DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS

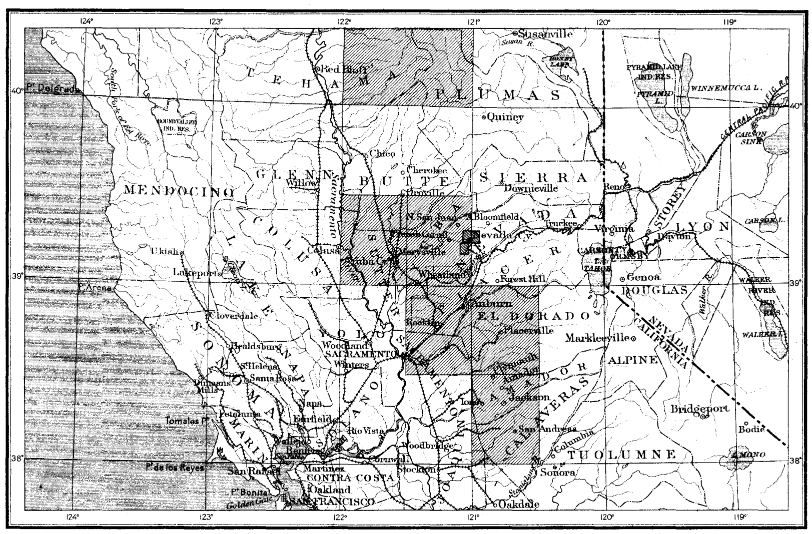
OF THE

UNITED STATES

NEVADA CITY SPECIAL FOLIO

CALIFORNIA

INDEX MAP



SCALE: 40 MILES - 1 INCH


AREA OF THE NEVADA CITY SPECIAL FOLIO


AREA OF OTHER PUBLISHED FOLIOS

LIST OF SHEETS

GRASS VALLEY · NEVADA CITY · BANNER HILL

DESCRIPTION · TOPOGRAPHY · ECONOMIC GEOLOGY · STRUCTURE SECTIONS

FOLIO 29 · LIBRARY EDITION · NEVADA CITY SPECIAL

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

BAILEY WILLIS, EDITOR OF GEOLOGIC MAPS · S. J. KÜBEL, CHIEF ENGRAVER

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 stated on the map by numbers. It is desirable to show also the elevation of any part of a hill, ridge, or valley; 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 constant 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:

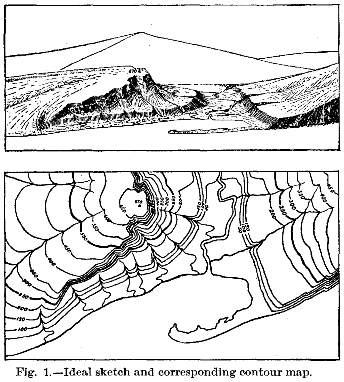


Fig. 1.—Ideal sketch and corresponding contour map.

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 to a precipice. Contrasted with this precipice is the gentle descent of the western 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 occur 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 so with any other contour. In the space between any two contours occur 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 240 feet long and 180 feet high this would cover, on a scale of 1 mile to the inch, 3,025,000 square inches. 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 special 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 fractional scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250{,}000}$, the intermediate $\frac{1}{125{,}000}$, and the largest $\frac{1}{62{,}500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile of natural length to an inch of map length. 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 three scales are stated, 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.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. Each sheet on the scale of $\frac{1}{250{,}000}$ contains one square degree; 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. These areas correspond nearly to 4,000, 1,000, 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. For convenience of reference and to suggest the district represented, each sheet 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 region 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 areal geologic map represents 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 maps show 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 very 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 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 made are carried as solid particles by the 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 subsoils 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 rocks 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 a guide 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 and formed 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 one was deposited first.

Fossil remains found in the rocks of different areas, of different provinces, and of different 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 below. The names of certain subdivisions of the periods, frequently used in geologic writings, are bracketed against the appropriate period names.

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, with the exception of the first and the last, are distinguished from one another by different patterns, made of parallel straight lines. Two tints of the

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	Є	Pinks.
Algonkian	A	Orange-browns.
Archean	Æ	Any colors.

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. 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 of surficial formations of the Pleistocene is so great that, to distinguish its formations from those of other periods and from the igneous rocks, the entire series of colors is used in patterns of dots and circles.

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.

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.

Areal 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. The formations are arranged according to origin into surficial, sedimentary, and igneous, and within each class are placed in the order of age, so far as known, the youngest at the top.

Economic 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 areal 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:

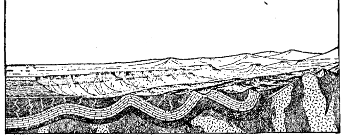


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape above.

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:

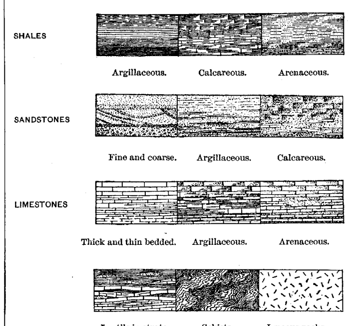


Fig. 3.—Symbols used to represent different kinds of rock.

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 position, 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 consist 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 constitute the local record of geologic history. 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 1,000 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.

DESCRIPTION OF THE SPECIAL MAPS.

TOPOGRAPHY.

The three maps contained in this folio illustrate, in a detailed manner, the topography and geology of the important gold-mining districts in the vicinity of Grass Valley and Nevada City, California. These districts are situated on the long western slope of the Sierra Nevada, at an average elevation of 2,500 feet, and about 15 miles north-northwest of the town of Colfax, on the Central Pacific Railroad. The Banner Hill map represents an area very nearly 4 miles long by 3 wide, embracing 11.65 square miles; the larger part of it is within the limits of the Colfax atlas sheet of the general topographic map of the Gold Belt. The tract shown on the Nevada City map, adjoining the Banner Hill on the west, has the same dimensions and forms a part of the area of the Smartsville atlas sheet. The district embraced by these two detailed sheets extends from 39° 13′ 50″ to 39° 17′ 16″ north latitude and from 120° 57′ 05″ to 121° 03′ 45″ west longitude. South of the Nevada City tract, but extending somewhat farther west, lies the tract represented on the Grass Valley map, also about 4 miles long by 3 miles wide, and containing an area of 12.09 square miles; it extends from 39° 10′ 22″ to 39° 13′ 50″ north latitude and from 121° 01′ 35″ to 121° 05′ 00″ west longitude, and forms a part of the area of the Smartsville atlas sheet. The total area of the three sheets is thus 35.39 square miles.

In addition to the large maps a smaller one has been prepared showing the vicinity of the Brunswick and Gold Point mines. This will be published in the final report on the district, and is referred to in the following pages as the Brunswick map.

NEVADA CITY AND BANNER HILL MAPS.

Relief.—The Nevada City and Banner Hill districts are, topographically as well as geologically, intimately connected and may well be described together. The dominating features are the two long ridges whose crests descend gently westward—the Harmony Ridge, near the northern boundary, and the Banner Hill-Towntalk Ridge, near the southern boundary. The northern ridge sinks with a gradual slope from an elevation of 3,660 feet to 2,840 feet at the western boundary line of the Nevada City map, and is cut in two by a gap north of Nevada City. A conspicuous pyramidal hill, the Sugarloaf, with an elevation of 3,075 feet, stands in the middle of the gap and reaches at its summit the gradient of the ridge line. The southern ridge, beginning at an elevation of 3,600 feet, is somewhat wider than the northern, and has at the western boundary line of the Nevada City map an elevation of 2,700 feet. Near Banner Hill this ridge is cut in two by the narrow canyon of Little Deer Creek; farther west several gaps are cut across it, the most prominent one being that at Towntalk. The average slope of the ridge line is $1\frac{1}{2}°$. At the eastern boundary of the Banner Hill district the ridges approach each other, and are in fact separated only by the deep canyon of Deer Creek. In the southeast corner of the Banner Hill tract, towering 500 feet above the ridges, stands the isolated and conspicuous Banner Hill (elevation 3,904 feet). From the edges of the ridge-tables steep slopes lead down to the watercourses, steepest as a rule near the summit, then flattening out somewhat, then again becoming steeper toward the stream bed. The distance between the ridges is greatest at the western edge of the Nevada City tract, and here, as well as south of Nevada City, the relief is less accentuated.

Drainage.—The principal stream is Deer Creek, which traverses the middle of the region from east to west, and which, 12 miles farther west, empties into the Yuba River. The total fall of the stream from the eastern side of the Banner Hill tract (2,840 feet high) to the western side of the Nevada City tract (2,160 feet high) is 680 feet, or about 100 feet to the mile. The fall is by no means uniform, however; in the steep canyon in the eastern part of the Banner Hill tract it is 150 feet to the mile; thence down to Nevada City, about 100 feet to the mile; from Nevada City to the Providence mine, through another narrow canyon, the fall is 150 feet to the mile; and from the Providence down to the edge of the tract it is but 53 feet to the mile, the creek meandering over gravelly flats. Lateral ravines, usually steep and narrow, lead to the creek from north and south. A somewhat larger tributary is Little Deer Creek, which heads in the vicinity of Banner Hill. South of Towntalk the drainage is toward Bear River, the ravines forming the northern headwaters of Wolf Creek, a tributary of that river. Southeast of Banner Hill the steep ravines lead down toward Greenhorn Creek, also a tributary of Bear River.

GRASS VALLEY MAP.

Relief.—The general relief of the country represented by this map is gentler and the outlines are more undulating than those of the region described above. The elevations range from 3,080 feet on the summit of Osborne Hill to 2,080 in the bed of Wolf Creek, at the southern boundary. The northeastern part consists of a series of rather flat-topped ridges, 200 to 300 feet high, with comparatively steep slopes toward the watercourses. The larger, southwestern part may be considered as an undulating plateau, with somewhat irregular hills and ridges rising to a height of 100 or 200 feet above the general level. In this plateau the principal drainage line has cut a canyon, which in some places is narrow and steep and the depth of which does not exceed 300 feet. Rising high above the other relief and occupying a position similar to that of Banner Hill, stands the high ridge of Osborne Hill.

Drainage.—The larger part of the area is drained by Wolf Creek, a tributary of Bear River. From the city of Grass Valley it runs south to the limit of the tract without larger tributaries. At Grass Valley it forks into two creeks, which have a general east-west direction. The fall varies from 50 feet to the mile in the Grass Valley basin to 130 in the vicinity of the Omaha mine. The smaller tributaries to the creek show a feature which is also marked in the other two tracts, though to a less extent: they flow with gentle grade over the undulating, plateau-like country, even forming marshes at their sources, but on approaching the main stream they descend to it with a steep, torrential grade. East of Osborne Hill the drainage is toward Rattlesnake Creek, a tributary of Wolf Creek. The extreme northwestern corner drains to Deer Creek.

VEGETATION.

The vegetation is of generally uniform character throughout the district of the three maps, and consists predominatingly of a second growth of yellow pine (*Pinus ponderosa*), the much more luxuriant growth once covering a large part of the ground having been cut for mining purposes since 1849. A few large white-oaks are found on the more open flats, and a strong, bushy growth of chaparral (Manzanita and Ceanothus) covers some of the hills. The serpentine ridges have a separate and peculiar vegetation of digger-pine (*Pinus sabiniana*)—elsewhere rarely growing above 2,000 feet—yew, stunted oak, and thorny bushes.

GENERAL GEOLOGY.

The general geologic features of the region here under discussion are delineated and described in the maps of the Gold Belt, especially in the Smartsville and Colfax sheets, and to them the student desirous of more extended knowledge of the Sierra Nevada must be referred. It is, however, desirable to indicate briefly the connection of the districts here described with the general structure of the surrounding country. Throughout the Sierra Nevada there is one sharp geologic distinction to be drawn: it is the difference between the older rocks—the "Bed-rock series," as it is usually termed—on one hand, and the "Superjacent series," or the much younger gravels, sands, clays, and volcanic rocks, on the other hand. The Bed-rock series consists of highly altered sedimentary rocks, crystalline schists, and older igneous rocks, on which the Superjacent series lies in approximately horizontal position. The rocks of the former series have been subjected to repeated orographic disturbances, and to a great extent have been compressed, broken, and crushed by these forces. The rocks which are now at the surface were once below it, probably thousands of feet; successive uplifts and constant erosion have removed the upper parts of the rock masses and exposed those once buried in the foundations of the range. Rightly to understand the geology this fact must be borne in mind, and the relation of the younger to the older series must be remembered.

EARLIER HISTORY.

While it is comparatively easy to unravel the later (Neocene) history of the Sierra Nevada, the same can not be said of the immeasurably longer periods preceding it. They included successive epochs of quiet sedimentation, when the ocean covered the place where the range now rises; several distinct epochs of intense volcanic action, when the lavas built up mountains of igneous masses; and other epochs during which mountain-building forces lifted and crushed together these sedimentary and igneous products. In these compressed and crushed masses occurred enormous, abyssal intrusions of coarse-grained, granitic rocks. Animal life, on the remains of which we depend for the identification of the sedimentary formations, was unusually scant during the intervals of deposition, or most of the fossils were destroyed during the metamorphism which the rocks have undergone. Many parts of the Sierra Nevada have, indeed, the aspect of pre-Cambrian complexes—the oldest known—though, from the evidence available, it is certain that the rocks of the range in general are of much younger age.

The Nevada City and Grass Valley district is located in the upper foothills, near the line where the old igneous rocks of the foothill region give place to the wide belt of slaty, sedimentary rocks of the middle range; east of this sedimentary belt the granitic rocks of the highest parts of the range begin. High ridges of fine-grained, dark-green rocks, diabases and augite-porphyrites, form the first foothills of the Sierra Nevada in Yuba and Nevada counties; in the latter county these rocks extend to near Anthony House and Indian Springs, where they are replaced by a belt of coarser-grained, granitic rocks (granodiorite, diorite, and gabbro), which terminates along a line drawn by French Corral, Rough and Ready, and Wolf Creek Mountain. Eastward of this line, up to Nevada City and Grass Valley, the geology is very complex; relatively narrow belts of more or less metamorphosed sedimentary rocks, standing at steep angles, alternate with large quantities of fresh or metamorphosed igneous rocks. Near Nevada City this complex is separated from the predominatingly sedimentary slates to the east by the rounded southern end of the great intrusive granodiorite mass extending more than 20 miles northward into Butte County. In the southern part of Nevada County the diabases and porphyrites of the foothills extend very far eastward, and an area of these rocks reaches northward, including Osborne Hill, to the east of Grass Valley.

The region of complicated structure begins at Rough and Ready, 5 miles west of Grass Valley, with amphibolites and gabbros; then follows a belt, from $\frac{1}{4}$ of a mile to $1\frac{1}{2}$ miles wide, of sedimentary clay-slates and siliceous slates, which, near the North Star mine, enters the Grass Valley tract. A branch of these slates is deflected to the southeast and traverses the northeastern part of the Grass Valley tract. Between Grass Valley and the main clay-slate belt lies a body of diabase and porphyrite about three-fourths of a mile wide, the continuation of which northward, though broken for a short distance by intervening slate masses, is found west of Newtown. East of this diabase belt lies the Grass Valley area of granodiorite, 5 miles long, a rather narrow body of coarse-grained, granitic rock, the northerly end of which is found in the city of Grass Valley. Eastward of this comes the great porphyrite and diabase area of Osborne Hill, limited again by the above-mentioned streak of sedimentary slates cutting obliquely across the Grass Valley tract.

