DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

104

GEOLOGIC ATLAS

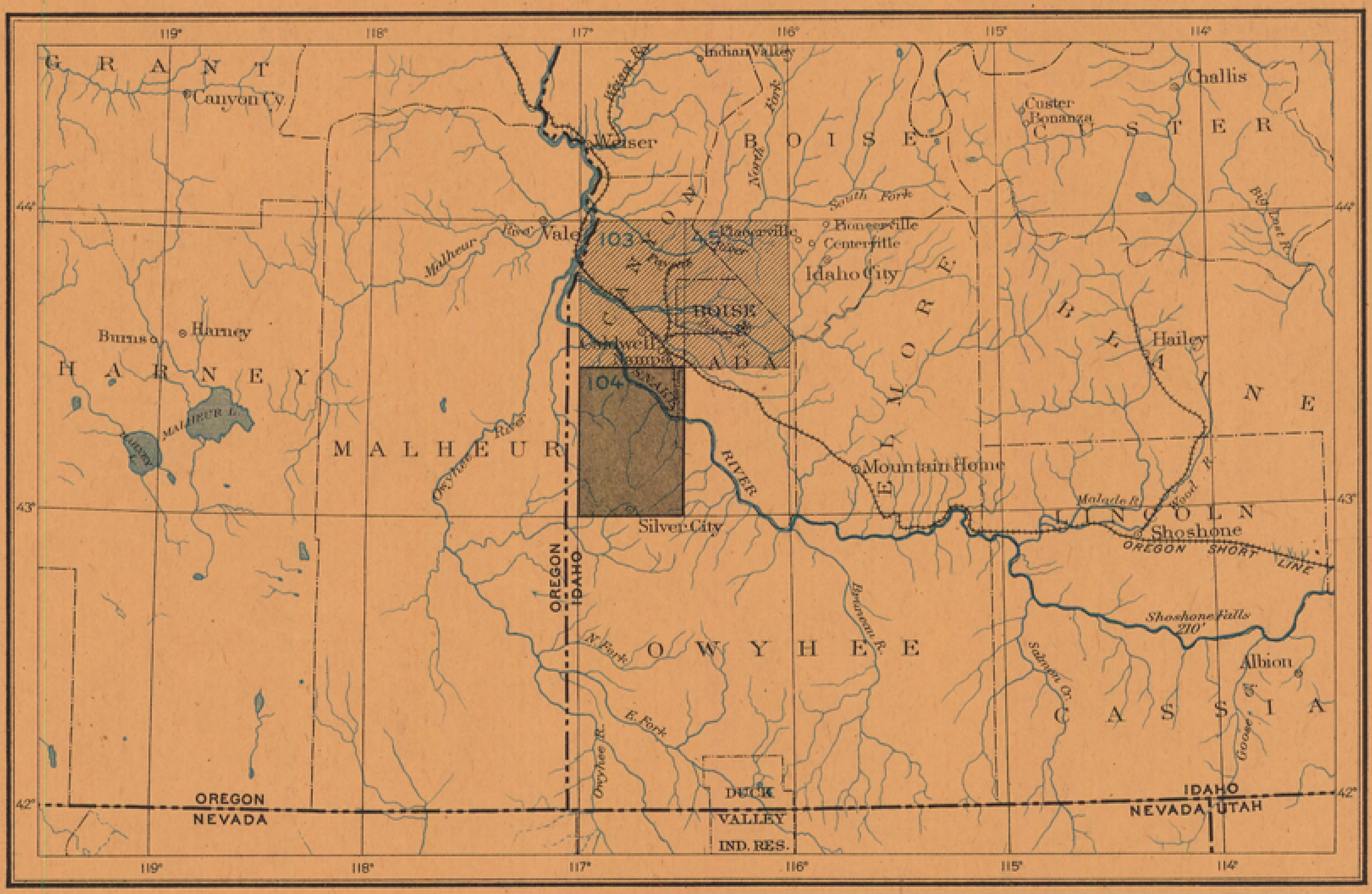
OF THE

UNITED STATES

SILVER CITY FOLIO

IDAHO

INDEX MAP



SCALE: 40 MILES = 1 INCH

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LIBRARY EDITION

SILVER CITY FOLIO
NO. 104

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GEORGE W. STOSE, EDITOR OF GEOLOGIC MAPS   S. J. KUBEL, CHIEF ENGRAVER
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GEOLOGIC AND TOPOGRAPHIC ATLAS OF UNITED STATES.

The Geological Survey is making a geologic map of the United States, which is being issued in parts, called folios. Each folio includes a topographic map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the outline or form of all slopes, and to indicate their grade or steepness. This is done by lines each of which is drawn through points of equal elevation above mean sea level, the altitudinal interval represented by the space between lines being the same throughout each map. These lines are called *contours*, and the uniform altitudinal space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map (fig. 1).

