.—See leverrierite.

Calcite.—Calcium carbonate, calcite (CaCO₃), was found as a true gangue mineral in only three of the veins, the Poorman, the Never Sweat, and the Banner, and not abundantly in any of them. When it is realized that a very careful look-out was kept for it, it is certain that as a gangue mineral it is very rare in the district as a whole. In some of the epidotized rock and in more or less massive epidote, and in much of the altered basalt, especially in De Lamar mountain, it is more abundant, especially in some of the altered basalt penetrated by the Mill Tunnel (16th level) of the De Lamar
mine. In some places in this locality it appears that from 8 per cent to 10 per cent of the basalt consists of secondary calcite. This, of course, is in no way associated with the veins and ores.

The only specimen of calcite from the Poorman vein available for study was a piece of ore saved from the early day work. The mineral, in small "nail head" crystals coated one side of a small piece of ore, and it in turn was coated with drusy quartz crystals.

The calcite from the Banner vein is of the so-called cellular or argentine type, and occurs in rather large masses in "clay," probably leverrierite. This variety of the mineral is made up of plates tabular to the basal pinacoid (the basal plane) of the usual crystal and these plates intersect each other at various angles. In size they range up to an inch or more in diameter (Pl. V). The occurrence of this type of calcite as a gangue mineral is of much interest because a replacement of the material by quartz would produce the so-called pseudomorphous quartz, which is so prominent as a gangue mineral in the De Lamar mine, and in many of the veins in War Eagle mountain.

Chlorite.—The term "chlorite" is the name of a group of minerals rather than a single species. However, it is commonly applied to any one of the group. The chlorites are essentially hydrous silicates of iron, alumina, and magnesia. In both composition and structure they are related to the micas and indeed many of the group may be derived from black mica. They are also common alteration products of minerals of basic igneous rocks through the action of heated solutions. The chlorites of the Silver City region were probably formed through hydrothermal alterations of the more basic igneous rocks, for most part basalt. They are rather widely distributed through the ores in all the mines, especially the veins in the basalt, but nowhere in great abundance.

Epidote.—Epidote, a silicate of iron, lime, and alumina, is a common alteration product of igneous rocks, produced under thermal conditions at moderate to high temperatures. As such, the mineral is abundant in the walls of veins that occur in the more basic rocks. The same also applies to fragments of basic rocks which are in many instances included within the vein. Epidote also occurs in the form of green, pistachio green, or yellowish-green crystals in the usual quartz-feldspar gangue of the ores. It is more abundant in Florida and War Eagle mountains than elsewhere in the region.

Fluorite.—Fluorite, calcium fluoride (CaF₂), was not found by the writers. Shannon (31e: p. 176) reports the mineral from a tunnel in Long Gulch below the Blaine tunnel, and in ore from the east drift of the Silver City mine. Of this occurrence he says: "The specimen consists of a comb of quartz crystals bearing loosely attached large grains of pyrrhotite and some small irregular white grains of fluorite, which seems to be later in age than the pyrrhotite."

Graphite.—Graphite, or "black lead" as it is popularly called, was found in only one place in the region, in a small area of graphitic schist in the Flint district and in quartz stringers cutting this schist. It occurs in small flakes and that in the quartz was probably derived from the schist.

Leverrierite.—Shannon (31e: pp. 388-389) describes under the name of leverrierite a massive smooth gouge clay from the Black Jack vein, and states that it is simply a hydrous aluminum silicate (Al₂O₃·3SiO₂·5H₂O), in which miscellaneous bases, such as calcium, magnesium, potassium, etc., replace water. Material, which optical determinations and qualitative chemical tests indicate as similar, occurs plentifully in a number of the veins, especially those of the De Lamar mine, where it carries silver in the form of naumanniite, argentite, and pyrrhotite in minute veinlets and as disseminated specks, and is known as "silver tale" and "cab." Since the individuals which make up the mass of the "silver tale" are so minute that they are not well resolved, even by an oil immersion objective, its identification as leverrierite must not be regarded as final. Material, the identification of which as leverrierite is more satisfactory, occurs abundantly in open spaces, in many of the veins, especially in the Banner vein, where it forms a filling in which the cellular calcite occurs. Shannon states also (loc. cit.) that E. T. Wherry in a forthcoming (1926) paper has given the name beidellite to leverrierite.

Muscovite.—Muscovite, the white mica, cannot be regarded as a true gangue mineral. However, since it is found occasionally in the form of irregular blocks up to one-half inch in diameter in those veins which occur in the granite, it is included among the gangue minerals.

Quartz.—Quartz in one form or another is by far the dominant gangue mineral of the Silver City region. It is invariably present in all the veins, and with few, if any, exceptions is more abundant
A. PSEUDOMORPHIC QUARTZ FROM A BARREN VEIN NEAR WEST END OF DE LAMAR MOUNTAIN

B. SECONDARY QUARTZ FROM A BARREN VEIN NEAR WEST END OF DE LAMAR MOUNTAIN

The peculiar structure of this quartz suggests that it was deposited in shrinkage cracks in "dry"

A. DRUSY QUARTZ VEIN MATTER FROM GOLDEN CHARGOLO-BOE VEIN, WAR EAGLE MOUNTAIN

B. RETICULATED OR DENDRITIC NAUMANNITE ON DRUSY QUARTZ FROM BANNER MINE, FLORIDA MOUNTAIN
than all other gangue minerals combined. It occurs in four forms, chalcedonic quartz, or chalcedonite; massive milk-white, common vein quartz; in the form of crystals often perfectly terminated; and as the so-called pseudomorphic or cellular quartz. Neither form was found wholly separate from all the others, but usually, although two or more types may be present, one predominates.

Chalcedony, or chalcedonite, is a translucent or semi-translucent agate-like variety of quartz nearly always dense and flinty in texture, rarely it shows a tendency toward a fibrous structure. The color is generally light with a "watery" appearance, but occasionally may be dark or brown. In the veins and in the country rock adjoining them the chalcedonic quartz is the result of replacement of the wall rock probably during the period of mineralization. The material is common in most of the veins in granite or rhyolite. The pyritic vein at the end of the "K" crosscut, eighth level, De Lamar mine, is made up largely of chalcedonic silica heavily impregnated with pyrite. It is occasionally found in the Never Sweat and the Oro Fino veins.

Massive milky-white quartz makes up the veins in most of the mines and serves as host for the gold and silver minerals. Such massive quartz veins are characteristic of the Flint district. Here and there in such veins open irregular spaces occur, and in most instances these are lined with well-formed quartz crystals occasionally more than one-half inch in diameter and an inch to one and one-half inches long.

Crystallized quartz, as just stated, is found with ore minerals in cavities, or vugs, fissures, and in any open spaces in the massive quartz veins, and frequently, especially in War Eagle Mountain, coating the pseudomorphic or cellular quartz. The crystals in these localities show fine prismatic development and are, in some instances, perfectly terminated. In a few cases doubly terminated crystals occur in clay-filled cavities, apparently loose in the clay. The best crystals of this type were found in a fracture zone in the Rising Star vein, Flint district. Occasionally well formed quartz crystals occur as coatings on the feldspar valencianite, especially beautiful specimens of such coatings were obtained from the Alpine vein (Pl. VIII-B).

Pseudomorphic quartz or cellular quartz, such as described here as a gangue mineral, is peculiar to the Silver City region. It is the characteristic, in fact almost the only, gangue mineral of the De Lamar district, is abundant on War Eagle Mountain, but not abundant on Florida Mountain. The material occurs in thin, plates
from a fraction of an inch to more than two inches in diameter which intersect and join each other at various, but no predominating, angles in such a manner as to produce a cellular mass. The plates are not portions of a crystal, nor do they represent developments of quartz along cleavage planes of a previously existing mineral. No mineral could possibly be arranged in groups so that its cleavage planes could intersect each other in such a manner as do these plates. Microscopic study of the plates shows that they are made up of mosaic of crypto-crystalline quartz arranged along the sides of a median line which marks approximately the center of the plate. Against this line the grains are often slightly larger than those in other portions of the plate and are frequently set with the vertical axis of the crystal at right angles to the median line. Upon these as a base the general mosaic rests. Rarely the median position of the plate is marked by a narrow line of sericite or leverrite. In some cases the grains of the mosaic are arranged with their vertical axes for the most part parallel with the median line instead of at right angles to it. When this is true the grains of the layer are very much elongated in the vertical direction, giving them the appearance of thin plates. In some instances the surfaces of the cellular quartz is coated with small drusy quartz, and in others the surface appears to be smooth.

It is clear from the foregoing description that both the larger and the microscopic features of the plates all but positively preclude the assumption that the plates represent a primary or original deposition of quartz, and consequently make it almost necessary to assume that the plates are pseudomorphs of some previously existing mineral that was deposited in the form of cellular plates. What mineral? The cellular calcite in the Banner vein is an exact replica so far as outward form is concerned, of the cellular or pseudomorphic quartz. It is, therefore, believed that the cellular quartz is pseudomorphic after cellular calcite. The two are shown in Pl. V. The cellular quartz also is found abundantly as cementing material in a large outcrop of rhyolite breccia near the west end of De Lamar Mountain. It is also found in the interior of geode-like spherulites which occur abundantly along the top and south slope of De Lamar Mountain about midway between the Big Reef and the west end of the mountain.

Sericite.—Sericite, in that it is produced through hydrothermal alteration of many types of igneous rocks, is of considerable importance to the miner and the prospector, since it shows him the loca-
ties which have been the courses of mineralizing solutions. Sericite is a variety of muscovite that occurs in minute scales or flakes, often so exceedingly small that even the high powers of the microscope fail to resolve the individual particles. As generally seen the mineral looks like massive white clay—gouge clay in part (see leverrierite). Sericite is abundant in all the mines of the region. In veins and fissures it is plentiful in the form of a light-colored clay, and it abounds in the altered wall rocks adjoining fissures and veins, especially where the veins occur in the rhyolite or the granite.

Siderite.—The iron carbonate, siderite (FeCO₃), is present only sparingly in the veins of the Silver City region. The writers did not find it, and Shannon (31e) does not mention it as occurring in Owyhee County. However, Lindgren (24b: p. 168) says that massive siderite was found on quartz in the Owyhee mine, War Eagle Mountain.

Valencianite.—The name valencianite has been used by Lindgren (24b: p. 168) to designate a variety of orthoclase which occurs in white, or colorless, crystals as a gangue mineral in ore deposits. Although abundant in certain veins in Florida and War Eagle mountains respectively, and sparingly present in De Lamar veins, valencianite is indeed a rare mineral. The mode of occurrence of the mineral makes it certain that the mineral is deposited from solutions and not as true orthoclase which crystallizes from cooling magma.

Valencianite is abundant in apparently all the veins on Florida Mountain, regardless of the type of rock in which they occur. Beautiful examples were found in the veins in basalt. It occurs as well developed crystals, occasionally nearly an inch in diameter, as a coating on walls and on fragments of various kinds in the brecciated veins, and often contains inclusions of chalcopyrite, naumannite, argentite, and other ore minerals or is coated by them.

Vivianite.—The iron phosphate, vivianite (3FeO.P₂O₇·8H₂O), although not found by the writers, is reported by Shannon (31e: p. 429) as occurring in the Trade Dollar-Black Jack and other veins in Florida Mountain. It is said to occur in colorless to deep blue well developed crystals.

TEXTURE OF THE ORES

The term "texture of the ores" refers to the physical relationships between the component minerals, that is, the relationships between gangue minerals and ore minerals, between the different gangue minerals themselves, and between the different ore minerals themselves—in other words, to the way in which the ore is put together. Since the most important of the minute or detailed relationships are discussed under mineralogy, a summary statement is sufficient for this place. In general, the textures indicate that vein matter and ore minerals are roughly of contemporaneous age and that both are from the same source. The veins are continuously developed in the fissure, whereas the ore is confined to limited areas within the vein known as ore shoots. In these ore shoots, the gangue minerals and the ore minerals are so intimately and intricately associated that it seems impossible for them to have been deposited otherwise than contemporaneously. There were, however, some periods during which ore minerals were abundantly formed, and others in which they were sparingly formed, and, in the main, the maximum ore deposition appears to have occurred toward the close of a long continued period of general mineralization. The ore minerals as a whole are remarkably free from intimate mixtures and minute intergrowths, only two or three such intergrowths having been noted in an extensive and detailed microscopic study of many specimens of typical ores. In the massive quartz veins, the ore and gangue minerals are intergrown, but not intimately. In the vugs and open spaces in such veins the ore minerals, generally, are intergrown with each other, and occur in small masses. Often in such places single minerals such as pyrrargyrite, miargyrite, polybasite, and jamesonite, occur as well developed but small crystals. In some instances the ore minerals occur as coatings on gangue minerals in alternating bands, in a kind of crustification structure, whereas in others they are found between the interlocking quartz and valencianite crystals, in a kind of "comb quartz" structure. In cases of the second sort the ore masses are usually mixtures or intergrowths of two or more minerals. In the brecciated veins, the ore minerals, generally as intergrowths but rarely as individual crystals, occur as coatings surrounding to a greater or less extent the individual fragments of country rock. This is especially true of the deposits in the south end of Florida Mountain, where the breccia consists of fragments of basalt. In both types of the pseudomorphic quartz veins, the ore minerals are found upon, rarely within, the lamellar quartz.

The ore minerals most commonly found as contemporaneous intergrowths are jamesonite with tetrahedrite, polybasite and pyrrargyrite with polybasite; tetrahedrite with miargyrite; and naumanite with argentite. In some cases tetrahedrite occurs as a hypogene
replacement of stibnite, and possibly of jamesonite, whereas naun-mannite and argentite are found in similar relationships with galena, pyrite, chalcopyrite, and possibly jamesonite and tetrahedrite. Naumannite and argentite occur also as supergene-surficial replace-
ments of these same minerals, especially galena, pyrite, and chalco-
pyrite. It also appears that naumannite and argentite under certain conditions mutually replace each other. The textures, however, which develop during surficial alterations and supergene enrichment present no unusual features. They are discussed briefly in the para-
graphs dealing with supergene alterations.

GENESIS

According to modern theories of ore deposition, such ores as occur in the Silver City region come from sources deep within the earth and are brought into the rocks in which they are found by heated aqueous solutions, and furthermore it is believed that both ores and solutions are derived from medium to acid magma. Such magma, if cooled far below the surface of the earth and hence very slowly, forms granular igneous rocks, such as granites, granodiorites, and other types less silicious in character. Thus it is held that medium to acid intrusive magmas are the source of certain types of igneous rock and also of the metallic ores.

The gangue minerals of all the ores of the district are highly silicious, almost exclusively quartz and a peculiar variety of potash-bearing feldspar, valencianite. The veins occur in three types of rock, passing from one into the other with little or no change in composition. Two of the rocks are highly siliceous or acid, a granite and a rhyolite. The third is a decidedly basic rock, a basalt. The veins are thus clearly younger than the rock formations in which they occur and are not apparently related genetically to any of the host rocks.

The writers can see no way of connecting the Silver City ores genetically, with the Central Idaho granitic batholith to which so many ore deposits of the State are believed to be related. According to present concensus of opinion of geologists familiar with this great batholith, it is probably of late Cretaceous, or possibly early Eocene age, whereas the Silver City ores occur in rocks of probable Miocene age. The time interval therefore between the two events, the incoming of the batholith and the formation of the ore deposits, appears to the writers to be too great to connect the ores genetically with this batholith. Furthermore, the vein minerals, both gangue and ore, and their relationships are unlike those of mineral deposits related to the Central Idaho batholith but are similar in almost all respects to the rich silver and gold ores of the Tertiary volcanic rocks of Nevada. The writers, therefore, believe that these ores are related genetically to the Tertiary ores of the Great Basin region rather than to the Central Idaho batholith.

PERSISTENCE WITH DEPTH

The question whether or not the ores are deep and consequently persistent, or shallow and readily exhausted, or possibly already worked out, is of course the most vital economic point in the geology of the region. If the ores are of deep seated origin, and have the characteristics of persistent deposits, there is hope for a revival of mining and a “come-back” of the once famous camp of Silver City. If not, there is no hope. The subject is considered in some detail in the discussion of the origin and localization of ore shoots, p. 68, and to a certain extent in the descriptions of the individual districts, and in the pages devoted to the individual minerals. Hence a brief summary will be sufficient in this place. The veins are true fissure veins, developed in fissures produced by profound diastrophic forces, and are certain to extend to depths far below the possibility of mining. The vein fillings, both gangue and primary ore minerals, are those derived from deep-seated sources. They are in no way genetically related to the rocks in which they are found, and their composition is such as to all but prove a deep-seated source. We conclude, therefore, that the veins will probably extend to unknown but great depths.

There remains yet the question as to the richness of the primary or hypogene ores, and the influence of the secondary or supergene enrichment, upon the value of the ores. In other words, how much of the value of the ores as developed came from primary mineralization and how much from secondary enrichment? Unfortunately, the writers have not had as much access to the ore bodies as would be desirable in order to make quantitative answers to these pertinent queries. While the mines were in operation, a final answer could have been found by a careful study of the ores which were then available, but no such study was made and very little of the critical material was saved. However, through the kind cooperation of a few persons in the district who had saved specimens of the early-day ores, sufficient material was made available to the writers for the studies upon which dependable qualitative statements concerning the general effects of secondary enrichment can be made.
In general, it may be said that much of the silver in the bonanzas above the 300- or 400-foot level was probably the result of secondary or supergene enrichment, the secondary minerals being, for the most part, naumannite, argentite, and cerargyrite. The silver for the formation of these minerals was taken into solution in the upper portions of the veins and redeposited near and somewhat below the average level of ground water. The amount of silver thus added can be determined only approximately, but it is certain that exclusive of all of it, the remaining ore would have been of good grade. These statements must not be taken as precluding a similar enrichment in gold, in fact, there is some evidence in support of such enrichment, especially in the upper levels of the Florida Mountain veins, in which there was a relatively greater increase in gold than in silver content. This, however, may have been the result of primary deposition. The ratio between silver content and gold content is discussed in the description of the individual mines, and is shown on the longitudinal section of the Trade Dollar mine.

The ore minerals (except the horn silver and the argentite and naumannite which occur both as primary and secondary minerals) are all characteristic of deep-seated origin. Their relations to each other and to the gangue in which they occur are typically those of primary or hypogene ores. Hence the writers have no hesitancy in classifying them as deep-seated ores, and can see no reason why good workable material should not extend to great depths, probably deeper than the possibility of mining. In fact, they see many valid reasons to warrant the belief that deep development work may be undertaken with reasonable hope of success.

SURFICIAL ALTERATION AND ENRICHMENT

The ore deposits of the Silver City region show the usual results and effects of weathering. Their outcroppings and those portions near the surface have the oxidized and leached aspects common to all deposits of the metallic ores. However, since the region is mountainous and the topography rugged, erosion lags but little behind weathering, and thus the altered and enriched ores in most cases appear to extend only short distances below the surface. In many instances even the sulphides and selenides are found in the very outcrop. Of the material taken into solution during weathering—and under such conditions, all the minerals and metals of the ores are affected—some is dissipated, but much is carried downward in the vein and redeposited, thus enriching that portion of the ore shoot. This so-called secondary or supergene enrichment is probably responsible for most of the bonanza deposits in the upper portions of the veins—probably those within the upper 100 or 300 feet. The dominating or controlling factor in this process of supergene enrichment is probably the upper surface of permanent ground water, the enrichment extending neither far above nor very far below this surface. It, however, is by no means stationary but fluctuates with changes of rainfall, being higher when surface water is abundant, and lower when such water is scarce.

It is also influenced greatly by the topographic relief of the region and by the nature of the veins and the enclosing rocks. These fluctuations in the level of ground water produce many variations in the nature and the extent of the enrichment. An understanding of this should make it clear that although the enrichment varies greatly in extent and depth from place to place, it is, nevertheless, limited to the upper portions of the deposits, and rarely extends downward more than a few hundred feet.

Careful examination of such material as was available shows clearly that much of the best ore produced in all the important mines is in no way affected by secondary enrichment, and consequently the ore as originally deposited carried workable amounts of gold and silver probably not much below the averages shown by returns from the last several years of operations. These facts are shown, where available, in the discussions of the individual districts.

