

DESCRIPTION OF THE NAMPA QUADRANGLE

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GEOGRAPHY.

Location and area.—The Nampa quadrangle lies between meridians 116° 30' and 117° west longitude and parallels 43° 30' and 44° north latitude. It is 34.5 miles long and 25.1 miles wide, and has an area of 863.82 square miles. The quadrangle embraces a large part of Canyon County, Idaho, and a small fraction of Ada County, while the southwest corner is occupied by a portion of Owyhee County. A few square miles of Malheur County, Oreg., are included in the northwest corner.

Relief.—The Nampa quadrangle is situated near the lower end of the great Snake River Valley, which here is bordered by the Boise Mountains on the north and the Owyhee Range on the south. The very lowest foothills of the latter lie in the southwest corner, while the northeast corner does not quite reach the corresponding foothills of the Boise Mountains. The width of the valley here is between 35 and 45 miles. The highest elevations are naturally found in these foothills; they reach 3600 feet in the southwest and 3400 in the northeast corner. The lowest elevation is found in the northwest corner, where Snake River leaves the quadrangle, and is approximately 2140 feet. Flat relief characterizes the whole quadrangle. Flood plains 2 to 4 miles wide, bordered by broad terraces, cross it along Payette, Boise, and Snake rivers. These flood plains and terraces are separated by gently rolling complexes of hills or dissected low mesas. In places the higher lands are sharply eroded, gulches and bluffy drainage borders remaining as secondary features. The southern half of the quadrangle has the flatter relief, while the divide between Boise and Payette rivers rises 200 to 600 feet above the stream, and the hills north of the Payette and near Emmett attain an elevation of 1000 feet above the river. The main complex of hills between the Boise and the Payette forms a sloping plateau gradually descending westward from an elevation of 3100 to 2750 feet, until it abruptly drops off toward Snake River. A broad, low ridge separates Boise and Snake rivers, having a comparatively steep slope southward and a more gentle descent toward Boise River.

Drainage.—The main watercourse is Snake River, which flows across the southwest corner of the quadrangle and again enters it near the northwest corner. Snake River, as is well known, is the largest affluent of Columbia River; it has a drainage area of about 22,600 square miles and carries a large volume of water in a channel which usually is deep and well defined. A short distance south of the Nampa quadrangle it emerges from a canyon cut about 700 feet in the lake beds and the intercalated basalt flows. This canyon, which is 220 miles long, begins below American Falls, where the Oregon Short Line crosses the river. In the southwest corner of this quadrangle the river still flows in a well-defined channel and is apparently eroding its bed. Along this part of its course the bottom lands are of slight extent and the course is relatively straight. The grade here is approximately 5 feet to the mile. The nearest point at which the volume of water has been measured is at Montgomery Ferry, 175 miles east-southeast of Nampa, and there the river carries considerably less water than in the Nampa quadrangle. The maximum flow at Montgomery Ferry for the year 1899 was 29,200 second-feet, in June, while the minimum, 5400 second-feet, was measured in March.

Below the junction with the Boise the narrow valley widens to a well-defined flood plain, reaching to a point 10 miles below Weiser, where the great canyon of Snake River begins. In this distance the river receives five important tributaries, the Boise, the Owyhee, the Payette, the Weiser, and the Malheur. The river grade in this valley is less than 2 feet to the mile.

Boise River, a large tributary of the Snake, joins

the latter just beyond the western boundary of the quadrangle. It drains 2500 square miles, embracing much of the mountainous region of central Idaho. In the Boise quadrangle, adjoining the Nampa quadrangle on the east, the river emerges from a deep granite canyon and, turning to the northwest, continues to Snake River across a broad alluvial valley of sediments brought down from its upper watershed. The river banks are usually but 1 to 2 feet above the river level, and the stream swings in frequent meanders across the wide flood plains down a grade of 10 feet to the mile. The quantity of water measured at the mouth of the canyon varied in 1899 between a maximum of 12,200 second-feet, in June, to a minimum of 1150 second-feet, in September, the average flow being 4000 second-feet. In 1895 the amount varied from 916 second-feet in December to 6026 second-feet in May.

In general position, direction, and grade Payette River is entirely similar to the Boise. Like the latter, it has an extensive watershed in the central mountain regions of Idaho. It flows across the northeastern part of the Nampa quadrangle and joins the Snake at the town of Payette, a few miles north of the northern boundary line, in the Weiser quadrangle. In 1895 its mean flow was 988 second-feet in November and 13,137 second-feet in May. Since that date no measurements have been made. By comparing the data it will be seen that Payette River ordinarily carries a considerably greater quantity of water than the Boise, and that its flow is more regular.

Besides these three streams there is practically no watercourse which carries permanent water, except, possibly, Succor Creek, which enters Snake River from the southwestern side. All the rest are either dry gulches or contain water only during the wet season.

Climate.—Snake River Valley is entirely in the arid belt and its climate and vegetation are closely allied to those of the Great Basin. The Pacific meteorologic influences make themselves strongly felt, so that the climate of the valley may be characterized as comparatively mild. The precipitation is somewhat larger than in the Great Basin. In the valleys the temperature may exceed 100° F. for a few days in summer; in winter the mercury rarely sinks to 0° F., though occasional invasions of cold waves from the north may drive it down to -27° F. This, however, happens very rarely. At Boise the mean annual temperature ranges from 50° to 53° F. The winds are generally southwesterly and seldom very strong, but they often carry great quantities of dust.

The normal rainfall at Nampa is reported to be 10.06 inches, but this average does not cover many years. Most of the rain falls between September 1 and June 1 and is fairly well distributed through these months. During the summer months there is scarcely any precipitation. In ordinary winters but little snow falls in the valley and it does not remain long on the ground.

Vegetation.—The vegetation is, on the whole, very scanty and the entire quadrangle might be briefly characterized as a sagebrush desert. Along the river bottoms of the Boise and the Payette cottonwoods, alders, and aspens grow, and the fact that the water stands within a short distance of the surface makes irrigation in many places unnecessary. Snake River, flowing in a deeper bed, is not bordered by trees, and the fringe of grasses is confined to the immediate vicinity of the stream bed. The river terraces and flats are covered by a luxuriant growth of sagebrush. The higher hills and dissected mesas are exceedingly barren; white lake beds appear for long distances, bright in the sunlight and only occasionally half hidden by scanty desert brush.

Culture.—The population of Canyon County, which occupies the greater part of the quadrangle, was 3143 in 1890, and 3951 in 1900. The Oregon

Short Line traverses the quadrangle diagonally from southeast to northwest. On this railroad are located the towns of Nampa and Caldwell, the latter being the county seat of Canyon County. Smaller towns or settlements are Emmett, Falks Store, and New Plymouth on the Payette, and Middleton and Parma on the Boise.

