STATE OF IDAHO

Robert E. Smylie, Governor

IDAHO BUREAU OF MINES AND GEOLOGY

E. F. Cook, Acting Director

THE GEOLOGY AND MINERAL RESOURCES OF THE REGION ABOUT CROFINGO, IDAHO

By

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FOREWORD

The title of this pamphlet is somewhat misleading. A glance at Plate VII (in the pocket inside the rear cover) will show that Dr. Anderson mapped over 6,400 square miles of northern Idaho, an area which he modestly described as "The Region about Orofino, Idaho." No geologic publication has since treated more than a small fraction of this vast area; in view of this, Pamphlet 34 remains, in spite of its age, one of the fundamental sources of geologic information about North Idaho.

To duplicate the geologic field work represented by this pamphlet would today require even more effort than Dr. Anderson put forth in the summer of 1929, for then, as he happily tells us in the Introduction, a disastrous forest fire had "satisfactorily" exposed the bedrock.

Within the area covered by this report the Idaho mining industry was born, with the discovery of gold at Pierce in 1860. As we near the Centennial of this discovery, it seems fitting to reissue Pamphlet 34 which is an early work of a man who, by his research during more than thirty years, has contributed greatly to the growth of the mining industry of Idaho.

E. F. Cook, Acting Director
Idaho Bureau of Mines and Geology
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THE GEOLOGY AND MINERAL RESOURCES OF THE REGION ABOUT  
OROFINO, IDAHO  

by  
Alfred L. Anderson  

INTRODUCTION  

PURPOSE AND SCOPE OF THE INVESTIGATION  

Mineral deposits of several kinds have long been known in the region about Orofino, Idaho, but few of them have been described or have received more than mention. This is true of both the metalliferous and nonmetalliferous deposits. Parts of the region had been studied in geologic surveys, but large areas had never been investigated. Curiously, this region, one of the least known in the state, geologically, was the scene of the first discovery of mineral in what is now the state of Idaho - the discovery of placer gold by Captain Pierce on Orofino Creek in 1850.

To satisfy the demand for information on the mineral deposits and the geology of the region, the writer was detailed by the Idaho Bureau of Mines and Geology in the summer of 1929 to study all the known mineral deposits as well as to make a reconnaissance geologic examination of the entire region, to prepare a geologic sketch map, and to determine as far as possible the mineral potentialities of the present unproductive areas.

As a result of these studies, the known mineral resources were augmented by the addition of several others. The northern boundary of the main Idaho batholith was also definitely fixed, thereby solving one of the perplexing problems that has confronted those interested in the distribution of the geologic formations in the state. The east margin of the Columbia basalt, where it flanks the older rocks of the Clearwater Mountains, was also determined. In addition, other interesting geologic features were found and these have been briefly incorporated into the report.

CONDITIONS AFFECTING FIELD WORK  

The field work began the fifteenth of July with a trip into the most inaccessible part of the region. This was made by pack train from the Bungalow ranger station at the end of the wagon road and on the North Fork of the Clearwater River. The traverse was carried down river to the mouth of Isabella Creek and then upstream to the drainage divide between the Clearwater and St. Joe rivers. The divide was followed eastward to Chamberlain Meadows with side trips across critical areas. The route was continued to Fish Lake at the Montana line and then southward to the Blacklead district not far from the old Lolo trail and the Lochsa divide. Side trips were taken wherever necessary, and return was made to the Bungalow ranger station by way of Kelly Creek and the North Fork, 16 days later. As nearly the entire region had been burned by the disastrous forest fire of 1919, bedrock was satisfactorily exposed everywhere and geologic mapping was easy and rapid. Only the Belt series and Idaho batholith were differentiated and their contact could easily be traced across country from any commanding point.

During the remainder of the season, which ended the third of September, traverses were conducted by automobile and on foot, usually to lookout
stations near the border of the mountainous tract. This was necessary, as the country that was more or less accessible by car was heavily timbered as well as covered by deep soil. From the high peaks, occasional outcrops of bedrock could be distinguished and identified on the steeper slopes and ridges. The topography also gave clues as to the underlying rocks, whether basalt, granite, or sediments, as each have a different control on the relief and drainage.

After the middle of August, work was seriously hindered by smoke from forest fires. Fires also prevented the writer from examining some very critical areas. Generally traverses were pursued but a short distance upon the Idaho batholith and over the Columbia basalt. This procedure permitted rapid mapping. Some parts of the region had been previously mapped and the early work was in many cases accepted by the writer without question and transferred to his maps. Fortunately, a large part of the area was familiar to the writer, who had spent a number of years in the Clearwater Mountains and this familiarity was in the main responsible for the rapid progress of the reconnaissance.

ACKNOWLEDGMENTS

The work was conducted under the direction of Dr. F. B. Laney of the Department of Geology at the University of Idaho. The writer was accompanied in the field by Andrew H. Thomson, a student of the University of Idaho, who rendered most efficient field assistance and aided greatly the rapid progress of the studies. Valuable assistance and much information was given by many people in the region, and the writer is especially indebted to Mr. Paul Wohlen, Forest Supervisor of the Clearwater National Forest; to Mr. J. M. Molloy, Secretary of the Orofino Commercial Club; to Mr. Walter Sewell of Orofino; and many others.

PREVIOUS GEOLOGIC WORK

Previous geologic work in the region is summarized in the following list of publications, each of which is briefly abstracted as it pertains to the geology of the region. The arrangement is alphabetic.


4. Kirkham, V. R. D., Underground water resources in the vicinity of Orofino, Idaho; Idaho Bur. Mines and Geol. Pamphlet 24, 1927. Describes the structural relations of the Columbia basalts and Latah formation to each other and to the older rocks. Includes a geological sketch map of part of the area.

6. ---------------, A geological reconnaissance across the Bitterroot Range and Clearwater Mountains in Montana and Idaho: U.S. Geol. Survey Prof. Paper 27, 1904. The most complete description of the geology of the Clearwater Mountains available, but includes little of the country along the North Fork of the Clearwater River. The topography of the Columbia Plateau and the Clearwater Mountains is described at length. Gold deposits, both lode and placer, are described about Pierce and vicinity, also lode deposits near Harpster on the South Fork of the Clearwater. Reconnaissance geologic map of part of the area.


10. Shannon, E. V., Minerals of Idaho: U.S. Nat. Mus. Bull. 131, 1926. Contains descriptions of minerals that have been identified in the black sands of placer deposits, also detailed mineralogical descriptions of the anthophyllite asbestos, certain minerals of igneous and metamorphic rocks, and minerals of some of the veins.

The area studied about Orofino totals more than 6,400 square miles. Its location and boundaries may be seen in Figure 1. The area is mainly rectangular with greatest length north and south of 78 miles and east and west of 84 miles. Township boundaries were arbitrarily selected, except along the northeast border where the state line serves. The 182 townships, some surveyed but many unsurveyed, cover the whole of Clearwater County and parts of Idaho, Nez Perce, Lewis, Latah, and Shoshone counties. The principal towns within each of the counties in the mapped area are Orofino (county seat), Elk River, Cawndish, Teakeen, Ahaska, Pierce, Welppo, Greer, and Headquarters in Clearwater County; Grangeville (county seat), Cottonwood, Winona, Kooskia, Stites, and Harperst in Idaho County; Nez Perce (county seat), Craigmont, Kamiah, in Lewis County; Peck in Nez Perce County; and Bovill in Latah County.

About half of the area lies in the National Forest Reserves, the St. Joe, the Clearwater, the Selway, and the Nez Perce, and most of the remainder is on the plateau that lies to the west of the Clearwater Mountains.

ACCESSIBILITY

A part of the region is served by railroads, and a still greater part by an excellent system of highways, but the remote districts far back in the mountains must be reached over trails. The Stites branch of the Northern Pacific railroad along the Clearwater River is the only rail entry to the mountainous district. A branch line (controlled jointly by the Northern Pacific and Union Pacific systems) extends from Orofino to Headquarters, 42 miles to the east and some distance within the mountainous tract. Logging railroads radiate from Headquarters. The plateau country west of the Clearwater River has the Camas Prairie line from Lewiston to Grangeville. Bovill and Elk River have a branch of the Chicago, Milwaukee, and St. Paul Railway.

The highways are generously distributed over the more thickly populated parts of the region and several extend well back into the mountains. One of these is the Greer-Pierce highway which mounts the plateau from the Clearwater River over a very excellent grade. This highway has been continued as a surfaced forest road to the Bungalow ranger station on the North Fork of the Clearwater. Another surfaced road, not yet completed, has been extended from Pierce to Headquarters. The Lewis and Clark highway has been completed from Ahaska to Greer. A road, mainly rough and narrow, extends up the North Fork from Ahaska to Don and then on to Elk River. A surfaced highway also climbs the west side of the canyon at Orofino and joins near Nez Perce with the surfaced highway between Craigmont and Kamiah. The Lewis and Clark highway has also been graded and surfaced from Kamiah to about 20 miles above Kooskia on the Middle Fork of the Clearwater. Excellent roads of lesser width continue many miles farther up the Clearwater; one, the future extension of the Lewis and Clark, to the lower end of Black Canyon on the Lochea River, and another up the Selway River to Selway Falls. A surfaced highway also extends from Kooskia to Harperst and is soon to be joined with the highway that is being built from Grangeville to Elk City along the South Fork of the Clearwater. The North and South highway lies along the west margin of the area. The open plateau country has the usual assortment of country roads, likewise the west margin of the mountains.
Index map showing location of area covered in reconnaissance.
The mountainous area has a good system of trails, built for the purpose of fire protection, and all parts are relatively accessible by horse or on foot. Some of the trails are old and historical, as the famed Lolo trail.

TOPOGRAPHY

RELIEF

More than half the area is mountainous, for it covers a large part of the Clearwater Mountains, while the remainder is mainly the relatively level surface of the great Columbia Plateau. Lindgren has given an excellent picture of the Clearwater Mountains which he describes as a broad, deeply and maturely dissected plateau with an average elevation of about 7,000 feet, but varying between 6,000 and 8,000 feet. The principal ridges between the streams he describes as generally broad and flat, but in places they are dissected into sharper crests and peaks. Their combined crest lines appear to represent an undulating plain, sloping very little, if at all, in any given direction, and their surface rises 4,000 feet above the indented lava-filled bays of the bordering Columbia Plateau. To this description the writer can only add some interesting details which give evidence of a complex physiographic history as recorded by three systems of rock terraces or ridge levels.

Most of the higher ridges and peaks have been sculptured by mountain glaciers and given sharper crests, with glacial cirques, many holding lakes, clustered on the north sides. From the higher peaks the glaciers have descended into the valleys, to elevations as low as 3,000 feet, but usually not much below 5,000 feet. The valleys between the ridges are generally narrow with rapid streams. Only along the western border where the valleys have been filled or obstructed by the Columbia basalt are they notably flat and wide and occupied by gentle meandering streams.

The basalt plateau, which lies to the west of the mountains, is dissected by more recent streams whose canyons are separated by wide expanses of plateau surface. The surface of the plateau is nowhere exactly horizontal but exhibits a variable amount of tilting and even folding. The plateau slopes gently westward from the margin of the mountains east of Crofino where the elevation is about 3,100 feet, to the river where its surface is at 2,900 feet. Then westward its surface rises gradually to 5,000 feet at Craigmont near the summit of Craig Mountain. Craig Mountain, a partially dissected broad fold with longer axis east and west, has a wide, flat summit but its edges slope steeply on the north to Lawston Valley and less steeply on the south to Camas Prairie. The surface is again folded south of Grangeville on Grangeville Mountain where the basalt has been raised locally above 5,000 feet. The tilted surface of the plateau is also noticeable near Harpster where the South Fork of the Clearwater River follows the axis of a perceptible downwarp, and also near Cavendish where the surface, at 6,000 feet, tilts northward to 2,500 feet.

Several islands or hills of older rock also rise above the surface of the plateau. The most noticeable of these are Kamiah Buttes near Winona, which rise as high as 1,000 feet above the plateau and whose common base covers

Fig. 1. The Clearwater Mountains in the North Fork drainage. Several systems of ridges, each with accordant summit levels, are visible.

Fig. 2. Massive outcrop of the Seven Devils volcanics in the canyon of the South Fork of the Clearwater River a few miles above Harperster, Idaho. This series of rocks forms narrow and steep canyon walls wherever cut by streams.
about 22 square miles. Cottonwood Butte, northeast of the town of Cottonwood, is another island, rising to even greater heights above the plateau surface.

The margin of the plateau is irregular, for the lava which built the plateau flooded back into the valleys of the mountains. In most places, the mountains rise steeply from the plateau's edge, but in some places the foothills stand barely above the plateau surface.

**DRAINAGE**

Most of the drainage of the area is by the Clearwater River and its numerous tributaries. An exceedingly minor part in the north drains to the St. Joe River and a small part on the southwest to the Salmon River.

The Clearwater system has three main forks, the North Fork, which drains the northern part of the area and joins the main river at Ahsahka; the Middle Fork, which carries its name from the junction of the Lochsa and Selway rivers at Lowell about 30 miles above Kooskia to the mouth of the North Fork at Ahsahka; and the South Fork, which rises in the region about Elk City and joins the Middle Fork at Kooskia. The drainage of all branches, in general, is westward to the Columbia Plateau. Here the rivers have cut narrow canyons in the plateau, as much as 2,000 feet deep. On entering the plateau region, the South Fork turns abruptly north and continues in that direction to Kooskia where it joins the Middle Fork, which then takes a northerly direction to Ahsahka. This is at nearly right angles to former pro-basalt valleys, for the rivers are continuously crossing ridges of older rock which appear as windows in the canyon side. The canyon invariably narrows where the ridges of less easily eroded rock are encountered, and again widens in the basalt.

Tributaries are so numerous, especially in the mountainous region, that no attempt will be made to describe or list them. They invariably occupy valleys or canyons of the same nature as their master streams.

**CLIMATE AND VEGETATION**

The area, located as it is on the east margin of the Columbia Plateau, and on the higher mountains to the east, is well watered and enjoys a temperate climate. The annual rainfall is normally above 18 inches on the Plateau. It is more than doubled in the higher mountains. The summers are usually hot and dry, especially in the canyons where temperatures above 100°F are not uncommon, but the remainder of the year has sufficient precipitation to assure good crops and is not excessively cold, even in mid-winter. Temperatures naturally decrease with increase of elevation, and the snows are deep in the winter in the mountains, as well as in the higher parts of the Plateau.

The climate of the region is reflected in the vegetation. The mountains and the eastern margin of the Plateau (as well as Craig Mountain) have a heavy growth of timber, and lumbering is one of the two most important industries of the entire region. The largest stand of white pine in the United States is in the lower North Fork drainage about Headquarters. The other important industry is the raising of grains in the open prairie country west of the mountains on the plateau. Camas Prairie south of Lawry's Canyon and Nee Force Prairie on the north are widely known for their yields of grain.
GENERAL GEOLOGY

GENERAL FEATURES

The mountainous area is carved in part in very old sedimentary rocks in which are intercalated some igneous sills nearly as old, but the greater part is carved in a younger batholith and its enveloping zone of gneissic rocks. Minor masses of other rock also occur in the mountainous tract, including a limestone, also a great series of volcanic rock overlain by a thick series of sedimentary beds. The plateau area, on the other hand, is built up by younger lavas which were poured over the surface of the lower country. Some masses of older rock rise above the lava surface as islands, other patches are disclosed in the bottoms of canyons where streams have cut through the lavas into the underlying rocks.

The old sedimentary rocks are of pre-Cambrian (Algonkian) age, although a part may be older. They belong to the Belt series which is so widely distributed over western Montana and northern Idaho. These form a banded succession of sediments many thousand feet thick of fine-grained arenaceous, calcareous, and argillaceous materials, indurated and, near the younger batholith and outliers, converted to mica schists and gneisses. The sills, which invade them, occur mainly in the lower part and are a continuation of a great series that is known to extend from British Columbia southward through the entire northern part of Idaho.

The limestone, an engulfed block or pendant in the batholith, is new to the region. It is probably Paleozoic in age. The thick series of volcanic rocks, mainly flows and pyroclastics of intermediate composition and of Permian age, forms a partial border of the mountains as well as occurring in the lower parts of canyons cut through the lava plateau, and also in one of the islands which rises above the surface. Overlying the volcanics is a thick succession of argillaceous sediments, limestones, buffs, and intercalated volcanics, which are believed to be Triassic. Dikes and lenses of ultra-basic rock may also have been intruded during this time. These rocks by their alteration have given deposits of amphibole asbestos.

Among the most interesting of the older formations in the Idaho batholith which bears intrusive relationship to the rocks mentioned above. This is one of the largest batholiths on the continent. In this region it has a wide marginal zone of gneissic quartz, diorite, and a great inner core of quartz monzonite and granite. In places the quartz monzonite facies invades the border zone and this relation suggests two periods of intrusion, but all are probably differentiated rocks of a parent magma. This great body was probably intruded following the great period of mountain building near the end of the Jurassic when the earlier rocks were folded and faulted as a result of great compressive stresses. The batholithic intrusion was accompanied by a host of associated dikes such as porphyry, pegmatite, aplite, malchite, and lamprophyre, the pegmatites showing great similarity in composition to both the dioritic and monzonitic masses. Most of the mineralization is probably related to this intrusion. The invasion of the batholith was accompanied by great pressures and thrust action, resulting in a great zone of gneiss, largely of igneous origin, about its border. Contact metamorphism was also important about some parts of the batholith.

Subsequent events, other than erosion, took place mainly in the plateau area. Early in the Tertiary period volcanism occurred and a series of
andesitic and latitic lavas was poured on the surface of the deeply eroded older rocks. This series of lavas of which there are only remnants perhaps correlate with the very extensive series in the south-central part of the state believed to be of Miocene age. Later more extensive volcanism occurred when the Columbia basalt of upper Miocene flooded and buried the lower country to the west of the mountains, building up the Columbia Plateau. As the basalt flooded back into the valleys, it obstructed the drainage and sands and clays were deposited in ponds and lakes to be later buried by the advancing flows. The intercalated sedimentary beds have been named the Latah formation. Higher gravels were also deposited about the margin of the mountains as a result of this obstruction to drainage.

Pleistocene glaciation left some small moraines about the higher peaks and ridges, and also valley trains or aggraded valley floors in the valleys below, but these younger deposits are not extensive, nor are the deposits in the present stream channels. Some of the latter have been worked for gold.

The older rocks were much disturbed by the Jurassic diastrophism and the invasion of the batholiths. The beds are folded and faulted. In the northern part of the district the Belt rocks trend in general northwest to southwest and west to east. The dip is moderate and invariably to the northeast or north, occasionally south. The gneissic rocks nearer the batholith also maintain a strike far west of north and a steep dip to either north or south. The Permian and Triassic rocks, on the other hand, trend east of north at a moderate angle and dip to the southeast.

The plateau surface has been moderately warped by more recent movement. The basalt has been thrown into an east-west anticline constituting the Craig Mountain uplift. This fold plunges eastward to the Clearwater River, where a less prominent syncline or depression runs nearly northward between Craig Mountain and the Clearwater Mountains. Other folds in the plateau surface have been mentioned under topography.

STRATIGRAPHY

ALGONKIAN ROCKS

Belt Series

The Belt series was traced from southern Shoshone County where the several formations have been mapped by Pardee\(^1\) and Calkins\(^2\) to the Idaho batholith well down into the district. Additional areas were observed in the batholith as roof pendants, but in general these were not mapped as the patches were small and thin with granitic rocks just beneath. Perhaps, in all, about one-fourth of the region is underlain by Belt rocks.

These rocks show some differences in charactor and thickness from the section in the Coeur d'Alene district\(^3\) where they have been studied in detail.

but division into the same units is possible, although less easy to make than in most other places because of the intense metamorphism induced by batholithic invasion. All members, except possibly the Striped Peak, are represented. No attempt was made to map the individual members.

The series in general comprises a great thickness, more than 20,000 feet in all, of stratified thin to thick sedimentary beds, mainly of shallow water facies with ripple marks and sun cracks preserved where contact metamorphism has not been severe. The rocks are quartzites, shales, argillites, and impure limestones, but near the Idaho batholith and outliers these have been changed to mica schists, micaceous quartzites, gneisses, and schapolite rocks.

Assigned provisionally to the Belt is a series of highly metamorphosed igneous and sedimentary rocks with beds of exceptionally pure crystalline limestone or marble in the lower Clearwater drainage near Orofino. These can not be correlated with any of the Belt members farther north. They must either be older or belong in the lower part of the Prichard whose counterpart, in other places has not been exposed by erosion or is not present. The term, Orofino series, has been given to these rocks.

Orofino Series

The Orofino series as defined above is assigned to the lower part of the Belt (Prichard formation). It apparently lies beneath the known Prichard and conforms with it in strike and dip, although the precise plane separating one from the other is unknown. The series is best exposed in the Clearwater Canyon near Orofino, the lower eleven miles of Orofino Creek in the lower canyon walls and along the lower course of the North Fork between Elk Creek and Ahsahka.