The greatest complication is found between Nevada City, Newtown, and Grass Valley. Within this area the rocks may be divided into three groups: (1) The two narrow belts of siliceous clay-slates with steep dip, one following the contact of the Nevada City granodiorite area for a long distance, the other embedded in porphyrites one-fourth of a mile eastward. (2) The diabases and porphyrites, occupying a considerable area to the south of Nevada City and continuing down to the vicinity of the Maryland mine. These dark-green, fine-grained rocks form pointed areas running out northward; the largest, adjoining the first-mentioned slate belt, comes to a point about 3 miles west-northwest of Nevada City. (3) The diorite-gabbro-serpentine complex, beginning north of South Yuba River, forming a lenticular mass 9 miles long and not over 3 miles wide, and running out in several points a short distance east of Grass Valley. The largest part of the latter area consists of a coarse-grained, lighter or darker green diorite or gabbro, or a rock intermediate between the two. In it lie several lenticular masses of serpentine, usually running out to sharp points; the road from Nevada City to Newtown crosses the two largest of these serpentine masses. Less-altered pyroxenites and peridotites are found in or near the serpentine. There is excellent reason for believing that all the rocks of this complex are of similar age and origin.

Turning now to the more interesting question of the relations of all these different rocks, it should be stated that no fossils have thus far been found in the sedimentary rocks of the district. The greater part of the latter have been referred to the Calaveras formation, which embraces the Paleozoic sedimentary rocks of the Sierra Nevada. Among the Paleozoic rocks the Carboniferous strata doubtless predominate, but the paucity of fossils has permitted identification only at relatively few points. The determination of the rocks in question as "Calaveras," therefore, rests on circumstantial evidence only, and this evidence consists partly in their lithologic similarity to beds determined farther south, near Auburn, and partly in their position in the prolongation of these strata northward. These slates of the Calaveras formation are probably the oldest rocks in the district. During a mountain-building disturbance toward the end of the Paleozoic or the beginning of the Mesozoic, these beds became folded and compressed. This earliest uplift was associated with the outbreak of igneous rocks, which, indeed, in some localities took place even during the deposition of the Carboniferous beds, but of those igneous rocks there is no positive trace in the region under discussion. It is believed that all of the igneous rocks of Grass Valley and Nevada City are post-Carboniferous, and probably none of them antedate the end of the Juratrias period.

During the last portion of the Juratrias period a large part of the Sierra Nevada was a land area; part of it, however, was submerged, and in that sea the latest sedimentary division of the Bed-rock series—the Mariposa beds—was deposited. These are black, carbonaceous clays, interbedded from the thirty-eighth parallel northward with volcanic tuffs, which shows that during their formation volcanic forces had already begun to act. A narrow belt of black clay-slates, interstratified with clastic, volcanic material, beginning about 2,000 feet west of the Champion mine and thence running southeasterly by Towntalk and the Merrimac and Washington mines, has been determined as belonging to the Mariposa beds. The slates are much less altered than those of the Calaveras formation, possess great similarity to the well-known Colfax beds, and, while not directly connected with them, lie in their natural continuation to the northwest. Though not absolutely certain, this identification has a very great degree of probability. After the Mariposa epoch followed a time of the most intense mountain-building disturbance, accompanied by the outburst of an enormous quantity of igneous material of different character and texture. The younger sedimentary rocks were folded and compressed, and welded with the older series of the same kind, while intrusive masses were injected in them far below the surface, and volcanoes with thousands of feet of lavas and ash masses were built up on the surface along what are now the foothills of the range. The diabases and the porphyrites, as well as the diorite-gabbro-serpentine series, belong to this volcanic period, the former as partly surface flows and dikes, partly deep-seated intrusive masses; the latter entirely consolidated as coarse, granular rocks far below the surface.

Finally, as the last and farthest-reaching phase of that period of igneous activity, came the intrusion of the large granodiorite masses in the then deep-seated part of the range. This took place on so gigantic a scale that the mind strives with difficulty to comprehend the mechanics of the process. Thus, the granodiorites of Nevada City and Grass Valley are the most recent rocks of the Bed-rock series. Finally, after the intrusions of the granodiorite, dynamic forces, acting on the mass with different intensity and in different directions, produced fissure systems in which auriferous solutions ascended and deposited their contents. This forming of the mineral veins was the last phase of the Mesozoic revolution in the Sierra.

By no means all of the rocks of the district are now in the same condition in which they were formed. Successive dynamic forces have acted on many of them, producing deformation and schistose structure. Chemical forces have acted on them in at least three distinct ways, changing their mineral constituents until their original form is sometimes scarcely or not at all recognizable: first, as a result and concomitant of dynamic metamorphism; second, by the heat and mineralizing exhalations of the intrusive granodiorite; third, by the action of the hot auriferous solutions on the rocks adjoining the fissures through which they circulated. Often several or all of these effects have been combined in one locality, rendering very difficult the task of unraveling the changes through which the rock has passed. In the region covered by the Smartsville sheet, in which the larger part of the area described in this folio is located, there has been less of that intense dynamic action producing slaty and schistose structure by compression than in some parts of the Gold Belt farther south. One line along which the rocks have been crushed and rendered schistose extends in a northerly direction through nearly the whole region, and passes some distance beyond the western boundary of the Grass Valley tract. As in certain localities along that line the granodiorite has been rendered schistose, it follows that this line of disturbance was produced later than the intrusion of granodiorite. Another line of schistose structure in the Calaveras formation follows the granodiorite contact south and west of Nevada City, while a partly parallel line of schistosity follows the area of the porphyrite and the Mariposa slates to the west of the contact. But most of the rocks in the area of the special maps are of massive character.

LATER HISTORY.

At the beginning of the Neocene period the Sierra Nevada formed a mountain range of substantially the same outlines as that of to-day, but of much less height, the summits — located along the same line as the present ones — having an elevation probably of about 5,000 feet, in latitude 38°- 39°. The range had been above water since the end of the Juratrias period, and in its lower part long-continued erosion had reduced it to a hilly, undulating country, frequently broken by high ridges and isolated peaks. A drainage system somewhat similar to the one of the present day had been developed, and auriferous gravels accumulated along the streams from the débris of the numerous quartz veins. The stream receiving the drainage of Grass Valley and Nevada City corresponded closely to the Yuba River, but also embraced the watershed of the upper Bear River. Its southern branch came down from Dutch Flat and You Bet with a northerly direction, crossing Deer Creek at Scotts Flat and the South Yuba at Blue Tent; then turned westward and flowed down to the Great Valley by Badger Hill, North San Juan, French Corral, and Smartsville. During the latter part of the Neocene period (the Pliocene) volcanic eruptions began near the summit of the Sierra, and masses of volcanic material began to pour down the river channels. The first material erupted was the light-colored, siliceous rock called rhyolite, which was of comparatively small volume, confining itself as a rule to the river channels. The eruptions consisted only to a small extent of molten material, the larger quantity poured out forming volcanic muds, which easily found their way down to the foot of the range. On the lower slopes they became mixed with more or less gravel and sand, and their eruptive character is now less apparent. Very heavy flows of this kind found their way down the old South Fork of the Yuba, and part of them flooded a low divide and filled the Nevada City basin. After a short interval, during which considerable erosion took place, the so-called "cement channels" or "channels of the volcanic period" were formed in certain parts of the Sierra, wherever erosion cut through the rhyolitic flows. No such channels have been found in the district here described. Then the period of andesitic eruptions began, and mud-flows again poured down from the vents near the divide, at first as dark-colored, fine tuffs and sands, later as a gray or brown tuffaceous breccia, containing, in the foothills as well as in the high range, larger, more or less angular bowlders of the dark-colored porphyritic rock called andesite. These last flows, coming down in rapid succession, flooded everything and covered up the middle slopes to such an extent that only isolated ridges and peaks protruded above them. The whole area here considered was thus once a gently sloping lava field, above which only Banner and Osborne hills protruded. The rough, high diabase ridges of the foothills also rose above the flows. The last of the andesitic flows is supposed to mark the close of the Neocene period. During the volcanic epoch the Sierra Nevada was subjected to a tilting uplift, which at the summit probably amounted to several thousand feet, and the streams at once began the work of cutting into this desolate lava plateau. The directions they took were more generally transverse than formerly. Their similarity to the old drainage was caused by the high, protruding ridges of bed-rock, which in many places confined the new river to the old valley. This work of canyon-cutting has been continued with ceaseless energy until the present time. Not only has much of the enormous lava masses been washed away, but, owing to the uplift, the rivers have cut down far below the old Neocene bed-rock surface and created the characteristic features of the Sierra Nevada of to-day; these are deep, abrupt canyons separated by broad or narrow ridges of more gently undulating surface.

In the district described in this folio the sloping ridges — Harmony Ridge and the Banner Hill-Towntalk Ridge — are the only remnants of the lava-sheet which once covered nearly the whole region, while the present watercourses, here wholly unlike their Neocene predecessors, are sunk several hundred feet below the Neocene surface. Between the close of the andesitic eruptions and the present day occurred the extensive glaciation of the High Sierra, but the glaciers terminated about 30 miles above Nevada City; and it may be stated with certainty that neither in the Neocene nor in the Pleistocene period have any ice streams extended as far down as the latter place.

DESCRIPTION OF THE ROCKS.

BED-ROCK SERIES.

This series consists of sedimentary rocks which were forced into a nearly vertical position at or before the post-Juratrias upheaval, together with the associated igneous rocks.

SEDIMENTARY ROCKS.

Calaveras formation.—The sedimentary rocks referred to the Paleozoic age and designated the Calaveras formation are represented on all three maps. In the Banner Hill district they surround the granodiorite area on the east and south. In the canyon of Deer Creek they are splendidly exposed, and consist of hard, black to dark-brown, very fine-grained, siliceous rocks which show no slaty structure and only doubtful traces of stratification. Exposed to atmospheric influences, they soon bleach and are decomposed to a soft, white, clayey mass, as may be seen on the road to Scotts Flat, near the edge of the areas. Weathering sometimes brings out an inherent schistosity not apparent in the fresh rocks. The strike of this is then north-northwest, and the dip steep to the east. In the southern part of the area the rocks are more like imperfectly fissile clay-slates, and show a nearly vertical schistosity about parallel with the contact of the granodiorite. On the surface they appear as grayish, fine-grained rocks, breaking into irregular, flat fragments. Along the contact with granodiorite the influence of the molten magma has rendered these rocks more crystalline and somewhat coarser in texture. They contain much mica, which gives them a dark-brown color. Such contact-metamorphosed sediments are usually designated hornfels. The most intense metamorphism, well exposed in the bed of Deer Creek, extends only a few hundred feet at this locality, but a slight alteration can be recognized for several thousand feet to the east of the contact.

In the Nevada City district the Calaveras formation is confined to a narrow belt running diagonally across the district. Throughout this belt there is a well-defined schistosity practically parallel to the contact and either vertical or dipping east at steep angles. In the southern part of this belt, and farthest away from the contact, there are exposed black clay-slates alternating with a fine-grained quartzite. Near the contact the slates are more crystalline and metamorphosed. From the vicinity of the Providence mine westward the rocks are so much altered as to deserve the designation of crystalline schists, micaceous and chloritic in character. Mingled with the slates of sedimentary origin there are in this vicinity smaller dikes and masses of old igneous rocks, diabases and porphyrites, which have also been affected by the metamorphism to such a degree as to render them schistose and difficult to distinguish from the altered clay-slates. Such masses are exposed in Deer Creek below the Wyoming mill.

In the Grass Valley district there are three areas referable to the Calaveras formation. (1) The small area just south of Maslin shaft, embedded between serpentine and diabase, consists largely of fine quartzite and fissile clay-slate. (2) The central belt, which crosses the area of the map in a northwestern direction, extends northwesterly below the andesitic tuff and joins, near Newtown, the belt along the western margin. It also continues southwesterly below the tuff area, and a small exposure of it is shown about 3,000 feet east of the Electric mine. It consists of black clay-slate and black, hard, quartzose sandstone, neither being very much altered. Weathering bleaches both to a gray or white color. The schistosity is nearly perpendicular and is directed northwest. The stratification probably coincides with the schistosity, though the exposures are not good enough to be conclusive. A little crystalline limestone, of gray color, is also exposed on the dump of the New Eureka shaft. South of Little Wolf Creek there is, mingled with the sediments, much porphyrite breccia. Along the contact with the granodiorite the sediments are highly altered to brown, compact, and hard hornfels, but the contact zone is not wide. (3) The area along the western margin of the district consists of grayish, not very fissile clay-slates, alternating with much white or light-colored chert, breaking in small, sharp, angular fragments. This chert is probably derived from limestone by a process of silicification. There are no outcrops of limestone within the area, yet the peculiar bowl-shaped depression on the top of the ridge 2,500 feet northwest from the North Star mine, known as the "Devil's Punch-bowl," can be explained only as a collapsed cave formed by the leaching out of a limestone mass.

Mariposa formation.—The narrow slate belt running in a northwesterly direction from near the railroad on the southern margin of the Nevada City tract across Deer Creek, as well as the narrow band south of Indian Flat, has been tentatively referred to the Mariposa formation. It is characterized by black, very fissile clay-slates interstratified with fine and coarser tuffs. The stratification and the schistosity appear to coincide and are nearly vertical. Good exposures are seen at the tunnel on the south bank of Deer Creek. A short distance south of the Nevada City district this belt is interrupted by massive porphyrites, but soon reappears in the district shown on the small Brunswick map, and is here nearly 3,000 feet wide. The tuff-slates are well exposed on the road a short distance above the Washington mine.

IGNEOUS ROCKS.

Granodiorite.—The granodiorite of the Nevada City and Banner Hill districts is a coarse-grained, grayish, granitic rock, composed of dark-green hornblende, dark-brown mica, colorless or gray quartz, and white or slightly yellowish feldspar. The grains average 2 to 3 millimeters in diameter. The hornblende is relatively more abundant than the mica and is frequently present in large, prismatic grains. The feldspar is predominatingly a soda-lime-feldspar of the composition of oligoclase or andesine. A smaller quantity of orthoclase is always present. Analysis of a typical specimen gave $66\frac{1}{2}$ per cent silica, $4\frac{1}{2}$ per cent lime, $3\frac{1}{2}$ per cent soda, and $2\frac{1}{2}$ per cent potassa. It is thus an acid rock, in composition between a diorite and a granite. The texture and composition of the rock are pretty constant throughout the area. In the vicinity of the contacts — near North Banner, for instance, and on the north side of Deer Creek — the rock is more basic and contains more hornblende, thus resembling a diorite. From the Nevada City mine to the western border of the district it apparently gradually changes to a normal diorite. The granodiorite is soft and weathers easily; frequently, especially in the eastern part of the Banner Hill district, it is decomposed to great depth, producing a deep-red, clayey soil. It often shows a tendency to concentric weathering, leaving round "bowlders" undecomposed in the resulting clayey mass. Outcrops are usually well rounded. Dikes of granodiorite are found at several places in the adjacent sedimentary rocks, for instance, in Deer Creek at the contact below Federal Loan mine, and in the cliff on which the Providence mill is built.

The granodiorite of Grass Valley is slightly different from that of Nevada City. It is a grayish-green rock, medium- to coarse-grained, and contains black hornblende, red and greenish feldspar, and quartz; only exceptionally is there much brown mica in the rock. The tendency to weather in rounded outcrops is not quite so pronounced as in the Nevada City rock, and the rock is also somewhat harder. Dikes of granodiorite in diabase are found at the crossing of Rhode Island ravine, a little south of Peabody mine, and at several points along the contact south of Little Wolf Creek.

A specimen from Kate Hayes Hill gave 64 per cent silica, $4\frac{3}{4}$ per cent lime, $3\frac{1}{4}$ per cent soda, and 3 per cent potassa, but it appears that in other parts of the district there is considerably less potassa. Accessory in the granodiorite are titanite, zircon, apatite, and magnetite.

