STATE OF IDAHO
D. W. Davis, Governor
BUREAU OF MINES AND GEOLOGY
Francis A. Thomson, Secretary

THE COPPER DEPOSITS
OF THE
SEVEN DEVILS and ADJACENT DISTRICTS
(Including Heath, Hornet Creek, Hoodoo, and Deer Creek)

By
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(Published in Cooperation with the United States Geological Survey)

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COPPER DEPOSITS OF SEVEN DEVILS AND ADJACENT DISTRICTS

By

D. C. LIVINGSTON and F. B. LANEY

INTRODUCTION

The Snake River copper belt of western Idaho and eastern Oregon lies along both sides of the Snake River in a strip of country about 120 miles long and varying in width from a mile or two to thirty or forty in the Wallowa and Seven Devils Mountains. (See Map No. 1). Along this strip of territory the Snake River has excavated a deep canyon which has exposed a series of highly metamorphosed andesite and rhyolite tuffs, called in some cases greenstones, which were formerly overlain by the lava flows of the Columbia basin. Copper deposits of widely varying types are found throughout this strip of greenstone rocks. Some of the more notable districts and properties in this region are the Mineral district in the Hitt Mountains, Idaho; the Heath district on Cuddy Mountain; the McDougal property north of Homestead on the Oregon side of Snake River; the Seven Devils contact-metamorphic deposits; the Red Ledge on Deep Creek in the Seven Devils Mountains; the old Eureka mine on the Oregon side of Snake River near the mouth of the Imnaha River, and similar deposits on the Idaho side near the mouth of Salmon River; and the Deer Creek and Horseman properties on Craig Mountain, Idaho. There are also many other properties less known but possibly of equal importance.

North of this belt of greenstones, in the same northeasterly direction, the country rock consists chiefly of the quartzitic and schistose Belt series of pre-Cambrian sediments intruded by Cretaceous granite, wherever the Columbia lava is absent. In this region lie the mineralized districts near Troy, Idaho, the Hoodoo district in northern Latah County, and the copper district near Mullan in the Coeur d'Alenes. The latter deposits, too, in a different rock are possibly of the same metallogenic epoch as those in the andesite rocks of the Snake River and all of them are associated with the batholithic intrusions of granitic rocks which are exposed over such a large area in Central Idaho.

The work outlined by the State Bureau of Mines and Geology, for the summer of 1919, was intended to be confined to the Seven Devils district and the immediately adjacent properties. During the summer, however, some of the other districts were visited by one or both of the writers and it was decided to describe these districts also, but in a more cursory manner than
in the case of the Seven Devils, which was regarded as the main theme. At the present time the only producing mine of importance in this region is the Iron Dike at Homestead, Oregon, but from the examination of these districts the writers are of the opinion that several of the other properties possess great economic possibilities with a strong likelihood of becoming important producers of copper from low-grade ore on a large scale. Among these should be mentioned the Red Ledge mine in the Seven Devils, and the mineralized monzonite zone in the Heath district. There are also other deposits, which, the smaller, are considerably richer in copper content than the ones mentioned above and should, by intelligent development, be producers of fairly high-grade copper ore on a smaller scale. Among these might be mentioned the River Queen mine on Snake River below Homestead; the Horseman property on Craig Mountain; the Merger mine of the Hoodoo district and probably several of the rich but irregular bornite deposits of the Seven Devils.

It does not follow from this that these are the only properties in the region that the writers consider will make mines. There are many properties that were not visited at all, but of those which were visited the above appear at the present stage of development to be worthy of active exploitation and quite likely to become important producers of copper.

The Seven Devils quadrangle, with which this bulletin is chiefly concerned, lies between latitude 45° and 45° 15' and longitude 116° 30' and 116° 45'. (See Map No. 1.) Before the summer of 1919 the topographic branch of the U. S. Geological Survey had done no work in this quadrangle. Arrangements were made in the spring of 1919 for the U. S. Geological Survey to make a topographic map of this quadrangle for use as a geologic base, and the work was started on June 1st. As nothing had been done previously, it was necessary to extend the triangulation system into the quadrangle from Cuddy and Council Mountains, and also to carry levels in from Council, Idaho. By July 1st the triangulation was completed and the notes computed by Capt. R. W. Berry of the U. S. Geological Survey with some slight assistance from one of the writers and the levels were finished about three weeks later by Lieut. R. W. Burchard. Altogether owing to the illness of Capt. Berry in August the topographic survey of the whole quadrangle was not quite finished in 1919, yet that part of it containing the principal mines and prospects was, and the preliminary map was drafted in the winter of 1919-20.

The geological field work was done by Prof. D. C. Livingston of the University of Idaho, assisted by R. W. Davidson, Dr. F. R. Loney, geologist of the U. S. Geological Survey, ex-
COPPER DEPOSITS OF SEVEN DEVILS

THE SEVEN DEVILS MINING DISTRICT

The Seven Devils mining district is situated along the western border of Idaho near the middle of the State and its location can be seen by referring to maps No. 1 and 2. It lies in about the center of a mineralized belt which extends from the south end of the Hitt Mountains in Washington County to Craig Mountain in Lewis County and runs parallel to the Snake River for a distance of about 120 miles. This mineralized area might be termed the Snake River copper belt, as this metal is found throughout the region, associated with a series of andesite rocks of supposed Triassic age.

There are several small towns, or rather villages, in the Seven Devils district, the most important of which is Cuprum, which lies in the valley of Indian Creek. Two others, Landore and Helena, were at one time prosperous camps, the former particularly, as it is reported to have had at one time a population of about 1500 people but both of these places are now practically deserted. There is a postoffice at Cuprum and the postoffice in Landore was opened in the summer of 1919 for a short time. The nearest place where provisions, gasoline, etc., can be bought is at Bear, where there is a store and postoffice located on Bear Creek on the eastern edge of the district in a somewhat sparsely settled farming region.

The nearest railroad point is Homestead, Oregon, which is on a branch of the Oregon Short Line Railroad extending down the Snake River from Huntington. The mail is brought in from Council, Idaho, a small town on the Pacific and Idaho Northern Railroad, locally known as the “Jason” road, which runs between Weiser and New Meadows. The distance from Homestead to Cuprum is about 12 miles but there is a vertical rise of about 3500 feet in that distance, and in addition the Snake River has to be crossed on a ferry which is difficult to approach when the water in the river is low.

The distance between Council and Cuprum is in the neighborhood of 40 miles and the mail is carried by automobile over this road from about the end of May until the middle of November during a normal season. The difference in elevation between Council and Cuprum is only 1300 feet and the road is fairly good over the greater part. From Cuprum a well graded mountain road runs as far as Helena and although rough in places, this road can be traveled by automobile during the summer months. A mile or two south of Helena this road, which is known as the Kleinschmidt grade, crosses the divide from Indian Creek and comes out upon the upper edge of the Snake River Canyon, and from it a magnificent view of the Snake Canyon, and of the Wallowa Mountains of Oregon can be obtained.
Cuprum, Idaho

Photo by R. W. Berry

Monzonite Dome at Head of the East Fork of Brownlee Creek
Smith Mountain From the South

Old Erosion-surface Topography (Eocene) East of Helena
PHYSIOGRAPHY.

The country is extremely rugged and it is doubtful if there is any region in the United States where the relief is much greater than in this district. From the top of the Seven Devils Mountains to the Snake River there is a fall of over 7500 feet in a distance of less than 6 miles and the last 2000 feet of this fall, in the Snake River Canyon, is almost vertical. The creeks which flow from the Seven Devils Range into the Snake River have a heavy fall. For instance Deep Creek, which is probably the largest of these, drops over a mile vertically between its head and the Snake River in a distance of about 9 miles, and the greater part of this fall is in the last 4 miles, as the upper part of the valley is glaciated and considerably flatter than the lower, which is almost one continuous water fall.

There is a remarkable wealth of physiographic forms shown in the district. A detailed description would be out of place in an economic report but they are deserving of a brief mention. They may be enumerated as follows:

1. Old erosion surface topography.
2. Columbia River basalt plateau.
3. Snake River Canyon.
4. A system of parallel northeast southwest valleys with abnormal drainage in relation to Snake River (probably due to faulting or folding).
5. Seven Devils Mountains.

1. Old Erosion Surface Topography.

Before discussing these various features, a brief description of the Seven Devils Mountains in their relation to the mountain mass in Central Idaho is necessary in order to arrive at a clear understanding of the problems involved.

The Seven Devils Mountains are undoubtedly a westward spur or extension of the mountain mass which covers nearly 50,000 square miles in the central part of Idaho. That the Blue and Wallowa Mountains of Oregon are likewise extensions of this physiographic province is highly probable.

It has been advanced by both Lindgren * and Umpleby † that the mountains of Central Idaho have been carved out of an elevated erosion surface of Eocene age, and this statement is supported by sufficient evidence to warrant its adoption as a correct interpretation of the conditions. In the Seven Devils there are several areas where the topography is strikingly different from the steeply and recently eroded mountain slopes which prevail in the district. The main topographic feature dis-

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† Prof. Paper No. 27, U. S. Geological Survey.
played in the old erosion areas is a rolling country with gentle slopes, usually at fairly high elevations, and covered with bunch grass and a few scattered pinon pines. Examples of this type of topography are found in the area around Helena, which is probably the largest, another is Horse Mountain which lies between Indian Creek and the Snake River and another is Placer Basin on the divide between Indian and Dear Creeks. This old erosion surface has been covered in places with basalt flows of the same age as those in the basin of the Columbia with which they are directly connected.

Accordingly it is reasonable to suppose that this surface is older than the Miocene and younger than the granitic rocks which have been referred to the Cretaceous or Late Eocene and which have themselves been eroded to this gently rolling topography, and it is safe to assume that this is a part of the old Eocene peneplain described by Lindgren and Umpleby.

South of the Seven Devils this old erosion surface has been broken up into blocks, either by folding, or faulting, or by both. One of these fault blocks, or elevated areas, is Cuddy Mountain, another is Hitt Mountain still further to the south and the Seven Devils themselves may be regarded as an elevated block which is still attached on the east side to the main mountain area, but separated from the neighboring mountains by structural depressions.

A well defined structural depression lies between Hitt Mountain and Cuddy Mountain and is occupied by Brownlee and Pine Creeks, the former of which flows into the Snake and the latter into the Weiser River. A similar though somewhat less noticeable depression lies between Cuddy Mountain and the south end of the Seven Devils. This is a much wider depression than that between Cuddy and Hitt Mountains, being over three miles in width, and possessing to a large extent the typical topographic features of the portion of the Columbia basalt plateau that lies in eastern Washington and northwestern Idaho, and is in fact a detached or isolated portion of that plateau. From this depression, which has an elevation of between 4600 and 5000 feet Cuddy Mountain rises with a rather abrupt escarpment to the south and the Seven Devils, with a somewhat more gradual slope to the north.

The top of Cuddy Mountain also shows the same typical old erosion surface type of topography on its north end; its south end, however, is covered with basalt.

Whether these alternating elevated areas and depressions are caused by faulting or folding cannot be definitely stated at this time, although Cuddy Mountain, which is covered on its south end with basalt lying about horizontal, suggests an elevated fault
Cuddy Mountain from the South, Showing the Basalt Flows Overlying Granite Rocks

Sketch Explanatory of Geological Conditions in View Above
View across Snake River looking down Eckels creek from trail to Lyne's ranch. Shows folded limestone strata in the canyon wall overlain by basalt flows.

Sketch, Explanatory of Geological Conditions in View Above.
block. Whatever the nature of the movement might have been it was subsequent to the outpouring of the basalt which is found in scattered patches on the south end of the Seven Devils Mountains up to elevations of nearly 8000 feet and the only way in which it could have reached these points was by a differential uplift of the country since the lava was outpoured. This basalt evidently flowed out upon the old erosion surface and most of this surface has since been eroded away in the high mountains, but the few isolated areas remaining have a distinct topography of their own and are easily recognized either on the topographic map or upon the ground.

2. Columbia River Basalt Plateau.

This has already been mentioned as occurring in the structural depression that lies between Caddy Mountain and the Seven Devils. It is a rolling country underlain throughout most of the area by basalt and covered with soil residual from that rock. Most of it is timbered, but in the neighborhood of Lick Creek and from thence to Bear postoffice the country is open and strikingly similar in appearance to the so-called Palouse country of eastern Washington and northwestern Idaho, particularly to that part of the Palouse country cut by the canyons of the Clearwater River and its tributaries. It is chiefly a stock country as the rainfall is too scanty to make certain of the success of raising grain except in unusual years, due to the Wallowa and Blue Mountains to the west, which precipitate most of the moisture. Wherever water is available excellent crops can be raised and the bottom land in the valleys is particularly fertile.

3. Snake River Canyon.

This canyon has been well described by Lindgren but the details of its topography and structure have not as yet been fully worked out. From Huntington to Lewiston the Snake River flows thru a canyon which in the vicinity of the Seven Devils Mountains is over 7000 feet deep on the Idaho side, and is practically a narrow box with steep rock-slide covered slopes and perpendicular bluffs for a distance of over 20 miles. Both above and below the Seven Devils Mountains the canyon widens out slightly but is a forbidding gorge nevertheless. A branch of the Oregon Short Line Railroad extends from Huntington to Homestead and below Homestead there is a wagon road which continues down the river on the Oregon side for about seven miles. From the end of this wagon road trails continue as far as Lyne's ranch and Eagle bar, but below this point there is practically no route except a few disconnected trails to the mouth of the Grande Ronde River in Washington.
sequently travel along the river is difficult and about the only way it can be accomplished is by keeping high up on the plateau on the Oregon side and coming down the steep gullies to the river. Travel along the river except for occasional short distances is practically impossible. A gasoline boat is being arranged for carrying mail once a week between Lewiston and Pittsburgh Landing, which is near the foot of the Seven Devils Canyon. Supplies for the sheep ranchers have been brought up from Lewiston during high water in the spring as far as Pittsburgh Landing for several years past, but this is the first attempt to establish a regular service. A trail is being built from Lyne’s ranch to Deep Creek by a mining company that is operating the Red Ledge mine at that place so that this inaccessible region is beginning to be opened up by slow degrees.

The bottom of the canyon has been cut in the old andesite and rhyolite tuffs and breccias which are hard and resistant and form the steepest and narrowest part of the canyon. On the Oregon side these old rocks are overlaid by horizontal flows of Columbia River (Miocene) basalt up to an elevation of about 5000 feet. At the contact between the two, which varies considerably in altitude because of the irregular topography of the old surface, there is a well marked bench representing a small exposed strip of this old erosion surface. At Lyne’s and Huntley’s ranch between the mouth of Allison and Eckels Creeks, there is a wide bar of several hundred acres, forming one of the finest strips of farming land on this part of the river. This bar is due to the presence of an extensive area of limestone through which the river has cut its channel at this point and is a fine example of the effect of weathering and river erosion upon rocks of different structure and composition. In the soft limestone Snake River has been able to cut laterally as well as vertically, while during the same lapse of time it has only been able to cut vertically downward in the hard andesite. Accordingly the river has swung back and forth across the limestone belt undermining the steep mountain sides and depositing the material for the bar on the opposite side. Comparatively recently the river changed its course from the eastern side to the western and is now undermining the limestone on that side. The old channel of the river on the east side of the bar is now nearly 100 feet above the river at the lower end of the bar and is separated from the present channel by a ridge of boulders, the top of which is at least 150 feet above the water.

One of the most interesting problems to the physiographer is why the Snake River should have chosen to cut its way thru the Wallowa and Seven Devils Mountains when there is apparently an easier course to the Columbia thru the lake region of eastern Oregon and the Deschutes River.

The writers are of the opinion that between Huntington and the mouth of the Grande Ronde the Snake River has flowed in its present general course for a very long time and was in fact one of the principal streams that drained the old Eocene erosion surface previously mentioned.

This old channel must therefore have been older than the Miocene and should be covered by the lava flows of that age. One of the writers has in two places observed ancient river gravels overlain by the Miocene basalt. One of these is a short distance above the mouth of the Grande Ronde River in Washington and the other is on the Snake River side of the ridge that separates the Snake from the Salmon River at a place called Crooks Corral. At the latter place the gravel is made up of coarse boulders of quartz or quartzite which are supposed to be gold-bearing and this old bar has been placer-mined to a certain limited extent. Near the mouth of the Grande Ronde the wash is made up of boulders of quartzite and granite, the latter being completely disintegrated because of the decomposition of the feldspars. The boulders in the wash are of large size and evidently represent the wash of a big stream. Both of these areas of gravel lie on the old erosion surface from 2000 to 2500 feet above the present water level of the river.

This would appear to be strong, but not conclusive evidence that there was an ancient stream which followed the present course of the Snake, but the absolute proof of the existence of such a stream rests upon the discovery of other gravel areas which will match with those that already have been found.

The next question that arises is, why did the Snake persist in its present channel in spite of the thick lava flows that were poured out? From observations made in the Seven Devils the following explanation seems the most probable. The places where the Columbia River lava is now the thickest were undoubtedly the lowest places on the old erosion surface. On the Oregon side of Snake River, opposite the Seven Devils, the lava flows are very thick (two or three thousand feet in places), while on the Idaho side they are almost entirely missing except for a few small isolated patches. During the late Eocene the Snake River probably flowed nearer the Wallowa uplift than it does today and where now the thick layers of lava exist, there was then a wide but rather shallow valley bordered by rolling hills like those around Helena. One source of these basaltic lavas was in the Wallowa * Mountains, and it is more than probable that the great flows of basalt on the Oregon side of the Snake River came from these vents. If such was the case they would naturally first fill the old channel of the Snake and

crowd Snake River against the Seven Devils Mountains. That the Snake was able to hold its original course in spite of these lava flows can only be accounted for by the fact these flows either came at considerable intervals apart or that there was no other available outlet for the water.

Whatever the topography of the country may have been, it seems perfectly clear that the large tributary lakes that existed in the southern parts of Idaho and Oregon were formed by the Miocene lava flows damming the ancestral Snake River of that time, which river appears to have flowed between the Seven Devils and Wallowa Mountains where Snake River does today. Also in spite of the thick lava flows at that place, the gap between the Wallowa and the Seven Devils was the lowest point in the rim of this lake and the river cut its channel anew forming its present rugged canyon. It is evident that there has been an orogenic movement since the Miocene, consisting of a general uplift of the Wallows, Seven Devils, and Central Idaho, and a downward movement in the case of many structural valleys in eastern Oregon, as for example the upper part of the Grande Ronde, and adjacent valleys, but this movement seems to have had little effect upon the course of the Snake, showing that the uplift was slow.


South of the Seven Devils Mountains there are several streams which flow into the Snake River pointing up stream at an angle of about 45° to the general course of the river. The two most prominent of these are Indian Creek and Wildhorse Creek, which flow in a general southwesterly direction. In addition to these two streams there are several tributaries to Wildhorse Creek such as Bear Creek and Lick Creek which flow in the same direction.

The most remarkable stream is Crooked Creek, one of the principal tributaries of Wildhorse Creek which in the upper part of its course flows northeast, parallel to Wildhorse for a distance of 10 to 12 miles, but in exactly the opposite direction. It then makes a right-angled turn across the lava plateau and flows into Wildhorse Creek in a distance of about five miles. Streams occupying northeast-southwest valleys are not confined to the east side of Snake River but occur on the west side also, as for example—Pine Creek and North Pine Creek whose courses bear the same relationship to one another as do those of Crooked Creek and Wildhorse Creek. The course of at least part of the Snake River valley below Homestead is also in the same general direction.

That these streams are flowing along parallel lines of weakness caused by folds or faults is very evident but time was not available to determine the nature of these movements. A clue might be found by an examination of the remarkable oxbow on the Snake River at the mouth of Indian Creek, an explanation for which would undoubtedly account for the northeast-southwest valleys with which this oxbow bend is closely connected. These northeast-southwest valleys have some bearing upon the economic problems in the region as the main lines or directions along which mineralization has taken place are roughly parallel to the course of these valleys. That these facts as stated are due to coincidence is very unlikely and there is here a fine field for the physiographer in the investigation of the reason for these parallel valleys and also the reason for the abnormal drainage of Indian and Wildhorse Creeks in relation to the Snake River.

5. Seven Devils Mountains.

The name of this range has been derived from a ridge of jagged peaks which lies between Granite Creek and the head of Rapid River. These mountains owe their ruggedness almost entirely to erosion by the streams which on the Snake River side have an extremely steep grade. The grade on the Salmon River side is almost as great and the steepness of these mountains is due to the fact that they lie between two large streams which have cut their way down very rapidly leaving the rugged ridge which forms the Seven Devils mountains between them. These mountains have been carved into their present form by the tributary streams and modified to a certain extent by glaciation.

The highest peaks are on the north end of the range and are over nine thousand feet in altitude.


Glacial topography is very well developed in the higher parts of the range. The upper part of Deep Creek is a broad glacial valley bordered by hanging valleys the most prominent of which, Six Lake Basin, has a floor which is over a thousand feet above the bed of Deep Creek. The Deep Creek glacier extended down the valley almost as far as Tom Heady's Creek, which is below 5000 feet in altitude. The flat upon which the Heady homestead was located is part of the terminal moraine of this glacier. Hanging valleys or small glacialts existed at the heads of Heady and Trail Creeks but did not extend down the mountain much below the 7000 ft. contour and these are the most westerly glaciers, the water from which drained into Deep Creek. For some unknown reason the valley of Copper Creek, which flows through Helena by the Peacock Mine, remained unglaciated and the old Eocene erosion topography is still preserved in the upper part of this valley. The lower part of Copper Creek falls over the glaciated and moraine-covered side of the Deep Creek
valley and plunges down 2000 feet in a little over a mile. The unglaciated condition of Copper Creek is probably due to the fact that the high but rolling ridge above Helena faces the west and snow did not lie on it deeply enough to form glaciers. Devils' Hollow, a deep gorge with a cirque at its head, lying due east of Helena, was occupied by a fair-sized glacier. The south side of Deep Creek above the Devils' Hollow consists of a succession of cirques which have cut down almost to the level of Deep Creek, while on the north side two prominent hanging valleys exist, one of which, Six Lake Basin, has already been mentioned and the other is known as Horse Pasture Basin.

The topography is quite different on the north and on the south sides of Deep Creek, and this is explained by the fact that the greater amount of sunshine received by the southward-sloping north side of the valley probably caused the ice to melt more rapidly on that side than on the other. The result was that the tributary glaciers on the north side were melted before reaching the main glacier but continued to work headwards forming the two wide basins mentioned above. Six Lake Basin derives its name from the six glacial lakes that exist there. Two of these lakes were non-existent during the summer of 1918, which was a particularly dry year, but the other four are typical glacial lakes or tarns, with the deep blue water so noticeable in these lakes. The upper part of Oxbow Creek was occupied by a large glacier, as was also the upper part of Granite Creek, and the west fork of Rapid River. Between these masses of ice the black sawtooth ridge of the Seven Devil range emerged in the form of nunataks.

At the head of one of the west forks of Rapid River, known as Lake Fork, lies Black Lake, one of the most beautiful glacial lakes to be seen anywhere. This lake now occupies the site of what must have been a large glacier, and has been formed partly by the eroding action of ice and partly by the damming of the stream with masses of morainal debris.

The glaciation in this region was entirely local, being confined to the heads of streams in the Seven Devils Mountains, and except in the case of Deep Creek is seldom exhibited below 6000 feet. The glaciated part of the Seven Devils Mountains is one of the most beautiful countries to be found in the state of Idaho.

**SCENERY.**

This region possesses some of the finest scenery in the west but on account of its comparative inaccessibility it is less famous than other celebrated mountain resorts of lesser scenic grandeur.

The wealth of topographic forms just described has naturally given rise to a considerable variety of splendid mountain views. On the basalt plateau in the neighborhood of Bear P. O.
Six Lake Basin, Looking Northwest

Seven Devils Peaks, and one of the lakes in Six Lake Basin
Pyramid Peak from Black Lake

Photo By R. W. Berry

View down Granite Creek from Purgatory Saddle, showing Emerald Lake

Photo by R. W. Berry
and Lick Creek the country is rolling and park-like, with magnificent yellow pine trees in scattered clumps, changing to heavy forest as the southern foothills of the Seven Devils Range are gained. Thru this rolling park-like and partly timbered country, Bear, Lick, and Crooked Creeks unite to form Wildhorse Creek which plunges thru an ever deepening canyon on its way to Snake River. From this plateau can be seen the snow-capped Wallowa Mountains, lying to the west across the Snake River in Oregon, and the frontal hills of the Seven Devils to the north. Of these latter Smith Mountain is the most prominent, and it hides the ragged peaks of the main range beyond it. The Seven Devils Mountains are most impressive when viewed from the north, as when seen from this direction they form a line of bare, jagged, sawtooth peaks, usually snow-covered and rising abruptly from the forest-covered plateau.

Probably the most impressive piece of scenery in the region is that part of the Snake River canyon lying between the Seven Devils and Wallowa Mountains. The most accessible place from which this canyon may be viewed is the wagon road to Helena where it skirts the head of Kinney Creek below the White Monument ridge. From some of the high points west of this road one can look down almost a mile vertically into the bottom of this remarkable gorge, while across the canyon the Wallowas rise to over 10,000 feet like islands above the sea of level basalt thru which the Snake has cut its channel. This canyon has a more somber grandeur than either the Grand Canyon of the Colorado or the canyon of the Yellowstone. This is due to the almost universally dark color of the rocks in which the canyon has been carved. Below Kinney Creek the black beetling cliffs and talus-covered slopes with the narrow side-gorges debouching into the main canyon are strikingly like the scenic setting of the lower regions as depicted in Dante's Inferno. In viewing this canyon even a personversed in geologic processes cannot fail to be impressed by the tremendous results accomplished by the comparatively simple means of running water when given sufficient time.

This canyon is a scenic asset of the states of Idaho and Oregon in the same class as the Colorado and Yellowstone canyons, and it is hoped that in these days of highway building this little known but remarkable canyon may be made more accessible to the public, so that it may take the place that it deserves among the scenic wonders of the western states.