The series is composed of a great thickness of banded micaceous and hornblende rocks including micaceous quartzites, mica schists, hornblende gneisses, and with intercalated beds of crystalline limestone or marble. Many of the gneisses and schists are undoubtedly of igneous origin, but much also has fairly distinct bedding planes. Probably much of the metamorphism was induced by the batholithic invasions as the younger granitic bodies are numerous in the vicinity of this series, and some is intercalated as injection gneiss, but part of the metamorphism was probably much earlier.

Most of the schist and gneiss has scattered crystals of reddish garnets, more numerous than is ordinarily observed in the altered Prichard. The bedding is most distinct in the massive micaceous quartzites and these are most prominent near the limestone members. The crystalline limestone or marble is for the most part of exceptional purity, classified as high-calcium, and is composed almost wholly of white fine to coarsely crystalline calcium carbonate, in some beds partly grayish. The number of limestone horizons is not definitely known, but several beds are present ranging from 10 feet to over 800 feet thick. The beds are more or less lenticular in shape and of varying thickness. Most of the limestone members are near Orofino, beginning near the mouth of Jim Fords Creek and lying parallel to the river to Ahsahka. The beds are neither as thick nor as pure near Ahsahka as farther south above Orofino. An isolated bed about 600 feet thick also outcrops in the canyon wall of Orofino Creek about 11 miles east of Orofino, also with sedimentary and igneous gneisses and schists. No part of the Wallace has limestone members as pure or as thick, or as metamorphosed as these.
Prichard Formation

The Prichard formation is the oldest of the known Belt members and apparently the thickest. It is widely distributed over the west part of the area mapped as Belt rocks, the contact between it and the overlying members extending into the region from the north along Collins Creek and trending in a southeasterly direction to near the mouth of Kelly Creek where it ends against the Idaho batholith. East of this line the rocks belong mainly to the younger members, with possibly here and there a faulted mass of the Prichard. The western margin of the formation is determined by the Columbia basalt and the Orofino series. Not all the rocks west of the boundary outlined above are Prichard for younger members, probably Wallace, cutout in the region east and south of Clarkia. Some of the pendants in the batholith were recognized as Prichard, and one of these near Pierce was mapped.

The Prichard is divisible into three well-defined units, a lower series of mica schists and gneisses, much of it garnetiferous, alternating with thin beds of quartzite, metamorphic equivalents of argillites or shales and argillaceous quartzite, in general more silicious than in the Coeur d'Alene districts; a middle white quartzite member as much as 2,000 feet thick; and an upper series of mica schists and gneisses greatly similar to those of the lower division with thin beds of white quartzite. The middle quartzite member is particularly interesting as it does not occur in the Coeur d'Alene district but makes its first appearance along Pine Creek where it is 200 feet thick and from there increases in thickness to 1,500 feet along upper Marble Creek and to 2,000 feet in the upper Clearwater drainage. It forms particularly white massive outcrops and may be easily traced along the ridge top and peaks. The white bold top of the Mallard Peak and the Nub are due to this member. It apparently ends south of the Nub where it attains its greatest thickness by faulting, for it does not appear across the valley of Skull Creek or on Indian Henry Ridge. White massive quartzite also outcrops near the mouth of Lake Creek in the main valley of the North Fork apparently in Wallace rocks. It is probably the quartzite member of the Prichard with its location due to faulting. The lower and upper Prichard can not be readily distinguished except from their relations to the middle quartzite member or to other formations. The upper part is perhaps 1,500 feet thick, and the lower more than 10,000 feet thick. One part of the lower Prichard is much the same as any other and precise horizons are difficult to determine.

Burke-Revett Formations

The Burke and Revett formations extend into the region from the north between Mallard Peak and Surveyors Peak, but the boundaries were not followed far to the south nor were the formations definitely recognized in other parts of the region. Where they have been highly metamorphosed they ordinarily can not be distinguished from the schists and gneisses of other formations. They overlie the Prichard conformably.

The two formations are considered as a unit, although there is a fairly distinct upper and lower division. The rocks are mainly quartzitic corresponding closely in character to the Burke and Revett in the Coeur d'Alene district.

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2 Calkins, F. C., and Jones, E. L. Jr., op. cit., p. 78.
but the thickness of each is somewhat less. The lower division consists chiefly of soft-weathering light gray micaceous sandstone with which some flaggy quartzite and muscovite schist is interbedded. The upper division is of quartzite, although more micaceous and thinner bedded than the Revett in the Coeur d'Alenes. It is, therefore, less distinct from the beds which represent the Burke formation. The Burke may be about 1,000 feet thick and the Revell only slightly greater.

St. Regis Formation

The St. Regis formation lies to the east of the Burke-Revett, mainly along Collins Creek but probably outcrops in other parts of the region, everywhere conformably above the Revett. It is the most difficult of all the formations to identify because it shows considerable lithologic variation from the Coeur d'Alene district, namely, a lack of the characteristic and diagnostic purplish and reddish bands. It is with difficulty separable from the underlying Revett, composed in its lower part of thin-bedded quartzitic sandstone and shale (usually altered to glistening muscovite schists). The upper part is composed of pale greenish, indistinctly banded shale with thin interbedded layers of sandstone, and merges gradually with the overlying Wallace formation. It is distinguished from the lower Wallace only in being somewhat more siliceous. In the highly metamorphosed areas the St. Regis, because of its more argillaceous character, passes mainly to a glistening mica schist, with more mica than is common in older formations. The St. Regis is probably no more than 500 feet thick and may give out entirely as a distinct unit near the batholith.

Wallace Formation

The Wallace formation has an exposure nearly as great in area as the Prichard, but is not nearly as thick, perhaps not much more than 6,000 feet. It is the prevailing country rock of the upper drainage of the North Fork, its western and lower boundary lying a short distance to the east and north of the top of the Prichard. Some of the sedimentary rocks which occur between Bovill and Elk River probably belong to this formation or to the Burke-Revett.

The Wallace, as in the Coeur d'Alene district, is characterized by numerous thin calcareous beds. The lower part consists in general of gray or brown, rather siliceous mica schists and micaceous quartzites with a little scapolite in certain beds of schist indicating the presence of a small amount of lime. North of the district where metamorphism has been less severe, the Wallace is composed of greenish shale and sandstones, in part calcareous. This lower part is perhaps about 500 feet thick. Above, the Wallace consists essentially of alternating thin beds of calcareous argillite and sandstone with some thin irregularly spaced beds of impure limestone. The argillites vary in color from greenish to blue, and the sandstones are gray or white, similar to the Revett. The metamorphosed beds are pale greenish and brownish hornfels of fine texture, generally studded with white grains of scapolite about the size of buckshot. This structure is very useful in identifying the formation in the field. With the hornfels are alternating beds of quartzite, marble, and mica schist. The upper part of the Wallace is notably free of lime, and is mainly regularly banded bluish and greenish shales and sandstones, comparatively resistant to erosion. The upper division is much thicker than in the Coeur d'Alone district. Ripple marks and sun cracks are usually abundant in the upper part.

The effect of metamorphism is most pronounced in the lower beds of the Wallace, mainly because these are nearer the great bodies of intrusive granitic
rock. Some of the argillaceous members on the ridge east of Collins Creek have been converted to a crinkled muscovite schist, and other members contain scapolite. Eastward, the effect of igneous metamorphism becomes less and less pronounced, and near Chamberlain Meadows and the extreme head of the North Fork shows little sign of igneous metamorphism. The beds east of Bovill and south and east of Clarkia also show metamorphism, but not as much as in other places. Usually there is little difficulty in distinguishing the schists or micaceous beds of the Wallace from those of the Prichard.

Striped Peak Formation

The Striped Peak was not recognized in the area covered in the reconnaissance, but it may possibly occur in the extreme northeastern part of the district near the Montana line, a region which was not adequately covered, or masses may occur in downfaulted blocks in the Wallace or other rocks. If so, its character has greatly changed from other places, for no reddish beds so typical of it elsewhere were seen in the district.

Igneous Intrusives

Distribution

The ancient series of sills that invade the Belt series were probably intruded near the end of Beltian sedimentation but before the Algolian had drawn to a close according to conclusions made farther north where a continuation of these have been studied in greater detail. These range in thickness from a few inches to several hundred feet, mainly conformably with the enclosing sediments, and the larger traceable for many miles along the strike of the strata. The largest body seen was perhaps not over 1,000 feet thick, but larger ones may occur, for in the Cabinet Range some attain a thickness of 2,000 feet. These intrusives are most numerous in the Prichard, being well distributed throughout, and one or probably two occur in the lower and middle part of the Wallace. The exact number are unknown, but probably exceed a dozen.

Composition

The intrusives are composed of a notably uniform kind of rock both in composition and texture, except where metamorphism attending the intrusion of the Idaho batholith has affected the original texture and caused some minor changes in mineralogy. The rock is prevailingly a quartz-rich diorite of dark gray to grayish black color and of fine to medium grain. The most characteristic mineral is a greenish-black hornblende, invariably comprising more than half of the rock and whose abundance readily distinguishes these intrusives from the younger igneous rocks of the region. The texture is usually even granular except when the rock has been much metamorphosed in which case it assumes a pronounced gneissic texture and in places changed to an amphibolite schist or gneiss.

The rock is composed mainly of hornblende, plagioclase (from oligoclase to andesine) and quartz, with such minor accessaries as biotite, titanite, apatite, magnetite, and zircon. The hornblende normally comprises about two-thirds of the rock and usually occurs in clusters. The plagioclase generally shows good polysynthetic twinning, but where metamorphism has been severe has largely lost

that structure. The quartz comprises from eight to 10 percent of the rock. In the rocks with gneissic textures, the plagioclase has become more acid in character (through breaking down of more basic feldspars), and quartz more abundant. Other changes are in the growth of small reddish garnets, and the extensive development of epidote from both the hornblende and plagioclase. Many contain secondary pyrite or pyrrhotite.

PRE-PERMIAN PALEOZOIC (?) ROCKS

Blacklead Limestone

The Blacklead limestone, provisionally assigned to the Paleozoic, lies far back in the Clearwater Mountains at the head of Cayuse Creek, a tributary of the North Fork of the Clearwater River. It forms an engulfed block or podant about two miles long and one-half mile wide near the north margin of the Idaho batholith and not far from the great area of Wallace rocks nor far from the Montana line.

Unlike the nearby impure thin-bedded calcareous members of the Wallace, the Blacklead limestone is massive, thick-bedded and greatly resembles the grayish thick-bedded limestones of Paleozoic age in Montana or in Idaho southwest of the Salmon River Mountains. As much as 400 feet of massive beds are exposed and the base is not in view. The limestone has been considerably metamorphosed by the intrusion so that no fossils are preserved, but bedding is everywhere distinct. It is interesting to note that magnetite in seams and lenses is extensively developed through the limestone along bedding planes and fractures, the result of contact metamorphism. This feature will be discussed in greater detail when dealing with the economic geology of the region.

PERMIAN ROCKS

General Features

The Permian rocks are a continuation of those in the Seven Devils region and the Snake River Canyon where they are dominantly of volcanic origin, mainly andesitic flows and pyroclastics with some fossiliferous calcareous tuffs bearing a Phosphoria fauna. This lava group is herein designated as the Seven Devils volcanics, named from the type locality in the Seven Devils Mountains.

Seven Devils Volcanics

Distribution

The Seven Devils volcanics outcrop in three places in the southwestern part of the district. The largest area of these rocks is along the South Fork of the Clearwater between Harpster and the Dewey mine east of Mount Idaho, where they appear in the canyon sides beneath a capping of the younger Columbia basalt. A higher hill of the volcanics also rises above the plateau on the west side of the canyon and another ridge or spur extends northeastward up Green Creek around the margin of the plateau east of Harpster. On the south, the rocks are cut off by an outlier of the Idaho batholith, or pass beneath the Columbia basalt, reappearing again in the canyon of the Salmon River south of Whitebird. A second patch of these rocks outcrops in the Cottonwood Buttes north of Kooterville, covering there an area somewhat less than a township.

1 Laney, F. B., oral communication.
The third exposure is in the canyon of the Salmon River south of the Cottonwood Butte. The last two areas are separated only by a narrow and shallow rim of basalt between the upper part of the canyon and the butte.

Character and Composition

There was no time for more than a cursory examination of these volcanics. As a whole they are greatly altered and in most places resemble greenstones. Apparently the series includes both surface lava flows, mainly of andesitic composition, and intrusive dikes and stocks of dioritic and gabbroic composition. The dikes and stocks cut the flows in a most bouldering fashion, and, as both look so nearly alike because of extensive alteration, it is difficult or even impossible to determine the mode of occurrence anywhere with certainty. Some of the intrusives are probably much later than the flows and probably related to Triassic or Jurassic activity. The thickness of the volcanics was not measured but is probably more than a mile.

Along the South Fork of the Clearwater the series consists of both flows and intrusives folded and faulted so that no sequence is easily determinable. In general the tilted dikes and flows trend about N. 40° E. and dip about 50° S.E. The rock is massive and has much the same appearance in flows and dikes except for slight differences in texture. The series is notably free of pyroclastic material and has no interbedded sediments. It is overlain by sediments, apparently conformable, a short distance above the Dewey mine. They are thought to be Triassic.

The flows are greenish to grayish in color, aphanitic, and have few phenocrysts. Specimens collected between Sears Creek and the Dewey mine have the composition of andesite, but other kinds may be present as the number of thin sections prepared were wholly inadequate for precise determinations. The thin sections show much epidote and, in some, apparently a secondary amphibole as well as a clay-like substance and chlorite. The secondary products are usually so abundant as to nearly obscure the primary minerals. However, a few tiny plagioclase laths of intermediate composition and arranged in the groundmass as in a normal andesite (andesitic groundmass) indicate that the flows are andesites. The phenocrysts, also probably plagioclase, are wholly destroyed and composed mainly of epidote. The original dark minerals are a mass of epidote and chlorite, but their outlines suggest an altered pyroxene or hornblende. Secondary quartz is abundant. Two rocks collected as representative of the flows turned out to be altered diorites and probably therefore intrusive. Rocks of this character seem as widely distributed as the flows. These are grayish in color, of fine to medium grain, equiangular to slightly porphyritic. Hornblende is the dominant mineral, but is largely altered to epidote and chlorite. Enough of the feldspar remains to indicate that it is acid andesine in composition, but most crystals are a mass of epidote and kaolin. Quartz is also abundant as a secondary mineral. Magnetite and titanite are accessories. Another rock proved to be an altered gabbro. It was grayish, coarsely crystalline, with pale greenish feldspar nearly one-half inch across. Chlorite is easily recognized in the hand specimens. Thin section shows in part an ophitic or diabasic texture, with coarse labradorite crystals, twinning lines widely spaced, in part cemented by less abundant augite. The latter is usually altered to uralite or hornblende, and these in turn to epidote and chlorite.

No sections were made of the rocks in the Cottonwood Butte or the Salmon River canyon. At the summit of the Butte and on its western side the rocks are compact and massive, and consist largely of altered lavas and intrusives, best described as greenstones of probable andesitic composition. Some retain
reddish colors. The eastern part consists of greenstone schists alternating with partly tuffaceous clay slate and quartztitic slates.

**TRIASSIC (?) ROCKS**

**Sedimentary Series**

**General Features**

In the Snake River canyon the Permian volcanic rocks are overlain by a thick succession of shales and limestones and intercalated lavas and tuffs of probable Triassic age. A definite break, apparently in the nature of a disconformity¹ occurs between the two groups of rocks where they are in contact at Spring Creek and several other points along the Snake River. Limestones in the upper series in Oregon contain Triassic fossils. Apparently the same group of rocks, mainly sedimentary, overlies the Permian volcanics in the Clearwater region composed largely of argillaceous sediments with a single bed of crystalline limestone which in turn is overlain by more sediments of argillaceous character.

**Distribution and Character**

The Triassic (?) rocks are best exposed along the South Fork of the Clearwater River a short distance above the Dewey mine, where they apparently conform in dip and strike with the underlying volcanic group. Their northeasterly trend brings them east of Harpster where they end a short distance north of Switchback, in part passing beneath the Columbia basalt. The series must be several thousand feet thick but the top is eroded. These rocks are apparently a continuation of the belt exposed in the Salmon River canyon near Lucile and in the Seven Devils Mountains farther to the southwest, and resemble them lithologically as well as in stratigraphic relations. Some of the sedimentary materials intercalated with the volcanics in the Cottonwood Buttes may belong with this group.

In the Salmon River canyon the prevailing series consists of clay slates and a persistent bed of crystalline limestone (about 200 feet thick) with associated partly sheared greenstones (chiefly old surface lavas), having a general northeasterly strike and a southeasterly dip of about 45°. Along the Clearwater the relations and lithology are similar. Greenish shales and slates immediately overlie the Permian volcanics, and then a limestone bed from 100 to 200 feet thick, and, above more shales and slates, in most places highly altered where in contact with younger intrusive rocks. Some of the shales and slates are fissile and all have a pronounced greenish color. The limestone is persistent but to the northeast it appears to decrease in thickness and near Switchback is only about 50 feet thick, associated with greenish slates, and, nearby, with thin laminated whitish clay shales. The limestone is white to grayish-blue and has in a number of places been burned for lime.

**Ultra-basic Intrusives**

**Distribution and General Relations**

A group of ultra-basic rocks whose relation to other rocks is not wholly clear and for that reason whose age can not be definitely fixed, occurs in the region as dikes and stocks invading the Belt series and possibly the Triassic. These rocks are of more than scientific interest, for in them are found deposits

¹Laney, F. B., oral communication
of asbestos. The dikes and stocks have been profoundly altered by the attendant thrust and the solutions emanating from the Idaho batholith, and are, therefore, older than Jurassic, the age assigned to the batholithic invasions. On Blacktail Mountain, in the Harper district, rocks belonging to this group seemingly are in association with Triassic sediments occurring in their upper part, but unfortunately the critical contacts are so obscured by vegetation and the rocks themselves so intensely altered that precise relationship can not be obtained. Elsewhere dikes and stocks of the ultra-basic rocks are in the intensely metamorphosed schists and gneisses of the Belt and no useful information is furnished.

The dikes and lenses of the ultra-basic rock conform closely to the prevailing trend of the enclosing schists and gneisses, but whether they were folded with these could not be ascertained, as the relations beneath the surface are not observable. It is possible that they were intruded along the bedding of the tilted Triassic and older beds after these had been folded during the orogenesis which terminated with the intrusion of the Idaho batholith during the late Jurassic and thus genetically related to the Idaho batholith itself as one of the earliest expressions of that invasion. It is more probably, however, that the ultra-basic intrusives were intruded as sills and dikes into the sedimentary strata during the Triassic and later folded with them prior to the invasion of the Idaho batholith, especially as these intrusives show more marked petrogenetic resemblance to some of the Permian and Triassic volcanics than to the rocks associated with the Idaho batholith and like the older rocks show a greater degree of alteration than is shown by the known rocks of the younger intrusion.

These rocks are widely distributed along the western margin of the Clearwater Mountains from as far north as Teakean, and as far south as Harper and even into the Salmon River Mountains far beyond the area studied. Exposures were especially noted near Teakean, in the river canyon near Ahshaka, in the canyon of Orofino Creek, in the canyon of the Lolo, at Glenwood and along the west border of Maggie Buttes, near the mouth of Pete King's Creek on the Lochsa, and on Blacktail Mountain south of Harper.

The intrusives occur as seams and lenses of irregular size and distribution. In general, the bodies are small, most of them a few feet wide but a number are as wide as 75 feet and as much as 100 yards long.

Character and Composition

The most outstanding character of the rocks is their extensive alteration, apparently the result of deep-seated circulation of magmatic solutions. Most of them have been converted largely to serpentine, asbesitos, and talo. A few, however, retain remnants of the primary unaltered or partially altered rock, and from these the original character of the intrusives can be reconstructed. As a result of microscopic studies of a large number of bodies, two kinds of peridotites can be distinguished; dunite, composed essentially of olivine; and harzburgite, composed essentially of olivine and enstatite. Perhaps further studies will reveal additional peridotites.

Dunite

The dunite was found in lenticular dikes and seams, mainly in the vicinity of Glenwood or Maggie Buttes, and also near the mouth of Pete King's Creek. These are now composed almost entirely of mass-fiber asbestos (anthophyllite),
but some contain remnants of the dunite, usually in the form of granules or as small grayish-green masses scattered more or less uniformly throughout the body.