Aplite.—In the rocks adjoining the granodiorite, and more rarely in the latter rock itself, are dikes and smaller bodies of a white, medium-grained, granular rock consisting almost entirely of feldspar and quartz, with occasionally a very little brown mica. This rock, which should probably be considered a product of differentiation in the granodiorite magma, occurs in the Nevada City district as a dike in contact metamorphic slates above the Champion mill, and as a larger mass, with ramifying branches in diorite and pyroxenite, about a mile northwest of the Nevada City mine. The exposures in Rush Creek show well the intrusive character of this rock. A typical sample contained 77 per cent silica, $\frac{3}{4}$ per cent lime, 5 per cent potassa, and $3\frac{1}{2}$ per cent soda. It is thus a dike rock composed chiefly of alkali feldspar and quartz, and should be designated an aplite. A small mass of similar material occurs in the Grass Valley district, in Little Wolf Creek, south of Golden Treasure mine.

Quartz-porphyry.—In the vicinity of the Omaha mine, in the Grass Valley district, there are, in diabase and near the granodiorite contact, one large dike and several smaller ones of quartz-porphyry, the latter principally on the east side of Wolf Creek. Smaller dikes of the same rock also occur in the diabase in the Omaha mine. These rocks are gray or white, fine-grained, and porphyritic, sometimes also showing a microscopic spherulitic structure, and are typical quartz-porphyries. Like the aplite, they should probably be regarded as a differentiation product of the granitic magma. The rock near Omaha contains $\frac{1}{2}$ per cent lime, $4\frac{1}{4}$ per cent potassa, and $3\frac{1}{4}$ per cent soda. A white dike found in the Peabody mine evidently also belongs to this class of rocks.

Diabase and porphyrite.—Rocks of dark-green color, fine- or medium-grained texture, and often of porphyritic habit, occupy considerable areas in these districts. Collectively they might be referred to as "greenstones." They include several species of rocks, so intimately connected by transition that it is not, as a rule, possible to subdivide them in the field. They comprise medium-grained diabases, going over into hornblende-diabases, augite-porphyrites, and hornblende-porphyrites, as well as fine and coarser breccias and tuffs of the same rocks. Very frequently they are considerably altered to uralite-diabases and uralite-porphyrites, and sometimes they have become schistose by pressure. In some instances they have been converted to crystalline schists by an almost complete recrystallization of their original minerals. They are probably of substantially the same period of eruption. They certainly antedate the granodiorite, but, on the other hand, dikes of them are found intrusive in the diorite-gabbro-serpentine group. They are believed to be in general contemporaneous with or in part somewhat later than the Mariposa slates.

In the Banner Hill district east of the granodiorite contact, north and south of Deer Creek, there are contained in the sedimentary series a great number of dikes, most of them small and traceable only for short distances. Although occurring abundantly close up to the granodiorite contact, none of them have been found in the latter rock. The dikes are all porphyrites, brownish, gray, or green in color, and carry porphyritic hornblende, in long, slender crystals, and usually also feldspar. A few, such as the dike at the foot-bridge a short distance east of Federal Loan mine, carry only augite, in abundant porphyritic crystals, and appear to be fourchites. The dikes exposed at the summit of the Scotts Flat road and at the eastern border of the district are hornblende-porphyrites with some free quartz. Some of the dike rocks are brownish, from finely disseminated biotite in the ground-mass. Pyrite and pyrrhotite are very common as small grains. The ground-mass has usually a fine-grained, holocrystalline structure. The dike at the northern border of the district is very much altered and almost converted to an amphibolite.

The southern part of the district contains two larger masses of greenstone, both of which are decomposed to considerable depth and form a dark-red, clayey soil. Good continuous outcrops are rare. The rock at the extreme southeast corner of the Banner Hill district is variable in composition and texture. It is made up in part of greenish or brownish porphyrite with large crystals of black hornblende or augite, or both. The porphyritic feldspar crystals are usually small. The ground-mass is fine-grained and holocrystalline. Other rocks are fine-grained diabases composed of augite partly converted into uralite and feldspar in granular mixture. Still others are granular, almost coarse, and composed of large augite crystals, frequently surrounded by black primary hornblende, between which lies a fine, granular aggregate of soda-lime-feldspars. Between this area and the sedimentary rocks there is first a belt of volcanic breccias, the fragments of which are principally hornblende and augite-porphyrites with very fine-grained holocrystalline ground-mass; there are also some fragments of a pale-gray or brown, dense, flinty rock similar to the siliceous rock from near the Federal Loan. Pyrrhotite is extremely abundant in this breccia, which is not very coarse, the fragments seldom exceeding an inch in diameter and being firmly welded together. The next belt, including the summit of Banner Hill, is a grayish or brownish breccia composed chiefly of gray or brown fragments of the siliceous sedimentary rock, with a small amount of volcanic, more or less altered material. This breccia gradually changes into the normal sedimentary rocks. There can be little doubt that these areas represent "contact breccias" or "friction breccias" formed by the violent disruption of the hard and brittle sedimentary rocks by the porphyrites, and that the former were thus not only deposited but also at least partly altered before the porphyritic eruption took place. The small area shown in the southwest corner of the map, bordered on the east and north by sedimentary rocks, is the continuation of a similar area seen on the Nevada City map. The rock of part of this area is a greenish to brownish hornblende-porphyrite, with small feldspar crystals and larger crystals of black, prismatic hornblende. This rock contains 59 per cent silica, 6¾ per cent lime, ¾ per cent potassa, and 3 per cent soda. Other dense, dark-green rocks are found, under the microscope, to consist of a fine breccia or tuff of augite-porphyrite. In places coarser breccias with fragments of sedimentary rocks also occur, and there are several smaller areas of breccia in the sedimentary rocks to the east, the outlines of which are difficult to determine accurately on account of surface decomposition. In a few places the rock is coarser and diabasic in composition.

Entering the district of the Nevada City map in the southeast corner, the greenstones extend diagonally across it as a band about parallel to the granodiorite contact, and narrow down considerably in the western portion. They are decidedly more altered than in the Banner Hill district, and the extent of the alteration increases as the area becomes narrower.

Along the southern edge, and north of the race-track, dark-greenish to brownish hornblende-porphyrites prevail, sometimes showing small porphyritic feldspar crystals. Similar rocks also occur in the northern part of the small Brunswick tract. About Herring reservoir the dark-green rocks are of varying grain, and have, as seen under the microscope, a distinctly brecciated or tuff-like character, being made up of fragments of augite-porphyrites. Massive and fresher augite-porphyrites occur near the railroad, at the eastern end of the small greenstone area included in the sedimentary rocks. In the vicinity of the Pittsburg mine, and thence northwestwardly, at very many places the rocks are dark-green, fine- to medium-grained, and are, to the naked eye, largely made up of small hornblende grains with some pale-greenish feldspar and occasionally epidote and pyrite. By aid of the microscope these rocks are proved to be much-altered diabases. The augite is very largely converted to uralite, and the soda-lime-feldspars are often to considerable extent converted to secondary epidote-albite-muscovite aggregates. Brown mica is also extensively developed as a secondary mineral in the uralite. The rocks are best designated uralite-diabases. A streak in which are developed augite and hornblende-porphyrites, as well as tuffs of these rocks, follows the narrow band of Mariposa slates to some distance north of Deer Creek. About 2,000 feet south of Deer Creek these rocks begin to show slaty structure. This is well exposed at several places along Deer Creek, and does not affect all parts of the belt equally, but is strongly developed at many points between Deer Creek and Indian Flat. In this vicinity the greenstones are extensively altered, but in most places the derivation from diabasic rocks can be clearly demonstrated. In extreme forms, not only has all of the augite been converted to amphibolite, but all of the original soda-lime-feldspar is converted to new feldspars, principally albite and other minerals, so that the rock becomes in fact a schistose amphibolite. Smaller dikes of the same uralite-diabase or amphibolite occur in the Calaveras formation to the east. Wherever the contact between these two is exposed, as for instance on Home Bluff, south of Deer Creek, the massive or only slightly schistose uralite-diabase is found to break across the strongly schistose or slaty sedimentary rocks, showing not only that the former rock is the younger but also that the latter obtained its slaty structure prior to the occurrence of the diabase eruption.

At the contact of the serpentine and the diorite there are two distinct dikes of highly altered, but not schistose, fine-grained uralite-diabase. A large dike-like mass of the same material divides the diorite area into two parts. On both sides of this there are numerous smaller dikes of the same rock.

In the Grass Valley district the western area of diabase and porphyrite borders with sharp contact against the Calaveras formation to the west, and, with equally sharp contact, against the granodiorite on the east. No contact metamorphism can be observed along the latter contact, the freshest rocks frequently occurring close up to it. Good exposures are not common, as the rock is deeply decomposed on the ridges and produces a clayey, dark-red soil. In the southeastern part of the district the rock approaches a normal diabase, being fresh, fine- to medium-grained, and dark-green, composed of dark-green bisilicates and pale-green feldspar. The augite is very fresh and partly surrounded by brown hornblende, evidently primary; the feldspar shows twin striation only in part, and the diabasic or "ophitic" structure is not so marked as in typical diabases. Primary pyrite, pyrrhotite, and titaniferous magnetite are present. A specimen was found to contain 53¼ per cent silica, 9½ per cent lime, 2¾ per cent soda, and ¼ per cent potassa. In the northern and larger part of the area this coarser granular rock changes, by gradual transition, into a more or less fine-grained, dark-green, porphyritic rock, containing white feldspar crystals of varying size. The ground-mass shows, under the microscope, a structure very similar to that of the coarser diabases, but the augite is largely converted into uralite and the feldspars are more or less decomposed. The coarse, diabasic structure of the ground-mass changes sometimes to a finer-grained structure characteristic of the porphyrites. Porphyritic hornblende crystals do not occur. Schistose structure has not been observed. The rocks in this area thus grade from diabases and hornblende-diabases to porphyritic uralite-diabases and augite- or uralite-porphyrites.

The principal eastern area, extending from the southeastern part of the town of Grass Valley to the southeastern corner of the district, and including Osborne Hill, borders toward the west with a sharp contact against the granodiorite. It shows considerable variation in composition and texture. The coarse, normal diabases are less common in it. The northern end is occupied by fine-grained, dark-green rocks, sometimes carrying small, white, porphyritic feldspar crystals. Under the microscope the apparently massive rocks are found to be largely porphyritic tuff or finely ground-up breccias, greatly altered, but showing no schistose structure. The ground-mass is fine-grained, microcrystalline. The rocks are now largely uralite-porphyrites, but were originally augite-porphyrites, some rocks still showing fresh augite. The porphyrites in places, such as those east of Heuston Hill and near the Golden Treasure mine, go over into fine-grained uralite-diabase, similar to the rock near the Pittsburg mine (Nevada City map). Uralite-diabases, frequently changing to uralite-porphyrites with larger white feldspar crystals, occur at several points along the granodiorite contacts. Sometimes they contain abundant iron pyrites. Coarser, dark-green porphyrite-breccias, containing some fragments of a brown or light-colored, dense, siliceous, sedimentary rock, begin south of Prescott shaft, and form the summit and whole eastern slope of Osborne Hill.

Quartz-porphyrite.—Beginning some distance south of the Empire mine and extending at least to within a few hundred feet south of the Daisy Hill mine, there is, in the dark-green porphyrite, a series of branching dikes of a lighter-colored, more siliceous porphyrite. The rock is much altered and consists of porphyritic, decomposed feldspar crystals and wholly decomposed bisilicates (augite or hornblende) in a light-gray, flinty ground-mass of small feldspar crystals and quartz grains. This rock is no doubt closely related to the normal porphyrites. South of the Daisy Hill mine the exposures are very poor on account of deep soil, but similar rocks are found on the Lafayette tunnel dump, as well as near the Comet mine. A small outcrop of a similar porphyrite is found about 400 feet southwest of the Comet tunnel. All occurrences contain much epidote. The latter rocks, however, do not appear to be so acid as the typical ones first described. On the Indiana claim, at the south end of Osborne Hill, is a dark-green, dense, hard rock containing much epidote, small greenish feldspar crystals, and needle-shaped crystals of black primary hornblende. On the Goodall claim, a little farther south, the highly altered rock is dark grayish-green, fine-grained, and contains abundant epidote and pyrite.

The large greenstone tract between Grass Valley and Colfax (see Colfax sheet) reaches up into the Grass Valley district and terminates in the vicinity of the Maryland mine; toward the north and east, in the Grass Valley district, it borders with sharp contact against serpentine; toward the west, with irregular and very ill-defined contact, against coarse, light-colored gabbro, the diabase appearing to run out into the gabbro in a maze of dikes. The exposures between the Maryland mine and the railroad are not good. In this northwest part of the area, where the rock also forms the hanging wall of the Maryland mine, it is a dark-green, medium-grained diabase, carrying also some brown primary hornblende. It contains 51 per cent silica, 10¼ per cent lime, ¼ per cent potassa, and 4¼ per cent soda. Along the serpentine contact at the east edge of the area it is similar in appearance, but proves under the microscope to be a fine breccia or tuff made up of fragments of augite-porphyrite. Over the remainder of the area, at Goldpoint mine, along the railroad, at Brunswick mine, and in the southern part of the small Brunswick tract, the rock is a green to grayish-green breccia of augite-porphyrite, sometimes carrying fragments of sedimentary rocks, which has a more or less strongly defined schistose structure with northwest direction and vertical or steep easterly dip. In a few places, such as at the Lucky and Brunswick mines, the force producing the schistose structure has been more intense and has resulted in the formation of a grayish-green, chloritic schist bearing scarcely any resemblance to the original rock.

Very numerous dikes of diabase are found in the serpentine north of the Maryland mine, mostly running about east-west, parallel to the vein system. Quartz veins frequently occur on the contacts with the serpentine. Such a dike, for instance, accompanies the Eureka vein, in the serpentine area. The large body to the south of the Spring Hill vein is a dense, dark-green rock of soft, chloritic character, and should be considered as a decomposed diabase. Dikes of augite or hornblende-porphyrite also occur at several places in the diorite and serpentine to the north of the Maryland mine. A small area of a dark-green, medium-grained rock of diabasic appearance occurs 3,000 feet to the east of the railroad station of Grass Valley. It is of exceptional composition, containing as much orthoclase as soda-lime-feldspar, and should be classed as an augite-syenite. Its affiliations are not certain, but it is probably only a form or facies of the normal diabase. Dikes of greenstone also occur in the sedimentary area of Grass Valley. Some of them range from fine-grained uralite-diabases to augite-porphyrites or uralite-porphyrites, while between the Crown Point and New Eureka mines they consist of peculiar hornblende-diabases having a great tendency to serpentinization. Some of the serpentine in this vicinity is, beyond doubt, derived from these rocks by chemical alteration.

Diorite.—It has already been mentioned that in places the granodiorite changes to a diorite. There are other areas of the latter rock, which, however, are not geologically equivalent to the granodiorite, but, on the contrary are associated with gabbro and serpentine. To the northwest of the Nevada City mine the granodiorite appears gradually to go over into a diorite, which again, near the edge of the map area, changes into a coarse-grained, uralitic pyroxenite. However, it is possible that there is a contact line, even though it can not be distinguished on account of the similarity of the two formations along the contact; for farther north, at Shady Creek, and also in the South Yuba River where the exposures are good, the diorite and the granodiorite border against each other with sharp contact, and the latter is intrusive into the former. Along Deer Creek, at the western edge of the Nevada City district, the main diorite area begins; it has a width of 1½ miles, and is bordered on both sides by serpentine. This diorite continues into the Nevada City district, south of the andesitic ridge, and is found in the vicinity of the race-track, as well as in the adjacent portions of the Grass Valley district and the small Brunswick district, bordered on the northwest by porphyrite and on the southwest by serpentine. The diorite is a coarse-grained, gray to greenish rock, and consists of green hornblende and soda-lime-feldspar, with occasionally a little quartz. On the whole, the rock is more altered than the granodiorite, though it never shows schistose structure. The hornblende in some of these diorites has a uralitic appearance, as if in part derived from pyroxene, and in its northerly continuation the diorite frequently changes into a gabbro by gradual transition. Frequently the grain varies much in a short distance, and the more basic varieties are mixed with those containing considerable quartz. On the dump of Carl's tunnel (Nevada City map) an extremely coarse-grained variety occurs, which should perhaps be regarded as a uralite-gabbro. The contact with the serpentine is mostly sharp, and the latter often extends into the diorite as wedge-like masses. Lenticular, ill-defined masses of diorite are included in the serpentine at the northern edge of the Grass Valley district. Smaller masses and outcrops of dioritic rocks are found in the serpentine near the western edge of the Nevada City district. Two dike-like masses of coarser diorite, with somewhat gabbroitic habit, are contained as intrusives in the schistose diabase to the west of the Nevada City mine. It is probable that they should be regarded in a geologic sense as belonging to the granodiorite eruptions.