In the higher parts of the Seven Devils Mountains typical alpine scenery abounds and small rock-bound glacial lakes lie hidden in the circular amphitheaters of the heads of the creeks. Above these gem like lakes rise the ragged peaks of the Seven
COPPER DEPOSITS OF SEVEN DEVILS

Devils ridge and from them issue clear cold mountain streams abounding with trout.

The region enclosed within the boundaries of the State Game Preserve would make a magnificent state or national park, and the Seven Devils might well become a world famous summer resort and a great asset to the state of Idaho.

CLIMATE.

It is natural that a region of so great relief as this should possess also a wide climatic range. In the canyon of the Snake River the climate is mild and almost semi-tropical, snow seldom falls there and then only lies for a day or so; spring comes early, and grapes, peaches, and walnuts, as well as all the hardy vegetables grow wherever soil and water are available. The summers are hot and in some parts of the canyon temperatures up to 116 degrees F. in the shade are reported. This extreme heat is explainable by the fact that nearly all the rocks in the canyon are black or nearly so. These black rocks absorb heat to a remarkable extent and give it up very slowly, as shown by the fact that in the early mornings during the summer many of the rocks are still warm to the touch. The high parts of the Seven Devils Range, where the glaciated mountain valleys and rugged peaks are situated, have, of course, a typical mountain climate. Snow is likely to fall during any month in the year, with winter setting in the latter part of October or early November and continuing into April. No records of snowfall are available but it probably runs from 3 to 8 feet in Cuprum, from 5 to 10 feet in Landore and from 6 to 12 feet or more in Helena. With a normal winter snowfall the road between Landore and Black Lake is blocked with deep drifts until well into July and even during the dry, hot summer of 1919 snow still lay as late as August in protected hollows only a few hundred feet above this road.

Between these two extremes lies the plateau country, with an intermediate climate and there is no need for the inhabitants of this region to migrate to California if the winter or Canada in the summer as almost any climate desired can be obtained by moving only three or four miles.

One of the great advantages of this range of climate is in stock raising for which this region, tho somewhat limited in area, is particularly adapted. Cattle, horses, and sheep can range out all the winter along Snake River and as the season advances can follow the fresh grass up the mountains, spending the hot dry months of the summer in the high, cool mountain meadows. On this account a man with only a few acres of land on the river can keep a good sized herd of sheep or cattle on the Forest Reserve as winter feeding is seldom necessary.

There is practically no timber below an elevation of 4000 feet but between that level and 7000 feet there is a heavy growth of yellow pine, tamarack, and fir, the latter growing more abundantly on the north hillsides and the yellow pine on the southern slopes. The valleys of Indian Creek, Bean Creek, and Lick Creek, are particularly well timbered. At and above 7000 feet the white bark pine and the alpine fir are the common trees but these grow only in a scattered fashion on the grassy ridges and hill sides. Timber line would appear to be somewhere between 8500 and 9000 feet, altho Smith Mountain which is only 8000 feet in altitude is devoid of timber on the top, whereas Mt. Eckels has stunted timber growing to the summit. The rugged peaks of the Seven Devils between Granite Creek, Oxbow Creek, and Rapid River are destitute of vegetation.

Dry farming has been practiced on the basalt plateau with some success in former years but the last three years, 1917-19, have been particularly dry and it has been impossible to raise anything except a little hay on land where water for irrigation was not available. Agriculturally the country has practically reached its maximum of development unless the climate of the plateau should change. On this section, after the pine timber was removed, farming could be carried on if there was sufficient rainfall during the growing season.

The country is peculiarly destitute of large game. A state game preserve has been established which extends from a few miles south of Landore northward and includes the Seven Devils Mountains and the country to the north as far as the latitude of Lucile on the Salmon River, and embraces all the country lying between the Snake River and the Salmon and Little Salmon Rivers for that distance. The establishment of this game preserve is a worthy act but there does not appear to be anyone whose duty it is to look after the game except the federal employees of the Forest Service, and it is a question whether this game preserve is of very much value. There are a few deer along the ridges that extend from the Seven Devils Mountains into the Snake River. Mountain goats and also sheep are reported from the more rugged parts of the range tho none were seen by the writers. This lack of game is probably due, to a large extent, to the fact that most of the high country is overrun by sheep during the summer months which has naturally an adverse effect upon the game. There are plenty of grouse in the higher and more inaccessible parts of the range where the automobile of the “game hog” cannot penetrate. There are also many trout in the more inaccessible streams, as for instance the upper waters of Rapid River, where excellent fishing can be obtained.
HISTORY AND PRODUCTION.

Owing to the fact that the Seven Devils district is almost deserted at the present time it is a difficult matter to get a concise statement of its history.

The following has been pieced together from descriptions given by some of the old timers whose memories in regard to dates are naturally somewhat uncertain.

Like many another mining camp in the west the discovery of the district was due to placer mining. About 50 years ago the Simpson brothers were washing for gold on Copper Creek, a tributary of Deep Creek, and discovered the Peacock mine which outcrops close to this creek. Apparently they did not stake it, or if they did they must have allowed their title to lapse as it was located by Levi Allen in 1894. The claim had to be recorded in Lewiston, the nearest office at that time, over 100 miles distant.

Shortly after this other claims were discovered and located, such as the Arkansaw, Bluejacket, Queen, and several more by Chas. Wagner, who was in partnership with Arthur David, or "Frenchy" as he is commonly called.

There was practically no activity in the district for about 20 years following this but in 1883 patent was obtained for the Peacock, White Monument and Helena claims.

The first ore shipped from the district was in 1888 from the Bluejacket mine and following this from the Peacock mine in 1889. This ore was taken on pack horses to Bear Creek and shipped from there to Weiser by wagons, a total distance of approximately 130 miles.

The year of 1900 seems to have seen the greatest activity in the camp. At this time the Kleinschmidt grade from Ballard's Ferry to Helena was built. This road was well located, and of all the mountain wagon roads built before the days of highway construction this is by far the best graded road that the writers have seen in the state. It rises from about 1500 feet in elevation at the Snake River to about 7200 on the divide above Helena and there are only one or two really steep pitches in the whole of this distance, and with a little repairing trucks could be operated over it without any particular difficulty.

About this same time the Pacific and Idaho Northern Railroad (known locally as the "Pin" road) began building from Weiser up the Weiser River, with Helena as the final objective. It is locally reported that Mr. Louis Hall of Boston, who was building this road took options on a number of the more promising claims of the district but was unable to stand the heavy expense entailed in the building of the road and was forced to abandon the project. Railroad grading from the Helena end of the line was actually commenced and the grades around White Monument Mountain are still prominent landmarks.

During 1900 practically all the more important properties in the district were shipping ore. From this time there was a gradual decline with the shutting down of one property after another until in the summer of 1919 the only property in operation in the lime-garnet belt was the Arkansaw.

A smelter was erected at Weiser and a reverberatory furnace at Landore by the Ladd Metals Co., but both of these have long been idle. The one at Landore is now dismantled.

During the last few years activity has been confined almost entirely to the Red Ledge on Deep Creek and at the time of writing active development work is in progress on this property.

The short lived activity of the bornite mines in the lime-garnet zone is due chiefly to the irregular manner in which these rich pockets of ore occur and the difficulty of finding new ore bodies by underground development. Litigation in the earlier days of the camp was also an important factor in the curtailment of development and production, and transportation is an expensive item.

It is difficult to estimate the amount and value of the ore shipped from the camp. Geological Survey reports did not segregate the different counties of the state during the first few years of production in the Seven Devils, and the State Mine Inspector's reports, (first issued in 1898) give the figures for the counties only and not for the individual districts. Prior to 1898 there are no reliable figures available but since that time Washington and Adams Counties, (which were one county up to 1911) have produced about a million two hundred thousand dollars in copper, gold and silver, the copper constituting about 70 per cent of the total value.

The ore that was shipped from the Seven Devils assayed between 20 to 50 per cent in copper with from 0.1 to 0.2 oz. of silver and about 5 cents in gold to every unit of copper.

How much of this total of $1,200,000 came from the Seven Devils cannot be stated definitely as there were other places in the county, such as the Mineral district, from which copper was also shipped. It should, however, be safe to assume that 80 per cent of this came from the Seven Devils, which would give the camp a production since 1898 of approximately one million dollars.
COPPER DEPOSITS OF SEVEN DEVILS

GENERAL GEOLOGY.

Limestone

The oldest rock in the district is limestone which is exposed in two or three places only.

The largest exposure is on the Snake River at the mouth of Allison and Ekel's Creeks, and the reason for the wide bar on the river at this place has been explained by the presence of this limestone and was mentioned in the discussion on the topography. No fossils were found within the limits of the Seven Devils quadrangle but fossil shells of the genus Productus are plentiful in a lime breccia said to occur at the base of the limestone near Homestead, Oregon, which would place this rock probably in the lower Carboniferous or Mississippian period of the Paleozoic.

The rock is a normal bluish gray limestone weathering to abrupt slopes along Snake River. At Lyne's ranch near the mouth of Allison Creek it shows a thickness of about 1000 feet though its base has not been exposed. The beds show a thickness of from one to six feet. On the Oregon side of the river the beds are sharply folded and contorted (see Plate No. 2) into a number of steeply pitching and irregular folds which disappear below the basalt capping. On the Idaho side it shows less disturbance and lies nearly horizontal. About a mile above the mouth of Allison Creek the limestone is in contact with the andesite series of tuffs and flows.

The line of contact is marked by a narrow trench or depression extending up the north side of the canyon and by saddles in the ridges. The limestone dips sharply away from the contact, in some places the beds being almost vertical. Along the contact there are small tongues of andesite intruded into the limestone and on the andesite side there is a brecciated greenish colored andesite due to chlorite, with considerable calcite occurring in the seams of the breccia. The general appearance of the contact at a distance is suggestive of a fault rather than an intrusion but the narrow tongues of andesite intruded into the limestone would exclude this possibility and the latter supposition is the more likely. There is very little metamorphism of the limestone in the neighborhood of the andesite showing but slight temperature development.

A small area of limestone is exposed on the Kleinschmidt grade below Huntley's ranch, on the Indian Creek side of the saddle in the ridge, through which the road passes. This small disconnected mass was evidently torn from the main area when invaded by the andesite. It is a dark gray, thinly bedded rock and grades in places into a limer shale. It has a strike of 30° to 35° E with a northwesterly dip of 60 to 70 degrees. Under the microscope it is seen to be an extremely fine grained limestone which has been subjected to considerable stress as it shows a distinct flow structure. A small amount of graphitic material is present and considerable kaolin. Another area of this rock occurs at the mouth of Deep Creek.

The areas of limestone described above are evidently a part of what was at one time a continuous belt of lime that extended through the country in a northeasterly direction as they would seem to be a part of the same series of rocks which are exposed in the Salmon River canyon between Riggins and Lucile.

At Lucile this series consists of interbedded limestone and shale and is several thousand feet thick. In the Seven Devils quadrangle these limestone rocks have been invaded by the andesites in the form of flows, tuffs, and intrusions, and also by granodiorite at a still later date, and these repeated invasions coupled with active erosion have left nothing but a few scattered remnants of what must have been at one time a very widely distributed rock.

The best example of invasion of one of these limestone areas by the granodiorite is between Landore and Helena. In this locality great limestone blocks were engulfed in the granodiorite and entirely crystallized to a white marble, accompanied in some instances by the formation of contact metamorphic minerals as garnet and epidote.

The fact that this limestone has been invaded and intruded by igneous rocks more than once has an economic bearing which might be briefly stated as follows. The contact metamorphic copper deposits between Landore and Helena occur associated with this highly altered limestone. Contact metamorphic deposits are known to be of an irregular character even when they occur along a contact of limestone of considerable area and extent but when this metamorphic action has taken place along scattered and disconnected masses of limestone this irregularity is naturally greatly increased.

Andesite Series.

With the possible exception of the Columbia River basalt the andesites are by far the most widely distributed rock in the district and they form part of an area extending north and south a distance of about 100 miles and of unknown width. The best exposures of these rocks are usually in the deep canyons of the Snake and Salmon Rivers where these streams have cut below the lava flows with which most of the country is covered.

In the Seven Devils quadrangle, however, these rocks are exposed on some of the highest peaks and the ruggedness of

* Subsequent work has shown this limestone to be younger than the andesite tuffs.
the region is partly due to the resistant character of this series.

The so-called andesites vary in composition and character to a considerable extent and are far from being a simple series of lava flows like the Columbia River basalt which overlies them. They consist of fine grained andesites, andesitic tuffs, breccias and porphyries; dacites; quartz latite porphyries; rhyolites and in one place what is probably a phonolite. They vary in color almost as much as they do in composition, the commonest color being a dark green grading to a purple but there are also large areas that are red. With the exception of the rhyolites they are dark rocks and it is this characteristic that gives the canyon of Snake River the somber and gloomy appearance that it possesses. It is only occasionally, along the wall of some side canyon, that a hint of flow structure can be seen. One of these places is on the south side of Deep Creek between Heady's ranch and the Red Ledge mine. On looking across Deep Creek from the Gaarden trail the andesite flows appear to have a strike of about N. 65° W. and a dip of 20° to the northeast or towards the Snake River and away from the intrusive granite dikes as might be expected.

Another place where the andesites show a semblance of flow structure is on the ridge west of Cuprum, where they appear to have a northeast strike and southeasterly dip which is also away from the granite intrusion.

It is impossible to estimate with any degree of accuracy the thickness of this highly complex series of flows and tuff but it is safe to say that it cannot be less than 10,000 feet and may exceed this figure two or three times.

No attempt was made to differentiate the various members of this series and with the exception of the rhyolite they were mapped as a unit. To work out the history and sequence of these rocks would involve a great deal of time and very careful mapping accompanied by microscopic work, which would have to be done in the field, and even then it might not be possible to arrive at a satisfactory conclusion. It seems doubtful if such a piece of work would throw much light upon the deposition of the ores and as this report is chiefly of an economic nature no attempt has been made to separate them on the map.

Below follows a brief description of some of the typical examples of this andesite series.

A specimen taken from a cut on the road between Landore and Bear and about one mile from the former is a dark gray to purplish banded rock somewhat tuffaceous in texture with a dense groundmass and small phenocrysts (one or two millimeters long) of feldspar. Under the microscope the rock is seen to be com-
the region is partly due to the resistant character of this series. The so-called andesites vary in composition and character to a considerable extent and are far from being a simple series of lava flows like the Columbia River basalt which overlies them. They consist of fine-grained andesites, andesite tuffs, breccias and porphyries; dacites; quartz latite porphyries; rhyolites and in one place what is probably a phonolite. They vary in color almost as much as they do in composition, the commonest color being a dark green grading to a purple but there are also large areas that are red. With the exception of the rhyolites they are dark rocks and it is this characteristic that gives the canyon of Snake River the somber and gloomy appearance that it possesses. It is only occasionally, along the wall of some side canyon, that a hint of flow structure can be seen. One of these places is on the south side of Deep Creek between Henry’s ranch and the Red Lodge mine. On looking across Deep Creek from the Garden Trail the andesite flows appear to have a strike of about N. 65° W. and a dip of 20° to the northeast or towards the Snake River and away from the intrusive granodiorites as might be expected.

Another place where the andesites show a semblance of flow structure is on the ridge west of Cuprum, where they appear to have a northeast strike and southeasterly dip which is also away from the granodiorite intrusion.

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posed of a very fine grained, almost glassy groundmass with
phenocrysts of plagioclase and a small amount of quartz. There
is a considerable amount of sericite in flakes, which is second-
ary and a sprinkling of fine magnetite grains all through the
rock. The plagioclase has the optical properties of labradorite
or bytownite and a little orthoclase is also present. This par-
ticular rock is therefore more nearly akin to dacite or quartz-
latite-porphyry than to andesite. Rock similar in outward ap-
ppearance to this is very widely distributed and is one of the
commonest forms of the series.

A specimen taken from Allison Creek, about one mile from
Snake River and close to the lime contact is a red to purplish
rock with a dense reddish groundmass containing well defined
greenish phenocrysts of altered plagioclase from a few milli-
meters to nearly a centimeter long. This is a decidedly handsome
rock and might be valuable for ornamental purposes if near to a
large city. Under the microscope the groundmass shows as a dense
and almost opaque reddish colored mass containing a number of
fine lath-like plagioclase crystals, but the greater part of the
groundmass is too dense and fine grained for its component parts
to be distinguished. The large phenocrysts of feldspar have been so
completely altered to sericite, chlorite and kaolin as to be almost
indistinguishable. Only one crystal in the slide was sufficiently
unaltered to show twinning and this appeared to be an andesine.
No quartz could be distinguished and the rock can be classified
broadly as an andesite.

This rock seems to grade into a somewhat fine textured
reddish colored tuff which is made up of a number of irregular
fragments of the different andesitic flows, none of them, how-
ever, exceeding an inch in length.

Very similar appearing tuffs outcrop on the Kleinschmidt
grade below Huntley’s ranch and on the Smug Harbor road
south of the Indian Creek Saddle. A specimen taken from this
locality shows under the microscope a dense reddish ground-
mass with microscopic crystals of plagioclase and pyroxene. The
rock was somewhat vesicular and these small vesicles have been
filled with secondary quartz. It has also been subjected to in-
tense alteration due to movement and crushing as all the minera-
sals show wavy extinction which is so strong as to obscure the
twinning lines of the feldspars and so renders their identification
almost impossible. Of the pyroxenes both diopside and augite
are present and although the feldspars cannot be identified with
any certainty the rock is unquestionably an andesite and probably
belongs to the same flow or tuffaceous deposit as that on Allison
Creek.

Another typical rock of this series which occurs widely dis-
posed of a very fine grained, almost glassy groundmass with phenocrysts of plagioclase and a small amount of quartz. There is a considerable amount of sericite in flakes, which is secondary and a sprinkling of fine magnetite grains all through the rock. The plagioclase has the optical properties of labradorite or bytownite and a little orthoclase is also present. This particular rock is therefore more nearly akin to dacite or quartz-latite-porphry than to andesite. Rock similar in outward appearance to this is very widely distributed and is one of the commonest forms of the series.

A specimen taken from Allston Creek, about one mile from Snake River and close to the line contact is a red to purplish rock with a dense reddish groundmass containing well defined greenish phenocrysts of altered plagioclase from a few millimeters to nearly a centimeter long. This is a decidedly handsome rock and might be valuable for ornamental purposes if near to a large city. Under the microscope the groundmass shows as a dense and almost opaque reddish colored mass containing a number of fine lath-like plagioclase crystals, but the greater part of the groundmass is too dense and fine grained for its component parts to be distinguished. The large phenocrysts of feldspar have been so completely altered to sericite, chlorite and kaolin as to be almost indistinguishable. Only one crystal in the slide was sufficiently unaltered to show twinning and this appeared to be an andesite. No quartz could be distinguished and the rock can be classified broadly as an andesite.

This rock seems to grade into a somewhat fine textured reddish colored tuff which is made up of a number of irregular fragments of the different andesitic flows, none of them, however, exceeding an inch in length.

Very similar appearing tuffs occur on the Kleinschmidt grade below Huntley’s ranch and on the Snag Harbor road south of the Indian Creek Saddle. A specimen taken from this locality shows under the microscope a dense reddish groundmass with microscopic crystals of plagioclase and pyroxene. The rock was somewhat vesicular and these small vesicles have been filled with secondary quartz. It has also been subjected to intense alteration due to movement and crushing as all the minerals show wavy extinction which is so strong as to obscure the twinning lines of the feldspars and so renders their identification almost impossible. Of the pyroxenes both diopside and augite are present and although the feldspars cannot be identified with any certainty the rock is unquestionably an andesite and probably belongs to the same flow or tuffaceous deposit as that on Allison Creek.

Another typical rock of this series which occurs widely dis-
tributed, but usually in small areas, and has more the appearance of a dike than a flow, can be seen exposed a short distance from Landore on the road to Bear P. O. as well as in many other places. This a greenish-gray rock with a dense groundmass and well defined phenocrysts of plagioclase a few millimeters long. Under the microscope this rock shows a fine but well crystallized and almost diabasic groundmass consisting of lath-shaped plagioclase crystals and augite. The plagioclase phenocrysts conform to andesine and there is also a very little orthoclase present. The rock is more porphyritic in texture than the majority of the flows and was probably intrusive into the latter in the form of dikes and sills and is a typical andesite porphyry.

A rock which is totally different to anything that has been described above but which undoubtedly belongs to the same series of volcanics occurs on the summit of Smith Mountain. This rock has been so thoroughly broken up by frost action that the whole summit of the mountain, which is about 8000 feet above sea level, is a mass of rockslide and nowhere can solid rock in place be seen. It is a hard, fine grained, dense, greenish-gray rock which weathers to a brown along the joint planes and rings like phonolite when struck with a hammer. Under the microscope it shows a dense finely crystalline groundmass of plagioclase and hornblende with a typically diabasic texture, the minerals being interlocked into a dense mosaic which accounts for its hardness and resistant qualities and it is due to the structure of this rock that Smith Mountain has resisted erosion to the extent that it has. The plagioclase crystals are either albite or oligoclase, showing a high soda content, and although no nephelite could be recognized it may be there in exceedingly minute crystals, as the rock has the appearance of phonolite as well as the metallic ring and the high soda content as shown by the feldspar. One large crystal of light colored hornblende was visible in the slide as a phenocryst. About 15 per cent of the rock is made up of small crystals and grains of magnesite which accounts for the great variations of the compass on this mountain. In fact the presence of magnesite is characteristic of all the rocks of the andesite series and the consequence of this is that compass surveying is totally unreliable wherever these rocks occur. As variations of from 10° to 20° will be obtained within a distance of a few feet, and a compass traverse which passes over any of these rocks will probably contain an error of several hundred feet in less than a mile.

Another important rock of this series is a coarse andesitic breccia composed of angular fragments, up to an inch or so across cemented by a dark porphyritic matrix. The fragments seem to be made up chiefly of the andesite series but fragments of quartzite and lime are occasionally seen. This rock is coarsely bedded and forms rather prominent outcrops wherever it occurs, one of the best of which is on the Black Lake wagon road on the west side of Smith Mountain at the place where the trail to the Smith Mountain ranger station leaves the main road.

In addition to these main types of the series there are also local variations in the andesites due to metamorphism which has in some cases developed a slaty structure. A good example of this occurs on the road between Landore and Bear P. O. on the hill above Mr. David's house, known locally as the "Frenchman's." At this place the andesites have been crushed until they are in the form of a greenish slaty looking rock.

Summarizing this series of rocks, they might be considered as belonging to five distinct types: (1) A typical purplish andesite tuff which approaches a dacite petrologically and is the most wide-spread rock of the series. (2) A greenish andesite porphyry with well defined plagioclase phenocrysts. (3) Reddish andesite tuff grading into a fine grained breccia, a good example of which occurs near the mouth of Allison Creek. (4) A coarse andesite breccia. (5) The pseudo-phonolite of Smith Mountain. Of these the two first would appear to be the older rocks, No. 1 being the older of the two, and the others younger, but this should be considered as a tentative classification of this complex series of volcanics only and not as a final classification.

Rhyolite.

Rhyolite rocks occur in one or two places in the district the most important of which is in the canyon of the lower part of Deep Creek near the Red Ledge mine, and at the Head Prop-erty. In the vicinity of the Red Ledge mine the rhyolite has been so intensely mineralized that its original structure has been obscured, but on the ridge between Deep Creek and Oxbow Creek there is a prominent outcrop of the unaltered rock, and along the trail to the Gardan cabin this rock is exposed in several places. It is a light colored, almost white rock of fine smooth texture and contains no phenocrysts, but shows many small hollow spaces stained with limonite which evidently represent the oxidation of small crystals of pyrite. It shows well developed hexagonal jointing wherever exposed along the Garden trail. Under the microscope it shows a fine glassy groundmass made up largely of minute quartz crystals. No phenocrysts are visible but the microscope reveals a well defined flow structure. A number of cubes and triangular shaped truncated corners of cubes of limonite, pseudomorphs after pyrite, are present.
A somewhat similar appearing rhyolite is exposed on the Gaarden trail west of Tom Heady's property. This rock differs from the one just described in the fact that it contains well defined quartz phenocrysts and somewhat less limonite staining.

These two areas of rhyolite seem to run through the country in an almost parallel northeasterly direction from Deep Creek, and both grade into a highly mineralized rock along their eastern contact with the darker andesites. In the case of the Red Ledge this mineralized portion of the rhyolite is half a mile wide and forms a prominent and striking landmark of almost perpendicular blood-red iron-stained bluffs rising from the canyon of Deep Creek.

Whether these rhyolite exposures are dikes or whether they represent the exposed edges of flows which are intercalated with the andesites is difficult to determine, the general appearance along the western contact of the Red Ledge is more suggestive of an intrusive dike than an intercalated flow. These rhyolite dikes do not seem to extend very far on the south side of Deep Creek, although there is one iron stained exposure on the ridge between Deep Creek and Snake River but this appears more like an iron stained andesite than a rhyolite and is only about 100 feet wide. Along the south side of Deep Creek the rock exposures are scarce as the mountain slopes are covered with slide rock. On the north side of Deep Creek the Red Ledge rhyolite can be traced to the divide between Oxbow and Granite Creeks, which is to the limit of the map, and the Heady rhyolite nearly to the divide between Deep and Oxbow Creeks and possibly beyond.

The only other place in the Seven Devils quadrangle where rhyolite can be seen is a small exposure on the ridge west of Huntley's ranch. Rhyolite also occurs at the River Queen mine on the Snake River outside of the quadrangle, where it is associated with chalcopyrite ore and is also full of pyrite crystals and grains.

The rhyolite is either younger or contemporaneous with the andesite series but its relation to the granodiorite cannot be determined as there is no contact between these two rocks anywhere in the district so far as the writers are aware.

Granodiorite.