The unaltered remnants have a greenish-gray color and are composed wholly of olivine with accessory chromite magnetite, and spinel (picotite). In some sections the accessories are relatively abundant, the magnetite and chromite in scattered grains and crystals in the olivine as well as in cleavage cracks, and, later, replacing veinlets. The picotite mainly occurs along cleavage cracks in the olivine. The alteration of the dunite will be discussed elsewhere in the section on economic geology. It is sufficient to say here that the olivine shows extensive replacement by anthophyllite, thin sections being unnecessary to show these relations. Antigorite (limnolite serpentine) and talc are also secondary minerals, although much subordinate to the anthophyllite. The anthophyllite replaces the olivine, whereas the anthophyllite replaces both the antigorite and olivine, and talc replaces all three. Other minor secondary minerals are chlorite, tremolite (in place of anthophyllite in the Pete King dikes), magnesite, kammersite, and pyrite.

Harzburgite

Harzburgite was recognized as the original rock in the altered dikes near Teakean and in a dike along Grosino Creek, 11 miles east of the town. The Blacktail deposits are probably associated with the same kind of rock although these are so completely altered that none of the original minerals can be definitely identified.

The original rock is dark grayish in color and is composed of olivine with variable amounts of enstatite, an orthohombic pyroxene. In places the enstatite predominates and probably if the masses were studied in detail they would show zones of nearly pure enstatite. A little phlogopite has been noticed in some of the sections, and in one place forms narrow compact seams as much as two inches wide enclosed in a grayish clayey substance. Accessories are magnetite and a little chromite. The enstatite and olivine are extensively altered, usually first to a colorless monoclinic amphibole, resembling tremolite, and to serpentine. These in turn show replacement by anthophyllite, and lastly by talc.

JURASSIC (?) BATHOLITHIC AND ASSOCIATED INTRUSIVES

General Features

The date of intrusion of the Idaho batholith has been placed in the late Jurassic or early Cretaceous. It probably followed some time after the end of Triassic sedimentation, for these rocks are involved in the diastrophism which inaugurated the magmatic invasions. Elsewhere it has been mentioned that the batholith has not a uniform composition but shows much differentiation and is made up of two rather distinctive kinds of rock, a broad border zone of more basic composition, and a much greater inner core of more acid composition, the latter in part invading the border facies. The marginal zone of more basic rock is unusually broad, and because it has its own distinctive kind of associated dikes or differentiates, and has been given a more or less gneissic texture induced by the great thrust action of the younger inner core, it and its differentiates will be given separate treatment.

Border facies

Distribution and Character

The more basic rock that makes up the border of the Idaho batholith, and perhaps much of the upper part in some places, is most widely distributed along the western margin of the Clearwater Mountains. Some dikes and stocks also occur along the north margin of the main batholith and are also widely distributed in canyons of the plateau region and in some of the ridges which stand above its surface. The number of exposures in the canyons strongly suggest that granitic rocks of this character underlie a large part of the basalt plateau. In places, dikes and apophyses from the inner core are found in these rocks, but in no place was an actual transition noted from one to the other, although such zones probably exist.

The largest exposure of this rock is in the region about Pierce and Headquarters, the contact between it and the more acid core of the batholith lying somewhere east of Bertha Hill and trending southeasterly to the vicinity of Elk Mountain and then southwest to the Musselshell and Maggie Buttes. The western boundary may be seen on the geologic map as it is either the contact with the pre-Cambrian sediments or the Columbia basalt of the plateau region. This kind of rock is exposed continuously along the canyon of Lolo Creek south of Welippe to its mouth near Greer. From there it forms the lower walls of the Clearwater Canyon as far north as the mouth of Jim Ford's Creek and as far south as Kamiah. Higher hills of the rock rise above the plateau on both sides of the canyon near the mouth of Lolo Creek. A ridge higher than the basalt surface extends from Kamiah Buttes to Cottonwood Buttes. Many stocks, some large enough to be mapped, others unmapped, are exposed in the canyon sides of the Clearwater near Ahsahka, and also near Kamiah. Others outcrop a few miles below the junction of the Lochsa and Selway, and in the canyon of the South Fork near Harper.

Pegmatite dikes, related to the marginal facies in composition, are very numerous in the outer shell of the batholith and larger stocks, and in the adjoining country rock, especially near Greer and along Lolo Creek. They are also numerous along the North Fork from Ahsahka to a few miles below the Bungalow ranger station. In some places they are difficult to distinguish from the pegmatites related to the core of the batholith, but when studied microscopically, they show a more basic composition than the others.

Dikes of ultra-basic rock also occur about the border of the batholith and stocks but they apparently are not numerous as only one was actually seen.

The marginal facies has the composition of quartz diorite, in places approaching granodiorite. Everywhere the uniformity of composition is striking. The pegmatites show a close relation to the diorites. They have the composition of quartz diorite pegmatite. The ultra-basic rock is represented by a single large dike of hornblendite.

Quartz Diorite

The quartz diorite is usually a medium-grained rock, rarely coarse, and in most places shows a more or less pronounced gneissic structure. This structure is particularly typical of the rock near the younger core of the batholith and becomes fainter and fainter westward, disappearing altogether in some of the bodies exposed in the canyon of the plateau and near the Cottonwood Buttes.
The color is gray to dark gray, depending on the amount of dark minerals, hornblende and biotite. These usually compose from 18 per cent to 50 per cent of the rock. Both minerals are invariably present, but in vastly different proportions from place to place. The main mass of the facies near Headquarters and Pierce has biotite and hornblende in about equal amounts, but southward the hornblende greatly predominates, and the rock in the canyons near the mouth of the Lolo and near Pardee, has only accessory biotite. Quartz may usually be detected in all the rocks as glassy grains against the white or gray feldspar. It comprises from eight to 25 per cent of the rock, increasing somewhat with an increase in biotite. Epidote may usually be distinguished in all the rocks, generally as pale greenish grains.

The gneissic structure is well revealed under the microscope, not only the biotite and hornblende often showing a parallelism, but the plagioclase as well. Near the eastern margin cataclastic structures indicated by granulation and slicing are also prominent. Where metamorphism has been less severe, the normal hypautomorphic granular texture of quartz diorite is usual. In most of the rocks the only feldspar is andesine, either of medium composition or acid, usually, but not always, zoned with outer borders of basic oligoclase, well twinned polyphaseetically, and showing all stages of alteration from slight to heavy masses of epidote, kaolin, and white mica. In general rocks which show the greatest evidence of stress have the clearest feldspar grains. A few rocks contain a little accessory orthoclase or microperthite; in some, sufficient to nearly class the rock as granodiorite. Epidote is especially abundant in the rocks that have suffered most metamorphism and replaces especially the biotite and hornblende. Other secondary products are zoisite and chlorite, the latter abundant in some rocks, and formed after the hornblende and biotite. Other accessory minerals are apatite, zircon, and magnetite.

Quartz Diorite Pegmatite

There are two kinds of quartz diorite pegmatites, a biotite-bearing kind and a hornblende-bearing variety. Their distribution depends on the character of the quartz diorite to which they are related, the biotite variety occurring in the region of the biotite-bearing diorite and the hornblende variety with the hornblende diorite.

The biotite variety is most abundant near the northern margin of the main batholith, especially along the North Fork of the Clearwater and in the region about Pierce, but is not confined to those areas alone. It is more widely distributed than the hornblende variety. The dikes range from less than a foot to as much as 20 feet in thickness, usually lenticular in shape. The rock is characterized by its coarse grain, with quartz and feldspar often showing coarse graphic structures, and by its brilliant white color on fresh surfaces. Scattered irregularly through the coarse rock are black plates of biotite in some dikes as much as five inches in diameter. There is usually a little muscovite. Undoubtedly, some dikes will contain hornblende in addition to the biotite. Thin sections show that only one feldspar is present, oligoclase, most of it well twinned. It usually shows slight alteration to kaolin and white mica, and holds a little zoisite.

The hornblende variety is found mainly in the quartz diorite near the mouth of Lolo Creek. The dikes are usually narrow, seldom over two or three feet wide. One dike which was studied has greenish black hornblende crystals as much as five inches long and an inch wide, spaced at random, in a coarse white
felspar mass with some quartz. The plagioclase is more basic than in the biotite variety and has the composition of andesine. It is strongly twinned and shows only slight alteration to secondary muscovite and zoisite. On the other hand, the hornblende shows considerable alteration to both chlorite and epidote. Quartz is not as abundant in this variety as in the other.

Hornblendite

A dike of hornblende more than 60 feet wide, and trending N. 75° E. across the canyon of the Clearwater until lost beneath the basalt on either side, is exposed in the first railroad cut west of Ahsahka, about a mile below the station. This rock is exceptionally coarse grained and is composed almost wholly of greenish-black hornblende in crystals as much as five inches long and in places a little longer, and very little altered. In thin section the hornblende has the same characteristics as that composing the quartz diorite. The hornblende is accompanied by a little accessory biotite, pyrite, and magnetite. The magnetite crowds the interior of the hornblende crystals as tiny grains in cleavage cracks. Some larger grains are of later date and fill in between the hornblende crystals. The dike is not far from some asbestos-bearing peridotites and the contrast in alteration between this and the others of somewhat older age is indeed striking.

Inner Facies

Distribution and Character

Although the quartz diorite marginal facies of the batholith is of very large size, the more acid inner core is very much larger and comprises the bulk of the entire intrusion. The western boundary of the inner core has been vaguely defined in a preceding section where the limits of the dioritic facies were given. Typical rock of the younger core is found along the North Fork of the Clearwater near the Bungalow ranger station and over Pot Mountain, extending southward over Humlock Butte and Rocky Ridge to the Musselshell and thence southeastward along the west side of the Craggs to Elk City and beyond. The same rock prevails continuously eastward across the state. The boundary of the batholithic core is not everywhere easy to define, neither where it is in contact with the quartz diorite nor where in contact with the sediments. This is because the intense metamorphism induced by the batholith has changed the sediments to gneisses, mainly as the result of injection of igneous material along bedding or schistosity planes. The gneissic shell is many miles broad in places and it is exceedingly difficult to know whether the rock should be classed as sheared batholith or as gneissic sediments as in many places there is apparently a gradual transition of from one to the other. Near the most acid core, however, the gneiss is everywhere shattered and intruded by granite dikes, but even so the boundary of the batholith must be a matter of arbitrary decision. This is especially true of the rocks along the Middle Fork of the Clearwater east of Kooskia and of the rocks between Harperst and Elk City.

Several large stocks whose composition is that of the core occur well north of the main batholith, one of these north of Elk River and another a number of miles to the northeast. Another stock occurs near Bovill.

Porphyry dikes and stocks related to the core are relatively numerous about the north margin of the batholith along the North Fork of the Clearwater. These form a fringe about the batholith, but in places form an outer casing or shell.
Pegmatite dikes are not very common except in some portions of the gneissoid areas. The same is generally true of aplites. Basic dikes, malchite(?), and lamprophyre are relatively numerous about and in the batholith in some parts of the area.

The core and several outliers have mainly the composition of quartz monzonite and granite. In places the rock may become more basic and like the batholiths in the extreme north part of the state approach granodiorite. The porphyry dikes also have essentially the same composition as the batholith, being mainly granite, and less commonly quartz monzonite porphyry. Pegmatites too show a close resemblance to the more acid facies and have the composition of granite pegmatite. The basic differentiates are described in a separate section.

Quartz Monzonite and Granite

The main batholith is, in general, a light gray granular rock containing scattered foils of biotite and some muscovite with quartz and variable amounts of orthoclase, microperthite, microcline, and oligoclase, besides accessory apatite, zircon and magnetite. The grain is usually medium, but in some places coarse and even porphyritic. Quartz usually constitutes from 20 to 25 per cent of the minerals and is much more abundant than the scattered flakes of biotite. The quantity of oligoclase is variable. It is usually less abundant than the potassic feldspars and in many places the rock is a normal granite. In general a decrease in oligoclase is accompanied by an increase in muscovite which is of some value in classifying the rock in the field. The orthoclase is usually perthitic. It may or may not be accompanied by microcline. The feldspars show much greater alteration than do those in the border facies and have much secondary kaolin and sericite.

The stock north of Elk River shows some slight differences in that it is faintly porphyritic and has some hornblende crystals in addition to biotite. The feldspars are perthitic orthoclase and acid andesine, with the former in slight excess. Hence the rock is still classed as a quartz monzonite. The hornblende and biotite together comprise about 18 per cent of the rock and the quartz 20 per cent. Accessories and secondary products are the same as in the main batholith.

Granite and Quartz Monzonite Porphyry

The porphyries differ little in composition and show great similarity to the batholith. A rock specimen from the upper course of Kelly Creek, and typical of much of the batholith margin and its offshoots, has more than 50 per cent phenocrysts, consisting mainly of partially rounded orthoclase, and lesser quartz, hornblende, biotite, and oligoclase crystals embedded in a grayish microcrystalline groundmass very rich in quartz (one third) and with orthoclase and a little oligoclase. Magnetite and apatite are accessories. The feldspars show much alteration to kaolin. This rock is a granite porphyry. Another rock several miles distant and intrusive into the Blacklead limestone must be classed as a quartz monzonite porphyry. This has about 30 per cent phenocrysts, mainly pinkish feldspar (alklite-oligoclase), quartz, and hornblende, in a pinkish-gray groundmass. The groundmass is microcrystalline and is composed of about one third quartz and the remainder mainly orthoclase with a little plagioclase. As usual, the feldspars are heavily kaolinized and have some sericite.
Dikes are very numerous along Orogrande Creek between the Oxford and Bungalow ranger stations. A typical specimen is porphyritic (18 per cent phenocrysts) with rounded quartz grains and chalky feldspars (oligoclase and orthoclase) and in addition has a few crystals of hornblende. Unlike the other porphyries in which the phenocrysts are the size of the minerals in the normal granites or quartz monzonites, these grade downward into finely crystalline groundmasses. When viewed with the microscope the groundmass is mainly microcrystalline but in part granophyric. Quartz is exceptionally abundant (about half) and the remainder is mainly orthoclase with a little plagioclase. The rock is a granite porphyry, but closely approximates quartz monzonite.

Granite Pegmatite

The granite pegmatites differ from those related to the quartz diorite in that they contain much potassic feldspar (orthoclase, microperthite, and microcline) and only subordinate plagioclase (albite or oligoclase). Other minerals are quartz, muscovite, and rarely biotite. The rock is either grayish or pinkish in color and is ordinarily coarse-grained and usually graphic. The feldspars are two inches or more in length and in some dikes the muscovite is several inches. It is in dikes of this kind that muscovite crystals measuring as much as 18 inches in diameter have been found near Avon in Latah County, several miles outside the area studied.

Aplites

Aplitic dikes with the same minerals as the granite and quartz monzonites, but in different proportions, especially a higher percentage of quartz and potassic feldspar, and characterized by a fine grain have been described in parts of the region. They are especially noticeable in the area of asbestos bodies near Glenwood and in the roof and walls of the stock north of Bovill. As a rule, they are practically restricted to the immediate vicinity of the contacts of the batholith or its outlying stocks, but are not present about all parts of the batholith.

The aplites are generally white and fine-grained, consisting almost wholly of quartz, microperthite, or microcline, and a little acid plagioclase. The proportions of these minerals are highly variable. Some have widely scattered foils of biotite and muscovite. In general, the feldspars are much more kaolinized and sericitized than those in the related granite or quartz monzonites. The alteration is apparently associated with magmatic emanations from the cooling batholith. Some aplites merge with pegmatites.

Malchite? Dikes

Dikes and small stocks of a medium to dark gray rock of fine grain, (equigranular to sparsely porphyritic), cut the gneissic rocks and the batholiths, especially in the region about Pierce and to the east. In some ways these rocks resemble fine grained diores, but on examination of thin sections they show much greater resemblance to lamprophyres, yet are not typical lamprophyres. Malchite is defined as a microdiorite in which the phenocrysts are not conspicuous. The dikes in the Clearwater region seem to be intermediate between fine grained diores and lamprophyres and have some characteristics of each.

A rock which most nearly corresponds to typical malchite occurs in a dike several hundred yards long and twelve feet wide on the upper slope of Elk Butte about six miles north of Elk River. It is fine grained, although coarser
than most, even grained, and has about 35 per cent brownish-green hornblende and the remainder mainly highly zoned plagioclase with interiors of andesine and outer borders of orthoclase, besides a little interstitial orthoclase and about 5 per cent quartz. Accessories are magnetite and apatite, and secondary products chlorite, white mica, and kaolin. This is very similar to another rock cutting the granite on upper Kelly Creek. The latter, however, is finer grained and has about 40 per cent dark minerals, mainly brownish hornblende, but also a little augite, and the remainder is a mix of zoned oligoclase laths. Minerals are notably uniform in size. The feldspar is considerably altered, mainly to kaolin.

Porphyritic rocks of this kind are much more abundant around Pierce, both along upper Orofino Creek and Shanghi Creek. Some of them have heretofore been described as lamprophyre porphyry and diorite porphyry. A number of dikes were examined, some in the batholith and some about its margin. A number have rounded and embayed phenocrysts of quartz and oligoclase as much as one half inch long, clearly telluric in origin, formed deep within the granitic magma and removed from it during the maficite intrusion. These are embedded in a dark grayish microcrystalline groundmass in which many flakes of biotite can be recognized. In some rocks biotite plates and hornblende crystals are a little larger than those in the groundmass. The texture of the groundmass may usually be described as hypidiomorphic granular and in one rock is composed of about one third hornblende, a little biotite, plagioclase, orthoclase, and a little quartz. In other rocks biotite far exceeds the hornblende. Accessories are magnetite and apatite. The rock is strongly akin to lamprophyre.

**Lamprophyre**

The lamprophyre dikes are dark green to gray-black rocks of fine grain, which cut both the batholithic intrusive masses and the country rock. Many of them occupy fissures with veins and they are usually most numerous in mineralized areas. The most common variety of lamprophyre of the district belongs to the spessartite group, which typically is composed of brownish hornblende and acid plagioclase with some augite. Several dikes of kersantite were also found, these composed of biotite and plagioclase. The feldspar in both groups is usually oligoclase and, in some, andesine. The spessartites are porphyritic with small scattered augite phenocrysts (about 10 per cent of the rock) in a microcrystalline groundmass of slender hornblende crystals and poorly twinned oligoclase or andesine laths. Some have a little accessory orthoclase and quartz and usually much magnetite and a little apatite. The dike in the tunnel of the Wild Rose tunnel near Pierce is typical of the kersantites. This rock is non-porphyritic, fine grained, composed of twinned and untwinned oligoclase laths with possibly a little quartz and orthoclase and considerable biotite and the usual accessories magnetite and apatite. Secondary minerals due to alteration are invariably present in all the dikes and may be very prominent; they comprise calcite, chlorite and epidote.

**Contact Metamorphism**

One of the most striking features of the geology of this district is the vast amount of contact metamorphism in the country rock induced by the intrusion of the Idaho batholith. Mention before has been made of the change

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of the argillites, shales, and impure sandstones of the Belt sediments to
micaceous schists and gneisses in the vicinity of the batholith or outliers,
even many miles from any contact. The most metamorphism appears to be where
pegmatites and aplites are most abundant. Apparently much of the change has
been induced by transference of volatile constituents from the magma, ex-
pecially water vapor and even chlorine as the presence of soapolite in the
calcareous Wallace rocks testify. Thermal alteration has also undoubtedly
played a role for in some of the calcareous members of the Belt, diopside
and even microcline are extensively developed. Additional evidence of ther-
mal and hydrothermal alteration is also offered by the Permian greenstones
which contain unusually large amounts of epidote.

The pressure and thrust attendant upon the intrusion of the Idaho batho-
lith magma, with the resultant mashing, have produced gneiss from the older
intrusive rocks where they border the younger igneous mass. This is true not
alone of the pre-Cambrian rocks but the chilled marginal facies of the batho-
lith as well. This mechanical mashing of the older intrusives may or may not
be accompanied by hydrothermal alterations of the minerals. Some of the rock
shows the effects of mechanical crushing without noteworthy alteration. In
many places, however, the plagioclase feldspars are partly or completely al-
tered to epidotie aggregates or to sericite aggregates with a little associ-
ated chlorite and epidote, and the hornblende and biotite to aggregates of
epidote, chlorite, and magnetcite. In some of the older intrusives garnet is
also developed.

Other features of metamorphism, particularly that relating to the
gneissic shell overlying the batholith and obviously the result of the in-
jection of igneous material, will be described in the section on structure.

TERTIARY ROCKS

General Features

The Tertiary rocks comprise both igneous extrusives and sedimentary
strata; the former, of two distinct ages. The older is a thick series of
andesite and latitic lava which heretofore had not been recognized in this
part of Idaho, although rocks of apparently similar character are widely
distributed over the south-central part of the state. In other localities
these rocks have been assigned to the Miocene with the lower part of the
series probably in the Oligocene, but their age in this region cannot be
accurately fixed. The name, Kamiah volcanics, has been given them. They
rest on the eroded surface of the quartz diorite facies and were much eroded
before the Columbia basalt upper Miocene age welled up about them.