Gabbro.—Normal gabbro is not abundant in the area under description. In most of the gabbro rocks the pyroxene (diallage) has been converted to uralite. A long dike of coarse-grained gabbro with white lime-feldspar and pale-green uralite lies in the Nevada City district at the contact of diabase and serpentine on both sides of Deer Creek below the Providence mine. At its southern end it is contained in the serpentine, and in places the gabbro appears to change gradually into that rock. In the northern part of the Grass Valley district lenticular, ill-defined masses of gabbro are embedded in the serpentine. The largest body of gabbro is the crescent-shaped area west and south of the Maryland mine; it is pale-greenish, coarse-grained, and consists of white or greenish feldspar and pale-green, uralitized diallage. Good exposures are seen at the Maryland assay office. The area beginning near Maslin shaft (see Grass Valley map) extends for some distance into the Brunswick district, and is very mixed. It contains much normal, pale greenish-gray gabbro, but along with it there is also much of a fine-grained and darker, diabasic rock, which may either be a local modification of the gabbro or represent intruded dikes of a later rock.

Pyroxenite.—Coarse, dark-green, uralitized pyroxenite occurs, as stated, near the aplite area in the northwestern part of the Nevada City district. In connection with serpentine it is mentioned below. Separate bodies of pyroxenite occur to the west of the Nevada City district in intimate connection with the serpentine.

Serpentine.—As is well known, this rock is always a product of alteration of other rocks, such as peridotite, pyroxenite, gabbro. The large mass in the western portion of the Nevada City district is very prominent and easily traceable by abundant rocky outcrops, weathering brown or red. Smaller and often ill-defined masses of diorite, hornblende rock, or gabbro frequently occur in it. The normal rock is black, lusterless, fine-grained, and rather soft; this is only partially serpentinized, and under the microscope gives ample evidence of having been derived from a pyroxenite or a peridotite, as remains of pyroxene and olivine are abundant. A considerable part of the rock in this area is, however, completely serpentinized, and forms the well-known smooth, green fragments, with waxy luster, which are so characteristic of serpentine areas. The small area south of Towntalk shows a similar origin. The large area lying chiefly within the Grass Valley district is characterized by the same surface appearance, but the serpentinization seems to have advanced further, and remains of the original minerals are rarely to be seen. The serpentine to the northwest of the New Eureka mine and in the vicinity of the St. John mine shows an extremely close connection with diabase and porphyrite, and has evidently been derived from these rocks. Pyroxenite and peridotite, and also to some extent gabbro, are, however, so intimately and frequently associated with these serpentine masses, especially with their continuation northward beyond the limits of the areas of these maps, that they must be considered as the principal mother-rocks.

The small area to the south of Towntalk appears in a form suggestive of an intrusive dike in porphyrite, while the similarly shaped area in the northeastern part of the Brunswick district appears to be a dike in the Mariposa slates.

The sequence of igneous rocks.—Though the general succession of rocks has been established, there are several obscure points as yet undetermined.

It is probable that none of the igneous rocks of the Bed-rock series are older than the Mariposa formation, and that they all were erupted within a comparatively short period. The granodiorite is certainly the youngest member of the series, and it is of late Juratrias or very early Cretaceous age. It is probable that the diabases and porphyrites were the next older eruptions, though it can not be asserted that they are all of the same age. The diorite-gabbro-serpentine group would seem to be the oldest; but even of this it can not be said confidently that all parts of it have the same age. Though dikes of diabase are abundant in this group, there are also one or two serpentine-pyroxenite-gabbro masses which appear in porphyrite in dike-like form.

Most of the igneous rocks are of the granular type, which we associate with deep-seated intrusions, while some others, at not much different elevations, show the pronounced porphyritic types of structure which generally occur in rocks consolidated nearer to the surface. It may be suggested that in early Cretaceous times vast masses of volcanic origin, perhaps several thousand feet thick, probably covered what is now the surface of this part of the Sierra Nevada.

SUPERJACENT SERIES.

NEOCENE PERIOD.

Auriferous gravels and rhyolitic tuffs.—In the southern half of the Banner Hill district there is hardly any gravel exposed on the bed-rock below the volcanic capping. In the hydraulic cut south of the Murchie mine, about 2 feet of fine, well-washed quartzose and metamorphic gravel rests on the bed-rock, and this is overlain by fine, andesitic tuff containing scattered, fine gravel in its lower portion. In the deep hydraulic cut 3,500 feet east-southeast of the Murchie mine, there are exposed 6 to 10 feet of rounded or subangular bowlders of granodiorite up to a foot in diameter, cemented by fine quartzose and metamorphic gravel. This channel is about 200 feet wide, and the gravel is immediately overlain by 10 feet of clay of clearly volcanic origin, containing fragments of decomposed rhyolite. Above this lies normal, soft, andesitic tuff. On either side of the deposit the andesitic tuff rests directly on the bed-rock. At the Mayflower hydraulic cut, 2,000 feet southeast of the Canada Hill mine, 2 to 3 feet of gravel rests on the bed-rock and is covered by andesitic tuff.

Much larger accumulations of gravel are found under Harmony Ridge. In the small hydraulic cut 3,500 feet east of the East Harmony mine, 10 feet of fine gravel is exposed, overlain by clays and rhyolitic tuff. Below that mine occurs, principally, metamorphic gravel, with a maximum depth of 20 feet, resting on the bed-rock and covered by rhyolitic tuff. The same body of gravel was found in the East Harmony incline. South of the West Harmony mine the rhyolitic clays rest directly on the bed-rock and no gravel is exposed in the incline. West of that mine 2,500 feet, well-washed gravel appears again, at first forming lenticular bodies in the clay, and then, at the edge of the district, reaching a thickness of about 60 feet, with some intercalated bodies of clay and sand. In the deep channel mined by the Harmony and Cold Spring mines the gravel on the bed-rock is largely quartzose and subangular, of bluish color, frequently well cemented, and does not often exceed 10 feet in thickness. It is usually thinner, and is frequently mixed with irregular masses and streaks of sandy clay.

On the north side of Harmony Ridge gravel bodies appear in the vicinity of the old Harmony shaft. They are intermixed with clay and sand and aggregate 50 feet in thickness. This is at the inlet of the north branch of the Harmony channel. Along the river from this point to the inlet of the Stokes shaft channel, there is a good deal of well-washed gravel, frequently interstratified with clay. North of the Stokes shaft the gravel is about 70 feet deep, and is exposed in the hydraulic pit just north of the road. In the vicinity of the Yosemite incline heavy clay masses again appear. On the Rock Creek ditch, near the incline, two small streaks of gravel are enclosed in this clay. The Yosemite incline shows 20 feet of sandy clay, underlain by 30 feet of extremely well-washed black gravel, well cemented. This gravel rests on the bed-rock, which, however, dips rapidly into the hill. Below the black gravel in the channel lie at least 120 feet of clay and sand, with some gravel in the deepest part.

The gravels are much more extensively developed in the area of the Nevada City map. The northwesterly slope of Harmony Ridge, below the andesitic tuff, shows a succession of light-colored clays and soft sandstones, with smaller bodies of gravel. The excellent exposure at Howe Cut shows, on the bed-rock, 60 feet of light sands and clays, containing frequent impressions of deciduous leaves. Above this lies, unconformably, a heavy body of coarse gravel, containing well-washed pebbles of metamorphic rocks and quartz. In the Odin cut (a short distance west of the Odin mine) 40 feet of white and yellow sandy clay with some fine gravel is exposed. On the south side of the ridge the line of demarcation between the light-colored clays and sandstones (rhyolitic tuffs) and the gravels is usually distinct, and the gravels are heavier than at any other place. In the Manzanita channel, now largely worked out, a blue, quartzose gravel rested on the bed-rock. The average thickness of this was 6 to 10 feet; above this gravel lies 20 feet of white clay, with some quartzose sand. The next 175 feet, up to the level of the east gap, is occupied by clays and sands containing several bodies of well-washed, chiefly metamorphic gravel. Owing to rapidly varying, fluviatile structure, the section is quite dissimilar in different portions of the cut. Between the level of the gap and the lower limit of the andesitic tuff, there is 40 feet of sandstone, with a little fine gravel; and above this, 40 feet of white clay; both of rhyolitic origin. In the Odin mine, on the northerly continuation of the Manzanita channel, there is 6 or 7 feet of gravel on the bed-rock, mostly quartzose, of medium to fine size, and not always well-washed. Heavy bodies of clay cover this gravel. The largest bodies of gravel were found west of the Sugarloaf. Their maximum thickness is 60 feet, as shown in the excellent exposures in the hydraulic banks; the strata are alternately coarser and finer, with very fine fluviatile stratification in places. The gravel is composed largely of metamorphic pebbles with some quartz. On the bed-rock it is rather coarse, hard, and firmly cemented. Above the gravel lie from 100 to 200 feet of light-colored clays, sandy clays, and sandstones. On the northeast side of Cement Hill—as the ridge west of the Sugarloaf is called—there is but little gravel exposed along the rim, and this is overlain by about 160 feet of white, rhyolitic clays and sands. The tunnels driven by Dean and others have, however, shown that large bodies of well-washed gravel lie on the southerly slope of the rim, under the hill. At Stevens and Trevaski there is, below the clay and sand, about 30 feet of well-washed, black gravel. The gravel on the bed-rock is coarser and angular. At Ragons no gravel is exposed on the surface. On the rim, which dips rapidly northward, sometimes clay, sometimes 5 to 6 feet of well-washed gravel, is found on the bed-rock. Eighty feet of light-colored, rhyolitic clays and sands are exposed below the andesite. At Peck's diggings, in the extreme northwest corner of the district, 2 to 4 feet of fine angular quartz gravel is exposed in the bottom of the channel. Above lie quartzose sandstone and a stratum of hard, black conglomerate, both often cemented by opal. Immediately below the andesite there are again light-colored sands and clays.

In the southern portion of the Nevada City district, and in the Grass Valley district, there are no considerable bodies of Neocene gravels. A little fine gravel is sometimes mingled with the andesite tuff along the rim in the depressions of the Neocene surface, for instance, just north of Towntalk and along the contact of porphyrite and andesite east of the Empire mine. In the Alta channel, extending under the andesitic area in the north-northwestern corner of the Grass Valley district, there is gravel 2 to 3 feet thick, overlain by clay. In the hydraulic cut just north of Mill street, Grass Valley, a few feet of yellowish-white clay rests on the gravel in the channel, and directly above this there lies a fine-grained andesitic tuff. About 3,000 feet southeast of the Empire mine a small channel has been drifted on under the andesite. On the bed-rock lies 3 or 4 feet of a subangular gravel, consisting mainly of diabase fragments; above this lies 5 to 6 feet of sandy clay; then an almost normal, but rather fine, andesitic tuff.

Underlying the andesitic tuff there is, as stated above, a series of white or light-colored clayey or sandy rocks, commonly described as pipe clay and sands, and which are largely rhyolitic tuffs brought down as mud-flows from the volcanoes in the upper part of the Sierra. Being of smaller volume than the andesitic flows, they were usually confined to the valleys, and are therefore often valuable as indicating the position of the auriferous channels. The connection of these tuffs with the auriferous gravels in the bottom of the ancient stream-beds is a very intimate one, and it is indeed impossible in most cases to draw a sharp line separating the two terranes. The line indicated on the map is at best approximate, and is intended only to convey the fact that the upper part of the really continuous series is composed of comparatively pure tuff, while the lower part is derived largely from the disintegration of the older rocks. The series of rhyolitic tuffs and gravels are of unusual thickness in the Nevada City basin, aggregating 300 feet in the vicinity of the Manzanita mine.

The typical tuffs appear as soft, light-gray or yellowish sandstones, and are made up almost wholly of angular fragments of glassy rhyolite. Such is the character of a rock outcropping on the road 850 feet west of the West Harmony mine. These almost pure glass-sandstones are well adapted to certain abrasive and polishing purposes. Other tuffs are more clayey, soft, and have a somewhat greasy feel, but a certain amount of sand is almost always present. The composition of the pure tuff from the locality just mentioned is 69 per cent silica, 16 per cent alumina, 1 per cent lime, 5 per cent potassa, and $1\frac{1}{2}$ per cent soda.

The stratum of sandstone cropping out on the North Bloomfield road 1,000 feet southwest of the Sugarloaf is of yellowish-gray color with small black-mica foils. It contains abundant grains of quartz, feldspar, hornblende, etc., derived from the granodiorite, but also many grains of undoubted rhyolitic origin, and carries $3\frac{1}{2}$ per cent soda and $1\frac{3}{4}$ per cent potassa. Between this and the normal tuffs there are all gradations.

The occurrence of the rhyolitic series is confined to the northern half of the Banner Hill and Nevada City districts. It is well exposed in the Manzanita pit and along the ditch on the northeastern side of Cement Hill; also along the road and ditches in the vicinity of the West Harmony mine. In good exposures the rapidly alternating character of the beds is well shown. A tendency to form gently sloping benches is frequently noted on the north side of the Harmony Ridge, which contrast strongly with the abrupt declivities of the andesitic tuffs. The soft and easily disintegrating rhyolitic tuffs show, as a rule, poor exposures, and are usually covered by débris slidden from the overlying andesitic tuffs. In some places the rhyolitic series rests directly on the bed-rock, while in others it covers the auriferous gravels. The principal occurrences have already been described.

As the line between these two formations is so difficult to draw, it was of interest to ascertain how far down in the series the rhyolitic tuffs extended. It has already been stated that the sandstone on the southwestern slope of the Sugarloaf at the elevation of 2,760 feet is tuffaceous. Another sandstone, from near the bottom of the Manzanita channel, has also been found to contain grains of rhyolite. Furthermore, rhyolitic tuffs and fragments of normal rhyolite are found in the Odin cut at an elevation of 2,700 feet, or about 40 feet above the lowest bed-rock. It is thus evident that the whole series, except the very lowest gravel, contains rhyolitic fragments, and that the deposition of it went on about contemporaneously with the rhyolitic eruptions in the high Sierra, although only the upper part of the series contains so much rhyolitic detritus as to be properly classed as tuff. Thus the age of the gravel and pipe clay is confined within relatively narrow limits, and only the very lowest layers of gravel antedate the beginning of the rhyolitic eruptions.

The Neocene topography and drainage systems.—The surface forms and the channel systems of the Neocene topography, as they were before the volcanic eruptions began in the Sierra Nevada, may be determined with considerable accuracy from the remaining exposures of the gravels and the later volcanic rocks. In order to obtain a correct view of these relations, it is necessary to include in the statements a somewhat larger territory than that embraced in these sheets. The results obtained will be given briefly. The topography was in general decidedly accentuated, though not so strongly as at present. The ridges rose to a maximum height of 1,300 feet above the lowest channels, and a height of 500 feet was quite common. The drainage of the whole region was toward the Neocene South Yuba River, but divided into two distinct watersheds. The first embraced the larger part of the area covered by the Banner Hill and Nevada City maps, and the direction of its principal stream is indicated by the Manzanita channel. Continuing outside of the special areas, by Round Mountain and Montezuma Hill, whence it turned westward, joining the Yuba River near French Corral (see the Smartsville sheet), the upper part of this stream drained the southern end of the soft and easily eroded granodiorite of Nevada City, which was surrounded on all sides by higher ridges of slate and metamorphic rocks. Toward the east it was separated from the adjoining South Yuba by a high bed-rock ridge running northward from Banner Hill and continuing high up to the vicinity of Patterson; a lower gap existed, however, near where the Blue Tent road crosses Rock Creek, and probably another in the vicinity of the Fountain Head mine on Harmony Ridge. From Banner Hill westward the divide followed closely the present ridge up to Towntalk, whence, without much doubt, it continued across Deer Creek in a northwesterly direction parallel with the contact of the granodiorite. Within this watershed there are several sections of the channel preserved. The large Manzanita channel running northward from the Manzanita mine to the Howe cut is almost level, with a slight fall southward. It is probable that the channel was originally nearly level and that the present slight inclination southward has been caused by the general tilting of the Sierra Nevada.