This rock is exposed over a considerable area in the central part of the quadrangle in the form of a stock or batholith. It has been intruded into the andesite series and has also intruded and engulfed large blocks of limestone and caused the contact metamorphic zones which occur in places around the latter. It is undoubtedly a spur or outlier of the great batholithic mass of granite in Central Idaho and in its general appearance
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is similar to it. It is somewhat darker in color, due to a larger proportion of basic minerals, near its contact with the andesites than it is near the center of the intrusive mass.

It is a medium-coarse textured rock of gray color with well defined crystals of hornblende and biotite several millimeters in length, quartz is not easily recognized by the eye and the feldspars are white in color. Under the microscope the rock is seen to be made chiefly of plagioclase feldspar, biotite mica, quartz, hornblende and a little orthoclase. In a specimen taken from near the head of Camp Creek, which is about in the middle of the intrusive stock, about 70 per cent of the rock is seen to be feldspar, 15 per cent biotite, the balance being quartz, hornblende and accessory minerals. A specimen taken from the Arkansaw ground showed considerably more hornblende and a little more orthoclase, and is decidedly darker to the eye than the specimen from Camp Creek.

The plagioclase corresponds to an andesite with a fairly high lime content while the orthoclase is entirely subordinate, only one or two pieces being recognized in the slides. Of the ferromagnesian minerals biotite is the most abundant in the Camp Creek specimen but in certain parts of the slide the hornblende is equally plentiful. In the specimen from the Arkansaw, hornblende is in excess of biotite, but this is a local phase near the lime contact and is not typical of the rock, whereas the sample from Deep Creek is a good type specimen of the rock as it occurs generally throughout the district. The rock may be safely classified as a granodiorite containing biotite and hornblende and is very similar to certain phases of the granitic batholith of Idaho as seen in places in the northern and central parts of the state.

A finer textured but otherwise similar appearing rock occurs on Witte Mountain and in the bluffs surrounding the hanging valley of Horse Pasture on the north side of Deep Creek. The writers were of the opinion at one time that this rock was more closely associated with the andesite series than with the granodiorite as fragments of it are found in the coarse textured granodiorites showing that it is older than the latter. The micro-
scope reveals it to be almost identical mineralogically to the
granodiorite just described and it is evidently an earlier and
finer textured phase of that intrusion. The principal feldspar
is andesine which is more abundant than orthoclase but the
latter is more plentiful than in the coarser textured rock. The
hornblende is in excess of the biotite and quartz is quite
prominent. The rock approaches more nearly to a quartz monzonite
than a granodiorite and as stated above may be considered an
early phase of the intrusive granitic mass.

**Basalt.**

The only other rock of importance in the district is the
Columbia River basalt which has been referred to the Miocene
in other parts of the Columbia basin. The southeastern part
of the quadrangle is almost entirely covered by this rock which
apparently is not more than a few hundred feet deep over most
of the area that it covers. Isolated patches of it are found up
to elevations exceeding 7500 feet and it undoubtedly covered
many square miles of country in the form of a thin sheet from
which it has since been removed by erosion.

One of the most striking of these isolated remnants is a
little patch that occurs on the grassy slope of the mountain
southeast of Helena. Some enterprising prospector explored
this patch of basalt with a tunnel evidently supposing it to be
an example of contact metamorphism.

On the Oregon side of the Snake River the basalt is two or
three thousand feet thick and the place of contact between it
and the underlying formations is expressed topographically by
a narrow but fairly well defined bench or terrace in the canyon
wall.

Indian Creek appears to be the boundary line of the basalt
flows from the southeast, as in one place only does this rock
cross the creek and extend a short distance up the mountain on
the other side. The place where this occurs is about half a
mile below the Huntley ranch and the basalt flow at this point
evidently dammed Indian Creek for a time and caused the forma-
tion of the flat where Huntley’s ranch stands today. Along
the east side of Indian Creek, the basalt flows appear to be 400
to 500 feet thick and lie almost horizontal but they do not ap-
pear to reach the creek except in the case just described.

To the east of Indian Creek the streams flow almost entirely
in basalt but occasionally the older rocks are exposed below show-
ing a rather thin flow.

The geological history of the region might be summarized
as follows: Following the deposition of the limestone in the
upper Carboniferous ocean there came a series of volcanic flows
and intrusions of andesite accompanied by the formation of beds
of tuffaceous material of the same character. This took place
sometime in the Mesozoic. This was followed by the batholithic
 intrusion of the granodiorite into the andesite which engulfed the
few scattered remnants of limestone with which it came in con-
tact. *

The smaller masses of the limestone were undoubtedly com-
pletely dissolved by the granodiorite magma while the larger
ones were marmorized and contact metamorphic minerals ac-
companied with bornite were formed in places around their
periphery. After the granodiorite intrusion there was a long
period of erosion which apparently took place during the Eocene.

In the Miocene came the basalt flows which covered the low
lying parts of this old surface to great depths and the higher
parts with a thin layer only, and some parts not at all. Follow-
ing this came an elevation of the country accompanied by the
settling of certain blocks and the uplifting of others and the
streams eroded the country to its present form, which has been
modified by glaciation in the high elevations.

* As previously stated later work has shown the limestone to be younger than the
tuff series.
THE ORE DEPOSITS OF THE SEVEN DEVILS

The ore deposits of the Seven Devils district can be classified under four heads. (1) Mineralized Shear Zones, (2) Fissure Veins, (3) Disseminated Deposits of Large Size, and (4) Contact Metamorphic Deposits.

Of these the last type has produced practically all the copper that has been credited to the district up to the present time. The disseminated deposits, of which the Red Ledge on Deep Creek is the most important, have considerable prospective value and may ultimately be the big producers of the district, while the fissure veins have produced a little gold, as for instance at Black Lake and some copper as at the River Queen mine which, however, lies outside the Seven Devils quadrangle.

MINERALIZED SHEAR ZONES

Occasionally copper ores are found in irregular fractures and shear zones and as replacements in the country rock adjoining such fractures. In such deposits there are no true veins, neither does the mineralization involve large masses of rock as in the disseminated ores, and there are no true and well defined walls to the ore bodies. The ores simply occur in fractures, with or without quartz and other gangue material, and as minor replacements of the country rock, which, adjacent to the ores, is usually more or less altered. So far as known at present such ore deposits are confined almost wholly to basic rocks—andesites, basalts, or the greenstones resulting from their metamorphism, and in such rocks the alterations intimately associated with the mineralization consist for the most part in epidotization and silification. While there are no true veins, the mineralization is usually related genetically to shearing zones which, occasionally may be traced for varying distances, the mineralization occurring at irregular intervals. In deposits of this type thus far known the principal mineral is native copper, associated with which are its surface alteration products, malachite, azurite, and cuprite. Chalcocite, bornite, and chalcopyrite are usually much subordinate to native copper. Such copper deposits are common in the greenstones of the Appalachian region in North Carolina, Virginia and Pennsylvania. They were first described by Weed, who proposed the name "Catoctin type" for them, a term which has

GEOLeDIC MAP OF PART OF WASHINGTON AND ADAMS COUNTIES
been generally adopted. One of the authors * has recently des-
scribed in considerable detail such copper deposits in Virginia
and North Carolina. These ores consist almost wholly of native
copper, cuprite, and malachite, and occur in shear zones in
greenstone, metamorphosed andesite and andesitic tuff of early
Paleozoic or pre-Cambrian age, which closely resemble the
andesite series of the Seven Devils region.

Copper deposits similar in most details to those of the Cata-
oc tin type occur in many places in the andesitic rocks in and ad-
joining the area included within the accompanying map. They
are especially abundant in the region immediately west and
northwest of Cuprum, where considerable prospecting has been
done in the copper-stained andesite. So far as developments have
gone the deposits have proven to be rather lean and the ore
bunchy, and nothing of much importance from a commercial
standpoint has been developed. Many of the outcrops present
glowing surface indications in the way of copper staining—
usually malachite—in the country rock and catch the eye of the
prospector. Consequently the territory mentioned is dotted with
shallow pits and short tunnels, all offering mute testimony to
blasted hopes and vanished expectations. The ores consist of
chalcopyrite, bornite, tetrahedrite and their alteration products, and
occur in fractures and shear zones, accompanied with varying
silicification and epidotization of the andesite. Occasionally they
occur in narrow quartz veinlets, but generally in fractures and
as replacements of the adjacent rock. There are usually no well
defined walls, and the ores are difficult to follow in prospecting.
In addition to copper, these ores are said to carry high silver
values. The following descriptions include only the most im-
portant of these prospects, but they are characteristic of all such
deposits in the district, as well as of the Catoctin type of copper
deposits in which they belong. It must be remembered that at the
time of the field examination no deposits of this type were in
operation and that many of the statements in regard to the
different prospects are based upon such information as could
be picked up.

Badger Mine.

The Badger mine consists of a tunnel and a number of pits
and surface trenches on the east slope of Horse Mountain in
Sections 2, 3, 34, and 35, Townships 20 and 21 North, Range
3 West, from two and one-half to three miles north of Cuprum,
and includes in all eleven unpatented claims. The principal
opening is a tunnel about 300 feet long and a winze about 70
feet deep, both put in to develop a so-called ledge, or mineralized

*Laney, Francis Baker, The Geology and Ore Deposits of the Virginia District of
Virginia and North Carolina, Virginia Geol. Survey, Bull. XIV, 1917, pp. 67,
97, 134-136.
zone in the andesite, striking some 12 or 15 degrees east of north and dipping steeply, about 80 degrees toward the east. It has a gradational foot wall, but a fairly well defined hanging wall, which, from slickensides and striations, appears to be a fault plane. The general conditions seem to indicate that the fracturing and faulting are both pre-mineral and that they are responsible for the mineralization. The ore as exposed in the tunnel and winze consists of an average of six inches of quartz containing high-grade chalcocite, with considerable tetrahedrite, a little bornite, and the usual supergene alteration products. The paystreak is variable and often pinches down to a mere seam, again, however, widening to ten or twelve inches. The ore is said to be high grade, it being reported that smelter returns from a small shipment gave 25 per cent copper, $2.00 gold and 10 oz. silver. This doubtless was selected material, and for such, the values as given are probably not too high. In many places the mineralization appears to be confined, for the most part, to and in the foot wall, but in a few places, especially near the bottom of the winze, which was sunk in the high-grade ore shoot, the ore occurs almost exclusively in the hanging wall. It is perfectly clear that much of the ore has replaced the country rock, such replacement being confined, usually, to within a few inches, or at most a few feet, of the fractures.

About one-half mile south of the tunnel and perhaps 1000 feet southwest of the Badger cabins are some pits and trenches in copper-stained andesite, the mineralization is apparently chalcocite, in fractures and as replacements in the adjoining rock. Certainly no vein has been exposed in any of the work, all ore found being in fractures near fractures in the country rock, and the fractures are most irregular. The mineralized areas appear to have no walls of any kind. Very careful examination revealed much staining in the rock but surprisingly little of the copper-bearing sulphide. Quartz veins or stringers were noted in some of the fractures, as well as considerable epidotization of the country rock, all probably associated with the mineralization. The deposit is interesting from a geological point of view but the mineralized zone is entirely too narrow to have any commercial value.

In the gulch which comes down to the northwest corner of Cuprum and adjoining the townsite on the northwest are some claims, known as the Hitchcock property or the Talk mine. The workings consist of about 800 feet of tunnel and drifts in a somewhat altered, sericitized, area of andesite, and are located in the gulch about 1500 feet from the town. So far as could be learned the "mine" never furnished anything of greater value than the waste rock in the dump. In fact, no ore of any kind could be found in or on the property and the writers are still wondering what kind of hallucination possessed the man or men who did the work.

Wilford Mine.

Situated near the head of the first ravine west of Cuprum and perhaps one-half mile west of the town is an abandoned tunnel and a small dump of waste rock by the side of which is a little pile of "ore"—copper-stained andesite with here and there a speck of chalcocite. These comprise the earthy remains of the Wilford mine, and constitute a blasted hope of one of a group of some thirty claims, sometimes known as the National Group. The little ore that occurs consists of the usual chalcocite and supergene alteration products. It occurs in a zone of close fracturing as fracture-fillings and as replacements in the adjoining rock. Accompanying the mineralization was a certain amount of rock alteration, principally chloritization and epidotization. The deposit occurs in a brownish red, or maroon-colored phase of the andesite series which closely resembles a slate. In fact, the rock may be made up of a mixture of ferruginous matter and fine andesitic ash. Rock of this character is found in abundance in this vicinity.

1905 Mine.

The 1905 mine is located about one-half mile west of the Wilford prospect, and consists of a tunnel in a mineralized and silicified area or zone of the usual andesite. Considerable quartz and epidote and rarely a little feldspar occur as gangue minerals. The ore minerals are chalcocite, a little bornite, small amounts of tetrahedrite and the usual supergene alteration products of these minerals, malachite, azurite, and a little cuprite. The mineralization occurs in a shear zone in which the rock was much fractured and fills the fractures and has replaced the adjoining rock to a limited extent. It is reported that a small amount of high-grade ore was taken out and shipped, and the appearance of the dump tends to confirm the report. The work thus far done is not sufficient either to prove or disprove the prospect which with the Badger form two of the most promising of the shear-zone deposits. It was reported that the owners planned to do further development work on the property during the fall and early winter of 1919.

Near the 1905 tunnel are a number of other pits and tunnels in similar mineralized areas of the andesite but none of them has been developed beyond the prospect stage. Two of these on which the most work has been done are called the Blue Wing, and the Red Wing, respectively.
FISSURE VEINS

The term fissure vein is used to designate any mineralized vein that has formed in a fissure which before mineralization may have marked either a simple fracture, joint, or fault. Fissure veins occur in any kind of rock or formation, may carry any type of gangue minerals, and the values may lie in almost any metal or any group of metals. Such veins usually have well defined walls and the mineralization is usually confined within the walls, although occasionally a limited amount may have taken place in the wall rock immediately at the contact. They present many irregularities in the way of branches and in pinches and swells, as well as much variety in the distribution of the values. The vein matter may either break free from, or be frozen to, the walls. They form one of the commonest and most widely distributed types of ore deposits. The descriptions of the fissure vein deposits that follow will serve as typical examples of such veins.

Within the area covered by this report a number of fissure veins have been prospected and a few of them, Black Lake, Gaarden's, and Frenchy's, have been developed to a limited extent. Just outside of the area two others, the Azurite, and the River Queen, have had considerable development. At least two types of such veins are found, those in which the value lies almost wholly in gold, as Black Lake and Frenchy's, and those which carry sulphides of the other metals with little or no free gold. While nearly all, if not all the gold in the quartz veins just mentioned is probably free, it is intimately associated with pyrite, and occasionally, as at Frenchy's, with pyrite and small amounts of chalcopyrite. The gangue matter is also variable, those of the pyrite-gold quartz containing little but quartz, while the sulphide type contains a much greater variety of minerals, notably feldspars, especially orthoclase. The copper-bearing Panama-Pacific, (Victoria) vein in Devils' Hollow near Helena contains a large amount of well crystallized orthoclase and a little muscovite in small bunches, and hence is a typical pegmatite. The Gaarden vein on Oxbow Creek near the Red Ledge, is peculiar in that a typical, but narrow, aplite dike forms the footwall of the sulphide-bearing quartz vein. These veins while differing from the gold quartz veins in the Mother Lode region in carrying considerable sulphides, and in containing copper, silver, and other metals, often of greater value than gold, resemble them in that several veins of variable size occur in closely spaced parallel fissures. This is especially true of the Panama-Pacific group of claims in which three or four narrow veins, all more or less mineralized, are known to exist.

The fissure veins are found both in the andesite and in the hornblende granite. So far as developed those in the granite carry higher values in copper and silver than in gold, while those in the andesite are predominantly gold veins and carry little or no copper values. These last statements are based on observations made within the area included in the topographic map, and it is doubtful if they will hold true for the region as a whole. Indeed it appears that the River Queen and the Azurite mines may both be exceptions. The veins in the granite contain more feldspar and less calcite than those in the andesite.

Frenchy's Mine.

The property known as Frenchy's mine consists of six unpatented claims held and to a limited extent developed by a pioneer miner of the district, Arthur David, known throughout the district simply as "Frenchy." They were located by Mr. David in 1880 and, consequently, are among the oldest claims in point of location in the Seven Devils district. They have been worked intermittently for the past 30 years by Mr. David. Seldom does one witness more faithful work than that of this man who has spent a lifetime digging away, during a great part of the time single-handed, in his attempt to develop some quartz veins. His faith in the property and his hard work have certainly merited better success than has come to him.

The property is located in Sec. 6, T. 20 N., R. 2 W., on the Bear Creek slope of the main ridge leading southward from Smith Mountain and about one mile north of Bear Ranger Station of the U.S. Forest Service. The country rock is a tuffaceous phase of the great andesite series, and shows the effects of considerable regional metamorphism, in many places being decidedly schistose. Two prospects, both in quartz veins, have been opened by tunnels. To the main and longest vein, "Frenchy" has given the name "Great Eastern," the second he calls the "John D."

The principal workings, called the Great Eastern, consist of tunneling and cross-cutting in a quartz vein varying in width from 10 to 35 feet, striking about N. 10° W. and which, as exposed on the surface and by the tunnels, is about 250 feet long. The vein has a rather flat dip—50° to 60°—toward the east. Thruout all the development work, over 200 feet of tunnel, it apparently has a width of 25 or more feet. The walls are well defined and along the hanging wall, so far as developed, there is a narrow seam of gouge.

The vein is shattered and in a place or two includes horses of country rock, and in other places it presents a banded or "ribboned" structure. A few well marked, so called water courses, are found and one of these contains considerable black
material, apparently for the most part made up of soft oxides of manganese. Scattered irregularly through the mass of quartz are patches of rather coarsely crystalline calcite interlocking with the quartz. Where the calcite has been dissolved from such a combination, which has occurred in a few places, the remaining quartz presents a coarse honeycomb structure. By far the greater part of the vein is made up of coarse, white, so-called “bull quartz.” Occurring persistently but irregularly are bunches or masses of pyrite with a little chalcopyrite and now and then a minute speck of molybdenite. It appears that the gold is closely associated with these bunches of sulphides, but not in all cases confined to them. So far as is known the gold is in the native state. There is apparently not enough copper present to be of any commercial value. The location of the sulphides is shown in the weathered portion of the lode by bunches of iron oxide surrounded by rusty and copper-stained quartz. These bunches are said to have carried the best values, which, according to Mr. David, run up as high as $100 per ton when carefully selected. There are so many conflicting reports as to the value of the ore that any statements as to its value would be only guesses. It seems probable that certain, probably small portions of the vein, will run from $8 to $12 per ton, and that there is an occasional patch from which can be selected ore that will run much higher. However, when considered as a whole, the vein will probably carry very low values. Mr. David operated an arrastra for a short time on some of the richest ore, but he has no records of the results beyond the general statement that he saved “lots of gold.” Some ore has been shipped, but records of the returns were not available. A few assay returns on selected material were shown the writers. As things stand at present, the Great Eastern must be regarded only as an undeveloped and unproven prospect. So far as the writers could learn, the vein has never been systematically and correctly sampled, and until this is done, and it certainly should be, nothing reliable can be said as to its value. The work already done by Mr. David is such that the prospect can be easily sampled. The workings consist of a short cross-cut from which a drift runs northward in the vein for about 200 feet, from this a number of cross-cuts have been run, and a few small raises made. The deepest workings are probably less than 75 feet from the surface vertically.

The “John D.” is located about 300 yards northeast of the Great Eastern and consists of a tunnel about 125 feet long driven to intersect a quartz vein, similar to that at the Great Eastern, only not so wide. This vein strikes approximately N. 40° W. and dips steeply toward the northeast. The value is said to lie in gold which is white, free, is closely associated with irregularly distributed pyrite which carries a little chalcopyrite. The country rock is an epidotized phase of the andesite. There is no doubt as to the values of small selected samples of the ore from this place, but there are no data upon which to base an estimate as to the value of the vein as a whole. It should be carefully sampled.

**Placer Basin.**

At Placer Basin, on the road between Bear P. O. and Smith Mountain, very similar quartz occurs. The veins here are on a flat which forms part of the ridge between Bear Creek and Indian Creek and this flat is one of the best examples of the old Eocene erosion surface and was mentioned under the head of topography. A number of caved-in workings are distributed over this flat but none of them are accessible enough to show the occurrence of the veins or the direction in which they run. It is reported that some high-grade gold-bearing float quartz was found on this flat which was probably the reason for the origin of the name of Placer Basin.

The quartz in these veins is similar in appearance to that at “Frenchy’s” property and they are probably of the same age and origin. The gold-bearing quartz veins at Black Lake are also likely to be of the same period of mineralization, which was probably associated with the intrusion of the grano-diorite. It is interesting to note that “Frenchy’s” property, Placer Basin, and Black Lake are all roughly in a line having a northeasterly direction, which is also the general direction of the mineralized copper-bearing zones and of the parallel-flowing creeks mentioned under topography.

**Black Lake.**

The mine at Black Lake, which is about 12 miles northeast of Landore, consists of some gold-bearing quartz veins, one group, known as the Summit claims, lying above Black Lake, and the other group, called the Maid of Erin, a short distance below the lake. The veins were located in the early ‘90’s with five claims, now patented, upon each. In 1903, a dry process mill was erected, but was apparently not a success. It was burned in 1904 and in 1905 a cyanide plant, the present mill, was put up. The mill as it was operated had a rated capacity of 50 tons, the principal equipment consisting of a big Blake crusher, two sets of Gates rolls, and five 80-ton tanks. No means of fine grinding were provided and no classification of the pulp was attempted, nor was any means installed for agitating the pulp in the tanks. None of the ore was crushed below 20 mesh and most of it only to 10 mesh. The extraction was, on this account, not very satisfactory. The mill is located about 2500 feet below the portal of the lower
tunnel, and over a mile from the upper, and the ore was taken down on an aerial tram. It is reported that in all about $125,000 was taken out. The place is a long distance from a railroad, transportation facilities were poor, winters long and severe, operating expenses were high, and the mine failed to make satisfactory savings. Consequently the venture proved to be a disastrous financial failure. It was operated under the title, Idaho Gold Coin Mining and Milling Company, under the management of Edwin D. Ford of Weiser, Idaho. It appears that most of the money for the venture was put up by Henry A. Salzer, a schoolman of La Crosse, Wisconsin, and his son, B. F. Salzer of Denver, Colorado. When the work was stopped in 1915 several thousand dollars worth of equipment and supplies which could easily have been salvaged, were abandoned on the ground, most of which have either been stolen or wantonly destroyed.

The Maid of Erin group of claims comprises about 2500 feet of the outcrop of a narrow, gold-bearing quartz vein, varying in width from a few inches to perhaps three feet, averaging about 15 or 16 inches, striking about N. 25° W. and dipping perhaps 70° to the northwest. Walls are well defined and there is little or no mineralization outside of the vein. Like the veins at Frenchy's prospect the gold is definitely and closely associated with sulphides, almost exclusively pyrite, which are scattered irregularly through the ore shoot. It appears that all the quartz in the ore shoot probably carries a little gold, but it is only the concentration which occurs in the sulphides that brings the value up to a commercial possibility. So far as could be learned, all or nearly all the ore taken from this vein came from a single ore shoot about 18 inches wide and varying from about 40 feet in length in the upper tunnel to perhaps 25 feet in the lower, the two tunnels being about 200 feet apart vertically. It is reported that portions of this ore shoot carried as high as $40 per ton. However, it was stated that about 900 tons mined in 1914-1915 ran only about $6. It is, therefore, probable that the average was not more than $10. The deepest working in the tunnel is approximately 400 feet below the crest of the ridge and there is not much oxidation at this depth. The development consists of two tunnels and the stoping between them. The lower tunnel is about 800 feet long and the quartz vein is continuous for this distance. Only one small ore shoot, however, is rich enough to be regarded as ore. The country rock is massive fragmental andesite.

The Summit group of claims are on a quartz vein which has an average width of about 2 feet, strikes about N. 15° E. and dips about 70° to the northwest. Two tunnels were driven into the vein, the upper one opening an ore shoot which is said to have been about 200 feet long, nearly 2 feet wide and to have carried about $12 in gold per ton, and to have had a vertical depth of nearly 500 feet. The lower tunnel, some 200 feet below the upper, was driven for about 1200 feet thru the country rock and then about 1000 feet on the vein. One ore shoot about 80 feet long and 15 inches wide, averaging about $10 is said to have been found and partly worked out. Reports are conflicting as to the condition of the Summit ore body. Some say it was worked out while others report considerable good, but inaccessible ore. Little could be learned about either group by actual observation. The account here given is based on the most reliable reports that could be obtained and is not vouchesd for by the writers.

Lucky Strike (Walter James) Prospect.

The Lucky Strike prospect is located on the west bank of Indian Creek about one-fourth mile above the bridge on the Camp Creek road, and about one-half mile northeast of Landore. It consists of two short tunnels driven thru the hornblende granite to intersect some narrow copper-bearing quartz veins which occur in fissures, evidently joint planes in the granite. The mineralization consists of copper-bearing sulphides, largely chalcopyrite in true fissure veins in the granite, the vein matter consisting of quartz and a little feldspar, which for the most part is orthoclase. The veins thus resemble true pegmatites. So far as developed the veins are all narrow, from 6 inches to perhaps 2 feet wide. The sulphides are not uniformly distributed throughout the vein, but occur in small bunches in various places in it. A small amount of mineralization is occasionally found in the country rock at the contact with the vein. Much of the vein is apparently barren. Very little pyrite was noticed. Small amounts of bornite are occasionally intimately intergrown with the chalcopyrite. The workings are all within 50 feet of the surface and consequently the usual oxidized minerals of copper, malachite, azurite, a black silicate of copper, and a little azurite are present, but only in small amounts. The chalcopyrite shows the customary enrichment of chalcocite and a little covellite, both of which occur as replacements along fractures in the chalcopyrite. There were no data available as to the percentage of copper and silver carried by the veins, but judging from the general appearance of the prospect, the veins when taken as a whole, as they must be in mining, will be found to be very low grade.

