DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

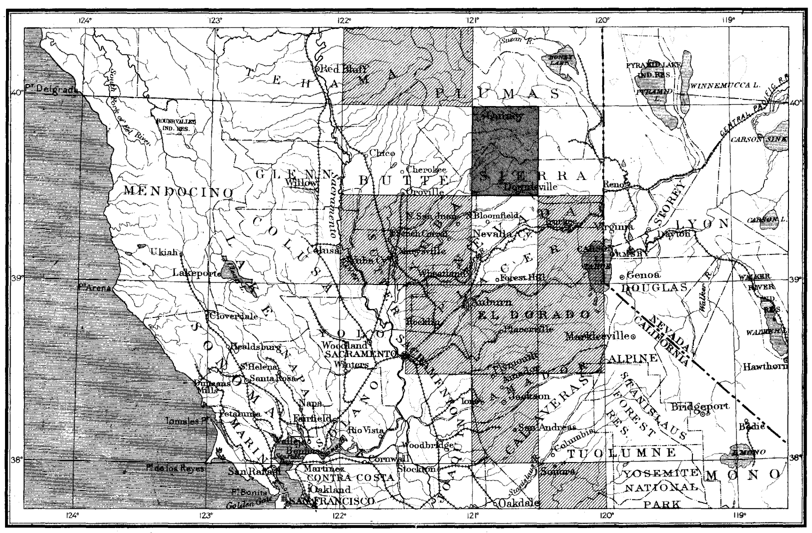
OF THE

UNITED STATES

DOWNIEVILLE FOLIO

CALIFORNIA

INDEX MAP



SCALE: 40 MILES = 1 INCH

AREA OF THE DOWNIEVILLE FOLIO

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FOLIO 37 | LIBRARY EDITION | DOWNIEVILLE

WASHINGTON, D.C.

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EXPLANATION.

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base 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 horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical 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:

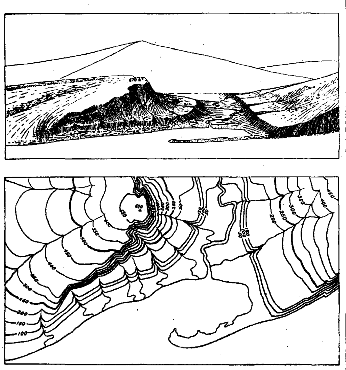

Fig. 1.—Ideal sketch and corresponding contour map.

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 in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. 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 approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all 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 nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The 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 vertical 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 used 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 the stream flows the year round 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, and artificial details, are printed in black.

Scales.—The area of the United States (excluding Alaska) is about 3,025,000 square miles. On a map with the scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be 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 $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

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 n les, 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 and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory 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-quarter 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, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or 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 sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a map for local reference.

THE GEOLOGIC MAP.

The maps representing areal geology show by colors and conventional signs, on the topographic base map, the distribution of rock formations on the surface of the earth, and the structure-section map shows their underground relations, as far as known, and in such detail as the scale permits.

KINDS OF ROCKS.

Rocks are of many kinds. The original crust of the earth was probably composed of *igneous rocks*, and all other rocks have been derived from them in one way or another.

Atmospheric agencies gradually break up igneous rocks, forming superficial, or *surficial*, deposits of clay, sand, and gravel. Deposits of this class have been formed on land surfaces since the earliest geologic time. Through the transporting agencies of streams the surficial materials of all ages and origins are carried to the sea, where, along with material derived from the land by the action of the waves on the coast, they form *sedimentary rocks*. These are usually hardened into conglomerate, sandstone, shale, and limestone, but they may remain unconsolidated and still be called "rocks" by the geologist, though popularly known as gravel, sand, and clay.

From time to time in geologic history igneous and sedimentary rocks have been deeply buried, consolidated, and raised again above the surface of the water. In these processes, through the agencies of pressure, movement, and chemical action, they are often greatly altered, and in this condition they are called *metamorphic rocks*.

Igneous rocks.—These are rocks which have cooled and consolidated from a liquid state. As has been explained, sedimentary rocks were deposited on the original igneous rocks. Through the igneous and sedimentary rocks of all ages molten material has from time to time been forced upward to or near the surface, and there consolidated. When the channels or vents into which this molten material is forced do not reach the surface, it either consolidates in cracks or fissures crossing the bedding planes, thus forming dikes, or else spreads out between the strata in large bodies, called sills or laccoliths. Such rocks are called *intrusive*. Within their rock enclosures they cool slowly, and hence are generally of crystalline texture. When the channels reach the surface the lavas often flow out and build up volcanoes. These lavas cool rapidly in the air, acquiring a glassy or, more often, a partially crystalline condition. They are usually more or less porous. The igneous rocks thus formed upon the surface are called *extrusive*. Explosive action often accompanies volcanic eruptions, causing ejections of dust or ash and larger fragments. These materials when consolidated constitute breccias, agglomerates, and tuffs. The ash when carried into lakes or seas may become stratified, so as to have the structure of sedimentary rocks.

The age of an igneous rock is often difficult or impossible to determine. When it cuts across a sedimentary rock, it is younger than that rock, and when a sedimentary rock is deposited over it, the igneous rock is the older.

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be changed by the development of planes of division, so that it splits in one direction more easily than in others. Thus a granite may pass into a gneiss, and from that into a mica-schist.

Sedimentary rocks.—These comprise all rocks which have been deposited under water, whether in sea, lake, or stream. They form a very large part of the dry land.

When the materials of which sedimentary rocks are composed are carried as solid particles by water and deposited as gravel, sand, or mud, the deposit is called a mechanical sediment. These may become hardened into conglomerate, sandstone, or shale. When the material is carried in solution by the water and is deposited without the aid of life, it is called a chemical sediment; if deposited with the aid of life, it is called an organic sediment. The more important rocks formed from chemical and organic deposits are limestone, chert, gypsum, salt, iron ore, peat, lignite, and coal. Any one of the above sedimentary deposits may be separately formed, or the different materials may be intermingled in many ways, producing a great variety of rocks.

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in successive 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 over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

The character of the original sediments may be changed by chemical and dynamic action so as to produce metamorphic rocks. In the metamorphism of a sedimentary rock, just as in the metamorphism of an igneous rock, the substances of which it is composed may enter into new combinations, or new substances may be added. When these processes are complete the sedimentary rock becomes crystalline. Such changes transform sandstone to quartzite, limestone to marble, and modify other rocks according to their composition. A system of parallel division planes is often produced, which may cross the original beds or strata at any angle. Rocks divided by such planes are called slates or schists.

Rocks of any period of the earth's history may be more or less altered, but the younger formations have generally escaped marked metamorphism, and the oldest sediments known, though generally the most altered, in some localities remain essentially unchanged.

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and sub soils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

Rocks are further distinguished according to their relative ages, for they were not formed all at one time, but from age to age in the earth's history. Classification by age is independent of origin; igneous, sedimentary, and surficial rocks may be of the same age.

When the predominant material of a rock mass is essentially the same, and it is bounded by rocks of different materials, it is convenient to call the mass throughout its extent a *formation*, and such a formation is the unit of geologic mapping.

Several formations considered together are designated a *system*. The time taken for the deposition of a formation is called an *epoch*, and the time taken for that of a system, or some larger fraction of a system, a *period*. The rocks are mapped by formations, and the formations are classified into systems. The rocks composing a system and the time taken for its deposition are given the same name, as, for instance, Cambrian system, Cambrian period.

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

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those 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 formations are remote one from the 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 rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

Colors and patterns.—To show the relative ages of strata, the history of the sedimentary rocks is divided into periods. The names of the periods in proper order (from new to old), with the color or colors and symbol assigned to each, are given in the table in the next column. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period name.

To distinguish the sedimentary formations of any one period from those of another the patterns for the formations of each period are printed in the appropriate period-color, with the exception of the first (Pleistocene) and the last (Archean). The formations of any one period, excepting the Pleistocene and the Archean, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations.

Period.	Symbol.	Color.
Pleistocene	P	Any colors.
Neocene { Pliocene / Miocene }	N	Buffs.
Eocene (including Oligocene)	E	Olive-browns.
Cretaceous	K	Olive-greens.
Juratrias { Jurassic / Triassic }	J	Blue-greens.
Carboniferous (including Permian)	C	Blues.
Devonian	D	Blue-purples.
Silurian (including Ordovician)	S	Red-purples.
Cambrian	€	Pinks.
Algonkian	A	Orange-browns.
Archean	Æ	Any colors.

Each formation is furthermore given a letter-symbol of the period. In the case of a sedimentary formation of uncertain age the pattern is printed on white ground in the color of the period to which the formation is supposed to belong, the letter-symbol of the period being omitted.

The number and extent of surficial formations of the Pleistocene render them so important that, to distinguish them from those of other periods and from the igneous rocks, patterns of dots and circles, printed in any colors, are used.

The origin of the Archean rocks is not fully settled. Many of them are certainly igneous. Whether sedimentary rocks are also included is not determined. The Archean rocks, and all metamorphic rocks of unknown origin, of whatever age, are represented on the maps by patterns consisting of short dashes irregularly placed. These are printed in any color, and may be darker or lighter than the background. If the rock is a schist the dashes or hachures may be arranged in wavy parallel lines. If the rock is known to be of sedimentary origin the hachure patterns may be combined with the parallel-line patterns of sedimentary formations. If the metamorphic rock is recognized as having been originally igneous, the hachures may be combined with the igneous pattern.

Known igneous formations are represented by patterns of triangles or rhombs printed in any brilliant color. If the formation is of known age the letter-symbol of the formation is preceded by the capital letter-symbol of the proper period. If the age of the formation is unknown the letter-symbol consists of small letters which suggest the name of the rocks.

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet 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 particular colored pattern and its letter-symbol on the map 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 symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet 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 symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

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 name 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 the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting 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:

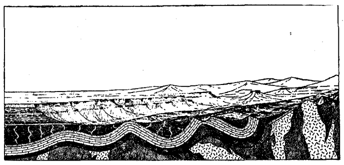

Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane that cuts a section so as to show the underground relations of the rocks.

The kinds of rock are indicated in the section 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:

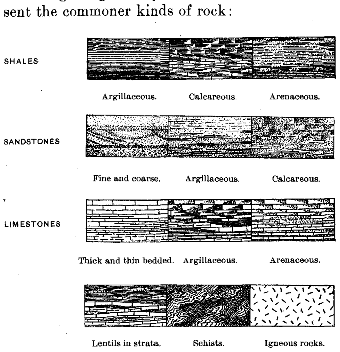

Fig. 3.—Symbols used to represent different kinds of rock.

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 beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

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.

When strata which are thus inclined are traced underground in mining, or by inference, it is frequently observed that they form troughs or arches, such as the section shows. But these sandstones, shales, and limestones were deposited beneath the sea in nearly flat sheets. That they are now bent and folded is regarded as proof that forces exist which have from time to time caused the earth's surface to wrinkle along certain zones.

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

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the 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 swelled upward 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 strata thus rest upon an eroded surface of older strata 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 this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration 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, marking a time interval between two periods of rock formation, is another unconformity.

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

Columnar-section sheet.—This sheet contains a concise description of the rock formations which occur in the quadrangle. The diagrams and verbal statements form a summary of the facts relating to the character of the rocks, to the thicknesses of the formations, and to the order of accumulation of successive deposits.

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation 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 is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

The formations are combined into systems which correspond with the periods of geologic history. Thus the ages of the rocks are shown, and also the total thickness of each system.

The intervals of time which correspond to events of uplift and degradation and constitute interruptions of deposition of sediments may be indicated graphically or by the word "unconformity," printed in the columnar section.

Each formation shown in the columnar section is accompanied by its name, a description of its character, and its letter-symbol as used in the maps and their legends.

CHARLES D. WALCOTT,
Director.

Revised June, 1897.

DESCRIPTION OF THE GOLD BELT.*

GEOGRAPHIC RELATIONS.

The principal gold belt of California includes a portion of the Sierra Nevada lying between the parallels of 37° 30′ and 40° north latitude. It is bounded on the west by the Sacramento and San Joaquin valleys, and on the east by a diagonal line extending from about longitude 120° 40′ in the neighborhood of the fortieth parallel to longitude 119° 40′ in the neighborhood of parallel 37° 30′. There are other gold-bearing regions in the State, both to the north and south of this belt, but by far the largest quantity of gold is produced within these limits. The area thus defined contains approximately 9000 square miles. At the northern limit the gold deposits are scattered over nearly the entire width of the range, while to the south the productive region narrows to small dimensions, continuing as a very narrow strip for some distance south of latitude 37° 30′. The whole southern part of the range is comparatively barren. North of the fortieth parallel the range is not without deposits, but the country is flooded with lavas which effectually bury the larger part of them.

GENERAL GEOLOGY.

The rocks of the Sierra Nevada are of many kinds and occur in very complex associations. They have been formed in part by deposition beneath the sea and in part by intrusion as igneous masses, as well as by eruption from volcanoes. All of them except the latest have been more or less metamorphosed.

The northern part of the range, west of longitude 120° 30′, consists prevailingly of clay-slates and of schists, the latter having been produced by the metamorphism of both ancient sediments and igneous rocks. The trend of the bands of altered sediments and of the schistose structure is generally from northwest to southeast, parallel to the trend of the range, but great masses of granite and other igneous rocks have been intruded among these schists, forming irregular bodies which interrupt the regular structure and which are generally bordered each by a zone of greater metamorphism. These slates and schists and their associated igneous masses form the older of two great groups of rocks recognized in the Sierra Nevada. This group is generally called the Bed-rock series.

Along the western base of the Sierra occur beds of sandstone and clay, some of which contain thin coal seams. These are much younger than the mass of the range and have not shared the metamorphism of the older rocks. They dip gently westward beneath later deposits, which were spread in the waters of a shallow bay occupying the Valley of California and portions of which have been buried beneath recent river alluvium.

Streams flowing down the western slope of the Sierra in the past distributed another formation of great importance—the Auriferous gravels. The valleys of these streams served also as channels for the descent of lavas which poured out from volcanoes near the summit. Occupying the valleys, the lavas buried the gold-bearing gravels and forced the streams to seek new channels. These have been worn down below the levels of the old valleys, and the lava beds, with the gravels which they protect, have been isolated on the summits of ridges. Thus the Auriferous gravels are preserved in association with lavas along lines which descend from northeast toward southwest, across the trend of the range. The nearly horizontal strata along the western base, together with the Auriferous gravels and later lavas, constitute the second group of rocks recognized in the Sierra Nevada. Compared with the first group, the Bed-rock series, these may be called the Superjacent series.

BED-ROCK SERIES.

PALEOZOIC ERA.

During the Paleozoic era, which includes the periods from the end of the Algonkian to the end of the Carboniferous, the State of Nevada west of longitude 117° 30′ appears to have been a land area of unknown elevation. This land probably extended westward into the present State of California and included part of the area now occupied by the Sierra Nevada. Its western shore was apparently somewhat west of the present crest, and the sea extending westward received Paleozoic sediments which now constitute a large part of the central portion of the range.

At the close of the Carboniferous the Paleozoic land area of western Nevada subsided, and during the larger part of the Juratrias period it was at least partly covered by the sea. At the close of the Juratrias the Sierra Nevada was upheaved as a great mountain range, the disturbance being accompanied by the intrusion of large amounts of granitic rock.

The Auriferous slate series comprises all of the sedimentary rocks that entered into the composition of this old range of Juratrias time. Formations representing the Algonkian and all of the Paleozoic and Juratrias may therefore form part of the Auriferous slate series.

Fossils of Carboniferous age have been found in a number of places, and the presence of Silurian beds at the northern end of the range, north of the fortieth parallel, has been determined. A conglomerate occurs in the foothills of Amador and Calaveras counties, interbedded with slates containing Carboniferous limestone; this conglomerate is therefore presumably of Carboniferous age. The conglomerate is evidence of a shore, since it contains pebbles of quartzite, hornblende-porphyrite, and other rocks, which have been rounded by the action of waves. The presence of lava pebbles in the conglomerate shows that volcanic eruptions began at a very early date in the formation of the range, for the hornblende-porphyrite pebbles represent lavas similar to the hornblende-andesites of later age.

The great mass of the Paleozoic sediments of the Gold Belt consists of quartzite, mica-schist, sandstone, and clay-slate, with occasional limestone lenses. On the maps of the Gold Belt these sediments are grouped under two formations:

(1) The *Robinson* formation, comprising sediments and trachytic tuffs. This contains fossils showing the age to be upper Carboniferous. The formation is known on the Gold Belt series of maps only in the Downieville quadrangle, a short distance south of the fortieth parallel.

(2) The *Calaveras* formation, comprising by far the largest portion of the Paleozoic sediments of the Gold Belt. Rounded crinoid stems, corals (Lithostrotion and Clisiophyllum), Foraminifera (Fusulina), and bivalves have been found in the limestone lenses, and indicate that a considerable portion at least of this formation belongs to the middle or lower Carboniferous. In extensive areas of the Calaveras formation no fossils have, however, been found, and older rocks may be present in these. It is not likely that post-Carboniferous rocks are present in these non-fossiliferous areas.

POST-CARBONIFEROUS UPHEAVAL.

After the close of the Carboniferous and before the deposition of at least the later Juratrias beds (Sailor Canyon, Mariposa, and Monte de Oro formations), an upheaval took place by which the Carboniferous and older sediments under the then retiring sea were raised above water level, forming part of a mountain range. The beds were folded and compressed and thus rendered schistose. Smaller masses of granite and other igneous rocks were intruded at this time.

JURATRIAS PERIOD.

The areas of land and sea which existed during the earlier part of this period are scarcely known. Fossiliferous strata showing the former presence of the Juratrias sea have been recognized in the southeastern portion of the range, at Mineral King, where the sediments are embedded in intrusive granite; at Sailor Canyon, a tributary of American River; in Plumas County at the north end of the range about Genesee Valley and elsewhere; and in the foothill region from Butte to Mariposa counties in the slates of the Mariposa nd Monte de Oro formations.