The best-preserved channel is that of Harmony Ridge, coming with a steep grade from the east and having its outlet near Laney's tunnel. Somewhere between the Laney tunnel and Round Mountain it probably joined the Manzanita channel, and the two united continued down toward Montezuma Hill. The Harmony channel splits up into several branches, the principal one continuing up through the Cold Spring ground. This is doubtless near the headwaters, and the high bed-rock ridge mentioned before is probably continuous below the Harmony Ridge. There is a possibility that a narrow gorge may cut through this ridge and extend the watershed a short distance eastward, but the probability is that the Fountain Head claim covers the head of the gulches that emptied directly eastward into the South Yuba between Scotts Flat and Blue Tent.

On the south slope of Sugarloaf and Cement Hill the lowest bed-rock is well exposed, and continues nearly as low as the channel at the Manzanita pit. At the extreme western end of the hydraulic ground it is even 20 feet lower than at the Manzanita, and that the channel was continuous between these two points is certain. Between the big hydraulic diggings and "cement diggings" in the northwestern corner of the tract, there is, beyond a doubt, a continuous channel which is almost level. Many strong reasons appear, however, in favor of a former southeasterly direction of the stream. On the north side of Cement Hill there are also strong indications of a channel, though its depth, direction, and extension are doubtful. It is evident that the whole district from the narrow portion of Cement Hill to the Manzanita was a low and flat country, over which the stream ran in changing channels. A granitic hill 150 feet high at the western gap of the Sugarloaf protruded above this basin, and it is not improbable that the channel at one time ran to the north of this knoll and at a later time to the south of it. Though at first glance it would seem more likely that the Manzanita channel agreed with that of the present Deer Creek, there are many facts bearing strongly against such an opinion, a chief one being the entire absence of rhyolitic deposits beneath the andesite in the vicinity of Rough and Ready. It is much more probable that the whole southern end of the Nevada City granodiorite formed a depression open only toward the north, and which, through one or more low gaps toward the Blue Tent channel, became filled to a certain level with the extensive rhyolitic mud-flows coming down that principal valley from the vicinity of Towles and Emigrant Gap. None of the channels about Nevada City belong to the main Neocene rivers, and many of the richest deposits represent only Neocene creeks which were richly laden with the products from the disintegration of the several quartz veins they crossed.

Numerous creeks led down to the valley from the highlands in the vicinity of Banner Hill. They contain little gravel, and that is directly covered by andesitic tuff. Hydraulic cuts have been made at the outlets of several of them, but of their direction under the lava little more can be said than has tentatively been indicated on the map. The steep gulch crossing Little Deer Creek below the North Banner mine should be noted. Its bottom is apparently lower than the bed of the creek, and has never been exposed.

The other drainage basin includes the area covered by the extreme southern part of the Nevada City and Banner Hill maps. The direction of the drainage was westerly, and, passing by Rough and Ready, it emptied into the Yuba River about where Deer Creek now debouches. One channel of this drainage system undoubtedly lies below the ridge west of Towntalk, and, running down near Hughes's ranch, finds its outlet at Schroeder's tunnel, a short distance outside of the special area.

In the southern part of the Grass Valley district the Neocene topography is probably pretty accurately represented by the present plateau, except where it has been cut down by Wolf Creek. Above this plateau rose in Neocene times, as it does now, the great ridge of Osborne Hill. In the vicinity of the North Star mine the present configuration of the surface is probably substantially the same as it was in Neocene times. The broad depression south of the mine doubtless represents a part of a Neocene drainage channel. A large part of the Grass Valley area drained toward the Yuba River, and the principal stream is indicated by the Alta channel, which passes down under the andesitic flow in a westerly direction toward Rough and Ready.

Andesite.—It has already been mentioned that the high, gently sloping ridges at the northern and southern borders of these districts are covered by andesitic flows, and their general character as tuffs and tuffaceous breccias has also been described. As a rule, these flows consist of a detrital mass, well cemented and made up of andesitic grains. Abundant angular or roughly rounded fragments of andesite, of all sizes up to a foot or more in diameter, are enclosed in this finer-grained mass. This andesite is of a gray to brown or reddish color, hardly ever greenish, and is usually distinctly porphyritic, with small crystals of white feldspar and black augite or hornblende. As a rule, it has a rough, trachytic appearance. Mica is rarely found. Pyroxene (both augite and hypersthene) is almost invariably present. Black, basaltic hornblende frequently occurs with the pyroxene, and usually in larger crystals. The ground-mass is glassy, or of a fine-grained, holocrystalline texture. The thickness of the volcanic flows ranges from 400 feet in the Banner Hill district to about 200 feet in the Nevada City district. The easily disintegrating cement renders the exposures unsatisfactory, and a deep, reddish soil usually covers the tops of the ridges. This disintegration, and the tendency of the decomposed material and residual andesitic bowlders to slide down hill, often make the contacts with the underlying formations obscure and difficult to trace. Good exposures are found in the vicinity of the Harmony gravel mines. The best exposure, though practically inaccessible, is in the bluff of the Manzanita hydraulic pit north of Nevada City. Resting unconformably on the sloping surface of the white clays and sands, there are here at least four separate flows of andesitic tuff, each 20 to 30 feet thick and separated by irregular, worn surfaces. The amount of angular andesitic bowlders is not constant, and some flows consist entirely of the fine, detrital, cementing tuff. Of such character are the tuffs overlying the clays and gravels exposed in the hydraulic pit just north of Grass Valley.

PLEISTOCENE PERIOD.

Alluvium.—The alluvial deposits of the Banner Hill district are of small extent, and consist principally of a few gravel flats along Deer Creek and Little Deer Creek. Most of these bodies of gravel are formed of débris from hydraulic gravel mines.

In the adjoining district alluvial sands and clays have accumulated in several swampy flats to the south and southeast of Nevada City, and also to some extent near the race-track. The largest alluvial deposits lie in Deer Creek below the Providence mine, and consist of well-washed gravel of quartz and metamorphic rocks, with some sand. They are largely made up of the débris from the extensive hydraulic mines just north of Nevada City, which had their principal outlet through the first gulch emptying into Wood's ravine from the east. In the Grass Valley district extensive flats of sand and clay occur on both branches of Wolf Creek above the city, and smaller gravel flats are also found at intervals along the creek below the city. In the southwestern part of the district there are, at the headwaters of the gulches, a number of shallow alluvial flats of sand and clay, usually of a marshy character. The largest is found south of the North Star mine.

ECONOMIC GEOLOGY.

GOLD.

Although gold is widely distributed over the Sierra Nevada, in veins and placer mines, there are but few regions in it which show such a concentration of valuable deposits within a narrowly circumscribed area as occurs in the districts described in this folio. The mines in the Grass Valley district have been and are especially productive. Next in production follows the Nevada City district, and the Banner Hill district comes third. Statistics for the first decades succeeding the discovery of the gold in 1849 are very defective, but it is estimated that the mines in the three districts together have produced $120,000,000 up to the present time. Most of the production of early days came from the placer mines, which were often of extraordinary richness. Of late years the gold from Grass Valley is derived almost exclusively from the quartz mines, while in the other districts the placer mines still contribute a small part of the product. Since 1889 the product of Nevada County has been constantly about $2,000,000 per year. Of this, from $1,100,000 to $1,500,000 comes from the areas of these special sheets (including the Brunswick area and the smaller mines on Deadmans Flat, 4 miles southwest of Grass Valley). Grass Valley and vicinity leads, with a production of from $750,000 to $1,000,000, while Nevada City (Nevada City and Banner Hill maps) follows, with from $300,000 to $600,000. The larger amount of the production from Grass Valley has come from a few prominent mines, such as the Eureka, Idaho, Empire, North Star, Omaha, and W. Y. O. D. In the vicinity of Nevada City the mines west of the town, usually referred to as the "Creek mines," have yielded the largest quota.

AURIFEROUS GRAVELS.

The disintegration of the gold-bearing quartz veins has, as is well known, yielded the material for the gravels. The gold set free is in part distributed through the mass, but as a rule the larger quantity has been deposited on the surface of the older rocks on which the gravels rest, or as the miners say, on the bed-rock. The Neocene auriferous gravels, some of which are exposed, others being buried under several hundred feet of unproductive clay, sand, and volcanic material, lie in the channels of the Neocene streams from 200 to 500 feet above the bed of Deer Creek. Wherever exposed without heavy covering material they have been washed by the hydraulic process, by which the whole mass of the gravel is removed. The richest gravels in the bottom of the old stream are removed by drifting along the bed-rock and subsequently washing the mined gravel. By the former process gravels containing only 5 or 10 cents per cubic yard may be made to pay, while the latter process requires a value of at least $2 or $3 per cubic yard. Hydraulic mines have not been operated in the district for the last ten years on account of the débris litigation. The only ground adapted for extensive mining with the hydraulic process is found near Nevada City. The alluvial gravels are the auriferous accumulations in the depressions of the present surface. Every creek and ravine in these districts has been worked over one or several times by sluicing, and very little gold is now obtained from this source.

Within the area of the Nevada City and Banner Hill maps a small hydraulic cut has been made in the fine gravel to the east of the Cold Spring tunnel. A large opening has been made to mine the channel south of Deer Creek, a short distance southwest of the Lecompton mine. As the gravel is very thin and a bank of 100 feet of andesitic tuff is already exposed, not much more can be accomplished by hydraulic methods. Drifts have been run for a short distance, but no work is being done now. The same statement applies to the hydraulic cut south of the Murchie mine, where a minor channel runs north and south. For some distance from this point along the rim, hydraulic work could be prosecuted. To the east the bed-rock rises rapidly. Thence southward to the reservoir smaller hydraulic cuts have been made at intervals along the lava contact, either on smaller channels or, more frequently, on the decomposed croppings of quartz veins extending under the lava. Especially extensive are the old pits in the vicinity of the Mayflower mine, where some ground is yet left for hydraulic operations. Small tunnels have been run in under the lava at various places.

The drifting operations under the Harmony Ridge are extensive. The Harmony channel with its branches has been opened and worked profitably by the Cold Spring incline and tunnel, and lately by the East and West Harmony inclines. A northern branch has been mined from Stokes shaft and other places in the vicinity of Munroe's vineyard. South of this, attempts to reach the same channel have been made at the Yosemite incline and at the edge of the Banner Hill district. Allison's tunnel and incline are now being driven in search of the continuation of the Harmony channel. In the adjoining district it has been mined almost continuously from Coleman shaft and Nevin's and Laney's tunnels to its outlet. The pay gravel in the Harmony channel is from 150 to 200 feet wide and only from 2 to 4 feet deep. It is frequently subangular, and contains many quartz bowlders. Gold-bearing quartz veins are sometimes exposed in the bed. As it is firmly cemented, it is necessary to crush the gravel in stamp mills in order to extract all of the gold.

The Manzanita channel has been worked extensively by hydraulic methods from its southern end, and also to some extent at the northern end, at Howe cut. Between these points it has also been drifted nearly continuously by the Manzanita, Nebraska, Live Oak, Odin, and other companies. Near the Nebraska incline the channel was narrow and especially rich, while to the north the gravel spreads out considerably and is more spotted in character. The channel is estimated to have produced over $3,000,000. The most extensive hydraulic mines are southwest of the Sugarloaf, where an area of at least 100 acres of bed-rock has been exposed. The different portions of this ground, going westward, are referred to as Buckeye Hill, Oregon Hill, Coyote Hill, Lost Hill, Wet Hill, and American Hill. Over this ground the gravel probably averaged 60 feet in thickness. The last work done before the débris litigation was in the extreme northwestern corner, and is referred to as the Hirschmann cut, from which, it is said, $100,000 have been taken. The whole mass hydraulicked contained, roughly speaking, 10,000,000 cubic yards, and has probably yielded several million dollars. The hydraulic operations could be continued for some distance northward, until the overlying clays and tuffs become too heavy for profitable handling.

To the north the bed-rock rises slowly, but in a northwesterly direction it continues low, and the ground has been opened by the Knickerbocker and Grover tunnels, in which good pay is found in spots. Still deeper is the Phoenix tunnel, on which the last work was done fifteen or twenty years ago. It is about 1,200 feet long, in hard granodiorite, and struck gravel in an upraise of 15 or 20 feet near the end. The gravel did not show good pay. From here on northwestward there are no developments till Ragon's claim and the old Empire shaft are reached. The latter is 146 feet deep, and some rich gravel was extracted from it long ago. The channel has here the character of a narrow ravine. Some good pay has also been found higher up on the rim in Ragon's incline. The same channel is again exposed in the hydraulic cut on the north side of the ridge, in the extreme northwestern corner of the district. Some drifting has also been done at this place, and the pay streak is said to have been 50 feet wide. At Stevens and Trevaski a little hydraulic work has been done in the black gravel, and several tunnels have been run in. The principal one is 420 feet in, with the bottom in bed-rock at the face. Another is being driven 16 feet lower, and is 200 feet in, entirely in bed-rock. At the northeastern side of Cement Hill, near Dean's, several long tunnels have been driven, which at a certain distance in lose the bed-rock and run into black gravel. Dean's new tunnel is 600 feet in, at an elevation of about 2,700 feet, and still entirely in bed-rock. Black gravel has been struck in a 20-foot upraise. Under the andesite ridge west of Towntalk there is a channel the bottom of which has not thus far been exposed. It seems to head near Towntalk, where the presence of a small channel was indicated in the railroad tunnel. The tunnel 1,000 feet west of Towntalk was made in 1880 and proved too high. Several tunnels have been run in along the rim on the north side of the ridge. Carl's tunnel was run 1,000 feet in bed-rock and struck only clay and sand in an upraise. Hughes's tunnel is 500 feet in, in bed-rock. Schroeder's tunnel is located at the outlet in a small hydraulic cut just outside the map limit, and drifting was going on there on a small scale in 1894. The elevation there is about 2,516 feet.

In the Grass Valley district, the Alta channel has been drifted for about 3,000 feet from several shafts. The width of the channel was from 50 to 150 feet, but beyond the Hope shaft it appeared to widen, making the extraction less profitable. The total production is estimated to be $1,000,000.

Along the northern edge of the andesite area east of the Empire mine, smaller hydraulic cuts have been made and 700 feet of the channel drifted. A small channel southeast of Heuston Hill was drifted upon for about 400 feet in 1894.

The alluvial gravels are still occasionally worked in the vicinity of Nevada City and Grass Valley, and a gradual process of re-concentration is going on in them. The gravels of Deer Creek will probably be worked again at some future time.

GOLD-QUARTZ VEINS.