Panama Pacific (Victoria) Claims.

The Panama-Pacific prospect, formerly called the Victoria, consists of three unpatented claims, in Devils Hollow about 1000 feet south of Deep Creek, and one and one-half miles northeast
of Helena. The prospect is made up of three or four narrow quartz-pegmatite veins carrying considerable copper, which, for the most part, occurs in the form of bornite. The veins vary in width from a few inches to perhaps 2 feet, have a northwesterly strike and a flat dip toward the southwest. The country rock is normal, rather coarse textured hornblende granite which shows no alteration at or near the veins, which have developed in rather closely spaced—8 to 20 feet—joint planes in the rock.

The place was located more than 30 years ago by Charles Walker, a famous prospector during the pioneer days of the Seven Devils district. The claims are now held jointly by Dr. W. M. Brown, F. F. Fife, of Council, Idaho, and John L. Thompson of Landore, Idaho. The development consists of a few shallow pits and an inclined shaft, following the dip of vein which is about 30° toward the southwest. All the openings show considerable ore which carries high values in both copper and silver. The vein on which the shaft was sunk varies from 8 to 10 to perhaps 18 inches in thickness, and is mineralized as far as exposed, about 40 feet. Two of the pits, those most recently worked, show good values in the narrow veins. In fact, if the veins were larger, or if they were near enough to each other to be worked from a single drift, the place would be regarded as an excellent prospect. At present the place located in the Deep Creek gorge is all but inaccessible, there being only a narrow pack trail from Helena to the prospect.

This prospect is very interesting to a student of ore deposits because one of the richest veins is a typical pegmatite, consisting of quartz, feldspar for the most part coarse crystalline, flesh-colored orthoclase, and small bunches of muscovite. The ore minerals, while more abundant in the quartz, are associated with both the orthoclase and the little bunches of muscovite. The other veins contain varying amounts of feldspar, thus approaching pegmatite in composition. The ore minerals consist of bornite and small amounts of chalcopyrite, both of which show secondary enrichment due to development of chalcocite and covellite in and along fractures in the original sulphide. In many places the order of secondary enrichment has been reversed and secondary (supergene) chalcopyrite has been developed in hair lines and dots along cleavage directions in the bornite, apparently with no relation to fractures in the host mineral. Much of this chalcopyrite occurs in such minute seams or films and dots that it is invisible except under the highest power of the microscope. It is possible that it may be of hypogene origin and contemporaneous with the bornite, but general conditions indicate that it is probably of supergene origin. The silver-bearing mineral, while certainly of hypogene origin, was not satisfactorily identified. However, a silver-white mineral, similar in all respects to one of the supposedly silver-bearing minerals in the Red Ledge ores, is present in appreciable amount. Its relations to the bornite indicate that they are contemporaneous. The usual oxidized copper minerals, malachite, chrysocolla, and a little azurite are present in small amounts.

Gaarden (Cliff) Mine.

The Gaarden mine, called Cliff mine by the owners, is located on the north side of Oxbow Creek, about a mile above its mouth. The workings consist of a tunnel about 300 feet long, following a well defined quartz vein which varies in width from two to four feet, and which has a northwest strike and a northerly dip of about 50°. The country rock is the fragmental or tuffaceous phase of the great andesite series. Following the vein so far as developed, and forming its foot wall is an aplite dike which varies in width from 10 to 15 or more feet. There are no indications of metamorphic activity caused by the dike in either vein or country rock, and there was no means of determining the relative ages of dike and vein. No mineralization was noted in the dike. The walls of the vein are well defined and no mineralization was noted outside of the vein. The values lie in copper, silver, and gold. No records were available, however, it is generally stated that the ore runs high in both gold and silver. The ore consists of chalcopyrite and pyrite. The chalcopyrite so far as developed always shows considerable secondary enrichment by the development of chalcocite, covellite, and little bornite in a network of fractures. This enrichment is all due to supergene agencies and probably does not continue to very great depths. The silver-bearing mineral was not recognized. The gold is said to be free, but it does not show up very well when the ore is panned.

The development work has not been sufficient to either prove or disprove the prospect. As is the case with all the mines in the district, the most serious detriment is the lack of transportation facilities. As conditions are at present gold or silver bullion are about the only metals that could be packed out at a profit. It is believed, that if railroad transportation were at hand, this place could be worked in a small way very profitably, that is, assuming that current reports in regard to the value of the ore are true.

Azurite Mine.

The Azurite mine consists of one patented, and five unpatented claims, and is located on the Snake River slope about seven miles southwest of Cuprum and about one-half mile above the Klein- schmidt road. It lies almost due east of Ballard's Landing and is not in the area included within the accompanying geologic
map. The vein is made up of white quartz with small amounts of calcite, barite, and other minerals, and varies in thickness from one to five feet. So far as developed it will probably average three feet. This vein strikes approximately S. 60° E. and dips about 65° toward the northeast. Walls are well defined and the mineralization does not extend into the country rock. The ore which is irregularly distributed throughout the vein in bands and bunches, consists of pyrite, galena, and chalcopyrite, with local development of considerable amounts of sphalerite and tetrahedrite. But little could be learned as to the value of the ore, no data being available. However, it is reported that about $9000 worth of selected ore, averaging $25 per ton was hauled to Homestead and shipped. The development consists of two tunnels and a shaft about 75 or 80 feet deep. The upper tunnel has been driven some 300 feet in the vein. The lower one runs about 200 feet as a cross-cut through the country rock, which isandesite, and then about 80 feet in the vein. The two are about 100 feet apart, vertically.

River Queen Mine.

This property, which consists of 6 claims and a fraction is situated on Snake River about a half mile below Ballard's ferry in Sections 22, 23, 26 and 27 T. 20 N., R. 4 W., Boise Meridian and is owned by Has Bros. of Weiser. There is fairly good wagon road to the property from Homestead, Oregon, which is the nearest railroad point and about 5 1/2 miles distant.

The claims have been worked intermittently for a number of years, the most important development in recent years having been done by Mr. Ferdinand Alecs who has a lease upon the property and has shipped over 200 tons of ore averaging 17 percent copper, 2 1/2 to 3 1/2 oz. of silver and a little gold. Previous lessees have taken out about 100 tons from a shaft and open cuts. The country rock is the andesite series and consists of andesite, andesite tuffs and rhyolite. A series of northeast-southwest fractures cuts these andesites the most important of which has a strike of N. 65° to 75° E. and dips to the northwest 60°.

This particular fracture zone contains massive chalcopyrite which has been followed for a horizontal distance of 100 feet and varies in width from a few inches to 6 feet. There is a small amount of secondary covellite present and occasional bunches of tetrahedrite, called locally "copper glance." This particular zone shows an absence of vein quartz or other gangue minerals, the wall rock having been replaced by the sulphides only.

In addition to this fissure containing massive chalcopyrite, there is a cross "vein" with a strike of N. 25° E. and a dip of 45° to the southeast, upon which a few feet of tunnel work has been done. This shows finely disseminated chalcopyrite in a siliceous gangue and has a width of from 6 to 8 feet. It is probable that this is a part of a silicified rhyolite dikes or sill. This cross vein does not cut the main vein but has been faulted by the latter and is an older deposit. The surface indications consist of a heavy gossan outcrop about 6 feet wide alongside of which there is about 8 feet of crushed andesite. An open cut shows this outcrop to have a strike of N. 50° E. and shows as oxidized copper minerals cuprite and malachite. At the present time there is no direct connection between this outcrop and the stope from the lower tunnel but it seems highly probable that it is the same zone of mineralization.

The workings consist of an upper tunnel, several hundred feet long, from which a vertical shaft has been sunk which connects with the lower workings about 80 feet below. The lower workings consist of a cross-cut tunnel about 270 feet long and about 150 feet of drifting most of which has been done upon the main vein. Above this drift there is a stope 45 feet high and about 60 feet long.

The ore deposit is evidently of the replacement type and the volcanics which are largely rhyolite and andesite have been replaced by chalcopyrite along fault fissures. It seems highly probable that the copper came originally from the disseminated rhyolite and that the massive chalcopyrite in the main fault fissure is due to local concentration and owes its origin to the disseminated material by means of the action of circulating water of probably hypogene origin.

Disseminated Sulphides

Disseminated sulphides is a term applied to a very common type of ore deposit, one in which the ore minerals are more or less regularly distributed throughout large masses of altered rock or rocks as the case may be. Ore deposits of this type are found in many kinds of rocks and in many places. In the majority of such deposits, pyrite is by far the most abundant sulphide, while chalcopyrite and occasionally pyrrhotite are usually present in small and varying amount, but often in sufficient amounts to form very valuable ores of copper. In most cases galena, sphalerite, and other common sulphides are only sparingly present. Genetically considered such deposits are usually attributed to the activities of one or more of several geological agencies, such as volcanic emanations, the solutions, emanations, etc., of intrusive magma. In each case the nature of the metamorphism of the rock, the nature and character of the mineralization, and the position of the altered and mineralized rock form the premises for conclusions and theories as to the agencies involved.
COPPER DEPOSITS OF SEVEN DEVILS

The factors assumed by students of ore deposits as responsible for the largest and most valuable occurrences of disseminated sulfides are the exhalations from intrusive magmas given forth both during the intrusion and afterward as the magma slowly cools. Some of the largest and most valuable ore deposits of the world are believed to have been formed in this manner, such, for example, as the immense so-called "porphyry coppers" in Arizona and Utah.

As has been stated, certain mineralogical alterations in the impregnated rock, dependent of course upon its nature, are characteristic of this type of ore deposit when genetically related to magmatic emanations. To these alterations, as a whole the term, hydrothermal metamorphism, is generally applied. If the original rock was siliceous or acid in character there are almost invariably developed large amounts of sericite, the feldspars and groundmass of the rock, if not holocrystalline, being changed into sericite, cryptocrystalline quartz and orthoclase, and the quartz phenocysts are often surrounded by tabules or anuoles of minute interlocking quartz grains somewhat larger than the cryptocrystalline quartz of the groundmass. Scattered with more or less regularity throughout the rock thus altered, occur the sulfides, often as well developed crystals. If the rock involved is basic in nature, that is, if it is an andesite or basalt, or similar rock, the alterations, when carried to completion, result in its so-called propylitization. That is, it is changed into a mass of chlorite, with varying amounts of carbonates, sericite, and cryptocrystalline quartz, through which the sulfides are scattered as in the altered siliceous rock. It must not be assumed that all the changes are as simple as those just stated. In fact these are mentioned only as the broader and more general or typical changes, and there are many variations and complications dependent upon local conditions. The subject is discussed fully in standard handbooks on ore deposits, and there is no need for further discussion here. Furthermore, the Red Lodge is an excellent example of this type of deposit and the detailed descriptions of it which follow furnish good examples of the characteristic alterations, and of the geological and mineralogical phenomena accompanying them.

THE RED LEDGE

The Red Lodge mine, as shown on the accompanying topographic map, in pocket, is located in the canyon or gorge of Deep Creek about 2½ miles from the junction of the creek with Snake River and about 3½ of a mile above the mouth of Oxlow Creek. It is about 6 miles northwest of the deserted mining camp of Helena, and perhaps 15 miles northwest of Cuprum, the nearest post office and stage station for connections with Council, Idaho, and Homestead, Oregon, the nearest rail-

Head of Deep Creek from the West.

View down Deep Creek from the head, showing Glaciated Valley.
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THE RED LEDGE

The Red Ledge mine, as shown on the accompanying topographic map, in pocket, is located in the canyon or gorge of Deep Creek about 2 1/2 miles from the junction of the creek with Snake River and about 3/4 of a mile above the mouth of Oxbow Creek. It is about 6 miles northwest of the deserted mining camp of Helena, and perhaps 15 miles northwest of Cuprum, the nearest post office and stage station for connections with Council, Idaho, and Homestead, Oregon, the nearest rail-
road points. Council is about 45 miles from Cuprum, while Homestead is perhaps 12 miles distant. Fair roads connect Cuprum with both these places but the one leading to Council has the better grade of the two and does not cross the Snake River as does the Homestead road. On this account it is used by the stage, which during the summer makes three trips per week. The road from Cuprum to Helena has an excellent grade and is kept in fair condition. From Helena to the Red Ledge there is no road, the only means of access being a narrow winding mountain trail, which in addition to its windings makes a descent of nearly 5000 feet in the six miles. Helena has an elevation of about 7200 feet and because of this the road is usually closed by snow from the first of December until the first of July each year. The heavy snowfall also renders much of the trail almost impassable to any but expert snowshoers. This trail, however, is a temporary means of access and is intended to be used only for a limited amount of prospecting and development work. The natural approach to the property is by way of Snake River and lower Deep Creek canyons. The Snake River gorge thru which the road must be made below Lyne's ranch is very rugged, in many places consisting of almost vertical walls, and the construction of a road would be very expensive. It would, however, render the property easily accessible at any time of the year, and can be built on a good grade. Such a road was surveyed a short time ago, and it is reported that preliminary work, for the construction of a good pack trail was carried on during the fall and winter of 1919-20.

Altho located in a region which as a whole is winter-locked from five to six months during the year, the most highly mineralized and most promising portion of the Red Ledge, so far as developed, is situated in the Deep Creek gorge below the line of heavy snows and extreme cold, and can be worked through the winter with little or no inconvenience because of snow and cold weather.

If the property is ever developed on a large scale the railroad can be extended down the Snake River from Homestead to Eagle Bar, which will form a good mill and town site. From this point it will probably be necessary to drive a tunnel thru the mountain, a distance of about 7500 feet, to the mine. Such a tunnel, in addition to intersecting the Red Ledge about 1000 feet below the outcrop and thus affording drainage, would pass thru and explore considerable ground that possibly contains ore. It is reported that the company which is at present (1919) doing exploratory work on the property, has considered and planned such a railroad and tunnel, if the development and exploratory
work now in progress should justify the expense of developing the property on an extensive scale.

While no measurements upon which to base estimates are available it is believed that by utilizing all the water power which could be developed from Deep Creek there would be sufficient for an extensive development of the mine. As has been stated, this stream has a very steep gradient, (shown by the topographic map accompanying this report), a fact which makes it possible to install a number of power plants within short distances of the mine and at minimum expense. There is also an abundance of timber, available on the nearby mountains for mining and other purposes in developing the property.

History

As the Red Ledge stands at present (1919) there has not been enough development either to prove or disprove the value of the excellent prospect. Historically it has had a rather checkered career. A number of attempts have been made to explore and develop it, but, excepting the present attempt, they have accomplished nothing of commercial value. The principal cause for the failures seems to have been the inaccessibility of the property and the great expense and difficulty of packing in supplies and equipment. Associated with this and to a large extent resulting from it has been the difficulty of interesting sufficient capital to carry out exploratory work on a scale large enough to develop the property. At best it must be considered a low-grade deposit, but a very large one. Prospectors and locators of mining claims are usually men of little means and with no great influence in the financial world. It is all but impossible for such a man or such men to explore so large a property as this or to bring in sufficient outside capital to develop it. Each attempt, however, has added something in the way of development, until enough has been done to encourage the present lessees of the property to undertake extensive work which if carried out as planned will either prove or disprove it. It is reported that they also have the capital in hand to carry thru the undertaking.

The property was discovered by the early prospectors in the region, but the values so far as they could be determined were low and in those days when the ore had to be packed and hauled over one hundred miles to Weiser, the nearest railroad point, it was not considered worth locating. Finally, when the development of the copper deposits near Landore and Helena in the early '90's had created a new interest in mining, and had caused the transportation facilities to be greatly improved, the place was located by Thomas Heady, who still lives at Cuprum. His work consisted of the necessary assessment requirements and such exploration as his limited means would permit. Thru his efforts

Robert N. Bell, State Mine Inspector, was attracted to the property, and with others took a lease upon it and did considerable prospecting. Thru the efforts of Mr. Bell, Seeley W. Mudd of Los Angeles with other influential men became interested in the property. They continued the tunnels which had been started by Heady and Bell and did about 1000 feet of diamond drilling. Financial troubles, due to the world war, caused a suspension of all activity. Nothing further was done until the spring of 1919 when the present lessee began preparations for extensive exploration of the prospect. As it stands today the property consists of 25 surveyed but unpatented claims.

Development.

Excepting a few open cuts and short tunnels in the mountain sides north of Deep Creek where the rocks show copper staining, the workings up to date consist of three tunnels and about 1000 feet of diamond drilling. Two of the tunnels have been driven from the creek and one from the Red Ledge formation, while the third, begun by the present lessees in the summer of 1919, is in the non-mineralized rhyolite near the mouth of Red Gulch. This tunnel is really a cross-cut and should intersect the mineralized formation about 400 feet from its portal. It is planned to make this one of the main working tunnels of the property.

The highest of the two tunnels on Deep Creek has been driven about 400 feet in a southeasterly direction, (S. 60° E., astronomic or true bearing) and since the general strike of the Red Ledge is approximately N. 75° E., this tunnel may be considered a cross-cut. From this cross-cut two drifts turn off about 200 feet from the portal, one running northeast for a distance of 160 feet, and the other southwest about 70 feet. From this tunnel and the cross-cuts about 1000 feet of diamond drilling has been done in such manner as to explore as much of the deposit as possible. The records of this drilling were not available for study. Many of the results, however, were courteously supplied by lessees. The lower tunnel, located about 150 feet further down the creek, was driven only about 100 feet and affords little information not obtainable from the main tunnel. It is interesting to note that Umpleby, states that the water issuing from this opening in 1915 was so heavily charged with iron that in the course of one year it had deposited about eight inches of vesicular iron oxide on the floor of the tunnel. In 1918 this deposit of iron oxides had practically rendered the tunnel inaccessible.

Nature of the Deposit.

The Red Ledge as seen from a point on Sheep Rock, the ridge which forms the west bank of Deep Creek, is certainly one of the

most impressive bits of mountain scenery in the whole Seven Devils range. The outcrop stands as a precipitous ridge with nearly vertical cliffs several hundred feet high, attaining as a whole an elevation of some 3500 feet above the surface of Deep Creek, the whole strikingly decorated as it were with kaleidoscopic patches of yellow, tan, brown, maroon, and bright hematite red, the colors changing and glowing in the sunlight.

The ledge consists of a mineralized mass of rock, porphyritic, and tuffaceous or fragmental rhyolite with small local patches of andesite, massive and tuffaceous, rising to a height of 3500 feet above the water of the creek, nearly 3000 feet in width, and three or more miles long, all more or less uniformly impregnated with pyrite and local areas in which chalcopyrite sphalerite and other sulphides have been deposited. The pyrite occurs in the form of minute, oftentimes perfectly developed crystals, usually cubes, scattered plentifully and with considerable uniformity throughout the rock, regardless of its nature whether fragmental or massive, rhyolitic or andesitic. The copper, zinc, lead, and silver-bearing sulphides appear to have been deposited only locally in the lode and are apparently connected with fractures of more recent development than the pyritization and they are clearly younger than, and replace, the pyrite. The rocks wherever they contain the disseminated pyrite, invariably show the effects of extensive hydrothermal alterations. The rhyolitic rocks have been sericitized and silicified while the basic rocks have been chloritized, sericitized and more or less silicified, the original texture of the rocks in all cases being more or less completely destroyed, and nearly all the original minerals except quartz altered into other substances.

Rocks Involved.

Two types of rocks were involved in the mineralization and metamorphism of what is now the Red Ledge, porphyritic and fragmental (tuffaceous?) rhyolite, and tuffaceous and massive andesite. As they occur in the formation the rocks have been subjected to the hydrothermal activities connected with the deposition of the sulphides and their original textures and mineralogical composition have suffered such profound changes that statements as to their original natures are, to a certain extent, matters of inference. However, in many places near the borders of the mineralized area, fairly fresh rock of both types are found and when such material is compared with the altered rock, reasonably accurate inferences are possible.

Two phases of rhyolite, massive porphyritic, and fragmental or tuffaceous, make up by far the greater part of the Red Ledge formation. So far as could be determined from a careful study of the least altered material that was found, and by comparing it with the highly altered and mineralized rock, it appears reasonably certain that the acid or siliceous portion of the ledge is rhyolitic in character.

In the outcrop or in the hand specimen when examined by the unaided eye the rock has a light gray color, is very fine-textured for the most part, and is seen to be in part fragmental and in part porphyritic, both phases being apparently alike in mineralogical composition. In other words, the siliceous portion of the ledge consists of a porphyritic and a fragmental phase of the same magma. The fragmental material may represent either a flow breccia or a silicified tuff. The data collected were not conclusive but they appeared to favor the assumption that it is tuffaceous in character. Such material may be seen in a number of places in the formation. It is well exposed in the most highly mineralized portions of the rock in the main tunnel. In this place the fragments are angular and subangular in shape and vary in size from a small fraction of an inch to two or more inches in diameter. The microscope shows that in this rock the quartz is occasionally fragmental, a fact which indicates rather strongly that the material represents a silicified tuff rather than a flow breccia. In most, but not in all cases, the phenocrysts, both of clear quartz and sericitized feldspar, in the porphyritic phase of the rock may be recognized by the unaided eye. In both phases the sulphides and the sericite are easily seen.

Microscopic study of thin sections shows that both phases of the freshest rock obtainable have the same rather simple mineralogical composition, viz., quartz and feldspar phenocrysts in a dense cryptocrystalline groundmass made up of quartz and feldspar—typical devitrified porphyritic rhyolite. The quartz phenocrysts almost invariably show the peculiar embayment structure indicative of partial resorption by the magma. The feldspars consist of orthoclase and plagioclase, both hardly altered even in the best material collected. The alterations of the plagioclases prevent their positive determination. However, the twinning bands are narrow, a fact which indicates that they belong well up toward the acid end of the plagioclase series.

Microscopic examinations of thin sections of both phases of the altered rhyolite rock reveal the fact that they have both suffered to the same extent similar alterations—alterations characteristic of hydrothermal metamorphism. One mineral, sericite, has been so extensively and uniformly developed that the change suffered by the rock can well be designated as sericitization, accompanied, of course, by the impregnation of the rock by pyrite in the form of minute crystals, usually cubes. The sericite is un-
formally and plentifully present in the groundmass of the rock along with the mixture of cryptocrystalline quartz and orthoclase, and as masses, polygonal in outline, of minute scales which mark the remains of original feldspar phenocrysts. Usually the mineral occurs only as microscopic scales or plates, but occasionally it is found in tabular masses up to one-half inch in diameter. In such cases it should be designated muscovite rather than sericite. Frequently it occurs as a layer of minute plates surrounding the little pyrite cubes, the edges of the plates normal to the faces of the pyrite crystal. In other instances larger plates are found as fillings in small fractures. Accompanying the sericite are quartz, zoisite, orthoclase, and in most instances large amounts of a whitish translucent, non-polarizing substance which resembles clay or massive kaolin. This substance is especially abundant in all the thin sections that were made from the richest ores. Quartz occurs abundantly as cryptocrystalline grains in the groundmass along with the sericite, in such manner as to cause the rock to resemble a quartz-sericite schist in many instances. It also occurs very frequently in somewhat larger grains as a rim, a kind of halo or aureole as it were, closely surrounding the quartz fragments and phenocrysts of the porphyritic rock. Orthoclase developed during the hydrothermal metamorphism is plentifully present in the form of small grains interlocking with quartz grains. It is not uniformly distributed throughout the rock but is fairly abundant in some localities. Muscovite, also probably a product of the metamorphism, is widely though sparingly present in the rock. The plates are usually small, rarely more than half an inch in diameter. Occasionally the mineral occurs in the form of veinlets apparently having developed in fractures. Zoisite is rather widely distributed throughout the rock, and in some places, especially in the highly mineralized rock forming the ore shoot in the main tunnel, it is abundant. It usually is found as irregular masses of interlocking bladed crystals. It was apparently developed from both the feldspathic material in the groundmass and the feldspar phenocrysts. In fact much of it occurs in the vicinity of more or less completely altered phenocrysts. In some places in which the rock did not suffer such intense metamorphism, the original plagioclase phenocrysts are only partially destroyed. However, none was found that could be positively identified. All that were studied showed narrow twinning bands, thus indicating that they belong in the acid end of the plagioclase series.

The basic rock involved in the metamorphism and the mineralization was noted in only one place, in the Gaarden trail near the southern boundary of the formation. In the freshly broken hand specimen it has a grayish green color, is very fine grained and dense, with little or no tendency toward a porphyritic texture. It is impregnated with pyrite in rather uniformly and widely distributed crystals and irregular grains, usually cubes, and is readily recognized as a much altered rock—probably a massive andesite. Microscopic study of thin sections of this rock reveals numerous minute lath-shaped plagioclase crystals, too much altered for satisfactory identification, in a ground mass of crypto-crystalline quartz, chlorite and sericite. Sericite is not very abundant in the sections studied and is not uniformly distributed. Much of the quartz occurs in the form of small irregular patches made up of minute interlocking grains. All such patches of quartz always contain varying amounts of chlorite. A large part of the chlorite occurs as minute patches practically free from other minerals, such patches being widely and uniformly distributed throughout the rock. The pyrite impregnations show relationships to the rock minerals, similar in all respects to those in the rhyolite. None of the altered andesite was found in the highly mineralized portion of the ledge in the prospects and tunnels.

Mineralization.

The foregoing descriptions of the rock alterations involved in the mineralization of the rhyolite and andesite making up the Red Ledge formation make it clear that the writers believe the pyritization of the great mass of rock was the result of hydrothermal metamorphism. They also believe that the emanations which produced these results were derived from the cooling granitic magma which now forms the great mass of hornblende granite a short distance to the south and east of the ledge, and with which the contact metamorphic ore deposits of the district are genetically associated.