The silver-bearing minerals of importance in the Silver City region are pyrargyrite, polybasite, tetrahedrite, naumannite, argentite, electrum, native silver, proustite, miargyrite, and cerargyrite. Of these only the following are known to be formed by processes of supergene or surficial enrichment: argentite, cerargyrite, native silver, and naumannite. This last mineral was found for the first time in the Silver City ores as a supergene mineral. Of these few both naumannite and argentite occur also in important amounts as hypogene (deep-seated) or primary minerals. Detailed microscopic study of many specimens of naumannite from many localities shows clearly that by far the greater part of it is a primary mineral and not a product of secondary enrichment. This is also true, although to a much less extent, in the case of argentite. These studies have also shown that naumannite is probably ten times more abundant in the ores of the Silver City region than argentite. It must be borne in mind that only a few specimens of naumannite from the upper or bonanza portions of the ore shoots were available and that
these were in every case mixtures of naumannite and argentite, and probably of supergene origin. It, therefore, seems to be clear that secondary or surficial alterations were in large measure responsible for the great richness of the upper portions of the ore shoots. The facts as stated above also show that the primary or hypogene ore contains a great many silver-bearing minerals.

Someone may wonder how it is possible from laboratory and field study of ores to determine the extent of superficial enrichment. It may, therefore, be stated that the criteria for determining downward enrichment of ore deposits are well known and are as a rule easily recognized. Among them may be mentioned the presence of the products of oxidation such as iron staining, copper staining, alterations of the gangue minerals, and the occurrence of the secondary mineral in cracks, and as border rims around the primary mineral which it replaces. The primary minerals most readily and extensively replaced by silver minerals in this region are galena, chalcopyrite, and pyrite. The secondary minerals may also replace gangue minerals or be deposited upon them.

SUMMARY

By way of summary, it may be stated that the field and laboratory studies of the Silver City ores have shown: (1) that the exceedingly rich bonanza ores in the upper portions of the ore shoots were formed by the surficial enrichment of already rich primary bodies, and, (2) that the primary ores are from good to high-grade ores and that they may be expected to continue as good ores to depths much greater than any thus far reached in the district.

DESCRIPTIONS OF THE MINES AND PROSPECTS

The following descriptions of mines and prospects of the Silver City region is by no means a complete catalogue of mining properties. Inclusion among those described does not constitute a recommendation of a property; neither is omission in any sense a condemnation. Not every property could be searched in utmost detail in the all-too-brief period available for the field examination. Many have been idle for decades so that no change has taken place since they were described by Lindgren (24b: pp. 122-157), and still others show no relations of critical geologic importance. Complete description of all would therefore be idle. An endeavor has been made to describe those in which the fundamental geologic conditions of each district are best disclosed or may be most readily established, in order that the possibility of future revival of mining activity may be most expeditiously tested.

MINING PROPERTIES OF THE DE LAMAR DISTRICT

DE LAMAR MINE

Location.—The De Lamar mine is situated on Jordan Creek about nine miles west of Silver City and near the settlement of the same name. The property comprises 23 patented mining claims and 11 patented mill sites, with a total area of 376 acres. This group extends southward more than a mile from Jordan Creek across the crest of De Lamar Mountain (Pl. I).

Production.—The total recorded production of gold and silver is shown by the following table, which is based upon data taken from the annual reports of the mine manager (27) and from the report of an examining engineer (36). Unfortunately the returns from sales of high-grade shipping ore, whose value lies chiefly in its silver content, quote only the total cash value of the shipment, except for the records of the first two years of production. The content of precious metals in this shipping ore has been computed on the assumption that the ratio of gold to silver by weight that obtained during the two years for which detailed records are available, is applicable to the subsequent production. Obviously, this assumption is not sound, so that uncertainty exists in that part of the tabulation. However, the computed quantities do not differ greatly from the actual, and are a valuable index of that portion of the production.
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<td>19,031</td>
<td>357,307</td>
<td>35</td>
</tr>
<tr>
<td>1905-06</td>
<td>23,655</td>
<td>458,856</td>
<td>35</td>
</tr>
<tr>
<td>1907-08</td>
<td>10,657</td>
<td>39,085</td>
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</tr>
<tr>
<td>1909-10</td>
<td>5,739</td>
<td>16,307</td>
<td>35</td>
</tr>
<tr>
<td>1911-12</td>
<td>6,678</td>
<td>39,232</td>
<td>35</td>
</tr>
<tr>
<td>1913-14</td>
<td>7,122</td>
<td>181,115</td>
<td>35</td>
</tr>
<tr>
<td>Totals</td>
<td>401,065</td>
<td>4,443,586</td>
<td>1,497</td>
</tr>
</tbody>
</table>

* Shipping ore was produced only from the upper filling of the De Lamar fault ("Iron Dike"). The returns from 13 shipments made during the period 1888-1890 show an average ratio of gold to silver of 1:15 by weight. This ratio has been used as a basis for computing the subsequent production in ounces from the known values of the ore.

** Approximate estimate. A. M. Feis.

Throughout the entire period of activity, the amount of silver produced has exceeded that of the gold by weight, although not usually in value. As is shown by the table, the ratio of gold to silver is not constant throughout the period. The value of the silver has been as low as 10 per cent of the silver recovered as bullion, and as high as 17 per cent of the silver recovered as metal. In 1899, the ore was treated by cyanidation, and from 1902 to 1912, the ore was treated by other processes. The average value of silver produced during the period has been approximately $125 per ounce.
Until 1906, No. 8 tunnel served as the main working level, with boiler plant at the portal, a large underground hoist station, and a gravity tramway for transporting ore from the portal to the mill on Jordan Creek. In 1906, however, the No. 16 tunnel was connected to the upper workings by a raise and ore chutes, so that this lowest level became the main working entry. All future exploration and mining should be carried on through this lowest entry, inasmuch as its use will minimize problems of ventilation, drainage and transportation.

The surface plant includes a 100-ton mill building on Jordan Creek, office and manager's residence, hotel building, boarding house, machine shop, electric sub-station, and miscellaneous storage sheds and warehouses, all in a fair state of repair. A large part of the mining and milling equipment with salvage value has been removed from the property, so that virtually complete re-furnishing must be carried out before operations could be resumed.

**History of Mining Development.**—The Wilson and the Wahl claims, the nucleus about which the De Lamar property was to grow, were located in 1874 and worked in a desultory manner for the gold content of their ores until 1886. In that year these claims and others were acquired by Captain J. R. De Lamar and a group of associates, and a program of intensive development inaugurated. In 1888 Capt. De Lamar acquired sole possession, drove the No. 4 (Voschay) tunnel (Pl. X), disclosed the large ore-body of the Seventy-seven vein (so named from its reputed width of 77 feet where first penetrated), erected a 20-stamp mill on Jordan Creek, connected it to the mine by a gravity tramway, and commenced active mining. In 1890 the Sommercamp group of claims, which adjoined the original or 'old' mine on the west, was purchased, and the Voschay and Sommercamp tunnels were connected by the old Sommercamp crosscut (Pl. X). This crosscut was driven its entire length in or near the clayey filling of the Sommercamp fault (one of the 'iron dikes') and failed to disclose any ore bodies.

In 1891, after it had produced $819,427 in gold and silver, the property was sold to the De Lamar Mining Company, Ltd., of London. The following discussion of the history of the De Lamar mine is gleaned from the very full annual reports of this company (28b, 19b, 27). Under the management of Capt. J. W. Plummer vigorous prospecting was carried on and the annual production was raised to nearly $1,000,000, the highest output being attained in 1893-4. The No. 8 (Wahl) adit was started in 1892 and the following year the entire vein system of the old mine was developed on that level (Pl. XI). Each of the several veins was prospected to its termination against the De Lamar fault (‘iron dike’) and the ore bodies were followed along their low-angle pitch. In 1893 and 1894, No. 2 inclined shaft was sunk from No. 8 level to No. 10, and during 1894 and 1895 the veins were explored on the ninth and tenth levels to their termini against the De Lamar fault. At the same time the new Sommercamp crosscut was driven on No. 4 level (Pl. X) and the veins of the Sommercamp series were found, but were not considered workable at that time. During 1896, the veins were being stope on all levels down to the tenth, and plans were formulated for deeper prospecting. These plans included sinking a new shaft, No. 3, in the country rock from No. 8 level to replace No. 2 shaft, which had been sunk along the Seventy-seven vein and required frequent re-timbering in the soft ground. The death of Capt. Plummer, however, prevented his carrying these plans to completion.

In 1896 D. R. Huntley became manager and undertook to complete the exploratory projects of his predecessor. No. 3 incline was started, and, by 1899, had been sunk to the fourteenth level and the Seventy-seven vein explored on the twelfth and fourteenth levels southeastward to what was supposed to be the ‘iron dike’ or De Lamar fault (Pls. X and XI); no workable ore was found. In 1900 these levels were abandoned, although the conclusion had been reached in 1897 that the ‘De Lamar mine once contained large, rich and continuous ore bodies from near the surface to about the tenth level. Then a barren zone has been encountered, although the veins continue of good size and seemingly identical in general characteristics with those parts nearer the surface’ (13b). In 1897, it was thought that the ‘iron dike’ might be a post-mineral fault, and that an extension of the ore bodies might be found to the southward. The ‘iron dike crosscut’ (Pl. XI) was driven on No. 8 level but was suspended at 281 feet in 1898 after this conclusion had been reversed. A crosscut was also started on this level in 1897 to the Sommercamp section, but the veins were not explored. No. 16 tunnel was opened from Jordan Creek in 1900 and by 1901 had been driven 3,417 feet, with a 1,059-foot drift to the west under the Sommercamp ground, and an eastward drift of 895 feet (Pl. XII). No veins were encountered in the west drift, and the barren Seventy-seven vein was just reached by the east drift. The conclusion was drawn in 1901 that the 'barren
zone' extended 400 feet below the old ore bodies and that the active life of the mine was measured by months.

The development work of the period 1897-1901 failed to disclose new ore bodies, but it had not recognized the fundamental relation between the low-angle De Lamar fault (‘iron dike’), the veins, and the low-angle pitch of the ore shoots in the veins. Later paragraphs will develop this relation in detail, so that it suffices to state here that the De Lamar fault was not exposed by any of the development below the tenth level, and that both the twelfth and fourteenth levels, although driven along the Seventy-seven vein, were driven west of the projected position of the easterly-pitching ore shoots which had been mined down to the tenth level prior to 1897. Moreover, the prospecting below the tenth level was confined to the Seventy-seven vein which, although the widest and most persistent of the system, was at the same time characterized by the most erratic occurrence of ore bodies.

In July, 1901, the company was reorganized as the De Lamar Company, Ltd., with a reduced capital of £80,000 (approximately $400,000). E. V. Orford was appointed manager, with instructions to exhaust the known ore bodies and bring the enterprise to a close. Even under these instructions, however, the mine was to continue operation until 1914. In 1902 the east drift on No. 16 level was extended to a total length of 986 feet. short crosscuts were driven north and south, and diamond drilling was resorted to for further search for ore bodies (Pl. XII). None were found. In 1906 a raise was driven from No. 16 east drift to No. 14 level and No. 3 incline was re-opened for ore chutes and manway so that No. 16 adit could be used as the working entry. Until 1909, however, all mining was above the eighth level, the ore supply being derived from medium-grade stope filling and small bands and seams which had been left during the earlier years. In the period 1909-1911 some ore was extracted on the ninth and tenth levels, 24,852 tons, or more than half the total output, coming from these levels in 1911. In this same year No. 11 level was opened and prospected and in 1912 a small tonnage of ore was mined on this level and No. 12 near the eastern end of the working. The so-called ‘iron dike’ on No. 12 level was not penetrated, however, and prospecting was not extended eastward. Exploration of the Sommercamp section on No. 4 level (Pl. X) was inaugurated in 1906 and the veins, which had not been found in the ‘B-J’ crosscut driven years before, were opened to the limit of the ore bodies. In 1909 and 1910, No. 2 Sommercamp adit (Pl. I, No. 21) was driven to the veins, and mining in this section was carried down to the sixth level. In 1913 and 1914 the veins were partially explored on No. 8 level and, although ore was disclosed, development was not completed because of lack of profitable ground elsewhere in the mine to carry the cost of prospecting. Further discoveries of ore were also made on No. 4 level in the section of the mine. These discoveries are discussed further in a later paragraph. In 1912 the Stoddard section, which lies east of the old mine, was opened on the fourth level, and veins Nos. 1, 2 and 3 were explored (Pl. X). Very little workable ore was found. In 1914, after the known ore reserves of the old mine had been exhausted, the mine and mill were closed down, and in 1916 the property was sold for the reputed price of $10,000.

In May, 1919, the property was acquired under lease and bond to purchase by the De Lamar Company, a Maryland corporation, and prospecting and development was begun in the Sommercamp section on No. 8 level. In September of the same year the option was allowed to lapse and was taken over by the De Lamar Mining and Milling Company, an organization of a portion of the stockholders of the De Lamar Company, and operations were continued under the management of H. H. Bonnell of Silver City. In 1920, however, the enterprise collapsed before the exploratory program had been completed. Since that time the property has lain idle. At the present time it is owned by Messrs. W. R. Helm and J. B. Duncan of Jordan Valley, Oregon, and Mrs. Esther Bennett of Boise, Idaho.

Milling Operations.—During the early operations at De Lamar the ores were treated by pan amalgamation and the tailings were flumed down Jordan Creek and ponded just below the site of Wagontown. In 1896, the Pelatian-Clerici cyanide process was attempted in a 50-ton unit and operated experimentally for nearly a year. It failed to give complete satisfaction, and in 1898 it and the pan amalgamation process were replaced by a cyanide leaching plant of 100 to 150 tons daily capacity. At first the attempt was made to leach material that had been crushed only to three-quarter inch size, and for several years the coarse sand leaching tanks acted on feed of half-inch size. During the closing years of the mine's activity, however, finer crushing was practiced and steadily improved recoveries were effected as a result of the better control that was maintained over the milling cycle. In 1898 a 200-ton cyanide leaching plant was constructed at Wagontown and some 60,000 tons of
accumulated tailings were treated with profit. The plant was
cleaned up and closed down in October, 1901. The following table
summarizes the recoveries obtained during the life of the De Lamar
enterprise:

**Summary of mining and milling operations at the De Lamar mine**
(Data from annual reports of the mine managers of the De Lamar Mining Co.,
and of the De Lamar Co., Ltd.)

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Tons Milled</th>
<th>Cost Per Ton</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mining</td>
<td>Milling</td>
</tr>
<tr>
<td></td>
<td>Gold Oz</td>
<td>Silver Oz.</td>
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<tr>
<td>1891-1892</td>
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<tr>
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<tr>
<td>1893-1894</td>
<td>35,053</td>
<td>5.93</td>
</tr>
<tr>
<td>1894-1895</td>
<td>40,603</td>
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<td>1895-1896</td>
<td>41,117</td>
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<td>1896-1897</td>
<td>40,483</td>
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<td>1906-1907</td>
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<td>1912-1913</td>
<td>45,220</td>
<td>4.31</td>
</tr>
<tr>
<td>1913-1914</td>
<td>Little</td>
<td></td>
</tr>
<tr>
<td>Totals and Averages</td>
<td>787,590</td>
<td>$82.27</td>
</tr>
</tbody>
</table>

**Country Rock.**—The veins developed in the De Lamar mine are
enclosed wholly by rhyolite, mostly of the banded porphyritic type
which has been described elsewhere. In the east drift from No. 16
adit the Seventy-seven vein is bounded at one wall by rhyolitic
tuff or agglomerate, and it is probable that further development
will reveal more of this rock. So small a portion of the mine is
accessible that it has not been possible to establish any relation
between types of wall rock and the intensity of metallization,
although some relation probably exists. The rhyolites throughout
the mine have been intensely sericitized by the mineralizing agents
and strongly silicified along the veins in accord with the preceding
discussion of hydrothermal alteration. Weathering has reduced the
sericitized rhyolite at the surface to a fine debris of chalky white
fragments and fine clayey soil, and has probably kaolinized the
rocks throughout the inaccessible upper workings.

The rhyolite throughout the region is underlain by basalt and
that rock in turn by granite, although neither has been found enclosing
the lodes. The mill level adit, No. 16, penetrates basalt as far
as the Chatauqua fault, a distance of 2,960 feet, but none of the
other workings, so far as is known, disclose this rock. Prospecting
below the sixteenth level, if undertaken, may encounter basalt or
granite, or both, but the lack of precise knowledge of the succession
and thickness of the rhyolite flows makes it impossible to analyze
structural conditions in sufficient detail to predict the depth at
which these rocks may be found. Elsewhere in the region, as at
Florida Mountain, the productive veins continue down through
basalt into granite, and there is no reason to expect a different
condition at De Lamar.

**Structural Features.**—It appears to the writers that the struc-
tural problems of the De Lamar mine have not received the attention
which their importance justifies, and that much of the develop-
ment work was based upon the erroneous assumption of pre-mineral
faulting. In the western section of the old mine, however, some of
the ore bodies of the Seventy-seven, No. 5 and No. 9 veins were
"cut off by slides" (19b, 27) on the fourth, fifth, and sixth levels.
Apparently none of these were regarded as post-mineral and not
one was ever solved. Unfortunately this ground was inaccessible
in 1925, and the descriptions given in the mine managers' reports
do not permit plotting the fracture, even approximately, on the
plans of the various levels. Undoubtedly other "breaks" were en-
countered in the course of mining development. Clearly, structural
problems exist, and their correct analysis and solution is essential
to any further exploitation of the mine.

Most important of the structural features of the mine is the
'iron dike,' long considered as pre-mineral, but shown by the pre-
ceding discussion of the geologic structure to be far more probably
a fault of post-mineral age. Its importance in the past arose from
the fact that the known ore bodies occurred in a relatively narrow
zone immediately north of it; its importance in the future springs
from the possibility of finding the southward extension of the veins
beyond it.
What appear to the writers as serious misconceptions of the nature of the 'dike' have existed in the past, some of which have been already discussed. There has been a tendency to regard it as one fracture, rather than as a system of several fractures. This in turn seems to have led naturally to dubious and in some cases obviously erroneous correlations, made on the basis of similarity of the appearance of the 'dike' filling, rather than by projection of a known strike and dip from one occurrence to another. The same erroneous tendency has led also to assumptions of exaggerated thicknesses of 'dike' material. Over-emphasis of green color, clayey texture, and presence of pyrite as diagnostic characteristics appears also to have over-shadowed the probability that these characteristics, which have been shown to be the result of hydrothermal alteration alone, are local rather than general, and that the fracture may just as well be represented by a wide zone of distributed slicing, or by a single narrow band of attrition gouge, not accentuated by alteration.

The 'iron dike' of the old mine, the De Lamar fault, has been plotted on plans of the separate levels as accurately as possible from the descriptions available in the mine managers' reports (28b, 19b, 27). From these data it would appear that the average strike is N. 75° W., and that the average dip, from the fourth to the tenth levels of the mine, is 27° 10' S. The maximum departure of the dip from level to level is but four degrees from the average. Undulations in both strike and dip almost certainly exist, but the available information points to unusually close approach to a true plane. Correlation of this fracture with that penetrated by the southern block of the Henrietta fault; the veins of the Sommercamp group lying in the hanging wall block of that fracture; and the Cash vein (Pl. I, No. 24) has been interpreted as the hanging wall (27: 1914) of the Sommercamp fault. Careful mapping, however, indicates that it is a surface cropping of the Henrietta fault, a fracture parallel to the De Lamar fault, shown on the geologic map (Pl. I) as well as on the plan of the fourth level (Pl. X).

The short-lived attempts that have been made to penetrate the 'iron dike' in the search for a possible southward continuation of the vein system have established neither its presence nor its absence. It has been shown by an earlier paragraph that veins do occur south of the De Lamar fault, the veins of the Sommercamp group lying in the hanging-wall block of that fracture; the 'M' vein (Pl. X) in the hanging wall block of the Henrietta fault; and the Cash vein (Pl. I, No. 25) in the upper block of the Henrietta fault. The Zulu tunnel, which lies about 800 feet southeast of No. 4 Sommercamp adit (Pl. I, No. 24), has also produced pay ore from the south block of the Henrietta fault. The southern block of the De Lamar fault, it has been shown, has been displaced downward and eastward, the vertical component being unknown, but probably several hundred feet, and the longitudinal component being perhaps 1,200 feet. The continuation of the old mine vein system is, therefore, to be sought in the direction outlined. The direction of displacement along the Sommercamp fault as shown by the geological plans (Pls. X, XI, and XII) has been predicted from a theoretical shaft station lies exactly on the upward projection of a secondary fracture observed on the sixteenth level (Pls. X and XII). It is possible that the "hanging wall formation" encountered is the altered greenish breccia of the sixteenth level, which breccia bears no known relation to the De Lamar fault. If these are the true relations, a large block of unprospected ground north of the fault, as well as the block which lies to the south, become zones of potential ore reserves.