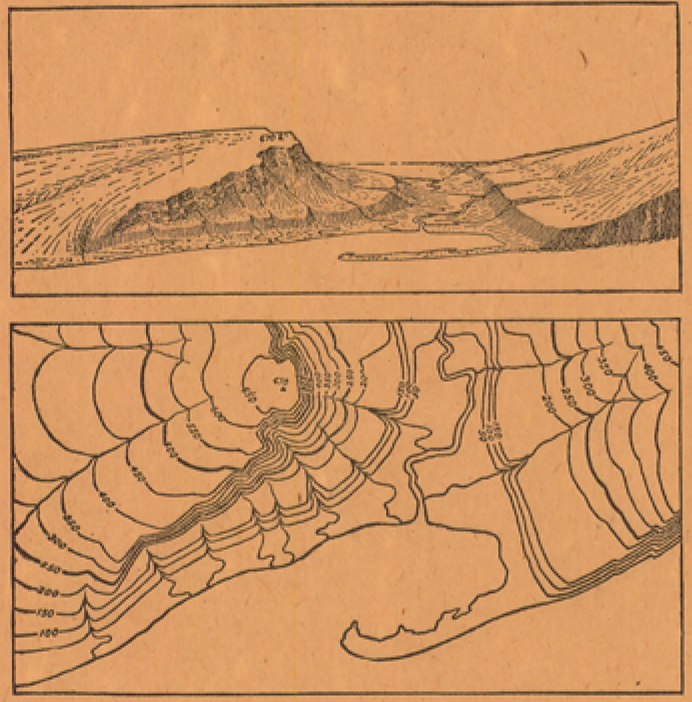


Fig. 1.—Ideal view and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply, forming a precipice. Contrasted with this precipice is the gentle slope from its top toward the left. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates a certain height above sea level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, and 200 feet, and so on, above mean sea level. Along the contour at 250 feet lie all points of the surface that are 250 feet above sea; along the contour at 200 feet, all points that are 200 feet above sea; and so on. In the space between any two contours are found elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration all the contours are numbered, and those for 250 and 500 feet are accentuated by being made heavier. Usually it is not desirable to number all the contours, and then the accentuating and numbering of certain of them—say every fifth one—suffice, for the heights of others may be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. These relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The altitudinal space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mountainous country a large interval is necessary. The smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is serviceable for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If a stream flows the entire year the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of man, such as roads, railroads, and towns, together with boundaries of townships, counties, and States, are printed in black.

Scales.—The area of the United States (excluding Alaska and island possessions) is about 3,025,000 square miles. A map representing this area, drawn to the scale of 1 mile to the inch, would cover 3,025,000 square inches of paper, and to accommodate the map the paper would need to measure about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the *scale* of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents about 1 square mile of earth surface; on the scale $\frac{1}{125,000}$, about 4 square miles; and on the scale $\frac{1}{250,000}$, about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three ways—by a graduated line representing miles and parts of miles in English inches, by a similar line indicating distance in the metric system, and by a fraction.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which represent areas bounded by parallels and meridians. These areas are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree—i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-fourth of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles.

The atlas sheets, being only parts of one map of the United States, disregard political boundary lines, such as those of States, counties, and townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature within its limits, and at the sides and corners of each sheet the names of adjacent sheets, if published, are printed.

Uses of the topographic map.—On the topographic map are delineated the relief, drainage, and culture of the quadrangle represented. It should portray to the observer every characteristic feature of the landscape. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property; save the engineer preliminary surveys in locating roads, railways, and irrigation reservoirs and ditches; provide educational material for schools and homes; and be useful as a map for local reference.

THE GEOLOGIC MAPS.

The maps representing the geology show, by colors and conventional signs printed on the topographic base map, the distribution of rock masses on the surface of the land, and the structure sections show their underground relations, as far as known and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. On the geologic map they are distinguished as igneous, sedimentary, and metamorphic.

Igneous rocks.—These are rocks which have cooled and consolidated from a state of fusion. Through rocks of all ages molten material has from time to time been forced upward in fissures or channels of various shapes and sizes, to or nearly to the surface. Rocks formed by the consolidation of the molten mass within these channels—that is, below the surface—are called *intrusive*. When the rock occupies a fissure with approximately parallel walls the mass is called a *dike*; when it fills a large and irregular conduit the mass is termed a *stock*. When the conduits for molten magmas traverse stratified rocks they often send off branches parallel to the bedding planes; the rock masses filling such fissures are called *sills* or *sheets* when comparatively thin, and *laccoliths* when occupying larger chambers produced by the force propelling the magmas upward Within rock inclosures molten material cools slowly, with the result that intrusive rocks are generally of crystalline texture. When the channels reach the surface the molten material poured out through them is called *lava*, and lavas often build up volcanic mountains. Igneous rocks thus formed upon the surface are called *extrusive*. Lavas cool rapidly in the air, and acquire a glassy or, more often, a partially crystalline condition in their outer parts, but are more fully crystalline in their inner portions. The outer parts of lava flows are usually more or less porous. Explosive action often accompanies volcanic eruptions, causing ejections of dust, ash, and larger fragments. These materials, when consolidated, constitute breccias, agglomerates, and tuffs. Volcanic ejecta may fall in bodies of water or may be carried into lakes or seas and form sedimentary rocks.