A little gold placer mining is done along the principal streams, and the hilly lands separating the rivers afford a somewhat scant range for stock, but the principal industry is agriculture. Naturally the agricultural lands are the bottoms and the terraces bordering the rivers. On the flood plains of Boise and Payette rivers there is, as stated above, a natural subirrigation that keeps vegetation growing and in places makes good grazing and forest lands without care. In some places along Willow Creek the underground water provides a similar subirrigation, so that wheat, corn, and fruit trees are grown without artificial watering. With these exceptions the agricultural lands of the quadrangle must be irrigated.

GENERAL GEOLOGY.

GEOLOGIC HISTORY.

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 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 a very deep and often very abrupt canyon through older rock, 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.

The old Snake River Valley.—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 with 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 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 near Weiser (elevation, 2100 feet), 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 earliest 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 redetermined 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 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 will not be 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 Eocene lake smaller valleys 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 a fair degree of certainty.

¹ Twentieth Ann. Rept. U. S. Geol. Survey, pt. 3, 1900; and Twenty-second Ann. Rept., pt. 2, 1901.

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

Later lake epoch.—The progress of erosion in the valley was checked at this time by some cause, as yet unknown. 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 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 Glens Ferry these deposits reach an elevation of 3700 feet along the brink of the Snake River Canyon. If they really are lacustrine, which seems almost certain, these relations would again indicate a tilting movement by which the beds at Glens Ferry have risen nearly 1000 feet relatively to those near Walters Ferry.

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

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

Résumé.—Summing up the Tertiary history of deposition and erosion in this basin, we have first an early Tertiary epoch of erosion, followed by outbursts of rhyolite and basalt and the deposition of

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

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

It should be noted that on the former assumption of a Miocene age of the Payette formation this history fitted in well with the paleontologic sequence. Accepting, however, the latest determination of the Payette formation as Eocene, there remains a long time-interval—the whole of the Miocene epoch—to be accounted for between the Eocene and the Pliocene, and this would seem to be somewhat inadequately represented by the epoch of erosion between the two series of lake beds. The excavation of the great Snake River Canyon below Huntington would, according to these last data, be placed in the Miocene and would occupy the larger part of that epoch. The upper canyon, from American Falls nearly to the edge of the Nampa quadrangle, was cut during the Quaternary period.

GEOLOGIC FORMATIONS.

TERTIARY ROCKS.

LAKE BEDS.

Extent of the lake beds.—As indicated above, the lake beds of the Payette and Idaho formations once covered the whole of the area of this quadrangle. Even now, though largely hidden under Quaternary deposits, they occupy about one-half of the quadrangle. Intercalated lava flows form a very insignificant part of the beds, although farther east in the Snake River Valley they become much more abundant.

In the Boise quadrangle, adjoining on the east, the lake beds rest against the steep granite slope of the Boise Range. The only place where an older underlying rock is shown in this quadrangle is in the southwest corner, where the lake beds rest against an outlying ridge of the great rhyolite area of the Owyhee Range; here they attain a maximum elevation of 2800 feet.

Characteristics of the lake beds.—The reason for dividing these lake beds into an Eocene (or Miocene) and a Pliocene series (the Payette and Idaho formations) is indicated more fully below. Practically, it is not possible to separate these two terranes, and in a large degree the same description applies to both. This is apparent since the material for both came from the same source—the great granite area of central Idaho; and further, a large part of the Idaho formation is simply Payette sediments worked over and redeposited. If clearly defined beach lines once existed they would soon have been obliterated owing to the soft and sandy character of the older, as well as of the younger, deposits. The majority of the deposits are unquestionably of lacustrine origin. This is proved by their uniform appearance as well as by the very even stratification and the persistence of certain strata over large areas. Gypsiferous beds are of very common occurrence in the Pliocene division of the lake beds. Near the margins of the lake, and especially near the débouchure of the canyons, gravels and other fluvial deposits are, however, mingled with the lake beds. Delta deposits, especially, were formed during the recession of the Payette lake, as indicated, for instance, by the heavy gravel deposits at high levels in front of Boise River.¹

In general, the strata consist of quartz sands

¹Lindgren, W., Description of the Boise quadrangle: Geologic Atlas U. S., folio 45, U. S. Geol. Survey, 1898.

with slight admixture of small mica flakes, and thin strata of clays; for the most part they are light gray, buff, or nearly white in color. Strata in which clay is predominant probably make up only one-tenth of the whole amount of the lake beds. Occasionally thin interstratified conglomerates and small deposits of pebbles occur. These pebbles consist of granite-porphry and quartz, more rarely of basalt and rhyolite. Toward the northern part of the quadrangle the strata are more sandy; angular quartz grains one-tenth of an inch, or less, in diameter are scattered through fine sediments showing imperfect assortment and rapid accumulation; rare and thin lignitic streaks appear in places and seem to be chiefly made up of carbonized grasses, indicating that at various times the lake was shallow and marshy. In the extreme northeast corner of the quadrangle and immediately north of this the strata up to an elevation of 3000 feet contain, along with the loose, friable sand, some white, compact, sandy clays and thin intercalated white or gray tufts which resist weathering so as to form slight breaks in the otherwise smooth, steep hill slopes. These tufts doubtless connect with the volcanic areas of Miocene age north of Square Butte. When well exposed the lake beds nearly always show smooth bedding planes. Cross bedding and lenticular structure are not common, but when occurring may be of considerable local extent. Usually the sands are but slightly consolidated and the exposures easily crumble to smooth, sandy slopes. On the east side of the rhyolite ridge in the southwest corner of the quadrangle is a nearly continuous outcrop of rather coarse-grained, well-consolidated sandstone. This sandstone belt, which again appears farther south, in the Silver City quadrangle, is about one-fourth of a mile wide, but is not shown regularly on account of debris coming down from the rhyolite hills, and because of a covering of softer lake beds. It is believed that these hard cemented sands are only a local development of the Payette formation, possibly due to hot springs. It is clear that the sediments of the lake were very largely derived from the granite areas to the northeast. The valley thus became the general dumping ground for coarse and fine granitic debris.

Thickness of the lake beds.—The visible thickness of the lake beds is fully 700 feet in the complex between Payette and Boise rivers, and as much as 1000 feet north of the Payette. Along Snake River a thickness of 200 to 300 feet is shown. How deep the beds extend is not ascertained, as no well in this vicinity has yet passed through the formation. At the Ballantyne well, near the eastern edge of the quadrangle, a thickness of 600 feet of sandstone was penetrated. The Nampa well exposed 320 feet of similar material.