The 'iron dike' of the western portion of the mine, the Sommercamp fault, has been classified as a complementary shear fracture. Its average strike is approximately N. 57° E. and its dip, from the second to the eighth level, is 26° 40' SE. Its projected trace on the sixteenth level is shown by the plan (Pl. XII). As in the case of the De Lamar fault, the block which lies to the southeast becomes a zone of potential ore reserves in which the extension of the Sommercamp veins may be expected.

Another 'iron dike,' disclosed by surface trenching northwest of No. 4 Sommercamp adit (Pl. I, No. 24) has been interpreted as the hanging wall (27: 1914) of the Sommercamp fault. Careful mapping, however, indicates that it is a surface cropping of the Henrietta fault, a fracture parallel to the De Lamar fault, shown on the geologic map (Pl. I) as well as on the plan of the fourth level (Pl. X).

The short-lived attempts that have been made to penetrate the 'iron dike' in the search for a possible southward continuation of the vein system have established neither its presence nor its absence. It has been shown by an earlier paragraph that veins do occur south of the De Lamar fault, the veins of the Sommercamp group lying in the hanging-wall block of that fracture; the 'M' vein (Pl. X) in the hanging wall block of the Henrietta fault; and the Cash vein (Pl. I, No. 25) in the upper block of the Henrietta fault. The Zulu tunnel, which lies about 800 feet southeast of No. 4 Sommercamp adit (Pl. I, No. 24), has also produced pay ore from the south block of the Henrietta fault. The southern block of the De Lamar fault, it has been shown, has been displaced downward and eastward, the vertical component being unknown, but probably several hundred feet, and the longitudinal component being perhaps 1,200 feet. The continuation of the old mine vein system is, therefore, to be sought in the direction outlined. The direction of displacement along the Sommercamp fault as shown by the geological plans (Pls. X, XI, and XII) has been predicted from a theoretical
The solution of this major fault problem is essential, but that presented by the secondary displacements which undoubtedly occur is quite as important and may be even more baffling to one engaged in underground exploration. Unfortunately it was not possible to ascertain the relation of such secondary fractures to the ore deposit, because of the inaccessibility of most of the mine. The fractures disclosed by the east drift, sixteenth level, are undoubtedly of this class, but the system should be studied on other levels and over a wider area before trustworthy rules can be formulated for the guidance of mining development.

A necessary part of a program for the further development of the De Lamar mine, a part which should precede any extensive underground activity, is a most thorough and detailed geologic examination. Critical portions of the mine workings which are now inaccessible should be temporarily re-opened to permit a study of both the major and minor fractures of the ‘iron dike’ system, at least on the eighth level and those below. This should be correlated with surface features, which should be mapped on a relatively large scale over a considerable area about the property. If such a study is executed by competent hands and subsequent development guided thereby, there is reason to believe that the complete solution of the system of displacements, both major and minor, will be attainable and that structural features will offer only a temporary hindrance to the program.

Vein System.—The De Lamar mine has developed two groups of veins, known respectively as the ‘old mine’ system and the Sommercamp system. Neither of these can be satisfactorily traced at the surface on account of the deep mantle of fine debris which results from the weathering of the intensely sericitized rhyolite. Here and there a definite cropping may be traced for a short distance, but usually only a suggestion of one can be read from an abundance of fragments of quartz and of silicified rhyolite in the debris. In other instances surface recognition of a vein is impossible. These conditions materially hindered the early development of the district, and make deep trenching necessary in most surface exploration.

The veins of the old mine group are formed in a zone of intersection between two fracture sets which are represented by the Seventy-seven vein on the one hand, and the Hamilton-Wilson and No. 9 veins on the other (Pls. X and XI). Accompanying these principal veins and interlinked with them, in part, are the Voschay, No. 5, No. 6, No. 7, No. 8 and No. 10 veins, and many small stringers and fingers of vein matter. One merges with another, in both the horizontal and vertical planes, so that in many cases it is difficult to trace a given vein from level to level of the mine. Many an ill-advised program of development has resulted from overstressing the continuity of a single vein, and failing to recognize the whole as a system of interlinked fissures. The plats of the various levels (Pls. X, XI and XII) show the data of width and precious metal content that it has been possible to glean from the mine managers’ annual reports (28b, 19b, 27). The Seventy-seven vein has an average strike of N. 62° W., the Hamilton and No. 9 veins of N. 25° W. Above the sixth level the veins dip 25° to 55° SW., but in the lower levels of the mine they steepen, the principal veins dipping 65°-80°. Very probably the lesser inclination on the upper levels is an effect of the distortion produced by the low-angle De Lamar fault. In the eastern part of the mine, most of the veins are individual-filled fissures with sharply marked walls, but where the veins are widest the walls become rather indefinite and the vein grades into silicified rhyolite. In the western part of the mine, however, in what is known as the “banded country” the wider veins are but silicified shear-zones with several stringers of quartz separated by bands of altered rhyolite.

The Sommercamp group includes 10 interlinked veins which lie about 800 feet west and south of the old mine group (Pl. X), and which strike N. 18° W. and dip 65-80° W. These veins are designated as the B, C, D, F, G, H, H-I, J, and K veins respectively, the J vein having been formerly known as the St. Clair. These veins show from 12 to 30 inches of ore where they are penetrated by the Sommercamp crosscut, but pinch out northward, so that only the B and J veins were found in the B-J crosscut, driven parallel to the Sommercamp fault and 350 feet north of it. Another vein, the ‘L’ vein, is exposed by a short drift just north of the Sommercamp fault on the fourth level and dips 70° E. The ‘K’ crosscut, driven westward from the drift on the K vein on the fourth level, intersects a 10-foot vein which dips 65° E. at a distance of 65 feet and reaches another vein about 25 feet further west. The first of these is probably the ‘Idaho footwall’ vein, which is developed near the surface; both will be referred to later
as probable ore reserves. Other veins in the Sommercamp section of the mine, which are not included in the above group, are the M vein (formerly the Crown Prince and Bismarkc) and the Idaho vein. The M vein lies in the hanging wall block of the Henrietta fault near the portal of No. 4 Sommercamp adit and dips 70° NE. The Idaho vein, which has produced a large amount of ore near the surface, is intersected by the west crosscut from the J vein, but is not developed. On the eighth level (Pl. XI) the “New” vein is intersected by a crosscut driven westward from the H-I drift. This vein, projected upward, passed through the ‘L’ vein, fourth level, and it is possible that the two are the same.

Ores.—The gangue minerals are two: cellular or lamellar pseudomorphous quartz, which has already been described, and a plastic white sericite derived by intense hydrothermal alteration of the rhyolite. Some of the sericitic material has been shown by Shannon (31d) to be the rare hydrous silicate beidellite (leverrierite). In the veins of the old mine, the lamellar quartz is soft and easily crushed and in many places is shattered into small platy fragments known to the miners as ‘sugar quartz.’ Irregular disconnected masses and stringers of the sericite or ‘talc’ may follow one or the other of the walls or may occur within the quartz filling. In the veins of the Sommercamp section on the levels above the sixth, the deposition of silica continued after the formation of the skeletal cellular pseudomorph and knit the vein filling into a rather dense mass. On the eighth level, however, the same veins display the soft quartz and ‘talc’ which occurs in the old mine. Lindgren (24b: p. 127) notes that the Seventy-seven vein, in the upper portion of the mine, is made up of streaks of quartz half an inch to four inches wide, separated by reddish clay. It is likely that this reddish clay is sericite or beidellite stained by the oxidation of iron-bearing surface waters.

The metallic minerals are not usually visible to the unaided eye. The supergene or secondary minerals identified in the material available for study in 1925 are: native gold, native silver, argentite, naumannite (?), cerargyrite, and marcassin. The latter mineral, however, may be wholly primary. The hypogene or primary species are: native gold, the native gold-silver alloy electrum, argentite (?), naumannite, miargyrite, pyrargyrite, proustite, jamesonite, polybasite, pyrite, and marcassin. It is noteworthy that in the specimens available, the sectile silver mineral which has been considered to be the sulphide argentite is not argentite, but rather the selenide naumannite or an intergrowth of argentite and naumannite in which the latter predominates. The usual ore, according to Lindgren (24b: p. 128) consists of finely divided native gold accompanied by less than one per cent of pyrite and the rich silver minerals. The clayey sericite or ‘talc’ is readily replaced by the silver minerals and may contain them in abundance; gold on the other hand, is not usually plentiful therein.

Above the fourth level the ores are oxidized, and it is very probable that the wide bodies of silver ore that were mined from the Seventy-seven vein in the early years of the mine’s activity are due, in part at least, to supergene secondary enrichment. The depth to which this process has been active can not be told in the absence of specimens whose original position in the mine is known. In the specimens available for study, the supergene minerals are not abundant; in many of them all evidence of secondary processes is lacking. It is probable, therefore, that the lower levels of the mine are below the zone of surficial enrichment and that the ores therefrom are strictly hypogene. There is no reason to think that these ores will fail to continue downward. The following table is annexed to show the variation in precious metal content of ores from the various levels of the mine. It is worthy of note that the ore from the deepest levels has quite as large a content of gold and silver as that from the upper levels, with the exception of the wide

<table>
<thead>
<tr>
<th>Year or Period</th>
<th>Width</th>
<th>Ozs. Gold</th>
<th>Ozs. Silver</th>
</tr>
</thead>
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<tr>
<td>1898-1900</td>
<td>3-2</td>
<td>0.31</td>
<td>1.3</td>
</tr>
<tr>
<td>1904</td>
<td>4-5</td>
<td>0.56</td>
<td>1.4</td>
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<tr>
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<td>4-2</td>
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<td>0.4</td>
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<td>9-0</td>
<td>0.60</td>
<td>18.0</td>
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<tr>
<td>1910-1912</td>
<td>4-1</td>
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<td>2.1</td>
</tr>
<tr>
<td>1910-1908</td>
<td>1-6</td>
<td>0.98</td>
<td>3.9</td>
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<td>50.5</td>
</tr>
<tr>
<td>1998-1902</td>
<td>3-7</td>
<td>0.51</td>
<td>1.7</td>
</tr>
<tr>
<td>1908</td>
<td>2-2</td>
<td>0.58</td>
<td>0.1</td>
</tr>
<tr>
<td>1900-1901</td>
<td>3-5</td>
<td>0.62</td>
<td>3.3</td>
</tr>
<tr>
<td>1900-1901</td>
<td>4-3</td>
<td>0.39</td>
<td>2.5</td>
</tr>
<tr>
<td>1989-1900</td>
<td>2-9</td>
<td>0.52</td>
<td>2.7</td>
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Approximate average character of ore stoped on the Seventy-seven and No. 9 Veins, De Lamar mine
(Data from Annual Reports of the De Lamar Company, Ltd.)
bodies of silver ore extracted from the Seventy-seven vein prior to 1894. The ore mined subsequently from that vein on the same levels is from narrower bands of ore that were left standing during the early operation.

### No. 9 Vein

<table>
<thead>
<tr>
<th>Level</th>
<th>Year or Period</th>
<th>Width</th>
<th>Ozs. Gold</th>
<th>Ozs. Silver</th>
</tr>
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<td>3-4</td>
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<td>3-8</td>
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<tr>
<td>7</td>
<td>1900-1904</td>
<td>1-0</td>
<td>1.00</td>
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</tr>
<tr>
<td>7</td>
<td>1895-1896</td>
<td>5-0</td>
<td>1.14</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>1900</td>
<td>3-0</td>
<td>0.53</td>
<td>4.6</td>
</tr>
<tr>
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<td>1-9</td>
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<tr>
<td>8</td>
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<td>1.14</td>
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<td>1899</td>
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<td>1895-1896</td>
<td>3-0</td>
<td>1.10</td>
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</tr>
<tr>
<td>9</td>
<td>1896</td>
<td>3-0</td>
<td>1.13</td>
<td>7.6</td>
</tr>
</tbody>
</table>

The ore from the New vein, eighth level Sommercamp section (Pl. XI), and the vein at the face of the K crosscut on the fourth level, differs from any disclosed elsewhere in the mine in that a large quantity of pyrite accompanies the usual silver minerals and that gold is not plentiful. It is possible that the silver minerals therein are the result of secondary enrichment and that the character of the ore might change with depth.

In some of the quartz stopes, particularly in the Hamilton and Wilson veins near their termini against the De Lamar fault, local bunches and seams of 'talc,' from one to 20 inches wide, carry a very high content of silver minerals. These 'silver talc' ores, which have been described on a preceding page, yielded a considerable tonnage of shipping grade.

Extremely rich silver ores, in which the gold content was very slight, were found along the footwall of the De Lamar fault ('iron dike') in the zone of the Seventy-seven, Hamilton, and Wilson veins and from the fourth to the seventh levels in depth. Some of these bodies of high grade ore are shown on the plan of the fourth level (Pl. X). This ore is described (28b: 1892) as small specks, 'shot,' and 'nuggets' of argentite (naumannite?) associated with 'talc.' Unfortunately no known specimens from this zone were available for study, and the ground is inaccessible. The description, however, suggests that the material is the result of drag, along the plane of the fault, although the subsequent circulation of hydrothermal agents, or deep percolation of surface solutions, may have
greatly modified its original character. This was the source of much of the high-grade 'shipping ore,' which averaged $500 per ton in value. In the late years of the mine's activity the 'clay lining' of the De Lamar fault ('iron dike') yielded a considerable tonnage of $35 silver ore from the third and fourth levels. In this material, known to the miners as 'cab,' the silver minerals were too finely disseminated to be visible to the eye except from an aggregate coloration. No known specimens were available for study and the precise mode of occurrence is unknown.

Ore Shoots.—Stope maps or longitudinal sections of the veins of the De Lamar and Sommercamp groups were never kept systematically, so that accurate knowledge of the shape and distribution of ore shoots is not available. It may be said, that in general these shoots pitch 20° to 30° eastward in the veins, and that they were nearly continuous within zones a few hundred feet wide immediately beneath the De Lamar and Sommercamp faults respectively. It has been brought out in the discussion of regional structure that both the ore bodies and the 'iron dike' faults are parallel to a set of secondary crustal fractures. Hence they are parallel to each other by coincidence. Too much stress has been laid on the average width of the zone of ore shoots and too little on its lack of regularity. Its greatest width is on the fourth level (Pl. X), and it decreases both upward and downward. On that level the Seventy-seven vein encloses three ore bodies, of which the most distant is 900 feet from the De Lamar fault, measured horizontally. The Wilson, Hamilton, No. 5, and No. 9 veins show ore bodies which are 265, 415, 485, and 450 feet long respectively. For the greater part of the mine, however, the zone of ore shoots is from 200 to 400 feet wide for the De Lamar veins, and averages 180 feet for the Sommercamp section. Apparent failure to recognize the flat pitch of the ore shoots and to project it accurately from level to level seems to have been responsible for the failure of many development projects, particularly the exploration below the tenth level. It is suggested that the regular practice in searching for ore bodies on a new level should be to crosscut the vein system parallel to the 'iron dike' and not more than 100 feet from it, in order that short veins may not be missed, and that all should be opened at the center of the zone of ore shoots.

Ore Reserves.—Only a relatively small tonnage of probable ore is known in the De Lamar mine, and that in the Sommercamp section. The 'New' vein, which has been opened for 80 feet on the
eighth level (Pl. XI), may with some uncertainty be correlated with the 'Idaho footwall' vein above the second level and with the veins opened by the K crosscut, fourth level. In 1920, since which time no work has been done on the vein, Gwinn (18) estimated that it would yield above the eighth level 31,800 tons of ore with an average width of 6.8 feet, and an average content of 0.025 ounces of gold and 11.4 ounces silver per ton. In the Sommervamp section, eighth level (Pl. XI), the 'Silver Talc' vein has been opened for 125 feet from the H-I crosscut, the last 50 feet being in ore. This vein is undoubtedly one of the B-J series, but specific correlation with these veins on the upper levels is impossible. Further development work will be required before probable tonnage can be estimated, but this vein undoubtedly contains ore. These constitute the only blocks of ore opened on more than one level.

One block of probable ore may be projected from drifts which open it on a single level. In the old mine, No. 9 ore body was opened in 1895 on the tenth level for a length of 365 feet, and was stoped in 1896 with an average width of 3.0 feet, and an average content of 1.13 ounces gold and 7.6 ounces silver per ton. This vein has been worked on every level down to the tenth, and is reported by the former manager, Mr. Orford, as the most consistent producer of the mine. Its ore is presumably primary and its precious metal content on this level is as high as on those above. In spite of this, its continuation was not sought below the tenth level during the deep prospecting program of 1897-1900. It is almost certain that this vein contains ore below the old workings. Several other veins of the old mine series were also stoped down to the tenth level prior to 1897 and were not searched for below. No data are available to show the size or precious metal content of their ore bodies, so that little can be predicted as to their possibilities.

The hope of renewed activity for the De Lamar mine rests wholly upon establishing the continuation of ore bodies in blocks of ground which have not been prospected. Two phases of this problem exist: first, the continuation of ore bodies to greater depths; second, their extensions beyond the De Lamar and Sommervamp faults. It has already been shown that there is no reason to expect any marked change in character of the ores with depth. This being true, exploration along the veins in the extension of known ore shoots below the old stopes should bring success. As a guide to the probable position of ore shoots on the lower levels of the old mine, the

Seventy-seven and No. 9 veins have been projected downward to the sixteenth level, as shown by the level plans (Pls. X and XII). There are also shown, in projected position, the probable average traces of the De Lamar and Sommervamp faults, and of an imaginary plane which bisects the zone of ore shoots as developed above the tenth level. The reason for the failure of the deep prospecting becomes apparent when these plans are studied. On the twelfth level, the one first opened below the tenth, a probable secondary fracture was taken for the De Lamar fault, and the exploration was carried out west of the position at which the low-angle ore shoot would be expected to intersect the plane of the level. The same error was made on the fourteenth level and again on the eleventh, which was driven later. On the sixteenth level the east drift terminates about 1,200 feet west of the probable center of the zone of ore shoots in the Seventy-seven vein, and yet it was considered to have exhausted the possibilities of ore being found. About 200 feet east of its departure from the main adit, the east drift penetrates a 12-inch quartz seam which lies approximately in the extension of the projected position of No. 9 vein. If this is the No. 9 vein, it is about 725 feet from the bisectrix of the zone of ore shoots: too far to be expected to carry workable ore, or to display its average width. In addition to the Seventy-seven and No. 9 veins, it is to be expected that the other veins of the old mine system could be developed on this level. As a result of the rapid divergence of the Seventy-seven and No. 9 veins and the flat dip of the De Lamar fault, the area that must be developed on each level, increases as depth is gained. Care must be observed in the development to recognize structural features and interpret them accurately. The diamond drill would doubtless be of great assistance in tracing veins and faults, although it may fail to give an accurate sample of the metallic content of a suspected ore body. All of the ground above the eighth level has been carefully combed for ore bodies, and none of it could be considered as a potential ore reserve. Between the eighth and tenth levels some stoping has been done, although no great quantity of ore has been extracted. It is unlikely that this ground has been wholly exhausted. Between the tenth and sixteenth levels, a vertical distance of 305 feet, the ground is practically undeveloped, and is to be regarded in many ways as virgin ground.

The Sommervamp section also gives promise of further production, none of the veins having been worked below the sixth level. The H-I vein was prospected on the eighth level and failed to show
workable ore, although small bunches of high-grade material were found (Pl. XI). Crosscuts were then driven east and west from the H-I drift, and it is reported that several veins were cut, although the development was not along the axis of the zone of ore shoots. Even though workable ore was opened in the New vein, none of the others were explored to the fault, until the development of the Silver Talc vein was undertaken in 1920 by the De Lamar Mining and Milling Company. Lack of ore in the H-I vein does not prove the series to be barren on that level, and further development appears justified. The projected trace of the H-I vein is shown on the plan of the sixteenth level (Pl. XII), not because it is the most promising vein of the series but because it may be projected with the most certainty. That the west drift from No. 16 adit (Pl. XII) failed to intersect this vein system is not at all strange, in view of the fact that the De Lamar fault intervenes. In the Sommercamp section also, the Idaho vein above No. 2 level varied from 4 to 10 feet in width and yielded a large tonnage of medium-grade ore. The same vein was intersected by a crosscut about 325 feet west of the K vein, fourth level (Pl. X), but was not developed because workable ore was not disclosed. The point at which the vein was pierced, however, is about 425 feet north of the Henrietta fault and very probably outside the northern limit of the ore body. The amount of potential ore, as measured by vein area, in these possible reserves may exceed that already mined from the Sommercamp section, and each vein should be systematically prospected from the eighth and sixteenth levels.

