

DESCRIPTION OF THE SILVER CITY QUADRANGLE

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GEOGRAPHY.

Location and area.—The Silver City quadrangle is situated in the southwestern part of Idaho, south of the Snake River Plains, close to the Oregon boundary line. It lies between meridians 116° 30' and 117° west longitude and parallels 43° and 43° 30' north latitude. It is 34½ miles (55.75 kilometers) in length and 25¼ miles (41 kilometers) in average width, and covers an area of 870.90 square miles. Most of it is in the northwestern part of Owyhee County, but the triangle northeast of Snake River embraces a part of Canyon County and a small portion of Ada County.

Relief.—This quadrangle includes the northern end of the Owyhee Range and a part of the sloping and dissected high plains bordering it on the east and west. It also includes, in its northeastern part, a small fraction of the Snake River Plains. The Owyhee Range extends across the quadrangle from its first foothills on the north down to the southern boundary line. Beyond this it widens, bends eastward, and becomes less clearly defined. Along the southern border the mountains extend almost across the quadrangle, while toward the north and northwest they gradually contract to a lower ridge, so that in the northwest corner they are only from 6 to 7 miles wide and have an elevation of about 4000 feet. The culminating points of the range are Florida, War Eagle, and Cinnabar mountains, which have an elevation of about 8000 feet. All of these are near the southern edge, and the last named is just outside the limits of the map. The lowest point, 2200 feet in elevation, is found where Snake River leaves the northern boundary line.

The topographic forms are complex, for the range is built up of igneous rocks of varying character and different ages. In general, the larger ridges and depressions extend from north to south, while the minor topographic features are likely to be very irregular. The oldest rock, the granite, is distinguished by deeply eroded gulches and high ridges, the rhyolite presents rough plateaus, and the basalt is characterized by shorter north-south ridges and broken table-lands.

About the center of this mountain group, at an elevation of 4000 feet, is a little valley—the valley of Reynolds Creek—about 4 miles wide at its widest part and 5 miles long, drained through a narrow, deep canyon on the north side of the basin. This valley probably had its origin in the damming of an old watercourse by rhyolite and basalt flows. Narrow terraces and bottom lands excavated below the general level of the Snake River Plains lie along Snake River, and the northeastern bank of the stream is marked by a bluff 500 feet high, from the edge of which the Snake River Plains extend, with a general elevation of 2700 feet, far beyond the limits of this quadrangle. Above these desolate plains a few basaltic buttes rise to an elevation of 3000 feet. Along the east foot of the range the Snake River Plains extend in broad ridges separated by shallow and mostly dry watercourses. From an elevation of 2300 feet near the river these plains gradually rise to 4100 feet at the base of the mountains near the southeastern corner of the quadrangle. A strip of higher plateau, deeply dissected by Succor Creek, abuts against the mountains along the middle half of the western boundary of the quadrangle. These high plains continue far westward into Oregon toward the Mahogany and Cedar mountains, with gradually decreasing elevation.

Drainage.—Snake River, which pursues an almost straight course across the northeastern part of the quadrangle, receives the drainage of nearly the entire area. It is a large stream, carrying an amount of water probably varying between 8000 and 40,000 second-feet, the highest stage being usually attained in June and the lowest some time during the winter. Its grade is about 5 feet to the

mile. It flows in a well-defined channel between banks ranging in height from 10 to 30 feet and is apparently still eroding its channel. Near Guffey it emerges from a sharply cut canyon in basalt and lake beds. Its course through this quadrangle is more open and becomes still more so northward, in the Nampa and Weiser quadrangles. During flood time the water is turbid, but ordinarily it has a bright-green color, due to fine, suspended sediments.

The drainage from the central part of the Owyhee Mountains finds its way northward through Reynolds Creek to Snake River. Near its head this creek flows through a deep valley that has sharply incised laterals, then through the open basin mentioned above, and finally through a narrow canyon opening a few miles from Snake River into the level terrace deposits of that stream. The eastern slope of the range is drained by Rabbit and Sinker creeks, tributaries to Snake River. These run first in deep canyons cut into the granite core of the range, then, in a northeasterly direction, across the plains down to Snake River. The northern rhyolite plateau is drained by the deep canyon of Squaw Creek, which empties into Snake River near the northern boundary line of the quadrangle. The western side of the range is drained by Succor Creek, the headwaters of which have cut deeply into the heart of the high basaltic areas. This creek empties into Snake River in the Nampa quadrangle.

The mining districts near Silver City, in the southern part of the quadrangle, are drained by Jordan Creek, a stream that extends south and west of the quadrangle and empties into Owyhee River, which, after a long westward detour in Oregon, finally joins Snake River opposite the mouth of the Boise.

Cow Creek, draining westward from near De Lamar, is the only stream in the area which does not drain into Snake River. It empties into a series of small lakes a few miles west of the Oregon boundary line.

Nearly all of these drainage lines, including Snake River, are of recent origin and were formed over the sloping lava flows and the old lake bottoms. In some places they have cut through these and excavated canyons in the underlying granite. It is possible, however, that the upper parts of Jordan and Sinker creeks may belong to an older pre-Miocene drainage system which has been largely obliterated by the overwhelming lava flows.

Climate.—That part of the quadrangle over which the Snake River Plains extend has the hot and arid climate characteristic of this region. The temperature rarely falls below zero in winter but in summer it sometimes exceeds 100° F. But little snow falls during the winter. The annual rainfall is probably about 14 inches, but as there are no meteorological stations in this region, exact figures are not available. The precipitation becomes greater with increase of altitude and snow lies for long periods during the winter on the higher elevations in the range.

At Silver City, which lies at an altitude of over 6000 feet, the winters are very severe; the snowfall is heavy and strong winds drift the snow into deep banks. During winter and early spring it is often very difficult to keep the roads open. The summers are comparatively warm and dry, though even then occasional showers occur. Large snow banks frequently remain throughout the summer on the eastern side of Florida and War Eagle mountains.

Vegetation.—The Snake River Plains and the higher plateaus on the western and eastern sides of the quadrangle are exceedingly arid and are covered with a scanty growth of sagebrush and other desert plants. Along Snake River the country is especially barren, and long ridges of bare white or gray lake beds rise with almost blinding glare above the sagebrush-covered lower plain. The

narrow bands of black basalt exposed in the bluffs on the north side of the river contrast vividly with the light-colored sediments and produce a weird and desolate picture. The banks immediately adjoining the river and the islands in the streamway are covered with grass, but no trees grow along the river bottom. The slopes and summit of the Owyhee Range are covered with a growth of nutritious grass, which is often luxuriant, but arboreal vegetation is very scarce; a few cottonwood trees grow along the creeks, and on the higher ridges there are scattered patches of gnarled juniper, pine, and mountain mahogany. It is said that the summits of the ridges were formerly fairly well covered with timber, but this has been cut so extensively for fuel in the mining districts that practically none remains.

Culture.—Silver City, the county seat of Owyhee County, is located in the southern part of the quadrangle and has a population of about 600. A few miles west of Silver City is the town of De Lamar, and a small place, Dewey, is located about halfway between them. The main road from Nampa to Silver City traverses the quadrangle and crosses Snake River at Walters Ferry. The road from Caldwell to Silver City crosses Snake River in the Nampa quadrangle and continues southward along the eastern boundary line of this quadrangle. A railroad connects Nampa with a small settlement on Snake River called Guffey. It is the intention to eventually extend this road to Silver City. A good road leads from Silver City across the range down to Sinker and other settlements on the Snake River Plains.

The principal industry is gold and silver mining, which has been carried on successfully since 1863 in the vicinity of Silver City and De Lamar. More extended notes regarding this district are found below, under the heading "Economic geology."

Though the region is well adapted for a stock range, yet there are but few cattle in the mountains. For many years the Owyhee Mountains have been utilized principally as a sheep pasture, and the headquarters of this industry are in the central valley of Reynolds Creek.

Agriculture, chiefly confined to the raising of alfalfa, is carried on at various places but is limited by the lack of water. The warm climate and fertile soil of Sinker Creek Valley and certain parts of Snake River Valley are well adapted to the raising of fruits and vegetables. That part of the Snake River Plains that lies northeast of the river is not under cultivation; and it would be very difficult to bring water to it. Small areas near Walters Butte are irrigated by large springs. At the point where Squaw Creek and Reynolds Creek emerge from their canyons their waters are diverted and utilized on many small ranches. There are considerable areas on the south side of the river which could be watered to good advantage were it practicable to take a ditch from Snake River higher up in its course. Many acres are under cultivation in Reynolds Valley, in the center of the quadrangle.

Rich and fertile lands are irrigated in a narrow strip along the bottom lands of Sinker Creek, and there are a few stock ranches along the lower course of Cow Creek. The main part of the mountains is too rugged and has too severe a climate to be adapted to agriculture. No exact data are available as to the amount of irrigated land in this quadrangle, but it is probable that it does not exceed a few square miles.

GENERAL GEOLOGY.

GEOLOGIC HISTORY.

The mapping of the Silver City quadrangle was undertaken in connection with the study of the mineral deposits of that region, and the broader features of dynamic and physiographic geology may therefore have received less attention than they deserve.

Before a detailed description of the formations is given it is desirable to present a brief review of the principal events that have taken place in the geologic history of the Snake River Valley.

The old Snake River Valley.—The present valley stretches across the whole width of southern Idaho in a broad curve that opens toward the north and has a radius of about 160 miles. The length of the valley from the base of the Teton Mountains in Wyoming to near Weiser, where the river enters a deep and narrow canyon, is over 400 miles, and its width ranges from 35 to 125 miles. The mountains of central Idaho clearly define the limits of this valley on the north, while its southern border in places merges into the lava plains and Quaternary silted valleys that separate the desert ranges of southern Idaho. For a long distance below Weiser Snake River has cut through older rocks a very deep and often very abrupt canyon which usually is referred to as the great Snake River Canyon. This continues to a point above Lewiston, whence the river pursues its way to its junction with the Columbia in a trench of lesser depth, cut in lava of early Tertiary age—the Columbia River lava.