The Columbia basalt is the most widespread of the Tertiary rocks and the
best known. Its outpour built up the great plateau that lies to the west
of the Clearwater Mountains. Occurring between some of the lava flows are
thin to thick beds of fossiliferous sedimentary strata to which the name,
Latah formation, has been given. These are water-laid beds of clays and
sands swept down from the surrounding mountains and buried beneath and
between the flows. The great lava flows also dammed the old drainage ways
and caused the accumulation of gravels in the lower reaches of the Clearwater
streams, many of which were subsequently worked for their gold content.
These are described as post-Miocene gravels, but are not to be confused with
the younger glacial and recent deposits which are found in the bottoms of
the valleys and canyons.
Kamiah Volcanics

Distribution and Character

The Kamiah volcanic formation is represented in outline and area by the Kamiah Buttes, a steppe rising above the Columbia Plateau south of Lawyers Creek and about 12 miles south of the town of Kamiah. The Kamiah Buttes cover about 22 square miles and in their highest point rise about 1,000 feet above the plateau surface. The buttes have been much dissected and in reality are two groups connected by a low wide ridge. Much of their dissection was completed before the basalt of the Columbia Plateau surrounded them. The volcanics have been little disturbed by folding or faulting and are essentially horizontal, resembling flat-lying sedimentary strata when viewed from a distance. The flows have been brought strongly into relief as a result of differential weathering and in the North Butte a half a dozen flows may be very easily distinguished. The stratification is not nearly so pronounced on the South Butte.

Most of the flows of the Kamiah Buttes have the composition of andesite with at least one of quartz latite. Most of the andesites are grayish in color and vesicular, but some are reddish. The typical grayish andesite is slightly porphyritic with phenocrysts of zoned andesine and occasionally augite (up to 18 per cent) in a finely microcrystalline groundmass of small acid andesine laths and interstitial augite grains, and occasionally with a little glass. Some rocks show a fluidal structure, others do not. Magnetite is usually an abundant accessory. One section has titanite. One of the reddish aphanitic rocks has somewhat of a speckled appearance because of small black bands or lenses alternating with reddish. A flow structure is suggested in the hand specimen and is strongly pronounced in thin section. The texture is typically "andesitic" with tiny acid andesine laths arranged with long dimensions along fluidal lines. A few small augite phenocrysts are scattered through the rock. About half the groundmass consists of pyroxene with a little glass, the reddish bands composed of reddish pyroxene (largely hematite) and the black with grayish pyroxene mixed with much magnetite.

The quartz latite from a flow in the South Kamiah Butte is light grayish, with a faint flow structure shown by some widely spaced glassy bands. The rock is slightly porphyritic with scattered phenocrysts of acid andesine and occasionally quartz and biotite in a partially crystallizing groundmass of orthoclase, oligoclase, quartz, and much glass. This flow is extensive along the southeast margin of the butte.

Columbia Basalt

Distribution and Character

The Columbia basalt forms an irregular boundary against the Clearwater Mountains with here and there islands of the older rock projecting above its surface or exposed in the bottoms of the canyons. As many as seventeen flows may be counted in the canyons in some parts of the area and they have attained a thickness of 2,000 feet and in a few places 4,000 feet. The thickness is,
however, very variable, as the relief of the old buried topography is itself very irregular and parts are covered with a single flow.

Each flow is from 25 to 150 feet thick, the upper and sometimes also the lower part of each being more vesicular than the central part. The flows show much columnar jointing, ranging from slender (four or five inches in diameter) to powerful columns with the contraction joints three to four feet apart. Some of the flows show pillow structures where the molten lava entered water. The fresh basalt is nearly black, aphanitic, sometimes vesicular, more often massive. The several flows show little differences in their composition. One flow, which occurs about 1,500 feet below the plateau surface in the lower parts of the canyons of Ford Creek, Crofino Creek, and the lower Clearwater, is strikingly porphyritic with labradorite phenocrysts as much as an inch long in a finely crystalline groundmass of acid labradorite laths, augite, and with some interstitial dark-brown glass. The texture of the groundmass is diabasic granular or ophitic. Some of the sections contain olivine, but most seem to be without. Ilmenite is the chief accessory. The surface flow east of the Clearwater River is uniformly grained, but in places is slightly porphyritic with slender laths of labradorite and small crystals of augite in a groundmass of augite and labradorite of nearly the same size as the phenocrysts and with considerable brownish glass. Both magnetite and ilmenite are accessories. In other places, olivine was noted as grains in the groundmass.

**Latah Formation**

As the Latah formation has been defined as sedimentary beds lying between flows of Columbia basalt its only exposures are in the canyon or valley sides where the streams have cut deeply into the plateau. The sedimentary beds as a whole appear very extensive and are known to be exposed along the margin of the lava area over an irregular eastern front of 250 miles. In the Crofino region, the sedimentary beds occur at two horizons, an upper series of beds about 150 feet thick separated from the top layer by at least 500 feet of lava. In most places the formation is obscured by landslides and much of the rock was observed in slide material. The formation may be traced for at least 15 miles up Crofino Creek, occurs many places along the North Fork, also, on Grangerville Mountain, is widespread around Elk River, and from well records is believed to underlie the entire basalt plateau in the mapped area, probably not everywhere with the same thickness nor with the same number of beds. Apparently the formation represents the accumulation of fine sediments in extensive ephemeral lakes caused by obstruction to drainage by the advancing basal flows, finally overwhelmed by the lava.

These waterlaid beds consist mainly of clays and sands swept down from the neighboring mountains, but includes some volcanic ash and limonitic or carbonaceous layers. The sandstone beds are usually brownish, but the shales or clays are white. Many layers are highly fossiliferous with a great number and variety of plant remains. Some of the carbonaceous layers have been described as coal seams of limonitic and subbituminous rank, but of doubtful economic value.

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POST-MIOCENE GRAVELS

Distribution and Character

The flows of Miocene basalt have also dammed the old drainage ways to present elevation of about 3,000 or 3,200 feet, and the result has been heavy accumulations of gravels where the streams debouched from the mountains upon the plateau. Remaining benches of such gravels, subsequently trenches by the present streams, are well developed at Pierce where the highest deposits reach elevation of 3,900 to 3,500 feet. Remains of gravels are also found on the ridge between Lolo and Musselshell creeks at an elevation of 3,700 feet, and gravels at similar elevations may be found along Shanghai Creek and the Orogrande.

QUATERNARY ROCKS

The present streams are actively deepening their valleys and for that reason recent deposits are the tools with which the streams are working. The distinctly Quaternary deposits of this region are principally those connected with glaciation, but as glaciation has rarely extended below an elevation of 5,000 feet and then only on the north sides of the ridges, their distribution is meager. Moraines may be recognized in some of the higher valleys as those which descend from The Hub, Pct Mountain, Rhodes Peak, Rocky Ridge, The Crags, and others. Deep gravels, representing the valley train, have accumulated on the floors of some of these valleys, decreasing their depth by several hundred feet in places. The streams are now gradually excavating and terracing these deposits, but some valleys still have flat aggraded floors for many miles in their upper courses.

STRUCTURE

BEDDED ROCKS

Most of the bedded rocks have an approximate west-northwest strike, except the Triassic, which trend northeasterly, and the Latah, which conform to the folds of the Columbia basalt and trend either north and south or at right angles. The dip of the older rocks is generally steep, while that of the Latah is seldom more than two or three degrees.

In the northern part of the district the Belt series forms in part the southwestward limb of a great syncline with axis along the St. Joe River. Faulting has greatly complicated the structure in places and locally the beds may trend nearly north. Invariably the dip is northeastward at a moderate angle, but in places the dip is also to the south, suggesting a variable amount of folding. South of Mallards Peak the strike of the Prichard is W. 30° N., but at the peak is W. 15° W. and the dip 55° N.E. East of Polo Mountain the Wallace beds strike N. 85° W. and dip 35° N.E., but some folding has occurred, for near Chambersia Meadows the beds dip south and likewise change in strike to N. 45° E. Faulting is much in evidence. East of Bovill the Belt strikes N. 30° E. and dips 55° N.W., but at the Ruby Creek mine the strike is N. 80° E.

Along the lower North Fork the prevailing trend of the schists and gneisses is N. 70° W. and dip 70° to 80° E. The same general trend is maintained along Orofino Creek, but here and there faulting has destroyed the continuity and the beds locally trend N. 30° E. to N. 10° W. and dip 55° to 65° E.
Similar trend lines are recorded along the Middle Fork and the Lochsa and in the gneiss and schist areas between. The general strike is about N. 70° W., or N. 70° E., usually the former, and the dip steeply south, locally to the north.

The Triassic rocks and the underlying Permian in general trend from N. 40° E. to N. 55° E. and dip 50° to 65° S.E., except in the Cottonwood Buttes area where the strike is more nearly north.

The Columbia basalt and the intercalated Latah formation as discussed elsewhere, tilt slightly westward from the mountains to the river between Kooski to Ashaka, and then change dip to the eastward in being carried to the top of Craig Mountain. The beds dip steeply north from the top of Craig Mountain to the Lowistow valley and at a more moderate angle southward from the Cottonwood Buttes to Camas Prairie. Relatively steep north dips also occur on the flanks of Grangesville Mountain. In other places the dips are nearly imperceptible, but in no place are the beds perfectly horizontal.

**BATHOLITH**

The marginal structure of the Idaho batholith is especially worthy of mention. In some places, particularly about the northern margin, it exhibits clean-cut separation from the invaded rocks with massive granite to the very contact and with only minor effects of contact metamorphism shown in the invaded rocks. In other places, and especially well marked along the western border of the batholith, the rock shows a gradual transition to the gneissic rocks through a belt many miles wide.

An excellent example of the gneissoid sherd of the batholith is to be found along the lower Lochsa and Salway rivers and for several miles below their junction. The rocks for many miles are foliated, and mainly of igneous origin, but with recognisable beds, here and there, of metamorphosed sediments. When the banded gneisses are examined microscopically they appear to belong to mechanically crushed and usually recrystallized quartz diorite with much biotite and usually some hornblende, oligoclase, quartz, and accessory orthoclase, with epidote and zodite as main secondary minerals, and also to sharded and crumpled granite composed of much microcline, orthoclase, quartz, and biotite, with much less plagioclase. Here and there wide bands of augen gneiss may be found. The gneissic gneisses conform in strike and dip with gneisses of sedimentary origin and many hold inclusions of sedimentary gneiss. Nearer to the massive batholith the gneisses hold seams, sills, and often dikes of pegmatite and granite, clearly offshoots from the batholith. Some of these have gneissic structures, but some are without and mainly intruded after the gneissic structure had developed. In places the marginal massive rock of the main batholith itself shows a pronounced gneissie structure. Apparently the gneissic zone developed at the time of intrusion of the main batholith and is largely the result of pressure and thrust attendant upon the intrusion as well as by the action of thin sills of igneous material (injection gneiss) from the batholith that were forced under great pressure between the bedding planes of the invaded rocks. The whole developed a foliated structure as the sedimentary material recrystallized under the influence of mineralizers from the igneous magmas. Distinctly sedimentary gneisses are rare near the batholith, but become increasingly more and more abundant outward from the contact. The relations strongly suggest that the batholith largely made its way by replacing the country rock in coll-like fashion. Similar gneisses occur along the lower North Fork and along Orofino Creek, and are reported widespread near Elk City.
The same structure but on a much smaller scale is shown along Kelly Creek about a mile above the mouth of Cayuse Creek. It shows the relations much better than elsewhere because the whole transition of granite to Wallace occurs in a distance not much over a mile. Approaching from the batholith side, the uniformly grained massive granite assumes a faint gneissic texture which becomes increasingly more pronounced and suddenly gives way to banded gneisses and schists, such as augen gneiss, injection gneiss, banded feldspathic gneiss of clearly igneous origin, all with accordant seams or sill of pegmatite and granite passing shortly into the distinctly recognizable sedimentary beds of the Wallace.

METALLIFEROUS DEPOSITS

GENERAL STATEMENT

The mineral deposits in the region about Orofino may be most adequately treated by dividing them into two main groups, the metalliferous and the nonmetalliferous. This grouping is also somewhat genetic, for the metalliferous deposits are directly related to the intrusion of the Idaho batholith, coming into being during the later stages of this magmatic activity, whereas the nonmetallic deposits are indirectly related or not at all.

HISTORY OF MINING DEVELOPMENT

The region had a remarkable early-day history, beginning with the time when Captain E. D. Pierce and his party in 1860 discovered gold on Canal Gulch near what is now known as Pierce City. This discovery, the first recorded in Idaho, eventually led to a stampede to the new gold field, and later over the entire region between the North Fork of the Clearwater and the Salmon River, with discoveries at Elk City, Florence, Dixie, Newsome, and other places. For the first few years after discovery of the Pierce district, production was large, but soon the population was attracted to richer camps elsewhere and production declined greatly. Unlike other camps, however, work never entirely ceased, for dredging in a small way had begun before sluicing and hydraulicking had ceased, and has continued to the present time but without the profits of early-day mining.

The development of lode or vein mining came later, probably in the late eighties or nineties. Numerous veins were found and located near Pierce, but none of them reached the standing of large mines. As so often happens in districts of this kind, the veins are worked intermittently and on a small scale. Perhaps the largest production from them was before 1910 and since then most of the properties have been idle. Veins were also located and prospected in the river canyon above Harpster in 1899 and worked for a number of years. These, too, have been inactive for more than a decade. Other veins were also discovered carrying other minerals but in general these have been worked sporadically and have not produced metal.

PRODUCTION

The total production of the region is unascertainable. Various estimates have placed the production of the Pierce district from the placer deposits at from $5,000,000 to $10,000,000 with the latter figure probably more nearly correct. Most of this was produced during the early boom period, and the production since then rarely exceeded $20,000 or $30,000 per annum. During the past two decades the production has seldom gone above a few
thousand dollars and in some years only a few hundred. The lode gold production is probably not in excess of $250,000, most of this before 1905.

GENERAL CHARACTER OF DEPOSITS

The valuable metalliferous deposits have consisted of fissure veins containing gold, together with associated placers, derived from vein disintegration. Other veins contain copper, and in one locality, lead and zinc. Most of the veins are in the Belt series or the gneissic or schistose shell surrounding the batholith, although a few copper veins are within the margin of the batholith or outliers. Iron ore as magnetite occurs as a contact metamorphic mineral in seams or bands in an engulfed block of limestone within the batholith. According to origin, therefore, the deposits may be classed as fissure veins (some modified by replacement) and as contact metamorphic. According to substance, they may be classed as copper, gold, lead-zinc, and iron, and will be described in the order listed.

COPPER VEINS

GENERAL FEATURES

The copper veins are not abundant and have been prospected in only three widely separated localities: One in the extreme northeast part of the district in the area of Wallace rocks at the very head of the North Fork; another in the Oxford district east of Placido, apparently in the batholith but very near the gneissoidal shell; and the last in the quartz diorite along the canyon of the Middle Fork of the Clearwater between the mouth of Lolo Creek and the station of Pardee. A few prospects are reported in other places.

In general, the copper as chalcopyrite occurs in moderate to steeply dipping veins (fissure fillings and replacements) trending either in a northerly direction or to the east. Veins are usually persistent and may be traced for several hundreds of foot. Their mineralogy is simple and the primary ores consist of pyrite and chalcopyrite in either a quartz or ankerite (ferriferous dolomite) gangu. Quartz constitutes the chief gangu in the deposits near Pardee, but at the head of the North Fork the mineralization is like that in the St. Joe region, the chalcopyrite accompanied mainly by carbonate (ankerite). In most of the veins, secondary processes have been unimportant and the surface ores have only a minor amount of chalcocite or bornite, and a little carbonate (malachite). Several of the veins have been extensively explored, but with few exceptions the disclosures have been disappointing.

Additional characteristics of these veins will be supplied in the individual treatment of the deposits. For convenience they may be listed in three districts: Chamberlain Meadows district, Oxford district, and the Pardee district.

CHAMBERLAIN MEADOWS DISTRICT

Location and Geologic Features

The Chamberlain Meadows district has apparently a single copper deposit of any extent. This district lies at the very head of the North Fork near the Montana line, mainly within Shoshone County. It should be considered as a part of the St. Joe district, for it is continuous with it, has the same
formations, the same kind of mineralization, and only lies on the Clearwater side of the divide.

The country rock is the Wallace formation, very little metamorphosed, outcropping many miles from any outlier of the Idaho batholith. Consequently, the formation consists of greenish, flaggy beds, much ripple marked, and divided by mud cracks. Little lime was observed and the rock probably is representative of the upper division of the Wallace. The formation has a general strike of N. 45\(^\circ\) E. in the vicinity of the copper vein and dips about 25\(^\circ\) N.W. Evidence of faulting exists, but no attempt was made to work out the structural features. The characteristics of the deposit will be incorporated with the description of the single property examined, the Clearwater Gold and Copper.

Clearwater Gold and Copper Property

The Clearwater Gold and Copper property lies along Niagara Gulch with an elevation of 5,200 feet at the creek and 6,000 feet on the St. Joe divide in the extreme southeast part of Shoshone County. The nearest town is Superior, Montana, 27 miles distant over mountain trails. The vein has been extensively prospected by tunnels and cuts, the lowest and newest workings comprising nearly 1,200 feet of tunnels on one level, exclusive of raises and stopes. Another tunnel higher on the hill must have at least 500 feet of workings. The property is equipped with power plant.

The vein is mainly a replacement of the Wallace formation along a fissure or extensively brecciated zone. The average width of the vein is between four and five feet, locally swelling to 12 feet. The footwall is fairly distinct, but the hanging is very irregular and in most places indefinite. It holds many stringers of vein matter extending many feet into the country rock. In places, horses or inclusions of country rock are numerous, but usually these are only remnants of former greater blocks of shattered rock that have not been entirely replaced by vein matter. Wall rock alteration is not particularly pronounced, but a little chlorite and sericite and consider- able carbonate is developed, especially in included fragments. In general the vein trends N. 10\(^\circ\) W., locally swinging to N. 20\(^\circ\) W., and dips 70\(^\circ\) E. It probably extends for several thousand feet, if the number of claims along its strike is reliable evidence, but underground it has been actually explored for about 640 feet in the lowest workings.

The vein filling is mainly ferriforous dolomite (ankerite) cut by quartz seams, and with scattered granules or crystals of chalcopyrite, usually less than one fourth inch across, but also with more massive veinlets or seams of sulphide an inch or more thick. Pyrite usually accompanies the chalcopyrite but is much less abundant. Most of the vein contains a generous distribution of the sulphides, especially the small disseminated granules. Some specimens, which were assayed, gave only a trace of gold in the ore, but gold probably exists, for the stream both above and below the vein has been treated hydraulically. The sequence of deposition of the primary minerals has been ankerite first, subsequently slightly broken, and then quartz and the sulphides introduced. Apparently the quartz mainly fills fractures in the earlier carbonate, but the sulphides, which accompanied it, replace the ankerite or ferriforous dolomite. The upper part of the vein has been considerably oxidized and contains much malachite and, a little lower, some bornite and chalcocite. Secondary enrichment, however, has probably not added much to the value of the deposit.
For the first 500 foot in the lower tunnel the vein is from four to five feet wide, locally, in particularly brecciated zones, twice as much, with sulphides scattered throughout although not uniformly. The tunnel then swings off the vein, but again intersects it about 120 foot farther on where it is much wider, twelve feet or more, and with rich masses of chalcopyrite. In another 140 feet, however, the vein ends in a very soft thin banded shale that was not adapted for replacement and additional prospecting has disclosed only fresh country rock. Raises have been made on the vein in several places, but the condition of the ladders discouraged examination. The upper tunnel is about 75 feet higher. It shows the same character of ore but with a greater quantity of secondary minerals. The tunnel is caved at the portal which prevents examination.

**OXFORD DISTRICT**

**Location and Geologic Features**

The Oxford district, too, has but a few deposits. This district lies about 14 miles northeast of Pierce on the southern slope of Elk Mountain. The mountains in this district are low and not especially rugged, lying at elevations between 4,000 and 6,000 feet. A heavy forest growth is a great handicap to prospecting.

The country rock is mainly quartz diorite, although the great body of quartz monzonite and granite lies not far to the east. A patch of metamorphosed Belt sediments cut by numerous porphyry dikes and stocks lies between the district and the river and may best be examined along Orogrande Creek. So far as known, veins have not been reported in this patch of sediments.

**Oxford Property**

The Oxford vein could not be satisfactorily examined. It had been opened by a shaft, but this was inaccessible as it had caved. Several short tunnels and cuts also gave inadequate exposures.

The vein is apparently in the batholith, not far below the roof, and has a dark green, highly altered lamprophyre dike as the hanging wall and a quartz diorite foot wall. At the top of the shaft the vein appears to be about three feet wide, to strike east and to dip steeply south. Its length could not be determined. The principal mineralization has been in quartz and chalcopyrite, but the quantity present could not be estimated. It is probably not great. Oxidation has apparently extended to considerable depth and only malachite is shown on the dump.