Sedimentary rocks.—These rocks are composed of the materials of older rocks which have been broken up and the fragments of which have been carried to a different place and deposited.

The chief agent of transportation of rock débris is water in motion, including rain, streams, and the water of lakes and of the sea. The materials are in large part carried as solid particles, and the deposits are then said to be mechanical. Such are gravel, sand, and clay, which are later consolidated into conglomerate, sandstone, and shale. In smaller portion the materials are carried in solution, and the deposits are then called organic if formed with the aid of life, or chemical if formed without the aid of life. The more important rocks of chemical and organic origin are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Another transporting agent is air in motion, or wind; and a third is ice in motion, or glaciers. The most characteristic of the wind-borne or eolian deposits is loess, a fine-grained earth; the most characteristic of glacial deposits is till, a heterogeneous mixture of bowlders and pebbles with clay or sand.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks, with reference to the sea, over wide expanses; and as it rises or subsides the shore lines of the ocean are changed. As a result of the rising of the surface, marine sedimentary rocks may become part of the land, and extensive land areas are in fact occupied by such rocks.

Rocks exposed at the surface of the land are acted upon by air, water, ice, animals, and plants. They are gradually broken into fragments, and the more soluble parts are leached out, leaving the less soluble as a *residual* layer. Water washes residual material down the slopes, and it is eventually carried by rivers to the ocean or other bodies of standing water. Usually its journey is not continuous, but it is temporarily built into river bars and flood plains, where it is called *alluvium*. Alluvial deposits, glacial deposits (collectively known as *drift*), and eolian deposits belong to the *surficial* class, and the residual layer is commonly included with them. Their upper parts, occupied by the roots of plants, constitute soils and subsoils, the soils being usually distinguished by a notable admixture of organic matter.

Metamorphic rocks.—In the course of time, and by a variety of processes, rocks may become greatly changed in composition and in texture. When the newly acquired characteristics are more pronounced than the old ones such rocks are called *metamorphic*. In the process of metamorphism the substances of which a rock is composed may enter into new combinations, certain substances may be lost, or new substances may be added. There is often a complete gradation from the primary to the metamorphic form within a single rock mass. Such changes transform sandstone into quartzite, limestone into marble, and modify other rocks in various ways.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried and later have been raised to the surface. In this process, through the agencies of pressure, movement, and chemical action, their original structure may be entirely lost and new structures appear. Often there is developed a system of division planes along which the rocks split easily, and these planes may cross the strata at any angle. This structure is called *cleavage*. Sometimes crystals of mica or other foliaceous minerals are developed with their laminæ approximately parallel; in such cases the structure is said to be schistose, or characterized by *schistosity*.

As a rule, the oldest rocks are most altered and the younger formations have escaped metamorphism, but to this rule there are important exceptions.

FORMATIONS.

For purposes of geologic mapping rocks of all the kinds above described are divided into *formations*. A sedimentary formation contains between its upper and lower limits either rocks of uniform character or rocks more or less uniformly varied in character, as, for example, a rapid alternation of shale and limestone. When the passage from one kind of rocks to another is gradual it is sometimes necessary to separate two contiguous formations by an arbitrary line, and in some cases the distinction depends almost entirely on the contained fossils. An igneous formation is constituted of one or more bodies either containing the same kind of igneous rock or having the same mode of occurrence. A metamorphic formation may consist of rock of uniform character or of several rocks having common characteristics.

When for scientific or economic reasons it is desirable to recognize and map one or more specially developed parts of a varied formation, such parts are called *members*, or by some other appropriate term, as *lentils*.

AGES OF ROCKS.

Geologic time.—The time during which the rocks were made is divided into several *periods*. Smaller time divisions are called *epochs*, and still smaller ones *stages*. The age of a rock is expressed by naming the time interval in which it was formed, when known.

The sedimentary formations deposited during a period are grouped together into a *system*. The principal divisions of a system are called *series*. Any aggregate of formations less than a series is called a *group*.

(Continued on third page of cover.)

DESCRIPTION OF THE SILVER CITY QUADRANGLE

By Waldemar Lindgren and N. F. Drake.

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 25½ 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 Mountains[1] 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 redeter-

[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 fluviatile 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 *Equus*; 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 Glenns 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 Glenns 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 débris 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-porphyry and granite-porphyry 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-porphyry and a granite-porphyry. Such rocks are called monzonite-porphyry or granodiorite-porphyry. 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. Fluviatile 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 fluviatile 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 water-courses 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:

Sequoia angustifolia? Lx.	Platanus sp.
Alnus carpinioides Lx.	Celastrus sp.
Quercus simulata Kn.	Acer trilobatum productum? Heer.
Quercus consimilis Newby.	Acer, fruits.
Quercus idahoensis Kn.	Ilex n. sp.
Quercus, two new species.	Juglans nigella? Heer.
Castanea ungeri Heer.	Pteris n. sp.
Platanus dissecta? Lx.	