During early Tertiary time the valley must have formed a broad and deep depression, north of which the mountains of central Idaho rose with an abrupt scarp, very probably due to faulting. Toward the south rose narrow, isolated mountains, like the Owyhee Range, with abrupt, deeply eroded outlines and the general trend and character of the desert ranges of the Great Basin, of which, in fact, they are the most northerly outliers. The whole indicates an early Tertiary or pre-Tertiary fault differentiating the central Idaho mass from the area of fractured and dislocated blocks lying farther south. Both the northern mass and the southern ranges were of granite, to which, according to observations made on Wood River and in the Blue Mountains¹ a post-Carboniferous and most probably post-Triassic age should be ascribed. From analogy with other similar granite areas in Montana and California this intrusion may very likely be assigned to the Cretaceous period. No lava flows had yet covered the eroded flanks of the granite mountains. The main rivers of central Idaho, such as the Boise and the Payette, had already been developed and had eroded their canyons to a depth as great as or greater than their beds of to-day. That this deep valley had an outlet to the sea seems probable from the fact that in its great canyon below Lewiston the Snake runs for long distances over basaltic bed rock and that its walls consist largely of flows of the Columbia River lava. This being so, it most probably follows that a large part of this region has been depressed since the eruption of the lava, for the depth of the valley sediments, as ascertained by borings in this quadrangle, is over 1000 feet. Near Weiser (elevation, 2100 feet) the depth of the lacustrine sediments, as proved by borings, is more than 1200 feet. Early Tertiary time, just before the deposition of the lake beds, was a period of active erosion and but little sedimentation, and even assuming that the above figure represents the deepest point of the valley (which is not probable) it would place the bottom only 1000 feet above sea level.

First lava flows.—At some time during the early part of the Tertiary great changes took place. The flanks of the Owyhee Range, the western part of the Boise Mountains, and the Blue Mountains became flooded by lavas, at first by diabasic basalts and rhyolite flows of limited extent, then by basaltic outbursts of immense volume. These basalts are usually referred to as the Columbia River lava, and the bulk of them has been considered as of Miocene age. As most of the older basalts in this region antedate the lake beds, and as the older lake beds have been recently rede-

¹ Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3; and Twenty-second Ann. Rept., pt. 2.

mined as Eocene, it would follow that a large part of the Columbia River lava in this portion of Idaho is of early Eocene age.

Earlier lake epoch.—The effect of the accumulation of these masses of lava was a damming of the upper drainage basin of Snake River. Our knowledge of this region is not yet extensive enough to enable us to decide without doubt just where this barrier was thrown across the older drainage lines, whether at Deschutes Gap or across an old and deep depression approximately following the present great canyon. At all events, a great interior basin was formed and rapidly filled with sediments from the central granite area of Idaho. While the outpouring of the main mass of lava evidently must have preceded the deposition of the lake beds, the eruptions continued during the earlier part of their accumulation, for tuffs and basalt flows are intercalated with the lower part of the lake beds. In the lake beds, especially near the shore lines, in bays and basins, abundant plant remains are found, which were first determined by Dr. Knowlton as of late Miocene age. A revision of the material has lately led him to consider them as Eocene and as equivalent to the Bridge Creek beds of the John Day Basin in Oregon. The flora gives evidence of a moist and warm climate.

Until the whole region is studied in greater detail it is not possible to indicate with certainty the exact contour of the lake. Along Boise Ridge the lake beds reach an elevation of 4600 feet; at the mouth of Boise Canyon they rest against the granite at an elevation of 4100 feet; on the western side of the Owyhee Range they lie at 5400 or 5500 feet; and on the eastern slope of the same range at 4200 feet. In many places, of course, erosion has carried away the highest beds, but it seems probable that slow crust movements have deformed the once horizontal line of highest lake deposits. A small remnant of waterlaid (Eocene?) deposits containing leaves of *Sequoia angustifolia* has been found on the slope of Wood River Valley 100 miles east of Boise, at elevations up to 6900 feet. This deposit seems to belong to the Payette lake beds and if so confirms the theory of considerable crust movements, consisting of a gradual uplift of the eastern part of the valley. Within the central mountain mass and not far from the border of the lake north of the valley smaller depressions are often found—such as the Idaho Basin in Idaho, the Mormon Basin and Rye Valley in Oregon—which clearly represent local depressions outlined by fault lines and which are usually filled with lacustrine sediments.

These sediments, of early Tertiary age, have been called the Payette formation, and because of its plant remains this formation is one of the few in this region whose age can be determined with fair certainty.

Erosion epoch.—Given a moist climate and no further orographic change and the lake could not long remain a closed basin. An outlet was formed along the line of the present great Snake River Canyon. The reasons determining this line of drainage across elevations that in places now exceed those of the highest known shores of the lake in this vicinity can not, at this stage of our knowledge, be accurately stated. It is probable, however, that the area through which the great canyon runs has been subjected to gradual uplift or warping since the river's course was established, and that erosion has kept pace with the uplift. If so, Snake River below Huntington is of antecedent character.

The erosion of the great canyon was most energetic, and during Miocene time a depth of from 2000 to 4000 feet was attained. The lake was drained, a large part of its deposits carried away, and the tributary rivers, prominent among which is the Boise, had scoured their old canyons to about the same depth that they have to-day. As the lake receded fluvial deposits spread over the lake beds in places. Of such character are, for instance, the great gravel beds that form the upper part of the Payette formation near the mouth of the Boise River Canyon. There is no evidence of volcanic action in this region during this epoch of erosion.

Later lake epoch.—The progress of erosion in the valley was checked at this time by some cause, as yet unknown. While degradation was still in active progress in the adjacent mountains, heavy masses of gravels began to spread out in front of

the tributary rivers, and the central part of the valley along Snake River again became a lake, probably shallow and marshy at times. A number of thin and very fluid sheets of basaltic lava poured down from the lower flanks of the Owyhee Range, from the foothills of the granite area north of the valley, and from numerous points of eruption within the valley itself, southeast of Nampa. These, one after another, became covered by sandy sediments, and thus originated the striking alternation of white lake beds and black basalt flows so well exposed in the deep trench which Snake River in Quaternary time has cut for a long distance above Walters Ferry.

In the vicinity of Nampa the later lake beds and basalt filled the valley up to elevations of 2700 or 2800 feet, and the sediments contain numerous bones of mammals and of fishes. Especially common are bones of *Egus*; also, those of *Mastodon*. Plant remains either are missing or, when present, indicate a flora consisting principally of grasses.

The age of the scant fauna has been determined as Pliocene by Professor Lucas and the name Idaho formation has been given to these beds. Similar beds of alternating sands and basalt flows extend at least 100 miles up Snake River Valley from the point where the Boise joins the master stream. At Glens Ferry these deposits reach an elevation of 3700 feet along the brink of the Snake River Canyon. If they really are lacustrine, which seems almost certain, these relations would again indicate a tilting movement by which the beds at Glens Ferry have risen nearly 1000 feet relatively to those near Walters Ferry.

For practical purposes the Tertiary lake beds form one continuous series, for it is not always possible to separate with certainty the deposits of the Payette formation from those of the Idaho.

Recent lava flows.—The highest basalt flow covering lake beds in the central part of the valley, in the Nampa and Silver City quadrangles, and the highest basalt flow at the mouth of the Boise Canyon are taken as the datum plane separating the Pliocene epoch from the Quaternary period. It marks the beginning of the present period of erosion and degradation of the whole valley. In the upper part of the valley, from American Falls to Walters Ferry, the Quaternary was a period of erosion, for during that time the deep trench of Snake River was cut through lake beds and basalt flows. This canyon is still being deepened. From the vicinity of Nampa down to the great canyon Quaternary erosion was very slow, because of the large masses of debris brought down by tributary rivers. The gradually deepening channels are lined by a terrace, or a series of terraces, remnants of old flood plains over which the rivers swung in changing curves and for a long time cut their banks in a lateral direction only.

Résumé.—Summing up the Tertiary history of deposition and erosion in this basin, we have first an early Tertiary epoch of erosion followed by outbursts of rhyolite and basalt and the deposition of the Payette lake beds, which, near the margins of the basin had a thickness of probably about 2000 feet. The fossil leaves of this formation are now regarded as Eocene, and as the same flora has been found at several levels throughout the series the whole of the Payette formation should be assigned to the Eocene epoch. The deposition of the Payette lake beds was followed by an apparently short and active epoch of erosion, during which the rivers cut down through the lake beds to the same depth that they have to-day. Causes as yet undetermined checked this erosion and produced a lake of smaller dimensions and shallower depth than the Payette sheet of water. In this shallow lake the beds of the Idaho formation were deposited in alternation with basaltic flows. The fauna of the Idaho formation is assigned to the Pliocene epoch.

The draining of this lake is considered to close the Tertiary period. Since then this region has been dry land, and a slow, frequently checked erosion has cut into the lake beds and deposited extensive areas of Quaternary sand and gravel.

It should be noted that on the former assumption of a Miocene age of the Payette formation this history fitted in well with the paleontologic sequence. Accepting, however, the latest determination of the Payette formation as Eocene, there remains a long time-interval—the whole of the Miocene epoch—to be accounted for between the

Eocene and the Pliocene, and this would seem to be somewhat inadequately represented by the epoch of erosion between the two series of lake beds. The excavation of the great Snake River Canyon below Huntington would, according to these last data, be placed in the Miocene and would occupy the larger part of that epoch. The Upper Canyon, above American Falls, was cut during the Quaternary period.

GEOLOGIC FORMATIONS.

PRE-TERTIARY ROCKS.

GRANITE.