**LOLO DISTRICT**

**Location and Geologic Features**

The Lolo district is herein defined as the region along lower Lolo Creek and the Clearwater canyon between Greer and Kamiah and including the hills on either side of the canyon.

The geology is simple, consisting of quartz diorite and the gneissoidal rocks which enclose the batholith. These rocks are exposed in the lower canyon walls beneath a basalt capping and in the hills that rise above the plateau on both sides of the Clearwater canyon near the mouth of the Lolo.
Veins carrying variable and usually small amounts of chalcopyrite, are
numerous in the quartz diorite, occurring as fillings of fissures. The veins
are usually narrow, a foot or less, although some enlarge to five or six feet.
Some may be traced for several hundred feet, but others are much less. In
general, they pinch and swell on the dip and strike and are characteristically
uneven and only sporadically mineralized in rather small uncertain shoots.
Most veins trend from N. 40° W. to N. 55° W., and dip from 30° to 65° to the
northeast.

Properties

One vein on the Dundas property at the mouth of Lolo Creek has been
prospected by a short tunnel and open cuts. It is typical of the veins in
the district. It is composed of quartz with here and there a few scattered
granules of chalcopyrite, showing little or no oxidation at the surface.
The vein strikes N. 40° W., and dips 30° E., but slope drag has caused nearly
a flat dip at the surface. The vein is from eight to twenty inches wide,
and has been explored for about 100 feet by surficial workings.

Other veins, no longer worked, lie one and one-half and three miles above
the Dundas property along the Lolo. The upper vein is opened by a 75 foot
incline, but most work has been on a 400 foot crosscut, said to lack 300 feet
from tapping the vein. The vein is reported to be three or four feet wide,
and the surface shows a little honeycombed quartz. Small amounts of chal-
copyrite appear along the incline.

More extensive work has been done near Perdue where the veins seem
particularly numerous. Most of them belong to the Trimetallic Mining Company.
The property has nearly 1,000 feet of tunnels, but no recent work has been
done because of litigation. Several veins were examined, all in the quartz
diorite. One near the camp is about eight inches wide and shows a little
chalcopyrite and bornite. The main workings are on a vein a short distance
below where a tunnel on the north side of a gulch exposes 130 feet of the
vein and another on the south side 425 feet more. This vein strikes N. 55° W.,
and dips 65° N.E. In the shorter tunnel it bulges from one foot to five feet
in thickness, and in the larger tunnel to even more. This vein is along a
very pronounced fissure, but the filling is mainly quartz with a little
chalcopyrite scattered here and there. Other veins were not examined.

Veins are reported to be numerous in the granitic rock near Woodland in
the hill on the east side of the canyon. Other veins have been reported
farther up the river canyon above Kamiah. One of these received much publicity
during the autumn of 1929 and was declared to show promise.

GOLD DEPOSITS

CLASSIFICATION

The gold deposits are of two kinds, vein and placer, of which the latter
has been by far the most important. The veins have not been extensively de-
veloped, mainly because of the uncertain pockety occurrence of the gold.

VEINS

General Features

The gold veins are not abundant except in a few scattered localities, the
most important being at Pierce, another in the Burnt Creek district, and a
third near Harpster. The veins are mainly in the gneisses surrounding the batholith or in the outer part of the batholith itself, except in the Harpster district where the enclosing rock is the altered Permian greenstones. Most of the veins are of considerable length, from 500 to 2,500 feet, and range from 2 to 10 feet wide. The veins characteristically pinch and swell, and are more nearly in the form of a continuous series of lenses or bulges. The mineralization in the greenstone series differs from the fissure vein elsewhere in that the deposition of values has been mainly by replacements and the veins constitute wide silicified and sericitized zones in the altered rock, determined by fissuring or extensive shattering.

The filling in the fissure veins is quartz, accompanied by minor sulphides, pyrite, and, in some veins, by arsenopyrite and free gold. Some of the free gold is probably the product of oxidized auriferous pyrite, but some is apparently primary. In the silicified volcanics the minerals are pyrite, chalcopyrite, gold, and occasional bunches of vein quartz containing the same minerals. Much oxidation shows in the upper portion of many of the veins with free gold, iron and manganese oxides, and, in the Harpster district, a little copper carbonate. In general, the oxidation has extended but a short distance below the surface. Much of the early vein production has been from this upper zone.

Pierce District

General Features

The Pierce district has been described in another report¹ and only the essential features will be summarized here. The veins are fissure fillings of usual erratic distribution, some in the gneisses and some within the quartz diorite batholith itself, but very near the gneissoidal shell. They are grouped within a relatively small area from one to three miles east of Pierce on Rhodes Creek and its tributaries, in reality in a small roof pendant of Prichard rocks entirely surrounded by the batholith. This pendant culminates in French Mountain. Pegmatite, aplite, and lamprophyre dikes are particularly abundant in this area and some are found in fissures with veins, but the association is structural and not genetic. The veins range from 2 to 10 feet in thickness, pinch and swell, contain scattered irregular shoots with auriferous pyrite and gold, in some veins with additional arsenopyrite. At least one of the pegmatites is reported to carry gold, assaying consistently from $2 to $4 a ton. The total production of the district was announced in an earlier part of this report.

For a description of the properties, the reader is referred to the Thomson-Ballard report, for the writer's studies add little to what has been published as the time spent in the reconnaissance was much too short to permit detailed studies. Some of the properties from past production evidently merit careful and systematic development and with modern practices of ore dressing the auriferous sulphides might be treated with profit.

Burnt Creek District

General Features

The Burnt Creek district lies from 10 to 15 miles south of the town of Elk River along Burnt Creek, a tributary of Elk Creek. Here occur both placers

and veins, but, so far as known, only one vein has been extensively developed, the Jericho. The geology is much the same as in other places, a ridge of gneissic Belt rocks with numerous dikes of pegmatite, lamprophyre, and granitic apophyses, projecting from the mountains into the basalt plateau. The veins are irregular, characterized by pinching and swelling, and certain sporadically mineralized shoots. They are fissure fillings of quartz with later sulphides, pyrite and arsenopyrite, and gold.

Jericho Property

The Jericho veins outcrop on the upper southwest slope of Jericho Mountain at an elevation of about 3,800 feet. These were discovered shortly before 1900 and later extensively prospected. A stamp mill was installed and operated during 1903, but the production was not ascertained. The older workings comprise about 2,000 feet of drifts and crosscuts, and the newer, at greater depth, of about 400 feet of tunnels, all on a single vein.

The vein in the upper workings trends nearly due north and dips 22° W. With depth its dip changes to 35° W. It is intersected by a vein striking nearly at right angles, and near their intersection values are reported to be especially good. The northerly trending vein is reported to bulge to 10 and 15 feet, although the average width is much less. The ore occurs in pocketed shoots, some reported to be rich and containing free gold. Pyrite and arsenopyrite are regularly scattered throughout the vein. The gold tenor is reported to increase with the sulphide content. The wall rock is micaceous schist and gneiss, and apophyses of granite or quartz diorite.

The vein is cut by a lamprophyre dike, well exposed in the lower tunnel. The lamprophyre occupies a very pronounced fissure with matted gneiss and schist on both sides. Apparently it is the variety spessartite, but biotite is abundant in some parts.

Harpster District

General Features

Many small quartz veins have been located and partly developed along the South Fork of the Clearwater near Harpster, but none of them have proved rich. Some are in the quartz diores, but most are in the altered Permian volcanics. About five miles above Harpster the form of the mineral bodies changes from veins to wide silicified zones in the brecciated and fissured greenstones. The trend of these mineral bodies is generally northeasterly and the dip is to the southeast at a steep angle. The minerals in the silicified zones, and in the small irregular bunches of vein quartz, consist mainly of pyrite and a small amount of chalcopyrite, besides reported free gold. Only two properties have been extensively developed.

Dewey Mine

The Dewey veins lie along the South Fork about five miles above Harpster. These were prospected in 1899 and considerable ore was shipped during the next few years from several operating companies. The properties have subsequently been united as the Dewey Consolidated Mining and Smelting Company and the development work aggregates about 7,000 feet of underground workings. The property has been idle for a number of years past, but during the summer of 1929 was reopened and an intensive sampling program undertaken. The result
of this work was not ascertained. In general the values in gold are low, about $2 to the ton, but there are some rich high grade seams. Mineralization has been extensive and the deposits, although of low grade, are large.

The property has three or four parallel veins or mineralized zones, trending about N. 10° E. and dipping 75° S.E., the principal being the Evergreen, the Dewey, and the St. Patrick. The individual lodes might be considered as from 20 to 40 feet wide, but much of the rock between shows extensive hydrothermal alteration which may be noticed even as much as 300 feet from the lower wall. These lodes have well defined footwalls, determined by fissingure and a pronounced band of gouge, but the hanging wall is indefinite as would be expected where replacement or silicification is the dominant mode of mineral deposition. The volcanic rocks include both andesitic flows and intrusive dikes, whose relations are very complex. Their general trend is N. 40° E. with dip steeply southeast. Much shattering or brecciation has occurred along some zones, especially in the hanging walls of the fissures. The mineralizing solutions have been mainly directed along these broken or shattered zones. The volcanics show extensive silicification and sericitization, in the lodes proper so intense that outlines of the original structures or minerals scarcely remain. In some the secondary quartz has produced large rounded grains, much like phenocrysts in a grayish-white groundmass, and in appearance suggests an intrusive porphyry. Where the alteration has been less extensive, as in the footwalls of the fissures, the rocks are greenish, sheared, and when examined microscopically are composed largely of secondary chlorite, epidote, quartz and sericite, through which some of the feldspars and the original andesitic groundmass may be recognised.

The ore consists of the silicified greenstone with disseminated pyrite, usually in very tiny crystals and with small amounts of chalcopyrite whose oxidation at the surface has given some malachite. In addition are streaks and veinlets of quartz also containing pyrite and some chalcopyrite. The deposition has probably been in two stages; first quartz, subsequently shattered by renewed movement along the fissure zones, and second, the pyrite chalcopyrite, and gold. The richer portions probably represent those parts of the silicified zones that were most shattered in the inter-mineral stages. The silicified zone invariably carries low gold values, with here and there irregular shoots or seams assaying high. The ore as disclosed in the underground workings, is mainly oxidized. The oxidation has been unusually deep, extending a hundred feet or more below the surface. Much of the oxidation, and probably enrichment, is not related to the present surface topography, but to the pre-basalt surface, for the canyons are in youth. The delineation of ore shoots can be determined only by careful sampling and assaying.

The Evergreen vein has been most extensively developed and is apparently the largest in size. Much gouge occurs along the footwall and the hydrothermal alteration extends into the hanging for several hundred feet. The Dewey vein lies lower on the hill and to the east. It apparently is smaller, but contains irregular chimney-like shoots along smaller shear zones. The vein is somewhat more than 20 feet wide throughout. Tunnels have encountered a number of streaks of shipping ore reported very rich in gold, and also greater bodies of lower grade material. The St. Patrick vein is similar, except that it contains less chalcopyrite than the Dewey.

Sylvanite Gold-Copper Property

The Sylvanite Gold-Copper property lies about a mile and one-half below the Dewey on the river and in the same series of Permian greenstones. The work consists of a tunnel about 570 feet long in altered greenish and grayish
andesite with occasional small crystals of pyrite and grains of chalcopyrite. Several small slips are crossed in the tunnel, these showing some silicification and evidence of hydrothermal alteration, but most of the tunnel is in rock that shows little action of thermal solutions such as deposit sulphides. Some distance from the portal the tunnel follows one of the small fissures whose trend is N. 10° E., and dip 30° S.E. It contains a few scattered thin lenses or seams of quartz, some with a little pyrite. The ore is reported to be copper and gold.

PLACERS

Distribution

A discussion of the placers can only be a post mortem. The general features of those few placers which still continue to be worked for gold will be briefly described. A discussion of other minerals of the placers such as monasite and zircon is reserved for another part of the pamphlet.

The placer grounds occur in three widely separated places, at Pierce, along Moose Creek, and in the Burnt Creek district. Some placers occur elsewhere, but so far as known they have not been worked for many years.

Pierce District

General Features

The gravel deposits of the Pierce district are essentially of two kinds, those in the bottoms of the present valleys and those in benches on the valley sides or ridges. The origin of the higher terrace gravels has been stated elsewhere as due to damming of the Miocene drainage by the flows of Columbia basalt. This resulted in the heavy accumulation of the gravels near the margin of the plateau. The streams have subsequently lowered their valleys, leaving remnants of the earlier deposits as terraces, and causing further concentration of the gold in the present channels.

The gravels worked near Pierce have been partly the low benches along the creek (Orofino Creek) or the gravels of the flat valley bottom, and partly the high terraces extending to a height of 500 feet above the stream. Altogether, Orofino Creek has been worked for 12 miles above and 10 miles below Pierce. The tributaries, likewise, have been worked. North of Pierce, Canal Gulch was the scene of large operations both along the valley bottom and on several higher terraces. Rhodes Gulch, coming down from the north and joining main Orofino Creek a few miles above Pierce, has well-washed gravels. Other tributaries are Poorman Creek and Cow Creek. It is reported that the gold is usually fine as to size, and low grade as to value, being, at most, worth $17 per ounce, some of it running as low as $15. The bed rock is mainly quartz diorite, but some of the gravels that have been worked are on basalt. The gravel contains a great abundance of quartz pebbles, evidently derived from the numerous quartz veins in the district, such as occur between Pierce and French Mountain.

Other important operations have been along the Musselshell and Lolo Creek east of Weippe. The Musselshell, a tributary of the Lolo, has been mined all the way to its source near Rocky Ridge. The Lolo has been washed for gold in places, but ordinarily contains too many boulders to be readily and profitably mined. Many other streams have been mined in the region, notably Quartz, Snake, and Reed Creeks northwest of Pierce.
The gravels along Orofino Creek and Rhodes Creek have been reworked a number of times, the last by dredge. The dredge is still in operation along Rhodes Creek. Many gravel deposits, in the early period considered of too low value for working, have been sampled and are reported to be waiting the coming of dredges.

Another possible source of gold might be in buried placers, if these could be found. Pre-basalt valleys must have contained auriferous gravels that are now buried beneath a variable thickness of basalt. To find them might be like hunting for a needle in a haystack.

Moose Creek District
General Features

The Moose Creek district is another of the old placer camps founded soon after the Pierce discovery. This district lies along the valley of Moose Creek, a tributary of Kelly Creek in the North Fork drainage in the heart of the Clearwater Mountains. A two day pack-train trip from the Bungalow ranger station is required to reach this camp. The streams were worked in the early days but without spectacular results, and then sporadically to the present day. Some prospectors have worked every year, panning and sluicing the streams and making "fair wages." Only one placer is operating on a large scale, in 1929 employing seven or eight men and sluicing along Independence Creek, four miles above the Kelly Creek ranger station. The valley is rather narrow and the amount of workable gravel is probably not great.

The gravels are composed mainly of quartzite and gneissic and schistose rock derived from the Belt sediments. Granite, pegmatite, and porphyry comprise a small part of the gravels. The country rock is mainly the Belt sediments, cut by scattered dikes of the igneous rock. Whether quartz veins occur in the district was not determined.

Burnt Creek District
General Features

The streams, which radiate from Jericho Mountain, also contain auriferous gravels, no doubt derived from veins similar to those at the Jericho property. The region was placered shortly after the Pierce discovery and work has continued to the present day along Snipe, Burnt, and Swamp Creeks. The total production is not known, but probably has not been large. Some work is done along the streams each year, but the greatest handicap is the lack of water throughout most of the year, and only during the spring floods can the deposits be worked.

LEAD-ZINC VEINS

RUBY CREEK DISTRICT
Location

The Ruby Creek district has the only lead-zinc veins in the entire region studied. These lie in a small area near the upper part of Ruby Creek, a tributary of the Potlatch River, mainly in Clearwater County but extending westward into Latah County. The Elk River Branch of the Chicago, Milwaukee, and St. Paul railway passes through the district, also the highway between
Bovill and Elk River.

Until recently the district was known as one with gold veins. Several were worked a number of years ago, and then forgotten. The lead-zinc veins were also known but were not developed until several years ago when work started at the Ruby Creek property. Since then prospecting has been resumed in the surrounding region, but so far the Ruby Creek has been the only one to show notable amounts of mineralization.

Geologic Features

The veins are mainly replacements along fissures. These form one set, trending slightly west of north and another at nearly right angles. The country rock, formerly flaggy shales, argillites, and sandstones such as might prevail in the Burke or higher members, is now represented by quartzites and micaschists in which muscovite is usually abundant. Their metamorphism is largely due to intrusive dikes and apophyses of granite or quartz monzonite, but these igneous bodies are not large nor especially numerous and are rarely seen at the surface. The sediments have an easterly trend, averaging about N. 80° E. near the Ruby Creek vein, and dip about 60° N. Faulting is probably an important structural feature.

In discussing the form, structure, and mineralogy of the ore bodies, the main Ruby Creek vein must be taken as the example and the following description applies largely to it.

The chief minerals of the veins are sphalerite, accompanied by subordinate galena, in a siderite gangue. Other minerals are present, notably a few scattered grains of chalcopyrite and possibly tetrahedrite, also a little ankerite or ferriferous dolomite. Strangely, quartz is nearly lacking, except in the silicified wall, and the same is true of pyrite. The sphalerite has an unusually dark color, most of it black or reddish black, some inclining to a metallic steel-gray. It is not easily distinguished from the galena except on close examination, but the latter has a coarse cubical cleavage. Usually the galena occurs in scattered granules or masses through the sphalerite, rarely in veinlets cutting the sphalerite. The siderite has a pale buff color which distinguishes it from the minor amount of grayish ankerite or ferriferous dolomite.

In general, the sulphides form compact bands, seams, or stringers along the fissures, with little tendency to occur as disseminations. The structure of the veins, however, is complex, for the deposition of the minerals has occurred in several stages, corresponding to recurrent movement along the fissure and reopening of the vein. Apparently the first solutions, which pervaded the fissure, deposited quartz and pyrite in the wall rock by replacement. During the same time, or perhaps a little later, ferriferous dolomite or ankerite was deposited also by replacement of the silicified wall. Then followed extensive movement along the fissure and new solutions deposited siderite in the open spaces as well as enlarged the openings by replacing the earlier minerals and the wall rock. As a result, only minor masses of the ankerite or ferriferous dolomite remain. In some parts of the vein the siderite failed to entirely fill the openings and occurs there as curved rhombohedral crystals, as a lining of vugs. Recurrent movement again shattered the vein filling and this time the sulphides were introduced, depositing in order sphalerite, galena, and chalcopyrite, and possibly tetrahedrite. In the open clefs, the sulphides and especially the sphalerite, tend to form a crystal coating on the siderite, but in most parts of the vein the sulphides
replace the shattered carbonate in bands along fractures, or as rounded or nodular masses giving the filling a breccia-like appearance. Later the sulphides were slightly broken and the fractures filled with thin seams of calcite.

Along some of the fissures the mineralizing solutions have affected the rock to a dozen feet or more from the fissures, bleaching the rock and converting it mainly to sericite and to chlorite, which on weathering yields a white or grayish clay-like substance. About others the alteration is scarcely noticeable, and, as along the Ruby Creek vein, is shown by only a narrow zone of silicification with pyrite, sericite, and chlorite.

The secondary minerals are of little consequence, for in those deposits that have been sufficiently developed, the sulphides occur near or at the surface. Some carasite and anglesite, the carbonate and sulphate of lead respectively, were noted; also a little pyromorphite, a lead phosphate, and a minor amount of smithsonite, zinc carbonate. Most of the cappings are black from manganese oxides derived from the manganiferous siderite. This staining is most useful in prospecting as it indicates a mineralized area.

Ruby Creek Mine

The Ruby Creek mine, operated by the Ruby Creek Mining Company, lies about a mile north of the Elk River highway and the railroad in Clearwater County. Considerable ore is stored on the dump, but so far as known none has been shipped. A small mill was being constructed while the writer was in the district. The vein has been explored by a tunnel 120 feet long and a shaft 170 feet deep. A long crosscut had been started from lower on the creek, but work stopped at 670 feet before cutting the vein.

The vein strikes N. 85° W. and dips 65° N.E. It follows a well defined fissure with very little gouge remaining, and has walls of quartzite, in part micaceous. The ore occurs in more or less compact seams or lenses, forming a body from 8 to 18 inches wide, characteristically swelling and pinching on both strike and dip. In some places the vein has horses of country rock dividing the mineralization, in other places stringers enter the wall. The mineralization occurs through the full length of the upper tunnel, the sulphides being coarse-grained and of the kind and proportion described in the previous section. The shaft in the vein is near the creek bottom and at the time of the writer's visit was filled with water. The ore body is said to widen with depth. The lower tunnel is mainly through micaceous quartzites, but crosses a fault of some magnitude and also a malchite (?) dike.