The gold-quartz veins are fissures in the bed-rock series filled more or less continuously with quartz carrying native gold and auriferous metallic sulphides. These fissures were formed subsequent to the general metamorphism of the range, and also later than the granodiorite intrusions. They are arranged in several systems, the fissures in each system being approximately parallel. The force producing them had frequently the effect of dividing the country rock into a great number of parallel sheets, from a few inches to several feet thick. Along a few of these fissures considerable faulting took place, but where the rock was extensively divided into sheets the movement on each was probably small. Open spaces varying in width from a fraction of an inch to several feet resulted along the fissures. Solutions of thermal water charged with carbonates, silica, gold, and other metals entered these fissures, probably ascending from below, and deposited their contents in them, usually also penetrating the adjoining porous and often shattered rock for a distance varying from a few inches to several feet. The effect produced on the country rock was to convert it into a gray or light-colored rock, of greasy feel, consisting of carbonates, white mica, and pyrite. The gold is almost invariably concentrated in the quartz which fills the open fissure. The adjoining altered country rock, sometimes referred to as "cab" or "gouge," very seldom contains a paying amount of gold. Shattered zones, or seam-mines, in which the country rock is traversed by swarms of minute, often rich quartz seams, do not occur to any large extent in this district. The pay is chiefly confined to the quartz within the well-defined limits of the walls of the fissure. The ideal vein is a plate of quartz contained between two well-defined separating planes, the foot and the hanging wall. Such veins occur, but the ideal regularity is usually not preserved for any long distance. The quartz may pinch out entirely, leaving as guide only a narrow seam; the space between the walls may contain several smaller veins separated by masses of country rock, or "horses." While in certain mines all quartz may be pay-ore, it is usual to find rich and barren quartz alternating. The rich quartz forms irregular or, more frequently, long-drawn masses, usually with a steep dip on the plane of the vein; these are called ore-chutes, or shoots. The width of the pay-quartz varies from several feet to a fraction of a foot; the narrower the vein the richer the contents must be to pay. The general tenor of the pay-ore of the district varies between $5 and $50, though smaller masses of higher grade are met with. The sulphurets make up from a fraction of 1 per cent to 10 per cent of the quartz mined, and contain from $30 to $100 or $200 per ton.

The veins of the district may be divided into four classes, according to their direction and dip. 1. The Orleans-Idaho system; strike, west-northwest to east-southeast; steep southerly dip. 2. The Willow Valley system; strike, about east to west; dip, medium to flat, northerly or southerly. 3. The Omaha-Empire system; strike, north to south; dip, medium to flat, westerly. 4. The Providence system; strike, north to south; dip, medium, easterly.

In the Banner Hill district the veins are, as a rule, comparatively narrow. The ore is often rich and heavily charged with sulphurets, among which iron pyrites, arsenical pyrites, and zinc-blende are the most prominent. The sulphurets contain a considerable amount of silver. Along Deer Creek, especially in the eastern part, there is a strong system of sheeting developed, cutting both the granodiorite and the sedimentary rock. The sheets or benches usually show a dip of 30° to 50° toward the north, and strike east and west. In the fissures dividing the sheets a narrow line showing iron pyrites and a bleaching of the country rock may be noted. Most of the quartz veins are parallel to this fissure system. The Omega, Neversweat, Belle Fountain, Lecompton, Montana, Willow Valley, and Franklin are the most prominent of these mines. They are narrow veins, and have not been worked on a very extensive scale. The ore frequently runs above $100 per ton. The bullion contains much silver, and also, it is said, antimony. The developments on the Cyane, Constitution, and Levant are slight. The Federal Loan, which has been worked during the last few years down to the 600-foot level, dips south and is parallel to another and less-developed system of sheeting. The ore from the Federal Loan is of a character similar to that of the mines mentioned. The vein varies from a few inches to several feet in thickness, and rich stringers are frequently abundant in the adjoining rock. There is about 6 per cent of sulphurets. The vein system at the Texas mine is parallel to that of the Willow Valley mines, but little work has been done to develop the property. The ore is said to contain 4 per cent of sulphurets and to yield $10 per ton. The Texas shaft was sunk to a depth of 160 feet ten years ago. The Deadwood is a flat vein, dipping west. Its true direction is nearly north-south, though the topography gives its outcrop a nearly east-west direction. About $300,000 have been produced from this vein, on which no work has been done for the last ten years. In ore and character it is similar to the other Willow Valley mines. The deposits of the Murchie mine consist of two veins with flat westerly dip, the Independence and the Lone Star, and two east-west veins, the Big Blue and the Alice Belle; the principal work has been done on the first three. The veins are 2 to 3 feet thick; the ore contains 4 to 5 per cent of sulphurets and runs about $15 to the ton. The pay-shoots on the Big Blue are said to have followed the lines of intersection with the first two. The property was worked between 1878 and 1883, producing about $600,000.

Parallel to the Big Blue are the Caledonia and Kingsbury veins, the latter of which has been but slightly developed. The Caledonia has been opened to the level of Little Deer Creek. It is said to be a wide ledge with low-grade, heavily sulphureted ore. The large St. Louis vein also belongs to this group, which shows the somewhat unusual east-northeast direction and steep northerly dip. It is an exceptionally straight and strong vein, which can be traced from the point where it emerges from under the andesite as far as McCormick's place, just over the map-line in the Nevada City district. It is very wide in places, but the quartz is of low grade and has not been worked extensively at any place. The Charonnat or Canada Hill vein is faulted considerably by it. The Glencoe-Alaska, south of the St. Louis, is the continuation of the strong and well-defined Orleans vein in the Nevada City district. It runs about west 15° north, with steep southerly dip. It has been worked to a depth of 100 feet at the western end of the Glencoe claim, where the ledge is said to be 4 feet thick and heavily sulphureted. The ore is not of high grade. Between the strong vein of St. Louis and Glencoe lies a network of veins running in different directions. The most important is the Canada Hill-Mayflower group. An exceedingly well-defined sheeting of the granodiorite is noted near Canada Hill. There are several veins parallel to this sheeting and dipping west at slight angles. The Charonnat vein has been worked to a depth of 1,300 feet on the incline. Between 1879 and 1887 it produced about $350,000, from ore worth $15 per ton and containing $2\frac{1}{2}$ per cent sulphurets, with a value of $100 per ton. The Grant vein is parallel with the Charonnat, but dips to the east. Of the many veins in the Mayflower ground the Beckman is the most important. Its strike is east and west, and the dip is very flat southward. It is about a foot thick and the ore is very heavily sulphureted, containing, as do most veins in the vicinity, large quantities of arsenical pyrites and zinc-blende. A similar small flat vein, which has been worked at several places, is found to the west of this, on Sharp's and McCormick's ground. About North Banner an important group of veins occurs, which have in general a northerly direction and an easterly dip of from 35° to 60°. Formerly the most important was the Banner vein, worked principally from 1865 to 1875, to a depth of 620 feet. It yielded several hundred thousand dollars. The ore was heavily sulphureted and averaged $20 per ton. The vein lies in hard, black slate, and evidently shows the same tendency as the Federal Loan to splinter up in stringers. The Banner vein does not continue north of the creek, or at least can not be traced with certainty. On the North Banner ground there are four nearly parallel veins. These have recently been worked to some extent, producing from $30,000 to $50,000 for several successive years; the ore is not heavily sulphureted and contains a considerable amount of silver. To the west of the North Banner is the Union mine, on which the developments are slight. At 200 feet below the surface the vein cuts across the slate contact without change in direction or dip.

The quartz veins of the Nevada City district are as follows: The Orleans vein continues from the Banner Hill district across Gold Flat. In direction and dip this strong, continuous vein is parallel to the Idaho of Grass Valley. The developments are small, however, being chiefly confined to the old Orleans shaft, 200 feet deep, and the shaft at Fortuna mine. At the Gracie claim the vein is 1 to 2 feet thick. To the north of this vein there are many smaller veins, and still more to the south of it. The Sneath & Clay, in granodiorite, has a westerly, flat dip and is a comparatively narrow vein, but a pay-shoot proved very rich in former years. It has been idle for the last few years. The Pittsburg, in diabase, has a north-northeast direction and an easterly dip. The vein averages 15 inches thick, and the quartz, whenever present, is of high grade. The sulphurets are not abundant, consisting chiefly of iron pyrites and galena. The Pittsburg has, at intervals, been an important producer. The shaft is 800 feet deep on the incline. The Gold Flat-Potosi vein lies a short distance westward. In character it is similar to the Pittsburg, and has been worked to a depth of 200 feet. Both veins are repeatedly faulted by several east-and-west fissures. Considerable work has been done in former years on the Thomas and Mohigan veins. The shaft on the former is 800 feet deep; the ore was heavily sulphureted and rich, but the ore bodies were very irregular.

The veins of the Providence-Gold Tunnel system are of the greatest interest and economic importance. They have in general a direction ranging from north-northwest to north-northeast and on the whole a very uniform easterly dip of from 35° to 45°. A peculiar radiating arrangement is clearly noticeable, all of the veins converging toward a point a short distance west of the Fortuna mine, but apparently dying out before reaching it. The easterly veins are in granodiorite, and begin with the Nevada County and Midnight (Stiles) veins, on both of which comparatively little work has been done. Westward lies the long Gold Tunnel vein, which has been worked at several places. At the Reward mine the vein is about 1 foot wide and has been worked to a depth of 200 feet. On the California ground the shaft is 600 feet deep on the incline, and in former years much good ore has been extracted. Northward the Gold Tunnel claim follows, with an inclined shaft 600 feet deep. The Gold Tunnel was a heavy producer for many years, but has been idle of late. It is known to have produced several hundred thousand dollars. At the northerly end of the vein is the Pennsylvania mine, with a shaft 500 feet deep. The vein is from $1\frac{1}{2}$ to 2 feet wide, and the ore extracted averages $15 to $20, with 8 per cent of sulphurets.

The westerly veins of the Providence system begin, with the Mountaineer, which for many years has been a heavy producer. The shaft is 850 feet on the incline. The average thickness of vein is 1 foot, and the ore is often heavily sulphureted. The granodiorite adjoining the vein is usually very hard.

The Merrifield is probably the heaviest and longest vein in the district. It is first noted 3,000 feet south of the Providence mine. Farther southward is the small vein of General Grant and El Capitan, which may possibly indicate a still more southerly extension of the Merrifield. At the Providence mine the vein leaves the slate and enters the granodiorite; it continues strong up to above the Spanish mine, with a slightly more westerly direction; above the Spanish mine the vein splits up somewhat, but there can hardly be any doubt that Mount Auburn represents its continuation northward. It is probably the same Merrifield vein that emerges from under the lava in the northwestern corner of the map area and continues down to the South Yuba River, near Hoyt's crossing. The developments to the north of the Spanish mine are slight. At the Spanish mine there is a shaft 300 feet deep on the incline. The vein is of variable width, averaging 3 feet, and in places is heavily sulphureted. The next developments are at the old Merrifield mine and on the north side of Deer Creek. South of Deer Creek, in the Providence mine, the vein is most extensively developed by a shaft 1,800 feet deep on the incline. The vein is characterized by heavy masses of quartz, up to 10 feet wide, and contains much sulphurets; there is also a considerable percentage of silver in the ore. The granodiorite on both sides of the vein is usually greatly broken and crushed and is traversed by numerous seams parallel to the vein. Sometimes the crushing has gone so far that the rock is converted to a schistose, chloritic mass. In certain places there are two or more veins, separated by zones of crushed granodiorite, the whole mass "between walls" attaining 30 feet in width. To the south of the Providence mine, beyond the point where the vein enters slate, the old underground works, not accessible now, showed the vein to follow the contact for about 800 feet on the incline, as shown on the structure-section sheet. All this indicates beyond doubt that the force producing the Merrifield fissure was of unusual strength and that the resulting movement was considerable. From the relations mentioned it is believed that the movement along the dip of the vein must have been about 800 feet, and the fault is clearly an overthrust in which the hanging wall has moved up relatively to the foot wall.

The contact vein lies to the west of the Merrifield, and its southerly part is parallel to it in strike and dip. It is first seen at the Providence mine, where a rich pay-shoot has been opened on it. It is also extensively worked on the Champion ground, as well as at the old and new Nevada City shafts. Near the latter it turns rather suddenly, without break, to a west-northwest direction, running across the Chapman ranch. The vein exposed in the Coan mine is probably the same, but it can not be traced farther than this. It has not been opened extensively to the west of the Nevada City mine. Practically the whole southerly part of the vein lies on the contact between granodiorite and slate. About 500 feet south of the Nevada City new shaft it leaves the contact and enters the granodiorite. It is usually a wide vein, heavily sulphureted—even more so than the Merrifield—carries considerable silver, and shows abundantly the same indications of an extensive overthrust fault fissure, the throw of which must be larger than that of the Merrifield. A very short distance south of the Providence ore-shoot it runs into diabase (exposed on the 6th level) and slate, and closes down to a mere seam. The fissure has a strong tendency to throw out stringers and fissures in the slate foot wall; these have generally a flatter dip than the main fissure. Several such veins and stringers are seen in the Providence mine. A shaft near the Wyoming mill has been sunk on such a vein, which is found to unite with the contact vein. The northerly Wyoming shaft is sunk 900 feet on the incline on a slate vein, which may or may not be the same as that exposed near the mill, and which in depth will probably be found to unite with the contact vein, as it does on the strike near the old Nevada City shaft. Between Indian Flat and Deer Creek the schists contain a great number of seams, mostly dipping southwest from 10° to 40°, and which are sometimes very rich in coarse gold. The hydraulic method has been used in places to wash the surface soil containing the decomposed seams. This locality is known as Red Hill. The Home and Cadmus mines are located on this seam belt, south of Deer Creek.

A short distance northwest of Coan's mine, outside of the area of the map, the contact-metamorphosed slate runs out to a point. A little farther on the serpentine and pyroxenite also run out in a point in the diorite, leaving the granodiorite adjoined by a large area of darker, dioritic rock, sometimes containing pyroxene. The Ella or Oro Fino vein cuts across the granodiorite and diorite with a north-northwest strike and an easterly dip of 45°. The shaft is 300 feet deep. The Yellow Diamond has a northwest strike and lies in the chloritic and fine-grained dioritic rocks separating the serpentine from the coarser and more normal diorite. Still closer to the river, in diorite, but near the granodiorite, lie the heavy Ætna and Dement veins, both striking northwest and dipping east. While there is no one continuous and well-defined vein leading down to the South Yuba River from the Nevada City mine, it can not be denied that there is a system of linked and interrupted veins extending in that direction. On the river, also, three-fourths of a mile above Jones's bar, the diorite and the granodiorite are separated by a distinct fault fissure, with easterly dip and northwesterly strike, though at this point there is no quartz present.

In the northeastern part of the Grass Valley district, veins more or less parallel with the Idaho east-and-west system predominate. The Spring Hill, Kentucky, and Alpha are in serpentine or on the contact between serpentine and diabase dikes, and dip northward at a moderate angle. The Spring Hill is a very heavy vein, impregnated with fine-grained pyrites. The Coe mine is on a very heavy vein, in serpentine, also dipping north. The St. John shows a heavy but irregular vein on the contact of serpentine and slate at the 500-foot level, as well as several seams, all dipping north at steep angles. There is evidence of an overthrust fault in this mine. The Crown Point has a vein in serpentine striking northwest and dipping north 75°. Most of the gold in this mine is very coarse.

The celebrated Eureka-Idaho vein is first seen 2,000 feet north-northwest of the Maryland shaft, and forms here large, barren outcrops. Between the Maryland and the Maslin shafts the vein does not show on the surface, but its continuation is clearly shown underground. For some distance on each side of the latter shaft there are outcrops which are believed to be those of the Idaho vein. Beyond this the vein can not be traced on the surface. The Idaho vein dips southward at angles ranging from 50° to 70°. On the Eureka ground it is in serpentine, with a diabase dike in the hanging wall; at the Maryland shaft it is between a serpentine foot wall and a gabbro hanging wall, and then enters the serpentine. Underground, however, most of the vein east of the Maryland shaft lies between a diabase hanging wall and a serpentine foot wall. The vein is remarkable for its strong, continuous ore shoot, dipping east at a moderate angle on the plane of the vein. The vein is 2 feet thick and carries about 1 per cent of iron pyrites, copper pyrites, and galena; the sulphurets contain from $100 to $175 per ton. The average value per ton has been about $28. The annual production of the vein has rarely fallen below $300,000. Attempts have been made to find the continuation of the Idaho vein in the Brunswick district at Chevanne tunnel, but thus far without success. In the southwest corner of the small Brunswick district there is a series of parallel veins, dipping south and striking northwest, which may be considered as belonging to the Idaho system. Of these the Brunswick, Gold Point, Union Hill, Lucky, and Cambridge are the principal. All are contained in a schistose diabase-tuff, and considerable work has been done on them in former years.