The remaining major source of undeveloped ore lies in the extension of the veins south of the De Lamar and Sommercamp faults, the approximate expected position of which has been described. The most painstaking search will be required to develop this potential reserve and premature discouragement may ensue. It cannot be too strongly urged that a maximum of surface trenching be performed to pick up the croppings of the vein systems before extensive underground development is undertaken. Even in the mantle of fine debris that covers much of the south slope of De Lamar Mountain, trenching is more expeditious and economical than driving through solid rock, and much more critical information can be gleaned from it.

Future Possibilities.—If the analysis herein set forth is correct, there is reason to believe that the future of the De Lamar mine is by no means unpromising, if care and courage are turned to the task of rehabilitating it. To sum up, it may be said that the development might well be done in five distinct steps. These are: first, temporary re-opening of critical portions of the mine workings in order that features of geologic structure, distribution of ore shoots, and pattern of vein systems may be studied by direct observation and correlated with a most careful geologic mapping of the surface; second, complete exploration of the old mine vein system north of the De Lamar fault down to the sixteenth level, in accord with the detailed relations established by the preliminary mapping; third, development of the Sommercamp veins north of the fault of the same name, down to the eighth level, then to the sixteenth; fourth, search of the ground south of the De Lamar and Sommercamp faults to establish the continuation of the known vein systems; fifth, exploration of the ground below the plane of No. 16 tunnel on either side of the 'iron dike' faults. It is regrettable that the mine is so largely inaccessible and that much of the preceding analysis is based on indirect information and must be somewhat uncertain. Proper preliminary investigation to supplement this broad analysis of the problem will guard against ill-advised development projects.

OTHER PROPERTIES OF THE DE LAMAR DISTRICT

Conditions disclosed by the other properties of the De Lamar district have changed but little since the time of Lindgren’s examination, and the reader is referred to his report (24b: pp. 130-134) for more complete descriptions. The Henrietta (Pl. I, No. 7) and Silver Vault (Pl. I, No. 13) properties have remained idle since 1898 and are now completely inaccessible. The Chatauqua property (Pl. I, No. 15) remained idle for a long period and is not wholly accessible. Some ore has been extracted from two veins near the portal of the lower adit (Pl. X) but the stopes are inaccessible and the veins could not be observed. The adit is caved at its intersection with the De Lamar fault (‘iron dike’) about 1,250 feet from the portal. The Alta property (Pl. I, No. 18) has been recently re-located, although little work has been done. The properties of the Garfield group (Pl. I, Nos. 2, 3, 4) have been worked occasionally, but so far as could be ascertained no payable ore was developed. The workings were now largely inaccessible. The Ohio prospect (Pl. I, No. 27) southeast of De Lamar near the head of China Gulch, has been worked but little.
MINING PROPERTIES ON FLORIDA MOUNTAIN

Although the mineral deposits of Florida Mountain were extensively developed in the nineties and during the decade following 1900, little of this ground was accessible during 1925, and very little descriptive data could be gathered by direct observation. Consequently, many features of these properties are discussed as a unit, much of the material being adapted from Lindgren’s descriptions (24b: pp. 134-147), from the annual reports of the manager of the Trade Dollar Consolidated Mining and Milling Company, and from other records of that organization. Moreover, these mineral deposits should logically be developed as a unit, so that this method of treatment is advantageous.

The sketch (fig. 2) which accompanies this discussion shows, in a somewhat generalized fashion, the relative depths attained by development on the more important veins of both Florida and War Eagle mountains. It is striking that relatively little deep exploration has been carried on, as is shown graphically.

COUNTRY ROCK

The precious metal deposits of Florida Mountain are enclosed by granodiorite in the deepest workings; by basalt in the intermediate levels; and by rhyolite near the summit of the peak. The granodiorite is for the most part the normal phase that has been described on an earlier page, although irregular dikes of pegmatite are present, and porphyritic facies are abundantly developed. Throughout the zone of mineral deposits this rock shows slight chloritization of the biotite and kaolinization of the feldspar by hydrothermal agents. Locally, especially at the property of the Idawa Gold Mining and Milling Co., intense hydrothermal alteration along the vein has tinted the quartz crystals of the rock a brilliant rose hue by deposition of titanite (?) in fractures; elsewhere this process has produced a sericitic clay. The basalt, which overlies the granite with a flow-contact, is usually porphyritic. One of the sources of extrusion for this rock is a persistent basalt dike which follows the Trade Dollar vein through the granite in the lower levels and merges with the basic flows on the fifth level of the mine (24b: p. 139). The dike is not found in the rhyolite. The hydrothermal alteration of the basalt is a normal chloritization which may be slight next to the veins but intense several hundred feet away. Evidently the intensity of alteration has been controlled...
by the distribution of fractures which afforded avenues for circulation of the hydrothermal agents. These fractures have themselves been obliterated by the alteration. The mineralogic and physical changes produced in the rock have been discussed at length elsewhere. The rhyolites were extruded over the basalts and overlie them with a contact which approaches a true plane in Long Gulch, on the southern face of the mountain. The rock is, for the most part, of the banded porphyritic type, although the spherulitic phases are also present. Alteration has effected a silicification and sericitization which renders the rock deceptively fresh in appearance, although it readily disintegrates and decomposes under the influence of sub-aerial agents. Consequently the summit and higher slopes of the mountain are deeply covered by a mantle of fine debris in which prospecting can be done only by extensive trenching. As in the case of the other rocks, the petrography of the rhyolite has been treated on an earlier page in some detail and need not be repeated.

**STRUCTURAL FEATURES**

The earth fractures, that have been recognized, belong wholly to the period of diastrophism which opened the vein fissures, and post-vein faults are not known to exist within the area explored by the principal mines. It is very probable, however, that minor displacements of the veins exist although none were seen in the relatively small amount of accessible workings. Some of the fractures of larger displacement are shown by the geologic map (Pl. II), certain of these being encountered underground as noted by the preceding discussion of regional structure. The occurrence of other fractures is shown by the repetition of basalt and rhyolite in the "28" crosscut from Blaine tunnel (Pl. XIII) and in the Idaho tunnel (Pl. II, No. 6) as mapped by Lindgren (24b: pl. XXIV). It is regrettable that access to the ground could not be had to solve the fracture system in detail and to establish its relation to the veins.

**VEIN SYSTEM**

The veins of Florida Mountain constitute a set of roughly parallel fractures which usually strike N. 15°-30° W. and dip 75°-80° W. The northward extensions of the veins trend more nearly due north, as shown by the geologic map (Pl. II), and dips are locally vertical or steep toward the east. As structural features these vein fissures are to be correlated with the Hamilton and No. 9 veins of the De Lamar mine, and with the secondary veins of War Eagle Mountain, which are described on a following page. The most westerly of the larger veins is the Banner (Pl. II, No. 16), which may be traced northward from Long Gulch more than half a mile. Approximately 3,000 feet east of the Banner lies the Trade Dollar-Black Jack vein, which may be followed from Blaine tunnel (Pl. II, No. 20) northward across the summit of the mountain for more than a mile. Two veins, the Alpine (Pl. II, No. 12) and the Empire State (Pl. II, No. 8), lie west of the Trade Dollar and branch from it. Theoretical consideration suggests that these two veins occupy fractures opened by secondary stresses acting in the hanging wall of the Trade Dollar vein fissure, and that they should not be expected to extend northward. Unfortunately the veins are difficult to trace at the surface, and there is some doubt as to the plotting shown by the map (Pl. II); the pattern of underground workings (Pl. XIII) suggests the junction indicated, although the localities were not accessible to the writer, and nothing is known in detail of the relations of one vein to the others. Less extensively developed veins are the Tip Top (Pl. II, No. 10), Lone Tree (Pl. II, No. 13), Crown Point (Pl. II, No. 14), and Metallic or Miller and Walters (Pl. II, No. 25). Others are opened by the many prospect pits, but a detailed discussion of all is not warranted.

The Trade Dollar-Black Jack vein has been explored more fully than any of the others and may logically be described as a type. In the lower levels of the mine the vein almost invariably follows the basalt dike, referred to above, and shows from a few inches to 2 1/2 feet of quartz, either on the hanging or the footwall. Locally a band of vein matter occurs at both. The vein filling is separated from the dike by a clayey selvage but in many places is tightly 'frozen' to the granite wall. In the overlying basalt the vein may be either a single filled fissure with both walls sharply drawn, or a vein breccia filled by quartz, valencianite, and other mineral species. As a single filled fissure it may vary from a mere seam to six inches wide; as a vein breccia its width may attain three feet, of which not more than 12 inches in the aggregate represents vein-filling. In the vein breccias the enclosed fragments of basalt are highly chloritized and frequently quite soft. In the rhyolite, which lies upon granite and basalt alike, the vein ranges from 3 to 16 feet, and averages 4 feet wide. The vein matter consists of many narrow stringers of quartz and valencianite separated by bands of intensely altered rhyolite. The entire width may constitute medium-grade ore. The walls may be sharply defined by a band of vein-filling, or they may be very indefinite, or even indis-
The occurrence of cassiterite in the region has already been noted, but this mineral is not known to occur in the veins of the Banner vein, as is pictured in Plate XVA and described in the preceding treatment of the mineralogy of the region; sericitic clay, much of which is the species beidellite (leverrierite), forms the entire vein filling locally, accompanies comb quartz here and there, and fills the voids of the cellular calcite from the Banner vein. Other less abundant non-metallic minerals of the ores are epidote, chlorite, fluorite, and the iron phosphate vivianite.

The metallic species include the native metals gold and silver; the silver minerals cerargyrite, argentite, naumannite (the silver selenide), proustite, pyrargyrite, polybasite, and stephanite (?); as well as the non-argentiferous species pyrite, chalcopyrite (and its products of oxidation), sphalerite, galena, jamezonite (?), and the lead selenide clausenthalite. The occurrence of cassiterite in the region has already been noted, but this mineral is not known to occur in the veins of Florida Mountain. The properties of these several mineral species have been described in a preceding section.

A relatively small portion of the ores, recovered near the surface in the early days of the mine's history, carried a large content of native gold. At slightly greater depths the ores carried an increasingly large content of wire silver, of native gold, and of argentite (?). These, however, were not typical of the ore deposit as a whole and were in large part the result of enrichment by supergene agents. Unfortunately, the inaccessibility of the workings has made it impossible to obtain satisfactory specimens from which the downward extent of enrichment can be determined. An indirect solution of the problem is afforded in part by the following longitudinal section of the Black Jack-Trade Dollar vein (Pl. XIII), upon which the average precious metal content of the ore extracted from individual stopes is shown as completely as the available data permits.

GEOL OGY AND MET ALIFEROUS RESOURCES OF SILVER CITY REGION

There is a marked increase in the number of parts of silver to each unit weight of gold from the upper levels to the lowest, but the increase is by no means uniform. On the contrary, this gold-silver ratio varies but little below the tenth level and the increase occurs in the higher workings. If the downward change in tenor of the ore is due wholly to supergene processes, as is almost certainly true, this condition suggests an approximate lower limit of their activity. It is to be regretted that suitable production data are not available for the entire stoped area, in order that this lower limit could be precisely drawn. Moreover, ore specimens obtained from the twelfth level, Alpine vein, Trade Dollar mine are made up almost entirely of hypogene or primary minerals. It must be concluded, therefore, that the deep exploratory work on Florida Mountain was below the zone of activity of surface or supergene agents, and that the primary ores should continue downward without great change in tenor.

Silver has been many times more plentiful than gold in the normal ore, the ratio of gold to silver by weight being 1 to 138.6 for the total recorded production of the Trade Dollar-Black Jack mine. This is by far the highest known average ratio for any ore deposit of the Silver City region; and in small bodies of high-grade ore it was even higher. From the material that is available for study, it seems that the deeper ores carry a small but approximately constant amount (usually one or two per cent) of the non-argentiferous sulphides, chalcopyrite, galena, sphalerite, and pyrite, together with a variable quantity of the rich silver minerals, of which the selenide, naumannite, is by far the dominant species. Much less abundant are the other silver minerals, argentite, proustite, pyrargyrite, polybasite, and cerargyrite. The lead selenide-clausenthalite, occurs very sparsely and usually with the ores rich in naumannite. These metallic species are in large part strictly hypogene or primary and are contemporaneous with certain stages in the formation of the vein matter. The paragenetic relations have been discussed in detail in the section treating of ore deposits.

The relative abundance of the different metallic constituents of the ore is indicated by the following analysis of first class concentrate obtained from ore taken from the Alpine vein, levels Nos. 11 and 12, Trade Dollar mine:
precious metals; hence the tabulated ratios, which are the proportions for the bullion and concentrate combined, represent closely the character of the ore itself. The range of gold to silver ratio in the annual production is not great, inasmuch as each year’s activi-

<table>
<thead>
<tr>
<th>YEAR</th>
<th>WEIGHT IN FINE OUNCES</th>
<th>VALUE</th>
<th>Value of silver per fine ounce</th>
<th>Ratio of gold to silver by wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gold</td>
<td>Silver</td>
<td>Gold</td>
<td>Silver</td>
</tr>
<tr>
<td>1865-91</td>
<td>19,300</td>
<td>1,335,000</td>
<td>$ 400,000</td>
<td>$ 1,500,000</td>
</tr>
<tr>
<td>1892</td>
<td>2,000</td>
<td>200,000</td>
<td>41,500</td>
<td>174,000</td>
</tr>
<tr>
<td>1893</td>
<td>2,000</td>
<td>200,000</td>
<td>41,500</td>
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</tr>
<tr>
<td>1894</td>
<td>5,100</td>
<td>720,000</td>
<td>105,500</td>
<td>454,000</td>
</tr>
<tr>
<td>1895</td>
<td>4,900</td>
<td>855,000</td>
<td>101,000</td>
<td>442,000</td>
</tr>
<tr>
<td>1896</td>
<td>6,100</td>
<td>635,000</td>
<td>126,000</td>
<td>432,000</td>
</tr>
<tr>
<td>1897</td>
<td>6,000</td>
<td>625,000</td>
<td>124,000</td>
<td>375,000</td>
</tr>
<tr>
<td>1898</td>
<td>7,100</td>
<td>865,000</td>
<td>147,000</td>
<td>475,000</td>
</tr>
<tr>
<td>1899</td>
<td>11,750</td>
<td>1,075,000</td>
<td>243,000</td>
<td>645,000</td>
</tr>
<tr>
<td>1900</td>
<td>11,300</td>
<td>1,163,000</td>
<td>233,500</td>
<td>722,000</td>
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<tr>
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<td>217,000</td>
<td>726,000</td>
</tr>
<tr>
<td>1902</td>
<td>8,150</td>
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<td>127,000</td>
<td>414,000</td>
</tr>
<tr>
<td>1903</td>
<td>5,600</td>
<td>690,000</td>
<td>116,000</td>
<td>372,500</td>
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<tr>
<td>1904</td>
<td>7,050</td>
<td>785,000</td>
<td>145,500</td>
<td>428,000</td>
</tr>
<tr>
<td>1905</td>
<td>8,500</td>
<td>1,424,000</td>
<td>175,500</td>
<td>867,000</td>
</tr>
<tr>
<td>1906</td>
<td>8,250</td>
<td>1,242,000</td>
<td>170,500</td>
<td>845,000</td>
</tr>
<tr>
<td>1907</td>
<td>4,650</td>
<td>653,000</td>
<td>96,000</td>
<td>341,000</td>
</tr>
<tr>
<td>1908</td>
<td>3,550</td>
<td>642,000</td>
<td>85,000</td>
<td>340,000</td>
</tr>
<tr>
<td>1909</td>
<td>2,900</td>
<td>519,000</td>
<td>60,000</td>
<td>289,000</td>
</tr>
<tr>
<td>1910</td>
<td>3,900</td>
<td>71,200</td>
<td>7,900</td>
<td>38,400</td>
</tr>
</tbody>
</table>

| TOTALS | 132,550 | 15,421,700 | $2,741,400 | $10,105,900 | $12,847,525 | 18.6 |

1 From production data of the Trade Dollar Mining and Milling Co. and the Trade Dollar Consolidated Mining Co. For assurance in the compilation of these data and of other statistical matter, the writers are deeply indebted to Miss Alta Brumbaugh of Silver City.

ties were distributed throughout a large portion of the vein area developed, and variations from place to place in the mine were largely equalized thereby. As has been emphasized in a preceding paragraph, and as shown by the longitudinal section (Pl. X11), the gold to silver ratio changes progressively from the surface downward, the highest recorded portion of gold being one part to 33 parts of silver, by weight, for a stope on the third level near the northern end of the mine. On the deeper levels the average ore contains approximately 200 parts of silver to one of gold, although a ratio of one to 400 is not uncommon.

History.—Rich gold-bearing float was discovered on Florida Mountain in 1871, but subsequent prospecting in the surface debris was disappointing. In 1881, however, active mining was in progress at the Seventy-nine claim (Pl. II, No. 4) about half a mile north

- Gold.................. 36.20 oz. per ton
- Silver.................. 1290.0
- Lead .................. 0.8%
- Zinc .................. 61.2
- Iron .................. 23.8
- Copper ................. 0.9
- Antimony ............... 0.7
- Arsenic ................. 0.6
- Antimony ............... 0.8
- Sulphur ................. 27.8
- Lime .................. 0.3
- Insoluble ................. 18.9

STEELE PROPERTIES

EMPIRE MINES COMPANY (TRADE DOLLAR-BLACK JACK MINE)

Location.—The property of the Empire Mines Co. comprises 87 patented and seven unpatented mining claims, and five patented mill sites, with an aggregate area of about 1,000 acres. The group extends northward from Blaine tunnel (Pl. II, No. 20) in Long Gulch to Dewey tunnel (Pl. II, No. 1) on Jordan Creek, a distance of approximately three miles. Nearly 12,000 feet of the outcrop of the Trade Dollar-Black Jack vein and 3,000 to 5,000 feet along the Alpine and Empire State veins respectively, are included within the property. Dewey tunnel, the main working entry of the mine, is three miles by road from Silver City and approximately 250 feet below it.

Production.—The total production from the property from the time of its discovery until the suspension of active mining operations is presented by the following table, which has been compiled from a nearly complete file of records of bullion and concentrate shipped from the Blaine and Black Jack mills, from the annual reports of the manager of the Trade Dollar Consolidated Mining Co., and from the record noted by Lindgren (24b: pp. 136 and 140). For the years preceding 1895 the available records are quite fragmentary and the tabulated production, which is estimated therefrom, is somewhat uncertain. For the period 1895-1910 the record is nearly complete, although some part of each year’s production figures are missing; the tabulated production for this period is in part an estimate but probably does not deviate more than two per cent from the actual.

The amount of silver produced has been many times that of the gold, in value and in weight alike. In this respect the property differs from the De Lamar mine, in which gold usually predominated in value, although not in weight. The recoveries effected by metallurgical treatment were approximately equal for the two
of the summit. Two years later the Empire State (Pl. II, No. 8), Black Jack, Starlight, and others were also producing. For several years the activity was limited and sporadic, but from it grew three mines—the Booneville, the Black Jack, and the Trade Dollar—which were later to be merged into one.

The Booneville mine included the old Seventy-nine and Phillips and Sullivan properties (Pl. II, Nos. 4 and 5, respectively), and other claims along the northern end of the Trade Dollar vein, upon which the first discoveries of rich gold ore had been made. The ground was actively worked from shallow entries during the eighties, and several hundred thousand dollars produced therefrom. During 1895, 1896, and part of 1897, the group was operated by the Florida Mountain Mining and Milling Co. under the name of the Booneville mine, through the Humboldt tunnel (Pl. II, No. 3) and a drift northward from the Black Jack tunnel (Pl. II, No. 7). The property was shut down in 1897. In 1899 it was sold to the Trade Dollar Mining and Milling Co.

The Black Jack mine covered the central portion of the Trade Dollar vein between the Booneville group and the summit of Florida Mountain. The claims were worked intermittently and in desultory fashion by shallow entries during the seventies and early eighties. In 1889 the Idaho and Pittsburg Mining and Milling Company bought the property and started the Black Jack adit (Pl. II, No. 7) on the eighth level. The adit encountered the vein at a barren zone and operations were nearly suspended. In 1891, however, workable ore was encountered in drifting southward and the enterprise was assured of success. Production continued steadily and the vein was opened on the twelfth level by the Idaho tunnel (Pl. II, No. 6) and two levels were turned from a 237-foot vertical shaft sunk therefrom. Operation was suspended in 1897, due to lack of adequate drainage for the lower workings; in the same year the property was consolidated with the Trade Dollar and Booneville mines. Its total production to that year was about $2,885,000.