Careful field studies have led to the conclusion that two types of mineralization, both of hypogene origin, but of two distinct periods are shown by the Red Ledge. The first of these was a period of widespread and intense hydrothermal metamorphism during which the rocks were profoundly altered and extensively impregnated with pyrite. The second period occurred somewhat later than the first, and was definitely related to a time of earth movements which produced a notable amount of fracturing, but little or no hydrothermal alterations. During this period of mineralization the copper, zinc, lead, and silver-bearing sulphides were deposited, largely as replacements of the earlier formed pyrite and the hydrothermally altered rock of the formation in the vicinity of the fractures. The emanations and solutions which deposited the sulphides of both periods were both clearly of hypogene origin. It is not at all unusual for an ore deposit to
show two periods of hypogene mineralization. To assist in describing such deposits the terms a-hypogene and b-hypogene, designating respectively the first and the second periods of ore deposition, have been used by the U. S. Geological Survey. These terms will therefore be used in the detailed descriptions of the Red Ledge ores.

A-Hypogene Mineralization.

By far the greater part of the sulphide deposition, as well as nearly all the rock alteration in the Red Ledge, belongs to this period of hypogene mineralization. The rock alterations, sericitization and other changes characteristic of hydrothermal metamorphism are described in the paragraphs on alterations of the rocks, page 47 and will not be repeated here.

So far as has been determined pyrite is the only sulphide belonging to this period of mineralization. It is not improbable that chalcopyrite and other value-carrying sulphides were deposited but if they were, they were not recognized during the studies upon which this report is based. Throughout the immense mass of rock, the extent of which is shown on the geological map, page 28 pyrite, usually in the form of minute cubes, or masses of crystals, is widely and more or less uniformly distributed. In many places conditions were apparently more favorable and fairly large masses of the mineral were formed, replacing the rock on a somewhat extensive scale. In the heavier deposits the pyrite is usually massive and not in well defined crystals. The general relationships between the widely disseminated pyrite and its host rock is shown in Plate 12. It will be noted that much of the mineral is in the form of very minute grains and crystals. While it appears reasonably certain that little or no copper, zinc, lead, or silver-bearing minerals were deposited during this period of mineralization, it is not known whether or not the gold which is found in certain places was deposited at this time. It is usual for pyrite impregnations such as this to carry more or less gold. The question could easily be settled by assaying the pyrite concentrates. It is an important question in estimating the value of the Red Ledge and should be investigated very carefully. Small but varying amounts of magnetite and hematite, however, not uniformly distributed were deposited during this period of mineralization.

B-Hypogene Mineralization.

During the second period of primary, or hypogene mineralization, which for convenience is called the b-hypogene mineralization, chalcopyrite, sphalerite, galena, and two or three unidentified...
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During the second period of primary, or hypogene mineralization, which for convenience is called the b-hypogene mineralization, chalcopyrite, sphalerite, galena, and two or three unidentified

minerals, one of which appears to be tetrahedrite were deposited. So far as has been determined from careful microscopic studies of polished surfaces of the ores, these minerals are all of contemporaneous deposition and all occur as replacements of the altered rock and of the older, or a-hypogene pyrite. It also appears that more or less pyrite was deposited during this period, but the evidence so far collected indicates only small and insignificant amounts of this mineral.

Chalcopyrite appears to have been the only original or primary copper-bearing sulphide of this ore deposit. It is clearly younger than the pyrite with which it is intimately associated and occurs in fractures, in and as larger masses surrounding masses of pyrite so that they stand out, as it were, like islands of pyrite in a sea of chalcopyrite, or in other instances affording typical ice-cake structure, that is, irregular masses of pyrite surrounded by chalcopyrite. The relationship makes it perfectly clear that the copper-bearing sulphide is younger than and replaces the pyrite. The replacement by chalcopyrite however, is not confined but affects the rock in the vicinity of the pyrite as well. Apparently contemporaneous and often intimately intergrown with the chalcopyrite are sphalerite, galena, and an unidentified mineral which has many of the characteristics of tetrahedrite. Galena and the last mentioned mineral are sparingly present. The chalcopyrite, in all sections examined, showed the usual supergene alterations to covellite and chalcocite. In the ores studied, all of which were from the ore shoot in the main tunnel, the copper-bearing minerals, while present in every specimen, are by no means uniformly distributed and in many places chalcopyrite is subordinate to sphalerite.

Sphalerite, next to chalcopyrite, is the most abundant of the b-hypogene minerals, and so far as could be determined from the material studied, the relationships of sphalerite to the rocks and to the a-hypogene minerals are similar in all respects to those of chalcopyrite with which in many instances it is intimately intergrown. It is also intimately associated with the other sulphides of the b-hypogene group, viz., galena, tetrahedrite, and a bright silvery mineral which somewhat resembles bismuthinite, but which has a pinkish tinge in its color. Plate 12 shows photomicrograph of a polished section of this ore and illustrates the relations between both chalcopyrite and pyrite and sphalerite and pyrite.

Galena is sparingly but widely distributed throughout the ore, but so far as developments have extended, use in sufficient quantity to be of much commercial value. It is apparently contemporaneous with the other sulphides of the second period of deposition,
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and is intimately associated with them. In some specimens chalcocite and covellite were seen, the latter being very rare however.

The silver-bearing mineral or minerals, as the case may be, could not be positively identified in the material studied. It seems probable, however, that one or both of two unidentified minerals which appear to be uniformly present in the ores, may be responsible for the silver values. One of these very closely resembles, and indeed, may be tetrahedrite. The other has a bright silvery color with a slight pinkish tinge. As pointed out this mineral resembles bismuthinite. Both of these minerals are intimately associated with sphalerite, and chalcopyrite, but apparently less so with galena. They were present in such small amounts that neither could be satisfactorily identified with the means at hand.

The examinations thus far made have not located the source of the gold which the ore carries. Indeed, it is not known whether the gold belongs to the first or to the second period of hypogene mineralization. It is believed that it belongs in both, possibly more abundant in the first. The question is still being investigated.

Gangue minerals of the b-hypogene mineralization, so far as they have been determined, are quartz, barite, calcite, hematite and the minerals of the hydrothermally altered rock which have been previously described. Barite is a very important gangue mineral and appears to be the constant associate in much of the highest grade ore. A lot of 100 pounds of the ore was carefully sampled and analysed in the School of Mines Laboratory by Mr. J. H. Jones, analyst for the State Bureau of Mines and Geology. His work showed 20.65 per cent of barium sulphate in a total insoluble residue of 31.71 per cent, or in other words, that nearly two-thirds of the insoluble gangue matter of this lot of ore, which is supposed to be typical of the ore in sight in the mine at present, consists of the mineral barite. So far as examinations have extended, barite has not been recognized in the purely a-hypogene mineralization, but the conditions for the examination of such mineralization were not all that could be desired at the time of the field work, and the mineral may have been overlooked. It is believed, however, that the barite is largely if not wholly limited to the second or b-hypogene period. of ore deposition, and that it indicates that the sphalerite, chalcopyrite, and other sulphides with which it is associated were deposited at moderate to low temperatures. The occurrence of sulphate minerals while an important theoretical question in the study of ore deposits, is somewhat too theoretical for discussion in an economic bulletin. The question, however, has been investigated recently by Butler, and those interested in the subject are referred to his work.

Sources of Mineralization.

The hydrothermal metamorphism of the Red Ledge formation and the impregnation of the rock with pyrite, thus forming the period of a-hypogene mineralization is discussed in considerable detail on page 50 and the descriptions need not be repeated in this place.

It appears from careful examination of the ore shoots exposed in the main tunnel that the b-hypogene mineralization is definitely associated with a series of slips or fractures which in general have a northeastward trend. This tunnel intersects a number of such fractures which vary in strike from N. to N. 75° E. and have variable dips. Those which dip toward the northwest are apparently more numerous and are probably more important. One of these is exposed about 40 feet from the portal of the tunnel and the rock on the northwest side of the slip shows considerable copper staining. Another, the most important thus far encountered, occurs about 180 feet from the portal. It has a strike of N. 60° E. and dips about 60° to the northwest. Seventy feet beyond this, or about 250 feet from the portal, is another slip with similar strike but vertical dip. Near and between these two fractures occurs the largest and most promising ore shoot thus far found in the mine. While the development work has not been extensive enough to afford premises for definite statements in regard to the matter, it appears that the copper-, zinc-, lead-, and silver-bearing ores are genetically related to these fractures, and that they have controlled the deposition of the minerals which carry these metals, probably serving as trunk channels for the solutions which brought them in. This question is of very great importance in attempting to estimate the amount of ore available in the ledge, and should be given careful attention by any one attempting to develop the deposit.

Supergene Alterations.

Under the term supergene alterations are included those alterations or changes which have been produced in the ores and rocks by surface waters, such as the weathering of the rocks and ores, and the secondary enrichment of the ores in so far as it was produced by meteoric or surface waters.

The rock minerals of the Red Ledge formation are for the most part so simple that so far as most of them are concerned weathering produces few changes other than disintegration. Quartz which makes up a large part of the rock is such a mineral.
while sericite, though not reduced to its lowest terms, suffers little change, excepting disintegration, in weathering. Such, however, is not the case with zoisite and especially orthoclase and other feldspars. The most important end product resulting from the weathering of these minerals consists of kaolin and clay. There will, on this account, be found a considerable amount of very finely divided sericite and much clay in the weathered portions of the lode, much of which will be set free in crushing and grinding the ores for concentration. Such clayey material mixed with iron oxide, may be present in large enough quantity to be troublesome in concentrating the ores by flotation.

The end products of pyrite, the most abundant sulphide in the rock, are sulphates and sulphuric acid, and oxides of iron. The acid may react with other minerals and form other sulphates which may remain in the altered mass of ore. In the oxidation of pyrite to the oxides of iron and sulphuric acid, many stages are passed thru and different sulphates of iron or double sulphates of iron and other elements may form. Nearly all such sulphates are readily soluble in water and sooner or later are taken into solution by the water which circulates thru the ore mass. Chalcopyrite, under conditions of weathering, behaves as does pyrite and produces soluble sulphates of iron or copper or of iron and copper, sulphuric acid and oxides of iron. As illustrations of the extent to which such alterations are taking place in this ore body one may mention the thick coatings of sulphates of iron and other elements that are found in sheltered places along the Gaarden trail where it crosses the formation, and in other well protected places in the natural outcrop, and also the strongly acid character of the water that is discharged from the two tunnels, and the heavy load of sulphates carried by it. Umbly states* that the water flowing from the lower tunnel had deposited a layer of spongy iron oxide on the floor of the tunnel about eight inches thick in one year. This tunnel has not been used for four or five years and is at present practically inaccessible because of the deposition of such material. This water is only surface water which percolates thru the weathering outcrop of the ledge and takes into solution the sulphates with which it comes in contact. The color of the outcrop of the ledge is also due to iron oxide in different stages of hydration, derived wholly from the oxidation of sulphides of iron carried by the rock. The copper sulphates resulting from the oxidation of copper-bearing sulphides are either carried downward by the water percolating thru the weathering mass, and deposited at a lower level thus enriching the original ore or they are changed by chemical reactions into carbonates, silicates, or oxides and

deposited, or remain in solution and are carried away. The carbonates of copper, malachite and azurite, and the silicate chrysocolla, are present in the oxidized portions of the ledge in varying, but, so far as developed, unimportant amounts. No oxides of copper were noted. That the water flowing from the two tunnels, especially the upper one, carries considerable copper in the form of the sulphate may be shown by the coating of metallic copper which quickly forms on the surface of pieces of iron which may be immersed in it.

As was stated above much of the copper taken into solution as the sulphate is carried downward in the lode and deposited as rich copper sulphides which serve to enrich materially the original or hypogene ores. The secondary or supergene sulphides occur as replacements in the original copper-bearing sulphides, and are almost always the minerals chalcocite, covellite, or bornite, more often chalcocite than either of the others. This zone of supergene enrichment is definitely related to the level of permanent ground water and the depth of circulation of surface or meteoric water. It is therefore influenced by many factors such as the character of rock forming the lode, the nature of topography, and the rainfall and other climatic conditions.

All the ore thus developed in the Red Ledge shows very prominently the results of supergene (secondary) enrichment of the copper values. The greater part of the enrichment in copper has been the alteration of chalcocypirite into chalcocite, covellite, and occasionally into bornite. The alterations usually have occurred in and along fractures in and around the borders of the masses of chalcocypirite. A minor, altho apparently widespread, process has been the replacement of hypogene galena by supergene chalcocite and covellite. Small masses of galena were found in all stages of replacement from practically pure galena on the one hand to apparently pure chalcocite on the other. The alteration, so far as observations have extended, began along fractures either in or around the peripheries of the little masses of galena. Much of the chalcocite, whether replacing chalcocypirite or galena, has a decided purplish tinge which suggests that the mineral may be intermediate between covellite and chalcocite in composition. Any one interested in the development of the Red Ledge would at this point naturally wonder to what extent the original copper content of the ores has been enhanced or increased by this process of enrichment. While the evidence at hand will not warrant any quantitative statements, it certainly justifies the belief that the increase has been important.

The writers have kept constantly in mind the question whether or not the silver value has been increased by supergene agencies as has the copper value. So far little or no evidence
either in support of, or against, silver enrichment in this ore has been obtained. Silver ores are about as readily and as often enriched as are those of copper. Therefore, since the enrichment of the copper ores has been so extensive, one would logically expect to find that the silver value has been increased in a similar manner. The question must be left open until further study can be given to it.

The remaining important query in regard to supergene alterations in the ore body relates to their depth of extension. To what depth have they extended? The development as it stood at the time of examination was not extensive enough to afford any evidence upon which an answer to this query could be based. The tunnel had intersected the ore shoot at the point of change between the oxidized and leached, and the enriched sulphide zones. Consequently the roof of the tunnel is made up, for the most part, of thoroly oxidized material while the floor consists of heavy, enriched sulphides. This point has a vertical depth of about 100 feet and is perhaps 50 feet above the water surface of Deep Creek. The circulation of surface waters thru the ore body is therefore probably very active and the conditions very favorable for oxidation, and still the heavy sulphides are found at least 50 feet above the surface of the creek which is only about 300 feet from the ore shoot. This fact, when considered in connection with the extremely rugged nature of the surface, and the steep gradient of Deep Creek, would lead one to believe that secondary enrichment would not extend to very great depths in this ore body, possibly not over 100 feet. However this and any other statements on the subject, until further development work has been done, must be regarded as mere guesses.

Grade of the Ore.

Very little satisfactory evidence as to the grade of the ore as exposed in the tunnels could be obtained. At the time of the field examinations the lessees of the property were engaged in sampling it, but had not completed their work. Thru the kindness of their engineer, Mr. F. A. Kennedy, such information on the subject as he had was made available. According to his figures there is a body of ore having a width of over 60 feet where it is cut by the main tunnel which, according to properly taken samples, averages $1.28 in gold, 8 oz. in silver, and 2.34 per cent in copper, zinc not having been determined, although one would suspect the presence of as much zinc as copper. He also states that the promising ore body in the north drift, where the full width is not known, averages $1.34 in gold, 4 oz. in silver, and 2.33 per cent copper, zinc not determined. According to reports of the diamond drilling which was done prior to the coming of the present lessees, a hole was bored straight ahead...
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from the face of the main tunnel for a distance of 400 feet. It is
reported that this hole passed thru about 150 feet of ore which
assayed 50 cents in gold, 1.5 ozs. in silver, and 1.5 per cent copper.

Thomas Heady Prospect.

The Heady prospect, or mine as it is called, consists of a
short tunnel in an outcrop of pyritized and sericitized rhyolite
which occurs about 1000 feet a little west of north from where
the Red Ledge trail crosses Trail Creek, or about three-eighths
of a mile below the Fife cabin on Deep Creek.

So far as examination has been carried on, the conditions at
this place are in all respects similar to those at the Red Ledge.
The ore-bearing rock is a porphyritic rhyolite which has been
sericitized and impregnated with pyrite in minute grains and
crystals, usually cubes, thru hydrothermal metamorphism, and
the valuable minerals, chalcopyrite (enriched by supergene
agencies) sphalerite, and galena appear to be related to fractures
younger than the pyritization of the mass of rock. Only a small
amount of the value-carrying sulphides has been exposed. The
sericitized rhyolite outcrops on the mountain side for some
distance above the tunnel, and its areal extent was not de-
termined. The general appearance of the rhyolite in so far as
its relation to the andesite was determined seems to indicate that
it is a dike or a sill, but the question must be left unsettled until
more field work is done. The development work thus far done
is not sufficient to warrant any statements as to the size or the
importance of the deposit.

CONTACT METAMORPHIC DEPOSITS

The term contact metamorphic deposits is used to designate
ore deposits which have formed as a part of the metamorphism
of one rock formation resulting from intrusion into it or around
it of an igneous magma. Rocks of any type may be intruded,
but only a few types appear to be susceptible to the influences
of the magma to the extent of permitting the development of
contact metamorphic ore deposits. Of these the rock most
easily altered, the one in which nearly all of the important deposits
of this type are found, is limestone or dolomite. The ores accom-
panied by certain characteristic metamorphic minerals—altera-
tions of the rock in which they occur, are usually found in the
limestone at and near the contact with the intrusive. Occasion-
ally a minor and usually insignificant amount of mineral oc-
curs in the intrusive rock, near the contact. The mineralization
as well as the metamorphism of the intruded rock, limestone,
as the case may be, occurs in the most irregular manner. In
some instances the alterations are found at the immediate con-
tact and extend continuously from a few to more than a hun-
dred feet. In some cases there is very little alteration of any kind at the contact, when a few feet away may occur profound metamorphism and heavy mineralization. As a general rule the alterations and the mineral deposits occur rather near to the contact, rarely more than a few hundred feet away at most. There is also a similar if not a greater variation in the size of the different pockets, chimneys, or bodies of ore. In fact, it appears that no other classes of ores or types of mineralization are so dependent upon or so easily influenced by local conditions as are the contact metamorphic deposits. Such ores may form at the contact of any intrusive rock and an easily replaced formation, but the igneous rocks usually associated with important contact metamorphic deposits are intermediate or acid, i.e., granite, monzonites, or diorites.

The gangue minerals of such deposits are for the most part heavy lime-bearing silicates such as garnet, epidote, diopside, actinolite, tremolite, zoisite, vesuvianite and a few others. With these there may be scapolites, spinels, fluorite and others, all usually in small amounts. The oxides of iron, hematite and magnetite are always present. In fact, a number of well known deposits of iron ore, such as at Iron Springs, Utah, and Cornwall, Pennsylvania, are typical contact metamorphic deposits. In these and in many others the valuable minerals are almost wholly oxides of iron, with very few sulphides of any kind. However, the commonest type of contact metamorphic deposit is of copper ores which occur in the form of sulphides, chalcopyrite and occasionally bornite, with varying amounts of pyrite. There are usually present small amounts of sphalerite, galena, molybdenite and rarely tetrahedrite. In many cases, the sulphides, with the exception of the pyrite, are somewhat later in point of deposition than the silicates and often occur as replacements of them. As to the sources of the material out of which the different minerals of contact metamorphism have developed, they may be derived from within the intruded rock, and the mineral formed by recrystallization, as calcite; the materials may be derived from the igneous rock, as the various sulphides; or other minerals, such as the silicates, are made up in part of material from the original rock, and in part from substances brought in from the igneous rock. The subject of contact metamorphism is treated in the standard handbooks on ore deposits and need not be considered in greater detail here.†

The most numerous and also the most extensively developed ore deposits in the area included within the map which accompanies this report are clearly of the contact metamorphic type.

and the descriptions which follow may serve as characteristic examples of the group. It is of interest to note in passing that these were the first contact metamorphic deposits to be recognized as such in the United States. In 1899 Waldemar Lindgren visited the district and published a brief description* of the deposits then opened, the Blue Jacket, the Peacock, the Helena, the Queen, and the White Monument in which he said: "The copper deposits of the Seven Devils as described are typical contact metamorphic deposits formed by the chemical action of the diorite on the limestone when the former was intruded in a molten state into the sedimentary series. Especially intense, naturally, was the metamorphic action on the smaller masses of limestone torn loose from the main mass by the intrusion. The garnet, epidote, specularite, etc., which form the typical gangue of the deposits are the characteristic products of contact metamorphism of limestone."

In another publication** Lindgren stated that the credit for first recognizing the nature of these deposits belongs to R. L. Packard who published a description of the ores and the associated rocks in 1895.***

Rocks Involved.

The rocks involved in the development of the contact metamorphic deposits of the Seven Devils district are a limestone, probably of Carboniferous age, and a great mass of intrusive hornblende granite or granodiorite of undetermined age. The distribution and the relationships of the two formations are shown on the accompanying topographic map, and they are described in considerable detail in the chapter on the general geology of the area, to which the reader is referred for general relationships and considerations. In order to describe more conveniently the changes produced in the two formations in connection with the intrusion of the granite, and the formation of the ore deposits it seems to be necessary to repeat in a large measure the petrographic descriptions of both rocks.

The Limestone.

The limestone involved in the contact metamorphic ore deposits is a very small part of the limestone formation of the area as a whole and consists of a number of blocks broken off during the intrusion and engulfed by it so that they now occur as islands of limestone in a sea of hornblende granite. These vary greatly in size, the largest being about a mile long and from

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300 to 1000 feet wide, while the smallest is a mere patch scarcely a stone's throw in diameter. There are perhaps 10 or 12 such islands in the granite area as shown on the accompanying maps and sketches. It is around the borders of these that the contact metamorphism has occurred and the bumpy ores have been deposited.

The unaltered rock, or better, the least altered limestone that was found is a light gray, occasionally a bluish gray color, occurs in beds from a few to perhaps 15 or more feet thick, and excepting an occasional sandy or shaly band is a rather clean, fine grained carbonate rock. Rarely there occur beds with a pinkish tinge, but by far the greater part of the formation has a light gray color. A few fossils have been found; but as a whole the rock contains little in the way of organic remains. No fossils have been reported from any of the limestone in the granite area, and those that were found came from near Homestead and consisted of brachiopods and crinoid stalks, probably of Carboniferous age. No analyses were made to determine the purity of the rock and it is not known whether or not it is dolomitic. In one place it was burned and is reported to have produced a good grade of lime. In some places, especially in the outcrop on White Monument the rock weathers—disintegrates—and forms a "sand" just as do typical dolomites. Mineralogically the rock is very simple, consisting only of the small interlocking grains of calcite with specks of carbonaceous matter and an occasional grain of quartz. Of course, in the sandy and shaly bands there is much more of the impurities. It should be stated that the descriptions of the unaltered rock just given are based on material obtained in the Snake River gorge, from lower Deep Creek, and from Rapid River about four miles below Black Lake. All the limestone in the granite area is considerably metamorphosed.

As the limestone occurs in the granite mass, it varies in point of metamorphism from the typical garnet-epidote-pyroxene gneiss rock of the ore deposits to the coarsely crystalline white such as occurs in the White Monument or in the limestone ledge between the Queen and the Lockwood mines. As a general rule, it may be stated that the nearer the granite contacts the more profound are the alterations of the limestone. There are, however, many great exceptions to the rule, and in many instances there is little alteration at the immediate contact other than a large grain-size, while at a distance, varying from a few to 50 or more feet, the metamorphism has been so intense as to change great masses of the rock into the typical heavy silicates. Local conditions as regards both limestone and intrusive granite have apparently had as much to do in the processes and extent of metamorphism of the limestone as has the proximity of the two rocks. In other words, agencies other than the molten granite magma have been the determining factors. These were, as was stated in the beginning of the chapter, the emanations, probably hot gases and fluids, given off by the magma as it slowly cooled. Where these emanations could have easy access to the limestone the metamorphism was intense, and it varied in intensity directly with its accessibility to these gases and fluids.

The most prominent as well as the most extensive alteration of the masses of limestone as the result of the granite intrusion was a recrystallization of the original material of the rock which resulted in great increase in the size of the individual grains. All the limestone of all the "islands" or included masses shows the effects of recrystallization and the size of the interlocking grains varies from a small fraction of an inch to nearly an inch in diameter. Some of the finest grained material is found in the outcrops at the Helena mine upper tunnel, and some of the coarsest occurs in the White Monument and in the Humboldt prospect on Camp Creek. In the outcrop at the Helena mine there are narrow bands of shaly material in the limestone and these are much more highly metamorphosed than the purer rock intercing them. They contain epidote, garnet, scapolite, amphibole, and pyroxene, while the purer rock shows little or no metamorphism, except recrystallization. Impurities, therefore, are conducive to the development of the metamorphic silicates. As the metamorphism becomes more intense, following the recrystallization, also probably accompanying it even in the purest of the rock, garnets occur in the form of minute crystals. These seem to develop at the periphery of the calcite grains and as they grow they replace the carbonate mineral. Closely following the development of the garnets the lime-bearing silicates, wollastonite, tremolite, diopside, make their appearance, while last of all and marking the most intense metamorphism occur the epidote and the massive-brown garnet. The zones of these contact minerals, as has been stated, occur irregularly at and near the contact of limestone and hornblende granite. In some of the smaller masses of limestone as the White Monument, the limestone is practically bordered with such a zone, while in some of the larger masses as the Blue Jacket—Lockwood ledge, the metamorphism has occurred at different places while the intervening contact has suffered little or no change beyond recrystallization. Some of the smaller masses of limestone, as that at the Peacock mine, appear to have been more or less completely changed into metamorphic minerals. As a rule the most intense metamorphism has occurred at or near the contact, although it is not unusual to find heavy masses of silicates with or without ore from 75 to 100 feet away. Beyond 150 feet the effect has been slight and only
in the impure bands have the silicates been developed extensively. The outcropping limestone at the Helena cabins on Camp Creek shows bands of metamorphic minerals over 100 feet wide. The Arkansaw and the Peacock mines are examples of the most intense metamorphism in the district. The dumps at the Arkansaw tunnels contain a greater variety of metamorphic minerals, and probably better specimens from a mineralogical point of view than any other opening in the district, while the Peacock has by far the largest and purest masses of garnets. So far as developments have gone, the ores are confined almost, if not wholly to the limestone side of the contact, and they appear to have been deposited after the silicates had formed and to occur as replacements in and among them. This subject is discussed in detail in the paragraphs on the ores, and need only be mentioned here.