The land mass that originated with the post-Carboniferous upheaval became by gradual elevation very extensive toward the end of the Juratrias period. This continental mass of late Jurassic time probably reached eastward at least as far as the east base of the Wasatch Mountains. This conclusion is based on the fact that the latest Jurassic beds of California, the Monte de Oro and the Mariposa slates, are found only on the western flank of the Sierra Nevada. During the earlier part of the Juratrias period portions of the Great Basin were under water, as is shown by the fossiliferous beds of that age in Eldorado Canyon south of Virginia City and in the Humboldt Mountains, but nowhere from the foothills of the Sierra Nevada to the east base of the Wasatch, if we except certain beds near Genesee Valley, are any deposits known which are of late Jurassic age.

The following formations have been recognized on the Gold Belt maps:

(1) The *Mariposa* formation, which occurs in narrow bands along the western base of the range. The strata are prevailingly clay-slates, which are locally sandy and contain pebbles of rocks from the Calaveras formation. Tuffs from contemporaneous porphyrite eruptions also occur in them. The fossils of these beds, such as Aucella and Perisphinctes, have their nearest analogues in Russia, and indicate a very late Jurassic age.

(2) The *Monte de Oro* formation, occurring to the northeast of Oroville. This consists of clay-slate and conglomerate containing plant remains of late Jurassic age.

(3) The *Sailor Canyon* formation, which appears well up toward the summit of the range, and consists of clay-slates, altered sandstones, and tuffs. It is separated from the Mariposa formation by a broad belt of the Calaveras formation. The fossils indicate that the period of its deposition covered both the later part of Triassic and the earlier part of Jurassic time.

(4) The *Milton* formation, which has thus far afforded no fossils; it is lithologically similar to a portion of the Sailor Canyon series, and future research may show that it really was deposited at the same time.

THE POST-JURATRIAS UPHEAVAL.

Soon after the Mariposa formation had been deposited the region underwent uplift and compression. The result of uplift was the development of a mountain range along the line of the Sierra Nevada. The Coast Range also was probably raised at this time. The action of the forces was such as to turn the Mariposa strata into a nearly vertical position, and to fold them and other Juratrias beds in with the older Paleozoic strata. The Juratrias clay-shales, in consequence of pressure, now have a slaty structure, which appears to coincide in most cases with the bedding. This epoch was one of intense eruptive activity. The Mariposa and other Juratrias and older beds were injected with granite and other intrusive rocks. There is evidence that igneous rocks were intruded in varying quantities at different times; but that the intrusion of the great mass of the igneous rocks accompanied or immediately followed the upheavals is reasonably certain. Those beds that now form the surface were then deeply buried in the foundations of the range.

The disturbance following the deposition of the Mariposa beds was the last of the movements which compressed and folded the Auriferous slate series. The strata of succeeding epochs, lying nearly horizontal or at low angles, prove that since they were accumulated the rock mass of the Sierra Nevada has not undergone much compression. But the fact that these beds now occur above sea-level is evidence that the range has undergone elevation in more recent time.

THE GOLD-QUARTZ VEINS.

The extent of the gold deposits has been indicated in the introduction to this description. In character they may be classed as *primary*, or deposits formed by chemical agencies, and *secondary*, or those formed from the detritus produced by the erosion of the primary deposits. The primary deposits are chiefly gold-quartz veins,—fissures in the rock formed by mountain-making forces and filled with gold-bearing quartz deposited by circulating waters. The gold-quartz veins of the Sierra Nevada are found in irregular distribution chiefly in the Auriferous slates and associated greenstone-schists and porphyrites, but they also occur abundantly in the granitic rocks that form isolated areas in the slate series. While some gold-quartz veins may antedate the Jurassic period, it is reasonably certain that most of them were formed shortly after the post-Juratrias upheaval, and that their age, therefore, is early Cretaceous.

SUPERJACENT SERIES.

CRETACEOUS PERIOD.

Since no beds of early Cretaceous age are known in the Sierra Nevada, it is presumed that during the early Cretaceous all of the present range was above water.

During the late Cretaceous the range subsided to some extent, allowing the deposition of sediments in the lower foothill region. These deposits are known as the Chico formation, and consist of sandstone with some conglomerate. In the area covered by the Gold Belt maps this formation is exposed only near Folsom on the American River up to an elevation of 400 feet, and in the Chico district at elevations of from 500 to 600 feet. Since their deposition these strata have been but slightly disturbed from their original approximately horizontal position, but the larger part of them has been eroded or covered by later sediments.

Auriferous gravels are found to some extent in the Chico formation—for instance, near Folsom—showing that the gold-quartz veins had already been formed before its deposition.

EOCENE PERIOD.

In consequence of slow changes of level without marked disturbance of the Chico formation, a later deposit formed, differing from it somewhat in extent and character. The formation has been called the Tejon (Tay-hone′). It appears in the Gold Belt region at the Marysville Buttes, in the lower foothills of the Sonora district, and it is extensively developed in the southern and western portion of the Great Valley of California. During the Eocene the Sierra Nevada remained a separate, low mountain range, erosion continuing with moderate rapidity but no great masses of gravels accumulating.

NEOCENE PERIOD.

The Miocene and Pliocene periods, forming the later part of the Tertiary, have in this atlas been united under the name of the Neocene period. During the Neocene a large part of the Great Valley of California seems to have been under water, forming perhaps a gulf connected with the sea by one or more sounds across the Coast Ranges. Along the eastern side of this gulf was deposited during the earlier part of the Neocene period a series of clays and sands to which the name Ione formation has been given. It follows the Tejon, and appears to have been laid down upon it, without an interval of disturbance or erosion. Marine deposits of the age of the Ione formation are known within the Gold Belt only at the Marysville Buttes. Along the eastern shore of the gulf the Sierra Nevada, at least south of the fortieth parallel, during the whole of the Neocene formed a low range drained by numerous rivers. The shore-line at its highest position was several hundred feet above the present level of the sea, but it may have fluctuated somewhat during the Neocene period. The Ione formation appears along this shore-line as a brackish-water deposit of clays and sands, frequently containing beds of lignite.

The Sierra Nevada during this period was a range with comparatively low relief. The drainage system during the Neocene had its sources near the modern crest of the range, but the channels by no means coincided with those of the present time. Erosion gradually declined in intensity and auriferous gravels accumulated in the lower reaches of these Neocene rivers, the gold being derived from the croppings of veins. Such gravels could accumulate only where the slope of the channel and the volume of water were sufficient to remove the silt while allowing the coarser or heavier masses to sink to the bottom with the gold.

During the latter part of the Neocene period volcanic activity, long dormant, began again, and floods of lavas,[1] consisting of rhyolite, andesite, basalt, and plagioclastic glassy rocks chemically allied to trachyte, were ejected from volcanic vents, and these eruptions continued to the end of the Neocene. These lavas occupy

*Jointly prepared by Geo. F. Becker, H. W. Turner, and Waldemar Lindgren, 1894. Revised January, 1897.

[1] The term "lava" is here used to include not only such material as issued from volcanic vents in a nearly anhydrous condition and at a very high temperature, but also tuff-flows and mud-flows, and, in short, all fluid or semifluid effusive volcanic products.

small and scattered areas in the southern part of the Gold Belt, increasing in volume to the north until, north of the fortieth parallel, they cover almost the entire country. They were extruded mainly along the crest of the range, which still is crowned by the remains of the Neocene volcanoes. An addition to the gold deposits of the range, in the form of gold-quartz veins and irregular thermal impregnations, attended this period of volcanic activity.

When the lavas burst out they flowed down the river channels. The earlier flows were not sufficient to fill the streams, and became interbedded with gravels. They are now represented by layers of rhyolite and rhyolite-tuffs, sometimes altered to "pipe-clay." The later andesitic and basaltic eruptions were of great volume, and for the most part completely choked the channels into which they flowed. The rivers were thus obliged to seek new channels—substantially those in which they now flow.

Fossil leaves have been found in the pipe-clay, and in other fine sediments at numerous points. Magnolias, laurels, figs, poplars, and oaks are represented. The general character of the flora is thought to indicate a warm and humid climate, and has been compared with the present flora of the South Atlantic Coast of the United States.

THE NEOCENE UPHEAVAL.

In the latter part of the Neocene period a great dislocation occurred along a zone of faulting at the eastern base of the Sierra Nevada, and the grade of the western slope of the range was increased. These faults are sharply marked from Owens Lake up to Honey Lake. There was also a series of faults formed apparently at the very close of the Neocene within the mass of the range in Plumas County. Near the crest the Sierra Nevada is intersected by a system of fissures, often of striking regularity; it is believed that these fissures originated during the Neocene upheaval.

PLEISTOCENE PERIOD.

During Cretaceous, Eocene, and Neocene times the Sierra Nevada had been reduced by erosion to a range with gentle slopes, and the andesitic eruptions had covered it with a deep mantle of lava flows. The late Neocene upheaval increased the grade of the western slope greatly, and the rivers immediately after this disturbance found new channels and, rejuvenated, began the work of cutting deep and sharply incised canyons in the uplifted crustal block.

A period of considerable duration elapsed between the emission of the lava flows which displaced many of the rivers and the time of maximum glaciation. In this interval most of the deep canyons of the range were formed. Such, for example, are the Yosemite Valley on the Merced River, the great canyon of the Tuolumne, and the canyon of the Mokelumne. The erosion of these gorges may have been facilitated by the fissure system referred to above, for many of the rivers of the range appear to follow one or another set of parallel fissures for a long distance.

At what point the limit between the Neocene and the Pleistocene should be drawn is a somewhat difficult question. On the maps of the Gold Belt the great andesitic flows are supposed to mark the close of the Neocene, and this division is in fact the only one that can be made without creating artificial distinctions. But it is not positively known that this line corresponds exactly to that drawn in other parts of the world between these periods.

The Sierra, from an elevation of about 5000 feet upward, was long buried under ice. The ice widened and extended the canyons of preexisting topography and removed enormous amounts of loose material. It seems otherwise to have protected from erosion the area it covered and to have accentuated the steepness of lower slopes. Small glaciers still exist in the Sierra.

During the earlier part of the Pleistocene period the Great Valley was probably occupied for a time by a lake dammed by the post-Miocene uplift of the Coast Ranges. Later in the Pleistocene this lake evidently was drained and alluvial deposits were spread over the valley. There is no valid reason to believe that the central and southern part of the Sierra has undergone any important dynamic disturbance during the Pleistocene period, but renewed faulting with small throw has taken place along the eastern base of the range in very recent times.

IGNEOUS ROCKS.

Rocks of igneous origin form a considerable part of the Sierra Nevada. The most abundant igneous rocks there found are of granitic character. Rocks of the granitic series are believed to have consolidated under great pressure and to have been largely intruded into overlying formations at the time of great upheavals; they are thus deep-seated rocks, exposed only after great erosion has taken place.

The rocks called diabase and augite-porphyrite on the Gold Belt maps are not usually intrusive, but largely represent surface lavas which have been folded in with the sedimentary rocks and correspond to modern basalt and augite-andesite. In like manner hornblende-porphyrite corresponds to hornblende-andesite, quartz-porphyrite to dacite, and quartz-porphyry to rhyolite. In the Sierra Nevada the diabases and porphyrites are of pre-Eocene age, and contain in most cases secondary minerals, such as epidote, zoisite, uralite, and chlorite. The unaltered equivalents of these rocks—basalt, andesite, dacite, and rhyolite—are, in the Sierra Nevada, chiefly of Neocene or later age.

Tuffs are volcanic ashes formed by explosions accompanying the eruptions. Mixed with water, such material forms mud flows; and when volcanic ashes fall into bodies of water they become regularly stratified like sedimentary rocks and may contain fossil shells. Breccias are formed by the shattering of igneous rocks into irregular angular fragments. Tuffaceous breccias contain angular volcanic fragments cemented by a consolidated mud of volcanic ashes.

GLOSSARY OF ROCK NAMES.

The sense in which the names applied to igneous rocks have been employed by geologists has varied and is likely to continue to vary. The sense in which the names are employed in this folio is as follows:

Peridotite.—A granular intrusive rock generally composed principally of olivine and pyroxene, but sometimes of olivine alone.

Serpentine.—A rock composed of the mineral serpentine, and often containing unaltered remains of pyroxene or olivine. Serpentine is usually a decomposition product of rocks of the peridotite and pyroxenite series.

Pyroxenite.—A granular intrusive rock composed principally of pyroxene.

Gabbro.—A granular intrusive rock consisting of soda-lime or lime feldspars and pyroxene, or more rarely hornblende.

Diabase.—An intrusive or effusive rock composed of soda-lime feldspar (often labradorite) and pyroxene (more rarely hornblende). The feldspars are lath-shaped. The pyroxene is often partly or wholly converted into green, fibrous hornblende or uralite. From this change, also frequent in gabbros, rocks result which are referred to as uralite-diabase or uralite-gabbro.

Diorite. A granular intrusive rock consisting principally of soda-lime feldspar (chiefly andesine or oligoclase) and hornblende or pyroxene (sometimes also biotite).

Quartz-diorite.—A granular intrusive rock composed of soda-lime feldspar and quartz, usually with some hornblende and brown mica.

Granodiorite.—A granular intrusive rock having the habitus of granite and carrying feldspar, quartz, biotite, and hornblende. The soda-lime feldspars are usually considerably and to a variable extent in excess of the alkali feldspars. This granitoid rock occupies a position intermediate between a granite and a quartz-diorite, and is in fact closely related to the latter. The large areas occupied by it and the constancy of the type justify the special name.

Granite.—A granular intrusive rock composed of quartz, alkali and soda-lime feldspars, mica, and sometimes hornblende.

Aplite (also called *Granulite*).—A granitoid rock usually occurring as dikes, and consisting principally of quartz and alkali feldspar.

Syenite.—A granular intrusive rock composed chiefly of alkali feldspars, usually with some soda-lime feldspars and hornblende or pyroxene.

Amphibolite, amphibolite-schist.—A massive or schistose rock composed principally of green hornblende, with smaller amounts of quartz, feldspar, epidote, and chlorite, and usually derived by metamorphic processess from augite-porphyrite, diabase, and other basic igneous rocks.

Augite-porphyrite.—An intrusive or effusive porphyritic rock with larger crystals of augite and soda-lime feldspars in a finer groundmass composed of the same constituents.

Hornblende-porphyrite.—An intrusive or effusive porphyritic rock consisting of soda-lime feldspars and brown hornblende in a fine groundmass.

Quartz-porphyrite.—An intrusive or effusive porphyritic rock consisting of quartz and soda-lime feldspar, sometimes with a small amount of hornblende or biotite.

Quartz-porphyry.—An intrusive or effusive porphyritic rock, which differs from quartz-porphyrite in containing alkali feldspars in excess of soda-lime feldspars.

Rhyolite.—An effusive rock of Tertiary or later age. The essential constituents are alkali feldspars and quartz, usually with a small amount of biotite or hornblende in a groundmass, which is often glassy.

Andesite.—An effusive porphyritic rock of Tertiary or later age. The essential constituents are soda-lime feldspars (chiefly oligoclase and andesine) and ferromagnesian silicates (hornblende, pyroxene, or biotite), in a groundmass of feldspar microlites and magnetite, usually with some glass. The silica is ordinarily above 56 per cent. When quartz is also present the rock is called a dacite.

Basalt.—An effusive rock of Tertiary or later age, containing basic soda-lime feldspars, much pyroxene, and usually olivine. The silica content is usually less than 56 per cent. It is often distinguished from andesite by its structure.

Trachyte.—An effusive rock of Tertiary or later age, composed of alkali and soda-lime feldspars, with biotite, pyroxene, or hornblende.

GENERALIZED SECTION OF THE FORMATIONS OF THE GOLD BELT.

	Period.	Formation Name	Formation Symbol.	Columnar Section.	Thickness in Feet.	Character of Rocks.
Superjacent Series	Pleistocene	Recent.	Pal		1–100	Soil and gravel.
		River and shore gravels.	Pgv		1–100	Sand, gravel, and conglomerate.
	Neocene	River and shore gravels.	Ng		10-400	Gravel, sandstone, and conglomerate.
		Ione.	Ni		10–100	Shale or clay rock.
					10–100	Sandstone.
					....	..Coal stratum.
					50-800	Clay and sand, with coal seams.
	Eocene	Tejon.	Et		10–300	Sandstone and conglomerate.
	Cretaceous	Chico.	Kc		50–400	Tawny sandstone and conglomerate.
						GREAT UNCONFORMITY
Bed-Rock Series	Juratrias	Monte de Oro. Mariposa. Milton. Sailor Canyon.	Jo Jm Jml Js		1000 or more	Black clay-slate, with interbedded greenstones and some conglomerate.
		Intrusive granitic rocks.	gr grd			UNCONFORMITY
	Carboniferous and Older	Robinson. Calaveras.	Crb Cc		4000 or more	Argillite, limestone, quartzite, chert, and mica-schist, with interbedded greenstones.
		Intrusive granitic rocks.	gr grd			

DESCRIPTION OF THE DOWNIEVILLE QUADRANGLE.

TOPOGRAPHY.

The principal topographic features.

The Downieville quadrangle embraces a portion of the crest of the Sierra Nevada lying just south of the fortieth parallel. The district is as a whole well wooded, and in large part covered with brush. Those ridges that rise above 7000 feet are, however, scantily clothed with vegetation, and on some slopes where glaciers have removed the superficial material, as at the Sierra Buttes and the basins of Bear and Long lakes, the rocks are almost entirely devoid of covering. The region is rugged in the extreme, having many slopes with angles of 30° from the horizon. The highest elevation is the main peak of the Sierra Buttes, in the southeast section, which has an altitude of 8615 feet. A view of the peak is given on the page of illustrations. The lowest part of the quadrangle is Indian Valley, in the southwest corner, with an elevation of about 2400 feet. The Middle Fork of Feather River, which crosses the central part of the district, is peculiar in that its valley is cut across the main Sierra Nevada range. The source of this river is in Sierra Valley, which lies to the east of the higher crest of the range, and which is separated from the Great Basin only by the lower, eastern crest. This second crest extends from Honey Lake southeast across the Sierraville quadrangle, which lies immediately east of the Downieville. The main rivers in the Downieville quadrangle have a westerly course, but this is not true of their tributaries, which flow in various directions.

In the central and southeastern parts of the quadrangle are numerous lakes, which have been formed chiefly by glacial action. The group of lakes on the east slope of the high ridge that joins the Sierra Buttes and Eureka Peak is particularly attractive. One of them is pictured on the page of illustrations, fig. 3. A number of these lakes serve as reservoirs for ditches which supply the neighboring gold mines with water.