The Trade Dollar property comprised the claims on the southern slope of the mountain, along the extension of the Black Jack vein, and on the Alpine and Empire State veins. During the seventies and eighties the veins were worked sporadically through shallow adit drifts. In 1891 Blaine tunnel (Pl. II, No. 20) opened the vein on the twelfth level; the mine was purchased by the Trade Dollar Mining and Milling Company; and vigorous development and mining was inaugurated. The twelfth (Blaine tunnel) level was connected with the Black Jack workings, a shaft was sunk from it 2,000 feet from the portal, and the thirteenth and fourteenth levels were started. Rich ore was encountered in the northern portion of the ground and the production increased rapidly, the total prior to 1899 amounting to about $2,960,000.

The Booneville, Black Jack, and Trade Dollar mines were consolidated in 1899 by the Trade Dollar Mining and Milling Company, and in the same year a tunnel was started from Dewey (Pl. II, No. 1), on Jordan Creek, to explore the vein 500 feet below the level of Blaine tunnel. Development and mining were pushed to the utmost throughout the mine, and the precious metal production during the period 1899-1903 amounted to $2,580,000. In 1903 the property was acquired by the Trade Dollar Consolidated Mining Company, and, under the management of Mr. Frederic Irwin, was worked actively until 1910. The 1700 (Dewey tunnel) level was extended southward along the vein to a point south of Long Gulch, raises were put through to the 1200 (Blaine tunnel) level to afford ore chutes; and drainage ways and exploratory levels turned therefrom. The 1700 level was made the main working entry, milling operations were centralized in the large mill at Dewey, and a 100-foot exploratory shaft was sunk from the 1700 level. At the same time the quantity of ore handled was materially increased, and the milling practice improved. During the seven-year period 1903-1909, inclusive, the precious metal output was valued at $4,425,000. In 1910, after being worked almost continuously since 1889, and with a total output of gold and silver worth $12,850,000, the mine was abandoned. For nearly a decade the property lay idle. In 1917 it was acquired by the Florida Mountain Mines Company, Dewey tunnel was reopened, and the mill at Dewey was overhauled in part.

Little development work was carried out, however, and activity was limited to extracting and milling the low-grade stopes filling from the Alpine vein, between the 1200 and 1400 levels. Only 2,125 tons which averaged about $12 per ton were milled in 1919, and even less was handled the following year. In 1920 the enterprise failed. In 1923 the enterprise was acquired by Mr. Peter Steele of Silver City, and plans for re-opening the mine for thorough prospecting have been inaugurated.

The following table presents a summary of the mining and milling operations under the Trade Dollar Consolidated Mining Company:
Summary of mining and milling operations at the Trade Dollar mine for the period 1901-1919
(Data from Annual Reports of the mine manager, Trade Dollar Consolidated Mining Co.)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>Tons mined</th>
<th>Cost per ton</th>
<th>Precious Metal content of ore per ton</th>
<th>Percentage recovery</th>
<th>Mining</th>
<th>Milling</th>
<th>General</th>
<th>Oz. gold</th>
<th>Oz. silver</th>
<th>Total value</th>
<th>Gold</th>
<th>Silver</th>
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</thead>
<tbody>
<tr>
<td>1903</td>
<td>15,744</td>
<td>$14.44</td>
<td>$4.07</td>
<td>$6.76</td>
<td>$30.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>94.2</td>
<td></td>
</tr>
<tr>
<td>1909</td>
<td>9,303</td>
<td>20.75</td>
<td>3.44</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>81.0</td>
<td>95.8</td>
</tr>
<tr>
<td>1907</td>
<td>15,988</td>
<td>17.37</td>
<td>3.17</td>
<td>$196</td>
<td>$33.46</td>
<td>46.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>85.8</td>
<td>91.4</td>
</tr>
<tr>
<td>1908</td>
<td>14,455</td>
<td>17.41</td>
<td>3.40</td>
<td>$196</td>
<td>$33.46</td>
<td>46.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>85.8</td>
<td>91.4</td>
</tr>
<tr>
<td>1909</td>
<td>9,303</td>
<td>20.75</td>
<td>3.44</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>81.0</td>
<td>95.8</td>
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<tr>
<td>Totals and Averages</td>
<td>109,397</td>
<td>$16.24</td>
<td>$3.12</td>
<td>$4.68</td>
<td>0.248</td>
<td>47.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>89.9</td>
<td>92.9</td>
</tr>
</tbody>
</table>

1 Cost of power, generated in the company's hydroelectric plant on Snake River at Swan Falls, is included for the years 1901-1909.
2 Average for the period 1901-1909 only.

Two factors which have a very important influence on the enterprise are worthy of special comment: these are: the unit cost of mining, and the unit total value of the ore. The average mining cost for the enterprise is $16.24 per ton, a figure which is rather high, even considering that about 8.75 square feet of vein area was stopped per ton of ore. The labor cost of underground development is recorded as $1.00 to $1.58, with an average of $1.32 per ton, so that the cost of breaking and handling the ore underground and tramming it to the mill amounts to nearly $15 per ton. In mining, the stope was carried up along the footwall of the vein, and the ore was then stripped from the hanging wall. This procedure is perhaps not the most economical. Obviously, in the face of such high operating costs, the minimum value of profitable ore would be relatively great. The average unit total value of ore mined was $32.67 per ton for the duration of the period 1903-1909, and this figure represents approximately the minimum value of workable ore. It is interesting to note the rough constancy in value of the ore, indicating that the operation was not suspended due to a decrease in precious metal content, but because known bodies of ore of the tenor desired were exhausted. Records are not available to show the precious metal content of those portions of the vein which were not stopped, but it is possible that much of this ground might be worked profitably by large tonnage output at lower unit cost.

Development and Surface Plant.—The Trade Dollar-Black Jack mine is opened by adits and drifts, as shown by the partial plan of underground workings (Pl. XIII), to a depth of 1,700 feet beneath the apex of the vein. Dewey tunnel (Pl. II, No. 1), the lowest and main working entry, is driven to the Trade Dollar vein from an elevation of 5,935 feet and drifts southward along it for almost 6,000 feet. Short drifts are also turned on the Alpine and Empire State veins on this level. On the 1200 level the Blaine tunnel drifts along the vein for 3,900 feet, to the northern end line of the old Trade Dollar property, and the Idaho tunnel crosses the vein 2,300 feet from the portal, and drifts southward 1,200 feet to a junction with the Blaine drift. The portals of these two adits have elevations of 6,487 and 6,477 feet, respectively, and the level lies about 550 feet above the 1700 level. On the 1200 level, also, drifts have been extended along the Alpine and Empire State veins and the “28” crosscut has been driven westward nearly 3,000 feet from the Trade Dollar vein to the Banner (Pl. II, No. 16), cutting across the intervening veins. On the eighth level the Black Jack tunnel (Pl. II, No. 7) reaches the vein 900 feet from the portal, and drifts extend southward to join the 2,400-foot drift in Trade Dollar ground. The mine is also opened, by adits, on two higher levels used in the early years of its history. The several adit levels are joined by raises and shafts, as shown by the longitudinal section (Pl. XIII), and intermediate levels turned at intervals of about 100 feet. An exploratory winze has also been sunk below the 1700 level, and short drifts turned northward and southward on the 1800 level. More than 60,000 feet of development work has been driven, of which 44,000 feet was opened during the administration of the Trade Dollar Consolidated Mining Company. Very little of this footage is accessible at the present time, only portions of the 1200 and 1700 levels being open. The Dewey (1700) adit is caved near the portal, as are those of the Trade Dollar ground above the Blaine (1200) level; the Blaine drift is caved at the main shaft, just north of the “28” crosscut; the crosscut itself is blocked west of the Alpine vein; as is the Alpine drift. None of the raises which connect the 1700 and 1200 levels can be descended, and all stopes are inaccessible except those on two small ore bodies above the 1200 level in the Alpine vein south of the “28” crosscut. The Dewey tunnel (1700) level was completely open in 1920, however, and it should be possible to re-enter all this ground with relative ease.
The present surface plant of the Trade Dollar-Black Jack mine is centered at Dewey, the physical improvements formerly located at the Idaho tunnel having been abandoned or destroyed. The Dewey plant includes an office building, two warehouses, large rooming and boarding houses, concrete transformer house with full equipment, carpenter and blacksmith shops, timber shed, and mill building. All of these are well constructed and in a fair state of repair. The mill-building houses an Ingersoll-Sergeant compound duplex 16 by 8 by 14 compressor driven by a 100-horsepower electric motor. The boiler plant and Corliss steam engine are held in condition for emergency service. The milling equipment includes an 8½ by 17-inch gyratory crus tener, twenty 1000-pound stamps, and two Overstrom tables; the amalgamating pans and Frue vanners formerly used have been completely dismantled, and, in large part, removed. Two 75-horsepower motors furnish power for mill operation. The mill was never operated much beyond 50 tons daily, although its size is ample for at least twice that capacity. The Dewey adit is equipped with 40-pound rails and electric trolley for operation of a Baldwin-Westinghouse electric locomotive for haulage. An Edison storage battery locomotive serves the needs of transportation in the south drift along the vein.

**Ore Shoots.**—During the active operation of the Trade Dollar-Black Jack mine, about 2,000,000 square feet of vein area was stope. This is divided between one large ore shoot near the center of the workings, and three smaller ones, each of which pitches southward about 45 degrees in the vein, as shown by the accompanying longitudinal section (Pl. XIII). Theoretical analysis suggests that the position of the shoots is controlled by intersections of the main vein, and secondary fractures of that set which seems to control the locus of ore deposition in the De Lamar vein system, several miles to the westward. If this be true, it is to be expected that the present pitch will persist with depth.

Each of these shoots, to judge from the distribution of stopeing, has its strongest development between the tenth and twelfth levels, and becomes somewhat irregular in the deeper levels. Only a few small blocks of ore were stope on the 1700 level, and the conclusion was drawn that the zone of ore shoots had been bottomed. There is, however, no known geologic factor which suggests that this is the case. The high minimum value of profitable ore has been noted already, and it is quite possible that much of the "barren" vein matter reported from the deep exploratory work carries a sufficient precious metal content to be profitable under a lower cost of handling. Moreover, it is known that, in some of the stopes at least, the ore was composed of irregular scattered bunches of metallic minerals interspersed with vein filling. It may be, therefore, that the apparent fingering out and splitting of ore shoots throughout the mine is due, in part, to insufficient search for isolated small blocks of ore that may exist between the stopes shown.

By far the best ore occurred in the granite, although some high-grade bodies were found in the overlying basalt. It is reported that the older workings found very little workable ore in the lower 100 feet of the rhyolite, where it lay directly upon the granite, but that above this point the ore bodies were wider and of uniform but medium grade.

**Ore Reserves.**—With the exception of two short bodies of ore recently opened on the Alpine vein south of the '28' crosscut and above the 1200 level, there are no known ore bodies remaining in the mine. There are, however, several possible sources of additional ore which may spell a renewed activity for the enterprise. In the first place, it may be possible to work at a profit blocks of unstope ground in the zone already developed, provided the mining cost is lowered. The extent of this possible source can be ascertained only by sampling the mine thoroughly. Second, practically all the exploratory work has been confined to a single vein, although many were worked at the surface in former days. This fact warrants careful search on deeper levels, preferably through crosscuts extended from present workings, in order that the greater efficiency of centralized operation may be gained. Among these are the Alpine and Empire State veins, which have been explored to a very limited extent down to the 1700 level, and the Tip Top, Ontario, and others which have been opened for not more than a few hundred feet in depth. These must have been penetrated by the '28' crosscut, 1200 level, but none was ever explored at that depth. Third, ore bodies may be found by further search horizontally along the veins, as in the case of the two shoots on the Alpine vein. Throughout the history of the mine, development was never far ahead of mining and was extended only far enough to establish the continuation of a known ore body. Apparently no effort was made to establish the system of shoots and to search for new ones. This possible source of ore holds no great promise, and should preferably be exploited last. In the fourth place, the continuation of ore bodies may be sought at greater depths, for there is nothing to indicate that the
zone of ore shoots has necessarily been bottomed. Deeper exploration should be at the projection of the pitch axis of each known ore body and should be governed by a most careful preliminary examination and systematic sampling of the 1700 level drift.

BANNER MINING & MILLING COMPANY

The property of the Banner Mining and Milling Company comprises 7 patented and 15 unpatented mining claims, the group extending northward from Long Gulch along the outcrop of the vein (Pl. II, No. 16).

The vein has been explored through five adits from 200 to 1,700 feet long. The lowest and main working entry, Erdman tunnel (Pl. II, No. 18), is about 600 feet below the apex of the vein. From this level a 70-foot winze was sunk and levels run along the vein. Drainage problems became serious, however, so the ‘28’ crosscut from Blaine tunnel was extended westward to join the lower level, and supply drainage. The caving of the ‘28’ crosscut has caused complete flooding of the lower levels so that none of the workings were accessible to the writers.

The mill, which has about 30 tons daily capacity, is operated by electrical power. It is equipped with a 9 by 18-inch Blake crusher breaking to 1½-inch size, and four Nissen stamps crushing through 40-mesh. First-class and second-class concentrates are recovered from a Simplex diagonal deck table, and the tailing elevated to a Willey table, from which a further recovery of second-class concentrate is made and a tailing wasted. The character of the first-class concentrate recovered from ore extracted from the Alpine vein south of the ‘28’ crosscut, is shown by the tabulated analysis which forms a part of the preceding discussion of the ores of Florida Mountain. The mill was formerly equipped with Fuerzmann und pan amalgamators.

Nothing is known of the quantity and tenor of ore blocked out by the development, as the ground is inaccessible. Some excellent specimen ore has been recovered from small bodies, but the aggregate tonnage mined, and its average precious metal content, is likewise unknown. Logically, this deposit should be developed and mined as one portion of a unit covering the entire vein system of the mountain.

TIP TOP GROUP

The Tip Top group comprises three patented mining claims and one patented millsite, which cover the Tip Top (Pl. II, No. 10) and Apex veins at the summit of Florida Mountain. The development includes a shaft 280 feet deep, from which short drifts and crosscuts are turned, and a 300-foot adit tunnel driven from a point 250 feet south of the shaft and at a considerably higher elevation. The property has not been worked since 1895, and these workings are also inaccessible. The vein, which strikes S. 7° W. and dips 75° E., is described by Lindgren (24b: p. 146) as a 4-foot streak of soft white clay, marked at the hanging wall by a 4-inch seam of black gouge, and, at the footwall, by a 2-inch seam of red clay, which grades into the typical porphyritic rhyolite. The vein matter is a sericite clay, probably in part beidellite (leverrierite), derived from the rhyolite by intense hydrothermal alteration. The 4-foot band of clay constitutes the principal source of ore, whose value lay chiefly in its gold content. Some high-grade silver ore was found in the black gouge seam at the hanging wall. It is reported locally that the Tip Top produced 8,000 tons of ore, with an average value of $16 per ton.

The altered rhyolite that encloses the vein carries from a trace to 0.35 ounce of gold per ton at the surface, over a rather wide area adjacent to the vein. Undoubtedly this is an effect of supergene or secondary processes, although the depth to which these agents have been active is not known. So little work has been done on the property, that it justifies full and careful exploration underground. A vein, which is supposed to be the Tip Top, is penetrated by the ‘28’ crosscut from Blaine tunnel, and shows small amounts of the precious metals. It has not been drifted along on this level, or any other, beneath the old shaft. There is some doubt as to the validity of correlating this vein with that opened by the Tip Top shaft, and available data is not sufficiently precise to permit a final answer. The Tip Top vein, with others in the vicinity, is worthy of careful exploration.

IDAWA GOLD MINING AND MILLING CO. (SILVER CITY M. AND M. CO.)

The property of the Idawa Gold Mining and Milling Company, formerly known as the Silver City Mining and Milling Company, lies in the northern wall of Long Gulch, about a mile above Silver City (Pl. II, No. 22). The property is opened through an adit tunnel, raises, and drifts along two veins, the total footage of development work exceeding 2,000 feet. At the time of the writers’ visit the lack of ventilation made it impossible to examine the veins. The results of the exploratory work are not known. The property has been inactive for several years.
The Blaine mill of the Trade Dollar Mining and Milling Company (Pl. II, No. 21) was acquired and in 1917 wholly remodelled as a cyanide plant. The equipment includes a Blake crusher, breaking the ore to 2-inch size, a 5-stamp battery, reducing to 12-mesh, and a pebble mill for fine grinding in cyanide solution. The pebble mill operates in closed circuit with an Ovoca classifier. Two Door thickeners, three Pachuca agitating tanks, an Oliver continuous filter, filter presses for clarifying the pregnant solution and for separating the precious metals after precipitation, and solution storage tanks, constitute the remaining equipment. The flow sheet has been discussed briefly in the earlier section that treats of the metallurgical history of the region. This plant approaches the standards of present practice and should have effected a high recovery of the precious metals.

MINING PROPERTIES OF WAR EAGLE MOUNTAIN

In the following discussion of the mining enterprises on War Eagle Mountain many are treated as a unit, inasmuch as they form a geologic entity and should logically be developed as such. Whatever the outcome of the development program suggested, it will affirm or deny the possibility of extensive activity for all other enterprises as well. If it is affirmed, the development may be expanded to the limit of its feasible application. This treatment of the problem is followed, not because the unit described is the only one that promises success but because it offers the most direct attack upon the problem of depth-persistence of the ores, a problem whose solution is a necessary part of any exploratory project.

COUNTRY ROCK

The veins of War Eagle Mountain are enclosed by granodiorite throughout most of their length, although they pierce the dikes of diorite and dacite porphyry and the small outcrops of basalt that cap the peak. The veins are not known in contact with rhyolite flows or dikes. From the mineralogical similarity of the deposits to those of Florida Fountain, it is likely that only one period of vein formation is represented, and that the veins of War Eagle Mountain are definitely younger than the acid rhyolite. The granodiorite throughout the zone of mineral deposits has been affected by hydrothermal agents and slightly altered by them, the most apparent change being chloritization of the biotite and a very slight clouding of the feldspars. Even close to the veins the alteration is not intense and pyritization is not at all highly developed. One wall is usually relatively fresh in immediate contact with the vein filling, the other, generally the hanging wall, may be somewhat indefinite and more intensely altered. The more basic rocks, however, show more marked changes; pyrite and calcite may be abundantly developed, and an extreme development of zoisite and epidote is frequent where the veins intersect a dacite dike. The basalt, in immediate contact with the veins, is chloritized, although when 20 to 40 feet away it remains quite fresh.

VEIN SYSTEM

The veins are best discussed as a unit, inasmuch as most of them represent one system of fractures formed under similar conditions by the same geologic forces. Some of the weaker veins may apparently fail to agree with the system, but the apparent lack of harmony
may be due more to lack of precise information than to any other single factor. Two veins dominate the system, the Oro Fino-Golden Chariot and the Poorman. Their relation to the second period of diastrophism has already been discussed in the section dealing with the regional structure. The first of these veins strikes N. 4° W. on the average, and dips eastward 80°-90°, although westward dips are not unknown. The system may be traced, with some interruptions, from the Great Western Mines Company’s property (Pl. II, No. 55) southward for more than 1 1/2 miles to the Afterthought claim (Pl. II, No. 68), and it retains its normal character in Sinker Tunnel (Pl. II, No. 56), more than 2,000 feet below the outcrop. All of the old workings upon it are inaccessible and little is known of the usual texture of the vein filling. In the Great Western property, in the waste on the dump at Sinker Tunnel, at a cropping 250 feet north of the Oro Fino shaft (Pl. II, No. 57), and again in the Afterthought shaft, this vein is a breccia of granodiorite and basalt, cemented by quartz, which is in part massive and in part drusy, many of the cavities of the breccia not being fully healed. In the Afterthought some calcite accompanies the quartz. Lindgren (24b: pp. 147-8) notes that the vein carries up to three feet of quartz on the Quartz No. 2 claim, and that in the Oro Fino workings to the south, much of the vein matter had the peculiar lamellar texture that has been described elsewhere. At the cropping noted above, the vein breccia is about 3 feet in width. Raymond (29b: p. 243) refers to the Oro Fino vein as 3 to 14 feet wide. The Poorman vein strikes N. 2°-4° E. and stands nearly vertical; its apex crosses a spur ridge about 2,000 feet west of the summit of War Eagle Mountain (Pl. II, No. 40) and descends sharply both northward and southward. The vein is a silicified shear zone which varies from a single quartz-filled fissure, 4 to 5 inches wide, to a zone of altered granite traversed by several quartz stringers. 1 1/2 to 3 inches wide, the aggregate width being as much as 4 1/2 feet. It may be traced at the surface for nearly a mile, as shown on the geologic map (Pl. II) and persists downward for about 950 feet in the Poorman mine without change in character. The vein on the Deluge property (Pl. II, No. 36) lies about 3,750 feet west of the Poorman, and is, perhaps, to be correlated with it.