Main granite mass.—Along the center of the Owyhee Range occur several detached exposures of granitic rocks which, taken together, form a belt 10 miles wide by 25 miles long, extending from a point near Silver City as far north as Hardtrigger Creek, at which place it contracts to a small width. These detached areas were evidently once connected as a single granite range which, as shown by the sections, had a depression along the central north-south line. This range has since been cut by dikes and largely covered by lava flows and lake beds. On neither side of the granite can any indication of faulting be observed, but it is plain that at the beginning of the Tertiary this ridge, rising with steep slopes to a height of 8000 feet, must have formed a conspicuous feature in the landscape. If this block were outlined by faulting, as is very probable, it would not be likely that any evidence of this would be preserved at the present time, for the fault lines would lie at the bases of the range, which now are deeply covered by later deposits and lava flows. Granite is exposed in places for a long distance south of Silver City. Twenty miles south of this place, at South Mountain, a dioritic granite abuts against greatly contact-metamorphosed schists and limestones of doubtful age. Within the Silver City quadrangle no pre-Tertiary sedimentary rocks are associated with the granite except in one place 2 miles northwest of De Lamar. Here, below the lavas, is a small area of pegmatitic granite traversed by a belt, 150 feet wide, of quartz-biotite-schists and normal quartzites which, beyond doubt, are contact-metamorphosed sediments of unknown age. Tongues and stringers of granite penetrate the schist. The probable Cretaceous age of the granite has been referred to under the heading "Geologic history."

The topographic forms which the granite assumes are frequently long, sharp ridges separated by deep and narrow gulches. Occasionally large dome-shaped masses appear, like War Eagle Mountain. The rock is deeply weathered and shows fairly well-defined jointing. Masses that have resisted disintegration usually rise above the general surface. A rough sheeting is common in many places, but its direction is not constant. About Silver City the strike of the sheeting varies from N. 70° E. to N. 70° W. On Wilson Creek there is a well-defined sheeting striking N. 20° W. and dipping northeast.

Most prevalent is a coarse-textured, gray biotite-granite, containing at most of its exposures large crystals of orthoclase. The variations are mainly in texture and in the relative amount of biotite, quartz, and feldspar. It often contains much oligoclase and may in part be closely allied to the quartz-monzonites.

In the vicinity of Silver City the rock appears to contain more orthoclase and muscovite than elsewhere, and is thoroughly normal. It is decidedly more acid than the ordinary granite from the mountains north of Snake River, but is very similar to the rock from the Warren mining district in Idaho. The average grain is 4 millimeters, though larger porphyritic feldspar crystals reach 3 centimeters in diameter. As seen under the microscope, it contains abundant, often slightly crushed interlocking quartz grains. Smaller quartz grains may be included in feldspar crystals. Muscovite is always present in the Silver City variety as large, straight foils and is not uncommon elsewhere. Biotite is an essential constituent, frequently decomposed to chlorite. Orthoclase is abundant and a few grains of microcline also occur. A plagioclase with narrow striation and thick prismatic form, rarely showing Carlsbad twins, is never absent, but appears in varying quantities; it is sometimes rimmed with a little micropegmatite. The optical determinations were not satisfactory, but it is in all

probability oligoclase. The feldspars show some secondary muscovite and in places a little calcite. A few crystals of zircon were noted. The granite weathers easily, covering the ridges with a coarse sand.

Pegmatite dikes in the granite.—Though on the whole constant in type, the granite occasionally becomes coarse and almost pegmatitic, and may be traversed by dikes of still coarser pegmatite, which locally may consist chiefly of quartz. These quartzose pegmatite dikes contain no valuable minerals and bear no relation to the metalliferous veins. On the Oso claim, War Eagle Mountain, at the mouth of Sailor Jack tunnel, the rock is locally a medium-grained diorite, but this may be a later intrusion.

Diorite-porphry and granite-porphry dikes.—These rocks occur chiefly on War Eagle Mountain as dikes varying from a few feet to several hundred feet in thickness, trending from north to east, and sometimes parallel to the sheeting or jointing of the granite. Prominent exposures are seen at the Oro Fino vein on the east side and the Poorman vein on the west side of War Eagle Mountain. The dikes occasionally follow the veins for a short distance, but more commonly cut across them. The rock is grayish green and porphyritic, with feldspars up to 2 centimeters in length, and quartz crystals up to 5 millimeters in diameter. The feldspars are mostly oligoclase or andesine; the ferromagnesian silicates consist of altered biotite and augite; the groundmass is microcrystalline, consisting of quartz and unstriated feldspar. On the whole, the type is similar to the porphyries described from near Quartzburg, Boise County. No analysis has been made of this rock and it is very possible that it may be intermediate as to its composition, standing between a diorite-porphry and a granite-porphry. Such rocks are called monzonite-porphry or granodiorite-porphry. The porphyries of War Eagle Mountain are usually filled with secondary chlorite, sericite, calcite, and sometimes pyrite.

TERTIARY ROCKS.

LAKE BEDS.

Extent and character.—On the north, east, and west sides of the Owyhee Range extend sloping plateaus of almost horizontally bedded sediments which by their various features show that they were, for the most part, deposited in a large body of fresh water. The evidence of their lacustral origin is found in the persistently fine-grained character of the strata, the absence of cross-bedding, such as would indicate strong currents, and in the frequent occurrence of gypsiferous sands. Fluvial deposits were naturally formed in many places contemporaneously with the recession of the lakes, but they are of less extent and importance than the lake beds. These lake beds were laid down on the sloping sides of the old granite areas and also covered the heavy masses of basalt and rhyolite which had been poured out over the flanks of the granitic range. The lake beds are thus on the whole clearly later than the basalt and rhyolite, and the latter was in places eroded before their deposition. Occasional eruptions of these rocks may, however, have taken place during the first period of their deposition. Distinct from these older eruptives and decidedly later are a few thin basalt flows, which, in the northeastern part of the quadrangle, are intercalated in the uppermost strata of the lake beds. The sediments consist predominantly of sandy material, consolidated to a greater or less extent; but they also contain subordinate bodies of clay and volcanic tuffs. Usually the rocks are only slightly consolidated, but some of the older lake beds and occasional exposures of the younger series are indurated to compact, hard sandstones. The lake beds, which together occupy nearly one-half of the quadrangle, are naturally subdivided in three groups: (1) The high lake beds on the western side of the quadrangle; (2) those of the interior basin of Reynolds Creek; and (3) those of Snake River Valley, which cover the whole northeast corner and gradually rising, reach as far as the southern boundary line.

Lake beds of the western part of the quadrangle.—On the western side of the quadrangle the rocks consist of white shales, sandstones, and compact clays. In general, the rocks are finer textured and more consolidated here than elsewhere, and they

also extend higher up on the mountain side, reaching an elevation of about 5300 feet, their uppermost limit being most clearly indicated along the valley of Cow Creek. Here the fine-grained and well-stratified lake beds cease at this elevation, and the upper, gradually narrowing valley is filled with fluvial gravels. The lake beds dip gently to the west and to the northwest, their surface evidently representing the old lake bottom. Much of the surface has been destroyed by the erosion of Succor, Jackson, and Cow creeks and their tributaries. Trenches have been cut in the lake beds to a depth of 700 feet, but the mesas left between the watercourses show plainly that erosion has not lowered the general surface of the beds.

In the upper part of the lake beds, one-fourth of a mile northeast of Rockville, the following fossil plant remains were found: *Acacia*, pod; *Quercus* sp.; *Acer*, fruits; *Ulmus* sp.

Near the crossing of Succor Creek by the stage road from Caldwell to Jordan Valley, very near the State line, and at an elevation of 4800 feet, an extensive flora was found in the horizontal lake beds. The matrix is a pure white, fine-grained sandstone; partly, also a brownish clay shale. These beds are identical with the Payette formation in the Boise quadrangle. Occasionally mammalian remains occur in these strata but not frequently as compared with their occurrence in the beds in the Snake River Valley.

The following fossil plants were identified:

<i>Sequoia angustifolia</i> Lx.	<i>Platanus</i> sp.
<i>Alnus carpinoides</i> Lx.	<i>Celastrus</i> sp.
<i>Quercus sinuata</i> Kn.	<i>Acer trilobatum productum</i> ?
<i>Quercus consimilis</i> Newby.	Heer.
<i>Quercus idahoensis</i> Kn.	<i>Acer</i> , fruits.
<i>Quercus</i> , two new species.	<i>Ilex</i> n. sp.
<i>Castanea ungeri</i> Heer.	<i>Juglans nigella</i> ? Heer.
<i>Platanus dissecta</i> ? Lx.	<i>Pteris</i> n. sp.

These fossils were held by Dr. Knowlton to indicate a late Miocene age, and the geologic discussions in previous reports on the mining districts of Silver City, De Lamar, and the Idaho Basin were based on that determination. A revision of the Tertiary plants from various places, has, however, lately caused Dr. Knowlton to change his opinion, and in Bulletin U. S. Geological Survey No. 204, p. 110, he expresses himself as follows:

In a previous report¹ the Payette formation was referred to the Upper Miocene, but I was misled by the knowledge then current regarding the position of the Bridge Creek beds, as I have already pointed out, and it is now necessary to change that reference. The flora of the Payette formation undoubtedly finds its greatest affinity with that at Bridge Creek, a fact recognized all along, and, like it, is now referred to the Upper Eocene.

Lake beds of the interior basin.—The interior valley of Reynolds Creek, in the center of the range, was clearly formed by the damming of the creek's former outlet by basalt and rhyolite flows. During Payette time the basin was filled with sediments which, for the most part, are clearly lake beds. The strata extend up to an elevation of 4300 feet, or 500 feet above the bottom of the valley. The upper 100 feet consist principally of soil, sand, and pebbles, below which lie white or light-colored tuffaceous sands, tuffaceous clays, and occasional strata of fine conglomerates. Beds of impure lignite 2 or 3 feet thick have been found at a few places in the basin. No lavas cover these lake beds, but as the beds at considerable depths are in part composed of pebbles of granite, basalt, and rhyolite, it is evident that they are later than any of the igneous rocks around the basin.