**Contact Minerals.**

The contact minerals, so far as they have been studied appear to be similar in all respects as to kind, number, variety, and relationships to those of other well known contact metamorphic copper deposits. The most common of such minerals, garnet, epidote, pyroxene, and amphibole, are abundant, while only a few of the rarer ones such as antigorite, scapolite, anthophyllite, spinel, and ankerite are sparingly present. The following list is believed to be fairly complete, those of doubtful identification are designated by an interrogation mark. They are not listed in any definite order.

- Andradite
- Almandite
- Grossularite
- Epidote
- Pyroxene, for the most part diopside
- Actinolite
- Tremolite
- Wollastonite (?)
- Ankerite (?)
- Calcite
- Aragonite
- Scapolite, apparently diopside
- Zoisite
- Gypsum, var. selenite
- Chinozoisite
- Chalcedony
- Quartz
- Chlorite
- Hornblende, var. hedenbergite (?)
- Spinel
- Forsterite (?)
- Anthophyllite
- Antigorite
- Graphite
- Sericite
- Titanite
- Talc

Two minerals, one resembling pectolite, and the other showing beautiful polysynthetic twinning similar to plagioclase feldspars were recognized during the microscopic studies but were not identified. The usual supergene derivatives or weathering alterations or products are present in all the openings, but no attempt has been made to discuss other than the most important or most unusual of them. It is very difficult if not impossible to determine anything in the way of age relationships between the contact minerals. They are all intimately intergrown and apparently of contemporaneous origin. However, since garnet and pyroxene, probably diopside, are found in the least metamorphosed limestone and farther from the contact than the other minerals, it seems probable that they were the first to form and are probably the oldest of the group. Garnet, epidote and pyroxene together with the hornblende derived from it, make up probably three-fourths of the contact minerals. Zoisite, actinolite and tremolite are fairly abundant and are widely distributed. Scapolite appears to be for the most part confined to the impure, shaly portions of the altered limestone. Gypsum was found only in one reported to have come from the South Peacock mine, and was identified in only one specimen of the ore which came from a collection made by a local prospector. The mineral is clean, perfectly transparent selenite and is intimately associated with massive bornite. Some of the minerals especially the garnet, the epidote and occasionally the pyroxene, occur in good sized crystals. A portion of a broken, well formed garnet crystal about seven inches in diameter was found on the dump at the Arkansaw mine.

In most places along the contact between the hornblende granite and the limestone the metamorphism appears to have been confined almost wholly to the sedimentary rock. However, in a few localities, especially at the Arkansaw and the Helena mines, the granite shows considerable alteration. At the Arkansaw mine contact metamorphic alterations appear more prominently than hydrothermal effects, while at the Helena the reverse seems to be true.

In order to compare the fresh and the altered phases of the granite, it seems to be desirable to repeat briefly the description of the normal rock. As exposed through the central part of the district where the granite is the predominant rock, it has a medium-coarse typical texture and a light gray color and in both color and texture there is little variation except at and near contacts with other formations. Occasionally there are found schlieren, or segregations, usually ellipsoidal in shape, in which the darker minerals are more abundant and the texture much finer than in the normal rock. Mineralogically the rock is made up of plagioclase feldspars which vary from albite to andesine, a moderate amount of allotriomorphic quartz, a subordinate amount of orthoclase, considerable hornblende, a small and variable amount of biotite and the usual accessory minerals. No chem-
ical analyses were made, but as already pointed out on page 25, it is clear from its mineralogical composition that the rock can be safely classified as a granodiorite or a hornblende granite. In a few places, notably at the Peacock and the South Peacock mines, the hornblende granite contains numerous sharply angular inclusions of a rock of apparently similar mineralogical composition but of much finer texture. The source of these inclusions has not been determined.

The most important change in the hornblende granite at its contacts with the other formations, where it has been possible to examine them, is the usual decrease in the size of grain which gives the rock a much finer texture. In a few places, especially at the Arkansaw and the Helena mines, alterations in the granite at the contacts resemble both the hydrothermal and the contact types of metamorphism, in that the altered rock contains large amounts of garnet, much epidote, and abundant pyroxene, and also shows considerable sericitization. The color of the granite thus altered is a dirty greenish gray with a decided pinkish tinge due to the development of a pink mineral, probably the pink zoisite (thulite) in the feldspars. In some specimens this pink mineral is abundant, especially so in veins which seem to have developed along fractures in the granite. While no chemical work was done upon it, optical tests indicate that it is thulite. All the feldspars, whether pink or not, contain much zoisite. A few small cavities or vugs lined with perfectly terminated plagioclase, apparently albite crystals, were noted in the granite in the waste dump at the upper Helena tunnel, thus suggesting at least a certain amount of pneumatolytic activity. With the exception of a little pyrite and occasionally a few small areas of chalcopyrite and rarely a little bornite the altered granite contains nothing in the way of ore. So far as could be determined the alteration of the granite was confined pretty closely to the limestone contact, and in no case was appreciable metamorphism noted more than 75 feet from the contact. While the metamorphism of the granite at the limestone contacts just described is probably of no economic or commercial importance, it is of considerable interest from a scientific standpoint. It tends to corroborate the evidence shown by the relationship between gangue and sulphide minerals of the ores and proves that the deposition of the sulphides occurred after the granite magma had solidified and after the development of most of the heavy silicate minerals.

Ore Minerals.

Like other contact metamorphic ore deposits, those of the Seven Devils district consist of sulphides, principally of copper, in a gangue composed of heavy silicate minerals, garnet, epidote, pyroxene, etc., such as have been described in the foregoing paragraphs. They occur in irregular bunches, pockets, chimneys, or shoots in the metamorphosed limestone at and near its contacts with the hornblende granite. As is characteristic of nearly all known contact metamorphic ore deposits, these also present many irregularities as to size, shape, value, and position in the metamorphic zone. They are bumpy or pockety, occur in very irregular forms, and are exceedingly difficult to develop in mining. It has been stated that not in all places along the contacts between the masses of limestone and the granite are the zones of garnet and other heavy silicates found. In like manner a great part of the masses of heavy silicates are either barren or devoid of ore of commercial value. So far as studies have extended there has been found no satisfactory basis on which to account for the presence of a shoot or pocket of good ore in one mass of heavy silicates or for its not being present in a nearby mass of minerals similar in all respects. About the only safe statement that can be made in regard to this matter is that the ore shoots are where you find them.

The principal, and in many instances, practically the only valuable metal in the ores is copper. Usually, however, there are present small amounts of lead, silver, and gold, all in such minute quantity that the ores would have no commercial value if the copper were absent. The ores are of two general types, chalcopyrite or "yellow copper," with very little bornite or other minerals richer in copper, and those in which the values lie almost wholly in bornite or "peacock copper." The ores from the Arkansaw mine are of the first type, while those from the Blue Jacket, the Helena, and the Peacock mines belong to the second. As has been stated previously the writers regard the primary ores as of hypogene origin, and believe they were derived from the granite magma and that they were deposited, probably after the heavy silicates had been for the most part developed and after the granite magma had solidified as the holocrystalline hornblende granite. The ores have long been subjected to erosion and supergene processes in general, and the upper portions of the deposits as they stand have suffered many superficial alterations which have oxidized, enriched, and otherwise changed the primary hypogene minerals of the ores. No mines in the district have extended below the zone of these supergene or secondary alterations.

The gangue minerals are the silicates and other minerals which have been described on pages 58 and 62 and the description need not be repeated here. In the Arkansaw deposit pyroxenes and their alteration products, epidote, tremolite, and garnet, are the most abundant gangue minerals, while
in the Peacock ores garnets are more abundant than all other non-metallic minerals. Tabular hematite is present in all the mines and prospects, and in some places such as the Lockwood it is very abundant and occurs in large masses. However, so far as observations have extended, hematite does not occur in intimate association with the sulphides.

*Hydromagnetite minerals.*

In these deposits the original or hypogene sulphides consist of pyrite, chalcopyrite, bornite, galena, molybdenite, a little bismuthinite (?) and two or three other unidentified minerals, one of which resembles tetrahedrite, and so far as determined these are all contemporaneous in point of deposition. Bornite is apparently the most abundant, Chalcopyrite, however, is also abundant. The other minerals, while present in all the openings studied, are by no means plentiful. In some instances intergrowths of bornite and chalcopyrite were found, but none of them showed the graphic intergrowths that occasionally occur in such ores. Bornite is much more abundant than chalcopyrite in all the mines and prospects, except the Arkansaw mine in which bornite is only sparingly present and chalcopyrite is practically the only primary ore mineral. Galena while present in all the deposits studied occurs in such small amounts that it may be regarded as a rarity. Molybdenite is most abundant in the ores from the lower Queen tunnels, but even here it is probably of little or no commercial value.

All the hypogene ores thus far taken from the mines, show very prominently the effects of supergene or surface agencies, either being more or less oxidized or to a varying extent enriched by the formation of rich secondary copper minerals such as chalcocite or covellite in the bornite, and these two with the addition of bornite in the chalcopyrite. These occurrences, however, are considered in the following paragraphs.

*Supergene Minerals.*

These, in common with all other deposits of copper-bearing sulphides, present two types of supergene or superficial alteration. In one type the processes have been those of oxidation, and the oxidized copper-bearing minerals, sulphates, carbonates, oxides, and silicates such as chalcanthite, malachite, cuprite, and chrysocolla are formed as a result of active oxygen-bearing waters upon the sulphides of the metal. These reactions take place in the upper part of the ore body and the resultant minerals are usually found only in the upper portion of the ore shoot. The second type of supergene alteration consists of the enrichment of the original or hypogene copper minerals, by the development within them of richer copper-bearing sulphides, such as bornite, covellite, and chalcocite in chalcopyrite, and covellite and chalcocite (copper glance) in bornite. The chemical reactions which produce these results take place in the ore body at and somewhat below the level of permanent ground water and are therefore characteristic of the intermediate portion of the ore shoot. Below this zone of supergene enrichment which is limited by the depth to which surface or meteoric waters penetrate, only the original hypogene minerals occur in the ore body. The boundary between the two upper zones is not a sharp and fast line, but its position fluctuates, varying according to the rainfall and other factors. Since both zones are continually and constantly moving downward as the surface is lowered by erosion, the second zone is constantly encroaching upon the zone of unaltered hypogene ores. Thus it is that in the upper portion of the intermediate zone in any such ore deposit, there occur minerals formed in, and characteristic of all three zones. None of the openings in the Seven Devils district has reached the zone of the unaltered hypogene sulphides, the deepest being in the intermediate or zone of enriched sulphides with some of the minerals of the zone of oxidation.

The ore minerals of the zone of oxidation so far as they have been recognized are, in the order of their importance, chrysocolla, malachite, malachite (?), azurite, chalcanthite, anglesite, cerussite, molybdate, and a few that have not been identified. A small amount of powellite, a calcium molybdate, was reported to have been found in the Peacock mine years ago. Associated with these are oxides of iron and manganese and other alteration products of the gangue minerals. Chrysocolla, a silicate of copper, in many places, especially in the Arkansaw mine, is by far the most abundant of the oxidized copper minerals, in fact the mineral is forming today from drippings in many places in the abandoned workings. It is also abundant in all the other mines and prospects. Intimately associated with the chrysocolla, rarely in alternating concentric bands with it, is black or very dark brown copper-bearing silicate similar to the chrysocolla in all respects except color. These silicates and carbonates of copper (azurite is not abundant) are abundant and form valuable ores in the upper portions of the important mines. The different ore deposits are completely oxidized to varying depths, perhaps 75 feet from the surface will limit it in most cases. At these depths, the altered and enriched sulphides come in and inaugurate the intermediate zone, and the minerals of both zones then persist to the greatest depths of the present operations.

As has been stated on a previous page the rich secondary or supergene copper-bearing sulphides consist of chalcocite, covellite, and bornite, all three occurring in the altered chalcopyrite,
and the first two in the enriched bornite. The enrichment has occurred, as is almost always the case, by the development of the rich secondary sulphides in fractures in and around the peripheries of the masses of original or primary sulphides. Specimens may be found quite readily which show all stages of enrichment from the secondary mineral in microscopic cracks, invisible to the unaided eye, to instances in which practically the whole mass of the original has been altered to the secondary sulphide. Rarely a "flare back" has occurred and a supergene mineral carrying less copper is developed in a mass of rich primary or hypogene ore, as the development of chalcopyrite in fractures in bornite, a phenomenon not at all unusual in these ores, but which is of scientific rather than economic importance. Judging from the amount of rich secondary sulphides in the ores one would conclude that the value of the ores in the present depths of the mines has been materially increased by the processes of supergene enrichment. There is no way of knowing or of satisfactorily predicting the depth to which such alterations may extend. It is certain, however, that the unaltered sulphides have not yet been encountered in the deepest workings in the district, (about 300 feet.)

MINES AND PROSPECTS

As stated in the preceding chapter, the contact metamorphic deposits of the Seven Devils district occur at and near the contacts between bodies or masses of limestone and a batholith of hornblende granite or granodiorite in which the bodies of limestone were engulfed at the time of the intrusion of the igneous rock and in which they now occur as islands of more or less metamorphosed limestone in a sea of granodiorite. So far as known all the mineralization of any commercial importance occurs on the limestone side of the contacts and by far the most part is in the zone of heavy silicate minerals which was formed at different places in the limestone at and near the contacts with the igneous rock. As shown on the map, page 28, two of the largest islands of limestone occur near the southern boundary of granodiorite. At the contacts of these bodies of limestone are found the most important ore deposits thus far developed in the district. The easternmost of the two contains the Arkansaw, the Decorah, the Marguerite, and the Calumet ore bodies, while at the contacts of the larger mass to the west occur the Helena, the Blue Jacket, the Queen, the Alaska, and the Lockwood deposits. The latter ore bodies, so far as known, occur in smaller isolated bodies of engulfed limestone which have suffered at their contacts varying degrees of metamorphism. In one instance, the Peacock ore body, the mass of limestone was small in comparison with the others and appears to have been entirely altered into contact metamorphic minerals, garnet largely predominating.

The different ore bodies resemble each other so closely as regards gangue minerals, relation of mineralization to igneous rocks, the position of the ore and the metamorphic zones in relation to the contacts, that a description of one deposit, will, by simply changing the name and a few details, apply to any other. The most important difference is in the original copper-bearing sulphides. In the Arkansaw-Decorah-Marguerite, and the Calumet ore bodies the copper mineral is almost wholly chalcopyrite, while in all the others bornite is by far the most important mineral. Of course there is more or less variation in the relative abundance of different gangue minerals, but the same minerals in the same relation to each other and to the unaltered rocks are present in all the deposits.

In the following descriptions the mines and prospects are arranged in alphabetical order, and without any relation to their importance as producers.

Alaska Mine.

The Alaska mine workings are situated near the head of the right hand fork of Garnet Gulch, on the eastern side of the lime belt that extends northwest from the Helena mine. The workings consist of a tunnel which is probably 150 feet long, a raise to the surface, some small stopes near this raise and several short cross-cuts branching off from the main tunnel. The tunnel begins in the limestone and encounters granodiorite at a distance of 50 feet and evidently follows the contact to the upraise which is about 120 feet from the portal. At this point a garnet zone, which apparently occurred in the granodiorite, was encountered and some high-grade bornite ore extracted. Very little ore can be seen in the present workings but good specimens of bornite can be found on the dump. The garnet zone is evidently quite small and contains the normal association of contact metamorphic minerals in addition to the bornite.

Arkansaw-Decorah-Marguerite Mine.

The Arkansaw ground was located in the late eighties by Charles Walker and "Frenchy" David. Nothing, however, beyond the necessary location and assessment work was done and the property was soon sold.

The first real development work was done in 1900 and 1901 by the Boston and Seven Devils Copper Company which acquired the property in 1899. This work was almost wholly in the Decorah-Marguerite claims which adjoin the Arkansaw. During this period of operation it is reported that several thousand tons of ore were taken out and shipped. The Kleinschmidt grade was
extended to the mine and the town of Landore was established and attained the height of its glory, viz. 300 inhabitants, a newspaper, and an adequate supply of saloons and dance halls. The company failed in 1901 and the mine was closed. With the coming of the Ladd smelter the mine was reopened by lessees and worked during 1904 and part of 1905. With the closing of the smelter the work in the mine was stopped. Later it was taken under lease by John Arthur and two associates, the tunnel was extended from the Decorah into the Arkansaw ground, and a good ore body exposed. As a result of this work the mine was taken over in 1908 by the Seven Devils Copper Co., under management of Fred D. Smith. Work was carried on actively, cross-cuts driven, a shaft sunk, stopes and raises run, and a new tunnel, called the Iowa, was started near the water level in Indian Creek and driven through the granodiorite toward the ore body. During the beginning of the work the company mortgaged the property to the Lewisohn interests. It was soon unable to meet the payments as they came due, the mortgage was foreclosed in 1910, and the mine was again closed.

In 1915 the mine was again reopened by the Arkansaw Leasing Corporation, under management of Fred D. Smith who was formerly with the Seven Devils Copper Company. The Iowa tunnel was driven 600 feet farther, and reached the ore body. Rises and stopes were run and a few hundred tons of high-grade ore were taken out and shipped. The scheme was not successful, and the mine was again closed, January 1917. The last work consisted of a raise from the Iowa to the upper tunnel 100 feet above, and was done in the fall of 1919. This raise is said to have passed thru 60 feet of a mineralized zone.

Development. The development work in the Arkansaw-Decorah mine consists of an upper tunnel about 700 feet long with cross-cuts, drifts, raises and stopes, a lower tunnel, known as the Iowa tunnel, 100 feet vertically below the upper tunnel and about 1200 feet long with a little drifting, and a raise connecting with the upper tunnel. On the surface is a caved shaft and a big open cut. Three-fourths of the development work has been done in the granodiorite and has only served as a means of access to the ore zone.

Occurrence of the Ore. The ore deposits occur in a zone of contact metamorphic silicates, epidote, garnets, and pyroxenes with smaller amounts of quartz, calcite, tremolite, zoisite, hornblende, and a few other minerals. This zone was developed at and near the contact of a body of limestone with the granodiorite. Most of the ore is said to have occurred on the limestone side of the metamorphic zone in irregularly distributed shoots and chimneys. Much of the ore, however, occurs in the midst of, and is inti-
mately intermixed with, the silicates, and in the silicate mass it was common to find stringers and veinlets of the sulphides extending toward both limestone and igneous rock. The metamorphic zone is very irregular in size and shape, however, and is rarely more than 75 feet thick. In some places no silicate minerals were formed at the immediate contact of the limestone with the igneous rock, while a few feet away in the limestone a band of silicates from 25 to 50 feet wide would be found. All the silicate masses seem to contain at least a small amount of ore, but the workable deposits were always found in disconnected masses scattered here and there thru, and also bordering, the silicate zone. In these shoots or chimneys the ore was usually so rich that it could be readily raised to shipping grade by hand-picking. However, much of it is too lean—from 5% to 7% copper—to be so graded. It is therefore at best only a concentrating ore. Many thousand tons of such material are said to be available.

The Arkansaw ore body differs from all the other contact metamorphic deposits of the district in that the primary or hypogene ore mineral is almost exclusively chalcopyrite, while in all the others it is bornite. None of the development work has reached the limits of secondary enrichment and it is probable that all the sulphide ore so far taken out has been materially increased in value by this process. The rich secondary sulphides, chalcocite, covellite, and bornite occur as replacements in and along fractures in the chalcopyrite. The most important oxidized copper mineral is chrysocolla, the common green silicate of copper. In many places in the upper portion of the lodes it was abundant and constituted a valuable ore. In many places in the abandoned working it is today being deposited by water dripping from the roof or seeping from the walls of the tunnels and drifts. Along with the chrysocolla occurs a black silicate of copper, malachite, azurite, and a minute amount of cuprite. None of these except the silicates and the malachite are of any importance as ores. Erosion is rapid in the district, and as a result the altered sulphides are always found at very shallow depths, in some instances in the outcropping garnet zones.

Blue Jacket Mine.

The Blue Jacket claims, two in number, were located in the late eighties by Charles Walker, who did only location and development work and sold them at the first favorable opportunity. In the early nineties they were acquired and patented by the Kleinschmidt interests. The first important development was done by the pioneer mining organization in the district, the American Mining Company about 1895 and 1896. This company failed and the leases et cetera were acquired by the Northwest
Copper deposits of Seven Devils

Copper Company which took out considerable ore. With the failure of the Cuprum smelter in 1898, the company went out of existence and the mine was closed. In 1899 the property was taken by the Blue Jacket Mining Company, Frank French, manager, and preparations were made for more extensive operations than had previously been attempted. The Kleinschmidt grade had been extended to the mine in the summer of 1899, thus making the property more readily accessible. The mine was worked actively during 1900 and the summer of 1901 and several thousand tons of high-grade ore, some of which is said to have carried more than 40% copper, were taken out and shipped. Transportation facilities were inadequate, the long haul to Council, 45 miles away, was very expensive, the company failed, and the mine was closed. With the coming of the Ladd smelter in 1904, work in the mine was resumed under a lease by John Rogers who operated it two summers until the closing of the smelter in 1905. From 1909 until 1912 it was operated in a small way by P. H. Kleinschmidt and P. H. Miller, and several hundred tons of high-grade ore were taken out and shipped. In 1914 and 1915 P. H. Kleinschmidt came back, reopened the mine, and took out a small amount of good ore. The last work was done in the summer of 1917 by John Rogers who is said to have taken out and shipped two cars of high-grade ore. As a result of all this work on the part of lessees who were looking only for high-grade ore and not toward the future of the mine, practically every pound of developed ore has been taken out, and as the property stands today it cannot be regarded as anything more than a favorable prospect.

The property is opened by a short upper tunnel, a lower tunnel 350 feet long with portal about 15 feet below the level of the Kleinschmidt road, and a shaft 310 feet deep. From the lower tunnel there are drifts, crosscuts, and raises one of which reaches the surface. A number of stopes, varying in width from 6 or 8 to perhaps 20 feet and up to 100 feet in length, have been run. Much of the work is in bad condition, and the careless work on the part of the different lessees has caused the shaft to cave.

The Blue Jacket deposit occurs near the east end of the large body of limestone which is included in the mass of granodiorite near its southern boundary, and along the contacts which occur the Queen, the Alaska, and the Lockwood mines, and is at the south contact of the limestone and the igneous rock. The ore while occurring in varying amounts throughout the large body of contact minerals, is, for the most part, in the limestone side of the metamorphic zone. Garnet is by far the most abundant metamorphic mineral and the ore is often found intimately intermixed with it and the other heavy silicates. From the main masses of ore there were often found veinlets or stringers of ore extending thru the garnet zone across the contact and a few inches into the granodiorite, thus indicating that the ore, for the most part, was deposited after the contact metamorphic minerals had been formed. Microscopic study of thin sections of the gangue and ore minerals and of polished sections of the ore shows that much of the ore has replaced the silicate minerals and thus confirms the assumption that the ores are younger than the silicate minerals.

The strike of the granodiorite-limestone contact which appears to conform with the strike of the limestone beds, is about 50 degrees west of north. The beds dip steeply, perhaps 70 degrees, toward the northeast. A few stringers or veins of quartz which carry varying amounts of chalcopyrite are found cutting thru both the masses of rich ore and the bodies of lean silicates. The ore is not so intimately intermixed with the silicates as in the Arkansaw-Decorah mines and unlike the ore from these mines, the Blue Jacket—primary ore—consists almost wholly of bournite, there being only small and insignificant amounts of chalcopyrite.

None of the work has extended below the limits of supergene or secondary enrichment and it is probable that all the ore thus far taken out has been materially enriched by such processes. The enrichment consists of chalcopyrite and covellite which have developed in and along fractures in the bournite. The usual oxidized ore minerals, chrysocolla, malachite, azurite, cuprite and melaconite, are present, the last two only sparingly. Chrysocolla is apparently not so abundant as in the Arkansaw-Decorah mine, while cuprite appears to be more abundant. All the ore carries low values in both gold and silver. The gold seems to occur in the metallic state, and while some of the silver occurs in tetrahedrite which is found occasionally, part is believed to occur as argentite, although this mineral was not positively identified. So far as information was available, no definite ratio seemed to exist between the amounts of the precious metals and the copper content of the ores.

California Prospect.

The so-called California mine is an undeveloped prospect in a large garnet zone at a limestone-granodiorite contact on the west slope of a high ridge just east of Camp Creek, about 3 miles north of Landore and perhaps one mile east of the White Monument. There appears to be a large body of limestone in this ridge which extends southwest from Pepperbox Hill and which follows the divide between Camp Creek and the upper part of Indian Creek. In a few places along the limestone-granodiorite con-
tact there are wide and well developed metamorphic zones in which garnet is by far the most important mineral. However, so far as explorations have gone, nothing in the way of a commercial ore deposit has been found. The best that has been shown is a limited amount of copper-bearing sulphides and a considerable amount of copper staining in the gangue minerals. One of the most prominent of these garnet zones, which is nearly 100 feet wide, extends up the ridge for a few hundred feet from the California prospect.

Calumet Prospect.

The Calumet prospect consists of an outcrop of ore-bearing metamorphics at the northeast end of the body of limestone in which the Arkansaw-Decorah ore body occurs. The outcrop is on the east-facing slope of the hill about 200 feet from Indian Creek and perhaps 200 yards above the remains of the Ladd smelter. The development work consists of a tunnel about 100 feet long and a shallow shaft—little more than a surface pit—which have exposed a small body of oxidized ore similar in all respects to the ore from the upper portions of the Arkansaw-Decorah ore body. So far as developed the ore body, while otherwise favorable, appears to be small—not more than 10 feet across. However, the prospect is probably worthy of more extensive exploration than it has received.

Douglass Prospect.