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 report[1] 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 fluviatile 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; 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 *Protohippus*, 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 fluviatile 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

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

mass of basaltic eruptives. The rhyolite, which is a lava that is rich in silica and alkalies, 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 amygdules 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 amygdules 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 débris 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 bowlders 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 otner 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, chalcopyrite, 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, 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, chalcopyrite, 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 1¼ 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.
	Miles.	*Feet.*	*Deg. F.*	
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	13.40
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.

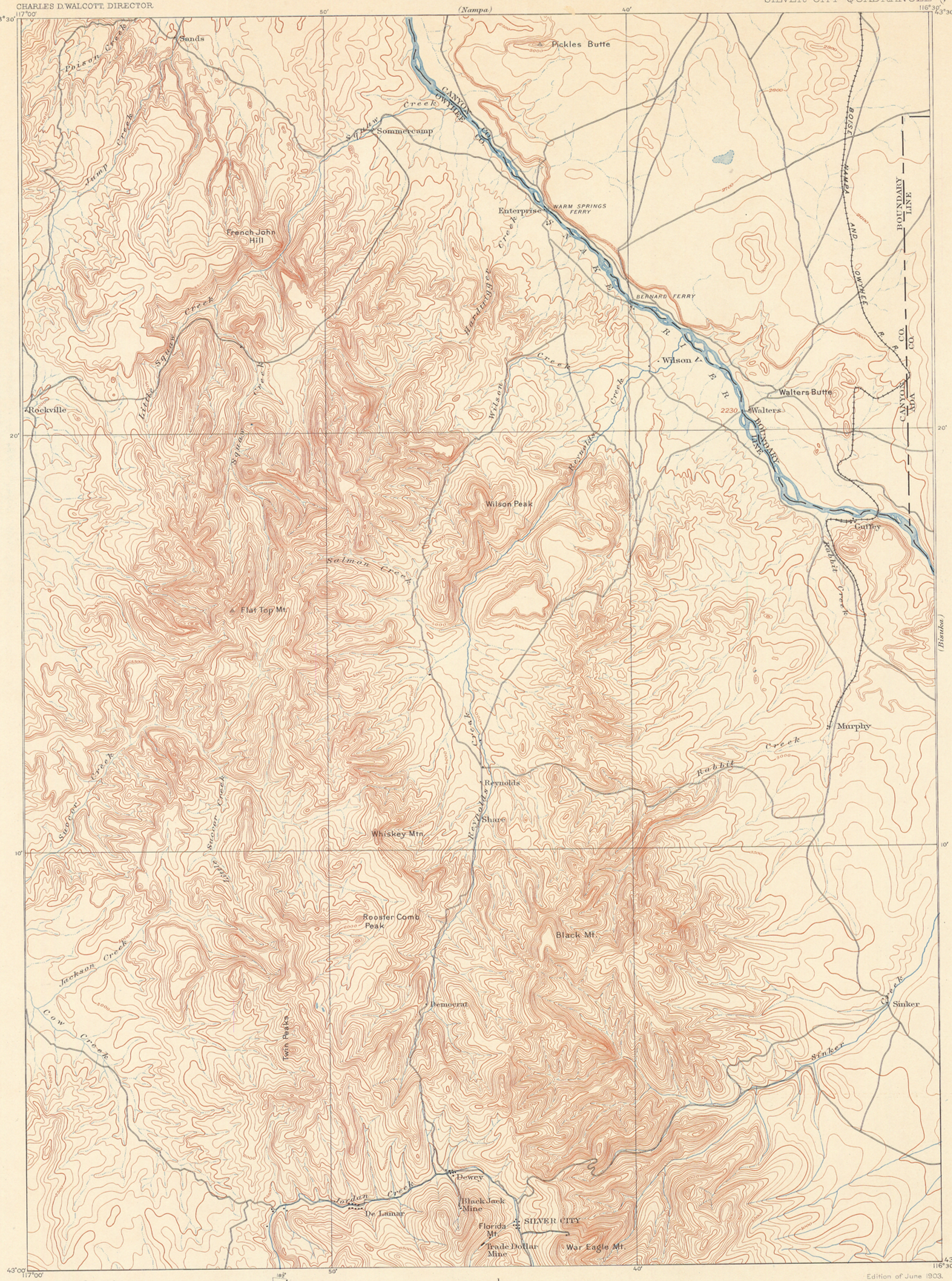
As may be judged from the facts above presented in reference to the occurrence of hot springs near the artesian wells now flowing, the most favorable localities for drilling additional wells may be assumed to be near where warm or hot springs rise through the Payette formation. A qualification of this 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.