Lake beds in the Snake Valley.—On the eastern side of the range the conditions are different. Though the beds here are on the whole similar to those on the western side, they are less indurated and consist of very soft, brilliantly white sandstones, changing in places to compact, gypsiferous clay. In a few places, as near Walters Butte and Bernard Ferry, the strata contain gravel beds and fluvial sand. Along Snake River the sandstones are interbedded with soft, black, basaltic flows which evidently were very fluid when erupted, and which spread out over large areas as thin sheets. These beds, along Snake River, contain no fossil leaves but do hold occasional carbonized grasses and silicified wood. Fresh-water shells are also common. The following fossil localities were noted:

Three miles west of Guffey; elevation 2500 feet;

¹ Eighteenth Ann. Rept. U. S. Geol. Survey, pt. 3, pp. 721-744; pls. xcix-cii.

Silver City.

porous sandstone with much detritus of shells. The following were determined: *Unio*, *Anodonta*, *Goniobasis*, *Ancylus*, *Corbicula*, *Lithasia antiqua* Gabb; also many fish bones. One mile west of Bernard Ferry; elevation 2800 feet; banks of *Unio* shells in soft sandstone. Though they indicate fresh-water conditions these fossils justify no more definite conclusion than that the deposits are of either Miocene or Pliocene age.

Though indistinct and silicified mammalian remains are not uncommon, few well-preserved bones have been found in the beds in this quadrangle. Near Sommercamp ranch, at an elevation of 2400 feet, bones encrusted with opal were found in sandstone and identified as *Protophippus*, a Miocene or Pliocene genus. In the adjoining Nampa and Bisuka quadrangles mammalian remains, principally *Equus*, are frequent in these same beds. The beds generally occur at a low elevation, rarely extending up to 3000 feet.

Recent borings to the depth of a little over 1000 feet along Snake River between Guffey and Enterprise have shown that this thickness of clayey and sandy beds underlie the surface. The borings disclosed no lavas. The predominantly clayey character of the beds is noteworthy as contrasted with the mostly sandy marginal deposits of the lake.

If there had been only one period of deposition in the lake-bed series, these deposits would certainly have been formed earlier than the Miocene plant beds of Rockville and Succor Creek. That this can not be the case is shown by the different petrographic character and decidedly later fauna of the Snake River beds; besides, the basalts intercalated in the series along Snake River are unmistakably later than the Miocene basalts of the Owyhee Range, and, as has been shown in the text of the Nampa folio, connect with the basalt flows in the Boise Canyon, which were poured out after the deep erosion of the Payette lake beds. Therefore, it is concluded that after this erosion a second transgression of the waters of the inland lake took place and filled the central part of Snake River Valley. The lake was probably shallow; at times it may rather have been a marsh. The earlier beds on the west side of the quadrangle have been referred to the Eocene (Payette formation), while the beds along Snake River up to an elevation of, roughly speaking, 3000 feet, probably belong to the Pliocene (Idaho formation). On account of the similarity of the deposits and the absence of well-defined shore lines, it is not possible to differentiate these two formations by separate colors on the map.

The beds along Snake River gradually attain higher elevation southward along the eastern boundary line of the quadrangle, and near its southeast corner reach an altitude of 4200 feet. Unless changes in elevation have taken place it is probable that these southeastern beds belong to the Payette formation, but no fossils have been found in them, and no distinct line can be drawn differentiating them from the beds exposed near Snake River. On the slopes of the Boise Range the lake beds reach an elevation of 4600 feet, while on the western slope of the Owyhee Range the shore line is clearly indicated at 5200 or 5300 feet; on the more sharply eroded eastern side of the Owyhee Range they attain a height of only 4200 feet. It is not impossible that slow changes of level have taken place since their deposition, so that the shore line of the Payette lake is no longer horizontal, but the evidence of such change is not yet clearly established.

Detailed description of lake beds.—On the western side of the range a large part of the lake deposits are white or slightly yellowish sands, possibly in part tuffaceous. The clays are at some localities decidedly yellowish, but at others they are brownish or greenish-brown. The brownish clays are usually lignitic and the greenish-brown clays and sands appear to be in part basaltic tuffs. Gritty sandstones, generally micaceous, are common. Conglomerates occur also, but they are rarely coarse, and consist chiefly of granite pebbles, except near the old shore line, where fragments of rhyolite and basalt enter into their composition. Diabasic basalt in a few places breaks through the lower part of the lake beds and spreads out in sheets near the top of the series. Silicified and opalized wood is common. The small basin of Jump Creek, north of Rockville, is also filled with lake beds, which are tilted so that the beds dip slightly northeast,

those on the northeastern side of the basin being about 200 feet lower than those on the southern side. Surficial deposits of gravel connect the deposits of Jump Creek with the main area near Rockville.

On the east side of the mountains the plains gradually descend from an elevation of 4300 feet, with a slope of about 100 feet to the mile. At several places 1 to 3 miles south of the mouth of Sinker Creek Canyon, at an elevation of 3500 feet, are deposits of well-stratified white sand, similar to the ordinary lake beds.

On the north side of Rabbit Creek the lake beds lie against the Owyhee Mountains at an elevation of 3800 to 3900 feet, and form an almost level table that extends out 2½ miles from the foot of the mountains, with a slope of 100 feet to the mile. From Rabbit Creek northward the beds present the peculiarities briefly alluded to above in the general description, and the basalt flows that lie north of this point are interbedded as narrow sheets with the light-colored sand.

About 3 miles west of Guffey, and 1 mile west of Snake River, at an elevation of 2500 feet there are coarse-grained, thick-bedded strata of brownish sandstones that have a maximum thickness of 75 or 100 feet. These sandstones are highly fossiliferous in places and contain the fauna described above. The beds are nearly horizontal and rest slightly unconformably on white, micaceous sandstone, the ordinary rock so characteristic of the lake beds. These sandstones lie about 200 feet above the river and are clearly remnants of more extensive deposits. On Castle Creek, in the Bisuka quadrangle, adjoining on the east, there are similar sandstones, which also are fossiliferous, and which, like those just described, should probably be considered as among the very latest deposits of the Pliocene epoch.

A section from the river to the top of Walters Butte would show the following succession:

The first 50 to 100 feet above the river are occupied by fine-grained, sandy lake beds. Above these is the first basaltic flow, approximately 100 feet in thickness. This basalt flow does not appear to lie quite level, but slopes slightly southeastward. At a place 1½ miles northwest of Walters Butte is a small outcrop of this flow, resting directly on a level floor of fine gravel that carries a large amount of water. Along the west side of Walters Butte, 200 or 300 feet of sediments lie above the first basalt flow. The lower part of these sediments consists of normal sandy lake beds, but the upper 50 feet are made up of coarser sediments, sandstones, and fine conglomerates, in places showing cross bedding and clearly of fluvial origin. This upper series occurs at an elevation of 2600 feet, and is probably equivalent to the fossiliferous sandstones found 3 miles west of Guffey. On top of these sediments rest 50 feet of tuffs, mingled to some degree with coarse sediments, and finally capping these tuffs, there are 100 feet of basalt, which forms the top of the butte. Farther back, east of the butte, a third flow appears, which is separated from the second by sandy lake beds and attains a thickness of 100 feet.

In the vicinity of Bernard Ferry and Enterprise the beds consist predominantly of white, sandy sediments, forming bare mesa-like hills which, with a gradual slope, extend up to the foot of the mountains—that is to a maximum elevation of 2900 feet. On the northeast side of the river the beds form a continuous bluff 500 feet high, capped by a sheet of black basalt not exceeding 75 feet in thickness. These lake beds and the basaltic flow covering them underlie a large part of the mesa that extends northward from the river.

The lake beds near Bernard Ferry form white, irregularly eroded bluffs of soft, unconsolidated sand. As a rule, the stratification is very indistinct, but where the outcrops are more compact, clear lines of level stratification are exhibited. Wells that have been sunk near Enterprise in search of artesian water penetrate at first some sand, but the rock below that is reported to be a yellowish shale. In several places about a mile west of this locality there are small outcrops of basalts, which apparently break through the lake beds and sometimes disturb the horizontal strata. Gravels are not altogether absent, as is shown by a prominent bluff 1 mile west of Bernard Ferry, where, at an elevation of 2600 feet, a gravel bed

5 feet thick rests on white sands containing streaks of clay. The gravel is partly cemented and contains cobbles that range from 3 to 4 inches in diameter, consisting of rhyolite, granite, and other kinds of rock. Above this gravel are 4 feet of sandy beds with abundant casts of *Unio* shells, which again are covered by undoubtedly Pleistocene gravel. At the bluff on the mesa about 1 mile east of the mouth of Hardtrigger Canyon, the following section is shown:

Section at bluff 1 mile east of mouth of Hardtrigger Canyon.

	Feet.
Basalt, at top.....	10
Light, micaceous sandstone containing, near the base, a 2-foot stratum of diatomaceous earth.....	20
Light-yellowish clay sand.....	15
Volcanic sandstone.....	5
Yellowish-white sand, at bottom.....	25

North of Squaw Creek the lake beds attain great development and extend close to the river as broad mesas, with an elevation gradually sloping from 3000 feet at the base of the mountain to 2700 feet near the river.

A section of a bluff 3 miles west of the river and west of Sommercamp is as follows, the elevation at the base of the section being 2675 feet:

Section of bluff 3 miles west of Snake River, north of Squaw Creek.

	Feet.
At top, sand and gravel, probably Pleistocene, resting on the lake beds.....	14
Exceedingly well and evenly stratified light gray to buff clay, in thin beds and interbedded with many thin streaks of gypsum and gypsiferous sand.....	190

At the northern boundary of the Silver City quadrangle, on the east side of Snake River, the basal part of the escarpment shows 50 feet of coarse-bedded sandstones, which are covered by friable white lake beds.

Along the northern foothills from Poison Creek down to Bernard Ferry the lake beds contain coarse sediments and are partly consolidated where they overlie the rhyolite, as if by action of hot springs. A locality clearly showing this consolidation is at the contact of the rhyolite and the lake beds a little north of Wilson Creek. The sandstone in places contains rhyolite pebbles and shows stratification with a notable dip—from 10° to 20°. This dip soon changes to the normal—that is, a slight northeasterly inclination of about 2°. The belt of hardened sandstone is at some points a quarter of a mile wide. In places it seems to be older than the rest of the surrounding lake beds, but this is probably due to its greater induration. Occasionally this hardened sandstone is used for building purposes.