GEOLOGY.

BED-ROCK SERIES.

The Bed-rock series consists of sedimentary rocks which were turned into a nearly vertical position during or before the post-Juratrias deformation, together with the associated igneous rocks.

The sedimentary rocks of this period represent beds of clay, sand, and gravel which have been hardened and metamorphosed. These beds were originally horizontal, but have since been folded and greatly compressed by forces acting chiefly from the NNE. and SSW. They have also been subjected to extensive erosion, so that the upper parts of the folds have disappeared. Intercalated in these sediments are layers of metamorphic lavas and tuffs, showing that volcanic eruptions occurred while the sediments were being deposited. Irregularly intruding the sedimentary rocks with their included volcanic layers are masses and dikes of various granular igneous rocks, such as granite and gabbro.

AURIFEROUS SLATE SERIES.

Reasons for correlation as Calaveras.

Calaveras formation.—In the Downieville quadrangle there are extensive areas of sedimentary rocks of the Auriferous slate series, all of which, excepting the Juratrias rocks of the Milton formation and the upper Carboniferous beds of the Robinson formation, are placed in the Calaveras formation. This has been done largely on general stratigraphic evidence, for fossils have been found in them in this quadrangle at only one point—near the mouth of Onion Valley Creek. As may be seen on the map, the Calaveras formation forms the bed-rock of about one-half of the quadrangle. While divided into different portions by igneous masses, and covered up over many square miles by Tertiary lavas, it nevertheless forms practically one area. The formation consists in the main of clay-slate, usually somewhat micaceous, and mica-schists and quartzite with numerous limestone lenses and smaller amounts of other schists. The older igneous rocks that have been intruded in the Calaveras formation consist of peridotite, quartz-porphyry, and granitic rocks. There are also some amphibole-gabbro masses and dikes of augitic rocks of the diabase series. Considerable masses of greenstones in the southwestern portion of the quadrangle are interbedded with the schists of the Calaveras formation. These are presumed to have been augitic tuffs of volcanic origin, formed at the time the inclosing sediments were deposited. These greenstones were originally similar to the Juratrias rocks described under the heading "Augite-porphyrite and diabase." Most of the gold-quartz mines in this district occur in the Calaveras formation.

Lithologic character and associated igneous rocks of the Calaveras.

Magnesian limestone of the Calaveras.

The rocks of the eastern portion of the large area of the Calaveras formation, forming the high ridge just west of Poplar Valley and the western slope of the Sierra Buttes ridge, have been grouped together in another publication* under the name magnesian limestone series. This series contains numerous limestone masses which have in general a light-gray color, while the limestones of known Carboniferous age are usually of a darker, bluish-gray color. Most of these limestone masses are noted on the map. Analyses of two specimens show a magnesia content of 10 and 19.5 per cent respectively.

In this series, in addition to the limestone, there are, in the neighborhood of Gold Valley, several deposits of magnetic iron. This belt of rocks, from its relation to known Mesozoic rocks that lie east of it, is thought to be of Paleozoic age. It may be older than the Carboniferous.

Lithology and age of the Robinson formation.

Robinson formation.—The rocks of the Robinson formation consist of certain metamorphic tuffs and non-volcanic sediments which form several areas in the northeastern portion of the Downieville quadrangle. In the largest area a number of fossils were found on the west side of Little Grizzly Creek. These are of upper Carboniferous age, and consist in part of the same species as are found in the Robinson formation on the north side of Genesee Valley. Fossils of upper Carboniferous age were also found on the eastern slope of the high ridge east of Little Grizzly Creek.

The tuffs of the Robinson formation contain large rectangular feldspars, which in some cases are orthoclase or microcline. The groundmass of the tuffs is finely granular and contains much secondary brownish-green mica, so that its original character is not evident. However, in some specimens it is plain that the groundmass was originally glassy. Analyses made of three specimens of the tuff show that it has the composition of a trachyte.

Doubtful occurrence of the Robinson formation.

At the west end of Grizzly Valley is a considerable area of metamorphic tuff, and east of Mohawk Valley is another similar area. Both are presumed to be of the Robinson formation, although no fossils were obtained from them.

At the east edge of the map may be noted two areas (symbol ms) colored as belonging to the Robinson formation, one lying east of Red Clover Valley and the other southeast of Grizzly Peak. These rocks are thoroughly recrystallized and are now practically gneisses. Another gneiss mass, that may be a contact form of a sedimentary rock or tuff, occurs as a lens in the granite 4 miles southeast of Milton. Although these areas are placed in the Carboniferous, they may be older, or if the recrystallization be the result of contact metamorphism they may even be younger.

Interbedded siliceous argillite and tuffs.

Juratrias beds.—Associated with the so-called quartz-porphyries of the Sierra Buttes ridge are certain lenses composed largely of siliceous argillite. These lenses are in part in the quartz-porphyry series and in part lie on its lower (western) border and its upper (eastern) border. One of these areas, southwest of Gold Lake, is 2 miles in length, but usually the lenses are not so long. Certain thin layers, a fraction of an inch in thickness, found in some of the argillite, weather white, contrasting strongly with the nearly black color of the remainder of the rock. At other places there are oval bodies, about three-fourths of an inch in maximum diameter, that resemble fossils, the origin of which is uncertain.

The impression of an ammonite on a piece of slate said to have come from the argillite lens at the Phœnix mine would indicate a Juratrias age for this lens. Since the other similar lenses noted on the map are in the same quartz-porphyry area as that of the Phœnix mine, it is supposed that all of them are of Juratrias age.

On the eastern spur of the Sierra Buttes is an argillite lens containing also coarser sediments, in part of volcanic origin. In certain brecciated layers radiolarian remains were found, but these proved of no value for determining the age. The vein of the Mountain mine is in this sedimentary lens, and the locality may be reached by the upper mine road, which ends at this point. The exposures along the road show remarkably well the relative age of the different rocks represented. Overlying the supposed Juratrias argillite lens containing the radiolarian remains are beds of fragmental quartz-porphyry, succeeded by heavy beds of augitic tuffs which represent the augitic greenstone series; and overlying the augitic tuffs are the red slates and tuffs of the Milton formation, well exposed in the bed of the North Fork of the North Yuba.

Four miles west of north from the Mountain mine argillite lens, to the east and northeast of Deer Lake, is another mass of siliceous argillite interbedded with tuffs. The strata of this lens dip to the east 35° at one point, but at other points the dip is greater. On account of the comparatively flat dip and of the erosion which the country has undergone, the siliceous argillite layers can not be traced continuously. The porphyry-tuff is the most apparent part of the mass, and its prominence might lead the observer to wrongly conclude that the rock should not be represented as sedimentary, as it is only by a careful search that the interbedded layers of black siliceous argillite can be found.

It is probable that the Juratrias beds above described are nearly related to the Sailor Canyon formation of the southeastern part of the Colfax district. Their exact age is not known, but all of the Juratrias beds of the Downieville quadrangle, including the Milton formation, are presumed to be somewhat older than the Mariposa slates.

Later Juratrias beds of tuffs and sedimentary rocks.

Milton formation.—In the neighborhood of the old stage station on the Middle Yuba known as Milton are fine exposures of beds, largely tuffs, all of which, being evenly stratified, present the appearance of having been laid down under water. These beds contain igneous fragmental (pyroclastic) material of the augitic greenstone series, quartzite, fine-grained red slates, a little marble, and a variegated breccia or conglomerate. A bed of the conglomerate occurs by the road at Milton. It contains abundant small fragments of chert and other rocks of various colors, and appears to be the source of the variegated pebbles subsequently referred to in a paragraph under "Auriferous river gravels." Marble was found at two points only. In both places the change of the original limestone into marble is regarded as due to the adjoining intrusive granite. This has also caused the development of yellow and reddish garnets and wollastonite, both of which are silicates rich in lime. These contact minerals indicate that the granite is later in age than the Milton formation. The hardened sandstone or quartzite of the Milton formation and the tuff layers contain a great deal of brownish-green mica in minute foils, which developed in the rock and may likewise be ascribed to metamorphism. However, this body of tuffs and sediments as a whole shows little evidence, either to the naked eye or under the microscope, of having been greatly compressed. Not only has very little secondary schistosity been developed, but even under the microscope the grains usually show little evidence of deformation. The dip of the beds in the neighborhood of Milton is quite uniformly to the east at from 40° to 50°, with occasional dips as low as 25°. At the contact with the mass of granite which lies to the east, however, the dip is much steeper, and this is likewise true of that portion of the Milton formation found in the North Yuba Canyon. The beds of the Milton formation are less compressed and altered than the much older Calaveras black slates, quartzites, and magnesian limestone. In the Calaveras formation secondary schistosity is the most evident structure, and the original bedding is with difficulty discerned. At most places in the Milton formation the original bedding is evident, although systems of joint planes intersect the bedding planes and occasionally disguise the true dip.

Milton and Calaveras compared

The Milton formation is later in age than the other rocks herein assigned to the Juratrias. It is, however, included in the Juratrias series, for the collective evidence is good that there are no Cretaceous rocks represented in the Auriferous slate series of the Sierra Nevada.

Doubtful occurrences of Milton formation.

The rock masses east and south of Mohawk Valley, called Milton formation on the geologic map, may belong to another series. However, the tuffs of the area by the Middle Fork of the Feather, one-half mile upstream from the mouth of Willow Creek, are plainly bedded and appear to have been laid down in water. They strike north and south and dip 68° to the east, and strongly resemble the tuffs of the Milton formation. The outcrop forming a hilltop 2½ miles due east of Denten's is composed in part of what is probably wollastonite-schist. This same schist forms a portion of the supposed Juratrias mass just northeast of the Sulphur Spring House. In the latter area also are some tuffs and garnet rock. In all of these small bodies the amount of igneous material is large, and further investigation will be necessary before their age can be known. If the writer is correct in regarding the district to the east of Mohawk Valley as a relatively sunken region lowered by faulting, these so-called Juratrias beds on the east of the valley may have been directly connected, before the faulting occurred, with the supposed Milton rocks extending from Howard Creek north to near Mohawk Valley.

IGNEOUS ROCKS.

Greenstones of diverse origins.

Amphibolite and metadiorite.—Under this heading are grouped much-altered igneous rocks consisting chiefly of green aluminous amphibole, usually of the finely fibrous uralite type, but in part a more coarsely fibrous recrystallized amphibole. They may be called greenstones, but this name is also given to other rocks occurring in the quadrangle. Some of the areas appear to have been originally augitic tuffs and surface lavas. Such is the greenstone west of Laporte and its continuation to the southeast, and most of the material in the southwest corner of the Downieville quadrangle. It is possible that other areas of greenstone, forming narrow streaks in the Calaveras slates—for example, those northwest and south of the Eureka gravel mines—were layers of volcanic material laid down in water along with the non-volcanic sediments which enclose them. Again, there are masses which are separated with difficulty from the distinctly sedimentary material. Such is an occurrence just west of Scales, where the indu rated rock contains much secondary hornblende; but the original sedimentary nature of this material seems so certain that it is mapped as part of the Calaveras formation.

On the west flank of Clermont Hill, to the east of the serpentine area, is a lens of a coarse amphibole-schist. Another area is crossed by the South Fork of Feather River to the east of Little Grass Valley. Besides these two areas there is a much larger mass of this peculiar amphibole-schist between Gibsonville and Canyon Creek. On the ridge north of Canyon Creek, at most points noted, the schist has a nearly east-west strike. The sedimentary schists on the ridge south of Canyon Creek are likewise displaced in the same manner. It is likely that the original rock of this coarsely fibrous amphibolite is not the same as the uralite-schist and epidote-schist above described.

Origin of serpentine.

Serpentine.—It is known that serpentine, which is a hydrous silicate of magnesia, is usually formed by the alteration of other minerals, chiefly olivine and pyroxene. It is thus a secondary rock, derived from other rocks by

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chemical changes, most commonly from peridotite and pyroxenite. It has also been shown that many talc-schists and chlorite-schists were formed from basic igneous rocks, chiefly pyroxenites. Such schists are often found associated with serpentine, both being alteration products of the same rock mass.

The largest area of serpentine is a huge dike-like mass which continues with some interruptions through the western portion of the quadrangle south into the Colfax district. The mass crosses the North Yuba at Goodyears Bar, Canyon Creek at Poker Flat, and Mount Fillmore on its west slope. To the west of Onion Valley it broadens into an area 4 miles wide, and extends across the canyon of the Feather River to Meadow Valley and beyond, in the Bidwell Bar quadrangle. From specimens collected at many points it is known that the mother rock of this serpentine dike is a peridotite, or in places a pyroxenite. Remains of olivine and pyroxene are still to be seen in thin sections. One mile west of St. Charles ranch the rocks of this magnesian belt are chiefly talc-schists and chlorite-schists.

Occurrences of serpentine.

There are several smaller dikes of serpentine, usually but a few hundred feet in width, in the eastern part of the area of Calaveras formation that covers such a large portion of the Downieville quadrangle. Two of these dikes have a length of about $4\frac{1}{2}$ miles. Associated with these dikes are small masses of altered gabbro in which the diallage is chiefly fresh, but is altered around the edges to fibrous amphibole. The feldspar is entirely replaced by saussurite and epidote.

Altered gabbro associated with serpentine.

The area $1\frac{1}{4}$ miles southwest of Bunker Hill is composed of serpentine and talc-schist.

The area of magnesian rocks that surrounds the south half of the Indian Valley granite area is composed of serpentine, talc-schist, chlorite-schist, and altered peridotite, in which the original pyroxene and olivine may still be noted.

There are a few streaks of serpentine along Spring Garden Creek downstream from Pine Creek. One of these, $3\frac{1}{2}$ miles northwest of Spring Garden ranch, forms a dike in the slates extending south up the ridge slope.

Quartz-porphyry (*rhyolite-porphyry*).—Rhyolitic rocks (lavas rich in alkali and silica) with porphyritic crystals of quartz and feldspar in a fine-grained crystalline groundmass have usually been called quartz-porphyry, although the name rhyolite-porphyry is the more correct one.

Nature of quartz-porphyry: ancient siliceous volcanic rocks.

Most rocks called quartz-porphyry were erupted before the Tertiary period, and are often much altered. Many of these rocks were originally glassy, but have undergone a change called devitrification, whereby the various elements of which the glass is composed crystallize out. The crystalline groundmass of such quartz-porphyries is thus a secondary and not an original one. The rocks called quartz-porphyry in this text are to some extent such devitrified rhyolites. That they were largely surface rocks seems plain, for, as above noted, they appear to have been in part originally glassy, and they occur in part as breccias formed by explosions from volcanoes. Typical quartz-porphyries contain more than 70 per cent of silica, and more than 7 per cent of potassa and soda. Those of the Downieville quadrangle have often less than 5 per cent of potassa and soda, and thus stand intermediate between typical quartz-porphyries and quartz-porphyrites, which are altered quartz-bearing andesites.

In almost any hand specimen of the porphyry there are numerous porphyritic quartz crystals to be seen. In the larger part of the quartz-porphyry a schistose structure has been developed, corresponding in strike and dip with the schistosity of the neighboring areas of sedimentary rocks and greenstones. The prevailing color is very light gray, nearly white when massive. Much of the schistose quartz-porphyry, as at Bunker Hill, has a bluish tinge. Where occurring in small amounts in the other rocks the color and aspect of this rock are less characteristic and the outcrops frequently resemble the surrounding rocks. Dikes of this rock occur in the Calaveras formation at various points. At Wades Lake they follow the stratification, so far as noted, but southwest of the Sierra Buttes and at other points are dikes which cut the slates at angles to the bedding and cleavage.

Occurrences of quartz-porphyry.

Extending from a point on the east slope of the Grizzly Mountains north of the fortieth parallel in a nearly south direction, passing just east of Tower Rock and thence across the crest of the Grizzly Mountains and down the west slope to Long Valley Creek, is a long, narrow area of quartz-porphyry. This is believed to represent a surface flow from an ancient volcano. A secondary schistose structure has been developed in much of the area. The age of this lava is uncertain, although immediately west of it is a long, narrow strip of siliceous argillite similar to a stratum which occurs north of the fortieth parallel associated with Silurian limestone. The age of this siliceous argillite strip in the Downieville district must, however, for the present remain an open question, as it pinches out to the southeast of Tower Rock and its relation to the Silurian siliceous argillite (Grizzly formation) has not been ascertained.

An area of schistose porphyry similar to the above extends from Eureka Peak to the ridge south of Sierra City. It forms the main mass of the Sierra Buttes. A portion of the mass is distinctly a breccia (see fig. 5), and it is supposed to have been likewise an effusive body. This breccia in places contains fragments of siliceous argillite and layers and angular pieces of porphyrite, but most of the fragments in it show porphyritic quartz crystals. The line of demarcation between the quartz-porphyry and the augite-porphyrite series, west and northwest of the Salmon lakes, is a somewhat arbitrary one. The contact of the quartz-porphyry with the Calaveras formation lying to the west is usually sharp. Dikes of this porphyry are common in the Calaveras formation, particularly to the west of Sierra City in the canyon of the North Yuba. These dikes are supposed to have been intruded into the slates at the same time that the effusive quartz-porphyry just noted was thrown out from volcanoes, and furnish additional evidence that the porphyry is later in age than the Calaveras. Half a mile west of Milton a quartz-porphyry dike about 40 feet in width contains abundant inclusions of black argillite, into which it was intruded. Two and one-half miles from the summit of Clermont Hill, on the top of its high northwest spur, is a small mass of quartz-porphyry. There is another mass on Jamison Creek 4 miles northeast of Eureka Peak, and a large area between Massick and Squirrel creeks about $1\frac{1}{2}$ miles northwest of Spring Garden ranch.

As may be seen by examining the geologic map, the main quartz-porphyry areas of the Downieville district form an interrupted belt extending across the quadrangle in a north-south direction, a little east of the middle. It is likely that all these rocks were erupted or intruded at about the same period. As was stated in describing the Juratrias beds, in the quartz-porphyry there are lenses of siliceous argillite which may be of Juratrias age, as an ammonite was found in one of them.