Several other veins occur on the property, but these have not been adequately exposed for study. Their cutcrops are manganese stained, more so than in the Ruby Creek vein. They apparently are of the same character as the latter.

A property whose ownership was not known lies several hundred yards south of the Ruby Creek vein. The property has about 670 feet of workings, apparently done many years ago. These are mainly in white quartzite separated by minor beds of mica schist. The tunnels cut several fissures trending about N. 85° E. and also one trending N. 35° W. Some of the former contain considerable quartz and a little pyrite, and one has a little sphalerite. A drift several hundred feet long has been driven on the ore that shows a little sphalerite. This fissure has a gouge zone three or four feet wide, scattered
quartz lenses, a little siderite, but is as a whole very lightly mineralized. Apparently the vein with most minerals is the one near the portal that parallels the strike and dip of the Ruby Creek vein. It has been prospected in short drifts and in several small cuts. It has the same kind of minerals as the Ruby Creek vein, but much less in quantity.

Victoria Lode

The Victoria Lode is a short distance below the Ruby Creek property, about a quarter of a mile from the railroad, also in Clearwater County. The vein is exposed in a bank and prospected by an inclined shaft, which, unfortunately, was filled with water. The country rock of quartzite, schist, and granite, is much shattered along the fissure whose trend is N. 80° W. and dip 65° N.E. The hanging wall is a granite apophysis. Hydrothermal alteration is extensive in the rocks, but the solutions apparently left little sulphides at this disclosure. The shattered rock contains a few small seams of sphalerite and galena whose relations are much the same as at the Ruby Creek vein.

Gold Hunter Lode

The Gold Hunter lode is in the north half of Sec. 15. T. 40 N., R. 1 E., on a tributary of Ruby Creek a mile or two west of the Ruby Creek property. It is very near the county line and is either in Clearwater County or Latah County. All that may be seen is a manganese stained outcrop, prospected in several small cuts, and a shaft 35 feet deep at the time of the writer's visit. The country rock seems to be a shattered porphyry that has been extensively altered by hydrothermal solutions. The fissure zone trends N. 20° W. and dips vertically. The manganese staining is 20 feet or more wide along the outcrop. No sulphides were seen, but some of the slippage zones as disclosed in the shaft have much graphite.

Other Properties

The Silver King and the Gold Eagle properties adjoin the Gold Hunter. These are reported to be old gold properties, unworked for many years, and no longer accessible. An old stamp mill remains on the Gold Eagle. Apparently the underground workings of each are extensive.

IRON ORE DEPOSITS

GENERAL STATEMENT

Vague reports of iron bodies in the region adjacent to Orofino had come to the writer before the field studies were begun, but exact locations could not be obtained. Special effort was made to find these deposits and in the course of the reconnaissance a body in which magnetite occurs in sufficient quantity to possibly constitute ore was located in the Blacklead district, far back in the mountains. On completion of the field work it was discovered that other deposits had been missed. One of these is believed to be in the vicinity of Headquarters, somewhere near Alder Creek. The deposit is said to show some promise and may have much larger masses of ore than in the Blacklead occurrence. The deposit is undeveloped, is probably concealed by timber and soil, and its presence is largely inferred from scattered boulders of magnetite and the deflection of the compass needle over an area of considerable size. Other deposits are only vaguely known as somewhere in the Orofino-Harpster region. These unstudied deposits are probably worthy of careful
and systematic prospecting. Should they prove of sufficient size and richness, those near a railroad or those not too isolated might make an important resource, if not at the present time, perhaps at some later date. All the iron deposits are probably alike and in their manner of occurrence and origin similar to the Blacklead; contact metamorphic deposits of magnetite in engulfed blocks of limestone in the batholith.

BLACKLEAD DISTRICT

General Features

The Blacklead district has been referred to elsewhere as the locality where the Blacklead limestone lies as an engulfed block near the northern border of the Idaho batholith, not far from the Montana line and miles from any railroad or highway. At present the district can be reached over pack trail, but eventually the Lewis and Clark Highway, when completed along the Lochea River, will pass within 10 miles of the deposit in air line, but between will exist the high divide between the river and the Cayuse Creek drainage. The deposit lies in a high glaciated valley between Blacklead Peak and Rhodes Creek and because of its elevation, above 6,000 feet, is deeply covered by snow until late in the spring.

The region has been prospected for many years, probably first soon after the Pierce placer discoveries, and annually thereafter. The probable impetus to prospecting is the presence of small amounts of chalcopyrite and its secondary oxidation product, malachite. It is reported that the district was at one time regarded with favor as a copper district, but the failure to find commercial ore has caused it to be abandoned.

The general geologic features of the district have been sufficiently discussed elsewhere. The block of Blacklead limestone is apparently about two miles long and about one half mile wide, with longest dimension trending in a northerly direction to Blacklead Peak. The thick-bedded limestone has been extensively shattered and invaded by apophyses of granite and quartz monzonite and by porphyry dikes of the same composition.

The ore is scattered throughout most of the limestone in irregular seams, lenses, masses, or pockets, rather widely spaced, and without definite system or arrangement. The seams range from less than an inch in thickness to several feet, at times five or six feet, in part following the bedding planes of the limestone and in part fractures which cut the bedding, produced probably by the general shattering of the rock by the intrusion. The limestone also shows a slight amount of silicification along the iron seams and has developed in it a minor amount of epidote, zoisite, and hornblende, besides several unidentified accessory minerals. The sequence of deposition or replacement has been quartz, hornblende, epidote, and magnetite. Perhaps this deposit is unique among contact metamorphic deposits in having such a simple mineralogy and such an abundance of magnetite as compared with other minerals, especially silicates.

The deposit is so isolated and has the magnetite in such small irregular seams or masses, and these so widely separated in the limestone, that there is little encouragement for the development of a commercial ore body. The deposit offers, however, an insight into the probable character of other iron deposits in the region and indicates their origin as related to solutions from the batholith precipitated by reaction with the limestone.
ORIGIN OF THE METALLIFEROUS DEPOSITS

The metalliferous veins and the contact iron deposits are believed to be genetically related to the intrusion of the Idaho batholith and to represent aqueous extractions given off by the magma after the rock had largely solidified. These solutions were forced into fractures in the overlying rock and deposited quartz and the various sulphides or gold either as a result of further cooling or more generally as a result of reaction with the wall rock as indicated by replacement. The gold placers are obviously the detrital accumulation of gold derived from the disintegration of the mineral-bearing veins and concentrated along former or present stream channels.

NONMETALLIFEROUS DEPOSITS

GENERAL STATEMENT

History of development of the nonmetalliferous deposits had best be given with the description of individual kinds of deposits. Several kinds have not as yet been utilized, but some have been productive for two decades or more. Their development is young compared with that of the metalliferous deposits, but at present the annual production from them exceeds that of the metalliferous and promises to show increasing value as time goes on.

CHARACTER OF THE DEPOSITS

The nonmetalliferous deposits have a greater number of products than do the metalliferous, and a greater diversity of origin. According to substance, these may be listed as asbestos, clay, feldspar, garnet, marble or crystalline limestone, mica, monazite, and road metal. Some of these are components of igneous rocks as for example the mica and feldspar, both minerals of pegmatites. To this group must also be added monazite which has accumulated in stream gravels along with other heavy minerals from the disintegration of quartz diorite and quartz monzonite. Several, such as the asbestos and clay, are products of altered igneous rocks, the former as an alteration of ultrabasic rocks, and the clay from the alteration of granite and quartz monzonite. With these should be included the sedimentary clays, ultimately derived from the weathering of the granitic rocks and transported from their source and deposited in ponds or lakes. As road metal the igneous rock, especially the basalt, is itself used. The marble or crystalline limestone is the only rock not in some way directly related to igneous rocks, these having their origin as sedimentary deposits, but they do owe their present crystalline character largely to the batholiths intrusion which subjected them to great pressures and high temperatures, causing an entire recrystallization of the rock.

ASBESTOS DEPOSITS

GENERAL CHARACTER

As commonly understood, the term asbestos embraces the fibrous varieties of several minerals, including anthophyllite, tremolite, actinolite, and crocidolite, which belong to the amphibole group, and chrysotile, a variety of serpentine. The usefulness of these minerals depends on their resistance to heat and the strength and flexibility of their fibers. All the varieties mentioned except crocidolite are about equally resistant to heat. The tremolite and anthophyllite asbestos are more resistant to acids than chrysotile and crocidolite, but in flexibility and strength of fiber, chrysotile
and crocidolite are far superior to the others.

The asbestos minerals in the region about Orofino belong to the amphibole group, including tremolite and anthophyllite, but the anthophyllite is so far exceeded the tremolite in quantity that when asbestos is mentioned anthophyllite should be understood. The anthophyllite is an orthorhombic amphibole, essentially a silicate of magnesium (MgO·SiO₂) but containing a small amount of ferrous iron. The tremolite is a calcium-magnesium silicate (CaO·2MgO·SiO₂) also containing some ferrous iron. It has nearly the composition of actinolite.

In this district the asbestos occurs as cross-fiber, slip-fiber, and mass-fiber, depending upon the arrangement of the fiber in respect to the wall rock, and in respect to each other. In the cross-fiber type the fibers are cross-wise to the walls of the body. Not much of this is present, and the seams or veins of the minerals are no more than an inch wide and apparently no more than a few feet long. In the slip-fiber type the fibers are parallel to the walls of the body and form veins on slip planes. The fibers are parallel not only to one another but to the direction of slipping. This type is more widely distributed than the cross-fiber, but the veins are narrow, seldom wider than four or five inches and are not persistent on strike or dip. Mass-fiber occurs in fibrous bundles or groups in which the fibers or groups of fibers stand at various angles, usually radial or divergent. It is strongly contrasted with the cross-fiber and slip-fiber types in that it does not occur in veins, but forms the whole mass of the rock in which it is developed. This is the dominant occurrence in the Orofino region, and although it is the cheapest grade of asbestos, it is the most valuable type of amphibole asbestos, commercially, because the whole mass of the rock can be utilized. As the slip-fiber and cross-fiber kinds are so very irregular and so far as known are of so small extent, they can furnish only a very unreliable basis for mining operations and can be regarded as of no commercial value.

The anthophyllite fibers often have the appearance of great length, especially the slip-fiber type, which may break into pieces 18 inches or more long, but the absolute length of fiber is very difficult to determine in that if the material is pulled apart and the bundles separated, the length is found to decrease with the size, the longer bundles being composed of a number of smaller, shorter ones. This may continue beyond the range of the microscope. In the mass-fiber asbestos the bundles are as much as four inches long, but in pulverizing the material the fibers are broken so many times that they are only a fraction of an inch. In the large crystals or bundles the fibers appear coarse and harsh, but when pulverized break into very fine fibers. The fibers are brittle, lack tensile strength and therefore cannot be utilized for spinning. Consequently the asbestos is suitable only as a constituent in millboards, roofing, flooring, plasters, cements, paint filler, pipe coverings, and similar articles.

For convenience in describing the deposits they will be listed under three heads, the Kamiah asbestos, the Teakleaf asbestos, and the Blacktail asbestos. The Kamiah asbestos is by far the most valuable, consisting entirely of the mass-fiber type, and is the only one with a commercial production. The other two have mainly slip-fiber, and locally a little cross-fiber asbestos.
KAMIAH ASBESTOS DEPOSITS

Location and Access

The Kamiah asbestos deposits lie at the very margin of the Columbia Plateau about 14 miles east of Kamiah, in Idaho County, at an elevation of about 3100 feet, in part on the lower western slope of the Clearwater Mountains, but mostly at their base where the basalt of the plateau has been partially removed by erosion. Most of them are in a comparatively small area of two or three square miles a mile or two south of Glenwood in the northern part of T. 35 N., R. 5 E., at the base of Maggie Buttes. Exposures are also known farther north near and in the canyon walls of Lolo Creek, also southeastward in the Clearwater canyon near the mouth of Pete King's Creek. The deposits near Glenwood are reached from Kamiah over a road that must climb the canyon walls to the surface of the plateau.

History of Development

The earliest record of development of the Kamiah deposits was shortly prior to 1909 when the Spokane Asbestos Fire Brick Company mined one of the deposits and saved the asbestos into bricks. In 1910 the same company produced a small amount of asbestos, using it for pipe and boiler covering and for wall plaster. Whether asbestos was mined the next six years could not be learned. Some work was done in 1916 and a small shipment made in 1917 by the Kamiah Asbestos Manufacturing Company, possibly a reorganization of the earlier company. Mining was again at a standstill until 1921 when the Western Mineral Company took over the property of the Kamiah Asbestos Manufacturing Company, made repairs to equipment and mined a small amount of asbestos. Shipments were again made in 1925, this time by the Panhandle Asbestos Company. The company built storage sheds and a grinding plant on the railroad at Kamiah, and shipped some asbestos. In 1929, the deposits owned by the Panhandle Asbestos Company and the plant at Kamiah changed hands, but no mining was done.

Geology of the Deposits

General Features

The asbestos deposits are enclosed in mica schists and gneisses of both sedimentary and igneous origin, the latter representing injection gneiss from the Idaho batholith. The sedimentary schists and gneisses are probably derivatives of the Belt series (Algonkian age). They show the results of intense metamorphism, near the asbestos deposits being entirely recrystallized and changed to garnet and cyanite-bearing schists. Apparently much of the metamorphism was accomplished by the intrusion of the Idaho batholith, for not only is much of the country rock an injection gneiss, but the mineral assemblages in the metamorphosed sedimentary rock suggest that much of the change has been induced by transference of volatile constituents from the magma, especially alkalis and water vapor. The schists and gneisses are highly foliaceous and have both muscovite and biotite in addition to garnet and cyanite as well as several accessories including magnetite, pyrite, and pyrrhotite.

The Idaho batholith, composed mostly of quartz monzonite, but in this region with a wide marginal zone of quartz diorite, is exposed at the surface several miles to the north and east. Apophyses of granite and quartz monzonite from the batholith are numerous in the vicinity of the asbestos deposits and also dikes and lenses of pegmatite and aplite, and quartz veins. These acid differentiates are apparently more numerous near the asbestos deposits than elsewhere in the surrounding region. The field relations indicate that the Idaho batholith
underlies the deposits at but slight depth.

The asbestos bodies have lenticular shapes and in general conform with the prevailing trend of the enclosing schists and gneisses, pointing mainly in the northwest quadrant and dipping steeply to the northeast or southwest. These have the form and manner of occurrence of intrusive bodies and, as discussed earlier, actually represent altered dunite. Whether they owe their present position to folding or were intruded along the bedding of the folded sediments is not entirely known, for the relations beneath the surface are not observable. As some of the bodies are cut by stringers of pegmatite, and as all show evidence of much alteration, probably from the batholithic emanations, their age is pre-Jurassic, for the oldest date assigned the Idaho batholith is Jurassic.

Size and Distribution of Deposits

The bodies are mainly lenticular and range from minor ovoids a few feet wide to dikes or lenses as much as 80 feet wide and 200 yards long. More than a dozen bodies greater than 50 feet wide and 100 feet long occur in the area. As the anthophyllite is very resistant to weathering, the bodies tend to form prominent ledges which stand from 10 to 40 feet above the more easily eroded country rock, as illustrated in Pl. III, Fig. 1.

The deposit last worked by the Panhandle Asbestos Company is on a lenticular body about 75 feet wide in its greatest part and more than 120 feet long. It rises about 35 feet above the low ridge. The body appears to trend N. 60° W. and dip 78° N.E. Only part of one side of the projecting ledge has been removed by quarry operations. The deposit lies about one and one-half miles south of Glenwood in Sec. 10, T. 33 N., R. 5 E. No bottom of the deposit was observable and thousands of tons are available by simple blasting from the ledge without sinking below the present working floor.

Many other ledges occur nearby, some of which have not been developed. One lies about three quarters of a mile south of the Panhandle quarry, and forms a prominent ledge from 20 to 50 feet high, 60 feet wide, and about 70 feet long. It tapers very abruptly from its widest part. A second ledge lies about 200 yards to the east. This one trends about N. 40° W., is about 80 feet wide, and probably more than 100 yards long. No development has been done on either and the deposits may be even larger than estimated, as the bodies are much obscured by vegetation and surface debris. Several outcrops also occur along the road that ends at the main Panhandle quarry. One appears as an immense boulder about 15 feet long and eight feet across. Nearby is one that trends N. 10° W. It is 20 feet wide and mined by cut for 40 feet. Its true dimensions could not be estimated. In none of these was the country rock disclosed by the development.

Some old workings, whose exact location cannot be given, as there are no ready points for reference, lie on a ridge south of the road to the Panhandle quarry site. One is explored by cut and incline. The incline leaves the body and enters the hanging wall and so discloses the contact between the asbestos and the country rock. The contact is sharp and the country rock is gneiss or schist, filled with seams and lenses of pegmatite and aplite. The asbestos body trends N. 40° W. and dips about 35° S.W. The footwall was not encountered, but the body must be more than 40 feet wide and perhaps several hundred feet long, as float can be traced for that distance. Even larger bodies, some developed by tunnels, are reported to be nearby, but these were not found.

Near the canyon of the Lolo, the asbestos bodies are much smaller, probably too small for commercial development. The deposits near the Clearwater are probably more than twelve feet wide and a hundred feet or more long, but these have been only partially changed to asbestos and are not commercial.
Fig. 1. Projecting outcrop of anthophyllite body near Glenwood. Because of its resistance to weathering, the anthophyllite forms massive ledges that rise 10 to 40 feet above the enclosing rocks.

Fig. 2. Typical radiating or rosette structure of the anthophyllite groups or bundles in the Ramiah deposits.
Structure and Mineralogy of the Deposits

In all the deposits that were examined, the anthophyllite occurs as mass-fiber and forms essentially the whole of the body. The fibers are arranged in small bundles and generally lie in all directions through the rock, but with pronounced tendency to form radial groups which in cross-fractures yield rosettes such as shown in Pl. III, Fig. 2. The rosettes are of nearly uniform size in each of the bodies, but vary in size from body to body. The largest measure six inches across, but average four to five. In others the radial group or rosettes measure usually not over two inches in diameter. The fibers are brittle and readily break into short lengths and split into fine threads that are polygonal in cross-section. The fibers have a dull to vitreous luster, some nearly glassy. The weathered anthophyllite is grayish or white. Small glistening flakes of talc may be noticed in most of the fibrous bundles, some between the anthophyllite fibers and some apparently merging with the anthophyllite. Locally some of the talc plates are two to three inches across.

Some of the bodies, however, are not composed wholly of anthophyllite, but retain remnants of an original rock. These remnants range from microscopic granules to masses the size of a man's fist and even larger, distributed more or less uniformly through some of the bodies, but always forming a very subordinate part as compared with the anthophyllite. In some of the deposits the remnants are so inconspicuous as to be recognized only in thin section. Many of the granules and masses contain outlines and traces of anthophyllite bundles or rosettes incompletely grown through them.

Detailed studies of the deposits indicate clearly that they contain minerals of two distinct ages; a group of early primary minerals as represented by the remnants of rock mentioned above; and a group of later minerals that have developed by replacement, the second group including the anthophyllite and several others. As discussed earlier; the remnants consist essentially of olivine with accessory magnetite, chromite, and pale yellowish-brown spinel (picrotite). The olivine occurs in interlocking grains, the texture and the mineral assemblage indicating that the remnants have the composition of dunite, and, as these are scattered more or less uniformly throughout the body, that the original intrusive was dunite.

From microscopic studies of the olivine remnants and the amphibole groups, a complete history of the transformation of olivine to anthophyllite may be worked out. Generally the anthophyllite shows direct replacement of the olivine, but some of it also replaces antigorite (lamellar serpentine). The direct alteration of olivine to anthophyllite, as observed in thin section, is not controlled in the slightest degree by the physical properties of the olivine; and thus the needles of amphibole pierce the olivine grains without regard to their boundaries, cleavages, or cracks. They extend continuously from one olivine grain to another, so that a single needle or bundle of needles may pierce consecutively as many as five or six or more differently oriented olivine individuals. The development of the amphibole needles and bundles in both size and number gradually leads to the diminution in the amount of olivine until the rock is converted from a dunite into amphibolite in which the olivine is entirely absent. Many sections show minor amounts of the antigorite and this mineral is clearly a secondary development formed by replacement of the olivine. It is obviously older than the anthophyllite, for the latter penetrates it as well as the olivine, the needles or bundles passing from one to the other with no apparent change in quantity or in ease of replacement, as illustrated in Pl. IV, Fig. 1. A very little kammererite(?) was also noted in one of the sections, it like the
antigorite, replacing the olivine, and in turn being replaced by anthophyllite. Although the anthophyllite is usually very finely fibrous, some of it occurs in coarse crystals, always with an excellent prismatic cleavage, and with cross fractures. The chromite and magnetite, which are present in some abundance in the remnants of olivine, are mainly absent from the anthophyllite or are in much less quantity. Apparently the solutions, which caused the alteration of the olivine to anthophyllite, largely removed the iron from the rock.