The remaining veins plotted on the geologic map fall into two sets, each secondary to the dominant two just described. One of these strikes N. 10°-20° W. and dips 45°-60° E., its relatively flat dip causing a somewhat tortuous outcrop. Among these secondary veins are the Empire (Pl. II, No. 43), Jackson (Pl. II, No. 50), Owyhee (Pl. II, No. 39), Silver Cord (Pl. II, No. 52), and Cumberland (Pl. II, No. 60). The Owyhee has been correlated locally with the Silver Cord vein, whereas its trace deflects eastward as it descends into Silver Cord gulch and passes nearly 500 feet east of that shaft. The Empire vein appears to cross the Poorman, near the north shaft on that vein, and continue northward. The second set strikes N. 25°-40° W. and dips 70°-90°, usually eastward. It comprises the Village Blacksmith (Pl. II, No. 37), Illinois Central (Pl. II, No. 42), Red Jacket (Pl. II, No. 43) and parallel veins. Like the Poorman, these secondary veins vary from simple filled fissures on the one hand to silicified shear zones on the other. The filling is dominantly quartz, of massive, crystalline, and pseudomorphous types, locally accompanied by calcite, sericite, probably beidellite (leverrierite), epidote, and chlorite. Lindgren (24b: p. 168) mentions massive siderite on quartz from the Owyhee mine and barite from the Cumberland. The fissure fillings vary from a few inches to three feet in width; the shear zones, made up of several quartz stringers separated by altered granite, attain a maximum width of 10 feet, but 4 or 5 feet is more common. Any given vein may exhibit the maximum range of variation in width, texture of filling, and structure, although they are all remarkably persistent along the strike.

**Structural Features**

None of the old workings on War Eagle Mountain were accessible for study and the old descriptions fail to mention any faults that offset the veins and ore bodies. Moreover, the methods of mining development of the seventies and eighties very probably would not recognize such features. Faults undoubtedly exist, however, and future development must be able to combat the problems that will arise from them. Reference has already been made, in the discussion of the regional structure, to a probable fault of post mineral age that descends Silver Cord Gulch and crosses Stormy Hill saddle just south of the shaft of the same name (Pl. II, No. 49). This fracture terminates the vein in the No. 2 level of the Afterthought mine (Pl. II, No. 68) about 350 feet south of the shaft; the southward continuation of the vein has not been found, so that the displacement at this locality is not known. This fault undoubtedly displaces other veins—such as the Poorman, Jackson, and Village Blacksmith—which lie north of it. The Never Sweat vein (Pl. II, No. 54) has been considered a continuation of the Poorman vein, and the “Flat"
vein, developed in that same property, an extension of the Silver Cord. It is impossible, however, to trace them on the surface, and there is some suggestion that the "Flat" vein is the southward continuation of the Village Blacksmith, rather than of the Silver Cord. Slight offsets of the veins are known to occur at fractures which have been considered as formed during a pre-mineral epoch of crustal adjustment. If these fractures are properly classified, the displacements may be the result of slight movement during the post-mineral diastrophism. On the other hand, it has been shown by the discussion of regional fracture that the vein fissures may not have been formed in strict continuity. The Oro Fino-Golden Chariot vein cannot be traced continuously on the surface and it is quite possible that it suffered minor displacements of this sort, as shown in tentative fashion by the geologic map (Pl. II). Such displacements are to be expected in future development. On the adit level of the Great Western Mines Company the development shows rather interesting evidence of secondary faulting, which is shown on a later page in the geologic sketch plan of the workings.

**PROPERTIES ON THE POORMAN VEIN**

**POORMAN MINE**

**Location.**—The Poorman mine, famous producer of the sixties and seventies, lies on the slope of War Eagle Mountain, nearly 2,000 feet west of the summit and 350 feet below it. Seven patented claims follow the strike of the mine for about one mile, descending northward into Wepfoot Gulch and southward into Silver Cord Gulch (Pl. II). These constitute the Poorman group, which is held by Mr. Fred Grete of Silver City.

**History and Production.**—The Poorman mine was discovered in 1865 and rapidly gained prominence as a producer of silver. Browne states that it "is, perhaps, for its size the richest deposit of silver ores ever discovered" (9a: p. 132). The early operation of the mine was severely hindered by litigation and conflict between rival contendents. In 1874 it came into the hands of the Poorman Gold and Silver Mining Co., and was actively worked until the financial crash of 1876. It is credited with a production, up to that time, of approximately $3,000,000 (21b: p. 152). Sporadic activity by lessees occurred in 1880, 1882, and 1885, but the production was presumably small. In 1888 the property was acquired by English interests, and in 1895 the Poorman Gold Mines, Ltd., of London, commenced operations. Active prospecting, accompanied by the extraction of a small quantity of ore, continued through 1902. The next year, however, operations were suspended and the property has remained idle since that time. The output of precious metals since 1900 is not known, but is probably not more than $100,000, so that the total production may be stated as $3,000,000.

**Development.**—The Poorman mine was originally opened by two shafts sunk from the crest of the ridge across which the vein strikes. The old or north (Hope) shaft (Pl. II, No. 40) follows the vein to a depth of 400 feet: the new or south shaft (Pl. II, No. 41) is situated 540 feet south of the first; and is sunk to a depth of 600 feet in the east wall of the vein. Two tunnels driven from the north side of the ridge connect with these shafts, the lower or Belle Peck tunnel (Pl. II, No. 34) serving as main working level during the eighties. Under the Poorman Gold Mines, Ltd., a 450-foot winze was sunk below the Belle Peck tunnel and the vein 'explored on five levels, of which the deepest was nearly 950 feet vertically below the apex of the vein. These workings are shown, in part, by the accompanying plan and section (fig. 3), which, however, is not complete for the levels above the Belle Peck. None of the openings was accessible in 1925, and the vein could not be observed directly.

The vein explored by the winze, and the levels turned therefrom, dip 45°-50° E. and be approximately in the projection of the easterly-dipping Owyhee vein, which crops (Pl. II, No. 39) about 450 feet east of the north Poorman shaft. It seems possible, therefore, that the exploration was diverted from the Poorman vein, which is nearly vertical from the surface to the base of the old shaft, to the continuation of the Owyhee vein, which must intersect the Poorman and perhaps offsets it.

**Ores.**—The dominant gangue mineral is quartz, usually of the massive type, although the occurrence of comb structure is attested by waste on the dump. Calcite accompanies the quartz locally. Lindgren describes massive siderite occurring on quartz at the nearby Owyhee property (24b: p. 168). It is very likely that it also occurs in the Poorman. Variable amounts of minerals derived from the enclosing granite by hydrothermal action constitute accessory gangue minerals; these are: epidote, chlorite, sericite, and probably beidellite (terrierite). Browne (9b: p. 523) reports the vein matter of the upper workings as soft, a great portion being a siliceous clay (probably sericite or beidellite, with quartz).

The metallic species include native gold and silver, and the rich silver minerals, cerargyrite, pyrargyrite, proustite, polybasite, steph-
anite, and owyheeite (chemically a silver-bearing variety of jamesonite). Argentite (naumannite?) is reported from the lower levels but not from the old bonanza stopes. With these minerals, particularly in the lower levels of the mine, occur small quantities of pyrite, marcasite (?), galena, sphalerite, chalcopyrite, and the usual oxidation products of the latter mineral. Browne (9b: pp. 523-4) reports that most of the silver, to a depth of 250 feet, occurred as chloride, cerargyrite, plates of this mineral more than a foot square by a sixteenth of an inch in thickness and weighing many pounds being recovered. He also reports that about 100 feet below the surface there was found a homogeneous solid mass of the light ruby silver, proustite, which weighed more than 500 pounds and displayed, in part, the planes and angles of a crystal. Browne concludes that there is probably no second example of a similar mass of crystalline proustite being taken from any mine.

Much of the ore extracted in the sixties was fabulously rich, one shipment of first class ore returning a gross profit of more than $4,000 per ton when sent by sailing vessel to Newark, N. J. In 1866, a lot of 880 tons of second class ore returned $302 per ton when milled, and third class ore, which was not worked when other ground was available, returned $60 to $70 per ton. Amalgamation, the process of milling employed, did not give even approximate complete extraction on such heavy silver ores and their true precious metal content is not known. It is reported (7) that the bullion from the bonanza surface stopes was worth $1.80 per ounce with silver at $1.29. This is equivalent to a gold:silver ratio of 1 to 37.5 by weight. The ratio of gold to silver was 1 to 5.6 in the bullion produced from the intermediate levels. In 1871 the dumps yielded 928 tons of ore which yielded $19.53 per ton, although no underground development was done. The following year stope-fills and dumps yielded 567 tons at $21.24 and 920 tons at $12.76 per ton. On the 450-foot level, the lowest in the mine, a body of ore, 12 inches wide and 60 feet long, yielded $35 per ton, the bullion produced containing 1 part gold and 1.1 parts silver (7). This ratio is somewhat lower than that which characterizes any other ore deposit of the region, so far as data are available, and, if authentic, fully refutes the former belief that the ore from the Poorman mine was predominantly a silver ore quite different from others of War Eagle Mountain.

Undoubtedly the high-grade cerargyrite ores of the bonanza stopes are the result of oxidation and secondary enrichment.
although the extent to which these processes have been active is not known. Britt (7) describes the ore from the 450-foot level as unoxidized, although the winze was sunk through oxidized material. Determination of the extent of secondary enrichment and of the tenor of the primary ore are essential before the promise of the deposit may be estimated.

Ore Shoots.—The longitudinal section of the mine (fig. 3) shows one main ore shoot which pitches about 45° N. in the vein and a second small shoot developed near the southern end of the workings. Apparently the bonanza ore terminated approximately at the Oso level. Mr. R. S. Hawes, foreman in the mine during the seventies, reports that the best ore was found wherever the main vein was intersected by a spur vein or a barren fissure. The strike and dip of the Empire vein are such that its intersection with the Poorman vein would pitch northward about 45°. The Empire vein at the surface passes near the north shaft, so that the intersection would approximately bound the ore shoot on the north. It seems probable, therefore, that the position of this ore shoot was controlled by the intersection of two fractures in which the vein forming agents were active. If this be true, it is to be expected that ore shoots elsewhere may be similarly controlled, and it becomes possible to anticipate their positions.

SILVER CORD MINE

The Silver Cord vein, formerly the South Poorman, has been referred to in an earlier paragraph. It is considered by some as an extension of the Owyhee vein, but that correlation is doubtful, and it seems more likely that it is an extension of the Jackson. The vein is opened by a shaft, 500 feet deep, reported to be sunk vertically in the hanging (east) wall of the vein so as to intersect it at depth. Five levels were turned, and a small body of ore, apparently of vertical pitch, was extracted from the uppermost three. A small 'bunch' of ore was also developed between the fourth and fifth levels (24b: fig. 20, pp. 152 and 154). The total production is not known, although the property was operated at intervals from 1866 until 1887. The vein averaged 18 to 24 inches in width and attained a maximum of 4 feet. Some of the first-class ore mined in 1887 returned $2,600 per ton, but that from the lower levels, and throughout most of the mine, rarely above $100 per ton. The Mint report of 1885 (10e) credits the mine with a production of $6,976, the bullion carrying approximately 1 part gold to 4 parts silver by weight.

GEOL0GY AND METALLIFEROUS RESOURCES OF SILVER CITY REGION

PROPERTIES ON THE ORO FINO-GOLDEN CHARIOT VEIN

MINES OPERATED PRIOR TO 1876

The Oro Fino-Golden Chariot vein has been described already as one of the dominant veins of War Eagle Mountain. It was this vein that supported the famous mines of the sixties and seventies, its total output prior to the financial crash of 1876 having been about $7,000,000 from a zone 3,600 feet long. The mines which contributed to the production are, in order from the north, the Oro Fino (Pl. II, No. 57), Ida Elmore (Pl. II, No. 58), Golden Chariot (Pl. II, No. 59), Minnesota (Pl. II, No. 61), South Chariot (Pl. II, No. 64), and Mahogany (Pl. II, No. 65). They may be referred to as the Oro Fino group. All these have been shut down for decades: their surface works have fallen to ruin, and theshafts and drifts have caved and become inaccessible. Unfortunately very little precise data regarding these properties are available, the passage of years having scattered the fragmentary records that were preserved, and diluted fact with legend to an amazing degree. The subsequent discussion is based upon facts gleaned from the reports of Browne (9) and Raymond (29) and from the descriptions given by Lindgren (24b: pp. 147-150).

The mines of the Oro Fino group were all located about 1865, although the Oro Fino had been discovered in 1863 during the first year of the camp's history. Operated at first by men of small means, and worked in a most reckless manner, the mines one by one came under the control of incorporated companies and were vigorously developed. The extremely rich surface ores having been exhausted, the mines operated against a steadily mounting cost of hoisting ore and water and a decreasing value of ore extracted. This condition was aggravated by the high unit costs of mining and milling and by the small area of ground operated by each organization. The mines had apparently reached such a depth in the early seventies, that the margin of profit was very small, and production was declining. The failure of the Bank of California, in 1876, swept away the financial support of the enterprises, and total collapse ensued. In 1885 the Oro Fino shaft was unwatered, and the mine was worked in a small way during that year and the next. In the same period there was some sporadic activity by lessees in the upper levels of the other mines from which the water could be drained, but production was negligible and none were unwatered and prospected at depth.
Although excellent tunnel sites were afforded by the steep slopes of Sinker Creek canyon, the mines were developed through shafts sunk on the vein. These shafts vary in depth from 350 feet or less (Oro Fino) to 1,250 feet (Golden Chariot). The Mahogany shaft, which is 1,180 feet deep, reaches the least elevation above sea level, or 6,160 feet. They are shown in projection on the vein by the accompanying longitudinal section (fig. 4). Plans of the underground workings are not available at the present time, so that the amount of development is unknown. The Ida Elmore and Golden Chariot shafts are situated but 75 feet apart and the workings were in part continuous. With this exception, it is not known whether the workings of the several properties made connection with one another nor that the vein was continuous and without structural offsets. Lindgren (24b: p. 150) notes that the sixth level of the Golden Chariot connected with the seventh level of the Minnesota, thus proving the continuity of the vein between these two.

The only sources of information bearing on the character of the ores mined are the reports of J. Ross Browne (9), Raymond (29), and of the Director of the Mint (10). This has been summarized by Lindgren (24b: pp. 148-150). All these sources have been freely drawn upon for the data of the following discussion. Gold exceeded silver in value throughout the mines, but only in some of the oxidized surface ores did it ever predominate by weight. In the Oro Fino, 80 tons extracted near the surface in 1869 returned $160 per ton, the gold to silver ratio being 1.1 by weight, although the average of the 2,050 tons mined prior to 1867 is given as $27 per ton. At a depth of 220 feet the ore returned $40 to $45 per ton, the bullion carrying 1 part gold to 7.3 parts silver. In 1871 the mine produced 958 tons averaging $28.09, and 2,262 tons averaging $17.35, and it is reported that little pay ore was found in the lower levels. In 1885 lessees extracted ore worth $66,870 in gold, and $12,553 in silver, and, in the following year, ore worth $18,827 in gold, and $6,464 in silver; the gold to silver ratios for the two years are 1 to 3.5 and 1 to 7.4 respectively. The increase of the relative amount of silver at depth is due to relative decrease in the intensity of enrichment by supergene agencies. A ratio of 1 to 7.3 exists for ore at a depth of 220 feet, and the maximum known ratio is 1 to 7.4, but in the absence of complete information, this should not be interpreted to mean that the effect of supergene agents has not extended much below 220 feet. An examining engineer (14) reported in 1886 that at the shaft station on the lowest level of the mine, 307 feet from the surface, the ledge was 16 feet wide and that a 4-ton lot of ore, taken across the ledge from wall to wall, averaged $20 per ton. This agrees closely in value with ore developed on the deepest levels of the other mines on the vein, ore which may be strictly primary. It may be, therefore, that in the Oro Fino, supergene enrichment has not extended much below 300 feet.

Less is known about the other mines of the Oro Fino group. The highest reported value per ton is $268 for a small lot of surface ore from the Golden Chariot, the least is $20 per ton for 5,965 tons taken from the same mine in 1872, when the shaft was approximately 700 feet deep. On the Ida Elmore the ore averaged $140 per ton at a depth of 150 feet, $101 per ton in 1869, and $26.67 per ton in 1871. The following year it is reported that the mine "after a long period of almost hopeless prospecting is at last giving promise of a heavy body of ore in depth. It has just been reached on the ninth level ** *" (29e: p. 190). The ore produced that same year averaged $44 per ton for 779 tons. At the Golden Chariot the ore averaged less than $30 per ton on the seventh level, but "good ore" was found on the eighth level in 1871. The production in that year was 13,751 tons at $55.36 per ton. The following year the statement is made that the mine "has been in low-grade ore for the last eighteen months. In the last two months, however, they have sorted the ore closely, and it is now paying about $36 per ton" (29e: p. 189). It was for this same year that the minimum recorded value of ore, as noted above, is reported. In the Minnesota the ore yielded $38 to $44 per ton. No notes are available for the South Chariot. At the Mahogany, the southernmost shaft of the group, the ore averaged $60 per ton in 1870, $50.08 in 1871 for 1,126 tons, and $40 in 1872, when the shaft was about 700 feet deep. In 1875 the shaft had attained its maximum depth of 1,180 feet, and it is reported that the eighth, ninth and tenth levels had been opened in good ore.

The failure of these enterprises to recover after the financial crash is not strange. As near as one can judge from the meager sources of information, the minimum value of profitable ore must have been at least $30 per ton. As each of the properties gained depth and encountered ore that is possibly but little enriched by supergene agencies, the margin of profit vanished. None of the reports cite ore of less than $20 average value per ton, even from the deepest levels opened.
Little is known in regard to size and distribution of ore shoots in the veins. Raymond (29i: p. 239) presents a longitudinal section of the Ida Elmore and Golden Chariot properties which suggests a northward pitch of about 70° for the surface ore body. This ore, however, is undoubtedly the result of supergene enrichment, and it cannot be properly assumed that this apparent pitch represents that of the primary ore body as a whole. The annexed longitudinal section of the Oro Fino-Golden Chariot vein (fig. 4) is prepared from a copy, reputed by seemingly adequate authority to be exact, of a section compiled in the eighties or early nineties by Frank Hewlett, formerly county and United States mineral surveyor. It outlines, in a somewhat generalized fashion, the amount and distribution of stoping. If the section is authentic, ore has been extracted almost without interruption for a horizontal length of about 3,600 feet, and to depths between 300 and 1,100 feet. Between the Ida Elmore and South Chariot shafts, a distance of about 1,400 feet, stoping has ceased uniformly at the eighth level of the Minnesota. If the true condition is accurately depicted, the ore body was not bottomed by the operations, prior to 1876. Apparently the Oro Fino-Golden Chariot vein has enclosed a large persistent ore body of medium precious metal content, a condition which gives distinct promise of further extension within the limitations created by the activity of supergene agents. The known ore body is developed in that portion of the vein in which it is intersected by numerous secondary vein fissures, and it is very possible that the conditions which pertain at the Poorman mine are also effective in the Oro Fino-Golden Chariot vein, and that the zone of ore deposition is controlled by these intersections. If this is the case, the ore body might have a considerable pitch in the vein, although conditions are not well enough known to predict that this pitch would necessarily be northward, as at the Poorman. Such a possibility would have a very direct bearing on any future development of the deposit, inasmuch as ore bodies would not be expected, except in those zones in which there exist shear fractures secondary to the main vein fissure.