Detailed sections.—In a general way the section of the hills south of Emmett shows the characteristics of the lake beds in this area.

Section south of Emmett, Idaho.

	Feet.
At top, highly micaceous fine sand, with occasional argillaceous thin strata.....	15
Argillaceous fine sand with thin layers of highly argillaceous sand and occasional layers of coarse-grained sand.....	15
Coarse, micaceous quartz sand containing quartz and occasional feldspar pebbles $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter.....	25
Fine-grained, argillaceous sand.....	5
Coarse, loose sand with small pebbles $\frac{1}{4}$ to 1 inch in diameter.....	5
Gray, argillaceous, fine sand with scattering quartz pebbles $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter.....	5
Loose micaceous quartz sands with occasional streaks or thin layers of argillaceous sands. This group of strata shows alternations in degrees of fineness, but otherwise is almost uniform. Usually the sands are coarse and the quartz grains angular.....	200
Gray, fine-grained, highly micaceous quartz sands.....	2
Highly argillaceous, gray, fine sands.....	1
Loose micaceous quartz sands, at bottom.....	50
Total.....	323

The following section, as seen in the escarpment about 3 miles northwest of the point where the Caldwell-Rockville road crosses Snake River, will suffice to show the general uniformity of the strata underlying the Nampa quadrangle. About 250 feet of the lake beds are here exposed.

Fifty feet from the base of the section 2 or 3 feet of clay sands contain a little lignite; the rest of the section shows very little variation. The beds are very sandy, loose, buff or light-gray colored, and practically free from the coarse quartz

grains and small pebbles so common in the northern part of the field. Some of the beds are made up of almost pure sand, but usually there is a slight admixture of clay. Bones of fossil horse, *Equus*, are common throughout the section, except in the upper 5 to 10 feet, which is composed of water-worn pebbles and coarse sand. This pebble deposit is clearly Quaternary, and appears to be laid unconformably upon the lower beds.

The following section occurs on the north side of Sand Hollow, north of Payette River, about 2½ miles from the mouth of the deep gulch:

Section in Sand Hollow, north of Payette River.

	Feet.
At top, sandy loam.....	5-10
Well-rounded pebbles. Most of the pebbles are granitic, but some consist of quartz and feldspar porphyries. A few pebbles of obsidian, as well as others of diabase and basalt, are found in this bed, which is clearly of Pleistocene age.....	3-5
Sand, with occasional minor strata of argillaceous sand. Most of the sand is coarse-grained or a mixture of coarse- and fine-grained sand. This imperfect assortment appears characteristic of the section. Small flakes of mica are common throughout. In the coarser sands small pebbles of quartz or quartz-porphry one-half inch, and less, in diameter are of rather common occurrence.....	250

A well bored at Nampa (elevation, 2490 feet) gave the following section:

Section of well at Nampa, Idaho.

	Feet.
At top, hardpan and loam.....	60
Basalt, below which roots, leaves, and vegetable mold are found.....	15
Boulders and sand.....	100
Clay seam.....	$\frac{1}{2}$
Sand.....	40
Clay seam.....	$\frac{1}{2}$
Sand.....	80
Clay.....	15
Sand. (From the lower part of this stratum the sand pump brought up a small image similar to a roughly shaped doll, which at the time created much interest, as the statement was made on seemingly good authority that the find was genuine. Further substantiation of this remarkable occurrence has not been forthcoming, and the image may have been dropped into the wellhole by someone wishing to perpetrate a practical joke).....	40
Coaly material at the bottom of this stratum. More consolidated sandstone at bottom of section.....	19
Total.....	320

Thus there is in this well, below the 60 feet of Quaternary material, 15 feet of basalt and 220 feet of sands with some clays. The latter probably represent the Idaho formation. Near the bottom, at an elevation of 2170 feet, was a layer of lignitic material. Finally, below this came a harder sandstone, which may represent the Payette formation.

The Ballantyne well, having an elevation at the top of 2575 feet, located on the mesa north of Boise River and 2 miles east of the eastern boundary line of the Nampa quadrangle, shows the following section:

Section of Ballantyne well, Ada County, Idaho.

	Feet.
At top, sand with boulders (Pleistocene).....	35
Sand with clay streaks.....	595
Total.....	630

At the bottom was found loose mud with leaves, fir cones, and fish bones, some of the fir cones being encrusted with pyrite. A large tree trunk was also bored through at this depth. The elevation of this stratum of carbonaceous matter was 1900 feet.

Age of the lake beds.—Fossil leaves indicating an early Tertiary age (probably Eocene) occur not uncommonly near the base of the Payette formation in the adjoining Boise quadrangle. In the Nampa quadrangle no well-preserved leaves have thus far been found, the only fossils noted being vertebrate mammalian bones, as follows:

Vertebrate mammalian bones found in Nampa quadrangle.

- (1) North side of Indian Creek, 4½ miles northwest of Nampa; elevation, 2400 feet; at base of small bluff of Quaternary, in sand probably belonging to Tertiary lake beds: *Equus*.
- (2) One and one-half miles north of Jump Creek, in bluff on north side of Snake River; elevation, 2400 feet; in soft lake beds: *Equus* bones, fairly common throughout the section.
- (3) East side of Snake River, 2 miles northeast of Nyssa; small bluff, probably of lake beds, underlying Quaternary; elevation, 2200 feet: *Mastodon*.
- (4) Two and one-half miles north-northwest of ferry where Caldwell-Rockville road crosses Snake River; soft lake beds forming bluffs facing Snake River; eleva-

tion, 2500 feet: *Equus*; *Procamelus*, size of *P. major*; *Mastodon*, not *M. americanus*; *Castor*, possibly n. sp.; *Olor*, size of *O. paleocynus*; *Pappichthys*.

(5) On west side of Sand Hollow, near the northern boundary of the quadrangle; elevation, 2700 feet; in the sandy lake beds: *Cervus*, possibly new, slightly smaller and more slender than *C. canadensis*.

All the species are considered to indicate Pliocene age.

If the paleontologic evidence is considered as a whole, it certainly would seem that the beds are divisible into two sections, since:

First, an older series consisting of strata accumulated to a level of 4000 to 5000 feet in the lake during the first period of filling. In these beds mammalian remains are certainly scarce; fresh-water mollusks, of little value for purposes of determining the age of the strata, occur in places; very abundant, especially near the shore lines and toward the base of the series, are impressions of deciduous leaves, indicating Miocene or, according to the latest determinations, Eocene age.