Other minerals in the asbestiform bodies are younger than the anthophyllite. Talc is the most abundant of these minerals and it shows replacement not only of the olivine and antigorite, but of the anthophyllite as well, as illustrated in Pl. IV, Fig. 2. A little magnesite (?) is also present in some of the sections as small grains or irregular masses, possibly younger than the other minerals and about contemporaneous with the talc. The relations are not wholly clear. Pyrite occurs as minute scattered crystals in some of the asbestos, clearly replacing all the other minerals. The minerals and their relations suggest hydrothermal alteration as the cause of the amphibolitization.

The dunite near the mouth of Pete King’s Creek has only scattered bundles of white to pale greenish-gray tremolite (near actinolite in composition). These needles are less than one inch long and replace antigorite and olivine, as well as a little clinochlore, secondary to olivine. Much more serpentine is developed in these rocks than near Glenwood and also much more talc.

TEAKEAN ASBESTOS DEPOSITS

Location

The Teakean deposits are mainly in Sec. 16, T. 37 N., R. 1 E., about three miles southeast of the village of Teakean in Clearwater County, on a low spur of metamorphic rocks that barely rises above the basalt plateau. Some of the deposits have been exposed on the side of the low ridge where the shallow covering of basalt has been stripped away by the streams. The same series of rocks with asbestos passes beneath the basalt and reappears in the canyon side at Absahka about three miles to the southeast.

General Features

The asbestos bodies, apparently altered harzburgites, are in the highly gneissic and schistose rocks of pre-Cambrian age associated with much younger injection gneiss mainly of dioritic composition and cut by numerous pegmatites and aplites. As in the Glenwood region, these deposits are apparently in the roof of the Idaho batholith. The gneiss is nearly east-west and dips steeply north. The asbestos-bearing rocks occur as dikes or lenses, and the major body appears to trend about N. 62° W. Whether it conforms to the bedding of the schists and gneisses could not be ascertained. The asbestos fails to give resistant ledges, largely because it only occurs in minor seams in the altered intrusives and the remainder of the rocks is soft and particularly susceptible to erosion.

The development consists of a small tunnel on one of the bodies and numerous small cuts. The overburden is deep and outcrops are therefore not generally available for study. Apparently, the anthophyllite occurs mainly in slip-fiber form as long woody blocks in fissures in the altered rock. The seams are irregular and pinch and swell from an inch to a foot or more. Some of the masses shown on the dump have thin seams of cross-fiber. Weathering has etched out the less resistant material in these and has produced a ribbon-like banding. Mass-
fiber asbestos also occurs in places but forms a very small part of the rock, most of which has altered to talc or serpentine. The size of the intrusives could not be determined. The relations shown in the cuts and tunnel suggest that the altered igneous rock and asbestos occurs in minor seams or lenses in the gneisses and is not in large masses like the Kamiah deposits. The deposits in the canyon above Ahsahka were not visited. No work has been done on them, but several ledges are said to occur, each about 10 feet wide, and in the gneisses and schists. The asbestos occurs as slip-fiber.

The slip-fiber is composed of parallel fibers of anthophyllite showing replacement of altered prismatic crystals of enstatite and apparently of tremolite, the latter an alteration of olivine. The individual fibers often appear 18 inches or more long, but the average is perhaps about five. The asbestos appears grayish to white, but that at the surface is somewhat iron stained. When fiberized, the fibers are fine, fairly flexible, and white. Some of the rock under the microscope contains two slightly different materials, both probably anthophyllite. The first is coarse prismatic under the microscope and is transparent and colorless with good prismatic cleavage. The second with the same optical properties is associated with the preceding and apparently derived from it by alteration or shearing. It is made up of very fine fibers in matted aggregates. The original olivine and enstatite of the bodies has apparently altered in part to tremolite (coarse prismatic crystals) and to serpentine, these in turn to the two forms of anthophyllite. Some of the anthophyllite replaces the olivine or enstatite directly. Talc is much more abundant in these deposits than at the Kamiah deposits and likewise serpentine. The walls of the anthophyllite seams are composed of partially altered olivine and enstatite, usually to serpentine and talc, but contain some groups of anthophyllite.

Similar deposits of asbestos also occur at in the valley of Orofino Creek about 11 miles east of Orofino, but the material is mainly the mass-fiber sparsely distributed through altered harzburgite. Several bodies are exposed in the railroad cuts. The dikes may be 40 to 50 feet wide, and intercalated with the gneiss series. In general the alteration of the olivine and enstatite has been mainly to tremolite and talc and with only a very little anthophyllite. The tremolite becomes somewhat fibrous when weathered, but it is more characterized by a good cleavage. These deposits give little encouragement toward commercial development.

BLACKTAIL ASBESTOS DEPOSITS

General Features

The Blacktail deposits are in T. 30 N., R. 4 E., near the top of Blacktail Mountain about six miles south of Harper. They cut across an elevation of about 4,000 feet near the head of a tributary of Lightning Creek on the northeast side of the mountain.

The deposits are apparently in greatly altered igneous rock in the upper part of the Triassic series. The bedrock is so obscured by brush and overburden that relations cannot be satisfactorily studied. The belt of rocks and minor veins of asbestos trend N. 30° E. and dip 50° S.E., conforming with the general trend of the Triassic rocks in that region. A short distance to the east are quartzites, gneisses, and schists, but by gneissic quartz monzonite. The schist series probably underlies the asbestos belt of rocks at no great depth.
The original character of the asbestos-bearing rock is difficult to determine. In the vicinity of the asbestos veins or lenses is much greenish serpentine and gray talc, all of it decidedly schistose and better classed as serpentine and talc schists. Much of the talc and serpentine (locally with a little chlorite) is knotty and has abundant specks or grains of the original rock, now so much weathered that recognition is impossible. On weathering this material has given much iron oxide and it is possible that it represents altered olivine. The presence of so much serpentine suggests that the rocks originally were peridotites. The talc in the rock shows replacement of the serpentine and also of chlorite.

The anthophyllite is the slip-fiber kind resembling long slabs of wood in slippage planes in the talcose and serpentine rocks. The seams or veins of anthophyllite are from one to four inches wide and suggest from their relations that the anthophyllite has developed by replacement. Many of these seams are to be seen, but none of them are of such size as to have commercial possibilities. The anthophyllite is grayish white in color, yellowish where weathered. It goes to fiber readily, the fibers showing a slight amount of flexibility. Splinters more than a foot long may be obtained from the seams. Development has been by several small cuts and a short tunnel.

ORIGIN OF THE ASBESTOS DEPOSITS

The study of the asbestos deposits indicates clearly that the anthophyllite and its associated minerals have formed by replacement of the olivine (also of enstatite in some bodies) in the original dunite or peridotite, the minerals replacing the olivine in fairly well established sequence. Without going into details of the process, the alteration may be summarized as involving the addition of water and silica in an early stage to form a minor amount of antigorite, later of silica alone to give anthophyllite, and of water, carbon dioxide and sulphide in the final stages to give talc, magnesite, and pyrite. This is essentially the sequence of events in hydrothermal processes.

Anthophyllite has been cited as a mineral formed by hydrothermal processes in the Webster dunite bodies in North Carolina in which zones of anthophyllite and talc surround the bodies, while within the dunite are sparsely disseminated grains of actinolite, kammererite, talc, and diopside. Locally, many small veins cut the dunite and these contain anthophyllite, tremolite, richterite, talc, chlorite, vermiculite, serpentine, and kammererite. Ross states that most of these disseminated and vein minerals are typical of mineral assemblages that have been formed by hydrothermal processes.

In the Rainy Creek districts of Montana, Pardee and Larsen describe the occurrence of amphibole related to tremolite as an alteration of a pyroxene mass changed by the hydrothermal metamorphism attending the widespread action of hot solutions of unusual character from an intrusion of alkaline rocks.

Gillson has also concluded from his study of the talc deposits that the type of solutions that formed talc, whatever was the original rock replaced, first

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formed an amphibole, a serpentine or chlorite, and later talc and in some deposits magnetite and pyrrhotite at about the same time as the talc or even later. He believes that in many cases, if not in all, these solutions, which caused the alteration, were emanations from granitic or dioritic rocks, or from the acid differentiates of basic intrusives, and that the solutions were hot, alkaline, and were at first siliceous and carried iron, calcium, and some aluminum, in addition to magnesia, later becoming less siliceous and rich in magnesia.

The Idaho deposits thus might well be considered the product of hydrothermal processes, formed by the action of magmatic waters at first mainly siliceous, but becoming richer in carbonates and sulphides in declining stages, the source of the solutions from the Idaho batholith that underlies the deposits at but slight depth. That magmatic solutions especially rich in water and silica invaded the area of asbestos rocks in the Kamiah region is evident from the abundance of apitites, pegmatites, and quartz veins in that immediate vicinity. Perhaps the hydrothermal metamorphism is much like the contact metamorphism described by Gillson¹ in the Pend Oreille district of north Idaho where the metamorphism of the invaded rocks was produced by a long procession of solutions that came out from the igneous rock (a supposed outlier of the Idaho batholith), these solutions rich in alkalies at first, but becoming more siliceous and in the last enriched in sulphides and carbonates. The character of the metamorphosed sediments in the Kamiah district also indicate that here too the earliest solutions were rich in alkalies, but these caused no appreciable effect on the olivine bodies.

In short, it is believed that the anthophyllite deposits, and especially those near Kamiah, are a replacement of dunite bodies, the anthophyllite and its associated minerals being the products of hydrothermal metamorphism or alteration related to igneous emanations. The dunites of uncertain, but of pre-Jurassic age, were invaded by the Idaho batholith and from this later great body probably came the magmatic solutions which permeated through the ultra-basic intrusives replacing the olivine by an assemblage of secondary minerals. The solutions in early stages had high temperatures (hydrothermal) and were mainly siliceous, and as they penetrated the dunite bodies added silica and in some parts water to change the olivine to fibrous amphibole (anthophyllite) and to serpentine (antigorite). Perhaps the high temperatures and great pressures that existed during the early stages did not favor extensive formation of serpentine with its possible lower temperature of formation and although a little was formed when the solution first encountered the relatively cool olivine, most of it was soon replaced by the more stable amphibole. During later stages the solutions became progressively cooler, probably more aqueous, and enriched in carbon dioxide and also in sulphides. The anthophyllite and serpentine no longer stable under these changed conditions, were attacked and along with the olivine were partially replaced by talc, apparently with the deposition of minor amounts of carbonate. Sulphides, as represented by pyrite, were soon deposited by replacement of the earlier dunite bodies.

CLAY DEPOSITS

GENERAL STATEMENT

Clay deposits are widely distributed in the district, especially along the margin of the plateau east and north of Orofino. Some of the clays are possibly high-grade and suitable for white ware or refractories if first washed. The clay is generally white, more or less plastic, in places iron stained and associated with variable amounts of muscovite mica, quartz, and partially altered feldspar. Some of the deposits are near or along railroads and are thus easily available, but whether the clays are of such a grade as to bear transportation costs to points of utilization has not been investigated.

GEOLeIC FEATURES

The possible high-grade clays are of two kinds, residual, and transported or sedimentary. The residual is from the decay of the feldspathic rocks, mainly the granite, quartz monzonite, pegmatite, and aplite. As the degree of kaolinization is not uniform over the surface and is more or less independent of topography, and as the kaolin deposits are restricted to certain areas or to certain zones whereas nearby rock similarly situated to the attack of weathering agencies shows little kaolinization, the writer favors the hypothesis that the residual deposits are not so much related to weathering as to hydrothermal processes active shortly after the rock had crystallized and while still far below the zone of weathering. The feldspars in the unweathered rocks, especially of the aplite, granite, and quartz monzonite, are largely obscured by kaolin and other secondary products, formed unquestionably while the rock was cooling as a consequence of endomorphic action during the escape of the volatile components of the magma, especially water vapor. Weathering only serves to liberate the kaolin.

The sedimentary clays are derived ultimately from erosion and transportation of the residual deposits mentioned above and from the partially kaolinized granitic rocks. Most of the sedimentary clays are in the Latah formation and are thus of Miocene age, having been deposited as the drainage was obstructed by the advancing flows of Columbia basalt. Some of the clays are between the basalt flows, but some of the thickest deposits and probably the most valuable are at the margin of the plateau in embayments into the mountain where they were not entirely covered by the basalt or from which the upper basalt flow has been partially removed by erosion. Some of the transported clays are relatively pure, whereas others have much volcanic ash, sand, carbonaceous matter, etc.

BOVILL DISTRICT

The largest area of residual clay noted is in the low country north and northeast of Bovill, where a large stock composed mainly of granite and quartz monzonite, but littorally filled with dikes of pegmatite and aplite, has barely been exposed by erosion. In some parts of the stock kaolinization has been very extensive. This is especially shown in the railroad cuts between Bovill and Clarkia where some of the cuts from 30 to 50 feet deep are in a brilliant white clay containing small flakes of mica. Large reserves of clay are disclosed, mostly under a thick overburden. The abundance of pegmatites and aplite suggests that the magma was "wet" and the clay the product of hydrothermal processes. The region is worthy of systematic and thorough testing, especially as the deposits are easily accessible. Bodies of sedimentary clays are also undoubtedly present.

The deposits are not far from the commercial deposits near Troy and Deary, also in Latah County, and are probably like them. Whether they are equally as
high-grade can only be determined by testing. Many small bodies of residual clay were also seen south of Bovill near Park where small dikes and stocks of granite are exposed at the surface.

ELK RIVER DISTRICT

The clays of the Elk River district are of sedimentary origin, their ultimate source being the partially kaolinized stock of quartz monzonite north of town. A hundred feet or more of the Latah formation is exposed near the town, in part covered by a flow of Columbia basalt. The sediments and the lava have been much dissected so that the clays are exposed in the hills with only here and there a remnant of the basalt capping. Southward a flow of basalt may be seen beneath the sedimentary formation. For the most part the Latah is clayey and micaceous. The color is usually a lustrous white or gray, but some beds are yellowish, bluish, or reddish. The clays are also stratified with some sandy members. As the clays are over a hundred feet thick and probably cover several square miles, the reserves will be very great, should the deposits be of commercial grade. The clays are easily available as a railroad crosses the area.

OROFINO DISTRICT

The relations in the Orofino districts have been adequately described in connection with the character and distribution of the Latah formation. The clays are exposed in the canyon walls or in land-slide blocks. Some also occur at the margin of the basalt near the base of the mountains. The sediments, apparently, a lower clay content than the Elk River Deposits and have much more volcanic ash and sand. Locally, however, beds of nearly pure clay may be found. In most places mining of the clay would be severely handicapped by a thick overburden, especially where the clay is in place between the basalt flows. So far as known, none of the clay has been tested.

Some of the clay has a deep reddish color. Such a deposit occurs near the margin of the basalt along Cow Creek, a tributary of Orofino Creek not far from Grangemont. The source of the red iron oxide in the clay was not determined, but its abundance brings up the question of whether the clay could not be utilized in paints. Large reserves of red clay are probably available.

COAL DEPOSITS

GENERAL FEATURES

Coal ranging from lignite to subbituminous in rank is described by Lupton, as occurring in beds three feet or less in thickness between layers of clay and sandstone (Latah formation) which are interstratified with the Columbia River basalt flows in the region around Orofino in Clearwater County, and extending into Lewis and Idaho counties. Much of the coal has a lignitic character, and some of it is in reality a carbonaceous shale, but some of it, according to Lupton must be designated as subbituminous. The latter is jet-black and is mostly dull, but has a few bright layers. Woody structure is evident in parts of the coal and as a whole it is laminated, showing thin plates ranging from film to bands a quarter of an inch in thickness.

Lupton describes a number of prospects in the region, and has assembled all the data that is available. To this the writer has nothing to add, as there has been no further development since Lupton's visit. He concludes that the inferior quality of the coal and the fact that extensive prospecting in the region has failed to reveal coal in commercial quantities suggest that the field will be of no importance as a producer of coal, except possibly in a small way by furnishing coal for local use in the distant future, when timber becomes scarce. He further concludes that it is questionable if any additional information regarding the coal or lignite possibilities of the general region of sufficient promise to justify further prospecting will be found, and does not advise anyone to expend time and money in such work.

**Feldspar Deposits**

**General Features**

Large reserves of feldspar are available in the region and would become important in the event that the clay resources were utilized in the ceramic industries. Most whiteware bodies consist of 10 to 35 per cent feldspar and glazes usually contain 30 to 50 per cent of this material.

Feldspar is found commercially in pegmatite dikes associated with quartz, biotite, and muscovite mica, and minor quantities of other minerals. In some the quartz and feldspar are intimately intergrown as graphic granite, composed normally of about 75 per cent feldspar and 25 per cent free quartz. Others resemble very coarse grained granites. The outstanding character of pegmatite in general is the large size of the constituent minerals.

The distribution of the pegmatites about the margins of the stocks and batholiths has been discussed elsewhere. About some parts of the stocks and batholiths they are entirely lacking; in other places they are very numerous. Such bodies are abundant along the North Fork of the Clearwater, especially below the mouth of Quartz Creek. They are also numerous near Bovill. Little difficulty should be experienced in finding suitable bodies of pegmatite or feldspar anywhere in the older rocks, should such deposits be desired. Those with plagioclase feldspar are not as desirable as those composed of orthoclase or albite.

As the bodies are usually small and irregular, the mines must also be small and irregularly developed and operated. Few deposits farther than five miles from a railroad can be operated successfully. Unless exceptionally well located or of unusual purity, deposits less than 25 feet wide are of little commercial interest. For economical operations, marketable feldspar should constitute at least 50 per cent of the rock mass; it should occur in fairly large clean masses so that sorting is easy; it should be free from iron stains, and other finely disseminated impurities; and quartz should constitute not over 25 per cent of the shipping product.

**Garnet Deposits**

**General Features**

Garnets, mainly as the reddish almandite variety, are more or less widely distributed in the region; in the highly metamorphosed schists and gneisses; in the stream gravels in which they are concentrated because of their relatively high specific gravity, their source being in the schists and gneisses; and to lesser extent as the lime variety in contact metamorphic deposits in limestone. Unfortunately, the impression is held by many people in the district that the garnets are corundums, the reddish being the variety, ruby, and consequently the
deposits, both in the schists and stream gravels, have been misrepresented as of great value.

The garnets in the schists and gneisses probably in no place compose more than five per cent of the rock. The crystals are small, usually less than one-half inch in diameter and are fractures and in no way of gem grade. No schists or gneisses were seen in which the garnet was sufficiently abundant to be regarded as commercial. The quantity in the gravels is probably not worth recovery as a by-product in placer operations with gold, monazite and zircon. Garnet is used chiefly as an abrasive, but there is little demand for it and the markets are more easily and cheaply supplied by deposits nearer at hand.

Deposits of the yellowish-brown lime garnet occur in the limestone in the canyon side between Orofino and Aheakka. Some of the crystals are two and three inches in diameter and are numerous. Unfortunately, the lime garnets are unsuitable as abrasives and there is no market for them.

**LIMESTONE AND MARBLE**

**DISTRIBUTION**

Crystalline limestone or marble occurs in the Orofino series of pre-Cambrian age and in the much younger Triassic series of sediments. The distribution of these deposits therefore conforms with the exposures of the two formations; namely, the ancient rocks in the Orofino vicinity and the younger series in the Harpster district. Limestone or marble deposits also occur in the region to the west, the canyon of the Salmon River near Lucile and in the canyon of the Clearwater and its tributaries between Agatha and Lenore, but these are outside of the area included in the reconnaissance and will not be described in this pamphlet. Most of the outlying deposits are probably of Triassic age, except, possibly, the deposits near Agatha or Lenore.

**OROFINO DEPOSITS**

**General Features**

The general occurrence or geological relations of the crystalline limestone or marble in the Orofino deposits has been given under stratigraphy. Suffice it to say that the limestone or marble occurs in lenticular beds from a few feet to as much as 800 feet thick enclosed in micaceous quartzites, micaceous and hornblende schists and gneisses of both sedimentary and igneous origin. The series of rocks has been invaded by cutters of the Idaho batholith and its structure rendered even more complex by injection of igneous gneisses along the bedding planes. In addition the series is cut by numerous stock and dikes of quartz diorite and pegmatite, offshoots from the body that is exposed a short distance above Orofino near Greer. In some places the calcareous beds are so filled with the pegmatite dikes and seams as to be nearly valueless. Hand sorting is usually a necessity. It is probably the heat and pressure that attended the intrusion of the Idaho batholith and its outliers that changed the limestone to its present crystalline state or to marble.