SUCCESSION OF ERUPTIVES.

The volcanic activity in the Owyhee Range began by the eruption of diabasic basalts in heavy flows, confined chiefly to the southern end of the range. Then followed rhyolite flows of very great volume, which in turn were succeeded by a large volume of basalts, in part diabasic, but usually more glassy and more thin bedded. Intrusion of dacite dikes closed this earlier volcanic epoch. These rocks antedate the Payette lake beds and are therefore to be considered as early Eocene if the determination of the Payette formation as Eocene be accepted.

Finally, during the Pliocene epoch, glassy basalts of great fluidity were again forced out, and this late activity may in certain parts of the Snake River Valley have continued into the beginning of the Quaternary period.

RHYOLITE.

Main rhyolite flows.—Rhyolite occupies large areas in this quadrangle, areas about equal in extent to those covered by basalt. Heavy flows of this rock are found in the northwest corner of the quadrangle and along nearly the whole of the southern boundary line. These two large areas almost connect by means of smaller detached flows along both the western and the eastern slope of the range. Thus it is seen that the rhyolite surrounds, as it were, the central part of the mountains. Large areas of this rock have been removed by erosion, so that its former extent was much larger than that seen to-day. The rhyolite was one of the earliest eruptives, but was preceded by some coarse diabasic basalts and was followed by the main

mass of basaltic eruptives. The rhyolite, which is a lava that is rich in silica and alkalis, flowed over the earlier basalt and over the granite in thick, viscous masses. It was poured out upon an irregular surface and moved slowly, so that its thickness is extremely variable from place to place. In the northern area its thickness reaches 1500 feet. On Florida Mountain it is 1200 feet deep, and on Cinnabar Mountain it rises in precipitous bluffs just outside of the southern boundary of the quadrangle, not far from War Eagle Mountain, with a total thickness of about 2000 feet. Where the rock is fresh its surface forms are characterized by rough plateaus bordered by abrupt and rocky bluffs, and the faces of the cliffs often present a rough columnar structure. Where softened by alteration the rock forms long, sloping ridges, such as Florida Mountain.

In appearance the rhyolite is very similar to that seen in most of the areas of that rock found in the West. It is compact, hard, and very resistant to weathering; more rarely it is vesicular, and is then generally filled with amygdulæ of opal. Its color is grayish, greenish, yellowish, or brownish in different shades, varying greatly and abruptly. A spherulitic structure is locally common, the spherulites often being 2 to 3 inches across. Sometimes, as in the small rhyolite area 3½ miles west of Flat Top Mountain, the spherulites form almost the whole mass of the rock. A streaky and banded appearance is very common. Along Cow Creek the glassy and the flow-structure rhyolites are often intermingled with wavy layers of reddish rhyolite that run irregularly through glassy magma. The rock often breaks into shelly, flat pieces on weathering. Brecciated rhyolites and tuffs are of frequent occurrence. Near the mouth of Reynolds Creek a thickness of 200 feet of light-colored tuffs rest upon granite and are capped by a heavy rhyolite flow.

Practically all of the varieties belong to the structural group comprising felsophyric rhyolite. Porphyritic crystals are represented by small sanidines, and by occasional, though not abundant, quartz grains. Biotite is seldom noted, although partially resorbed crystals of that mineral are sometimes seen under the microscope. The groundmass is nearly always cryptocrystalline, is frequently filled with small spherulites, and shows a banded structure of alternating lighter and darker brownish streaks. Pure rhyolite glass occurs in specimens from the small area 4 miles east of Dewey. More rarely is the rhyolite microcrystalline in structure. Rock of this type is found in the small area 4 miles east-southeast of Rockville. Its appearance, owing to the dark color of the rock and its dense texture, is not unlike that of certain basalts. This variety contains a few larger orthoclase crystals, smaller and rounded grains of andesine in a groundmass of feldspar grains, and micropoikilitic quartz. A specimen of this rock was partially analyzed.

Partial analysis of microcrystalline rhyolite.

	Per cent.
Silica	76.35
Lime	0.28
Potash	3.87
Soda	3.94

Over large areas near De Lamar and on Florida Mountain hydrothermal alteration has so affected the rock that it has become soft, earthy, or silicified, or filled with pyrite.

Rhyolitic dikes.—Not many rhyolite dikes can be found in the vicinity of the large areas, some being doubtless covered up by later eruptions, but in a few places the vents through which the rock was erupted are exposed. One of the most interesting of these vents is the neck in granite 1½ miles above Dewey, on the road leading to Silver City. In cross section it is roughly triangular, with sides about 1000 feet long, and was probably one of the main vents for the eruption that covered Florida Mountain. Dikes of rhyolite are visible at several places on War Eagle Mountain, the largest being about 40 feet wide and having strikes ranging from east to north. Rhyolite dikes breaking through basalt are exposed near the contact of the two rocks north of the Trade Dollar mine. Near the head of Succor Creek, below Rooster Comb Peak, a rhyolite dike from 50 to 100 feet wide breaks through granite. Its trend is northwestward, and it is traceable for at least 1500 feet.

Along the divide between Cow Creek and Succor

Creek many rhyolite dikes break through basalt and rhyolite. The largest of these is 50 feet wide. They have a general strike of N. 25° W., and one of them is traceable for 2 miles.

The rock of these dikes, in whatever part of the quadrangle they may occur, is usually light gray and has conspicuous phenocrysts of quartz scattered through it. Biotite is rare or absent. The groundmass is much more uniform than that of the rhyolite flows and consists of a microcrystalline mixture of quartz and unstriated feldspar. Numerous quartz crystals and a few small grains of orthoclase are contained in it.

Dacite dikes.—In a few places in the Owyhee Range there are dikes that belong to a family of rocks which is not elsewhere represented in the region. One of them occurs on the west side of Hardtrigger Creek, about 5 miles from the mouth of the canyon, at an elevation of 3600 feet. This dike is 10 feet wide and 1500 feet long, striking N. 15° E. About one-fourth of a mile farther down the creek is a larger dike of the same kind which forms a crescent-shaped mass that is 150 feet wide at its widest part. The first dike is evidently an offshoot from this. A third dike of smaller size was noted at an elevation of 3600 feet on the east side of the creek. All of these break through the older (Eocene?) basalt.

Near the head of Squaw Creek, 1 mile south of Keiths ranch, a small dacite dike cuts basaltic flows. Still another dike breaks through the granite 4 miles east of Dewey. These dikes are believed to represent the youngest of the early Tertiary (Eocene?) series of igneous outflows. The rocks have a trachytic appearance, light-gray to brownish color, and contain small phenocrysts of orthoclase, andesine or labradorite, biotite, and hornblende, in a very fine-grained microcrystalline groundmass of quartz and feldspar. The hornblende usually appears in prismatic, greenish-brown crystals, and the feldspars, though smaller, are equally well developed. An analysis of one of these rocks, the one that outcrops 4 miles northwest of Flat Top Mountain, gave the following result:

Analysis of dacite of dike near Flat Top Mountain.

	Per cent.
Silica	67.37
Lime	3.40
Potash	2.19
Soda	4.01

The rock is, therefore, most closely related to dacite. It should be noted that the chemical composition is nearly that of a granodiorite, although, of course, its structure is very different.

BASALT.

The basaltic flows of the quadrangle are very extensive and belong to several distinctly different periods of eruption. In the first place, the basalts that are older than the Payette formation should be separated from the thin and liquid flows interbedded with the sediments of the Idaho formation. To the former class belong nearly all of the basalts in the range proper; to the latter class belong those that occur in the lake beds in the northeastern part of the quadrangle and extend in patches to the southern boundary of the quadrangle.

Early basalt flows.—In the main Owyhee Range, there are a great number of superimposed flows of basaltic rocks, some of which have distinct characteristics. Generally speaking, the older basalts of these early flows have a diabasic structure and some of them are practically fine-grained diabases, while the younger part of the early flows belongs more clearly to the normal glassy basalts. Heavy eruptions of diabasic basalt certainly took place before the main eruption of rhyolite occurred; and this, again, was followed by another series of basaltic flows which were accompanied in places by large quantities of tuffs. This is not, however, a hard and fast rule, for occasionally diabasic basalts occur which are certainly later than the rhyolite.

The diabasic basalts occupy large areas around Silver City and De Lamar, and long ridges of these rocks extend northward through the center of the mountains, by Flat Top Mountain, to the vicinity of Squaw Creek.

Topographically these basalt areas form long, sloping ridges of dark-brown, somber color, relieved by patches of grasses and willows. The southern area, between Democrat and De Lamar, shows roughly terraced outlines, indicating the existence

of three or four heavy and distinct flows. The exposures show a thickness exceeding 1000 feet. Besides, a well 975 feet deep has been bored at De Lamar, all the way through black lava, so that the total thickness of the basaltic flow in this locality probably approaches 2000 feet.

The diabasic basalts are medium-grained to dense, black, or greenish rocks, composed of labradorite, augite, and ilmenite, with or without olivine. In structure they vary greatly. Most of them are holocrystalline and fine grained, the size of the grains varying from 0.5 to 2 millimeters; others are dense, sometimes vesicular, and contain more or less glass. The two kinds are connected by transitional forms. Near the Trade Dollar mine the rock contains large porphyritic crystals of labradorite. Under the microscope the holocrystalline varieties present the typical diabase structure, showing the development of lath-like feldspar crystals inclosed in large augite grains. Wherever the quantity of feldspar increases the augite will appear as a filling of triangular interstices between the laths. The former type prevails, as the rocks are very basic and ordinarily carry more augite than feldspar. In the varieties containing glass, this substance, which usually is of dark-brown color, is squeezed in between the grains. Transitions to normal basalts are formed by the appearance of increasing amounts of glass and by a reduction in the size of the feldspar crystals and augite grains.