Second, the mammalian remains are found chiefly in the center of the valley near Snake River and in beds the elevation of which seldom exceeds 2600 feet. In some sections along Snake River bones of *Equus* are very common—may, indeed, be said to be characteristic of the beds. *Mastodon mirificus* and *Equus excelsis* have been found in a similar position on Sinker Creek in the Bisuka quadrangle. Fish bones are frequently found, and twenty-two species of a clearly Pliocene age have been determined by Cope. Fresh-water shells and beds of *Unio* shells are very common. All this is certainly in distinct contrast to the lake beds appearing at higher elevations but apparently lower stratigraphic horizon in the Nampa, Weiser, Boise, and Silver City quadrangles.

From a stratigraphic standpoint it might at first glance seem most probable that the lake beds of this quadrangle were deposited in one continuous series, and were subsequently degraded and covered by Quaternary gravels. From this quadrangle alone no positive evidence against such a view can be adduced, but when one considers the exceptionally clear record of happenings which is apparent in the succession of rocks near the mouth of the Boise Canyon it becomes evident that the sequence of events was not so simple.

It is shown in the text of the Boise quadrangle that the canyon of the Boise existed practically in its present shape before any lake beds were deposited in the valley. After the accumulation of the Payette formation to an elevation of 4200 feet or more, erosion began. During the gradual establishment of an outlet to the lake the canyon of Boise River was scoured of its accumulations down to practically the present depth—that is, down to an elevation of about 3850 feet. This evidently very active erosion must have removed the lake beds along newly established river courses throughout this part of the Snake River Valley. As is shown by the long ridge between Boise and Payette rivers, these earlier (Eocene) lake beds attained an elevation along the shore line of at least 4500 feet, and from this point their surface sloped down very gradually to an elevation of 2750 feet. To this level, then, it must be considered that the whole valley was filled with deposits of the Payette formation. From the depth and evidently intense action of the post-Payette erosion it follows that the whole valley, at a period closely following the highest stage of the lake, was dry land, the newly deposited lake beds being deeply dissected by the newly established river courses. Probably the depth to which erosion had progressed in the center of the valley was about the same as at present. To some degree corroborating this we find in the Nampa well section a layer of lignitic material at an elevation of 2170 feet. The section of the Ballantyne well is entirely different from that of the Nampa well, and from its position in relation to Boise River it may be conjectured that it penetrated exclusively sandstones of Payette age, and that the coaly material found near the bottom, at an elevation of 1900 feet, is situated near the base of that formation.

Next followed several basaltic eruptions, the flows of which came down the canyon of Boise River and are separated by considerable masses of gravel. The lowest of these flows rests on granite and is, probably the oldest, showing a somewhat steeper grade of the river than that

Nampa.

which obtains at present. The uppermost flow spread out in considerable volume in front of the canyon, on top of the heavy gravels which had already dammed the canyon at an elevation of 3100 feet. This basaltic flow rests on one side against the deeply eroded gravels of the Payette formation, and the Quaternary gravels on the other side rest against the black cliffs of the lava. Further, it is clear that the basalt flows on Boise River and those exposed near Nampa and along Snake River are identical, or practically identical, in age. Evidence of this is their position, one being almost directly adjoined by the other; also, their vesicular and generally fresh character, and, finally, the characteristic of several thin flows superimposed and separated only by thin sediments. In both cases the only deposits on the top flow are thin Quaternary gravels and loam, and in some places thin lake beds.

At the mouth of the Boise Canyon the basalt rests at an elevation of 3000 feet on clearly fluvial gravel. Along Snake River the same flows are intercalated with lake beds which ordinarily show no cross bedding or other evidence of fluvial action and which contain remains of mammals of Pliocene age. At Nampa the same flow rests on coaly vegetable soil, forming the top stratum of a considerable thickness of sands.

All these facts taken together force us to conclude that, following the first erosion of the lake beds, to a depth equal to that of the present erosion, another period of sedimentation began, during which heavy gravels accumulated along the base of the mountains, and the central part of Snake River Valley was a shallow lake, or perhaps, in part, at times a marshy swamp.

The elevation to which these second lake-bed deposits reached can not be positively stated, but it is believed that they did not extend to a higher altitude than 2700 feet, which elevation is reached by the white lake beds along Snake River in the Nampa and Silver City quadrangles.

Another important fact tending in the same direction is the presence of large quantities of gypsum, indicating a slowly drying body of water, which occur in these later lake beds along Snake River in the Silver City quadrangle.

Although this chain of reasoning seems conclusively to prove the division of the lake beds into an older, Eocene or Miocene, series (Payette formation) and a younger, Pliocene, series (Idaho formation), still it is impossible to separate the two divisions in the field. If this conclusion be not accepted, the only alternative is that the lake beds and basaltic flows of Snake River were laid down in the regular succession of the Payette beds during the Eocene epoch. On this assumption the lowest beds along Snake River southwest of Nampa, at an elevation of 2300 feet, would be, stratigraphically speaking, 450 feet below the top of the Payette formation as exposed between Boise and Payette rivers. It is believed that the reasons indicated above are strong enough to completely refute this theory. There is, moreover, a marked difference in appearance between the basaltic flows which are intercalated in the Payette formation and were erupted during its deposition and the thin basalt flows of the Boise Canyon and Snake River. The more recent geologic age of the latter is clearly indicated by their great freshness and unoxidized condition, by their black color, by their extreme fluidity at the time of eruption, and by the general absence of secondary minerals, such as chlorite, serpentine, opal, and calcite.

RHYOLITE.

Occurrence of rhyolite.—The only area of rhyolite observed in the quadrangle occupies a few square miles in the southwest corner. This is the very edge of an extensive flow which occupies a large area of the foothills of the Owyhee Range. Along the contact with the lake beds it is clearly seen that the latter overlie the eroded face of the rhyolite. This agrees with the observations made along the foothills on the other side of the valley north of Boise, where heavy flows of rhyolite cover the granite of the range, the rhyolite in its turn being covered by lake beds of the Payette formation. Although the age of the lake beds at the rhyolite ridge in the Nampa quadrangle is not positively known, they are probably Pliocene, and the rhyolite and dacite are consequently pre-Pliocene.

But from the exposures in the adjacent Silver City quadrangle it is evident that these lavas were erupted just prior to the deposition of the Payette formation, which would establish their age, according to latest determinations, as pre-Eocene. In the Silver City quadrangle the dacite is later than the rhyolite.