GREAT WESTERN MINES COMPANY

The property of the Great Western Mines Co. (Pl. II, No. 55) is located on Sinker Creek drainage about a mile distant and nearly due north from the summit of War Eagle Mountain. The property comprises six and a fraction unpatented claims; five of which are held under lease and bond. The property was acquired by the pres-
ent operators in 1920, and furnished with an electrically driven 10 by 10 in. compressor, pneumatic drills, and complete equipment for efficient prospecting. The underground development has been on one level only, and through an adit crosscut 1,067 feet long. A drift which turns southward about 100 feet from the portal, reaches the probable extension of the Oro Fino vein about 800 feet to the south and follows it southward more than 1,600 feet. A second drift is turned near the face of the adit and has been prospected 600 feet along portions of two other veins of opposite dips. A plat of these workings is reproduced (fig. 5), and the multiple faulting shown thereon has been referred to previously. No workable ore has been developed, although a 1½ to 2-inch stringer of massive quartz at the west wall of the vein breccia has yielded a very small amount of specimen gold ore near the south end of the easterly drift. Fragments of "drag ore" were also encountered in the gouge filling of the fault zone which strikes westward across the vein about 1,800 feet south of the adit. Pyritized quartz is found in bunches scattered through all the vein segments developed, but a precious metal content is usually lacking. A small body of ore has been extracted from a shallow shaft on the Chapman claim, above the southern extremity of the Oro Fino vein drift, but the lower development found no continuation of it. It may be that this surface ore is the result of supergene concentration within a block limited by fracture gouge. At present the west drift is being driven beneath a second body of surface ore opened by an adit drift about 1,750 feet southwest of the Great Western adit portal. It has not yet, however, reached its objective.

AFTERTHOUGHT PROPERTY

The Afterthought property (Pl. II, No. 68) lies in the head of the South Fork of Sinker Creek about two-thirds of a mile southeast of War Eagle summit. The group comprises five claims, of which one is patented, and there is an unpatented mill site. The property was acquired as a prospect by the De Lamar Company, Ltd., about 1900, and opened by a 470-foot shaft sunk from the crest of the ridge between two forks of the creek. At a depth of 85 feet the shaft passed out of rhyolite glacial (?) debris into granite, and all development is in that rock. The total development does not exceed 2,000 feet. A deep tunnel was projected from the millsite, about 2,500 feet S. 60° E. from the shaft, and 530 feet below it, but it never became an actuality. A substantially built shaft-house and head-frame equipped with boiler and small steam hoist, a boarding
house, and a small mill-building on the creek, constitute the physical property. Five levels are turned from the shaft on a vein which dips 85° E. and is probably a southward extension of the Oro Fino-Golden Chariot. This vein varies in width between 4 inches and 6 feet, averaging 2½ or 3 feet. It is, in part, a breccia in the basalt dike which the Oro Fino vein seems to follow throughout much of its length, and, in part, a filled fissure in granite. A body of ore developed on the first four levels is 240 feet long on the second level and averages $45 per ton, and 0.14 ounce gold and 17.0 ounces silver per ton on the fourth. The shoot seems to be only about 35 feet long on the fifth level, with an average value of $54 per ton. The ore from the upper levels is oxidized, but that on the fourth and fifth showed abundant wire silver and silver sulphides, which were not found above. On the second level, 181 feet below the shaft collar, the vein is cut off by a fault-gouge dipping southward at a low angle. This fracture has been referred to in the sections treating of regional structure and of structural features on War Eagle Mountain. The continuation of the vein has not been sought southward. The shaft was filled with water in 1925, and was not accessible to the writers; the information upon which this discussion is based being gathered from oral discussion with the owner, Mr. E. V. Orford.

WAR EAGLE CONSOLIDATED MINING COMPANY

The property of the War Eagle Consolidated Mining Company comprises eight patented claims which cover the Oro Fino-Golden Chariot vein throughout that portion which was worked by the mines of the Oro Fino group. The company was organized to explore that productive vein system at depth. In 1899 an adit, Sinker Tunnel (Pl. II, No. 56), was started from the south slope of War Eagle Mountain at an elevation of approximately 5,450 feet, about 2,030 feet below the collar of the Ida Elmore shaft (Pl. II, No. 58), and driven toward that shaft. In 1902 a vein, believed to be the one sought, was encountered at a distance of 6,177 feet from the portal, and a drift was turned southward, although it is not known how much exploratory work was done on that level. Conflicting reports exist as to conditions found, and authentic information is not at hand. At the point the adit penetrated the vein a raise was started. Apparently, adequate survey had not been made to determine the position of the adit with respect to the base of the old shaft, although at the time the work was started those shafts could have been opened with relative ease. Subsequent operations were a blind groping for the old workings above. Levels were turned from the raise at 100-foot intervals and short exploratory drifts extended. In 1905, when the raise had been pushed to a height of 622 feet, it was pronounced unduly hazardous by the State Mine Inspector and further work was ordered suspended until the hazards were removed. At this time the top of the raise must have been about 400 feet below the bottom of the Ida Elmore shaft, and only 150 feet, or thereabouts, below the Golden Chariot. although their relative positions in the horizontal plane was not determined. Shortly afterward the enterprise was suspended without further work. In the present decade a lease on the project was acquired by the Sinker Tunnel Mining Co., of Nampa, Idaho, and exploration of the adit level was inaugurated. Drifts were driven on two veins, and a third was disclosed by an extension of the adit so that the total exploratory work on this level was about 2,600 feet. Workable ore was not developed, although specific data are unattainable. In 1923, this enterprise collapsed and has remained dormant since.

It has been shown that the large ore body of this group is probably controlled by the intersections of the main vein with secondary veins, and that it may have a marked pitch in the vein. Unfortunately this possible pitch cannot be predicted. It is quite possible that the relatively slight amount of exploratory work done on the adit level of Sinker tunnel may have been beneath a pitching ore body which it did not reach; exactly the condition that probably is true for the lower levels of the De Lamar mine. It cannot be concluded, therefore, that the development has exhausted the possibilities of the Oro Fino vein.

Sinker tunnel constitutes an ideal site for mining and milling operations, with ample dump ground, ample water supply for milling purposes within two miles or less of the portal, a minimum snow hazard, and a route of approach which could easily be made usable by trucks the year round. The physical property at the portal includes office building, boarding house, boiler house, and blacksmith shop, with auxiliary transformer house, powder magazine, and warehouse. All are in good repair. The power plant is equipped with an Ingersoll-Sergeant 14 by 17½-inch duplex compressor, driven by a 75-horsepower induction motor, with steam plant for emergency operation. A Green No. 4 rotary blower serves the needs of ventilation. Pipe threading machine, timber saw, 12-inch lathe,
and auxiliary equipment of various sorts is present. An electric transmission line extends to the sub-station of the Idaho Power Company at Silver City. The tunnel was penetrated for more than 2,000 feet by the writer, but further ingress was impossible without ventilation. With the exception of a cave near the portal, the adit was in excellent condition the entire distance and could easily be conditioned for further use.

PROPERTIES ON THE SECONDARY VEINS

Lindgren (24b: pp. 154-5) writes as follows of the secondary veins of War Eagle Mountain:

"Among the outer members of the system are the Derringer Resort (Pl. II, No. 62), San Juan (Pl. II, No. 63), Liberty, and other smaller veins which have not been extensively developed. Then follows, going westward, the strong vein extending from Stormy Hill to Salvador. This has been developed to a depth of 700 feet by the War Eagle shaft (Pl. II, No. 46), which was worked from 1870 to 1884. The production for 1873 is given in Raymond's reports as $31,626, the value of the ore being $35 per ton. The southern end of the vein is opened by the Stormy Hill shaft, from which some ore was produced in 1882, 1883, and 1884. The vein is here wide and well defined, containing much of the laminated pseudomorphous quartz similar to that from the horizontal feet farther west is the Illinois Central vein, which has been developed by a shaft (Pl. II, No. 42) 600 feet deep. The mine is credited with a production of $24,278 in 1873, the ore containing $75 per ton. In 1875 it is stated that the shaft was down 510 feet deep, following an 1815-foot body, averaging $75 per ton. The mine has been idle for the last fifteen years. The ore shoot is 200 feet long on the surface, narrowing with depth. Two hundred feet west of the Illinois Central is the Empire vein, which appears to extend across the Poorman, being traceable for a total distance of 3,000 feet. The principal developments are found at the southern end, where the Empire shaft (Pl. II, No. 43) is sunk to a depth of 460 feet, its bottom connecting by a crosscut with the Belle Peck tunnel. The vein dips 60° E. The following amounts are found credited to it in the early report: 1872, $55,394; 1873, $45,000; total, $100,394. The whole production is not known. In 1885 the mine was closed with a small production of $2,055. The vein ranges in thickness from a few inches to three feet. The gangue is a massive quartz containing a little pyrite, chalcopyrite, and sometimes native gold, which has a value of $10 per ounce. The main ore shoot was found in 1872, and followed the intersection of the vein with a perpendicular cross seam. The ore shoot was followed through three levels downward. Where cut by the crosscut from the Poorman vein, the Empire shows two seams of quartz, each two inches wide, separated by five inches of crushed granite. To the southward the Empire vein appears to be continued by the Idlewild, which is developed by two smaller shafts. The Idlewild is credited in the Mint reports with a production of $87,600 in 1884 and $62,214 in 1885. The proportion of gold to silver by weight is stated to have been 1:85."

FUTURE POSSIBILITIES OF THE VEIN SYSTEM

In the following paragraphs the future possibilities that lie in the veins of War Eagle Mountain are discussed as a unit, inasmuch as the problem of one is the problem of all. It has already been shown in the preceding discussion of ore deposits that the zone of primary ore bodies of the Silver City region may be expected to persist without great change in tenor to a depth considerably below any attained by past mining activity. If it is true that the ore developed on the lowest levels of the mines of the Oro Fino group is hypogene or primary, which seems to be likely, and if it has the reported tenor cited in the preceding discussion, there is considerable promise of future activity.

The promise is sufficiently great to justify closing the gap between the Sinker tunnel raise and the old workings above, so that, with drainage and ventilation solved, these workings can be entered, the vein sampled and examined, and development extended downward as conditions may warrant. Obviously, however, a careful preliminary survey becomes an essential part of such a program in order that the raise may be extended with safety and certainty. The Golden Chariot shaft was sunk in the granite wall rock, striking the vein at the ninth level (29e p. 189), below which it has been sunk about 350 feet. It is probable that this shaft, although caved at the collar, is in good condition for the greater part of its depth, particularly below the water level. Opening and unwatering it sufficiently to permit accurate surveying should not, if the expected condition prevails, be an extremely difficult task and should not be shirked. As has been pointed out already, the base of the shaft and the top of the raise are not much more than 150 feet apart vertically and perhaps even less horizontally, if the available data are all trustworthy. This program offers the most expeditious and economical solution of the problem. Should this development prove the existence of workable primary ore, the Sinker tunnel should be extended to crosscut the entire vein system to the Poorman, since the maximum of economy and efficiency may be gained by working the system as a unit.

OTHER PROPERTIES ON WAR EAGLE MOUNTAIN

MORNING STAR MINE

The Morning Star mine, which lies but a quarter of a mile north of Silver City, was one of the earliest lode discoveries and boasted the first mill of Owyhee County, erected in 1864. According to Lindgren (24b: pp. 165-7) it was worked intermittently through the sixties, seventies, and eighties, and was re-opened in 1895 but closed down permanently two years later. The total production is said to exceed $1,000,000, but accurate data are not available.

The mine is opened by an inclined shaft (Pl. II, No. 28) 450 feet deep, which dips westward at a high angle and from which five levels are turned. Most of the exploration has been northward
from the shaft, and the maximum length of level is 400 feet. None of these workings were accessible to the writers in 1925. The vein, which strikes nearly due north and dips westward, consists of 12 to 30 inches of quartz in which excellent comb structure is displayed. In most of the mine, the vein is enclosed by granite, although a dike of dacite porphyry has been encountered in the lower workings. These rocks are but slightly bleached by hydrothermal alteration and the dike rock contains small pyrite crystals.

Ore minerals are found only in the quartz and consist chiefly of chalcopyrite with small amounts of native gold and silver and other silver minerals. No ruby silver has been found. The Mint report of 1885 shows the gold to silver ratio for the year’s bullion output to be 1 to 5, although 1 to 100 more nearly represents the normal composition of the ore. The ore shoots are irregular and difficult to trace.

**ADDIE CONSOLIDATED MINING COMPANY**

The property of the Addie Consolidated Mining Co. included eight patented claims, and a patented fraction, the group trending about N. 10° E. along a probable extension of the Deluge vein. This company, about 1900, acquired the site of Bishop tunnel, which is described by Lindgren (24b: pp. 155-6), and drove a new adit (Pl. II, No. 31) along the vein, which strikes approximately N. 10° E. An aggregate of 2,800 feet of drifts have been opened on two veins on the main adit level, and an ore body reported to be 600 feet long, was stopped above it. Records are not available to show the tenor of the ore, the quantity extracted, or the exact size and pitch of the shoot. The workings were inaccessible to the writer and nothing of the vein in its relation to the enclosing rocks could be observed.

The mill on the property is equipped with a 6- by 10-inch jaw crushe, a battery of five 1,000-pound stamps crushing to 40 mesh, a Frue vanner, Wheeler amalgamating pan, Deister slime table, and accessory settlers, tanks, and bin. Electric power is available for operation. The milling cycle employed has been discussed on an earlier page under the section describing metallurgical processes.

**NEVER SWEAT MINING COMPANY**

The Never Sweat Mining Company's property comprises five unpatented mining claims on the western slope of Stormy Hill ridge and about a mile S. 25° W. from War Eagle summit. The group was acquired by purchase in 1923, and boarding house, mine and mill buildings, and complete mining and milling equipment were installed. A small tonnage of ore was extracted and concentrated during that year, and the sinking of a shaft was inaugurated. In 1924 the mill was wholly rebuilt and refurbished, development was pushed vigorously, and some ore was mined. During the latter half of 1925, operations were suspended and the property is now idle.

The property is opened by a crosscut adit (Pl. II, No. 54) 400 feet long, from which 1,700 feet of drifts have been extended on three veins: a two-compartment shaft, 100 feet deep, sunk from the adit level, and one of the veins explored by a drift 1,040 feet long. A raise from the upper level connects with the bottom of a shallow shaft formerly sunk from the surface. The shaft station is equipped with an electrically operated hoist with 5,000 pounds rope pull at a hoisting speed of 300 feet per minute, and a No. 7 Sturtevant blower for ventilation purposes. The surface plant is equipped with an electrically driven 10 by 10 Sullivan compressor, Ingersoll-Rand steel sharpener, and a complete suite of accessory equipment.

The mill, of 50 tons daily capacity, is electrically driven throughout. The equipment includes a 6 by 15-inch jaw crushe, 3 by 8-foot rod mill with open-end discharge, a cone thickener, two Willey tables, Callow pneumatic rougher flotation cell, and a Callow cleaner cell. Water storage tank, setting tank, sand pumps, flotation reagent feeder, and tailings thickener constitute the accessory apparatus. The flow sheet of this mill has been described on another page under the discussion of metallurgical processes.

Three veins have been explored. The Never Sweat vein, upon which most of the exploratory work has been done, strikes N. 20° W. and dips 70°-80° E. The California vein lies 200 feet east of the Never Sweat and is parallel to it. Near the northern end of the upper level the Flat vein, which strikes N. 5° W. and dips approximately 45° E., intersects the Never Sweat; its intersection with the California has not been disclosed by the development. Only the Never Sweat vein has been explored on the lower level. The enclosing rock is usually granite, although on the lower level the vein penetrates a dike of dacite porphyry.

The veins are fissure fillings which vary from a 1 1/2-inch stringer on the one hand to an 18-inch vein on the other. The vein filling is quartz, usually massive, which is accompanied by a very small quantity of calcite. Locally the vein filling is made up of an excellent comb of quartz at either wall, separated by a seam of chalky-white clayey sericitic material which may be in part the species beidellite.
The metallic minerals show plainly the effects of supergene agents and the tenor of the ore is undoubtedly due in considerable measure to secondary enrichment. This being true, the productive life of the mine depends directly upon the depth to which these processes have been active, a problem which can be met only by a development program which is at the same time conservative and courageous. In the present upper level, an ore body has been developed for a length of 250 feet which is reported to average 17 inches in width, 0.40 ounce gold and 92.8 ounces silver per ton. This ore decreased sharply in value about 30 feet above the level, and no such grade of ore was developed on the lower level. The ore shoot seems to pitch southward about 60°, although this cannot be positively recognized.

The relative abundance of the metallic minerals which constitute the ore may be estimated from the following analysis of flotation concentrate from ore extracted from the Flat vein and the California vein above the adit level:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>% of Concentrate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>66.5 oz. per ton</td>
</tr>
<tr>
<td>Silver</td>
<td>1617.0 oz. per ton</td>
</tr>
<tr>
<td>Lead</td>
<td>None</td>
</tr>
<tr>
<td>Zinc</td>
<td>1.5%</td>
</tr>
<tr>
<td>Iron</td>
<td>29.3</td>
</tr>
<tr>
<td>Copper</td>
<td>1.2</td>
</tr>
<tr>
<td>Antimony</td>
<td>2.2</td>
</tr>
<tr>
<td>Sulphur</td>
<td>24.6</td>
</tr>
<tr>
<td>Insoluble</td>
<td>33.6</td>
</tr>
</tbody>
</table>

**RED JACKET GOLD MINING COMPANY**

The Red Jacket Gold Mining Company's group comprises 13 unpatented claims, six of which are held under lease and bond. The property is opened by five adit tunnels with a total development of approximately 4,500 feet along the Dernier Resort and parallel veins of the southeastern slope of War Eagle Mountain. The main adit (Pl. II, No. 66) is being extended to reach the Red Jacket vein, which was worked during the eighties through a shaft (Pl. II, No. 45), but has not yet reached its objective. So far as is known, no workable ore has been developed on this level. The mine is furnished with an electrically driven Ingersoll-Rand duplex compressor, and complete operating equipment. A 15-ton mill adapted to amalgamation and concentration is fitted with Blake crusher, 4-foot Victory ball mill, Gibson amalgamator, and Isbel concentrator.

**MINING PROPERTIES OF THE FLINT DISTRICT**

**PRECIOUS METALS MINES COMPANY (RISING STAR MINE)**

**Location.**—The Precious Metals Mines Company's property, of which the old Rising Star mine forms the nucleus, covers the western slope of Black Warrior Mountain and the lower parts of Astor, Twilight, and Hardup gulches westward to Flint Creek (Pl. III). The group comprises four patented and 15 unpatented claims, some of which are held under lease and bond. It may be reached from Silver City by an inferior road, 9.8 miles long, which crosses a 7,600-foot divide, and descends Flint Creek; or from Jordan Valley, Oregon, by an equally poor but better graded road 22 miles in length, which could easily be improved and could be kept open throughout the winter. Neither road is at present adequate to the transportation facilities which extensive development of the property and district would require.

**History.**—The Rising Star mine was discovered in 1865 and worked by individual enterprise for many years. The property is mentioned in Browne's report of 1868 (9b: p. 528) as being well developed, and two small mills were being erected at that time to treat the ores. Several shafts were sunk, the main entry being an incline sunk along the vein (Pl. III, No. 14). The enterprise collapsed during the financial panic which swept the district in 1876, and the mine remained idle until the early eighties. The Perseverance mine (Pl. III, No. 12) was also located about this time, and was opened by two shafts, to a depth of about 150 feet. The veins were worked spasmodically for several years, and a large mill was erected about 1888, but activity ceased soon after. Some prospecting was carried on from 1897 to 1900. In 1909 an English corporation, the Flint Mines, Limited, acquired the property and carried on an extensive development program. The Mill tunnel (Pl. III, Nos. 11 and 13) was driven to the lodes, and a vertical shaft was sunk 200 feet from the lower level. The mill was placed in condition to operate, and some ore was mined. In 1914, however, the outbreak of the World War caused the withdrawal of financial support and the mine again ceased operation. In 1923 the property was acquired by the present company and the mine and mill were equipped, and a transmission line built for electric power. Active development was pushed throughout 1924, and about 400 tons of ore were mined and milled. Early in 1925 the mine was closed down, owing to financial difficulties.
The total production from the property cannot be accurately known, inasmuch as adequate records were not kept during the early years of operation. The Mint reports credit the following partial output from the district as a whole, most of which was from the Rising Star mine: In 1869, $90,000, the ore containing $90 per ton; in 1871, $34,822, the ore containing $178 per ton; in 1872, $8,000, the ore containing $151 per ton (24b: p. 188). The operations at the old Perseverance property are credited with having yielded a gross profit of $166,000, even after the ore had been freighted to Winnemucca by ox team, thence to San Francisco by rail, and thence by sailing vessel to Swansea, Wales. Mr. R. V. Thurston, manager at the property in 1925, has estimated, from the data available, that the total production is not far from 1,500,000 ounces of silver.