Augite-porphyrite and diabase (*augitic greenstone series*).—Under this heading will be grouped a series of old lavas, tuffs, and dikes which in most cases show grains of augite, and which in all cases can be shown to have been originally augitic rocks. Most of these rocks are probably of Juratrias age, but as there is some doubt as to certain areas, no age is assigned to them on the geologic map. The series as a whole shows much less evidence of compression than do the greenstones included under amphibolite, although the two series represent originally similar rocks and it is by no means unlikely that original augite may be found in some of the amphibolite areas. Uralite, which is a secondary amphibole, and often epidote and chlorite are, however, present in variable quantity in nearly every hand specimen of the augite-porphyrite, but as a rule the larger augites are still fresh.

Greenstones derived from augitic rocks.

On the east slope of the Sierra Buttes the augitic tuffs plainly overlie the quartz-porphyry that forms the summit of the buttes, and underlie the tuffaceous sediments of the Milton formation. The Juratrias age of portions of this belt of greenstone can therefore be considered as probable. This greenstone area broadens in the lake region, having a width in the latitude of Gold Lake of about 5 miles. Considerable portions of it seem to represent massive lava flows, as at Mount Elwell. To the north of the lake region the greenstone is buried under the large morainal area about Johnsville. It reappears about $1\frac{1}{2}$ miles north of that town and continues to Long Valley, north of which it is hidden under andesitic tuffs for a space of about 3 miles. Still farther north the greenstone area broadens and forms a part of the summit and much of the western slope of the Grizzly Mountains. If this belt of greenstone is continuous, as indicated, and all parts are younger than the adjoining Calaveras formation, as is probable, the relations suggest the possibility of a synclinal structure for this portion of the district, as is more fully explained in the paragraph on "Structural features."

The fact that the greenstones on the east slope of the Sierra Buttes are superimposed on the quartz-porphyry series indicates that they are younger than the quartz-porphyry. In the neighborhood of Bunker Hill dikes of greenstone cut the quartz-porphyry, giving additional evidence in the same direction.

The greenstone mass shown on the map to the east of Little Grizzly Creek contains abundant green crystals, which the microscope shows to be uralite (secondary amphibole) having the external form of augite, which the uralite has replaced. Forming a dike that crosses Canyon Creek 1 mile upstream from Poker Flat is a green rock which the microscope shows to be a diabase with ophitic structure—that is to say, a rock composed of lime-soda feldspar in little laths with interstitial pyroxene.

The greenstone area shown on the east slope of the Grizzly Mountains, which is crossed by Little Grizzly Creek at the fortieth parallel, is in part a typical diabase, but the mass as a whole is a mixed one. The extremely steep and brushy nature of the hillside and the altered character of the material made it difficult to determine the original nature of all portions of the area. It is not unlikely that some of the material included in this greenstone area is non-volcanic.

Along Howard Creek, bordered on the west by the large area of augitic greenstone of Juratrias age above noted, and on the east by a strip of sediments presumed to belong to the Milton formation, is a lens of porphyritic rock about $1\frac{1}{2}$ miles in length. This lens is mapped as part of the greenstone series. The most noticeable feature of the rock is the large tabular feldspars, often half an inch in length. The microscope shows the groundmass to be microcrystalline, and to be made up of grains and laths of feldspar, grains of iron ore, and grains of an augite-like mineral. The small size of the augite-like grains makes their determination doubtful. The large tabular feldspars are labradorite. This rock may be called a diabase-porphyry. On the east side of Mohawk Valley is a considerable area of a fine-grained rock, in a portion of which tabular plagioclase phenocrysts are developed, although of smaller size than in the Howard Creek rock. This rock may also be regarded as a diabase-porphyry. Such rocks are essentially identical with the labrador-porphyrites of Rosenbusch.

Diabase-porphyry.

Gabbro.—As limited by the writer, the feldspar of gabbro should be chiefly of the labradorite-anorthite series. In several of the areas called gabbro the feldspar is altered to saussurite, and is therefore not readily determinable. All of the rocks here called gabbros are medium- to coarse-grained, and, with one exception, of even texture. As noted under "Serpentine," there are frequently gabbro masses in the serpentine dikes that cut the eastern part of the large area of the Calaveras formation. The mass that lies just east of the serpentine dike south of Goodyears Bar is composed of amphibole-gabbro, some of which contains secondary quartz. To the east of this area, along the North Yuba and on the ridge north and south, is a peculiar garnetiferous quartzite-like rock, greatly crushed and altered, which may be a product of silicification of the amphibole-gabbro. This siliceous rock is, however, placed in the Calaveras formation.

Definition and statement of occurrences.

On the east slope of Eureka Peak is an area of gabbro, and along its west contact with the quartz-porphyry of Eureka Peak pieces of the gabbro are enclosed in the porphyry, showing the gabbro to be the older rock. A smaller mass of a similar gabbro lies about a mile north of the summit of the peak, and another little area about a mile southwest of Bunker Hill. A narrow gabbro dike about 2 miles long cuts the Calaveras formation a short distance east of Downieville.

By far the most interesting gabbro area is that lying in the Willow Creek drainage east of Penman Peak. On the north it is in contact with an area of quartz-mica-diorite. This gabbro is quite variable in composition. While the average rock is a normal gabbro, composed of monoclinic pyroxene, brown amphibole, iron ore, and basic plagioclase, at certain points rhombic pyroxene largely replaces the monoclinic, and there are developed porphyritic amphibole crystals more than an inch long. An interesting orbicular structure is also shown, in which there are concentric layers composed of olivine, hypersthene, iron oxide, and a little plagioclase, with lighter-colored layers of basic plagioclase and pyroxene in minor quantities. This rock may be called an orbicular norite or gabbro, and such a rock is known at only one other point—Romsas, Norway.

Granodiorite (*quartz-mica-diorite*).—Granodiorite and quartz-diorite have in general the characteristic appearance of granite, and are commonly spoken of as such. The chief components are feldspar and quartz. The feldspar is chiefly soda-lime-feldspar with a smaller amount of potash-feldspar. Usually biotite and hornblende are present. The feldspar varies from oligoclase to labradorite, with occasional microcline or orthoclase. The rocks show evidence, in their thoroughly crystalline texture, of having formed at some depth below the surface. Excepting an area just north of Scales, all the rock masses properly referable to the quartz-diorite family are in the eastern part of the Downieville quadrangle, where the rock is abundant. It is quite probable that all of the areas of this rock in this part of the district are actually connected and may be treated as one large mass, although the connection between them can not be demonstrated on the surface. At two points quartz-pyroxene-diorite forms a facies or variety of the quartz-mica-diorite. One of these occurrences is $6\frac{1}{10}$ miles southwest of Mount Ingalls on the west slope of the Grizzly Mountains, just below the andesite-tuff area that caps the ridge. The other locality is about Hay Press Valley, in the southwestern part of the quadrangle.

Granitic rocks: definition and occurrences.

Granite and granulite.—In the southwest corner of the Downieville quadrangle, forming a small area having a maximum diameter of about 2 miles, is a coarse-grained granitic rock which approximates a true granite in composition. In general it is characterized by the abundance of biotite and the lack of hornblende. The locality is a very interesting one on account of the great abundance and variety of dikes that cut the surrounding rocks. Indian Valley, on the North Yuba, has been carved out of this granite, which extends up the ridge to the south, forming the east part of the eminence known as Indian Hill. The dike rocks will be described under the next heading.

On the ridge 5 miles southeast of Downieville is a considerable mass of granitoid rock, which extends south into the Colfax quadrangle. This rock is characterized in general by an abundance of quartz in large grains, sometimes half an inch in diameter, and by the lack of ferromagnesian silicates. There are numerous quartz veins in this granitoid rock, and in Harris Meadows abundant green dikes were noted.

About 4 miles east of Downieville, in the canyons of the North Yuba, is a small mass of granitoid rock similar to the Harris Meadows area on the ridge to the south. No certainly original ferromagnesian silicates were detected in the section examined. The quartz has an idiomorphic tendency, and the feldspar is albite. The rock may be called a soda-granulite, or soda-aplite.

One and a half miles northeast of Rattlesnake Peak is a small area of a light-colored rock which the microscope shows to be a micropegmatite. It is classed with the granites, although the character of the feldspar of the micropegmatite was not determined. Plagioclase is present, but is in part altered.

Dike rocks.—About Indian Valley there are numerous white dikes cutting all the other rocks of that neighborhood. The microscope shows these rocks to be porphyries having a finely granular groundmass of quartz and feldspar, in which are embedded larger crystals of feldspar, biotite, and hornblende, with occasional large grains of quartz. Such rocks may be called quartz-diorite-porphyries. These dikes are particularly well exposed in the rocky bed and banks of the North

Occurrences of igneous rocks intruded in narrow bodies into older rocks.

Yuba, east of the valley. At one point, about 1400 feet upstream from the mouth of Humbug Creek, cutting the black hardened slates, several of these dikes, from 2 to 10 feet apart, were noted, all with a parallel strike of about 77° west of south, or nearly east and west. The strike of the slates at this point is approximately north and south. Quartz-diorite-porphyry dikes cut the granite of Indian Valley and the serpentine area that partly surrounds it, and are also found abundantly along the south and southwest shore of Gold Lake, where they are irregular in outline and inclose fragments of the neighboring greenstone. Similar dikes were noted in the greenstone-breccia south of the Bear Lakes. There are also dikes about 2 miles south of Limestone Point, and in the bed of Rock Creek about one-fourth mile downstream from Scales. The similarity in composition of these dikes to granodiorite suggests a direct genetic relation.

Granite-porphyry dikes were found on the ridge extending east from Indian Hill. These appear to be protrusions from an area of granite-porphyry in the Colfax quadrangle. A dike of granite-porphyry is shown on the geologic map about 2 miles northwest of Goodyears Bar, and along this dike is a quartz vein. Some granite-porphyry-like dikes were also noted in the bed of the east branch of Nelson Creek and in the bed of Onion Valley Creek, in both cases cutting the rocks of the Calaveras formation.

Granulite or aplite dikes were noted in the granodiorite east of Milton, by the main road south of Haskell Peak, and at other points. On the west bank of Clermont Hill, cutting the serpentine, are dikes that may be called soda-granulites, being composed chiefly of quartz and of feldspar rich in soda. Near Indian Valley, in addition to the quartz-diorite-porphyry dikes heretofore noted, numerous dikes of diorite and diorite-porphyry with primary hornblende needles were also found.

In rocks of the magnesian series just west of the Indian Valley granite area a white dike with porphyritic biotite crystals was observed. This rock proved to be a pyroxene-syenite, the only dike of the kind noted in this portion of the range.

SUPERJACENT SERIES.

The Superjacent series consists of late Cretaceous, Eocene, Neocene, and Pleistocene sediments lying unconformably on the Bed-rock series, together with igneous rocks of the same period. During late Cretaceous, Eocene, and Neocene times, the Sierra Nevada was a mountain range and the Great Valley of California was under water. During the same period, the rivers flowing down the western slopes of the range deposited the auriferous gravels. Volcanoes situated mostly along the crest of the range poured out floods of lava, chiefly in Neocene times. During the Pleistocene also, portions of the Great Valley were under water, but there were few volcanic eruptions.

NEOCENE PERIOD.

Deposits formed in the lake of Mohawk Valley.

Lake beds.—Underlying the Pleistocene beds of Mohawk Valley are sediments which are chiefly white shales with some carbonaceous layers. The beds are finely exposed along the Feather River north of Mohawk post-office, unconformably underlying the later Pleistocene lake gravels, which include blocks of the older shales. Similar Neocene beds may be seen at numerous points in Mohawk Valley, but the superficial exposures are in all cases too small to note on the geologic map. Beds which are probably of the same epoch are exposed on the banks of the Feather River, about 1½ miles northeast of Wash post-office. Here very abundant fossil leaves were found, which show the beds to be of Neocene age. The leaf beds have been disturbed and dip westerly at a gentle angle. At the same point are warm springs, which issue along a line of faulting on which movements have taken place in recent years. A fuller account of this faulting and its relation to earthquakes may be found in the Seventeenth Annual Report of the United States Geological Survey, Part I, pp. 592–594, and herein under "Faulting," p. 6.

At Gray Eagle Creek, about 1½ miles nearly south of Mohawk post-office, at an approximate elevation of 4600 feet, is another exposure of the Neocene lake deposit, consisting of beds of clay and sand with layers of carbonaceous shale. In addition there was observed a fine white layer, a few inches in thickness, composed almost entirely of volcanic dust of rhyolitic origin.

Position of an ancient dividing ridge and the Neocene rivers.

Auriferous river gravels.—The Sierra Buttes form the most prominent portion of the highest ridge in the Downieville quadrangle. This ridge extends northwesterly to the Feather River, gradually decreasing in altitude, but for 17 miles many points on the summit are 7000 feet or more in elevation. To the north of the Feather River the Grizzly Mountains form another ridge, with northwesterly trend. Both of these ridges are composed chiefly of pre-Cretaceous rocks. Together they appear to have formed a watershed between two distinct river systems in Neocene time. To the east of the former divide extended a north-south river system, remnants of which are still preserved at a number of points, while to the west the general course of the rivers seems to have been southwesterly. Faulting which occurred in late Neocene and Pleistocene time, and extensive erosion of the river gravels, have in many cases made it impossible to trace the former courses of the channels.

Occurrences of auriferous gravels.

The gravel deposits representing the Neocene rivers to the west of the Neocene divide will be first described.

Indian Hill.

The white quartz gravel channel of Camptonville and Depot Hill, which is east of Oak Valley in the Smartsville quadrangle, appears first in the Downieville district at Indian Hill, where it was formerly extensively hydraulicked. It was there at one time covered with andesitic breccia, a remnant of which is still preserved on the summit of the hill. The next trace of the channel is in the Bidwell Bar district at Grizzly Hill, Brandy City, and Council Hill, and it reappears in the Downieville quadrangle south of Scales. From there to Mount Pleasant and Poverty Hill the gravel beds may be followed continuously. This channel and its two main branches are the only old river channels in the Downieville district that can be traced for any long distance. The channel appears to fork north of Scales, one fork extending to Poverty Hill and the other to Mount Pleasant and farther north under the lava. The Poverty Hill branch appears on the north side of Slate Creek at Barnards diggings, and then successively at Secret diggings, Laporte, Thistle shaft, Gibsonville, Whiskey diggings, and Hepsidam.

Scales.

Mount Pleasant and Poverty Hill.

Laporte.

The white quartz gravel at Laporte may have come in part from the quartz veins immediately adjacent, which may still be seen in the bed of the old river, now denuded of its former covering of gravel by hydraulic washing. The gravel of the Laporte area is said to have been cut off under Bald Mountain by a wall of gray lava (andesite).

Poverty Hill fork.

The channel between Laporte and Gibsonville is covered with andesitic breccia. There is no doubt, however, of the existence of the river deposit under this lava, as it has been penetrated at the Thistle shaft, about 4 miles northeast of Laporte, and the gravel is now being mined there. The Yankee Hill gravel near Slate Creek by the road from Laporte to St. Louis is perhaps a part of the Laporte channel, but there is some doubt about it. From Gibsonville the gravel may be followed continuously through Whiskey diggings to Hepsidam, where the channel disappears under the lava. From Laporte to Gibsonville the average present grade of the bed of the Neocene river is about 80 feet to the mile; from Gibsonville to Whiskey diggings, about 250 feet to the mile; and from the latter place to Hepsidam, a distance of over a mile, about 400 feet to the mile. The measurements, while not accurate, have a comparative value, and as the character of the gravel and of the old channel does not appear to have changed in this distance, the rapid increase in grade is in all probability to be ascribed to a subsequent differential elevation toward the east. The Hepsidam channel has been followed by long tunnels under the lava-capped ridge that extends southeasterly from Pilot Peak.

Hepsidam.

Blue Nose.

On the other (eastern) side of this ridge the bed-rock at the present time sinks rapidly toward the Feather River. The Bunker Hill tunnel, on the east side of the ridge, working westerly, is said to be on the same channel. From there east no other gravel deposits are known to exist that can with any certainty be ascribed to this channel. There are, however, two masses of white quartz gravel at the north and west base of Blue Nose, at the edge of the lava, about 500 feet below the Bunker Hill tunnel, which may be downthrown portions of the Hepsidam river deposit. That extensive faulting has occurred there can be no doubt, and that the region about Blue Nose was formerly one of enormous volcanic activity, where the lavas issued, is also apparent. Much of the lava here is massive andesite, in part dikes, occupying fissures in the bed-rock. A little over a mile northeast of Mount Fillmore is some gravel under the andesite, and both are cut by basalt dikes.

The Blue Lead gravel mine is on the ridge north of Poorman Creek, 2½ miles northeast of Pilot Peak. Here there is white quartz gravel with a rubble of andesitic bowlders on top, like the massive andesite of the area immediately west.

Mount Pleasant fork.

The other fork of the Neocene river just described is well exposed about Mount Pleasant. There is also between this point and Poverty Hill a large amount of gravel made up chiefly of siliceous pebbles of pre-Cretaceous rocks, forming little wooded ridges just south of the fragmental lava of the ridge to the north. At the Iowa shaft north of Mount Pleasant this old channel has been mined. The next appearance of the gravel is on the north side of the volcanic ridge about one-half mile southwest of Port Wine. The claim is called the Bunker Hill, and should not be confused with other mines of the same name in the Downieville quadrangle. Here a tunnel is being run in under the lava. The Lucky Hill mine occupies some of the intermediate ground of the lava-capped ridge between the Iowa shaft and the Bunker Hill claim. This Lucky Hill property is as yet only partially exploited, but such work as has been done indicates that there is a channel under the andesitic breccia which connects with the Iowa Hill gravel. At Port Wine, where the deposit is next to be seen, there were very abundant dikes of basalt cutting the gravel, and some of these may still be seen just south of the village and east of the road. From Port Wine the channel has been almost continuously mined through Queen City, Grass Flat, Gardeners Point, Cedar Grove Ravine, St. Louis, Pine Grove, and Howland Flat. To the northwest of the latter place and to the west of the road there are some fine exposures of the gravel beds, showing, by their irregular upper surface, that they were considerably eroded before being covered by fragmental andesite.

Howland Flat.

Cold Canyon.