U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

TOPOGRAPHY

IDAHO
SILVER CITY QUADRANGLE



LEGEND

RELIEF
(printed in brown)

2230
Figures
(showing heights above mean sea level instrumentally determined)

Contours
(showing height above sea, horizontal form, and steepness of slope of the surface)

DRAINAGE
(printed in blue)

Streams

Intermittent streams

Lakes and ponds

Intermittent lakes

CULTURE
(printed in black)

Roads and buildings

Railroads

Bridges

Ferries

County lines

Triangulation stations

A. H. Thompson, Geographer.
W. T. Griswold, Topographer in charge.
Triangulation by W. T. Griswold.
Topography by E. T. Perkins Jr.
Surveyed in 1892.

TRUE NORTH
MAGNETIC NORTH
18½°
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.

Datum is mean sea level.

Edition of June 1903.

U. S. GEOLOGICAL SURVEY
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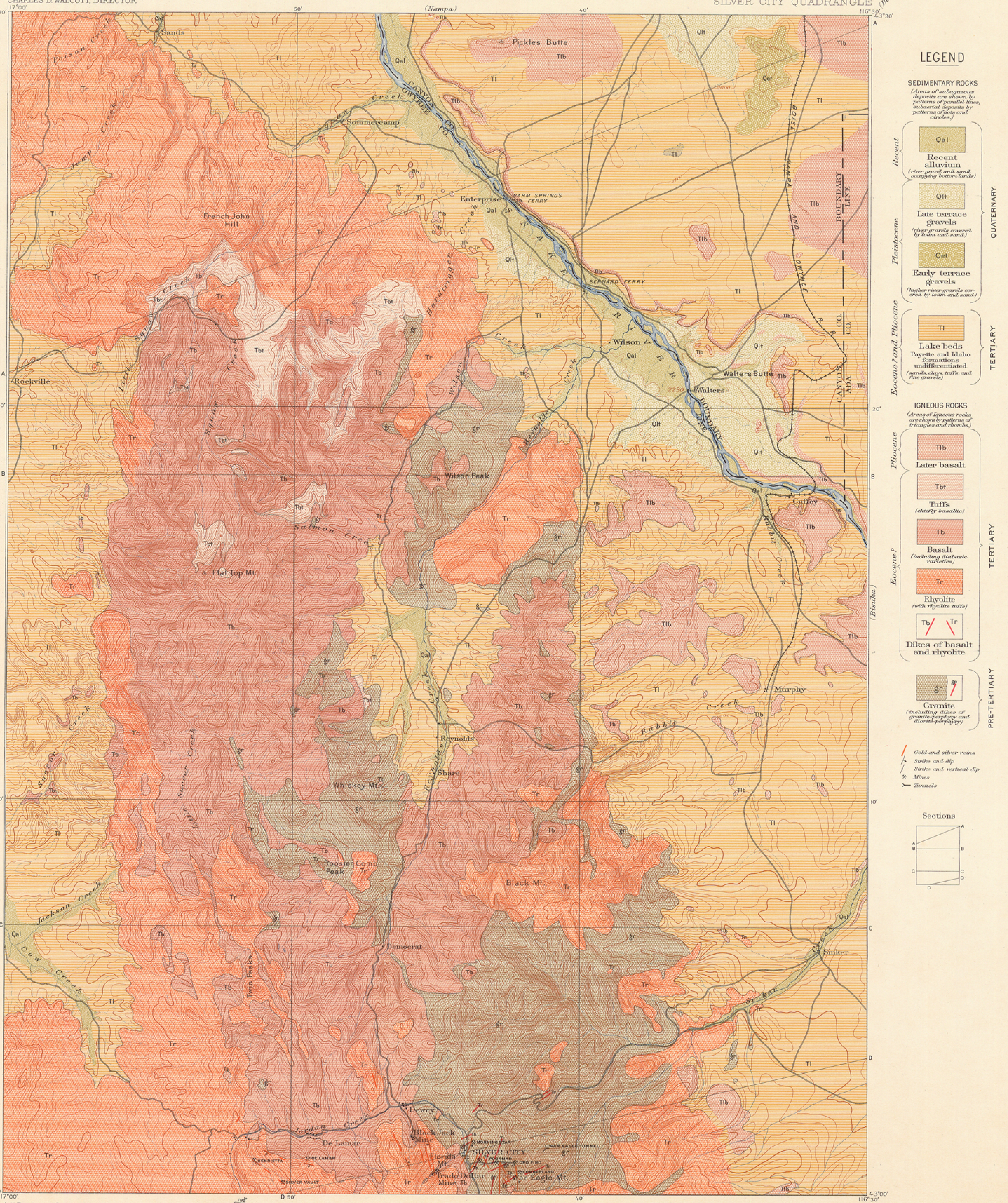
AREAL GEOLOGY

IDAHO
SILVER CITY QUADRANGLE



A. H. Thompson, Geographer.
W. T. Griswold, Topographer in charge.
Triangulation by W. T. Griswold.
Topography by E. T. Perkins Jr.
Surveyed in 1892.