Development and Equipment.—The old inclined shaft on the Rising Star vein was sunk to a depth of about 500 feet, and levels turned from it every 100 feet, slope distance. These levels are known as “old No. 2,” “old No. 3,” and so on to “old No. 5.” They are driven, so far as is known, only on the Rising Star vein and only northward from the shaft. The present main working level is the lower adit, known as No. 4 level, which opens the Rising Star vein about 30 feet below “old No. 4.” No. 2 adit or “Stanton Tunnel” (Pl. III, No. 13) connects with “old No. 2 level” and serves as an upper ventilation entry. On No. 4 level, drifts are turned along four veins. A 200-foot vertical shaft has been sunk from No. 4 level close to the Rising Star vein, and levels Nos. 5 and 6 turned therefrom. In the aggregate about 12,000 feet of workings have been opened, and the main adit being 2,100 feet long. The shaft levels were filled with water and only a small portion of those above No. 4 were accessible in 1923.

The property is served by a 4-mile transmission line, connecting with that of the Demming Mines Company and receiving power from the Swan Falls plant of the Idaho Light & Power Company. The milling scheme involves crushing to 40-mesh by two 5-stamp batteries and concentration in improvised pneumatic flotation machines of the Callow type. Water for milling purposes is available by a gravity line in moderate quantity within a mile of the mill site, also by pumping from a shallow well near the mill. Sufficient light timber for timbering operations may be cut in the head of Astor Gulch, there is also a small stand of timber about six miles to the northwest.

Country Rock.—The veins of the Flint district and of the Precious Metals Mines Company’s property are found only in the granodiorite intrusive and do not penetrate the overlying basaltic and rhyolitic lavas. Small blocks and masses of schist which are enclosed by the granodiorite form the walls of the veins here and there. The Rising Star vein is followed through most of the mine by a basaltic dike, so that it appears as though one of its walls is of basalt. The true relation between granodiorite, vein, and basalt is clearly exposed by No. 4 Rising Star drift, as shown by the accompanying sketch (fig. 6). The dike follows the footwall of the vein as it crosses the adit, follows a post-mineral fault along which the vein has been displaced, follows the footwall again for a distance, then diverges from the vein into the granodiorite. Elsewhere in the mine the dike follows the hanging wall.

Structural Features.—Throughout the Flint district the veins have been displaced by a complex system of faults so that none can be traced on the surface for any great distance without interruptions. The same system of displacements is exposed underground. The dominant fractures are shown by the geologic map (Pl. III), and the direction of displacement so far as known, has been discussed in the section that deals with structure of the region. The sketch
plan of a part of No. 4 level (fig. 6) shows other fractures, one of which cuts off the Rising Star vein about 250 feet north of the shaft. The displacement should apparently be to the northward in the eastern block. Unfortunately it was not possible in the brief field period to analyze the fault problem in complete detail, although it was recognized that shovelling or longitudinal movement along the fault is usually the greatest component of the displacement. Future development should be accompanied by careful geologic mapping.

Vein System.—At least six parallel veins have been disclosed by surface prospecting, of which the four most westerly ones have been developed underground. In order, from west to east, these are: No. 1 vein, No. 2, No. 3 or Perseverance (Pl. III, No. 12), and No. 4 or Rising Star (Pl. III, No. 14). These veins strike N. 10° W. to N. 10° E., except where they have been severely distorted by faulting, their dip is 65°-85° E. One vein, No. 1, dips 62° W. at a point due east of No. 4 adit portal and stands vertical at a point, 500 feet to the south. This sharp change of dip is likely to be due to the intense faulting. The Rising Star vein, the most strongly developed of the series, is from 10 to 20 feet wide and may be traced 500 feet northward and 600 feet southward from the old shaft. At the surface it dips 65° E., but about 20 feet below No. 4 level its dip steepens sharply to 85° E. The other veins of the series vary in width from one to five feet.

In age, the veins are clearly related to the granodiorite. Several aplite dikes follow the same joint set as the veins. Moreover, the veins do not penetrate the lavas that overlie the granodiorite. The basalt dike which follows the Rising Star vein is absolutely fresh and unaltered by the vein-forming agents, and it is clear from the relation that exists on No. 4 level that it was intruded after the vein had been displaced by faulting. Obviously the veins are older than the basalts and essentially contemporaneous with the aplite dikes. They must have been formed, therefore, as a late phase of the activity of the granodiorite magma.

Ores.—The dominant gangue mineral is quartz, accompanied by variable and very limited quantities of calcite, sericite and muscovite, beidellite (leuverrierite), and graphite. The quartz is usually dense and massive, although druses and vugs are abundant in some portions of the veins. Dystrophism has shattered the vein-filling in many places and locally a thin film of drusy quartz coats the faces of fracture plates, thereby proving that two periods of silicification have occurred. The later of these, however, was relatively unimportant.

The metallic species include the silver minerals miargyrite, pyrargyrite, polybasite, and stephanite; the silver-bearing variety of tetrahedrite, and pyrargyrite, together with small quantities of xanthoconite, argentite, naumannite (?), and stromeyerite. These silver minerals are accompanied by variable amounts of jamesonite, stibnite, chalcocite, galena, sphalerite, arsenopyrite, and pyrite. Gold occurs in the ores in relatively small amount, but its mineralogical form and its relation to the other minerals was not determinable. These minerals, with a few possible exceptions, are strictly hypogene or primary, and there is little evidence of secondary enrichment in any of the ore specimens. It is not likely, therefore, that the mineralogy of the ores will change materially as depth is gained; the tenor will change only as the relative amounts of the several species vary. The chemical nature of the ores is pictured by the following analysis of a sample of the flotation concentrate:

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Assay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gold</td>
<td>0.92 oz. per ton</td>
</tr>
<tr>
<td>Silver</td>
<td>63.5 oz. per ton</td>
</tr>
<tr>
<td>Lead</td>
<td>24.6%</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.4%</td>
</tr>
<tr>
<td>Copper</td>
<td>1.8%</td>
</tr>
<tr>
<td>Aresine</td>
<td>1.4%</td>
</tr>
<tr>
<td>Antimony</td>
<td>1.6%</td>
</tr>
<tr>
<td>Sulphur</td>
<td>28.6%</td>
</tr>
<tr>
<td>Insoluble</td>
<td>32.7%</td>
</tr>
</tbody>
</table>

The ores have been classified locally into high-grade and low-grade types, on the assumption that the mineralogy of the two differed. Such, however, is not the case, for all gradations exist as the rich silver minerals are diluted with progressively greater quantities of other sulphides. Jamesonite is the abundant diluent of some ores, stibnite in others. In the case of stibnite the gradation seems relatively complete from nearly pure antimony sulphide on the one hand to stibnite-free silver mineral on the other. A massive stibnite from the Silver Queen claim, one of the Birmingham group,
failed to show a trace of silver upon analysis; a similar material from No. 6 vein carried only 0.56 ounce of the precious metal per ton. Pyrite is not usually abundant in the shoots of silver ore, but is abundantly developed in other parts of the vein and is seemingly unaccompanied by either gold or silver.

**Ore Shoots.**—Detailed information as to the distribution and size of the ore shoots in the veins is not known, inasmuch as a complete mine map was not available to the writer, and most of the mine was inaccessible. The Precious Metals Mines Co. extracted its ore between "old" No. 5 and No. 4 levels from a block on the Rising Star vein about 135 feet long, the ore being limited to a hanging wall zone three to five feet wide, although the vein was as much as 15 feet wide in places. This block terminated northward against the fault that has been described and southward against the basalt dike; it is not, therefore, a true shoot and its apparent pitch is of no significance. Mr. Thurston reports that throughout the mine the ore bodies occur at one wall or the other of the vein, usually at the hanging; and that, locally, ore occurs at both walls where one shoot overlaps another slightly. There is some suggestion that the ore shoots pitch southward in the veins, but this suggestion remains unconfirmed.

**Ore Reserves.**—The quantity and tenor of ore remaining in the mine is not known, inasmuch as only No. 4 level was accessible for examination during the field study, and descriptions of the other levels were not available. The block mined on the Rising Star vein below No. 4 level assayed 20 to 30 ounces silver per ton. Whether ore remains untested on the deeper levels is not known. A body of good ore has been developed in the Perseverance vein on the same level, but the conditions on other levels are conjectured only. No ore is disclosed on veins Nos. 1 and 2, and the amount of exploratory drifting thereon is negligible.

Adequate reserves can be established only by unwattering the lower levels of the mine so that suitable examinations may be made: by intelligent and courageous prospecting of all known veins on each level; by deeper prospecting; and by search of new ground. The fact that no great change in the tenor of the ore is to be expected at depths greater than those now reached lends great promise of success for any development that is undertaken. The greatest potential ore reserve of the mine lies in new ground, south of the adit. In this area, the Rising Star vein can be traced at the surface for 600 feet, maintaining its average width, and yet none of it has been explored underground. None of the other veins of the series has been developed in that same area. The fifth and sixth veins of the series remain unexplored beneath the surface, and warrant careful search. Altogether the indications are distinctly favorable toward an active future for the Precious Metals Company's property and for the Flint district alike.

**DOUGHBOY PROSPECT**

The workings of the Doughboy claim (Pl. III, No. 5), on the vein of the same name, are situated in Hardup Gulch about three-quarters of a mile above Flint Creek and near the northeast corner of sec. 3, T. 6 S., R. 4 W. The vein, which is a quartz seam averaging 15 inches in width and enclosed by granite, is developed by two adit tunnels and shallow surface pits. The lower adit level has about 600 feet of workings. The vein is displaced 40 feet by a fault, the northern block being moved eastward as shown by the geologic map (Pl. III). Some high-grade ore was extracted from the property in the past, but little is exposed at the present time. The claim, which is not patented, forms one of the Precious Metals Mines Company's group.

**BIRMINGHAM GROUP**

Fourteen unpatented claims in Astor and Twilight gulches, located in 1921 by Messrs. Arthur and Howard Birmingham of Jordan Valley, Oregon, comprise the Birmingham group. These claims cover the most promising of the many workings. They were abandoned in the seventies and eighties and have lain idle since that time. They are not as yet wholly re-opened and adequate description of the ore deposits is not possible in most cases.

**Treasure Vault (Twilight).—**The Treasure Vault property (Pl. III, No. 6) lies on the south side of Twilight Gulch about two-thirds of a mile above Flint Creek. The property was actively worked as the Twilight mine in the early eighties and a considerable tonnage of ore was extracted from an inclined shaft and a drift along the vein, although the quantity of precious metals produced is unknown. These workings are now inaccessible. The vein strikes N. 5° E. and dips 65° E. It is also opened by a crosscut 245 feet long, driven from the level of the creek, and a drift 150 feet long. A body of ore 3' 6" to 5 feet wide and 105 feet long, which is reported to average $27 per ton in silver content, is exposed by the drift. The gangue consists of dense massive quartz; the metallic minerals are the same
as those of the Previous Metals Mines Co. deposit, the description of which applies in a general way to this occurrence. About 70 feet south of the crosscut, the ore body is cut off by a fault which strikes approximately N. 50° E. and dips 85° SE. At the northern end of the drift a second fault, which strikes N. 10° W. and dips 70° W., is converging toward the ore body and may cut it off. It is about 100 feet vertically from the drift up to the old stopes, with the length of the ore body increasing, due to divergence of vein and fault, so that a moderate tonnage of probable ore of good grade exists. Ore specimens show little positive evidence of secondary enrichment so that the tenor of the ore should change little with depth.

The drift from the lower crosscut turns about S. 40° W. at the south end of the ore body and penetrates the fault obliquely. It is reported that the drift was extended 500 feet or more without finding the extension of the vein, although it is caved 45 feet beyond the fault and is inaccessible. A strong heavily mineralized vein which crops on the summit of the ridge about 750 feet south of the lower adit portal and 275 feet above it, is probably an extension of the Treasure Vault or Twilight vein. This correlation, however, is only tentative. This vein terminates northward against a fault as shown by the geologic map (PI. III). Theoretical considerations suggest that the portion of the vein between the two segments shown on the map has been displaced eastward along the fault striking N. 50° E. and then southward along that striking N. 10° W. If this is true, it should crop across the summit of the ridge northeast of the southernmost of the two known segments. The amount of displacement is not known, but may be several hundred feet. Surface trenching should disclose the traces of the vein segments in sufficient detail to guide underground development.

Crescent Prospect.—The Crescent prospect (Pl. III, No. 9) lies in the head of Astor Gulch near the eastern edge of the district and slightly more than half a mile north of Black Warrior Mountain. A 5-foot vein of iron-stained shattered quartz is exposed at an old caved shaft, striking N. 15° W. and dipping 75° E. It is enclosed by granite, but does not penetrate the basaltic agglomerate which overlies that intrusive immediately east and north of the shaft. The property has been idle since the seventies or early eighties, so that little is accurately known about it, although the size of the dump indicates about 500 feet of underground work. A considerable amount of ore which is scattered over the dump, presumably represents material rejected in the old days when high-grade ore was cobbled over before shipment. The gangue is the usual massive white quartz with a small amount of the silver-bearing minerals characteristic of the district. Average specimens of this rejected ore assayed 40.9 ounces silver per ton, but no gold. An adit tunnel is being driven to intersect the old workings about 150 feet below the collar of the shaft, but lacks about 300 feet of reaching its objective.

Silver Queen Claim.—The Silver Queen property (Pl. III, No. 10) lies in Astor Gulch nearly half a mile below the Crescent property. It was opened in the early seventies, by shaft and adit tunnel, in the south wall of the canyon, and by adit drifts, into the north wall. It is reputed to have yielded a large tonnage of high grade ore. The dumps represent an aggregate of about 750 feet of underground development, although the ground was not open in 1925. A small pit on the northward extension of the vein yielded in 1925 several hundred pounds of stibnite ore from a 6-inch quartz stringer in the granite. A specimen of stibnite without gangue minerals failed to show a precious metal content when assayed. A narrow basaltic dike, 2 to 4 feet wide, follows the general course of the vein. In some places it follows one or another of the walls and elsewhere it follows a nearby fissure in the granite.

Other claims of the group upon which considerable work was done in the old days are the North Extension of the Silver Queen (Pl. III, No. 7), which is located in Twilight Gulch about 1,000 feet above the Treasure Vault, and the Gray Eagle (Pl. III, No. 8), situated on the crest of the divide between Twilight Gulch and Astor Gulch.

Nellie Ann Prospect

The Nellie Ann prospect (Pl. II, No. 1) is located near the head of Washington Gulch, a tributary of Jordan Creek, which drains the northern part of the Flint district. The group includes three unpatented claims, located in 1923, which strike about N. 15° E. and follow a 20-foot 'dike' which dips 70° W. This 'dike' is a zone of crushing in the granite which has been healed by intense silicification and thereby rendered weather-resistant. Numerous stringers and veinitlets of dense quartz branch from the 'dike,' striking N. 45°-65° E., and carry a variable content of auriferous pyrite. The ground is opened by 600 feet of adit, crosscut, and drifts with one 5-foot winze. Many quartz stringers 2 to 4 inches wide traverse
the crushed granite. Two ledges, silicified shear zones 2 to 3 feet wide, have been developed. Grab samples of the pyritiferous quartz assay 0.01 to 0.04 ounce gold and 0.3 to 3.5 ounces silver; a selected specimen of the most heavily mineralized quartz carries 0.64 ounce gold and 6.8 ounces silver per ton. This deposit of auriferous pyrite is not typical of the Flint district and is probably of the same age as the deposits at De Lamar and near Silver City.

A 15-inch band of quartz opened by the winze is reported to carry high-grade silver ore similar to that developed by the Precious Metals Mines Co. The winze was filled with water during 1925 and the relation of this ore to the auriferous pyrite could not be studied by the writer.

CONCLUSION

The re-examination of the Silver City mining region, upon which this report is based, has established two fundamental facts: first, the veins of the Silver City region have contained large ore bodies of medium and rather uniform tenor; second, there is no reason to expect that the ore bodies will fail to continue in depth. Moreover, a rather complex fault system has been analyzed as completely as the data of accessible mine workings permits, and the relations of the several sets of earth fractures to the ore deposits has been established. It is to be expected, therefore, that the lateral extensions of ore bodies beyond faults, and their extensions downward beyond the deep prospecting of the past, may be disclosed by further mining development.

The revival of mining activity in the region must depend upon the outcome of certain exploratory projects designed to test the application of theoretical conclusions to the problems of mining. In the expenditure of the large sums that will be necessary to prove or disprove the region, the utmost in boldness, tempered by technical conservatism, will be required of operators, lest the solution of fundamental problems be forgotten in the search for immediate profitable operation. It cannot be too strongly urged that detailed geologic mapping be made an essential part of every development program, and that the best geologic advice be made of use. Given means adequate to the extensive exploratory programs outlined, proper technical skill, and the courage and foresight that spring from a sound analysis of geologic conditions, it is likely that future development will revalesce this region, once a premier silver-gold mining camp of the West.

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NUMERICAL AND ALPHABETICAL
LISTS OF MINING PROPERTIES

2. Martin prospect.
4. Hornet claim.
5. Doughboy claim.
6. Treasure Vault claim.
7. North extension Silver Queen.
9. Crescent claim.
10. Silver Queen claim.
12. Perseverance shaft (1889).

EXPLANATION

- Rhyolite flows
  (Bandof porphyrites, massive spherulitic rocks, and vesicular rocks)
- Rhyolite dikes
- Basalt
  (Fine-grained felsitic and porphyritic rocks)
- Granodiorite
  (Includes areas of other rocks too small to differentiate)
- Gold and silver-bearing veins

Strike and dip

Faults

(Dotted line signifies a probable fault or the concealed trace of a known fracture; D—downthrown side; arrows indicate direction of throw if any.)

INDEX OF EARLY CRUSTAL DISTORTION

TOPOGRAPHIC AND GEOLOGIC MAP OF THE FLINT MINING DISTRICT

Control by A. M. Piper. Datum of elevations is based on the mean of three barometric elevations of 8,900 feet above mean sea level at the mill of the Precious Metals Mines Co.

Topography by A. M. Piper

Geology by A. M. Piper

Surveyed in 1925

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<tr>
<td>1000</td>
<td>3000 Feet</td>
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Contour interval 50 feet
Datum is mean sea level
GEOLOGIC PLAN OF THE EIGHTH LEVEL, De LAMAR MINE


EXPLANATION

- **Workable ore**
- **Low grade or barren ore** (includes all veins not definitely known to be of workable grade)
- **Faults** (Dotted line signifies a probable fault or the concealed trace of a known fracture. D = dip, arrows indicate direction of slope, if any)
- **Strike and Dip**

Of the notations along the veins, the first figure indicates the gold content of the ore in ounces per ton, the second figure denotes the silver content in ounces, the third figure denotes the width of the ore in inches.

No. 8 level
Mean elevation 5,045 ft
GEOLOGIC PLANS OF THE ELEVENTH, TWELFTH, AND SIXTEENTH LEVELS,
De LAMAR MINE

Base compiled from mine maps of the DeLamar Mining & Milling Co. and from annual reports of the DeLamar Company, Ltd.
Compiled by A. M. Piper, 1904.

Projections of veins and faults by A. M. Piper.
Geology by A. M. Piper.

Of the notations along the veins, the first figure indicates the gold content of the ore at ounces per ton, the second figure denotes the silver content in ounces; the third figure denotes the width of the ore in inches.

EXPLANATION

- Banded porphyritic shales
- Rhyolite rhyolite or breccia (marked present only, secondary altered and locally reduced)
- Breccia (fine-grained deposits and porphyry-like faces)
- Workable ore (includes all rocks not definitely known to be of workable grade)
- Low grade or barren ore (includes all rocks not definitely known to be of workable grade)
- Faults (shaded line represents probable fault or the structural trend of the fault plane. D - downthrown side, or may indicate direction of shear, if any)
- Strike and Dip

No. 13 level
Mean elevation 5,650

No. 14 level
Mean elevation 5,600

No. 15 level
Mean elevation 5,600
PLAN AND LONGITUDINAL SECTION OF THE BLACK J ACK-T RADE DOLLAR MINE

Of the notations at each stope, the upper figure denotes the gold content of the ore in ounces per ton, the second figure denotes the silver content in ounces, the third figure denotes the width of the ore where known. Each figure is an average for the stope.