The Howland Flat channel disappears under the lavas of the Mount Fillmore ridge at Potosi, from which point it was followed through the ridge by means of tunnels, and reappears on the south slope at Cold Canyon. There is said to have been a rise in the channel up to the middle of the ridge, then a fall, until at Cold Canyon the elevation is about that at Howland Flat. This rise and fall was not, however, gradual, but by steps, the channel being suddenly cut off at several points by polished and striated walls, evidently fault surfaces. The source of the channel east of Cold Canyon is unknown. Much and perhaps all of the gravels representing it are now eroded.

Studhorse Canyon.

At Studhorse Canyon, below Cold Canyon, is a mass of detached gravel, which is possibly a portion of the same deposit. The displaced character of the gravel is well seen at Brückermann's tunnel, where the gravel stratum stands in a highly inclined position. Between the gravel and the bed-rock is a dike of fine-grained proxene-andesite.

Vicinity of Deadwood.

On the south slope of the ridge to the southeast of the flat-topped hill known as Table Rock is a gravel deposit called the California diggings. This, at the present time, is said to be separated from the gravel at Howland Flat by a wall of lava, like that capping Table Rock, intruded after the gravel deposit had formed. This lava is an andesite of a type more recent than the andesitic lavas which form the tuffs and breccias that cover the gravel beds. It is likely that at one time the California channel was connected with the Howland Flat channel. On the south side of Canyon Creek, opposite the California diggings, is another deposit of white quartz gravel, known as Deadwood diggings. This has been followed under the lava in a southeasterly direction to a mine known as Bunker Hill.

Little Grass Valley.

Underlying the alluvium of Little Grass Valley, 2 miles northwest of Bald Mountain, is a considerable body of white quartz gravel, which has been much exploited by means of shallow shafts. From its peculiar position, lower than the South Fork of Feather River, it has not been practicable to mine it profitably on account of the excess of water. This channel may continue under the Grass Valley Hill ridge and thence northeasterly under the lava to Richmond Hill and Sawpit, northwest of Onion Valley. The white quartz gravel underlying Little Grass Valley is not all thoroughly rounded, and this is also true of the gravel at Richmond Hill and Laporte.

Vicinity of Onion Valley.

At the Richmond Hill hydraulic mine there is no lava on the gravel, but the extension of the same area to the east is covered by andesitic breccia, and on the east side of the breccia the Union Hill gravel mine is on the same channel. The latter mine has also been worked by the hydraulic method. At Sawpit there is said to be white quartz gravel under the black basalt. If so the deposit is undoubtedly part of the Richmond Hill-Union Hill channel.

Two and a half miles northwest of Onion Valley, on the north edge of the andesitic breccia area, on the slope toward the Middle Fork of Feather River, is an area of gravel on serpentine bed-rock. Immediately west is an area of the older basalt, which extends lower down on the slope than does the gravel.

Wahoo district.

There are some gravel deposits that have been mined by tunnels on the east side of the high ridge of which Table Rock is a part, about east of Port Wine. This is called the Wahoo district.

Morristown and Craigs Flat.

A considerable river deposit has been extensively mined on the ridge east of Canyon Creek. It is well exposed at Morristown and Craigs Flat. At the latter place the gravel shows evidence, by its very uneven upper surface, of having been eroded before being covered by the andesitic breccia. The very large gravel mass at Eureka, 1½ miles southeast of Craigs Flat, is undoubtedly a part of the same river deposit. It may thence be traced to the ridge east of Eureka Creek, where it has also been mined, and perhaps thence across Goodyears Creek to the Monte Cristo and Excelsior mines.

Eureka.

This Neocene river may have flowed westerly to Craigs Flat and thence over to Scales, being possibly the south fork of the same great river that deposited the gravels at Laporte, Howland Flat, and other points in the present drainage of Slate Creek.

Craycrofts Ridge.

On the summit of Craycrofts Ridge, east of Sailors Ravine, are three patches of gravel. Two of these, one 3½ and the other 4 miles northwesterly from Downieville, are composed largely of well-washed quartz gravel and are not capped with volcanic material. The third occurrence is on the east edge of an area of andesitic breccia 5 miles northeasterly from Downieville. In 1893 this deposit was being mined by the Wide Awake Drift Mining Company.

Nearly all of the river gravels that have thus far been described are composed very largely of white quartz and represent the earliest river system of which there are any traces in the district.

Rattlesnake Creek.

Six and three-fourths miles north of Downieville, just north of Rattlesnake Creek, is a small deposit of gravel known as Rattlesnake diggings. The elevation of the locality is approximately 5500 feet. Underlying the gravel is a bed of rather fine-grained volcanic tuff containing many well-rounded particles. This forms part of the bed of Rattlesnake Creek for about one-half mile above the mouth of the run that joins Rattlesnake Creek just west of the diggings. To the west, south, and east the bed-rock (clay-slates, etc.) rise several hundred feet. To the north the volcanic material is continued up to the large area forming the high Rattlesnake Peak ridge. The gravel is subangular and evidently was formed in a small watercourse. Whether the present position of the gravel and tuff is due to displacement or other cause was not ascertained. The gravel was washed by the hydraulic method.

Two and a half miles west of the Richmond Hill gravel area, at the south edge of the andesitic breccia and on the slope north of Onion Valley accounting for the formation underground of such fragmental material, a similar dike-like mass is known in the Bidwell Bar quadrangle which contains pieces of fossil wood, indicating a fissure filled from the surface. The Poker Flat fragmental dike may likewise be supposed to be a fissure opened by an earthquake and filled in from above.

There is another mass of fragmental andesite in the bed of Canyon Creek 1½ miles farther up the stream, at a point where a large branch enters it from the north. Here a dike of rhyolite forms part of the bed of the creek, and extends thence up the south side, as previously described. The andesitic mass is in contact with and in part apparently overlies the rhyolite, of which it contains fragments. The andesite-tuff forms the bed of the creek for about 300 feet, and thence extends north for about 600 feet, but does not extend up to the ridge top on either side, as at Poker Flat.

Occurrences as massive lava.

The coarse andesite here described occurs as a massive lava on Blue Nose ridge; at Pilot Peak; northeast of Onion Valley; on Mount Fillmore; west of Gold Lake (where it is columnar); on Fir Cap; and on Rattlesnake Peak ridge. The massive andesite just east of Bassetts, at the mouth of Howard Creek, and 2 miles north of Bassetts, where it is columnar, is finer-grained than much of the coarser type, but may be distinguished from the coarser portions of the fine-grained hypersthene-andesite, as the pyroxene is chiefly augite. This fine-grained augite-andesite occurs also as a distinct dike cutting the clay-slates in the bed of Canyon Creek 1 mile northeast of Poker Flat. This dike extends up the south slope, gradually broadening, and forms a conical butte 1 mile south of east from Poker Flat, where the lava in part lies in horizontal columns, and up the north slope, widening into an oval area 1¼ miles north of Poker Flat.

At most points in this quadrangle the andesite-breccia exhibits little evidence of stratification, as is shown in fig. 2 of the page of illustrations, but occasionally the material is distinctly arranged in layers, as on the east bank of the Middle Fork of Feather River, northwest of Mohawk Valley.

These is a small patch of andesite-tuff on the south slope of the Sierra Buttes at an altitude of about 7000 feet, and as the tuff may be presumed to rest on a bit of the old Neocene surface, there is here evidence that the Sierra Buttes formed a mountain mass in Neocene time, the present altitude being 8615 feet, or 1615 feet higher than the tuff.

Composition.

Doleritic basalt.—The doleritic basalt is macroscopically a medium-grained, light-gray or pinkish rock, often with large, scattered olivines. Under the microscope it is seen to be often nearly or quite holocrystalline, and it usually contains much hypersthene. The largest area of this rock is that forming the upper two-thirds of Mount Ingalls, which appears to have been a source of eruption. There is still on the summit of the mountain some red, scoriaceous lava, which may have formed part of the crater. It is thought that the eruptions of this late basalt took place in very early Pleistocene time, after the present drainage system had been initiated. It largely overlies andesitic breccia, and appears to have flowed down slopes that existed at the time of the basaltic eruptions. It occurs at numerous points in the large volcanic area north of Mohawk Valley, as at Big Hill and Penman Peak. There is a large flow just southeast of Mohawk Valley, and another at Haskell Peak.

Distribution of flows.

There is a considerable mass of it on the summit of the ridge 2¼ miles southeast of Sierra City, and several areas on the ridge south of Downieville, one of which is known as Table Mountain. It also caps the andesitic ridge west of the head of Woodruff Creek, and is found at several points on the ridge between Fiddle and Canyon creeks. It forms the summit of Deadwood Peak, southwest of Poker Flat, and the summit of Clermont Hill. There are several masses on the north slope of Clermont Hill, an area 4½ miles south of Tower Rock on the west slope of the Grizzly Mountains, one north of Bells Bar, and one north of Long Valley. It is thus evident that this late doleritic basalt is scattered over nearly the entire Downieville quadrangle. It seems probable that the lava came out chiefly at the points at which it is now found. Except the scoriaceous material on the summit of Mount Ingalls, all the doleritic basalt is massive.

The basalt area of the point one-half mile south of the summit of Haskell Peak presents the appearance of having flowed down over the rhyolite, which had previously been partially eroded.

Olivine-rich basalts and fine-grained hypersthene-andesites.

Other lavas.—Besides the four main types of lava above described, there are certain olivine-rich basalts and fine-grained hypersthene-andesites that occur as small flows or as dikes, intruded when molten into cracks in other rocks. These massive lavas often exhibit a columnar structure, due to contraction from cooling.

There are at several points small areas of massive, dark-colored basalts, usually showing olivine with the aid of a hand lens. These are provisionally grouped together, since they all appear to be later than the older basalt and differ from the doleritic basalt in structure and, to some extent, in mineral composition, although in some instances the two types appear to grade into each other. Many of the specimens with a resinous appearance resemble microscopically certain augite-andesites. On the geologic map these rocks are grouped with the doleritic basalts.

At many points in the large areas of andesitic material shown on the geologic maps are small bodies of massive andesite that usually has a marked slaty fracture or laminated structure. The same rock forms also some isolated areas, and as it occurs in dikes in the fragmental andesite, it is evidently later than that material, and is therefore considered separately, although on the geologic map it is not distinguished by color from the coarser andesite just described. Macroscopically the rock is usually of light slate-gray color. Under the microscope it is characterized by the universal presence of hypersthene in minute laths, and in many cases the plagioclase occurs in the same form. Often there is no hornblende present, but about Poker Flat and Table Rock and at some other points there are needles of brown hornblende, occasionally abundant.

The fine-grained hypersthene-andesite forms isolated areas at the following localities: on the high points 1½ miles northeast and 2 miles northwest of Goodyears Bar; about one-fourth mile east of Denten's, in Mohawk Valley, a dike-like occurrence; and 1½ miles northwest of Saddle Back. Dikes of hypersthene-andesite cut the fragmental andesite dike that crosses Canyon Creek at Poker Flat at several places southeast of that village (see fig. 1).

PLEISTOCENE PERIOD.

Glacial moraines and drift.—The ridge in the northern part of the quadrangle known as the Grizzly Mountains supported a few small glaciers on its eastern slope, but there appears to be no evidence of glacial action on the western and southern slopes. On the steep east slope of the ridge, at Tower Peak, there are several crescentic masses of morainal material; and on the east side of Little Grizzly Creek, opposite the mouth of the stream which heads at Tower Rock, is a piled-up mass of quartz-porphyry and greenstone bowlders that appears to be a terminal moraine, formed by the Tower Rock glacier.

Distribution of moraines.

Much the finest glacial district, however, is that of the ridge joining the Sierra Buttes and Eureka Peak. The east slope of the buttes (see figs. 3 and 4), and the névé basins about Gold, Bear, Wade, and the Jamison lakes, are well polished and scored. So also is the north slope of Eureka Peak, the moraines on the lower east and north slopes of which are very interesting, showing by their forms especially well the course of the glaciers. Eureka Lake is a reservoir, the construction of which was made easy by the manner in which the moraines surround it, forming a natural basin, open only to the north. A medial moraine runs from the moraine on the east side down the slope in an easterly direction, forming the backbone of the side ridge north of Johnsville. In this moraine are abundant bowlders of gabbro from the area on the east slope of Eureka Peak. The terrace on which Johnsville is situated shows stratification in its upper layers. All about Johnsville are enormous accumulations of morainal material. Over an area of 15 square miles none of the underlying formations are exposed. On Frazier Creek, and at other points, this moraine stuff has a depth of 700 feet. The bowlders are chiefly of quartz-porphyry and greenstone, from the extensive areas of these rocks in the névé region of Eureka Peak, Mount Elwell, and Gold Lake. This morainal area merges on the east into the terraces formed by a Pleistocene lake that appears to have filled Mohawk Valley at the time the glaciers were in existence. Opposite Jamison, on the east side of Jamison Creek, there is an exposure of the moraine material at the point where the highest lake terrace begins. The underlying coarse gravel and subangular material are roughly stratified. In the bed of Jamison Creek just below the bridge at Jamison a shaft was sunk some years ago to the depth of 270 feet, all in gravel. This shaft is still to be seen. There must therefore be a great thickness of detrital material here.

The sharpness of the line separating the bare glaciated surfaces of the rocks that were covered with glacial ice and the morainal material is rather remarkable in this region. This may be well seen in the canyon which contains the Sardine Lakes, on the northeast slope of the Sierra Buttes. From the upper (west) end of the lower Sardine Lakes (see fig. 3) to near the top of the buttes, all is bare, glaciated rock, with only occasional erratics. The morainal material of the moraine south of this canyon begins at the west end of the lake and extends diagonally up the ridge south of the lake, while to the east of that line the ridge is composed entirely of glacial débris.

There is practically one continuous sheet of moraine material from Gold Lake to the southeast slope of the Sierra Buttes. All of the level land east of Gold Lake, known as Church Meadows, appears to be underlain by moraine stuff. The valleys of the streams to the west of the high ridge of the Sierra Buttes and Eureka Peak likewise formerly contained glaciers, the one in the canyon of the East Fork of the North Fork of the Yuba originating north of Gold Valley.

Character of deposits in Mohawk Valley.

Lake beds.—The lake that filled Mohawk Valley in Neocene time became much more extensive in early Pleistocene time. This is testified to by a series of terraces of gravel and sand, seen on the west side of the valley. The highest of these have an elevation of about 5100 feet. Lower terraces are to be seen at numerous points in the valley. The lake at its highest level not only filled Mohawk Valley but extended east into Humbug Valley, having a surface of about 35 square miles. The deposits at the highest stage were largely rather fine material—andesitic and morainal detritus—which has since been much eroded, particularly on the east side of Mohawk Valley, where well-defined terraces are not to be found. The best-exposed terraces are crossed by the road from Mohawk post-office to Johnsville. They are composed of loose sand and gravel distinctly stratified, the bedding being approximately horizontal. Pebbles of andesite and rhyolite abound in the lake beds, and to the north and east of Mohawk Valley thin patches of the lake deposit may be seen at many points resting on andesitic tuff. It is therefore certain that the lake attained its maximum development after these andesitic eruptions. Moreover, the eruptions of the andesite appear to have been the cause of the formation of the lake.

Ancient drainage system.

Judging from the present contours of the surface of the pre-Cretaceous formations (granite and the Auriferous slate series), the Middle Fork of Feather River follows approximately an older drainage system, which existed before the latest volcanic eruptions. These eruptions, largely of fragmental andesite, filled up the drainage that then existed, and the waters, dammed back, formed the Pleistocene lake of Mohawk and Humbug valleys. Since that time the river has cut through the barrier and drained the lake. For 3 miles north of the Mohawk lake beds the Feather River of the present time flows through a canyon, the walls and bottom of which are composed entirely of andesitic material.

American Valley.

Alluvial deposits.—The most recent Pleistocene deposits forming the alluvial bottom lands occur along streams and form the lowest portions of most of the valleys. On the geologic map these most recent deposits have not been separated from the earlier Pleistocene. American Valley appears to represent a basin formed in part by orographic causes, and to have been subsequently filled with gravel, sand, and other sediments from the large creeks debouching into it from all sides. It is possible that this valley at one time was the bed of a shallow lake, but no definite evidence of this has been obtained.

Grizzly Valley.

Grizzly Valley is nearly surrounded by volcanic ridges, and may perhaps represent an inclosure formed by the piling up of volcanic material about it. The clay and fine sediment filling it are chiefly of early Pleistocene age, with later bottom lands along Grizzly Creek and its branches.

Feather River.

The deposits along the Feather River from Bells Bar up to the mouth of Jackass Creek are chiefly coarse gravels, and materials of the same sort underlie Long Valley.

Nelson Point.

On the west of Willow Creek, about 1 mile north of Nelson Point, is a considerable area of early Pleistocene gravel. The western border of this area has an elevation perhaps 400 feet greater than that of the portion of the area bordering on Willow Creek. Along most of the rivers are to be found the usual bars, of which English Bar on the Middle Fork of the Feather is a good example.

North Yuba.

Along the North Yuba from Indian Valley to Sierra City are gravel banks or bars, some of them as much as 150 feet above the present river. In these gravels there are pebbles of Tertiary volcanic rocks mixed with those of older rocks.

Downieville and Goodyears Bar.

Downieville rests on Pleistocene gravels, as does also Goodyears Bar. There are also narrow areas of these gravels extending for several miles along the branches of the North Fork of the North Yuba.

GENERAL STRUCTURAL FEATURES.

Suggestion of synclinal structure.

As is shown on the structure-section sheet, the slates and schists of pre-Cretaceous age in the Downieville area are highly compressed rocks with a steep dip, which is often vertical. As stated under the heading "Augite-porphyrite and diabase," a synclinal structure is suggested by the succession and dip of the beds of quartz-porphyry and porphyrite-tuffs and the rocks of the Milton formation, all of which are supposed to be of Juratrias age.

Calaveras formation.

The large area of the Calaveras formation lying to the west of the crest of the high ridge extending northwesterly from the Sierra Buttes may be regarded as a mountain mass which was land at the time the volcanic tuffs and sediments of Juratrias age above noted were deposited in the eastern portion of the quadrangle. These Paleozoic rocks are, as a rule, more highly compressed and metamorphosed than the supposed Juratrias series.