TRUE NORTH — MAGNETIC NORTH 18½°
APPROXIMATE MEAN DECLINATION 1902.

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour interval 100 feet.

Datum is mean sea level.

Edition of Sept. 1903.

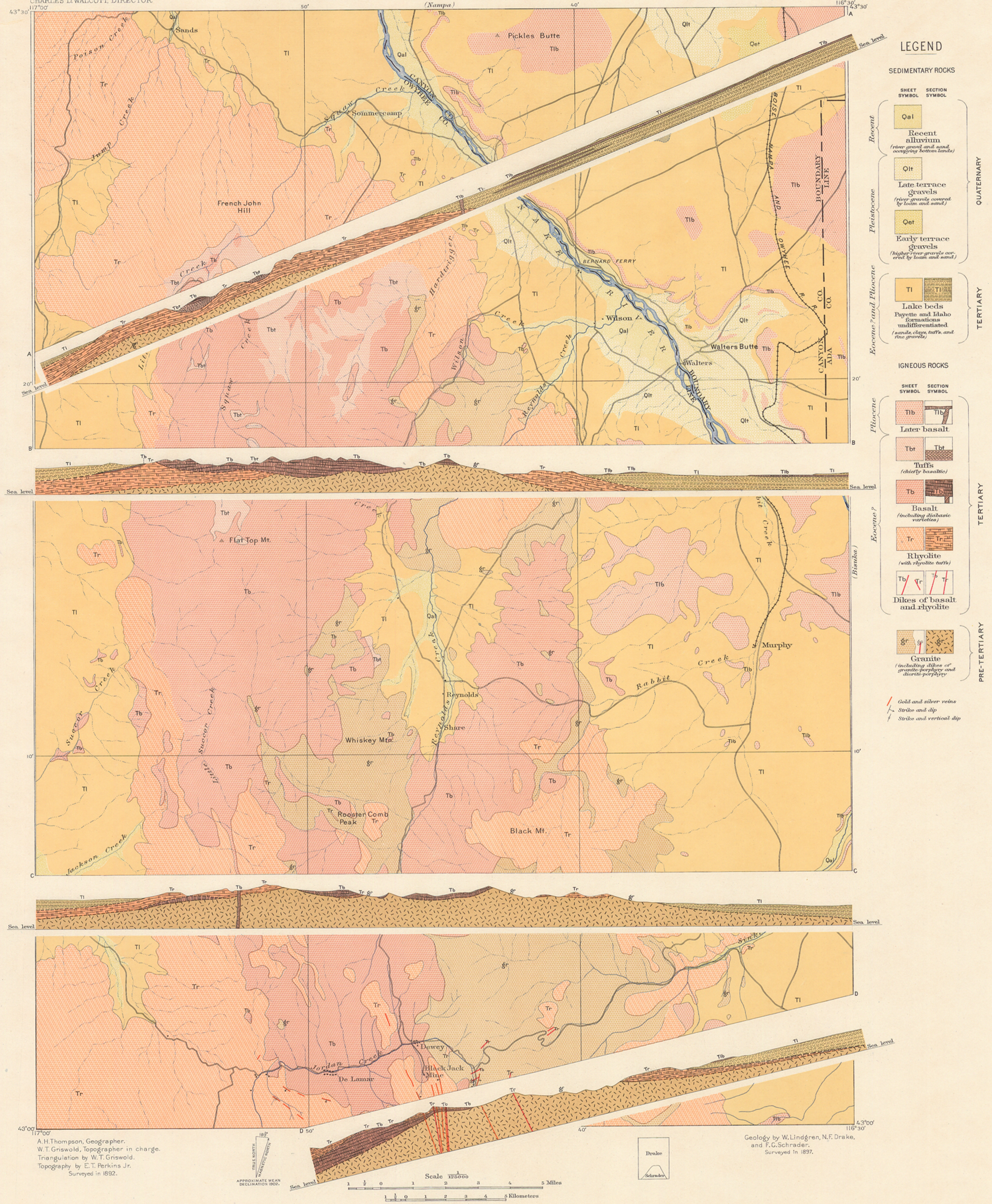
Drake
Schrader

Geology by W. Lindgren, N. F. Drake, and F. C. Schrader.
Surveyed in 1897.

U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

STRUCTURE SECTIONS

IDAHO
SILVER CITY QUADRANGLE



A. H. Thompson, Geographer.
W. T. Griswold, Topographer in charge.
Triangulation by W. T. Griswold.
Topography by E. T. Perkins Jr.
Surveyed in 1892.

Geology by W. Lindgren, N. F. Drake, and F. C. Schrader.
Surveyed in 1897.

Edition of Dec. 1903.

As sedimentary deposits or strata accumulate the younger rest on those that are older, and the relative ages of the deposits may be determined by observing their positions. This relationship holds except in regions of intense disturbance; in such regions sometimes the beds have been reversed, and it is often difficult to determine their relative ages from their positions; then *fossils*, or the remains and imprints of plants and animals, indicate which of two or more formations is the oldest.