The structure of the rocks is complex. The beds are steeply tilted, mainly to the east. The strike ranges from east of north to west of north, the change from one direction to the other occurring with great sharpness whose relations can be explained only by faulting. The number of limestone beds are not known. At least three occur, but there may be more. The beds have such a lenticular habit and are so much faulted that the members even within relatively short distances are not easily matched, if at all. The geologic sketch map of this area (Pl. V) shows these relations inadequately.
Character of Limestone

The crystalline limestone has an unusually white color, one of its most distinctive characters. Most of it has an exceptional purity, composed almost wholly of calcium carbonate and classed distinctly as high-calcium lime. Some has a little pyrite, some a little graphite, and some a low percentage of magnesia, but the most detrimental impurities are the seams and dikes of pegmatite and diorite. The deposits near Orofino have been extensively sampled and analyzed and in general give consistently high percentages of lime carbonate. The deposits of highest purity apparently are south of town. Northward to Ahsahka the magnesia content is said to show a decided increase. The following table of analyses1 may be taken as fairly representative of the composition of the better limestone in the deposits south of Orofino.

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<td>Silica (SiO₂)</td>
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<tr>
<td>Iron carbonate (FeCO₃)</td>
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<td>Calcium carbonate (CaCO₃)</td>
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<td>Magnesium carbonate (MgCO₃)</td>
<td>0.9</td>
<td>0.4</td>
<td>0.6</td>
</tr>
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</table>

1. Random sample in the upper quarry of the Clearwater Lime Products Company, collected by the writer.
3. Selected sample of the pure limestone.

Limestone of such purity is especially adapted to the manufacture of cement, poultry grits, and for many chemical purposes such as tannin to paper manufacture, lime, explosives, refining of sugar, glass works, tanneries, metallurgy, etc. Some of the deposits have been worked for lime, but more recently attention has been directed toward the utilization as poultry grits for which only high calcium lime can be used, and also as a chemical agent in explosive manufacture, which again demands lime of the highest quality. In most of the deposits near Orofino the marble is probably unsuited for buildings or monumental stone because of the numerous seams of pegmatite and because of failure to break into blocks of sufficient size. The rock is susceptible of a high polish and, if it can be had in blocks of desired size, should find a ready market for building and monumental purposes. The deposits are favorably situated for quarrying, all close to the railroad. The surface rock is considerably shattered, but is not deeply weathered. Whether the limestone is sufficiently massive at a moderate depth below the surface to be of value can only be determined by trial.

History of Development

The limestone deposits have been worked sporadically for many years, most of the limestone quarried and burned locally for lime. Early records of production and quarrying are not available. That some of the deposits were high-calcium lime had been known for many years and had attracted some attention, but it was not until 1927 that serious effort was made to utilize the limestone. In

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1 Analyses by R. V. Lundquist, Chemist, Idaho Bureau of Mines and Geology
Geologic sketch map of Orofino and vicinity showing distribution of limestone and marble deposits.
September of that year, the Clearwater Lime Products Company was organized and began the mining and marketing of some deposits several miles southeast of Orofino along the river. The product was sold principally to the agricultural industries both as poultry grit and as fertiliser, but later additional markets were found. During 1929 a crushing-screening plant was erected and equipped at the present site of operation (Pl. VI, Fig. 1).

An important new discovery of crystalline limestone was made during the early summer of 1929 along Orofino Creek about 11 miles east of Orofino. This deposit is as large as any yet discovered and contains some excellent lime. An organization known as the Sowell Lime Company has undertaken development of this deposit.

Clearwater Lime Products Company

The Clearwater Lime Products Company controls several quarry sites south of Orofino, the present operation being on those about two and one half miles above the town. Formerly the company maintained operations for nearly two years in a quarry about one and one half miles above the town and on the same road that passes the present site. From the first quarry 100 cars of lime were reported to have been shipped.

The limestone bed at this first point of operation (Pl. V, quarry site No. 7) is about 200 feet thick, strikes N. 40° W. and dips 58° N. E. The crystalline limestone or marble is both fine and coarse grained and has the usual white color. Unfortunately, the bed is cut by numerous apophyses, dikes, or seams of pegmatite and diorite and all the rock must be carefully hand-sorted. In the lower part, the limestone contains some beds of gneiss or schist alternating with beds of marble up to four feet thick, but the greater part of the bed is a pure calcium carbonate with all too numerous masses of igneous rock. The quarry face is about 75 feet high as the outcrop is in the steep canyon side. The bed extends along the strike for about 1,000 feet. The reserves are large as the deposit has scarcely been touched, but the large quantity of granitic material makes quarrying so expensive that work has been transferred to other deposits.

Three separate beds of limestone or marble are exposed at the present site of operation, each separated from the other by quartzites and schists. The lowest bed (quarry No. 9) is about 15 feet thick and strikes N. 70° W. and dips 70° N.E. It lies between thick-bedded, massive quartzite, and mica schist. The marble is coarse grained, has occasionally scattered crystals of pyrite, and is especially high in lime and low in magnesia. Unfortunately, it has narrow seams of quartz diorite ranging up to three inches wide and the entire rock must be carefully sorted.

The middle limestone bed has not been developed. It lies about 150 yards above the first and apparently forms a series of calcareous beds more than 100 feet thick but including much gneiss and calcareous quartzite. Its purity has not been determined.

At the time of the writer’s visit, work was directed at opening the third and highest bed a quarter of a mile up the gulch. This bed is probably as much as 800 feet thick composed mainly of white massive coarsely crystalline limestone which breaks into large blocks, probably in sufficient size for building and monumental stone. Chemical analysis of this rock is given in column one of the above table. It reveals a very low magnesia content and verifies the company’s analyses which show only a fraction of a percent of magnesia. The body appears to be cut by only a few scattered seams of pegmatite. A tunnel was being driven well into the lower part of the cropping so that glory hole methods could be used in quarrying. The bed appears to trend N. 65° W. and dip 65° N.E. It may be traced for more than a quarter of a mile, ending by concealment beneath landslide blocks of basalt.
Fig. 1. Crushing and screening plant of the Clearwater Lime Products Company near Orofino, Idaho. Quarries may be seen above in the gulch.

Fig. 2. Quarry in basalt near top of Greer-Weippe grade. Columnar jointing such as shown in the figure is an aid to quarry operations.
on the north and south. Whether a uniformity of composition is maintained throughout is not known to the writer.

**Sowell Lime Company**

The recently discovered deposit of the Sowell Lime Company is in Sec. 3, T. 36 N., R. 3 E., at 11 mile post of the Headquarters branch of the railroad. It lies along the south side of Crofino Creek canyon adjacent to the railroad and requires only a parallel spur for loading. This body of crystalline limestone measures about 600 feet thick, and has been traced southward from the railroad for about 1800 feet to where it passes beneath the basalt of the upper canyon wall. The beds strike N. 15° E. and dip 35° S.E. The limestone does not cross the canyon, having been interrupted by faulting. A short distance below the cropping the schists and gneisses strike N. 30° E. and dip 65° S.E., whereas a short distance above the strike of the strata is N. 70° W. and dip steeply north.

The marble is coarsely crystalline, mainly white, but in some places grayish. Locally it has scattered flakes of graphite and little talc. The white rock is of exceptional purity, but the grayish carries some magnesia. Analyses of both the white and gray are given in the following table.

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<td>Silica (SiO₂)</td>
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<td>Calcium carbonate (CaCO₃)</td>
<td>98.4</td>
<td>89.6</td>
<td>94.35</td>
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<tr>
<td>Magnesium carbonate (MgCO₃)</td>
<td>1.6</td>
<td>7.1</td>
<td>4.65</td>
</tr>
</tbody>
</table>

1. White facies of the marble (analysis by Lundquist)
2. Grayish facies of marble (analysis by Lundquist)
3. Analyses furnished by the owners

The deposit had not been systematically sampled so that the analyses shown may not be representative of the whole. However, as much as the limestone is white it is probable that most of it may be regarded as high-calcium lime and suitable for the chemical industries as well as for cement and lime. As no development had been done, the deposit could not be satisfactorily examined. No granitic seams were noticed in the outcrop. The rock where blasted had broken into large blocks, possibly of the kind desired for building and monumental purposes.

**Other Quarries and Deposits**

Limestone is said to outcrop four or five miles up Jim Forde Creek where the series again passes from beneath the basalt in the canyon wall. These have not been developed and were not visited by the writer because of a forest fire.

The ownership of other deposits near Crofino was not ascertained. As mentioned elsewhere, the deposits are much cut by pegmatites and seams of diorite and in general have a considerable amount of magnesia, becoming increasingly more dolomitic near Ahashka. The location of the deposits and quarry sites may be seen in (Pl. V.).

An old quarry site (6) lies on the point of the hill just south of Crofino, probably within the town limits. The quarry apparently has not been operated for many years. The deposit is about the same as the others described, having gneiss walls, and many seams of pegmatite and diorite. The bed is about 100 feet thick, but this includes some gneissic and siliceous layers in the lower part. The
strike of the beds is N. 5° E. and the dip about 60° E. Some of the limestone is probably high-calcium. Unfortunately, the results of analyses were not available to the writer.

A number of outcrops and quarry sites lie north of town. Quarry No. 1, near the village of Yellow Dog, is approximately 30 feet wide and 20 feet high on the upper hill side. The deposit is apparently large, but contains much calcareous gneiss and pegmatite veins. The quarry has probably been abandoned for a number of years, but may be worthy of further investigation. Quarry No. 2 lies about 300 feet west of No. 1, but only a small amount of work has been done. The quarry is nearer the center of the limestone body and is less contaminated with gneissic material and pegmatite. It is worthy of greater development than has been given it. Quarry No. 3 is along the Rock Creek road about one-half mile north of Orofino. About 30 feet of limestone is exposed, but its commercial value is doubtful. Other small quarries are shown on the map, one of which ($) has produced some lime. None of these were active during 1929 nor for many years previous.

HARPSTER DEPOSITS

General Features

Little can be added to the description of the Harpster deposits than has already been given in the discussion of the Triassic stratigraphy in an earlier section. The limestone bed has a persistent trend of about N. 30° E. and dip 45° S.E. Its thickness ranges from 60 to 200 feet. Near Switchback east of Harpster and in the canyon below Mount Idaho the rock has been quarried and burned for lime for local use. The deposits are far from a railroad, but the Elk City highway when completed between Harpster and the foot of the Mount Idaho grade will cross the limestone belt.

Unlike the Orofino limestone, this rock has a dark bluish-gray mottled color; intricately streaked or banded, but with some white layers. It is nearly as coarsely crystalline as the Orofino rock and should properly be classed as marble. It, too, has an exceptional purity, and should be classed as high-calcium lime rock. Its composition may be seen from the analyses in the following table. In the list is the analysis of the marble in the Salmon River canyon near Lucile, presumably from the same member.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica ([SiO₂].........)</td>
<td>0.8</td>
<td>2.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Iron carbonate (FeCO₃)</td>
<td>Tr</td>
<td>0.4</td>
<td>Tr</td>
</tr>
<tr>
<td>Calcium carbonate (CaCO₃)</td>
<td>97.1</td>
<td>94.8</td>
<td>97.1</td>
</tr>
<tr>
<td>Magnesium carbonate (MgCO₃)</td>
<td>0.8</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

1. Sample from outcrop on McConas ranch about 4 miles southeast of Harpster.
2. A second sample from same locality as No. 1.
3. Lucile marble, Salmon River canyon.

The limestone or marble, because of its similarity to the Orofino rock in chemical composition, should be adapted to the same uses and should make an excellent lime. It has all that could be desired in the production of Portland cement or for use in the manufacture of beet sugar, etc. The value of the stone as marble can scarcely be judged from the outcrop, but its dark color would make the demand for it small, even if on quarrying it is found sufficiently massive to be taken out in blocks of the desired size.

1Analyses by R. V. Lundquist, Analyst, Idaho Bureau of Mines and Geology.
MICA DEPOSITS

GENERAL FEATURES

Commercial deposits of mica in the district have not been demonstrated, but there is a possibility that such deposits may yet be discovered. Muscovite and biotite, the former the white mica and the latter the black mica, are widely distributed in the region in the pegmatite dikes associated with feldspar and quartz. They are also present in the schists, gneisses, and the granitic rocks, but in crystals so small as to be valueless. Biotite is of little commercial importance and its geographic distribution will not be considered. The chief mica of commerce is muscovite.

The distribution, character, and mineralogy of the pegmatites has been given both in discussion of the feldspar deposits and in the section on general geology. In some of the pegmatites that were observed along the North Fork of the Clearwater scattered plates of both biotite and muscovite as much as five inches in diameter are common. Some of the pegmatite bodies are over a dozen feet wide and are well supplied with these plates. None of them, however, have muscovite flakes of such size or in such quantity as to be commercial. The great number of these bodies and the presence of the plates of more than usual size gives a possibility that commercial bodies might be found with more extensive search. It is well to bear in mind, however, that for each pegmatite with commercial mica there are probably thousands of others with no mica of value.

A number of mica-bearing pegmatites with plates of muscovite as much as six inches or more in diameter were reported in the granitic hill near Woodland south of the mouth of Lolo Creek. Some of these have been prospected, but have not been productive. The dikes are relatively small. A pegmatite along lower Cedar Creek, a tributary of Orofino Creek, has been reported as having large masses of muscovite, a foot or more in diameter. The writer was unable to obtain its exact location and so cannot verify its occurrence. The deposit has not been opened. Pegmatites with crystals of muscovite over six inches in diameter have also been reported a few miles east of Bovill along the Potlatch River. Books from these deposits have been examined by the writer and these show great similarity to the mica deposits near Avon in Latah County that have furnished a considerable production.

The mica tends to be scattered irregularly through the pegmatite and is difficult to mine inasmuch as the quartz and feldspar gangue is hard to drill and blast without injury to the mica crystals. There is no way to forecast the occurrence or the distribution of the mica in the deposits and mining must of necessity be conducted in a blind manner. Should there ever be a demand for the feldspar, it and the mica could be mined together with advantage.

MONAZITE DEPOSITS

GENERAL FEATURES

Monazite in the gravels along Musselshell Creek has been described by Schrader who shows that the monazite contains several percent of thorium and could be saved with profit as a by-product in connection with gold placer operations. Unfortunately, the value of the mineral, the extent of its occurrence

and the facilities that exist for saving it are not generally known and as yet no effort has been made to save the monazite in mining operations. Monazite is apparently widely distributed in the area and warrants more attention than has been given it. Its principal use is as a source of thorium nitrate, used in the manufacture of incandescent gas mantles.

Monazite is a phosphate of the rare elements, cerium, lanthanum, and didymium, but it nearly always contains thoria (ThO₂) as an impurity, up to nearly 20 per cent. Commercially, monazite is valuable at present chiefly for its thorium content. Analyses given by Schrader indicate that the monazite in the region contains about 3.3 per cent of thorium. The monazite is yellowish-brown with a greenish tinge in places, and has a resinous luster. It is fine grained, with the grains predominantly subangular and in large part exhibiting bright facies.

A few monazite grains were noted by the writer in some of the granitic rocks, but the monazite under discussion occurs in the placer sands derived from the disintegration of these rocks. The deposits are, therefore, to be found in the gravels resting upon the valley floors and also in the gravels that cap the lower ridges and occur as terraces on the valley sides. In these gravels it is usually associated with gold and other heavy minerals, including garnet, magnetite, ilmenite, rutile, chromite, and zircon. In some gravels the zircon is relatively abundant and probably in such amounts that it too could be profitably recovered as a by-product.

Owing to its high specific gravity, the monazite, like the placer gold with which it is associated, is more concentrated in the lower part of the gravel and on the underlying bed rock than in the upper part of the gravel. The heavy sands seem to be more plentiful in the older terrace gravels than in the recent, and for this reason the ancient gravels seem to be worthy of exploration to bed rock for their monazite as well as their gold content.

All the streams which flow in or across bodies of the granitic rock contain monazite in their gravels. The gravels along Musselshell Creek have been studied and the relations found there apply to other streams in or from granitic rocks as well. It is reported that the monazite is much more plentiful in the streams around Pierce than on the Musselshell. The monazite is more widely distributed than the gravel and gold, for it is found also, though in less concentrated form, in the talus, disintegrated granite, and residual soil in the gulches and on slopes rising several hundred feet above the streams. It has been reported in a number of places along the North Fork of the Clearwater and the Middle Fork.

Owing to its high specific gravity the monazite tends to remain with and is difficult to separate from the gold and heavier black-sand minerals. It is usually mined by concentration in sluice boxes much the same as placer gold. It may also be recovered in dredging operations. Further concentration may be done on the Wilfly or any similarly constructed table and for still cleaner separation from other heavy minerals electromagnetic methods may be used, as magnetite, ilmenite, garnet, and similar minerals associated with the monazite respond to magnetic attraction.

The deposits of monazite at present prices are not workable for that mineral alone. In December, 1929, prices on monazite containing 6 per cent thorium or better were quoted at $60 a ton. The value of monazite with a smaller percentage of thorium is still less, as the cost of extraction of this oxide is considerably greater when the thorium content is low than when it is high.

In many of the gravels, especially around Pierce, zircons are abundant and might form an additional by-product. The zircons are likewise accessory minerals in the granitic rocks and are concentrated in the stream gravels the same as monazite. The mineral has many uses, the earliest as a source of zirconium nitrate in the manufacture of incandescent gas mantles but this use has been superseded by thorium nitrate. In recent years other important uses for zircon have been developed, the more important being as refractories, and in porcelains. Prices quoted on 55 per cent ZrO₂ in December, 1929, were $40 to $45 per ton in 30-ton lots.

Although the deposits may not be workable for the monazite or zircon alone, it is possible that these can be saved with profit as a by-product in connection with gold-placer operations, and such saving may enable some ground to be handled with a margin which could not be worked for its gold content alone. It is possible that some of the other heavy minerals such as rutile would also be worthy of recovery.

ROAD METAL

By road metal is meant rock suitable as a surface material on road or highways. For this purpose the Columbia basalt serves admirably and is extensively used on the highways where the rock is available. On the plateau the basalt lies beneath a relatively shallow cover of loess or soil and quarries are usually located near the margins of canyons where the overburden has been largely removed. Talus slopes often serve as crusher sites in the canyon. Because of the jointed character of the basalt (Pl. VI, Fig. 2) it is easily broken loose from cliffs or ledges and quarrying operations are not difficult, although the dense rock is not easy to drill. The basalt is relatively resistant to wear, cements well and usually bears up well under traffic.

A few highways leave the basalt area to go into the mountains. Road metal there must be obtained from the rocks at hand and those usually are some facies of the Idaho batholith. The gneissic rocks surrounding the batholithic shell are probably not as desirable as the granite, quartz monzonite, or quartz diorite because of the tendency for such to cleave into small fragments, but stocks or dikes of the granitic rock occur at frequent intervals in them. Some of the finer grained injection gneisses might be used. The fine grained rocks are more desirable than the coarser grained. The granite and quartz monzonite, perhaps would have better cementing qualities than the quartz diorites, for their feldspars show much more extensive alteration to kaolin and sericite. However, the same rocks because of their altered condition probably would not bear up as well under traffic as the quartz diorites, especially those of finer grain.

Further discussion of road metal is perhaps not justified in this report.

SUMMARY

The region has large deposits of crystalline limestone and marble of exceptional purity, much of it classed as high-calcium lime, and especially adapted for the chemical industries, Portland cement, etc. Because of its crystalline character and exceptional whiteness, some of the marble, if it can be quarried in blocks of sufficient size, should make most excellent building and monumental stone and should be as desirable for such purposes as the well known Georgia marble. In addition, the region has immense reserves of mass-fiber asbestos in the vicinity of Kamiah that can be cheaply mined, but whose development is held up by lack of markets. As the asbestos is but little weathered, there is some difficulty in separating the fibers, but with suitable equipment this should be accomplished without adding too greatly to the cost. The remnants of olivine both in grains and in granules as well as crystals and grains of magnetite and chromite must perhaps be separated from the asbestos, but this should not be a difficult task. The talc that occurs in minor quantities as well as the
serpentine are probably not objectionable for most purposes. The slip-fiber asbestos that occurs elsewhere in the region is in bodies too small to be profitably mined. Work on them is not advised. The region also has large reserves of clay of residual and sedimentary character that might some day be utilized. Not enough of its ceramic or other properties is known to forecast its future. Although no commercial bodies of muscovite mica were seen in the field search might well be directed toward their discovery. Attention also should be directed toward the recovery of monazite and zircon in gold placer operations. These nonmetallics could well become a profitable by-product.

The metallic resources should not be overlooked. It is possible that some of the gold veins in the region, if worked by modern and approved methods, might again be made to yield a profit. Apparently the placer resources are by no means exhausted although none of the ground whether previously worked or not can be regarded as rich. Large-scale dredging operations might continue for some time, and possibly if the monazite and zircon were saved, ground of lower value might be worked. More attention should also be given to the iron ore deposits of which so little is known at present. Lead-zinc veins occur in one part of the region. Copper veins are more or less widely distributed, but most of them hold little promise.