An extensive sheet of quartz-porphyry and quartz-porphyry-breccia forms the crest and the eastern slope of the Sierra Buttes. The original dip of the breccia beds is nowhere apparent except where interbedded with layers of siliceous argillite. The secondary schistosity, as a rule, shows a nearly vertical dip in this series. Overlying this acid volcanic series are the tuffs and flows of augite-porphyrite, which still show plainly the original bedding. Clearly overlying these augite-porphyrite-tuffs are the red slates, sandstone, and tuffs of the Milton formation. Where the original structure can be made out all of these Juratrias beds of the east slope of the Sierra Buttes dip eastward at angles of 35° to 60°. In the northern portion of the quadrangle, in the Grizzly Mountains, we have a somewhat similar series showing the same general relation but dipping to the west. The rocks at the east base of the Grizzly Mountains comprise the Robinson formation, known by fossils to be of Paleozoic age, with associated igneous masses. Forming the crest of the Grizzly Mountains for several miles to the south of the fortieth parallel is a long belt of quartz-porphyry which may be regarded as composed of flows and tuffs deposited on the Paleozoic rocks that lie to the east. Lying immediately west, and perhaps stratigraphically overlying the quartz-porphyry belt, is a strip of siliceous argillite which is indicated on the map as being of Carboniferous age, but it may be of the same age as the lenses of siliceous argillite in the Sierra Buttes ridge. To the west of this belt of siliceous argillite is a very large area of augite-porphyrite, which, so far as can be determined, is continuous with the rocks of the same nature lying to the east of the quartz-porphyry of the Sierra Buttes. The general dip of these rocks in the Grizzly Mountains, at least in the southern portion, is to the west. The rocks of the Milton formation, so far as known, do not appear in this portion of the area. There is here suggested, then, an obscure synclinal structure—the quartz-accounting for the formation underground of such fragmental material, a similar dike-like mass is known in the Bidwell Bar quadrangle which contains pieces of fossil wood, indicating a fissure filled from the surface. The Poker Flat fragmental dike may likewise be supposed to be a fissure opened by an earthquake and filled in from above.

There is another mass of fragmental andesite in the bed of Canyon Creek 1½ miles farther up the stream, at a point where a large branch enters it from the north. Here a dike of rhyolite forms part of the bed of the creek, and extends thence up the south side, as previously described. The andesitic mass is in contact with and in part apparently overlies the rhyolite, of which it contains fragments. The andesite-tuff forms the bed of the creek for about 300 feet, and thence extends north for about 600 feet, but does not extend up to the ridge top on either side, as at Poker Flat.

The coarse andesite here described occurs as a massive lava on Blue Nose ridge; at Pilot Peak; northeast of Onion Valley; on Mount Fillmore; west of Gold Lake (where it **Occurrences as massive lava.** is columnar); on Fir Cap; and on Rattlesnake Peak ridge. The massive andesite just east of Bassetts, at the mouth of Howard Creek, and 2 miles north of Bassetts, where it is columnar, is finer-grained than much of the coarser type, but may be distinguished from the coarser portions of the fine-grained hypersthene-andesite, as the pyroxene is chiefly augite. This fine-grained augite-andesite occurs also as a distinct dike cutting the clay-slates in the bed of Canyon Creek 1 mile northeast of Poker Flat. This dike extends up the south slope, gradually broadening, and forms a conical butte 1 mile south of east from Poker Flat, where the lava in part lies in horizontal columns, and up the north slope, widening into an oval area 1¼ miles north of Poker Flat.

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The basalt area of the point one-half mile south of the summit of Haskell Peak presents the appearance of having flowed down over the rhyolite, which had previously been partially eroded.

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PLEISTOCENE PERIOD.

Glacial moraines and drift.—The ridge in the northern part of the quadrangle known as the Grizzly Mountains supported a few small glaciers on its eastern slope, but there appears to be no evidence of glacial action on the western and southern slopes. On the steep east slope of the ridge, at Tower Peak, there are several crescentic masses of morainal material; and on the east side of Little Grizzly Creek, opposite the mouth of the stream which heads at Tower Rock, is a piled-up mass of quartz-porphyry and greenstone bowlders that appears to be a terminal moraine, formed by the Tower Rock glacier.

Much the finest glacial district, however, is that of the ridge joining the Sierra Buttes and Eureka Peak. The east slope of the buttes (see **Distribution of moraines.** figs. 3 and 4), and the névé basins about Gold, Bear, Wade, and the Jamison lakes, are well polished and scored. So also is the north slope of Eureka Peak, the moraines on the lower east and north slopes of which are very interesting, showing by their forms especially well the course of the glaciers. Eureka Lake is a reservoir, the construction of which was made easy by the manner in which the moraines surround it, forming a natural basin, open only to the north. A medial moraine runs from the moraine on the east side down the slope in an easterly direction, forming the backbone of the side ridge north of Johnsville. In this moraine are abundant bowlders of gabbro from the area on the east slope of Eureka Peak. The terrace on which Johnsville is situated shows stratification in its upper layers. All about Johnsville are enormous accumulations of morainal material. Over an area of 15 square miles none of the underlying formations are exposed. On Frazier Creek, and at other points, this moraine stuff has a depth of 700 feet. The bowlders are chiefly of quartz-porphyry and greenstone, from the extensive areas of these rocks in the névé region of Eureka Peak, Mount Elwell, and Gold Lake. This morainal area merges on the east into the terraces formed by a Pleistocene lake that appears to have filled Mohawk Valley at the time the glaciers were in existence. Opposite Jamison, on the east side of Jamison Creek, there is an exposure of the moraine material at the point where the highest lake terrace begins. The underlying coarse gravel and subangular material are roughly stratified. In the bed of Jamison Creek just below the bridge at Jamison a shaft was sunk some years ago to the depth of 270 feet, all in gravel. This shaft is still to be seen. There must therefore be a great thickness of detrital material here.

The sharpness of the line separating the bare glaciated surfaces of the rocks that were covered with glacial ice and the morainal material is rather remarkable in this region. This may be well seen in the canyon which contains the Sardine Lakes, on the northeast slope of the Sierra Buttes. From the upper (west) end of the lower Sardine Lakes (see fig. 3) to near the top of the buttes, all is bare, glaciated rock, with only occasional erratics. The morainal material of the moraine south of this canyon begins at the west end of the lake and extends diagonally up the ridge south of the lake, while to the east of that line the ridge is composed entirely of glacial débris.

There is practically one continuous sheet of moraine material from Gold Lake to the southeast slope of the Sierra Buttes. All of the level land east of Gold Lake, known as Church Meadows, appears to be underlain by moraine stuff. The valleys of the streams to the west of the high ridge of the Sierra Buttes and Eureka Peak likewise formerly contained glaciers, the one in the canyon of the East Fork of the North Fork of the Yuba originating north of Gold Valley.

Lake beds.—The lake that filled Mohawk Valley in Neocene time became much more extensive in early Pleistocene time. This is testified to by a series of terraces of gravel and sand, seen on the west side of the valley. The highest of these have an elevation of about 5100 feet. Lower terraces are to be seen at numerous points in the valley. The lake at its highest level not only filled Mohawk Valley but extended east into Humbug Valley, having a surface of about 35 square miles. The deposits at the highest stage were largely rather fine material—andesitic and morainal detritus—which **Character of deposits in Mohawk Valley.** has since been much eroded, particularly on the east side of Mohawk Valley, where well-defined terraces are not to be found. The best-exposed terraces are crossed by the road from Mohawk post-office to Johnsville. They are composed of loose sand and gravel distinctly stratified, the bedding being approximately horizontal. Pebbles of andesite and rhyolite abound in the lake beds, and to the north and east of Mohawk Valley thin patches of the lake deposit may be seen at many points resting on andesitic tuff. It is therefore certain that the lake attained its maximum development after these andesitic eruptions. Moreover, the eruptions of the andesite appear to have been the cause of the formation of the lake.

Judging from the present contours of the surface of the pre-Cretaceous formations (granite and the Auriferous slate series), the Middle Fork of Feather River follows approxi- **Ancient drainage system.** mately an older drainage system, which existed before the latest volcanic eruptions. These eruptions, largely of fragmental andesite, filled up the drainage that then existed, and the waters, dammed back, formed the Pleistocene lake of Mohawk and Humbug valleys. Since that time the river has cut through the barrier and drained the lake. For 3 miles north of the Mohawk lake beds the Feather River of the present time flows through a canyon, the walls and bottom of which are composed entirely of andesitic material.

Alluvial deposits.—The most recent Pleistocene deposits forming the alluvial bottom lands occur along streams and form the lowest portions of most of the valleys. On the geologic map these most recent deposits have not been separated from the earlier Pleistocene. American Valley appears to represent a basin formed in **American Valley.** part by orographic causes, and to have been subsequently filled with gravel, sand, and other sediments from the large creeks debouching into it from all sides. It is possible that this valley at one time was the bed of a shallow lake, but no definite evidence of this has been obtained. Grizzly Valley is nearly surrounded by volcanic ridges, and may perhaps represent an inclosure formed by the piling up of volcanic **Grizzly Valley.** material about it. The clay and fine sediment filling it are chiefly of early Pleistocene age, with later bottom lands along Grizzly Creek and its branches. The deposits along the Feather River from Bells Bar up to the mouth **Feather River.** of Jackass Creek are chiefly coarse gravels, and materials of the same sort underlie Long Valley. On the west of Willow Creek, about 1 mile north of Nelson Point, is **Nelson Point.** a considerable area of early Pleistocene gravel. The western border of this area has an elevation perhaps 400 feet greater than that of the portion of the area bordering on Willow Creek. Along most of the rivers are to be found the usual bars, of which English Bar on the Middle Fork of the Feather is a good example. Along the North Yuba from Indian Valley to Sierra City are gravel banks or bars, some of them as much as 150 feet above **North Yuba.** the present river. In these gravels there are pebbles of Tertiary volcanic rocks mixed with those of older rocks. Downieville rests on Pleistocene gravels, as does also Goodyears Bar. There are also narrow areas of these **Downieville and Goodyears Bar.** gravels extending for several miles along the branches of the North Fork of the North Yuba.

GENERAL STRUCTURAL FEATURES.

As is shown on the structure-section sheet, the slates and schists of pre-Cretaceous age in the Downieville area are highly compressed rocks with a steep dip, which is often vertical. As stated under the heading "Augite-porphyrite and diabase," a synclinal structure is suggested by the succession and dip of **Suggestion of synclinal structure.** the beds of quartz-porphyry and porphyrite-tuffs and the rocks of the Milton formation, all of which are supposed to be of Juratrias age.

The large area of the Calaveras formation lying to the west of the crest of the high ridge extending northwesterly from the Sierra Buttes may be regarded as a mountain **Calaveras formation.** mass which was land at the time the volcanic tuffs and sediments of Juratrias age above noted were deposited in the eastern portion of the quadrangle. These Paleozoic rocks are, as a rule, more highly compressed and metamorphosed than the supposed Juratrias series.

An extensive sheet of quartz-porphyry and quartz-porphyry-breccia forms the crest and the eastern slope of the Sierra Buttes. The original dip of the breccia beds is nowhere apparent except where interbedded with layers of siliceous argillite. The secondary schistosity, as a rule, shows a nearly vertical dip in this series. Overlying this acid volcanic series are the tuffs and flows of augite-porphyrite, which still show plainly the original bedding. Clearly overlying these augite-porphyrite-tuffs are the red slates, sandstone, and tuffs of the Milton formation. Where the original structure can be made out all of these Juratrias beds of the east slope of the Sierra Buttes dip eastward at angles of 35° to 60°. In the northern portion of the quadrangle, in the Grizzly Mountains, we have a somewhat similar series showing the same general relation but dipping to the west. The rocks at the east base of the Grizzly Mountains comprise the Robinson formation, known by fossils to be of Paleozoic age, with associated igneous masses. Forming the crest of the Grizzly Mountains for several miles to the south of the fortieth parallel is a long belt of quartz-porphyry which may be regarded as composed of flows and tuffs deposited on the Paleozoic rocks that lie to the east. Lying immediately west, and perhaps stratigraphically overlying the quartz-porphyry belt, is a strip of siliceous argillite which is indicated on the map as being of Carboniferous age, but it may be of the same age as the lenses of siliceous argillite in the Sierra Buttes ridge. To the west of this belt of siliceous argillite is a very large area of augite-porphyrite, which, so far as can be determined, is continuous with the rocks of the same nature lying to the east of the quartz-porphyry of the Sierra Buttes. The general dip of these rocks in the Grizzly Mountains, at least in the southern portion, is to the west. The rocks of the Milton formation, so far as known, do not appear in this portion of the area. There is here suggested, then, an obscure synclinal structure—the quartz-porphyry, augite-porphyrite, and Milton series lying on the older rocks of the Sierra Buttes ridge and dipping easterly; and the quartz-porphyry, siliceous argillite, and augite-porphyrite lying on the older rocks of the Grizzly Mountains and dipping westerly. To the north of the fortieth parallel, however, there is some siliceous argillite in the Grizzly Mountains, associated with Silurian limestone, forming the Grizzly formation of Diller, and it is not impossible that the belt of siliceous argillite noted above may be a continuation of the siliceous argillite series of the Grizzly formation. While there is thus a reasonable doubt as to the quartz-porphyry of the Grizzly Mountains being of the same age as that of the Sierra Buttes, there is little doubt that the augite-porphyrite of both regions is of the same age, as it forms one large area.

Grizzly Mountains.

In a general way it may be said that the strike of the older rocks of the Downieville district is to the northwest and southeast, or north and south. Local displacements, however, are not uncommon, as is the case with the mass of sediments of the Calaveras formation forming the ridge south of Canyon Creek, of which Deadwood Peak is the culminating point. These slates in general have an east-west strike, parallel to the contact of this area of sediments with the amphibolite-schist just north. The schistose structure developed in this amphibolite-schist, as seen along Canyon Creek and to the east of St. Louis, trends likewise approximately east and west. There is no apparent explanation of the displacement of this body of Paleozoic sediment unless we regard the amphibolite-schist as an altered form of an intrusive mass, very probably pyroxenite. This amphibolite-schist is a coarsely fibrous variety, containing little else than amphibole, and quite different in composition and structure from the uralite-epidote rocks which are the result of metamorphism of augitic tuffs.

Strike of older rocks.

There is no evidence in the Downieville quadrangle that any of the granitic masses are older than the pre-Cretaceous rocks by which they are surrounded. As a rule there is a distinct zone of greater metamorphism bounding the granitic masses.

Faulting.—That faulting has occurred at many points in the Downieville quadrangle is shown in a general way by the topography, and in a more definite way by the manner in which the old river channels are suddenly cut off under the lavas by walls of other rocks which often appear smooth and striated, indicating movement. The continuation of the gravel channel has then to be found by sinking or upraising, according as the displaced mass was lowered or raised. Such faults were found in the Hepsidam channel, in the Potosi-Cold Canyon channel, and at other points.*

To one standing on the summit of the high, wide plateau west of Mohawk Valley and looking eastward, the region to the east of the valley presents all the appearance of being a downthrown area. The slope to the west of the valley is an exceedingly steep one, rising at some points 2500 feet in 1¾ miles. This slope, moreover, is composed wholly of pre-Cretaceous rocks, although these are hidden at some points by morainal débris. To the east of the valley Tertiary volcanic material covers large areas and forms the summits known as Jackson Mountain, Penman Peak, and Pilot Hill. Where pre-Cretaceous rocks occur they are at low elevations, at no point within 3 miles of the valley having a greater altitude than 5300 feet, or 800 feet above the lower part of Mohawk Valley. The best evidence that a great displacement has occurred here in Tertiary time consists of the presence of river gravels on the high plateau to the west. At one point, about 2½ miles northwest of Haskell Peak, there is a heavy mass of well-rounded gravel at the very edge of the escarpment, and a considerable portion of this mass has by gravity traveled down the slope, so that the apparent thickness of the deposit is about 500 feet. To the northeast and west of Haskell Peak, and also close to the edge of the escarpment, are smaller masses of similar gravel, all of them capped with rhyolite and all at an elevation of about 7000 feet. It is evident that we have here remnants of an old river deposit formed by a stream flowing at a moderate grade. It is not likely that such a stream could have existed along the edge of a plateau having a steep escarpment. There can be no reasonable doubt that since these gravels were deposited a profound displacement has occurred, in virtue of which that portion of the former plateau lying to the east of the present escarpment has dropped down 2000 or more feet and now lies in part buried beneath the sediment of the former Mohawk Lake and beneath Tertiary lavas. This downward displacement must have been preceded by an elevation of the range.

Plateau west of Mohawk Valley.

Mohawk Lake, just referred to, occupied the present Mohawk Valley in Upper Miocene or Pliocene time, although the lake at this period may not have been a deep body of water. The basin occupied by this lake may be regarded as the result of the displacement above referred to, in which case the faulting probably took place or was initiated in early Miocene time. The lake beds lie at nearly all points approximately horizontal. Reference is made here particularly to the older Tertiary beds, composed chiefly of fine white sediments. It is of course equally true that the Pleistocene lake beds, which cover up and largely conceal the older beds, are also approximately horizontal. These more extensive Pleistocene beds were deposited by a body of water of some depth, due to the damming back of the water by andesitic breccia, as has been described under the heading "Lake beds." Slight displacements have, however, occurred in comparatively recent times in the lake beds, indicating a zone of weakness, presumably established at an early date, as above indicated. The lake beds are disturbed in the immediate vicinity of this line of faulting, but are horizontal a few feet to the east and west of the fault line, so far as determined.

Mohawk Valley the result of a displacement.

Faults with a small throw in Pleistocene sediments were noted on the east side of the Middle Feather River opposite Wash post-office, and on the south bank of the river about 1 mile upstream from Wash post-office. About a mile farther east, where most of the fossil leaves were collected that are referred to under the heading "Lake beds," a fissure was formed in the tuff and breccia beds at the time of an earthquake, about 1876.

Recent faults on Middle Feather River.

In 1889 warm, moist air still issued from this fissure, which when first formed is said to have been 2 feet wide. A little east of the fissure is a warm sulphur spring. Near this is another spring, which soon after the earthquake is said to have been so warm that the hands could not be held in the water. As further evidence of a disturbance at this point, it may be said that the leaf-bearing lake beds underneath the tuff dip from 5° to 30° to the west.