The second series of basaltic flows are mostly developed on the west and east side of Reynolds Creek Basin and extend northward to Squaw Creek and Hardtrigger Creek. One flow, which is probably the most uniform in character, is that lying on the east side of the hills northwest of Reynolds Creek Basin and on the headwaters of Hardtrigger Creek. This flow is distinguished from the others by its comparatively light, dark-gray color, by its content of small amygdulæ of hyalite, by its weathering into splintery or shaly pieces, and by the absence of flow structure. Microscopically, this basalt is glassy, containing larger augite crystals in a groundmass of glass filled with minute feldspar needles.

Another marked basalt flow covers in part the south end of the area just described and forms a belt extending from near the headwaters of Succor Creek to Little Squaw Creek. On the western side this basalt overlies rhyolite. The rock weathers in shaly fragments and contains small white crystals of feldspar. Its microscopic character is similar to that described above; it is principally a normal basalt of hyalopilitic structure.

Many of the younger basaltic masses consist of a number of thin superimposed flows, differing in this respect from the thick beds of the diabasic basalts.

Later basalt flows.—The basalts intercalated in the Pliocene lake beds along Snake River and Sinker Creek differ considerably from the early basalts of the Owyhee Range. They are feldspar-basalts with a glassy groundmass with or without olivine, usually very vesicular, and have an extremely fresh appearance. Unlike the early basalt their amygdaloid cavities are rarely filled with secondary material, as opal or calcite. The thin flows are occasionally underlain by thin beds of basaltic tuff.

Basalt dikes.—Near Silver City several basalt dikes of interest were noted. One of these follows the Black Jack and Trade Dollar vein where it cuts through the granite below the rhyolite and basalt of Florida Mountain. This is a coarse-grained, diabasic rock and evidently formed one of the vents from which the basalts in this vicinity were extruded. Another dike of the same material crosses the road junction half a mile north of Silver City. Still another crosses Jordan Creek half a mile south of the town and clearly joins the basalt on the western side, extending northeastward into the granite for a distance of 3000 feet. In different places in the mountains there are dikes of basalts with glassy groundmass, which are believed to be of comparatively late age and the equivalent of the Pliocene eruptives found along Snake River. One of these, only about 10 feet wide, appears 1½ miles southwest of Flat Top Mountain and continues due north for 1½ miles, breaking through diabase. A small area of basaltic glass covers the summit of the ridge a short distance east of the road between Democrat and Dewey.

Tuffs.—Small deposits of tuffs, associated chiefly with diabasic basalts and the basalts proper, but also with the rhyolite, are widely distributed over the quadrangle. In the rhyolite areas a little tuff is in many places associated with obsidian and with brecciated flows, as near the head of Little Squaw Creek, on the north side of Jackson Creek Canyon, and on the north branch of Cow Creek. The tuff areas that are indicated by separate patterns on the map comprise only the large masses that can be easily differentiated, most of which were evidently derived from basalt. Large areas of tuffs are found immediately north of Flat Top Mountain, along Squaw Creek (these are in part rhyolite tuffs), along Hardtrigger Creek, and along the head of Salmon Creek. Most of these appear to be of the same age and seem to have been deposited subsequent to the peculiar basalt having the shaly weathering mentioned above. On the north side of Flat Top Mountain are fully 100 feet of tuffs, laid down with smooth, regular bedding planes, and varying from beds of coarse, black, scoriaceous fragments to strata of fine-grained material resembling sandy clays. A thin flow of vesicular basalt, 1 to 2 feet thick, is embedded in these tuffs.

QUATERNARY DEPOSITS.

Quaternary sediments—that is, those that were formed after the deposition of the last Pliocene lake beds—do not occupy large areas in this quadrangle. These deposits were formed during the gradual erosion of Snake River and its tributaries, and might be subdivided into several groups. They are almost exclusively sands and gravels, the latter in part well washed, in part angular.

The flat table north of Snake River is almost continuously underlain by basalt, but has a thin covering of lake beds, which are capped by loam and gravel that in some places appear to rest unconformably on the Pliocene rocks.

Local stream fans.—Spread over the lake beds from both sides of the range is a thin sheet of angular gravel. These deposits are clearly the work of the many little streams and creeks of the mountains, which spread their debris fans over the gently sloping lake beds at a time not far distant from that at which the lake was drained. Ordinarily these gravels are considerably above the present drainage lines and consequently they are of considerable age. Part of them might, in fact, be regarded as Pliocene; at least those which overlie the Payette formation. This wash is, of course, best developed on the eastern side of the range, where erosion has been most intense. Owing to the difficulties of mapping it adequately it has not been indicated on the map. Along the northeastern slope of the Owyhee Range, as far south as Bernard Ferry the wash covers almost every ridge. Close to the mountains it is coarse and angular, but farther away from them it becomes finer and more rounded.

On both sides of Sinker Creek this sheet of wash is strongly developed and extends to a distance of 6 or 7 miles from the foothills with a slope averaging 100 feet to the mile—a little steeper near the mountains—and gradually lessening away from them. The wash consists of a uniform mixture of angular pebbles and loam.

Early terrace gravels.—In the northeast corner of the quadrangle, just west of the railroad, is a low hill about 4 miles in length, composed entirely of pebble deposits and coarse sand. The pebbles are well rounded, often 5 inches in diameter, and consist of granite or porphyry. It seems probable that these gravels were deposited by Boise River and mark one of the early meanders of that stream. It has been shown in the Nampa folio that the river formerly followed a more southern course than at present, and that very likely it emptied into Snake River at some point in the northeastern part of the Silver City quadrangle. The thin loam deposit previously mentioned as covering the whole flat north of the Snake, which is somewhat thicker along the northern boundary line of the quadrangle, is probably later than these gravels.

Late terrace gravels and recent alluvium.—Considerably more recent are the alluvial deposits that follow Snake River. These are ordinarily very sandy and narrow, occupying an average width of only a mile along the river bottom. Frequently they form a sloping bench that gradually rises to an elevation of 75 feet above the river and have

been distinguished from the alluvium on the map. Near Walters Butte is a somewhat higher river terrace, about 100 feet above the stream, covered with loam, sand, and gravel.

Small deposits of alluvium of the same age as the Snake River bottom lands occur in Reynolds Valley and on Sinker Creek, as well as on Jordan and Cow creeks.

Glaciation.—Although it is certain that no extensive glaciers existed in the Owyhee Range during the Pleistocene epoch, there seems to be some evidence that considerable masses of *névé*, and possibly small incipient glaciers, were forming under favorable conditions near the highest elevations. Certain local accumulations of angular gravel indicate such conditions near the head of Jordan Creek and in some of the gulches on Florida and War Eagle mountains. On the headwaters of Succor Creek also, there is some evidence of glacial action in the form of incipient moraines of angular boulders and fragments.

ECONOMIC GEOLOGY.

PRECIOUS METALS.

Gold- and silver-bearing veins.—The larger part of the rocks of this quadrangle do not contain fissure veins or other metalliferous deposits of any kind. The rhyolites, basalts, and granites show, as a rule, but little evidence of mineralization. The granite cropping on Hardtrigger Creek, in the northern part of the quadrangle, contains in places small quartz veins that have a southwestern or southern strike. These have been prospected to some extent, but thus far little of value has been found.

As indicated by the placer gold found in Succor Creek, a gold-bearing area occurs somewhere near its head, but the primary deposits have not thus far been located.

Along the southern boundary of the quadrangle there is a mining district of small extent, but of great importance. The deposits are located on both sides of Jordan Creek, on War Eagle Mountain, Florida Mountain, and near De Lamar. They were discovered in 1863, and have yielded a total of over \$30,000,000, of which amount approximately \$12,000,000 is in gold and \$18,000,000 in silver.

Soon after the discovery, in 1863, the War Eagle veins were extensively worked, the output up to 1878 being about \$15,000,000. After an interval of twelve years, the De Lamar veins came into bonanza in 1890, and in seven years produced \$6,000,000, mostly in gold.

About 1892 the deposits on Florida Mountain began to be exploited and now overshadow the De Lamar mines in output. The production in 1900 was nearly \$776,000 in gold, and 1,000,000 ounces of silver. The process used to recover the gold and silver from the ores is ordinarily that of pan amalgamation. In late years the cyanide process has also been used to treat low-grade ore and tailings.

In their general character the deposits are fissure veins containing native gold and silver, as well as argentite, chalcopryrite, and other sulphides rich in gold and silver. The gangue is predominantly quartz. The age of these fissure veins is comparatively recent; they cut the early Tertiary basalts and rhyolite as well as the underlying granite and are, therefore, post-Eocene. These deposits have been described in great detail in the Twentieth Annual Report of the U. S. Geological Survey, pt. 3, pp. 67 to 256.

The vein systems of War Eagle Mountain are contained in granite and the veins have a general north-south direction and usually dip eastward at angles above 60°. Considered more in detail there are three systems of veins: The first includes those with nearly north-south strike (Oro Fino group, Poorman); the second, those with northerly to southwesterly direction, crossing the Poorman vein (Empire, Illinois Central); the third, those with northerly and northeasterly direction. Of the latter but few are known. The vein systems are probably contemporaneous; they do not continue southward into the rhyolite area but apparently disappear before this rock is reached. The veins are narrow, often a few inches, rarely a few feet, in width. Gold almost always predominates in the values of the ore, which is ordinarily rich,

Silver City.

frequently containing \$40 or more per ton. Rich silver ores were frequently found in the upper levels, as, for instance, in the Poorman vein. The pay shoots may be several hundred feet long but ordinarily are much less. Sometimes they are vertical (Ida, Elmore, Illinois Central), or dip to the north on the vein (Poorman), or to the south (Oro Fino). On the whole they are irregular and pockety, and barren quartz often occurs between the pay shoots. The celebrated veins in the Oro Fino group (containing the Oro Fino, Golden Chariot, and Ida Elmore mines), which were exploited in the early days of the district, contained the largest masses of ore above the 900-foot level and were exploited to a depth of 1400 feet. The ore shoot of the Poorman vein, also celebrated for its richness, was chiefly confined to upper levels.