Character of the rhyolite.—The rhyolite is of a felsitic type, consisting chiefly of a very fine-grained, microcrystalline to cryptocrystalline mass of quartz and alkali feldspar, in which a few small, scattered phenocrysts of the same minerals are embedded. The groundmass is often characteristically streaky by irregular alternation of coarser and finer aggregates. Biotite is of rare occurrence. The rock is generally vesicular, in places also tuffaceous; the cavities are often filled by opal and other forms of silica.

Associated dacite.—On the northeast side of the rhyolite area appears a dike of somewhat different and apparently less acid rock. It is very similar to certain dikes in the Silver City quadrangle which have been determined as dacite or acidic andesite. This rock is light gray or brownish and contains small phenocrysts of orthoclase, andesine, biotite, and hornblende in a very fine-grained, microcrystalline groundmass. The dike does not break through the lake beds—although such is the appearance on the map—but is older and projects through the lacustrine beds, forming a somewhat prominent little ridge.

BASALT.

The Pliocene basalt occupies small areas on both sides of Indian Creek near Nampa, and local patches are also encountered at various points in the lake beds overlooking Snake River. Some of the latter may be due to small local eruptions. The basalt flow which occurs at Nampa extends far into the adjoining Boise quadrangle and almost connects with the large flow spread out at the mouth of the Boise Canyon. The two flows may not have originated from the same vent, but it can not be doubted that the two were erupted at practically the same period. The flow at Nampa extends far into the Bisuka and Silver City quadrangles. It is possible that its origin is to be sought in that basaltic dome or buckle which rises a short distance south of the railroad station of Kuna. According to borings near Nampa, the basalt is from 15 to 50 feet thick and rests on sandy beds. Immediately below it roots and coaly matter were found, indicating that it was poured out on a floor sustaining some vegetation—most probably of marshy character. Along Snake River, however, there is no indication of such coaly deposit, the basalt resting directly on well-bedded sands of probably lacustrine origin, except at Walters Butte (Silver City quadrangle), where the underlying deposit is a pebble bed. In some places, for instance about 2 miles southwest of Nampa, some of this basalt thins out to layers 6 to 12 inches in thickness and is so smoothly bedded that slabs of the rock are taken up and used for culverts and other rough constructions. Over a large part of the area indicated as basalt on the map the solid rock is really covered by a varying depth of loam, soil, or sand. The basalt is of black color, very fresh, and exceedingly vesicular; it is a normal feldspar basalt with small, closely crowded crystals of labradorite and grains of augite, occasionally also olivine embedded in a scant groundmass of glassy character. This lava was evidently extremely fluid when poured out. The basalt in the Nampa quadrangle, except the occurrence on Boise River near Caldwell, is probably Pliocene in age, as it is interbedded with or covers sediments belonging to that epoch. The basalt at Caldwell is described in connection with the Quaternary deposits.

QUATERNARY ROCKS.

RIVER DEPOSITS.

General description.—Deposits of Quaternary age cover about one-half of the Nampa quadrangle and may be subdivided into several formations. In all cases the beds cover lake beds or basalt of Tertiary age, and are spread over them as a thin mantle. The Quaternary deposits accumulated in the valleys of Snake, Boise, and Payette rivers, which gradually deepened their channels and eroded the sides of the valley as the watercourses swung across the flood plains. This accumulation

of river deposits has been steadily going on since the close of the Pliocene, assuming arbitrarily that this time limit is marked by the upper basalt flow in the Boise Canyon.

Over the whole quadrangle the Quaternary deposits consist of river gravels of moderate depth covered by fine sands and loams; sometimes, also, by hardpan to a depth as great as 50 feet. These gravels and loams are not a part of the lake beds, but rest unconformably by erosion on the latter. The mantle of gravel closely conforms to the present topography and is rarely broken except at erosional escarpments. On the highest terraces the pebble deposit is only 5 to 10 feet thick, but is found generally to thicken considerably toward the present rivers. All of this gravel-covered area is more or less distinctly terraced, the terraces becoming more plainly indicated and more extensive as the present rivers are approached. The grades of the old river deposits, where clearly indicated, are about the same as those of the present rivers. In the Boise quadrangle, however, it appears as if the modern river had a somewhat steeper grade than its early Quaternary predecessor. The pebbles are well rounded, of moderate size, and consist mainly of quartz and older porphyritic rocks, more rarely of rhyolite and basalt. The covering of the gravels sometimes consists of sand, but more commonly it is a fine, brownish or reddish loam. This loam is a persistent feature of the terraces, and is important economically on account of its excellent qualities as a soil. The origin of this deposit of loam is not quite clear in all cases; to a great extent it is probably of fluvial origin, sometimes showing distinct cross bedding, but in part, especially on the higher lands and on the basalt areas near Nampa, it is probably an eolian deposit accumulated by the dust-laden winds which so frequently sweep this region. The thickness of the loam varies from a few feet to 50 or 60 feet, and to the southwest of Nampa it is not uncommon to find a basalt flow underlying it. In nearly all places elsewhere it is underlain by 5 to 40 feet of gravel.

Broadly speaking, three stages of river deposition may be distinguished, represented by (1) the early terrace gravels, (2) the late terrace gravels, and (3) recent alluvium. The outlines of the gravel areas, especially where they cover the lake beds, are very indistinct and most difficult to map; the boundaries outlined on the map are, therefore, only approximately correct.

Early terrace gravels.—These deposits really form a series of terraces or shelves, often indistinct and gradually merging one into another. North of the Payette there are several terraces of comparatively coarse gravels below an elevation of 3000 feet. No deposits of this formation are found on the south slope of the Payette Valley, and there are but few of them north of the Boise. On the south side of Boise River they are, however, strongly developed at elevations ranging from 2400 to 2800 feet. They appear here as a thin sheet spread over the lake beds, which gradually slope from the escarpment near the Snake toward the first terrace south of Boise River. The deposits probably may be separated into several terraces, although on the gently sloping ground a distinction between each of them is difficult.

Late terrace gravels.—These spread over sloping shelves on both sides of the rivers and rise to elevations of 100 to 150 feet above the stream. The line between the late terrace gravels and the alluvium is usually marked by a steep bluff. These terraces are extensively developed on both sides of Boise and Payette rivers, but to a less extent along Snake River. Along Boise River the highest elevations of the lower terrace range from 2300 to 2600 feet, following the river from east to west; along Payette River similar benches descend from 2750 feet near the eastern edge of the quadrangle to 2500 feet near the junction with Snake River.

Recent alluvium.—This forms strips of almost level land along the present rivers, over which the Boise and Payette meander in swinging curves, often changing their channels. The river bottoms are 2 to 3 miles wide and gradually slope up to a height of approximately 50 feet above the river. Along Snake River the deposits are narrower and very sandy, with but little gravel. North of the junction with the Boise, as mentioned above, the

alluvium widens to a flood plain of considerable extent.