Earthquake fissure.

Farther south, just east of the springs at the Sulphur Spring House, the lake beds are likewise flexed, at one point dipping 22° to the southwest. The so-called sulphur springs had in 1890 a temperature of 75° F., as tested by an immersed thermometer.

Artesian wells along the west side of Sierra Valley are said in some cases to strike hot water, which may be regarded as evidence of the existence of a fissure. The fault shown on the map along Spring Garden Creek and near Cromberg on the Middle Feather may be correlated with the zone of faulting above indicated.

ECONOMIC GEOLOGY.

Gold-quartz veins.—No portion of the Sierra Nevada is more prolific in quartz veins than the Downieville quadrangle. Large and continuous veins are, however, not the rule, and the mines as a whole have not proved nearly so rich as in other districts. The most notable mines are those on the eastern slope of Eureka Peak, known as the Plumas Eureka, and the Sierra Buttes mine northwest of Sierra City. These have been worked with much profit for many years, but are now nearly exhausted. The vein matter in the Plumas Eureka consists of a firm, white quartz, carrying a large percentage of pyrite, with galena and some zinc-blende, the gold being about evenly distributed through the quartz and the sulphides. To the south of the Plumas Eureka the Little Jamison quartz vein is said to promise well.

The Sierra Buttes vein is a large one, in places 40 feet in width, dipping to the east from 40° to 50°.

The Young America vein, on the eastern slope of the Sierra Buttes, is composed of a soft, brittle quartz, with porphyry walls, and is said to have paid from $20 to $30 per ton. The quartz contained very little sulphide, the ore being free milling. The vein in general varies from 6 to 12 feet in width. The Mountain mine, on the spur south of the Sardine lakes, produces a high-grade ore. Like the Young America mine, it is most picturesquely located. The Phœnix mine is on the southeast slope of the Buttes.

There is considerable prospecting going on in the ridge south of Sierra City and Downieville, where quartz veins are numerous, but no mines of importance are being worked there at present. The veins occur both in the slates and in the granite area of Harris Meadows. At Gold Valley two quartz veins have been developed, the Gold Valley Mining Company's vein and the vein of the St. Johns mine; both strike northeast and dip southeast. The veins are about 5 feet wide. In the Gold Valley mine sulphides were so abundant that a chlorination plant was necessary.

Two mines have been developed on the west side of the North Fork of the North Yuba, to the north of Downievile. The Good Hope, about 500 feet above the stream, is a vein between slate and serpentine. The strike of the ledge is northwest and southeast. The Gold Bluff, farther up the ravine, is still being worked. The strike of the ledge is said to be north and south and the dip 45° to the west.

Quartz veins are abundant in the slates along Willow Creek east of Clermont Hill.

Gold in quartz-porphyry (*rhyolite-porphyry*).—One mile east of Onion Valley is a dike of rhyolite-porphyry in the Auriferous slate series, at the head of Poorman Creek, in a decomposed portion of which free gold occurs, associated with little veins of quartz. As the gulch was very rich below this dike it is possible that much of the gold in it came from the dike. At the time of the writer's visit the gravel and morainal débris about the gulch were being mined by the hydraulic method. This gold deposit is of unusual interest, as being in a dike of late Cretaceous or Tertiary age. The rock may be termed a rhyolite-porphyry. It is composed of crystals of brown mica, sanidine, plagioclase, and quartz, in a microgranular groundmass of apparently both quartz and feldspar.

Free gold at head of Poorman Creek.

Gold-bearing gravels.—The gravels that were deposited by the Tertiary rivers in the Downieville district have been described under the heading "Auriferous river gravels." In a general way it may be stated that all of these gravels are auriferous and in places exceedingly rich. Since the distribution of these Tertiary gravels has already been noted in detail, only a brief notice of them will be here given.

Those gravels that have produced the most in the Downieville district lie in the present drainage of Slate Creek. They have been mined by the hydraulic method very extensively at Whiskey diggings, Gibsonville, Laporte, Secret diggings, and Barnards, on the north side of Slate Creek; and on the south side at Howland Flat, Pine Grove, St. Louis, Cedar Grove Ravine, Grass Flat, Queen City, Port Wine, and intermediate points. The channel on the south side of Slate Creek is last seen at the Bunker Hill drift mine, about half a mile southwest of Port Wine. It is presumed here to go under the lava ridge, and to be the same as has been worked at the Iowa shaft north of Mount Pleasant. At Mount Pleasant the Neocene rivers of the Slate Creek drainage join and continue toward the south as one river. The hydraulic mines at Scales, Union Hill, Council Hill, Brandy City, and Indian Hill are on this main channel. The Neocene river gravels were also mined by the hydraulic method at several points north and west of Onion Valley and north of Blue Nose Mountain, and also at California diggings and at Deadwood, near Poker Flat. At Morristown, Craigs Flat, Eureka, Monte Cristo, and other points the deposits of another river were hydraulicked. A river entirely distinct from those above noted existed in Neocene time in the eastern part of the district. The gravels of this river have been mined at the Cascade gravel mine on the east slope of the Grizzly Mountains, and at a point farther south in the drainage of Little Long Valley Creek. In the southeast portion of the district the Neocene river deposit at Chips Hill, on the ridge east of the Sierra Buttes, was also mined. At many points these Neocene river gravels are being worked at the present time by drifting. Thus the Laporte channel is mined at the Thistle shaft, about 4 miles northeast of Laporte, where the gravel deposit is covered with lava, and at many points tunnels have been run in from the side of the lava-covered ridges to strike the river gravels that lie beneath the lavas. The objections to hydraulic mining do not apply to any considerable extent to the Downieville district, for the distance from the gravel deposits to the Sacramento Valley, following the course of the drainage, is so great that it is difficult to believe that any considerable amount of the detritus can reach the Sacramento River, where alone it can do any harm.

Neocene gravels of the Slate Creek drainage mined by hydraulic method.

Neocene deposits of other rivers hydraulicked.

Neocene gravels worked by drifting.

The Pleistocene gravels forming bars usually of some elevation above the present rivers have in nearly all cases been rich in gold. These are referred to under the head of alluvial deposits. They may be well seen in the canyon of the North Yuba and its branches, as well as along the Middle Feather. At Downieville remnants of gravel benches at a considerable elevation above the present river are still preserved. These gravels were formerly mined with good returns.

Some years ago a shaft was sunk in the middle of the American Valley, but little if any gold was taken out. The gravel in the present stream beds has also been mined at many places, the streams being temporarily diverted.

At some points also the soil and subangular loose material of subaerial origin have been sufficiently rich to repay mining. The Hayes mine on the ridge 3 miles east of Gold Lake is in material of this nature.

Gold in soil.

In 1890 morainal stuff was being mined on Poorman Creek, northeast of Pilot Peak, by the hydraulic method. The gold was mostly angular and perhaps came chiefly from the white dike of rhyolite-porphyry previously noted. On the slope west of Mohawk Valley, 2 miles south of Wash post-office, is Bennett's hydraulic gold gravel mine. The bed-rock is granite. On the north side of the ravine the material lying on the granite is seen to be made up of clay considerably compacted, with numerous pebbles and bowlders, which are generally well rounded. On some of them scratches were evident. The upper material was composed of sand and gravel, with many fragments of granite, and of pre-Cretaceous and Tertiary volcanic rocks. Traces of a rough stratification were noted. The material is supposed to be part of the higher terraces of the Pleistocene Mohawk Lake, and to have been furnished by the glaciers on the slope above, and therefore to be partly morainal.

Gold in moraines.

Iron ore.—There is a mass of magnetite by the creek north of Gold Valley, the surface of which has been smoothed by glacial action. On this surface are numerous figures drawn in former times by Indians. This mass is noted on the economic sheet, as is also a smaller mass just southeast of the Spencer Lakes, and another just west of Wades Lake.

Chrome iron.—In the gravel along Goodyear Creek waterworn pebbles of chrome iron have been found. These doubtless came from the neighboring serpentine area. Similar pebbles from the gravel at Howland Flat indicate bodies in place not far away, as the pebbles are too heavy for distant transportation under ordinary circumstances.

Limestone and marble.—The very abundant limestone masses that form a zone in the Paleozoic slates just west of the quartz-porphyry belt of Eureka Peak and Sierra Buttes are chiefly of a dirty light-gray color. A similar mass is found on the main southeast spur of Clermont Hill, and is known as Limestone Point. Analyses of two samples of these limestones are given in the paragraph on the Calaveras formation, and show that they are highly magnesian. On Little Long Valley Creek is a mass of crystalline limestone or marble. Some of this has been burned for lime. There is also a long reef of limestone that crosses the ridge north of Onion Valley Creek at Last Chance, and small lenses at other points, as noted on the map.

H. W. TURNER,
Geologist.

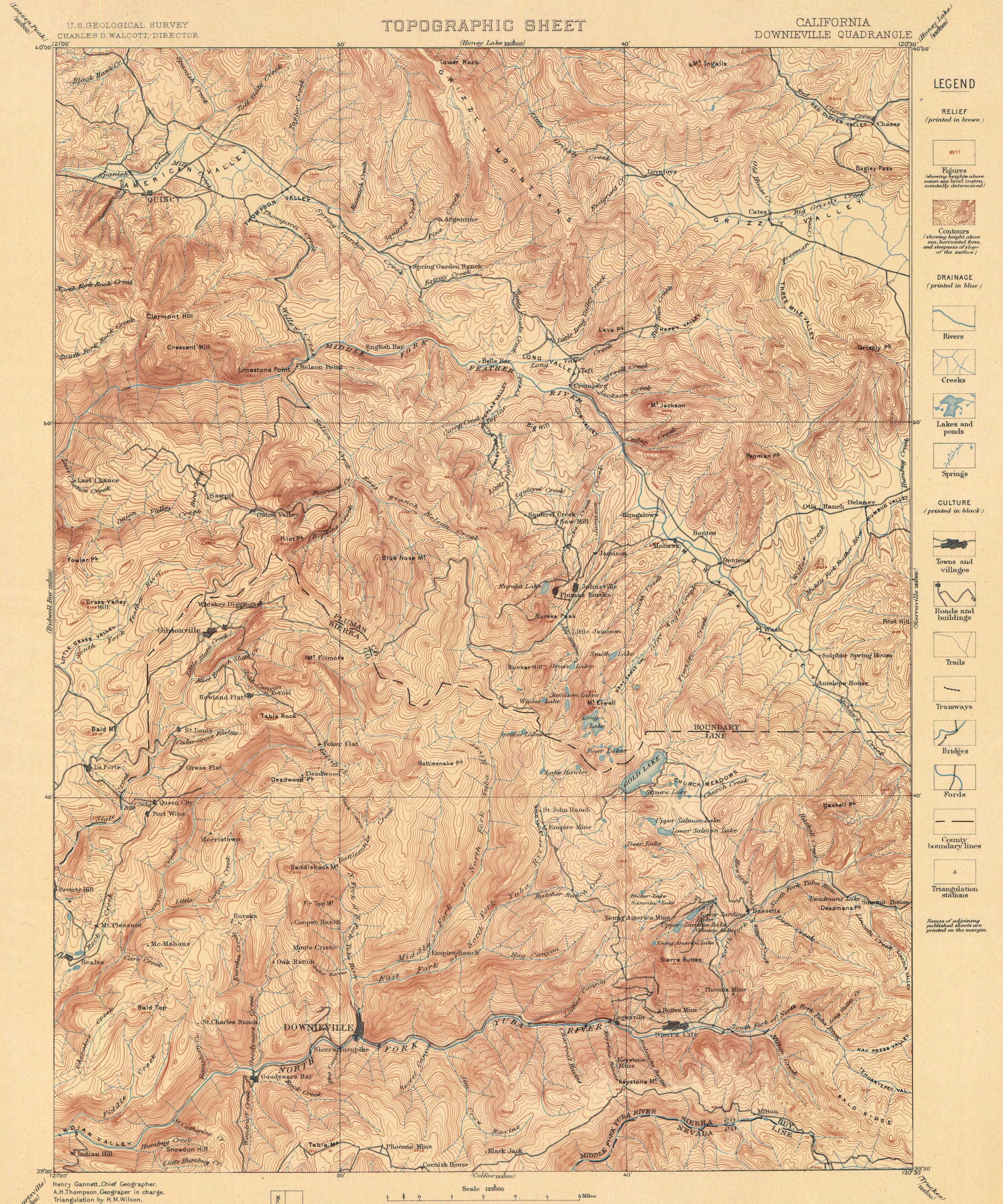
June, 1896.

*See Whitney, Auriferous Gravels, 1880; and the author's paper in the Seventeenth Annual Report of the United States Geological Survey, Part I, 1896.

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

TOPOGRAPHIC SHEET

CALIFORNIA
DOWNIEVILLE QUADRANGLE



Henry Gannett, Chief Geographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by H.M. Wilson and R.H. McKee.
Surveyed in 1886-88.

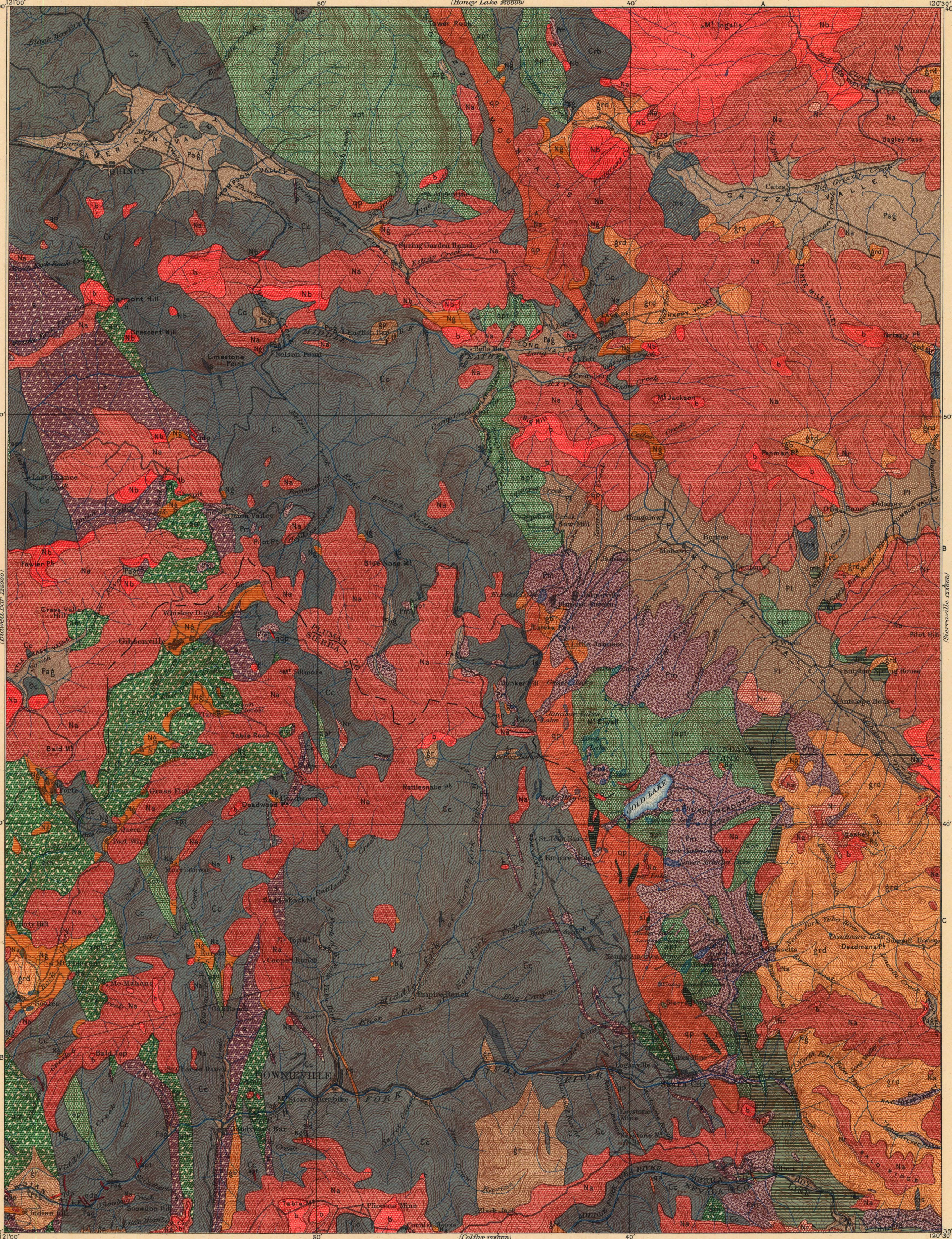
Scale 1/125000
Contour Interval 100 feet.
Datum is mean Sea level.
Edition of May 1897.

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

HISTORICAL GEOLOGY SHEET

CALIFORNIA
DOWNIEVILLE QUADRANGLE

(Lassen Peak 1/250000) (Honey Lake 1/250000)



LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles.)

SUPERJACENT SERIES

PLEISTOCENE

- Pag — Alluvial deposits (early and late)
- Pl — Lake beds
- Pm — Moraines and glacial drift

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

NEOCENE

- Ng — Auriferous river gravels

BED-ROCK (Auriferous slate) SERIES

JURATRIAS

- Jml — Milton formation (tuff, red slate, quartzite, limestone, and conglomerate)

JURATRIAS ?

- sl — Siliceous argillite (lentils in quartz-porphyry)

CARBONIFEROUS

- Crb — Robinson formation (tuff, trachyte, and red slate)
- ms — Micaceous schist (detached masses in granodiorite, probably of the Robinson formation)
- Cc — Calaveras formation (clay-slate, quartzite, and limestone)
- ls — Limestone lentils (in Calaveras and Milton formations)

IGNEOUS ROCKS

(Areas of Igneous rocks are shown by patterns of triangles and rhombs.)

SUPERJACENT SERIES

PLEISTOCENE ?

- b — Late basalt

NEOCENE

- Na — Andesite (massive and fragmental)
- Nb — Older basalt (fine grained, always massive)
- Nr — Rhyolite

Legend is continued on the left margin.