The Douglass, an unpatented claim held by John L. Thompson of Landore, is located on the Kinney Creek slope a few hundred feet below the top of the White Monument, and adjoins the White Monument claim on the southwest. Very little work has been done, and beyond a few copper stains in material on the dump, nothing indicative of the value of the claim was visible.

Glasgow-Green prospect.

The Glasgow-Green prospect, located on the Camp Creek slope about 400 yards southeast from the top of the White Monument, is an unpatented claim held by John L. Thompson of Landore. The location covers a small but prominent outcrop of metamorphic minerals, slightly copper-stained, upon which a little surface work has been done. The development work consists of a tunnel, perhaps 600 feet long, the portal of which is about 300 feet, vertically, below the outcrop which the tunnel is planned to intersect. Throughout its entire length the tunnel is wholly in the granodiorite, the work having been stopped perhaps 200 feet or more from the limestone contact. Thus far, nothing of value has been found and the work has neither proved nor disproved the value of the claim.

Helena Mine.

The Helena claim was located about the same time the Blue Jacket was staked out. Nothing but location and assessment work was done upon it until in the late nineties it was taken over and operated in a small way by the American Mining Company, which shortly afterwards failed. It was operated in a small way, and for a short time, by the Northwest Copper Company, but closed when the Cuprum smelter failed in 1898. In 1899 it was taken over by the Boston and Seven Devils Copper Co. and worked in a desultory way until the company failed in 1901. It was worked by lessees intermittently afterwards, but the last important work was done in 1905 by C. W. Jones, who is said to have shipped a few cars of high-grade ore.

Development. Two tunnels have been run, the lower one about 300 feet long, the upper an unknown length, with crosscuts, several prospecting drifts, and some surface pits. From the lower tunnel an overhead stope about 60 feet high and a small amount of underhand stoping below the tunnel level, constitute the development work as it was reported to the writers. The portals of the tunnels are caved and the underground work is all inaccessible. Near the portal of the upper tunnel a small outcrop of what appears to be workable ore is exposed at the surface. In fact several hundred pounds of this ore has been sacked, apparently for shipment, and lies beside the trail, the work of “high graders,” it is said, who were frightened away before completing their “haul”.

Occurrence of the Ore.

Little or nothing could be learned in regard to the position of the ore in the metamorphic zone. Such ore as was seen in place occurred in irregular bunches intimately intermixed with the usual heavy silicate minerals, especially garnet and pyroxene, epidote being less plentiful than in the Arkansaw-Decorah claims. The original or primary copper-bearing mineral is bornite, and so far as could be determined its mode of occurrence and its superficial alterations are similar in all respects to those of the bornite in the Blue Jacket mine. In a way the metamorphism of both limestone and granodiorite has been more extensive at the Helena than at the other ore deposits in the vicinity. The limestone contains many narrow argillaceous beds, and these show much alteration for more than 150 feet from the igneous contact. Scapolite, which is rare in the other deposits, is abundant in the altered impure bands. The granodiorite shows both the results of hydrothermal alterations, and the effects of pneumatolytic processes. It contains much zoisite, some of which is pink (probably thulite), it has suffered considerable sericitization, and in many places contains open vugs or spaces lined with drusy, well terminated plagioclase
crystals, largely albite. These alterations are perfectly
evident in the granodiorite over 75 feet from the limestone
contact. Small amounts of bornite and chalcopyrite were noted in
the igneous rock, but nothing even approaching commercial ore
was seen. In all the deposits the workable ore is confined to the
limestone side of the contact.

Humboldt Prospect.

The Humboldt claims are on the east slope of a ridge which
leads up to the White Monument and are almost due west of the
California prospect, but on the west side of, and a few hun-
dred yards from Camp Creek, about 3 miles north of Landore.
The development work consists of short tunnels and some surface
pits in garnet zones at the contacts between the granodiorite
and a small included body of limestone. The usual metamo-
orphic minerals are present in well defined metamorphic zones
and a small amount of ore shows at the different prospects, but
nothing of commercial value has been found. The most coarsely
crystalline limestone found thus far in the whole district was
seen at one of the Humboldt prospect pits.

Lockwood Mine.

The Lockwood claims are situated near Lockwood Saddle, at
the western end of the large body of limestone at the east end
of which are the Queen and the Blue Jacket mines. They were
located in the late eighties by Charles Walker. Along with his
other claims they were soon sold, and have passed thru many hands.
The present owners are Gus Gray and the estate of the late E. M.
Barton. Very little development beyond the necessary assess-
ment work was done until 1910 or 1912 when under the man-
agement of Gus Gray a tunnel about 100 feet long was driven
into the ore zone and a small amount of high-grade ore was
taken out and shipped.

The ore and gangue minerals are similar in all respects to
those at the Blue Jacket and the Queen mines, with the exception
that tabular hematite is much more abundant than at either of
these mines.

O'Leary's Mine.

A number of prospect tunnels and shallow surface pits in
Sucker Gulch at the head of Camp Creek, are known as O'Leary's
mine. The work consists of two tunnels, one north of the stream
in a fine-grained phase of the granodiorite, and the other south
of the stream in the Pepperbox Hill limestone body, and was
done by J. J. O'Leary, a hermit miner who formerly lived at
Wallace, Idaho, and who died in the summer of 1918. Nothing
of commercial value was disclosed in either of the tunnels. The
excellent work, and patient faithfulness of this miner, who lived
all alone near his tunnels for a number of years, working away
slowly and steadily, seems certainly to have merited better suc-
cess than came to him.

Peacock Mine.

In point of location the Peacock is the oldest mining claim
in the Seven Devils region. It was staked in the middle or late
seventies by Levi Allen who operated a small placer proposition
for gold, but did only location and assessment work on the great
garnet outcrop which was afterwards developed into the Peacock
mine. Allen, after exhausting the placer ground as he thought,
disposed of the claim. Finally, in 1885 it came into the hands of
Albert Kleinschmidt and his two associates, Holker and Hauser,
all from Montana. With this change in ownership, the actual
development of the mine and also of the whole district began.
Albert was soon joined by his brother, Reinhold Kleinschmidt,
who soon saw that the greatest obstacle to successful mining
operations in the district was the lack of adequate transportation
facilities. The summers of 1886 and 1887 were spent in testing
and exploratory work together with a little mining. The mine
was worked actively during the summer of 1888, and in the late
fall, the first ore, a few cars full, ran between 35% and
40% in copper, about $3 in gold, and from 6 to 10 ounces
in silver, was shipped from Weiser. It was packed from the
mine to the wagon road at Cuprum on horses and from there
hauled to Weiser, over 100 miles away. In order to obviate
this long and expensive packing and hauling a well graded wagon
road was surveyed from the mine to a point on the Snake River
about two miles below the present town of Homestead, Oregon,
and the years 1889 and 1890 were spent in building this road
which is known as the "Kleinschmidt Grade." The plan of the
Kleinschmidts was to haul the ore to the river and then take it
by boat to the railroad at Huntington, Oregon, a distance of
about seventy miles. In 1890 the scheme was tried, but resulted
in failure, as the river is too swift and contains too many rapids
to permit the operation of a boat. With this failure the mine
was closed but it was taken over in 1890 or 1891, by the American
Mining Company and reopened. This company failed and
in 1896 or 1897 the property was leased and operated by the
Northwest Copper Company which, in 1898 built a smelter at
Cuprum to handle the ores. The smelter and company both
failed in the fall of 1898, and the mine was once more closed.
In 1899 the property was acquired by the Boston and Seven
Devils Copper Company, was again opened and operated during
1900 and part of 1901, until the company failed. During the
operation of the Landore smelter in 1904 and 1905, the mine
was leased and actively operated by C. W. Jones, but when the
smelter failed the mine was again closed and nothing farther than "high grading" the ore on the dump was attempted until George M. Baggs obtained a lease on the property in 1909 and operated it in a small way until 1912. Nothing has been done since this date.

Development. The development of the Peacock mine consists of an open cut about 75 by 150 feet, a shaft between 250 and 300 feet deep, a tunnel which connects with the shaft about 75 feet from the bottom, four levels of varying lengths, a number of cross-cuts and a considerable amount of stoping. The stoping, which has been done on all the levels was located in the richest ores, and so far as could be learned, was continued until all the best ore was extracted. As it stands today the mine has been robbed of practically all the high-grade ore that has been developed. The ore zone is irregular in shape, is about 400 feet long and varies in width from 100 to 150 feet. The workable ore was found in irregular shoots or chimneys at various places in this great mass of heavy silicates. While most, if not all of the developed high-grade ore has been taken out, there yet remains a good tonnage of lower grade (5% to 7%) concentrating ore, and the mine is not by any means regarded as exhausted. The mine carries a power site about two miles away on Deep Creek, and it is probable that enough power could be developed for operating the mine in a small way. An abundance of timber for mining purposes is available near by.

Occurrence of the Ore. While the ore zone consists of an enormous mass of the typical contact metamorphic minerals, garnet largely predominating, little or no limestone has been found in the Peacock mine. There is, however, little or no doubt that the deposit, like the others near Landore, is of the typical contact metamorphic type, and that the body of limestone from which it was derived was small and that it was entirely changed into heavy silicate minerals and ore. The original copper-bearing mineral is almost exclusively bornite, which is irregularly distributed as shoots or chimneys in the mass of silicates, usually near the contact with the granodiorite. The usual superficial alterations have occurred and all the ore thus far developed in the mine shows either oxidation products, chrysocolla, malachite, azurite, cuprite, or secondary chalcocite and covellite, or both, oxidation having extended in most places to a limited extent, at least, to the greatest depths reached in the mining. All the ores carry low values in both gold and silver, but there appears to be no fixed ratio between the amounts of these metals and the copper content of the ores. The writers have been unable to obtain much reliable information as to the amount and the metallic contents of the ore that was mined. Reports say that
GARNET ZONES OF PEACOCK AND SOUTH PEACOCK MINES.
many thousand tons have been shipped and that some of it carried from 35% to 40% copper with silver and gold values as stated above. A mining engineer who examined the property for a client who was contemplating purchase, reported the average of 16 samples of ore taken from the dump, as it stood in 1910, to be 0.27% copper, 0.91 oz. silver, and 0.004 oz. gold.

On the flat about 300 yards west of the mine stands the remnants of the one-time flourishing mining town which was built during the pahmy days of the district. All that now remains of the town are about 25 dilapidated log cabins, some fallen in, others roofless, and only one or two habitable. The place is wholly deserted but the one or two best cabins afford shelter for sheep-herders and an occasional traveler, hunter or prospector.

Queen Mine.

The Queen mine was located in the late eighties by Charles Walker. Little work other than that necessary for location and assessment was done before 1890 or 1897, when the property was acquired by the Northwest Copper Company. Between 1897 and the failure of the Cuprum smelter the mine was opened and some ore taken out but was closed in 1898. It was operated actively by the Blue Jacket Mining Co. from 1899 to 1901 when it was again closed. It lay idle until the Ladd smelter at Landore was built, when it was operated by John Rogers who took out considerable ore. In 1906 it was operated, under lease, by a Dr. Peacock formerly superintendent of the Ladd smelter. He took out a good body of rich ore in the slope between the two tunnels. It was operated again in 1909, 1910, 1911, 1912, by F. H. Kleinschmidt and P. H. Miller. A considerable amount of good ore was taken out, in 1914-1915 by F. H. Kleinschmidt and in 1917 by John Rogers.

The workings of the Queen mine are situated on Garnet Gulch above the wagon road. There are three separate and distinct garnet zones upon the property two of which have been opened up by extensive tunneling. These lie on the east side of the gulch. Another garnet zone parallels the gulch on the west side and has been opened up by a few open cuts and short tunnels.

The garnet zone which lies at the end of the short branch wagon road has been opened by two tunnels about fifty feet apart. From the upper tunnel considerable stoping was done which is evidence of the fact that a good-sized ore body was extracted. There is no evidence that the same ore body was encountered in the lower tunnel, which may possibly connect with a shaft sunk in the garnet zone on the hill above.
The other garnet zone is on the hillside on the east side of the gulch and about 200 feet vertically above it and there are other small garnet areas in this vicinity. The greater part of the development work on the Queen property was for the purpose of developing this particular zone and the lime-granodiorite contact.

The lower tunnel starts in limestone and runs 640 feet N. 43° E., with a drift toward the northwest at the granodiorite contact, and a raise at a point 200 feet in the drift. This tunnel cuts the main contact 420 feet from the portal, and to this point is in limestone with a few granodiorite masses. Little ore was taken from this level, but the raise itself is in ore. The garnet zone is about six feet wide at the main contact. The garnet zone on the surface is 20 feet wide in one place and about 40 in another. Many solution cavities occur in the limestone, one about 300 feet from the tunnel portal is two sets wide and is filled with stratified lime-sand and clay surrounding boulders of limestone.

The intermediate tunnel is a crooked tunnel about 600 feet long which starts in limestone and passes thru a fault or crushed zone with about five feet of garnet and other silicates on a hanging wall of limestone. At this point there is a winze and nearly the raise that extends from the lower tunnel. There is also a fault striking N. 60° E. and dipping perhaps 20° toward the southeast. This fault offsets the contact 30 feet to the south on the hanging wall side, but the strata are inclined only 15° from the dip; hence there is a considerable throw. It seems to be a reverse fault.

**Croppings on Queen Claims.** Ore shoot No. 2 is about 900 feet east of shoot No. 1 and consists of a garnet and silicate zone 100 by 20 feet. In the central part of this was fine shipping ore. The garnet zone at this place is cut by quartz veins two to four inches thick, and by lenses up to 18 inches wide, these are later than the silicates. In the central part of the face of the open cut the ore was in veins or "floors" similar to the quartz, but widened with depth to a considerable body.

Near the center of the Queen claim is an 18-inch quartz vein striking N. 30° E., dipping about 30° toward the northwest which carries considerable chalcopyrite.

The Queen ore as shipped is reported to have carried $6 in gold and silver, principally silver, and approximately 30% copper.

The ore is bornite with the usual surficial alterations, the enriched ore is chalcocite, and covellite in and along fractures in the hornite. The full depth of the secondary enrichment has not been reached by the present development.

**South Peacock Mine.**

The South Peacock mine was first opened by the Northwest Copper Company in 1897 or 1898. A small amount of ore was taken out but all work ceased when the company failed in the latter part of 1899. It was reopened by the Boston and Seven Devils Copper Company who opened it in 1900 and 1901, and took out a few carloads of good ore. With the failure of the Boston and Seven Devils Copper Co., the mine was closed and was not reopened until 1915 when J. M. Venable obtained a lease on the property and took out a small amount of ore. His work, however, did not extend below the 100-foot level.

**Development.** The development work, so far as could be learned from persons familiar with the mine, consists of a shaft about 325 feet deep from which four levels have been extended one at 42 feet, one at 100 feet, another at 200 feet, and the last and deepest at 300 feet. The shaft is said to be in the garnet zone down to the 300-foot level where the granodiorite was encountered. Nothing could be learned as to the extent of either the 300- or the 200-foot levels. The 100-foot level is said to consist of a small amount of cross-cutting all of which is in the garnet zone, which is said to be more or less mineralized. Nothing could be learned as to the character of ore on this level. The first, or 42-foot level consists of three short drifts, toward the southwest, northwest, and the northeast respectively, all in the garnet zone. The northwest drift intersects the igneous contact about 25 or 30 feet from the shaft and in the garnet zone at and near the contact a small body of high-grade ore, for the most part enriched chalcopyrite, was found. Nothing reliable could be learned as to the amount or metallic contents of the ore taken out, or as to the amount of ore in sight in the mine.

**Occurrence of the Ore.** As in the other contact metamorphic deposits, the South Peacock ore occurs in a zone of heavy metamorphic silicates, similar in kind to those of the Blue Jacket, the Queen, the Helena, and other mines, but differing from these and resembling the gangue of the Peacock mine in that garnet predominates greatly over all other minerals. No limestone has been found in the mine but practically all the gangue minerals except quartz, which is not abundant, are rich in lime and are in every way similar to those at the limestone-granodiorite contacts in the other mines and prospects. It is therefore evident that the garnet zone in this mine represents a small body of limestone which was included in the granodiorite and completely altered into the contact minerals.

The ore minerals consist of chalcopyrite and bornite with the usual surficial alterations. Malachite is more abundant than the other oxidized minerals. Cuprite while not abundant, is not un-
usual, and native copper is found occasionally. The secondary
enrichment consists of chalcocite, covellite and bornite in and
along fractures in the primary sulphide.

White Monument Prospect.
The White Monument prospect consists of a patented mining
claim which includes the prominent outcrop of limestone on the
very top of White Monument Mountain, from which the mount-
ain's name was taken. The name is appropriate, for this mass
of limestone stands out as a veritable white monument that can
be seen from mountaintops miles away. The claim was located
in 1886 by Charles Walker, who did only location and assess-
ment work and sold it at the first favorable opportunity. Along
with other claims, it came into the possession of the Klein-
schmidt interests in the early nineties. In 1897 and 1898 the
Northwest Copper Company began development work on the
ground, drove a tunnel about 150 feet long into the mineralized
zone and took out a small amount of high-grade ore. When the
Cuprum smelter failed in 1898, the mine was closed and not
reopened until 1904 when C. W. Jones obtained a lease on
the property and operated it for about a year, and is reported
to have taken out two cars of ore that averaged more than 30% in
copper, with good values in both gold and silver. It is gen-
erally stated that the White Monument ores and those from the
Helena mine carried higher values in silver and gold than any
other of the contact metamorphic ores.

Occurrence of the Ores. As in the other mines the ores of
the White Monument claim occur irregularly in different places in
the garnet zone near the limestone-granodiorite contact. The
relationship between ore and gange minerals, the relation of
metamorphic zone to both limestone and igneous rock, and the
supergene or surficial alterations of both ore and gange of the
White Monument mine are similar to the other mines of the
same type. As exposed on the surface, both the south and the
north side of the limestone inclusions contain wide garnet zones,
from 50 to over 100 feet wide, and throughout both zones there
are appreciable iron and copper stainings.

THE HEATH DISTRICT.
I. X. L. Mine.

Location and Topography.
The Heath district is an old mining camp which has been
worked in a desultory sort of way for some twenty or thirty
years. Heath post-office is about eighteen miles due west of
Council and about fourteen miles northwest of Cambridge, both
small towns on the Pacific & Idaho Northern Railroad. There
are several fairly good wagon roads that extend into the dis-

The district embraces a large part of Cuddy Mountain and
several different types of metaliferous deposits occur there in-
cluding gold, silver, copper and lead.

The disseminated copper deposits in the vicinity of the I. X. L.
mine were the only ones visited by the writers and a description
of the other mineral features of the district must be left for some
future time. The district lies entirely within the borders of the
Weiser National Forest and there is a ranger station on Brown-
lee Creek about a half mile below Heath post-office.

The I. X. L. mine is situated on the west side of one of the
higher points of Cuddy Mountain at an elevation of about 6300
feet. The mountain, in which the mine is located, lies at the
head of the East Fork of Brownlee Creek and is a prominent
landmark as it consists of a dome of light-colored granite rock
which contrasts sharply with the dark, basaltic, and flat
summit of Cuddy Mountain to the north. See Plate No. 10.

The highest point of Cuddy Mountain, as well as practically
all of the low lying adjacent country, is overlain by flows of
Miocene basalt and the disseminated copper deposits have been
exposed by the erosion of the basaltic capping from what must
have been a fairly high point of country prior to the outpouring
of the lava. The territory from which these rocks have been
removed might be considered as the upper drainage basin of the
East Fork of Brownlee Creek which flows into Snake River at
Brownlee, which is about eight miles from Heath post-office.

The country is steep but not excessively rugged. There is
sufficient water in the East Fork of Brownlee Creek, where the
upper forks unite at Donart's cabin, to supply a fairly large mill
but no measurement of the flow was made. There is a good
supply of yellow pine timber with a little fir and tamarack on
most of the land, particularly on the north slopes.

Geology. The oldest rocks in the district are evidently a
part of the greenstone-andesite series which are so well exposed
in the Seven Devils district to the north. No very good exposures of these rocks were seen as they occur chiefly along the lower slopes which are covered with soil and rock.

Limestone is reported to occur at the head of No Business Creek and the fact that garnet zones occur south of Heath post-office indicates the presence of limestone in this vicinity similar to that in the Seven Devils quadrangle.

The greenstone series has been intruded by granite rock, which vary in appearance from place to place but which are undoubtedly a part of the same general intrusive.

A phase of these intrusives is exposed along the graded wagon road which comes down into the East Fork of Brownlee Creek between Heath and Donart's cabin. This is a rather coarsely-textured white rock made up entirely of feldspar and quartz and somewhat stained with iron in the seams. As one follows the trail which goes up the right hand fork of the creek to the I. X. L. mine this rock becomes more heavily stained with iron oxide and forms prominent red bluffs along the sides of the creek but particularly on the north side. Under the microscope it is seen to be a coarsely crystalline rock consisting almost entirely of quartz and feldspar in about equal amounts with practically no ferro-magnesian minerals present. The feldspars have been considerably altered to sericite and a little kaolin and are harder to determine than if they were fresh. The principal feldspar is orthoclase but microcline is also present in small amounts as well as a few crystals of plagioclase, probably albite.

There are a number of irregular grains and masses of pyrite disseminated thru the rock which appear to be of secondary origin and not a primary accessory mineral. The rock is best classified as a medium coarse-grained granite-apolite, heavily mineralized with secondary pyrite, evidently due to hydrothermal alteration of the original rock.

On the way up the creek towards the I. X. L. mine the rock becomes darker in color and more basic in appearance with a decidedly porphyritic texture, showing well defined-quartz phenocrysts. Under the microscope the porphyritic texture is more pronounced and the rock is seen to be made up of phenocrysts of orthoclase feldspar and quartz in a groundmass consisting of the same material finely crystallized. A few plagioclase crystals, probably albite, are also visible. Some shreds of biotite are present and some sericite, filling seams, as well as a few specks of chalcopyrite. The rock can be classified as a granite porphyry bordering on a quartz-latite or monzonite porphyry and containing a small amount of disseminated chalcopyrite in minute grains. Whether this rock is intruded into the aplitic or is simply a phase of that
rock is not entirely clear but the latter theory seems the more probable.

At the point in the creek where it divides into a number of small gulleys, which head on the mountain where the I. X. L. mine is situated, the granitic rock is stained with copper oxide minerals and there are also patches and irregular areas of reddish gossan showing a little copper staining. The rock in which this copper staining occurs is a light-colored granitic rock which can be classified as a quartz monzonite since it contains quartz, orthoclase and plagioclase in about equal amounts, the latter conforming to andesine.

This mineralized area apparently extends from this point, i.e., the junction of these gulleys to a little beyond the summit of the mountain above the I. X. L. tunnel, to the basalt cap on the ridge to the south, see Map No. 8, and in all likelihood to the basalt capping of Cuddy Mountain to the north. Although the two days devoted to the examination of this district it was not possible to cover all of this mineralized zone yet the observations made in that time indicate an area of approximately 500 acres, over which the surface conditions are apparently similar. This area consists of monzonite, stained with copper carbonate and silicate, which staining varies in intensity from place to place but is remarkably persistent throughout the area. In addition to this there are the irregular areas of gossanized monzonite already mentioned, which seem to be most noticeable in two zones, one near the point where the gulleys unite and the other on the mountain where the I. X. L. tunnel is being driven. These differ about 1500 feet in elevation and might be designated the upper and lower zones. A fine-grained dark-colored basic dike, which was not examined microscopically, is exposed on the south side of the creek a little way above the junction of the gulleys above mentioned. What is possibly the same dike is exposed on the ridge south of the I. X. L. buildings, where there are a number of small open cuts. In the vicinity of this dike the copper mineralization in the monzonite is rather more intense than usual.

The upper mineralized zone shows several gossan outcrops which occur on the hillside above the trail running from the boarding-house to the tunnel. Another gossan outcrop occurs on the steep hillside between the tunnel and a spring to the north and there are undoubtedly others in the country lying between this and the lower zone near the creek. Along the trail between the boarding-house and the tunnel the monzonite is copper stained, as it is also on the top of the mountain above the tunnel although in the latter place the staining is very scanty.

**Workings.** Apart from a few little open cuts and short tunnels the only development of importance on the I. X. L. ground
is a tunnel which in August, 1919, had been driven into the mountain a distance of about 800 feet in a southeasterly direction.

For the first 200 feet there is a small amount of mineralization in the form of sparingly disseminated chalcopyrite and some secondary oxide minerals in the seams and slits of the monzonite. From this point, to what was the face of the tunnel in August, 1919, the monzonite is disseminated with chalcopyrite to an extent indicating a copper content in excess of 1 per cent. A representative sample taken from the face of the tunnel gave a return of 1.2 per cent in copper. A drift was also being started at a point about 500 feet from the mouth of the tunnel running in a direction about N. 70° E. which showed a higher copper content than the average in the cross-cut, the sulphides being quite massive at this point.

Mineralization.

Under the microscope the mineralized monzonite is seen to be a highly altered rock in which the feldspars have been partly changed to a very fine-grained sericite. There are a number of shreds of biotite in the rock, and a little chlorite is also present. The rock in general is slightly more basic than the monzonite described from down on the creek. There is a considerable amount of secondary quartz in the section observed and both sericitization and silicification have been at work upon the rock to such an extent that its original condition has been obscured but its general appearance suggests that it was entirely similar to the monzonite previously described. It is full of metallic grains which have in many cases a hexagonal outline and their color by reflected light is more suggestive of pyrrhotite than chalcopyrite and it is possible that the mineral is an isomorphic mixture of chalcopyrite and pyrrhotite which would account for its copper contents being so much lower than its appearance would indicate. This is further borne out by the fact that the powdered mineral is slightly magnetic.