Stratified rocks often contain the remains or imprints of plants and animals which, at the time the strata were deposited, lived in the sea or were washed from the land into lakes or seas, or were buried in surficial deposits on the land. Such rocks are called fossiliferous. By studying fossils it has been found that the life of each period of the earth's history was to a great extent different from that of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are *characteristic types*, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present. When two sedimentary formations are remote from each other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first. Fossil remains found in the strata of different areas, provinces, and continents afford the most important means for combining local histories into a general earth history.

It is often difficult or impossible to determine the age of an igneous formation, but the relative age of such a formation can sometimes be ascertained by observing whether an associated sedimentary formation of known age is cut by the igneous mass or is deposited upon it.

Similarly, the time at which metamorphic rocks were formed from the original masses is sometimes shown by their relations to adjacent formations of known age; but the age recorded on the map is that of the original masses and not of their metamorphism.

Colors and patterns.—Each formation is shown on the map by a distinctive combination of color and pattern, and is labeled by a special letter symbol.

Symbols and colors assigned to the rock systems.

	System.	Series.	Symbol.	Color for sedimentary rocks.
Cenozoic	Quaternary	Recent, Pleistocene	Q	Brownish-yellow.
	Tertiary	Pliocene, Miocene, Oligocene, Eocene	T	Yellow ocher.
Mesozoic	Cretaceous		K	Olive-green.
	Jurassic		J	Blue-green.
	Triassic		Ћ	Peacock-blue.
Paleozoic	Carboniferous	Permian, Pennsylvanian, Mississippian	C	Blue.
	Devonian		D	Blue-gray.
	Silurian		S	Blue-purple.
	Ordovician		O	Red-purple.
	Cambrian	Saratogan, Acadian, Georgian	€	Brick-red.
	Algonkian		A	Brownish-red.
	Archean		Æ	Gray-brown.

Patterns composed of parallel straight lines are used to represent sedimentary formations deposited in the sea or in lakes. Patterns of dots and circles represent alluvial, glacial, and eolian formations. Patterns of triangles and rhombs are used for igneous formations. Metamorphic rocks of unknown origin are represented by short dashes irregularly placed; if the rock is schist the dashes may be arranged in wavy lines parallel to the structure planes. Suitable combination patterns are used for metamorphic formations known to be of sedimentary or of igneous origin.

The patterns of each class are printed in various colors. With the patterns of parallel lines, colors are used to indicate age, a particular color being assigned to each system. The symbols by which formations are labeled consist each of two or more letters. If the age of a formation is known the symbol includes the system symbol, which is a capital letter or monogram; otherwise the symbols are composed of small letters. The names of the systems and recognized series, in proper order (from new to old), with the color and symbol assigned to each system, are given in the preceding table.

SURFACE FORMS.

Hills and valleys and all other surface forms have been produced by geologic processes. For example, most valleys are the result of erosion by the streams that flow through them (see fig. 1), and the alluvial plains bordering many streams were built up by the streams; sea cliffs are made by the eroding action of waves, and sand spits are built up by waves. Topographic forms thus constitute part of the record of the history of the earth.

Some forms are produced in the making of deposits and are inseparably connected with them. The hooked spit, shown in fig. 1, is an illustration. To this class belong beaches, alluvial plains, lava streams, drumlins (smooth oval hills composed of till), and moraines (ridges of drift made at the edges of glaciers). Other forms are produced by erosion, and these are, in origin, independent of the associated material. The sea cliff is an illustration; it may be carved from any rock. To this class belong abandoned river channels, glacial furrows, and peneplains. In the making of a stream terrace an alluvial plain is first built and afterwards partly eroded away. The shaping of a marine or lacustrine plain is usually a double process, hills being worn away (*degraded*) and valleys being filled up (*aggraded*).

All parts of the land surface are subject to the action of air, water, and ice, which slowly wear them down, and streams carry the waste material to the sea. As the process depends on the flow of water to the sea, it can not be carried below sea level, and the sea is therefore called the *base-level* of erosion. When a large tract is for a long time undisturbed by uplift or subsidence it is degraded nearly to base-level, and the even surface thus produced is called a *peneplain*. If the tract is afterwards uplifted the peneplain at the top is a record of the former relation of the tract to sea level.

THE VARIOUS GEOLOGIC SHEETS.