River courses.—On the whole, Boise and Payette rivers appear to be more unstable in their courses than Snake River and are characterized by the possession of wide bottom lands and lower banks. Snake River, on the contrary, is confined between more distinct banks, carries a little gravel, but principally sand, in its sediments, and is evidently eroding its channel more actively than the other two. This takes place notwithstanding the fact that Snake River has a considerably slighter grade than the others, but may be due to the relatively small quantity of material which it transports, since the Boise and the Payette are overloaded with the products of disintegration of the Boise Mountains. The evidence of changes in the river courses is very clear. It has been shown that in the Boise quadrangle, adjoining eastward, Boise River during the earlier Tertiary had an almost due westerly direction from the mouth of its canyon, and that during the Quaternary period it has gradually swung northward to the course which it now occupies. Similar relations are noticed in this quadrangle. During early Quaternary times the river apparently ran south of Nampa, as indicated by the heavy and persistent gravel deposits in that vicinity; it probably emptied directly into the Snake near this point (see text of Silver City folio), but has since then gradually worked its way westward and northward. Payette River, in the eastern part of the quadrangle, has moved southward since the deposition of the upper terrace gravels. Snake River has gradually worked northeastward, but apparently has been more stationary than either of the other rivers.

Since the retreat of the rivers from the upper benches, rains and winds have worked over the surface to a certain extent and have formed at least a part of the now universal mantle of loam that covers the river gravels.

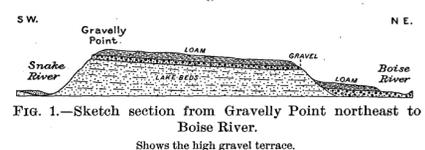
Detailed sections.—A few sections may be selected to represent the Quaternary deposits in the Nampa quadrangle.

Section of the face of the mesa east of Phyllis canal north of Pipe Gulch.

	Feet.
Soil.....	2
Light-colored sands.....	2
Brownish sands.....	3
Hardpan (sand, clay, lime, etc., in nodules and irregular layers).....	12
Waterworn gravel.....	12
Argillaceous and micaceous white sand.....	4
Grayish white sand.....	10
Bluish-white clay, slightly arenaceous.....	3
Total.....	48

This section is on the lower terrace.

A section from Snake River at Gravelly Point to Boise River, south of Parma, would show the relations illustrated in fig. 1.



Entirely similar would appear a section from Snake River to the Boise between Guess Gulch and Pipe Gulch. These sections are 8 miles apart.

Wells at Eastman's ranch, on the Ridenbaugh canal, 5½ miles southwest of Nampa, show 40 feet of soil and loam, the thickness varying greatly at closely adjoining places; below lies 65 feet of basalt.

On the first terrace south of Boise River and south of Parma 15 to 25 feet of stratified sands overlie gravel. As the first terrace is comparatively low at this place the gravel is probably the same as that underlying the flood plains of the river.

About half a mile east of the first railroad bridge across Snake River, below Parma, there is an exposure in the east bank of the river showing 50 feet of strata. At the top of the section is 10 to 12 feet of conglomerate and gravels. Below the gravels the strata consist of rather fine, compact sand in thin layers, often showing cross bedding. At the south end of this section are other sand deposits, unconformable upon the older sands and having the appearance of wind-blown deposits.

A section extending eastward from Snake River at a point 2 miles north of Nyssa shows sand overlying 10 feet of waterworn gravel, which in its turn is underlain by argillaceous sand. The gravels

in this section consist of well-rounded pebbles of granite-porphyrines, basalt, and more rarely rhyolite; probably one-half of the bulk of the deposit consists of pebbles that are 2 to 6 inches in diameter. The overlying sand and loam deposits are stratified, but where seen well exposed along the river they often show the wavy and flaky cross bedding characteristic of eolian deposits. This does not apply to the whole area in this vicinity, for the strata as a whole are too extensive and smoothly bedded to be other than water-laid deposits. The sands below the gravel bed appear like the regular Pliocene lake beds, and a bone of Mastodon was found in this part of the section.

Section on east side of Snake River in northwest corner of Nampa quadrangle.

	Feet.
At top, sand. The upper few feet of this stratum is of eolian origin.....	50
Calcareous sand and clay containing nodules and concretions of indurated material. This bed is what is commonly referred to as "hardpan".....	25
Gravel mixed with coarse sand. The pebbles consist of granite-porphry and some basalt.....	15
Very uniform, light-gray, compact clay sands. The bottom of this stratum is 15 feet above the level of Snake River.....	50
Total.....	140

It is believed that the material below the gravel bed belongs to the Payette formation and is of lacustrine origin. It may be seen that this section bears a strong resemblance to the preceding one. In fact, this succession occurs regularly along the east side of Snake River in the northwestern part of the quadrangle.

Well sections in the sloping lower terrace of the Payette Valley, about 2 miles east of the preceding section, pass through 30 to 50 feet of soil, sand, and hardpan, and then into the gravel bed.

A northeast-southwest section across the Payette Valley near Falks Store is shown in fig. 2.

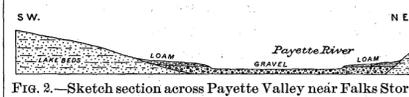


FIG. 2.—Sketch section across Payette Valley near Falks Store. The river gravels underlie the whole width of the valley.

The figure shows that the pebble deposits underlying the bottom lands of Payette River probably occupy the whole width of the valley, but are covered by sand and loam a short distance from the river.

Section in east bank of Indian Creek about halfway between Nampa and Caldwell.

	Feet.
At top, sandy loam, streaked with horizontal seams of hardpan. This stratum has in part the appearance of wind-blown deposits.....	5
Coarse, angular quartz and granite sand, with occasional small pebbles, up to 1½ inches in diameter, of granite and vesicular basalt. The basalt pebbles are probably derived from the rock outcropping east of Nampa. The bedding of this stratum is wavy, lenticular, and has the appearance of being Pleistocene river deposits.....	10
Uniformly textured, fine-grained, slightly clayey sand. This part of the section is regarded as probably a Pliocene lake deposit. <i>Equus</i> bones were found in it.....	5
Total.....	20

A north-south section extends across Boise River north of Nampa as seen in fig. 3. It shows the

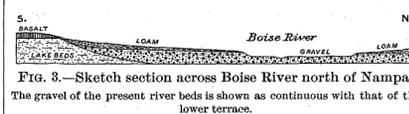


FIG. 3.—Sketch section across Boise River north of Nampa. The gravel of the present river beds is shown as continuous with that of the lower terrace.

gradual thinning of the loam toward the river and the probable identity of the gravel bed which underlies the present river bottom with that below the lower terrace.