During the last year the Oro Fino veins have been opened by a tunnel from Sinker Creek having a length of 6100 feet, which has cut the Golden Chariot vein at a depth of 2000 feet beneath the collar of the shaft. The vein was found to continue unbroken and some of it contained much native gold. The exploration of this level is not as yet completed.

The veins of Florida Mountain have only lately been worked on a large scale. The total production may be something like \$7,000,000 or \$8,000,000. Since 1891 there has been renewed activity and rich ore bodies have been discovered in the Black Jack and Trade Dollar mines.

The geology needs but a brief reference. Granite outcropping on the northeastern part of Florida Mountain is covered by a flow of coarse-grained diabasic basalt which, again, is capped by rhyolite. The principal vent through which the basalt was erupted is a long dike in the granite parallel to the Black Jack vein. The rhyolitic vents were numerous and formed dikes and necks. There are several parallel veins, the strike of which is about N. 20° W. Their dip is usually very steep toward the west. They are narrow, though straight, and well defined, the Black Jack being traceable for over 1½ miles. The croppings are not prominent. The veins are narrow, rarely reaching 2 feet, and often close down to a seam. The development of the ore bodies is accomplished by long tunnels run near the base of the mountains. From these tunnels, in the Black Jack and Trade Dollar mines, shafts several hundred feet deep have been sunk. The ore consists of finely divided argentite, chalcopryrite, and a little galena and zinc blende. Native gold and silver also occur. The sulphides are very rich but their value is chiefly in silver, the average content of the ore being 45 ounces per ton. Gold occurs in amounts varying from \$3 to \$8 per ton.

The veins of Florida Mountain are of special interest, as they cut through granite as well as the capping basalt and rhyolite. There is no material difference in the value and composition of the ore, whether it occurs in basalt, rhyolite, or granite. The largest amount of ore is, however, found in the granite. An interesting feature is the presence of orthoclase as a part of the gangue material, together with quartz in the Black Jack and Trade Dollar vein.

Near De Lamar, which is situated on Jordan Creek 5 miles below Silver City, the canyon is cut in heavy basaltic flows. This rock, however, does not contain any valuable minerals; the veins are confined to the rhyolite, which outcrops 600 feet above De Lamar on the south side of the creek. The prevailing strike of the veins is northwesterly. The dip is usually 45° to the southwest, but is occasionally vertical. The deposits may be divided into silver veins and gold-silver veins. To the former belong the Henrietta, Silver Vault, and many others of less importance. These are narrow fissure veins carrying only rich silver ores in a flinty, pseudomorphic quartz, and also in the clay, sometimes filling it. The gold-silver veins are chiefly represented by the De Lamar vein system. The ore carries native gold in an extremely finely divided state, together with a little pyrite, marcasite, and rich silver sulphides. The gangue is quartz, almost exclusively in a peculiar laminated form, showing its pseudomorphic derivation from calcite. The veins, of which a great number have been found, are parallel and well defined, being sharply separated from the country rock, and contain angular inclusions of rhyolite. The De Lamar mine is opened by tunnels and by a shaft sunk

several hundred feet on the incline below the deepest tunnel level, which is at an elevation of 6000 feet. The workings are very extensive. The main ore shoot extended from a short distance below the surface down to the tenth level, or 100 feet below the Wahl tunnel, following the dip so-called "iron dike." Nearly all of the veins were productive within this distance. The "iron dike" is a strongly pyritiferous sheet of clayey rhyolite, undoubtedly due to crushing and movement, with dips varying from 70° to 20° northward. The richest ore was found near the place where the veins abut against this "iron dike," which would seem to indicate that it acted as a barrier toward the ascending solutions by which the deposit was formed and caused the deposition of the load of dissolved metals at this point.

During the last few years a tunnel has been driven from the level of Jordan Creek into the De Lamar veins, thus opening them to a distance of about 800 feet below the croppings. The mine is still productive, although the ore bodies are not so large as during the bonanza period between 1891 and 1896. The principal producing mines in the district are the De Lamar, the Trade Dollar, and the Poorman.

Placer deposits.—The largest placer deposits of the region were found in the creeks draining the Silver City mining district. Most of them were neither extensive nor deep and were exhausted a long time ago. Jordan Creek has been worked more or less from below De Lamar to its head. All the less steep gulches leading down from War Eagle Mountain show evidence of placer work. Those on Florida Mountain have been equally productive. On its northern slope extensive placers have been washed near the Silver City cemetery. Especially rich were the placers of Long Gulch, Blue Gulch, and Jacobs Gulch. The gravels of Jordan Gulch below the Sullivan tunnel are in places 30 feet thick and are said to have yielded \$200,000. The placers of Blue Creek, also on Florida Mountain, were rich, yielding many large nuggets of gold containing a considerable amount of silver.

Cow Creek, heading 2 miles due west of De Lamar, contains gold throughout; near its headwaters the gravel is even now washed by Chinese during the short period of available water. If more water could be had a large amount of the surface gravels might possibly pay for working. These gravels are probably of early Tertiary age, having been accumulated during the high-level period of the Tertiary lake.

Scattered remnants of gravel occur on the slopes of the rhyolite 3 miles southwest of De Lamar. For some distance south of this the Jordan Valley road follows a long ridge which is covered by gravels. It is stated that it would pay to work these with sufficient supply of water.

On the west side of the mountains Succor Creek is stated to have been worked for placer gold, but it is said that the quantity obtained was very small.

Snake River contains in this quadrangle, as it does all through the Snake River Valley, a considerable amount of gold in its sandy gravel bars. The gold is extremely fine and flaky, containing about 1000 colors to the cent. During many years from several hundred to a thousand dollars were annually washed from the stream in this quadrangle, but at present only very little work is done at intervals.

COAL.

In other parts of the Snake River Valley the early Tertiary lake deposits frequently contain thin strata of lignitic material, or impure lignite. Such beds, up to 2 feet thick, have been prospected on Succor Creek near the base of the mountains, as well as in Reynolds Valley, but none of these beds are believed to be economically important.

OPALS.

The basalts and rhyolites of the northern end of the Owyhee Range contain at various places opals in the abundant vesicular cavities and as filling of little veinlets in the rock. Near the head of Squaw Creek and at various places along the contact of the rhyolite with the lake beds opals occur in the eruptive rock. Prospects are scattered from 2 miles south of Sommercamp up to the stage station on the Caldwell-Rockville road. Some good fire

opals are reported to have been found, and at one time there was a considerable mining excitement due to the reported finds of this precious stone. By far the larger quantity is, however, common opal of no value, for the precious variety apparently occurs only in few places. As to their quality, the stones are reported to have been soft and brittle.

About three-eighths of a mile below the junction of Little Squaw Creek and Squaw Creek fire opals were found as amygdaloid filling in highly vesicular basalt. The opals are abundant but are generally small and very brittle. The basalt in which they occur is a thin flow, probably not over 25 to 50 feet thick, which partially fills the canyon and rests on the rhyolite, the principal rock in the vicinity.

WATER SUPPLY.

Surface waters.—As stated above, the immense amount of water crossing the quadrangle along Snake River has not yet been utilized. The amount to be obtained from the smaller creeks where they issue from the mountains is not great and their flow is scant during the summer. In many cases it would be possible to store the water by building reservoirs in proper places. The waters of Jordan Creek below Silver City are used in the various mines and at De Lamar power is obtained from it, at least for a part of the year. The amount is not nearly sufficient, however, and plans have been suggested to introduce electric power generated at a point on Snake River. Springs of small volume are common throughout the mountains but they are rare in the Snake River Plains. A spring, flowing 2 miner's inches, breaks through the level lake bed at a point 2½ miles westward from Guffey.

Warm springs and artesian wells.—One and one-half miles north of Walters Butte, at an elevation of 2340 feet, a spring of considerable volume and a temperature of 67° F. issues from a gravel bed locally contained in the lake beds. A hot spring issues near the post-office of Enterprise, on Snake River, at an elevation of 2220 feet. It has a temperature of 128° F. and has a volume large enough to irrigate 10 acres of ground. A well has been sunk at this vicinity to a depth of 380 feet. The well traversed 6 feet of soil, 10 feet of gravel, and then continued through light-colored sediments referred to as "yellowish shale." Two strata of "iron rock," probably basalt flows, were also bored through and there was obtained a moderate flow of warm water containing a small quantity of dissolved salts. Another well, bored at Bernard Ferry, attained a depth of 520 feet but found no flowing water. Water was struck 200 feet from the surface and rose up to 40 feet from the surface. The well is said to have struck clay material at a depth of 20 feet and continued through this material all the way down except for occasional strata of sandstone.

A third deep well was sunk at De Lamar, which penetrated basaltic lava to a depth of 975 feet, from which level a few miner's inches of flowing water having a temperature of 120° are said to have been obtained. The flow did not persist.

There is a possible chance for artesian waters along the eastern and northeastern base of the Owyhee Range. But large quantities are probably not obtainable.

Further borings have been undertaken near Enterprise and Guffey. The developments made in 1902 have been described by Prof. I. C. Russell in Water Supply and Irrigation Paper No. 78, issued by the United States Geological Survey. Professor Russell writes as follows:

In the small valley cut by Dry Creek, about 1½ miles southwest of Guffey, Owyhee County, a well drilled to a depth of 568 feet, but not completed when examined (July 12, 1902), passed through 30 feet of loose surface gravel and then about 538 feet of soft light-colored strata belonging to the Payette formation, containing 3 seams of hard material, and reached a hard rock, perhaps quartzite, which checked the drill. The well is 3 inches in diameter. A surface flow was obtained from a depth of 160 feet, and an additional flow at 416 feet. The discharge is nearly one cubic foot of water per minute; temperature 76½° F. The well is not cased below a depth of 38 feet. Elevation at surface 2375 feet, or about 160 feet above the adjacent portion of Snake River.