With the exception of the North Star group, nearly all of the veins in the larger, southern part of the district have a general north-and-south direction and a medium to flat dip either east or west. They are usually rather narrow, and carry a high-grade ore, with occasional bunches of coarse, free gold. The sulphurets, which consist chiefly of iron pyrites and some galena, are not abundant, and are usually of only medium grade. In places a strong sheeting of the country rock parallel to the vein may be noted, as, for instance, in the granodiorite of the western part of Mill street, Grass Valley, or in the diabase in the vicinity of the Larimer mine on Wolf Creek. Intersecting the vein is a system of "crossings," or barren seams, with steep dip and general northeasterly trend. These crossings sometimes fault the veins slightly, and usually carry a great deal of water.

The Rocky Bar vein extends for 3,500 feet on the west side of Wolf Creek, and lies in diabase, the dip being flat to the east. It has been worked only to a depth of a few hundred feet, but is known to have produced several million dollars. During late years it has not been worked to any extent. The vein is very irregular in its tenor, sometimes being extremely rich in coarse gold, sometimes not paying milling expenses. On the east side of Wolf Creek lies the Dromedary vein, in granodiorite and with a westerly dip. It has not been worked to the extent of the former vein, but is known to have produced some rich ore. At the Granite Hill mine the vein is about 1 foot thick and carries coarse gold in rich but irregular shoots. The vein cuts the diabase contact without change.

In the continuation of this vein southward lies the Omaha vein system, all veins dipping west. The Omaha vein, which has long been an important producer, lies, like all others of this system, in very hard granodiorite, and has been opened up through the Omaha and Lone Jack shafts to a depth of 1,500 feet on the incline. The ore is high-grade, with $2\frac{1}{2}$ per cent of rich sulphurets, principally iron pyrites, with a little galena, zincblende, and copper pyrites, the vein averaging 1 foot in thickness. South of the Omaha and on the same vein are the Hartery and Homeward Bound, which have been opened up to a less extent. The Wisconsin is a parallel vein to the west. The system is continued southward by many veins, the most prominent of which is the Allison Ranch. It was worked between 1855 and 1866, but was opened only to a depth of 500 feet. It produced in that time $2,300,000. The vein is about $1\frac{1}{2}$ feet wide and shows no extensive croppings on the surface.

The great Osborne Hill vein system contains a large number of parallel and linked veins, nearly all with a moderate westerly dip. The W. Y. O. D. vein has been an important producer during the last few years. It is partly in granodiorite, partly in diabase, and has been sunk upon to a depth of 1,100 feet on the incline. The Pennsylvania mine lies to the west of the W. Y. O. D., in granodiorite. It is a narrow vein, averaging 1 foot, and has been worked to a depth of about 600 feet on the incline. The celebrated Empire mine contains two veins, Rich Hill and Ophir Hill, the principal work having been done on the latter, on which a shaft has been sunk to a depth of 2,400 feet on the incline. The vein is from 1 to $1\frac{1}{2}$ feet thick, and frequently contains coarse gold. The sulphurets amount to $2\frac{1}{2}$ per cent. The ore is high-grade and for many years averaged $25 per ton.

The veins in the continuation of the Ophir Hill were worked to a depth of a few hundred feet prior to 1870. From then till recent years but little was done. The developments in this vicinity during the last few years, however, are, on the whole, encouraging. The Osborne Hill mine has lately been opened to a depth of 500 feet on the incline, exposing good bodies of high-grade ore. The Osborne Hill vein is from a few inches up to $2\frac{1}{2}$ feet wide, and is characterized by a large amount of arsenical pyrites in the sulphurets, as are also several adjoining veins. Good ore shoots have also been found recently in the Electric and Centennial mines. To the south of the Osborne Hill mine there are several strong and well-defined veins, as shown on the map, but the developments on them are not extensive. The country rock in all these mines is diabase-porphyrite or porphyrite-breccia.

Along the granodiorite contact west of Osborne Hill and about in the continuation of the W. Y. O. D. vein, there are several veins, mostly in granodiorite and dipping east or west. The principal are the Bullion, Alaska, and Ben. Franklin, from all of which good ore has been extracted, but they have not been worked extensively for many years.

The North Star group of veins has a westerly or northwesterly strike and a flat northerly or southerly dip. The North Star vein, which dips to the north, has long been one of the principal producers of Grass Valley, and is opened by a shaft 2,400 feet deep on the incline. The vein is narrow, averaging 1 foot and sometimes closing down entirely. The ore is of high grade, running from $15 to $50 per ton, and carries 4 per cent of sulphurets (pyrites and galena) with an average value of $53 per ton. The country rock is a porphyritic diabase. The production for 1893 was about $356,000; considerably less, however, was produced in 1894. Roughly parallel to the North Star vein is the New York Hill vein, opened to a depth of 500 or 600 feet by the New York Hill and Chevanne shafts. This vein, also in diabase-porphyrite, averages 15 inches in width. The ore averages $40 per ton, carrying coarse gold and 2 per cent sulphurets of a tenor of $80 per ton. The vein has not been worked during recent years.

The workings on the New Rocky Bar mine have exposed an interesting, flat vein belonging to the same system, not cropping at all, but forming a flat arch, or "hog's back," as shown in the structure-section sheet.

Outside the limits of the area of the map, but usually considered as belonging to the Grass Valley district, are the veins of Forest Springs. They are located near Wolf Creek, 4 miles south of Grass Valley, the two principal ones being Norambagua and the Slate Ledge. The former is in granodiorite and dips 15° east. The vein averages 9 inches, carrying ore going about $50 per ton and containing $1\frac{1}{2}$ per cent of sulphurets, chiefly arsenical, worth about $50 per ton. The shaft is 500 feet on the incline, and has not been worked much since 1868. It is said to have produced $1,000,000. The Slate Ledge, close by, is in slate and porphyrite, with strike east and west, dip 30° south, and an average width of 1 foot. The ore contains much arsenical pyrite and is in part very rich.

About 4 miles west-southwest of Grass Valley, on Deadmans Flat, there are several veins with dips ranging from 30° to 70° west. None of them are opened below 300 feet. The country rock is diorite and amphibolite. The California (Pittsburg Consolidated) shows a narrow vein of high-grade ore with 5 per cent sulphurets. The Seven-Thirty is a little farther south, and shows a wider vein of good ore, while the Normandie, to the east of the veins before mentioned, contains two 6-inch veins of high-grade ore.

IRON ORE.

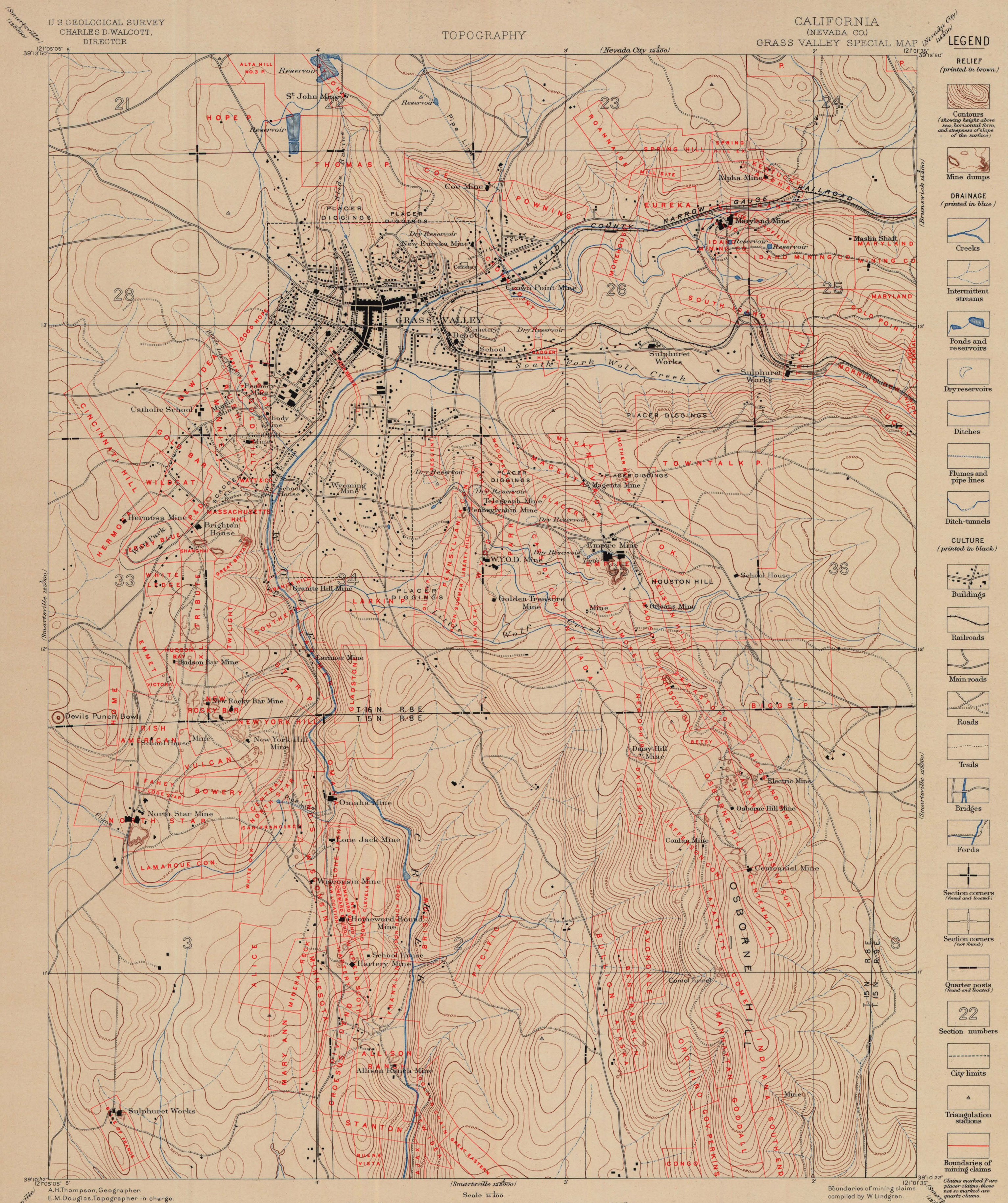
A small deposit of magnetite with quartz is found in the diabase near the granodiorite contact. The locality is 4,000 feet east of the Omaha mine, in Diamond Creek. Scattered fragments of magnetite are also found near the dry reservoir 1,700 feet east of the railroad station at Grass Valley.

WALDEMAR LINDGREN,
Geologist.

U S GEOLOGICAL SURVEY
CHARLES D. WALCOTT,
DIRECTOR

TOPOGRAPHY

CALIFORNIA
(NEVADA CO.)
GRASS VALLEY SPECIAL MAP



A.H. Thompson, Geographer.
E.M. Douglas, Topographer in charge.
Triangulation by E.M. Douglas.
Topography by A.F. Dunnington.
Surveyed in 1891.

Scale 1:14400

1000 500 0 1000 2000 3000 4000 Feet

1 ½ 0 1 Kilometer

Contour Interval 20 feet.
Datum is mean Sea level.
Edition of Mar. 1896.

Boundaries of mining claims compiled by W. Lindgren.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
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ECONOMIC GEOLOGY

CALIFORNIA
(NEVADA CO.)
GRASS VALLEY SPECIAL MAP

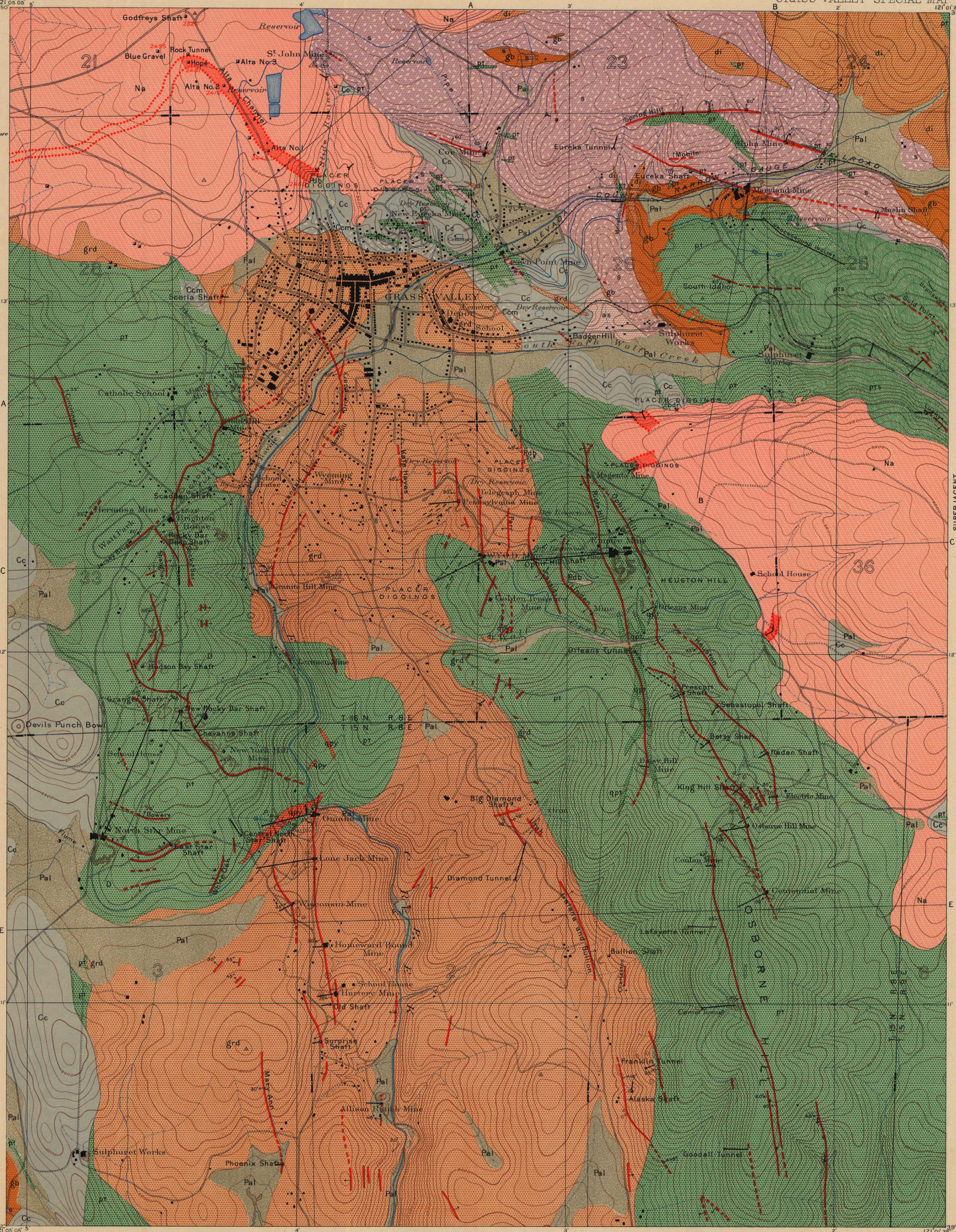
LEGEND
(continued)

SPECIAL SYMBOLS

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
70° *Dip and strike of joint structure*
Pits of hydraulic mines
× *Iron prospects*
Vertical shafts
Inclined shafts
Tunnels
Tunnels of known length but direction doubtful
2580 *Elevation of the Neocene surface under volcanic capping (bed-rock)*

Known productive formations

Quartz veins *(direction and dip of known outcrops)*
Quartz veins *(probable outcrop)*
Cross-seams *(usually without quartz and barren)*
Known course *(of auriferous, Neocene, drainage channels under volcanic capping)*
Probable course *(of auriferous, Neocene, drainage channels under volcanic capping)*



LEGEND

SURFICIAL ROCKS

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

SUPERJACENT SERIES — PLEISTOCENE

Pal — Alluvium *(sand and gravel)*
Pdb — Debris *(from hydraulic gravel mines)*

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines. Metamorphism is indicated by short dashes combined with the parallel lines.)