Areal geology map.—This map shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any colored pattern and its letter symbol the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the formations are arranged in columnar form, grouped primarily according to origin—sedimentary, igneous, and crystalline of unknown origin—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology map.—This map represents the distribution of useful minerals and rocks, showing their relations to the topographic features and to the geologic formations. The formations which appear on the areal geology map are usually shown on this map by fainter color patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A mine symbol is printed at each mine or quarry, accompanied by the name of the principal mineral mined or stone quarried. For regions where there are important mining industries or where artesian basins exist special maps are prepared, to show these additional economic features.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same term is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of formation of rocks, and having traced out the relations among the beds on the surface, he can infer their relative positions after they pass beneath the surface, and can draw sections representing the structure of the earth to a considerable depth. Such a section exhibits what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

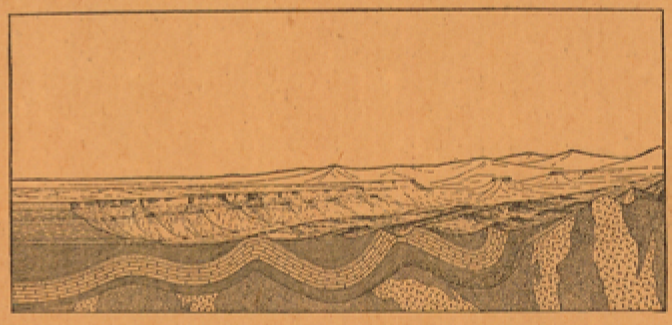


Fig. 2.—Sketch showing a vertical section at the front and a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground on a vertical plane, so as to show the underground relations of the rocks. The kinds of rock are indicated by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

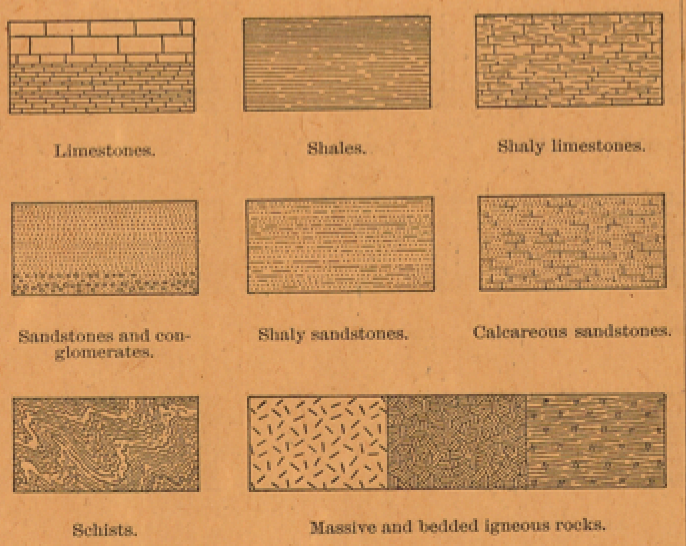


Fig. 3.—Symbols used in sections to represent different kinds of rocks.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section. The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to the outcrops of a bed of sandstone that rises to the surface. The upturned edges of this bed form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shale.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred. The direction that the intersection of a bed with a horizontal plane will take is called the *strike*. The inclination of the bed to the horizontal plane, measured at right angles to the strike, is called the *dip*.

Strata are frequently curved in troughs and arches, such as are seen in fig. 2. The arches are called *anticlines* and the troughs *synclines*. But the sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets; that they are now bent and folded is proof that forces have from time to time caused the earth's surface to wrinkle along certain zones. In places the strata are broken across and the parts have slipped past each other. Such breaks are termed *faults*. Two kinds of faults are shown in fig. 4.

On the right of the sketch, fig. 2, the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be

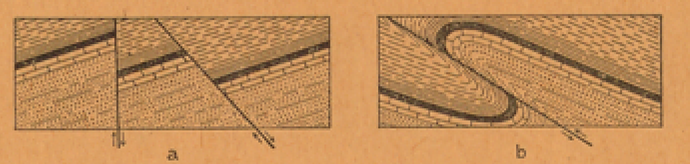


Fig. 4.—Ideal sections of strata, showing (a) *normal* faults and (b) a *thrust* fault.

inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

The section in fig. 2 shows three sets of formations, distinguished by their underground relations. The uppermost of these, seen at the left of the section, is a set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has been raised from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

The second set of formations consists of strata which form arches and troughs. These strata were once continuous, but the crests of the arches have been removed by degradation. The beds, like those of the first set, are conformable.

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger rocks thus rest upon an eroded surface of older rocks the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But the pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that a considerable interval elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets is another unconformity; it marks a time interval between two periods of rock formation.

The section and landscape in fig. 2 are ideal, but they illustrate relations which actually occur. The sections on the structure-section sheet are related to the maps as the section in the figure is related to the landscape. The profile of the surface in the section corresponds to the actual slopes of the ground along the section line, and the depth from the surface of any mineral-producing or water-bearing stratum which appears in the section may be measured by using the scale of the map.

Columnar section sheet.—This sheet contains a concise description of the sedimentary formations which occur in the quadrangle. It presents a summary of the facts relating to the character of the rocks, the thickness of the formations, and the order of accumulation of successive deposits.

The rocks are briefly described, and their characters are indicated in the columnar diagram. The thicknesses of formations are given in figures which state the least and greatest measurements, and the average thickness of each is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement—the oldest formation at the bottom, the youngest at the top.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition are indicated graphically and by the word "unconformity."

CHARLES D. WALCOTT,
Director.

Revised January, 1904.

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