Section on north bank of Payette River ¼ miles below Bissell Creek.

	Feet.
At top, loamy deposits. The lower part of this bed is somewhat sandy.....	15
Gravels. Nearly all the pebbles consist of porphyry and are from 3 to 6 inches in diameter; they are well rounded, and bedded with a small amount of coarse sand, and contain occasional small lenticular streaks of sand.....	15
Sands and argillaceous sands, slightly coarse bedded. Most of the bed is coarse quartz sand, with occasional pebbles.....	30
Total.....	60

Northwestward along the escarpment containing the above section the same succession was found

to run very regularly for 6 or 7 miles. The pebble bed gradually becomes a little lower or falls a little more rapidly than the river.

The lake beds lying north of Payette River are marked by terraces which are less conspicuous as higher elevations are reached. An ideal northeast-southwest section north of Payette River between Sand Hollow and Bissell Creek is shown in fig. 4.



FIG. 4.—Ideal sketch section of the north bank of Payette River between Sand Hollow and Bissell Creek.

From this section it is seen that the pebble beds are not continuous, but that they form the closely underlying bed rock of each terrace. The lower the terrace the greater is the thickness of the gravel bed. The gravel beds also slope slightly toward the river. Thus it seems that the original nearly level surface of the country, consisting of lake deposits, was more or less covered with gravels, and that, as erosion trimmed down the level plain to basins and these basins into successively narrower valleys, the gravels have been gradually lowered and only slightly transported.

LATE BASALT.

The basalt areas in the Nampa quadrangle are largely of Pliocene age, as explained in preceding paragraphs, but there is one flow which in its position and association indicates a later (Quaternary) age. This area is the thin flow of basalt appearing near Caldwell on both sides of Boise River. The hardness of this basalt flow is evidently responsible for the local contraction of the flood plain of the river at this point. It narrows suddenly from 2 miles to a few hundred yards, only to widen immediately again after having crossed the narrow basaltic tongue. Exposures near Caldwell show the following section:

Section in basalt area near Caldwell, Idaho.

	Feet.
Loamy soil.....	3
Vesicular basalt.....	10-20
Gravel and sand. The bottom of this stratum is at the level of the alluvium of Boise River.....	50
Total.....	63-73

From this it appears that this thin flow rests at an elevation of 2380 feet on typical Quaternary gravels, whereas the other flows in this quadrangle are intercalated with beds which are referred to the Pliocene lake beds. The flow is small in extent and can not be correlated with any of the other basaltic masses. In petrographic character it is a black, dense, vesicular rock, entirely similar to the Pliocene basalts previously described.

ECONOMIC GEOLOGY.

GOLD.

Placer gold is found in the gravels and sands of Snake, Boise, and Payette rivers and is occasionally worked in a limited way. The production of gold in Canyon County is given in the recent Mint reports as from \$7000 to \$10,000 per year. Most of this is probably derived from operations on a small scale along these rivers. Washing for gold is frequently done by persons from farms in the vicinity of the rivers, who have short periods to spare from their ordinary work, and who find it remunerative to wash the gravels for a limited time during the winter. Recently a dredging plant has been built near Nyssa and, it is stated, operated with satisfactory results. About ten years ago a dredge was built on Payette River below Emmett, but the results were found unsatisfactory. At that time, however, the dredging industry was in its infancy, so that the enterprise may not have been a fair test of what can be accomplished at the present day.

The gold along Snake River is extremely fine, flaky or floury, and occurs in thin and not very persistent pay streaks intercalated in the sands along the bends of the river. This fine gold is contained in the sandy bars all the way down from the headwaters, and its origin has been the source of much speculation. It is now believed to have been set free by the erosion of large bodies of old conglomerates near the head of the river in northwestern Wyoming. The sandy bars contain gold

varying in value from a few cents to several dollars per cubic yard. The latter values are ordinarily of very limited extent and the best bars have long since been worked out. Frequently, however, more gold is deposited by the action of the stream in the same place, so that after a certain time interval the same bars may be washed over again. The gravel ranges in size from fine sand to boulders which are seldom larger than a man's head. The current has a velocity of 3 to 5 miles per hour. The gold is very unevenly distributed through these bars, being generally found in strata of medium-sized gravel, from a few inches to a few feet thick, and usually overlain by 2 to 10 feet of barren sand or gravel. Below these strata, also, the gravel may be worthless. Depth does not seem to cause any increase in values; where the bed rock has been reached at a few points on the rim it holds but little gold. The Snake River gold above the mouth of Boise River is very fine, averaging about 1200 colors to one cent, and is worth from \$17 to \$19 per ounce. Below the mouth of the Boise the gold is not quite so fine, averaging about 900 colors to one cent; the value is said to be lower, being from \$14 to \$16 per ounce. The gold is always accompanied by much black sand or magnetite and ilmenite, probably derived from the basalt. When the gold and the black sand are carefully separated the latter contains but small values. The method of mining employed by men working on a small scale is usually the so-called "burlap" system. The sluices are made about 20 feet long and much wider than the ordinary box. The bottom is covered by burlap and the screened material allowed to pour over it in a thin, even stream. At intervals the burlaps are taken out and washed. The gold does not always amalgamate easily, and processes based on amalgamation on copper plates, or by forcing the sand through mercury, are generally failures.

In dredging the Snake River sands and gravels it has been found that the pay gravel contains from 5 to 15 cents per cubic yard. In order to make a profit on sand containing 10 cents per cubic yard, at least 1000 cubic yards must be handled daily. The gravel is screened to ½-inch size and the gold caught in broad and shallow burlap sluices with an area of 1300 square feet. The cost of dredging by means of suction pumps with a capacity of 2500 cubic yards per day is stated to be 4 cents per cubic yard. The ladder dredge is said to work somewhat cheaper, or at the cost of about 3 cents per cubic yard. The practical test now being carried on at Nyssa and at several points on the upper river will soon demonstrate whether large areas of dredging ground of remunerative grade are available.

COAL.

No coal beds of any importance have been found in the Tertiary lake beds, although layers rich in lignite are not uncommon. It is not likely that beds of commercial importance will be found. In the Boise quadrangle coal of fair quantity and of some commercial importance has been found at several places in these lake beds, but these localities are near the shore line or in sheltered bays of the lake, where there was more opportunity for the development of an abundant vegetation.

OPALS.