The sulphides are finely disseminated throughout the body of rock and are not confined to the slits and seams. The appearance of the rock under the microscope indicates intense hydrothermal alteration, which has resulted in both silicification and sericitization. It is more than likely that the impregnation of the copper-iron sulphides into the rock was contemporaneous with this hydrothermal alteration and probably took place shortly after the cooling of the monzonite mass by means of deep-seated juvenile waters derived from the cooling magma. The source of the copper cannot, of course, be definitely given, but the introduction of this mineral into the rock of the various districts of the Snake River copper belt took place undoubtedly at the same time and can in every case be associated with the intrusion of the monzonite or granite rocks. These rocks are unquestionably the source of the heated waters which caused the hydrothermal alteration accompanying the copper mineralization at the Red Ledge and elsewhere, but whether they also supplied the copper is not so clear. The copper deposits of this belt are associated not only with the granitic intrusions but also with the Triassic greenstoneandesite series.

These andesite flows and tuffs are themselves copper-bearing to a small extent, as shown by assaying clean unaltered specimens of this rock, which in most cases give a decided copper reaction, and it is possible that the andesite is the source of the copper and that the cooling granitic magmas supplied the solutions which dissolved this metal, dissolving, transporting and precipitating it into workable deposits.

There is an entire lack of secondary enrichment, the original sulphide zone occurring only a few feet underground and between this zone and the surface there are small amounts of copper carbonates and silicates in the seams of the monzonite. The absence of secondary enrichment is explainable by the topography. This body of mineralized monzonite is situated near the head of an actively eroding stream and what was at one time a high point of country has been worn down so rapidly that erosion has outstripped oxidation and enrichment. That the basin near the head of the branch of the creek which heads against the monzonite mountain was at one time a high point, is explainable by the fact that the basalt has been removed over a roughly circular area with this fork of the creek occupying the central part. The basalt outcrops on the ridge to the south of this basin and is very thin at that place. On Cuddy Mountain to the north the basalt flows are over a thousand feet thick. When these flows were outpouring they covered the country in practically horizontal layers and the high points were thinly covered while the low points were covered by flows in some cases several thousand feet thick. Other things being equal, the topography of the country before the outpouring of the basalt is reproduced best by a study of the thickness of the basalt. It is highly probable that the mountain above the I. X. L. mine was never covered by basalt and before the basaltic flows was the highest point in the country. Where the I. X. L. fork of Brownlee Creek now flows, there evidently existed a ridge running down from this high point. Because of an unfavorable situation with regard to the post-Miocene drainage this ridge was eroded very rapidly, while Cuddy Mountain which was a depression or slope in the pre-Miocene topography is now higher than any point in the country.

It is possible that if the mineralized monzonite extends be-
low the basalt that secondary enrichment might be found below this capping and that of course would depend largely upon the topographic and climatic conditions which existed before the lava was outpoured.

From conversation with other mining men who had visited the district the general viewpoint held in regard to the ore occurrence in the I. X. L. tunnel seemed to be that it was a well defined mineralized zone in the monzonite bounded by a foot and hanging wall of unmineralized rock. The writers did not receive that impression but are of the opinion that the deposit consists of a large area of mineralized monzonite in which chalcopyrite is disseminated all thru the rock of the area and that the mineralized part will gradually merge into mineralized monzonite. There are undoubtedly parts of the area which will be found richer in chalcopyrite than others and it is probable that the gossanized outcrops mentioned are the surface indications of these enriched places.

The present tunnel will apparently cut under one of these gossan outcrops but it does not necessarily follow that richer rock will be found at that point in the tunnel as the richer portions may have a vertical as well as a horizontal limit. The writers could see no evidence whatever of a well defined foot or hanging wall. The monzonite is jointed to a considerable extent and three sets of these joints are seen in the I. X. L. tunnel. The principal one of these has a strike of from N. 50° to 70° E. and dips to the SE. from 20° to 30°. Another one strikes N. 10° W. and dips 60° NE. and a third one strikes S. 30° W. and dips 25° NW. The monzonite is accordingly shattered or broken into a number of comparatively small blocks which should make mining of it by some large-scale process fairly simple. The sheeting of the monzonite along the direction of the major northeast joints is somewhat suggestive of a wall-like boundary and probably gave rise to the idea that the mineralized zone had a clearly defined wall.

In summarizing the facts regarding this deposit it is clear that there is a large area of monzonite containing disseminated chalcopyrite all thru it and that there will be found throughout this area locally enriched places which are probably due to rock structure, as major joint planes, etc. The chalcopyrite is apparently a low-grade form of this mineral due most likely to admixtures of pyrrhotite. The area exposed by removal of the basalt shows no secondary enrichment but it is possible that such enriched places might be found under the basalt cap especially where that capping was thin, as for instance along the southern edge of the exposed monzonite. See Map No. 8.

Whether this big mineralized area will ever be the site of a large producing mine depends entirely upon the grade of material which systematic prospecting may disclose. There is no question as to the size or permanency of the disseminated area. The only question is as to its copper content and it will take a sum of money running into millions of dollars to prove definitely its economic value. There is little doubt that one day this deposit will be utilized by man as a source of copper but whether that day will be within the near or the very remote future the writers are not prepared to say.

The fact that less than two days were spent upon the ground must be taken into consideration in regard to the statements made as to the deposition of the ore, etc. This extensive deposit, and the country adjoining are worthy of a careful detailed geological study and some of the views stated above might be modified or even entirely changed, after such detailed study was completed.
THE NORTH FORK OF HORNET CREEK

On the North Fork of Hornet Creek there is an area of mineralized and iron-stained rhyolite in which some chalcopyrite is exposed in a few open cuts along the side of the creek. The rhyolite at this place is part of an extensive area covering most of Peck Mountain and possibly extending on to the north end of Cuddy Mountain. See Map No. 4. It is situated about fourteen miles northwest of Council, on the Seven Devils wagon road, the Hornet ranger station being located in this mineralized rhyolite zone and the wagon road cutting across it.

The only workings in the district are a few open cuts on Peck Mountain and also along the North Fork of Hornet Creek in the canyon that cuts across the northeast border of Peck Mountain. The workings along the creek are best reached by taking a trail from Hanson's ranch, which is about thirteen miles from Council. This trail crosses a low divide between the main fork of Hornet Creek and the north fork and then follows up the latter. The distance from Hanson's ranch is about three miles and the elevation of the creek bed where the workings are situated about 4000 feet.

At this place the north fork of Hornet Creek has exposed the iron-stained rhyolite which is covered by a thin flow of basalt on the east side of the canyon. There are several small cuts and short tunnels on both sides of the creek which have exposed what appears to be a silicified zone in the rhyolite. This is about twenty feet wide and strikes about north and south with a steep dip to the east, following the general direction of the creek for several hundred feet. This particular part of the rhyolite is disseminated with chalcopyrite and probably runs better than 1% in copper. Under the microscope the section shows an almost complete replacement of the rhyolite by quartz and chalcopyrite. As at the Red Ledge, surface indications of copper are almost negligible and the appearance of the rock where the open cuts have been made differs very little from the general run of the rhyolite except that it is slightly more silicified.

The question naturally arises as to the extent to which this iron-stained rhyolite at the surface is indicative of disseminated chalcopyrite beneath. This cannot be answered at this time but the
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The question naturally arises as to the extent to which this iron-stained rhyolite at the surface is indicative of disseminated chalcopyrite beneath. This cannot be answered at this time but the region would seem to offer a good field for intelligent prospecting either by means of churn drills, or by tunnels from the creek, or both. This rhyolite area contains several hundred acres and some of the prospect pits on Peck Mountain have exposed what is practically a gossan with the rhyolite showing intense sericitization but the only place where sulphides have been exposed is in the creek.

The writer did not trace this area on to Cuddy Mountain but there is a possibility that it is an extension of the Heath zone which is covered with basalt over a large portion of the higher parts of the mountain. At any rate the fact that heavy sulphides have been found at the Red Ledge below an iron-stained rhyolite and that the general superficial appearance of this belt is somewhat similar should encourage prospecting at this place as there would seem to be possibilities of opening up bodies of disseminated chalcopyrite if the work were carried on intelligently.
THE HOODOO MINING DISTRICT

Location and Accessibility.

This district is situated in the northern part of Latah County, Idaho, at a distance of eighteen miles from Harvard, a station on the Washington, Idaho & Montana Railroad. It lies on the southeastern slope of the Hoodoo Mountains, which are outliers of the great mountain area of Central Idaho. Elevations in the district vary from about 3300 to 4800 feet while the elevation of Harvard, on the railroad, is 2500 feet. See Map No. 9.

The district is within the boundaries of the St. Joe National Forest and is reached by a fairly good wagon road from Harvard. This road is poorly located but with the expenditure of a few thousand dollars an almost even grade could be obtained from the railroad to the mines, so that trucks could be operated for the greater part of the year. A truck operated about a year ago was able to make four round trips in the 24 hours, but if a few changes were made in the present location of the road, the cost of freighting could be materially reduced as now several unnecessary and heavy grades greatly retard the loaded truck. The present cost for hauling ore is about $8 per ton.

There is plenty of good mining timber in the district, and there is sufficient water to supply one or two small concentrators, less than a mile from most of the properties. The two most important properties in the district are the Mizpah, operated by the Merger Mining Company of Palouse, Wash., and the Copper King.

The Mizpah was discovered before the days of the Klondike rush and was abandoned by its original locator who took part in that historic event. It was re-staked a short time afterwards by J. C. Northrup and associates of Palouse, Wash., who have been operating intermittently since that time.

Several carloads of ore carrying about 20 per cent in copper were shipped from the Mizpah mine in 1918 but most of the work in the district has been confined to development. Lumber is now being hauled to the Mizpah for the erection of a concentrator and diamond drill work is being carried on at the Copper King.

General Geology. Latah county is underlain by basalt over its greater part and is better known for the fertility of its soil and for wheat production, rather than mining. A large portion of the area is a rolling plateau, but the northern part is mountainous. This mountainous region belongs to the central mountain area of Idaho which extends from the international boundary to the Snake River plains. The general elevation of the plateau is about 2500 feet while the bordering mountains run up to 5000
fect. The mountain country is usually very brushy, due to a second growth of coniferous timber following forest-fires, and is difficult to prospect on this account. This difficulty is increased by the fact that the lower slopes are covered by a deep wind-blown soil, or silt, of the same texture and general character as that which covers the basalt rock in the plateau region, and which has been brought in by dust-storms that blow from time to time with considerable violence. This soil is valuable for its agricultural qualifications on the plateau, but is detrimental to prospecting in the mountains. In the latter it has completely covered the residual soil formed by the weathering of the rocks, so that indications of mineralization have been in most cases obscured by this silt.

From Map No. 10, which shows the general geology of the county, it is seen that the prevailing country-rocks in the northern part are quartzite and schist. These rocks are undoubtedly a part of the Belt series of pre-Cambrian sediments, which are extensive in northern Idaho, and have a thickness of at least 25,000 ft, where exposed by the north fork of the Palouse River. In comparing these rocks with the same series in the Coeur d'Alene region, the most striking feature is the absence of folding and faulting in the former as compared with the latter. No attempt has been made to subdivide this series, but in the neighborhood of the Mizpah mine they are probably the equivalent of the Prichard and Burke formations of the Coeur d'Alenes. At the Mizpah the prevailing strike is N. 45° to 50° E., with a dip of from 45° to 60° northwest, and they are remarkably uniform in this respect for a distance of seven or eight miles.

The lowest of the series exposed is a rather fine-grained quartzite intruded by a series of hornblende-diorite sills. These sills vary from a few inches in width up to several feet, and are more in the nature of a series of parallel bands of diorite in the quartzite than a sill, in the strict sense of the word. The thickness of these sills is not definitely known, but it is several hundred feet at least and they outcrop for a distance of seven or eight miles, their strike roughly paralleling the lower slopes of the mountains. The unaltered diorite consists almost entirely of plagioclase feldspar (andesine and oligoclase) and hornblende with a little zircon and a few minor accessory minerals. The hornblende predominates and gives a greenish color to the rock. A somewhat similar rock is exposed on Gold Hill, north of Princeton (See Map No. 9), where it forms a stock or boss, and these sills are probably connected with this intrusive stock and are both of them a somewhat basic phase of the granitic batholith of Central Idaho.

The quartzite is overlain conformably by mica schist which
has also been intruded by the diorite. The mica schist is made up chiefly of fine grained mica and a little chlorite. It contains also a number of garnets and is evidently the metamorphic equivalent of a clay slate or argillite. A highly metamorphosed bed of limestone occurs near the upper part of the mica schists which are about 2000 ft. thick. Map No. 10 shows the contact between the lower quartzite and the mica schist which is clearly expressed by an abrupt change in the topography; the mica schist, being the more resistant rock, forms steeper slopes than the somewhat crushed and intruded quartzite. The schist is overlain conformably by a hard massive and heavily bedded quartzite into which it grades. This upper quartzite is several thousand feet thick, but its upper boundary has not been definitely located.

Mineralization. There are a series of parallel zones which follow the strike of the quartzites and schists and with one exception appear to follow the dip as well, all of which are more or less mineralized with chalcopyrite, pyrrhotite, calcite, siderite, hornblende, actinolite, quartz and in some cases epidote. On Map No. 10 there are three principal zones lettered A, B and C, in which A represents the Mizpah zone, B the Copper King and C the Hecla.

The first work in the district was done upon the Hecla lode which forms a prominent rusty outcrop. A shaft was sunk about 100 feet and connected with a 200 foot cross-cut tunnel which opened up a bed of white crystallized limestone about 20 feet thick containing disseminated chalcopyrite and some quartz and siderite. No ore was found in this zone and there has been no work done upon it for several years.

The most important mineralization occurs in what has been designated the Mizpah zone, which was discovered more or less by accident in grading a road, and it was not until 1917 that the best ore was found. The reason for the difficulty of prospecting the surface, as has been explained above, is the presence of the heavy covering of wind-blown silt along the lower slopes of the mountain. This also explains the tardy discovery of an ore body on the surface after nearly 2000 feet of underground development had been done close to it.

In this zone the principal development has been done along a wide and sparsely mineralized belt which conforms to the strike and dip of the metamorphics. Two cross-cut tunnels have been driven about 100 feet apart vertically, the lower one being in about 700 feet. This lower cross-cut intersects the strike of the beds at about 45° and enters the mineralized zone about 250 feet from the portal. This zone is 200 feet wide or over and consists of a series of narrow sills of hornblende-diorite intruded into quartzite, a considerable amount of secondary calcite and very finely disseminated chalcopyrite with more massive bunches of pyrrhotite. The sulphides occur as replacements and disseminations in both the quartzite and the diorite.

At a distance of 500 feet from the portal the tunnel was swung to the right thereby cutting the formation at right angles and continued in this direction making a total distance of 700 feet. The face of the tunnel is in mica schist and the gradual change from quartzite to schist is plainly seen in the tunnel. A fault was cut at a distance of about 500 feet from the portal and followed a short distance in both directions. On the south side of the cross-cut a small body of sulphides was encountered consisting chiefly of pyrrhotite and a little chalcopyrite but was too low grade to be considered ore.

The upper tunnel showed good oxidized copper ore at the mouth but was driven into the mountain a distance of 50 feet away from what proved later to be the best ore zone, and shows only disseminated chalcopyrite in quartzite in the face of the tunnel.

In the spring of 1917 one of the owners of the property discovered some good looking gossan on the hillside above the mouth of the lower tunnel, and prospecting in the vicinity uncovered a body of copper carbonate ore of very good grade. Work was started upon this body of ore and it has been found to extend from the creek to the mouth of the upper cross-cut a distance of about 300 feet and probably beyond this point, since float is found near the quarter section corner on the line between sections 7 and 8, some 300 feet further on. Sulphide ore was encountered about 20 feet below the surface, and consisted of almost solid chalcopyrite with a little pyrrhotite enclosing crystals of biotite in a gangue of micaeous schist. A drift has been driven following this ore body for a distance of about 150 feet and shows a width of from 5 to 15 feet of mineralized material, most of which is milling ore of a high grade, which runs from 4 to 5% in copper and contains in addition bunches of massive chalcopyrite sometimes 3 or 4 feet wide and extending for 20 feet or more along the tunnel.

The oxidized zone is shallow, not much over 20 feet as a rule, and contains malachite, azurite, native copper, cuprite and pitch copper (silicate). This overlies the unaltered primary sulphides with only a mere film of secondary sulphides as chalcite, and covellite. This ore body, as exposed by open cuts, tunnels, and stopes, extends downwards almost vertically, cutting across the bedding planes of the metamorphosed sediments almost its strike parallels them.

The last described deposit is unquestionably a fissure as it
cuts the bedding planes of the metamorphics, and was probably caused by a strike fault along which copper bearing solutions replaced the country rock and crushed material of the fault zone. There is another explanation of this occurrence, viz. that it may be a replaced pegmatitic phase of the hornblende diorite or some other dike of granitic texture.

This possibility is suggested by the fact that large crystals of mica are completely enclosed in, and surrounded by, the sulphides and from this fact it might be supposed that other minerals of the dike have been completely replaced by the sulphides. This possibility seems less likely than the one first mentioned and it is altogether probable that the elements present in the wall-rock of mica schist might chemically combine again to form coarse crystals of biotite in the sulphides as the latter were in a colloidal form.

The vertical deposit has been exposed on the Copper King ground on the northeast side of the creek but its width there has not yet been determined altho it is reported that good ore was struck in a diamond drill hole and more extensive development was undertaken in the spring of 1920.

On the Copper King ground there is a heavily mineralized diorite sill in quartzite which has been opened up by a tunnel running northeast from the creek. There is an open cut on the hillside above the tunnel which is in the oxidized zone and gave assay returns of from one to two per cent of copper over a width of about 30 feet. A few tons of oxidized ore were shipped from this cut about fifteen years ago. The tunnel follows the sill for a distance of 200 feet and the contact between the diorite and the quartzite has been exposed in a short cross-cut tunnel.

This hornblende-diorite sill has been intensely altered and contains a considerable amount of calcite, siderite, secondary hornblende, a little epidote, and occasional bunches of pyrrhotite with which a little chalcopyrite is associated.

The primary sulphides are too sparsely disseminated thru the rock to be considered ore and the oxidized surface ore is simply the secondary enrichment of a very low-grade body of copper sulphides.

Summary and Conclusion.

The underground work done in the district has shown that there are two types of mineral deposits, one consisting of bedded or blanket deposits where pyrrhotite and chalcopyrite together with numerous other non-metallic minerals, some of which are suggestive of contact metamorphism, have been deposited in a somewhat sparse manner along sills of hornblende-diorite and the adjacent beds of quartzite and schist. The other type is a fissure, possibly at one time occupied by a dike of hornblende-diorite which follows the strike of the metamorphics but cuts them on the dip and in which the schist wall-rock has been replaced by chalcopyrite and pyrrhotite, the former predominating and occurring thruout the fissure in massive lenses. The low-grade blanket deposits dip towards the fissure deposit and it is highly probable that shoots of ore will occur at their junction with the fissure.

In some respects there is a similarity between the deposits of this district and those of Ducktown, Tennessee. *

COPPER DEPOSITS OF SEVEN DEVILS

THE DEER CREEK DISTRICT

This is an unorganized mining district situated in Lewis County on the southern slope of Craig Mountain and on the drainage of Deer Creek, a tributary of Salmon River. It is probably in the same general mineralized belt or zone as the Divide Creek district from which it is distant about eight miles.

Copper mineralization is known to occur over a considerable area but the only properties where work has been carried on to any extent are the Deer Creek mine and Mr. Geo. Horseman’s property. The latter property is reached by a fairly good wagon road from Winchester, the nearest railroad point, a distance of about sixteen miles. The nearest postoffice is at Forest, a small village near the top of Craig Mountain, about eight miles from Horseman’s claims. The Deer Creek mine is reached by trail from Horseman’s or else by a rather steep drag road that branches off from the road between Forest and Horseman’s. The latter property lies in Sec. 33 and 34, T. 32 N., R. 3 W., and the Deer Creek property is in Sec. 4, T. 31 N., R. 3 W., Boise Meridian and about 1400 feet lower than Horseman’s.

Topography. The district lies on what are locally known as the “breaks” of the Salmon River; i.e., at the top of the Salmon canyon on the south side of Craig Mountain.

Craig Mountain ** is a broad dome-shaped fold which rises at first gently from the Clearwater River at Lewiston, forming the Lewiston plateau and then more abruptly to its higher parts. The top is almost flat, covered with a heavy growth of yellow pine, and reaches an elevation of about 5000 feet. Its eastern end slopes rather gradually down unto the Nez Perce and Camas Prairies while the western end drops steeply into the canyons of the Snake and Salmon Rivers with a fall of over 3000 feet. Craig Mountain is undoubtedly an eastern extension of the western front of the Blue Mountains of Oregon and Washington and was formed at the same time and by the same orogenic movement. It is younger in age than the Snake River as that stream cuts across the fold, and the uplifting of the country at this place has had a marked effect upon the course of the Salmon River above its junction with the Snake. The latter stream, due to its greater volume of water, was able to cut across the rising fold while the Salmon River was turned from its course by the fold which is undoubtedly the reason for its extraordinary meanderings before entering the Snake. The Horseman property is situated where the flat timbered summit of Craig Mountain changes to the steep, grassy slopes of the Salmon River canyon. From the ridge where the Horseman cabin stands a remarkably fine view can be had of

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the canyon, the Joseph plains across the canyon, and the Seven Devils Mountains with their rugged peaks rising abruptly from the basalt plateau some fifty miles to the south.

**Geology.** Craig Mountain is composed almost entirely of Columbia River basalt, although the covering of this rock is probably rather thin over a large part of the mountain as granite is exposed in several places. Along the road from Lewiston a short distance above Horseman's the basalt has been removed by erosion and over most of the drainage area of Deer Creek the older rocks are exposed. These consist almost entirely of the so-called greenstone * series of supposed Triassic age. In this vicinity those rocks are in the main of a greenish color with a marked schistosity which has a general northwesterly strike and easterly dip. In places, however, they grade gradually into a dark purplish rock with well marked white phenocrysts of plagioclase, and they undoubtedly represent a highly crushed and altered portion of the great series of andesitic lavas so well exposed in the canyon of the Snake River below Homestead, Oregon, and also in the Seven Devils Mountains of Idaho. The same series is exposed in the canyon of the Salmon River above Whitebird and at the Dewey mine on the South Fork of the Clearwater River. The only other rock besides the basalt and greenstones that was seen in the district by the writers was a dyke of syenite or trachyte porphyry about ten feet wide which outcrops on the Horseman property. This is a grayish colored rock with well defined phenocrysts of green hornblende and white feldspar in a light-colored ground mass. As no thin section of this rock was made, its classification as trachyte or syenite porphyry might have to be revised.

**George Horseman's Property.**

This consists of nine mining claims and some patented ground in Sec. 33. The country rock is the green andesite schist previously described.

A number of fissure veins, which strike in different directions, have been exposed in several places by open-cuts, tunnels and small shafts. There seem to be three distinct series of these veins, one set has a strike of about N. 30° W.; another series has a strike a little east of north and a third runs almost east and west. Several of these appear to intersect on the ridge a short distance above the cabin.

Most of the work has been done upon one of the northwest veins, which might be considered as the main vein of the property. This vein is a fault fissure, with crushed vein material lying between almost vertical walls and a strike of about N. 35° W.

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* Lindgren, Waldemar, op. cit. p. 16.
The eastern wall contains a talc seam but the western wall is well defined. The vein filling consists of crushed and silicified country rock with chalcopyrite, calcite and siderite filling the spaces and also replacing the broken fragments of greenstone. A little molybdenite was also noticed.

The vein is from 7 to 10 feet wide and has been opened by a drift 135 feet long which exposes the vein in its entire length. The material exposed by this drift will average about 3 per cent of copper, 2 ounces of silver, and about 50 cents in gold to the ton. The outcrop of this vein is obscured very largely by soil and where exposed above the tunnel it shows very little oxidized copper minerals but only a red stain due to the iron. This vein can be traced for a distance of about 1000 feet and is probably more extensive even than this. It is worthy of far more extensive development and attention than it has received up to the present time.

The other veins on the property are only exposed by shallow open cuts but practically all of them show a little copper. An east-west vein has been exposed on the west side of the wagon road above Horseman's cabin. This vein is about 7 feet wide and has a strike of N. 80° E. and a dip of 60° to the NW. It consists chiefly of quartz stained with copper carbonate and contains also some "pitch copper" or dark colored chrysocolla or copper silicate. This is by far the strongest looking of the other veins and should intersect the main Horseman vein near the top of the ridge.

The property lends itself readily to development by means of tunnels as the mountain drops 1400 feet along the strike of the northwest veins in a distance of less than a mile.

The Deer Creek Property.

This property consists of twelve mining claims and is situated about 1400 feet lower down the mountain than the Horseman group, the mine buildings being located at the junction of the two principal forks of Deer Creek at an elevation of about 2400 feet (barometer reading). The country rock is the same greenstone andesite series as that described on the Horseman property.

Two veins, approximately parallel and about 100 feet apart, have been exposed. These veins strike about N. 20-30° W. and dip to the southwest from 45° to 60°. Most of the development work has been done upon the No. 2 vein which shows about 2 feet of quartz in places and contains a little chalcopyrite with some calcite and siderite also present. The chief value lies in the gold contents, the vein material being reported by Mr. F. F. Johnston, the superintendent, to carry about $7 to the ton of this metal. Over a thousand feet of development work has been done upon the claims. A little sylvanite or some other telluride is reported to occur in the vein but was not identified by the writers.

The property is equipped with a thoroughly up-to-date mill capable of handling from 125 to 150 tons per day which would seem to be considerably ahead of the development in the mine.

The flow sheet of the mill is as follows: The ore goes to a grizzly and from there the oversize goes to a No. 4 Champion crushe. The product from the crushe and the undersize from the grizzly goes to a Monarch (Chilian) mill, which crushes it to about 40 mesh. From there the pulp goes to four amalgamating tables and then over four Franz tables and thence direct to a Callow flotation unit.

* Figures furnished by Mr. Rowland King, Spokane, Wash.
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