LEGEND

(continued)

BED-ROCK SERIES

EARLIER THAN THE LATE CRETACEOUS, CHICO FORMATION

- Dikes of various rocks (quartz-diorite-porphyry, qdp; augite-porphyrite, apt; and undetermined rocks)
- gr — Granite and granulite
- gp — Granite-porphyry
- grd — Granodiorite (quartz-mica-diorite)
- gb — Gabbro
- s — Serpentine (associated with peridotite)
- apt — Augite-porphyrite (altered augite-andesite with some diabase)
- am — Amphibolite (schistose and massive, derived from various basic igneous rocks)
- qp — Quartz-porphyry (in part fragmental, sometimes schistose)

Probable faults

Sections

(Smartsville 1/125000) (Truckee 1/125000)

Henry Gannett, Chief Geographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by H.M. Wilson and R.H. Mc.Kee.
Surveyed in 1886-8.

Mc.Kee | Wilson

Scale 1/125000

Miles

Kilometers

Contour Interval 100 feet.

Datum is mean Sea level.

Edition of May 1897.

Geology by H.W. Turner.
Surveyed in 1890-4.

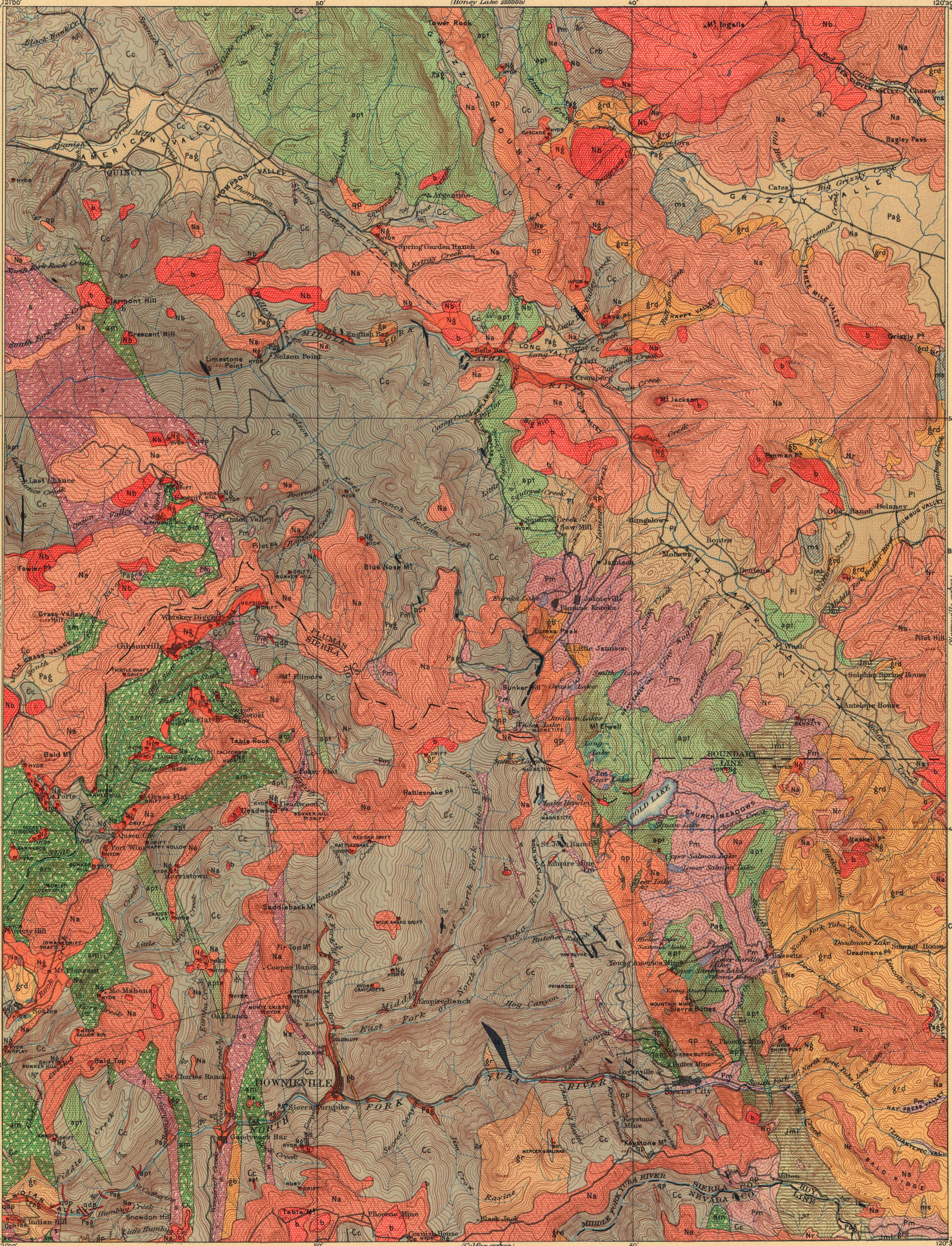
U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

ECONOMIC GEOLOGY SHEET

CALIFORNIA
DOWNIEVILLE QUADRANGLE

(Lassen Peak) (1/250000)

(Honey Lake) (1/250000)



LEGEND
(continued)

BED-ROCK SERIES

EARLIER THAN THE LATE CRETACEOUS, CHICO FORMATION

- Dikes of various rocks *(quartz-diorite-porphyry, qdp; augite-porphyrite, apt; and undetermined rocks)*
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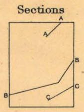
Probable faults

Sections



- *Dip and strike of stratified rocks*
- *Vertical dip and strike of stratified rocks*
- *Dip and strike of schistosity*
- *Vertical dip and strike of schistosity*
- *Gold quartz veins*
- DRIFT *Drift mines in auriferous gravels*
- HYDR *Hydraulic gold mines*
- *Magnetite prospects*
- *Gold quartz prospects*

Known productive formations

- *Auriferous gravels*
- *Limestone*

LEGEND

SURFICIAL ROCKS

(Areas of Surficial rocks are shown by patterns of dots and circles.)

SUPERJACENT SERIES

PLEISTOCENE

- Pag — Alluvial deposits *(early and late)*
- Pl — Lake beds
- Pm — Moraines and glacial drift

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines.)

NEOCENE

- Ng — Auriferous river gravels

BED-ROCK (Auriferous slate) SERIES

JURATRIAS

- Jml — Milton formation *(tuff, red slate, quartzite, limestone, and conglomerate)*

JURATRIAS ?

- sl — Siliceous argillite *(lentils in quartz-porphyry)*

CARBONIFEROUS

- Crb — Robinson formation *(tuff, trachyte, and red slate)*
- ms — Micaceous schist *(detached masses in granodiorite, probably of the Robinson formation)*
- Cc — Calaveras formation *(clay-slate, quartzite, and limestone)*
- ls — Limestone lentils *(in Calaveras and Milton formations)*

IGNEOUS ROCKS

(Areas of Igneous rocks are shown by patterns of triangles and rhombs.)

SUPERJACENT SERIES

PLEISTOCENE ?

- b — Late basalt

NEOCENE

- Na — Andesite *(massive and fragmental)*
- Nb — Older basalt *(fine grained, always massive)*
- Nr — Rhyolite

Legend is continued on the left margin.

(Smartsville 1/125000)

Henry Gannett, Chief Geographer.
A.H. Thompson, Geograper in charge.
Triangulation by H.M. Wilson.
Topography by H.M. Wilson and R.H. Mc.Kee.
Surveyed in 1886-8.

Scale 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 May 1897.

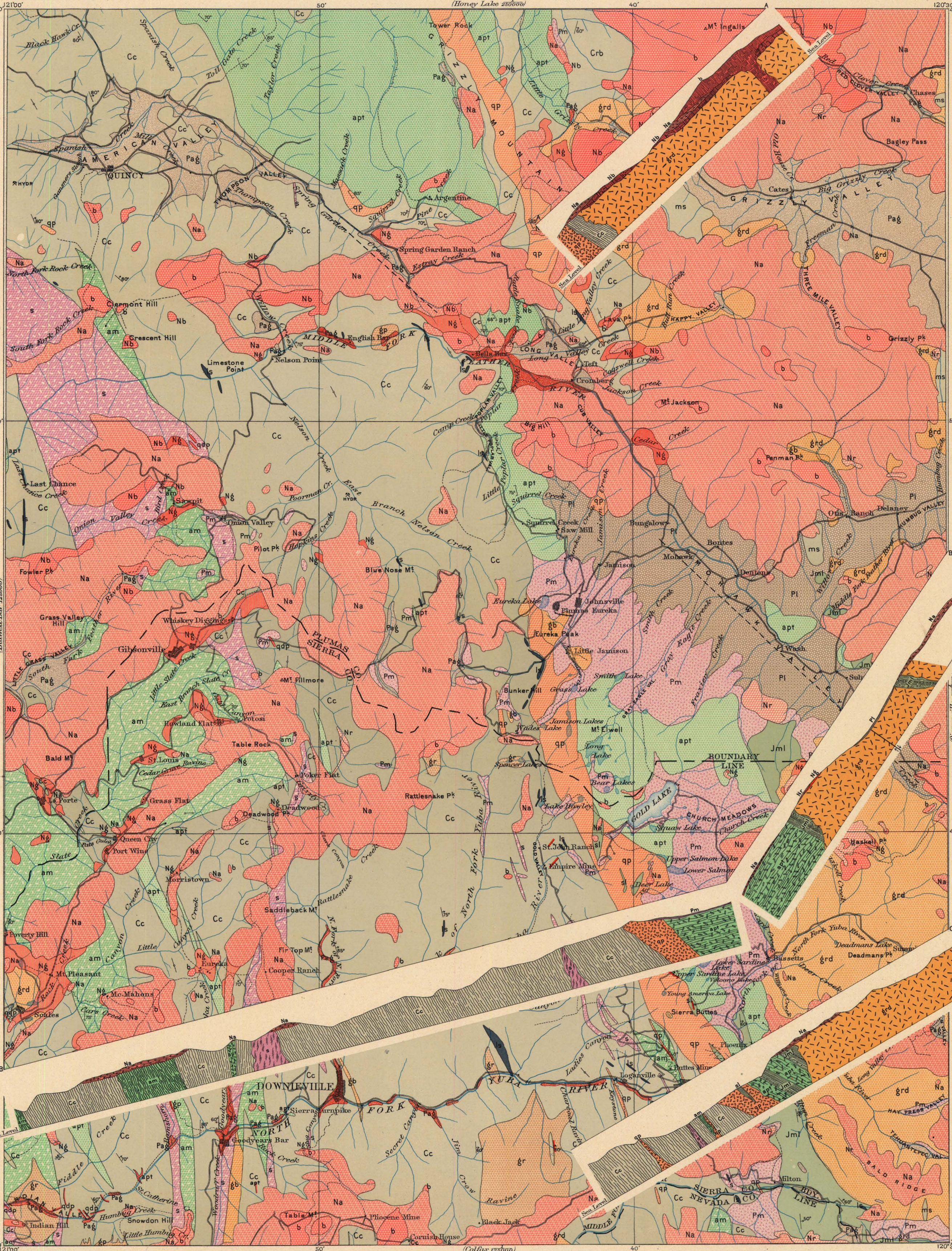
Geology by H.W. Turner.
Surveyed in 1890-4.

(Truckee 1/125000)

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

STRUCTURE-SECTION SHEET

CALIFORNIA
DOWNIEVILLE QUADRANGLE



LEGEND

(continued)

BED-ROCK SERIES — EARLIER THAN THE LATE CRETACEOUS, CHICO FORMATION

- Dikes of various rocks (quartz-diorite-porphyry, qdp; augite-porphyrite, apt; and undetermined rocks)
- gr — Granite and granulite
- gp — Granite-porphyry
- grd — Granodiorite (quartz-mica-diorite)
- gb — Gabbro
- s — Serpentine (associated with peridotite)
- apt — Augite-porphyrite (altered augite-andesite with some diabase)
- am — Amphibolite (schistose and massive, derived from various basic igneous rocks)
- qp — Quartz-porphyry (in part fragmental, sometimes schistose)

Probable faults

- 20° Dip and strike of stratified rocks
- Vertical dip and strike of stratified rocks
- 80° Dip and strike of schistosity
- Vertical dip and strike of schistosity
- Gold quartz veins

Known productive formations

- Auriferous gravels
- Limestone

LEGEND

SURFICIAL ROCKS

SUPERJACENT SERIES — PLEISTOCENE

- Pag — Alluvial deposits (early and late)
- Pl — Lake beds
- Pm — Moraines and glacial drift

SEDIMENTARY ROCKS

NEOCENE

- Ng — Auriferous river gravels

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IGNEOUS ROCKS

SUPERJACENT SERIES

PLEISTOCENE?

- b — Late basalt

NEOCENE

- Na — Andesite (massive and fragmental)
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1 ½ 0 1 2 3 4 5 Miles
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SPECIAL ILLUSTRATIONS

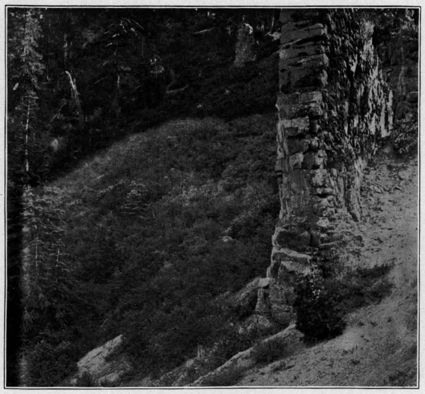

FIG. 1.—DIKE OF FINE-GRAINED HYPERSTHENE-ANDESITE IN ANDESITE-BRECCIA (Na), ONE-THIRD MILE SOUTHEAST OF POKER FLAT.

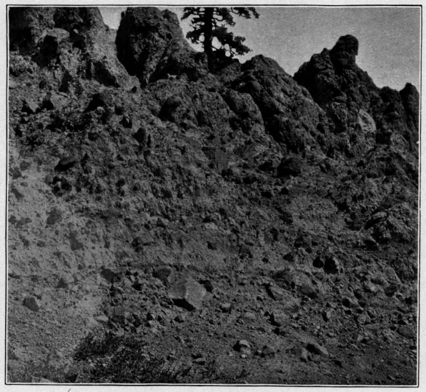

FIG. 2.—ANDESITE-BRECCIA SHOWING ABSENCE OF STRATIFICATION; EAST SLOPE OF SADDLEBACK MOUNTAIN.

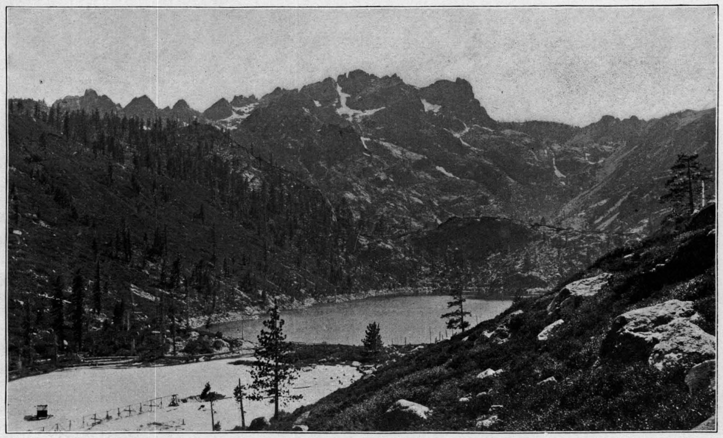

FIG. 3.—SIERRA BUTTES AND LOWER SARDINE LAKE.
The distant slopes are bare and smoothed by glaciers. The high ridge on the left is the beginning of a moraine.

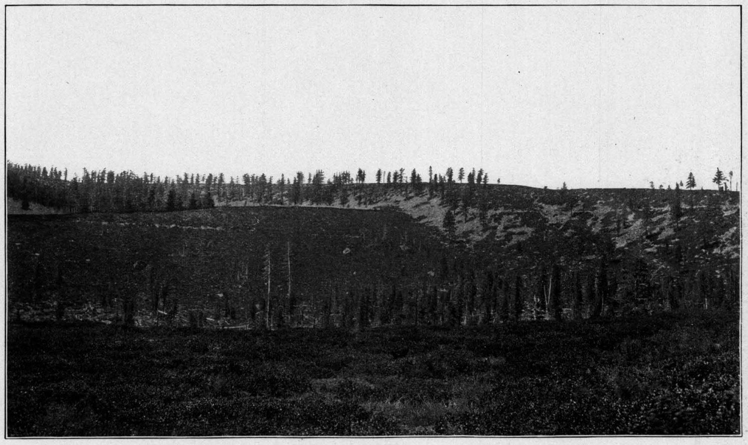

FIG. 4.—MORAINES SOUTH OF SARDINE CREEK, SHOWING A YOUNGER EAST-WEST MORAINE CUTTING ACROSS AN OLDER NORTH-SOUTH MORAINE.

FIG. 5.—QUARTZ-PORPHYRY-BRECCIA (qp) INTERSECTED BY A SYSTEM OF VERTICAL JOINT PLANES, ONE-HALF MILE SOUTHWEST OF UPPER SALMON LAKE.

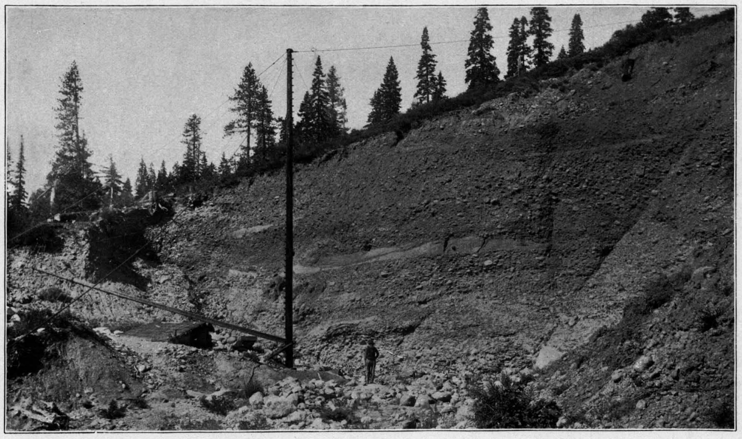

FIG. 6.—NEOCENE AURIFEROUS GRAVELS AT THE CASCADE GRAVEL MINE, ON THE EAST SLOPE OF THE GRIZZLY MOUNTAINS.