In a small gulch at Guffey and about 120 feet above Snake River, a well bored with a 1½ inch hand auger to

a depth of 30 feet through light-colored beds, probably shale of the Payette formation, at first discharged about 1 gallon per minute, but has since ceased to flow.

Near Central (Bernard Ferry) in the Snake River Canyon, and from 7 to 9 miles northwest of Guffey, four artesian wells have been drilled. All of them are situated near the bottom of the valley, and within a distance of 1½ miles of Central, toward the southeast, where the elevation is approximately 2300 feet. The records of these wells are as follows:

On the land of Alfred Cox a 3-inch well, completed in June, 1902, has a depth of about 1033 feet. It is cased from surface to a depth of 39 feet and discharges by estimate one-half gallon of water per second; temperature 100° F. Flowing water was first reached at a depth of 600 feet, and the delivery at the surface steadily increased as long as drilling was continued. The water brings sand and gravel to the surface with it.***

About one-half mile west of the Cox well a boring approximately 1000 feet deep was put down in 1901, which failed to reach water under sufficient pressure to force it to the surface. No other record in reference to this boring has been obtained.

On the farm of P. B. Smith, adjacent to the land of Mr. Cox, and about 1½ miles southeast of Central, an artesian well drilled in 1901 has a depth of 940 feet, is 3 inches in diameter, is cased to a depth of 30 feet, and discharges about one-third of a gallon of water per second; temperature 98° F. Water which rose to the surface was first reached at a depth of 550 feet. At 700 feet a seam of black sand, etc., was penetrated and the flow of water increased. At the bottom of the well the drill dropped about 3 feet, having reached a stratum of sand and gravel, from which the main supply of water is derived. The well discharges sand and gravel. * * *

On the land of Mr. Barnard, about one-half mile southeast of Central, a well drilled in 1901 has a depth of about 1035 feet, is 3 inches in diameter, cased for a short distance at the top, and discharges, by estimate, 1 gallon of water per second, with a temperature of 106° F. At Mr. Barnard's home, in Central, a well drilled in 1901, to a depth of 720 feet, delivers about three-fourths of a gallon of water per second, not measured, with a temperature of 99° or 100° F.

The four wells near Central just referred to were all drilled in the unconsolidated lacustral deposits, mostly sandy clays and soft shales of the Payette formation. A notable fact in connection with them is that no sheets of basalt were encountered. The water from each of the wells is used for irrigation.

About 3½ miles down Snake River from Central or Bernard Ferry, is the post-office known as Enterprise, situated near Warm Spring Ferry. Within a radius of about 1½ miles of Enterprise and to the southeast there are four artesian wells.

At the home of George Newell, there are two flowing wells, one with a depth of 340 feet, cased with 2½-inch pipe, temperature 87° F., and the other 385 feet deep, 6 inches in diameter; temperature 90° F. The surface elevation is about 2300 feet. The flow of water from the larger well, particularly, is strong, but on account of

leakage about the pipe could not be measured. An estimate places the combined flow from the two wells at about 1 gallon per second. The water is used for irrigation. About 1½ miles southwest of Mr. Newell's home, where the elevation is 2500 feet, a well drilled in 1901 to a depth of 165 feet, diameter 10 inches, discharges by estimate about 2 gallons of water per second; temperature 87° F. The water is used for irrigation. This well was begun in igneous rock, probably rhyolite, but at a depth of a few feet entered clay, and below the clay several changes in the nature of the material occurred, but an accurate record has not been preserved. Near where the well was drilled there is a small spring of warm water. Approximately one-half mile west of Mr. Newell's ranch, on land reported to belong to Mr. Shirley, a well was drilled in 1891 to a depth of about 580 feet.

The four wells just referred to, with the exception of the 10-inch well, were drilled in the light-colored sedimentary beds of the Payette formation and, like those near Central, have surprisingly high temperatures for their depth. They are within a distance of 1½ miles of the copious hot spring at Enterprise, which has a temperature of 128° F., and, as it seems justifiable to assume, derive a part of their water at least from that or some other similar source.

The records of two drill holes made at Ontario, Oreg., are as follows:

A well owned by the city of Ontario, incomplete in October, 1902, has, as I am informed by Mr. A. L. Sproul, of Ontario, a depth of 1025 feet, is 4 inches in diameter, and reached water at 195 feet which rose to within 6 feet of the surface. The material passed through is sand and gravel to a depth of 35 feet and the remainder blue clay. The water is charged with gas, which, when properly confined, burns constantly. Cost of the well, \$750.

The well thus described is situated where the surface elevation is between 2100 and 2200 feet, or well below the artesian head of the Lewis artesian basin. The well is not cased, and the rise of the water to within 6 feet of the surface makes it probable that if proper tests of the water pressure should be made, it would be found that a surface flow could be had by putting in proper casing.

The second well at Ontario, owned by A. F. Boyer, completed September, 1902, 3 inches in diameter, has a depth of 215 feet. Water rose and overflowed. Gas is discharged with the water. Material passed through: soil, 10 feet; gravel, 20 feet; and the balance shale. Cost \$100.

A flowing well at Vale, Oreg., drilled near a hot spring to a depth of 140 feet, as already stated, discharges a strong flow of water so long as the casing is not obstructed by mineral matter deposited from it, and has a temperature of 198½° F. This well may be considered as a developed hot spring, and has but little significance in reference to the artesian water supply of the basin in which it is located.

The artesian wells near Guffey, Central, and Enterprise, collectively present certain interesting facts.

They are located essentially on a line extending northwest and southeast and measuring about 11½ miles. At the west end of the line is the hot spring at Enterprise. The depth of the wells and their temperatures are as follows, beginning at Guffey and approaching Enterprise:

Depth and temperature of wells at Guffey, Central, and Enterprise.

Locality.	Distance from Enterprise hot springs.	Depth.	Temperature.	Temperature gradient.
	<i>Miles.</i>	<i>Feet.</i>	<i>Deg. F.</i>	
Guffey.....	11½	538	76½	18.42
Central.....	5	1033	100	19.66
Do.....	4½	940	98	18.54
Do.....	3½	1035	106	17.57
Do.....	3½	720	100	18.40
Enterprise.....	1	340	87	7.83
Do.....	1	385	90	8.37
Do.....	1½	165	87	3.10
Enterprise hot spring.....	128

The temperature gradient, it will be remembered, is obtained by dividing the depth of a well below the stratum of no seasonal variation in temperature, assumed as 50 feet, by the number of degrees the temperature of the water discharged exceeds the temperature of the stratum of no seasonal variation, assumed to be 50° F. The temperature gradient, then, shows the depth in feet for each increase of one degree in temperature.

As is indicated in the above table, the temperature gradient in the region considered increases in a conspicuous manner as the distance from the Enterprise hot spring decreases. An exceptional increase, however, is seen in the case of the last well mentioned in the table, which, as noted above, is near a small tepid spring, and no doubt for this reason shows a more rapid increase of temperature with depth than any of the others. Not considering the well just referred to, the temperature gradient increases as the Enterprise hot spring is approached, but the rate of increase can not be accurately determined from the data available, since the wells are not cased and are not supplied from the same stratum.

The facts just presented seem to indicate that the porous beds in the Payette formation in the vicinity of Enterprise are supplied in part at least from the hot spring at that place. A legitimate conclusion seems to be that the rocks beneath the Payette formation are fissured and hot water rising through the fissure has charged the porous beds above. Whether there is a deep artesian basin beneath the Payette formation or not, there are no data for judging. In general, however, hot springs rise through deep fissures and are probably in most cases not an indication of the presence of a true artesian basin. As has already been stated, the Lewis artesian basin was formed by a bending of the rocks after the Payette beds were laid down, and this bending no doubt affected a great thickness of the earth's crust

below the beds now forming the surface. For this reason it is possible that a true artesian basin exists, the porous beds of which are depressed in the vicinity of Snake River to a depth of 4000 or 5000 feet.

In addition to the supply of water reaching the Payette beds from below, the shape of the basin and the fact that the beds composing it outcrop in the hills and mountains bordering the Snake River Plains on the north and south make it evident that additional water may reach the central part of the basin by descending from the surface.

The most logical conclusion to be drawn from all the evidence presented in reference to the probability of obtaining water in the Lewis artesian basin seems to be that flowing water may be expected when a well is so drilled as to penetrate deeply or pass through the Payette formation at any locality within its borders where the surface elevation is less than 2500 feet. As already stated, 2500 feet is the minimum measure of the artesian head as shown by existing wells, but the true artesian head may considerably exceed this amount. The wells in Bruneau Valley, as shown by an unsatisfactory method, namely, aneroid barometer measurements, have an altitude of 2700 feet; and the artesian head at Boise is about 2850 feet. It is not safe at present, however, to accept any measurement of the artesian head in excess of 2500 feet, and until more wells are drilled all attempts to obtain flowing water should be confined to localities below that horizon. It chances that nearly all the good land along Snake River and in the lower portions of Malheur Valley and much of that in Boise Valley is below 2500 feet. Abundant localities for developing the Lewis artesian basin are thus available, and should be tested before attempts are made to obtain artesian wells on the uplands.

The wells drilled in Snake River Valley at Central, Enterprise, Ontario, and other places, passed through soft strata and did not show the presence of beds of basalt or other hard rock in the Payette formation. It is probable that only soft beds will be encountered in drilling to a depth of about 1000 or 1200 feet in the portion of Snake River Valley between Guffey and Weiser, but no positive assurance that such will be found to be the case can at present be given.

As may be judged from the facts above presented in reference to the occurrence of hot springs near the artesian wells now flowing, the most favorable localities for drilling additional wells may be assumed to be near where warm or hot springs rise through the Payette formation. A qualification of this statement is suggested, however, by the fact that the hot spring at Vale is depositing mineral matter in the beds it passes through in rising toward the surface, and presumably in this way forms for itself a conduit which prevents its water from spreading laterally. This exceptional condition is also indicated by the exceptionally high temperature of the spring referred to. In choosing a location for a well, therefore, it would be best, at least until more facts are gathered in this connection, to avoid the proximity of a hot spring.

August, 1902.