The rhyolite of the Owyhee Range, in the southwest corner of the Nampa quadrangle, contains considerable quantities of milk opals and has been prospected for fire opals, some of which are said to have been found, but the quantity was so small that no further work has been done. The opals usually occur as fillings of the cavities of the vesicular rhyolite, but some occur as filling of small veinlets. Good stones have been found in the adjacent area of rhyolite in the Silver City quadrangle.

BUILDING STONE.

The building stones are confined to two small areas. At either place fairly good building stone for ordinary purposes may be obtained. One of the localities is along about half of the eastern border of the rhyolite area in the southwest corner of the quadrangle; there the sandstones are rather coarse grained, forming strata of varying thickness and light-buff color. This belt of hard sandstones

is about 2 miles long by one-fourth of a mile wide. The other area lies in the escarpment on the east side of Snake River at and near the south line of the Nampa quadrangle. At this point there is a bed, about 50 feet thick, of rather coarse-grained, indurated sandstone. Some of the strata are thin, but more commonly they are massive, and cross bedding is a marked feature. The rock grades from friable to very hard, and from gray to buff colored.

The basalt is locally used for culverts and other rough work.

SOILS.

The soils may be classed under three headings, as follows: The highland soils, the river-terrace soils, and the flood-plain soils.

The highland soils are the thinnest and most sandy of the three and naturally are subjected to the most rapid erosion.

The river-terrace soils are confined to the terraces bordering the flood plains of Snake, Boise, and Payette rivers, as well as to the flood plains or Quaternary deposits of Snake River. This soil has a good mixture of sand and clay for agricultural purposes and is very productive and easily tilled.

The alluvial soils are nearly all confined to the flood plains of Boise and Payette rivers and to a little of the lowlands of Snake River in the northwest corner of the quadrangle. These soils have more organic matter than either of the above, and also more or less alkaline salts, so that they are often unfit for cultivation. They are also damper, heavier, and more difficult to till.

The soil of the terraces and flood plains is exceedingly fertile, and when water is applied it transforms the dreary sagebrush desert into beautiful and prosperous farming districts. The total amount of irrigable land along Payette River in this quadrangle is about 100 square miles. In the valleys of the Boise and the Snake, in this quadrangle, there is a total area of 240 square

Nampa.

miles below the canals already constructed. Taken together with the 117 square miles below the ditches in the adjoining Boise quadrangle, this makes a total of 357 square miles of irrigable land in the Boise Valley. It is not believed, however, that the water in Boise River is sufficient to irrigate this amount of land. Already a scarcity of water is felt during occasional dry seasons. In order fully to utilize the available land, it will be necessary to construct reservoirs to store some of the flood waters of the river. In this quadrangle a large part of the lower terraces along the Boise is already irrigated, as well as some parts of the uplands south of Nampa. Not much more land is available for irrigation in this valley, except some parts of Deer Flat and the top of the ridge separating the Boise from the Snake. There would be some difficulty, however, in carrying water to these localities. The hills of lake beds to the north of Boise are practically nonirrigable. Along the Payette a large part of the southern terrace, as well as the river bottom, is already under irrigation and supports prosperous communities. The northern terrace, also, could easily be watered by a ditch from the same river.

The crops most generally cultivated on the irrigated farms consist of alfalfa, more rarely of grain. Fruits, also, such as apples, pears, and prunes, do well, and large orchards have been planted in this and the adjoining Boise quadrangle.

Snake River is not as yet utilized for irrigation. Although some of its bottom lands and lower terraces would be well adapted to agriculture, the difficulty of taking out the water from its channel is great on account of its low grade and the precipitous character of its canyon, along which the ditch must be conducted. A body of good land is located at the mouth of Jump Creek and would seem to include at least 30 square miles. It is said that part of this, at least, could be irrigated by storage of water on Jump and Succor creeks. The prob-

lem is complicated by the fact that these water-courses in great part flow through the State of Oregon, though their heads and lower courses are in Idaho.

WATER SUPPLY.

Surface waters.—The quantity of water available in the rivers has been referred to. If all the water that flows across the quadrangle could be utilized, there would be ample to irrigate all the fertile lands in the quadrangle and much more. Payette River probably carries more than enough water to irrigate the whole valley below Emmet, but in the case of Boise River a shortage is anticipated unless storage reservoirs are constructed. On September 1, 1898, measurements were made on the Boise by the United States Geological Survey, which showed that a total of 1160 second-feet of water was being taken out by the ditches in Boise Valley below the canyon, while the river a short distance above the mouth of the canyon contained a total of 734 second-feet. This year, however, was one of unusual scarcity of water. A certain amount of this water, which was taken out by the canals, returned to the river by seepage; the gain by seepage per mile was estimated to be 7.65 second-feet.

There are few natural springs in the quadrangle, and those are of slight volume. However, another source of water is available—that is, the large quantity of underground water which is present throughout a large part of the quadrangle. In the flood plains of Boise and Payette rivers water is usually found at depths varying from 4 to 10 feet. In the lower lands of the valley of Willow Creek, also, water is found from 4 to 6 feet below the surface. In the mesa lands bordering the river flood plains the water level is from 25 to 50 feet below the surface. At Nampa water stands 15 feet below the surface in the deep well sunk to 320 feet. Finally, in the hills between Boise and Snake rivers, water is reached at about 100 feet below the

surface. It will thus be seen that the surface of the ground water to some extent follows the contour of the surface, but, as might be expected in this arid climate, the water surface is much flatter than the topographic surface. Much of the ground water could doubtless be obtained by means of windmills. Regarding the amount used for irrigation, it should be noted that there is a considerable waste, many farmers using much more water than is necessary.

Artesian wells.—The gravels and underlying sands of the valley are saturated with ground water, and there is no difficulty in obtaining large amounts by pumping. The deepest well thus far sunk in this quadrangle is that at Nampa, which attained 340 feet. Water is said to stand within 15 feet of the top. Owing to the sandy character of the strata, the apparent absence of water-tight, clayey strata, and the relatively small precipitation of the region, it is not likely that flowing wells will be found in the higher parts of the quadrangle. In the Boise folio attention was called to the probability that the Snake River Valley is a tectonic trough and that the conditions are favorable for artesian wells in the lower parts, provided that clayey beds are found in depth, to retain the water within certain limits. Along Boise and Payette rivers there is, however, little need for more water. On the south side of Snake River near the mouth of Jump Creek, where there is a considerable body of good land available less than 100 feet above the river level, artesian water in moderate amount may be obtainable. It would also seem possible to obtain artesian flows in Willow Creek, near the eastern edge of the quadrangle, and also in the small alluvial valleys on the western slope of Squaw Butte, a high basaltic mountain in the Boise quadrangle, close to the northeast corner of the the Nampa quadrangle.

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