BED-ROCK SERIES — CARBONIFEROUS

Cc — Calaveras formation *(siliceous and clay-slates and sandstone)*
Ccm — Calaveras formation *(micaceous and quartzose schists metamorphosed by contact with granodiorite)*

IGNEOUS ROCKS

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

SUPERJACENT SERIES — NEOCENE

Na — Andesite *(tuff and breccia)*

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

grd — Granodiorite
grd — Dikes of granodiorite
qpy — Quartz-porphyry *(facies of granodiorite)*
di — Diorite *(sometimes containing pyroxene)*
gb — Gabbro
as — Augite-syenite
pt — Porphyrite and diabase with their tuffs and breccias *(largely altered to amphibolitic rocks. Porphyrite is chiefly augitic)*
qpt — Quartz-porphyrite
s — Serpentine *(largely derived from pyroxenite and peridotite)*

(Areas of schistose rocks are shown by patterns of wavy dashes.)

pts — Amphibolitic schist *(principally derived from breccia and tuff of augite-porphyrite)*

Sections

Legend is continued on the left margin.

A.H. Thompson, Geographer.
E.M. Douglas, Topographer in charge.
Triangulation by E.M. Douglas.
Topography by A.F. Dunnington.
Surveyed in 1891.

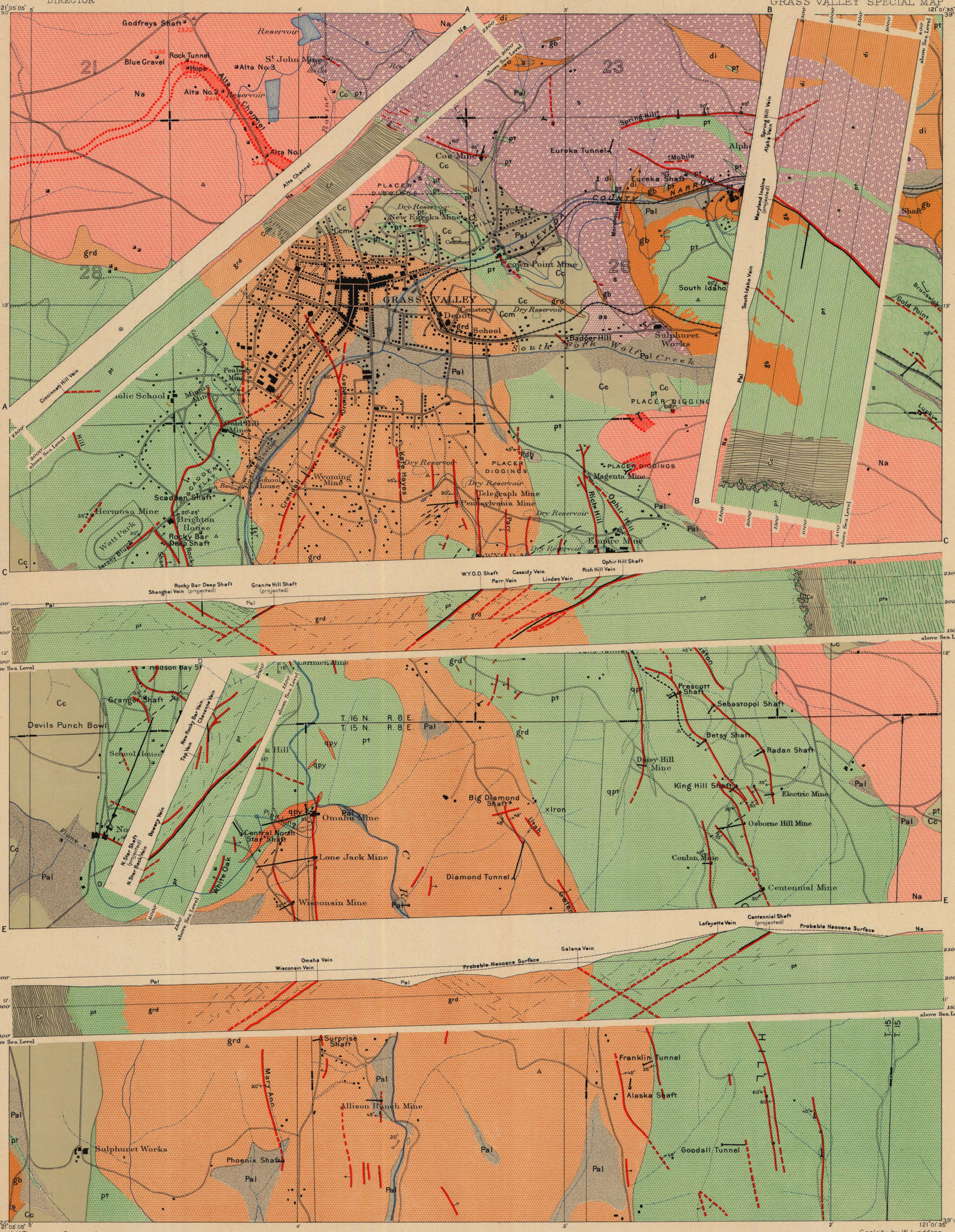
Scale $\frac{1}{14400}$
1000 500 0 1000 2000 3000 4000 Feet
1 Kilometer
Contour Interval 20 feet.
Datum is mean Sea level.
Edition of Mar. 1896.

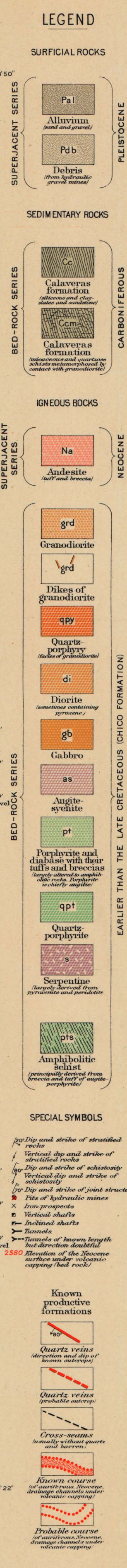
Geology by W. Lindgren.
Surveyed in 1893-94.

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

STRUCTURE SECTIONS

CALIFORNIA
(NEVADA CO.)
GRASS VALLEY SPECIAL MAP





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1000 500 0 1000 2000 3000 4000 Feet
1 Kilometer

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U.S. GEOLOGICAL SURVEY
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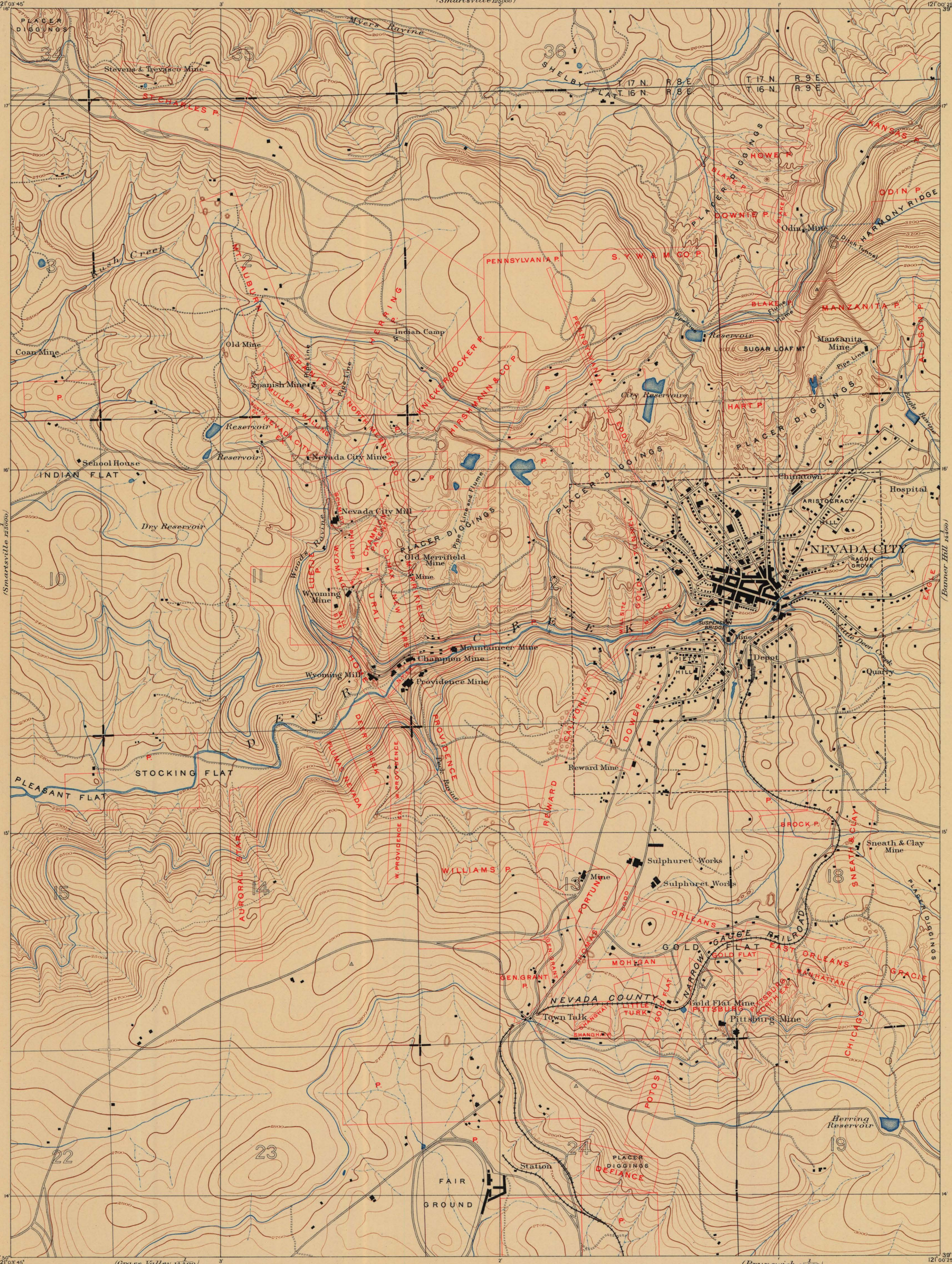
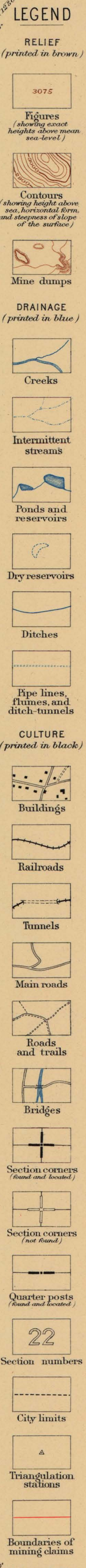
TOPOGRAPHY

CALIFORNIA
(NEVADA CO.)
NEVADA CITY SPECIAL MAP

(Smartsville 1/125000)



(Grass Valley 1/62500) (Brunswick 1/62500) (Smartsville 1/62500) (Banner Hill 1/62500)



Claims marked P are placer-claims; those not so marked are quartz claims

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Edition of Mar. 1896.

Boundaries of mining claims compiled by W. Lindgren.

U.S. GEOLOGICAL SURVEY
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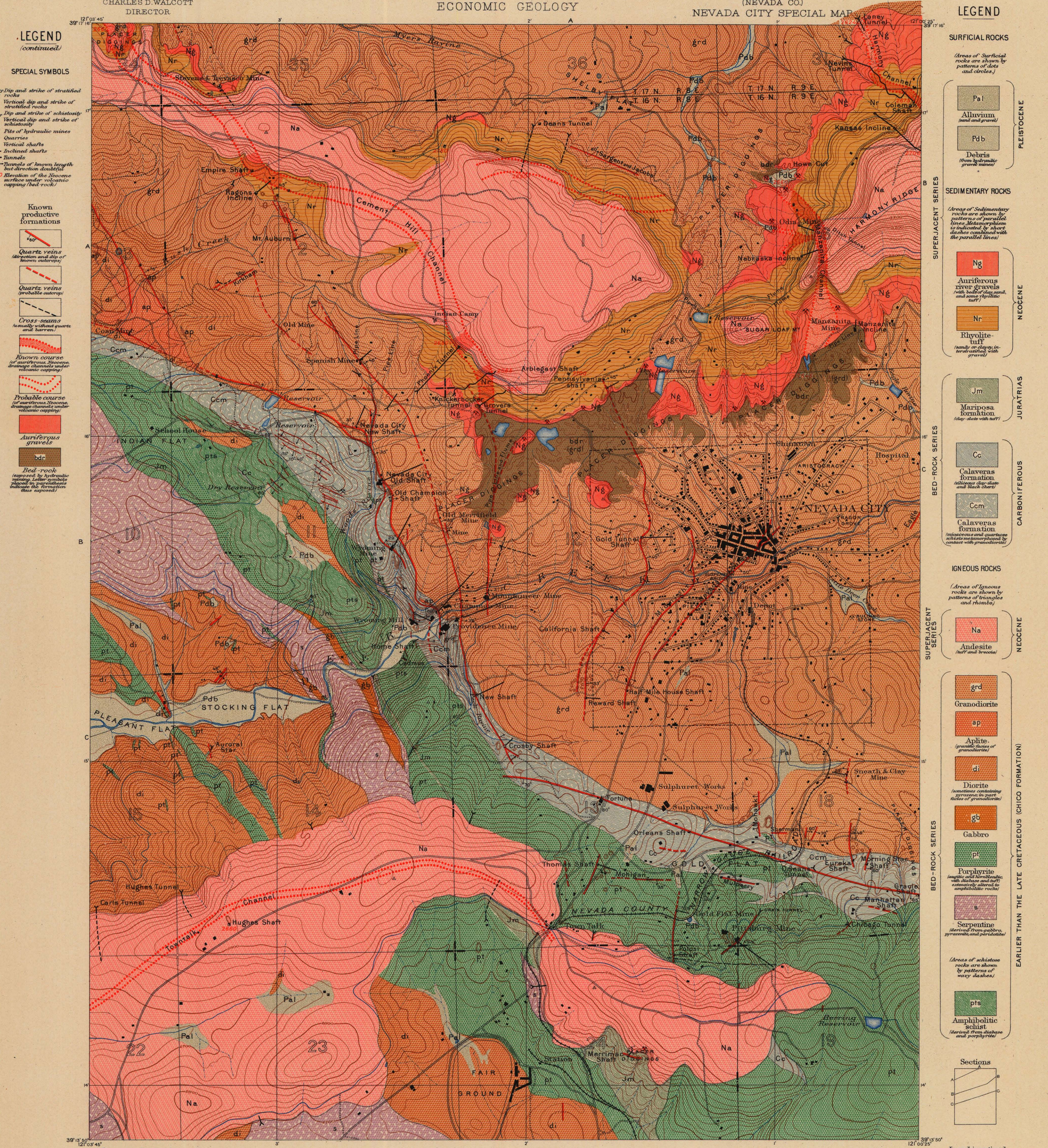
ECONOMIC GEOLOGY

CALIFORNIA
(NEVADA CO.)
NEVADA CITY SPECIAL MAP



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Scale $\frac{1}{14400}$

1000 500 0 1000 2000 3000 4000 Feet

0 ½ 1 Kilometer

Contour Interval 20 feet.

Datum is mean Sea level.

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U.S.GEOLOGICAL SURVEY
CHARLES D.WALCOTT
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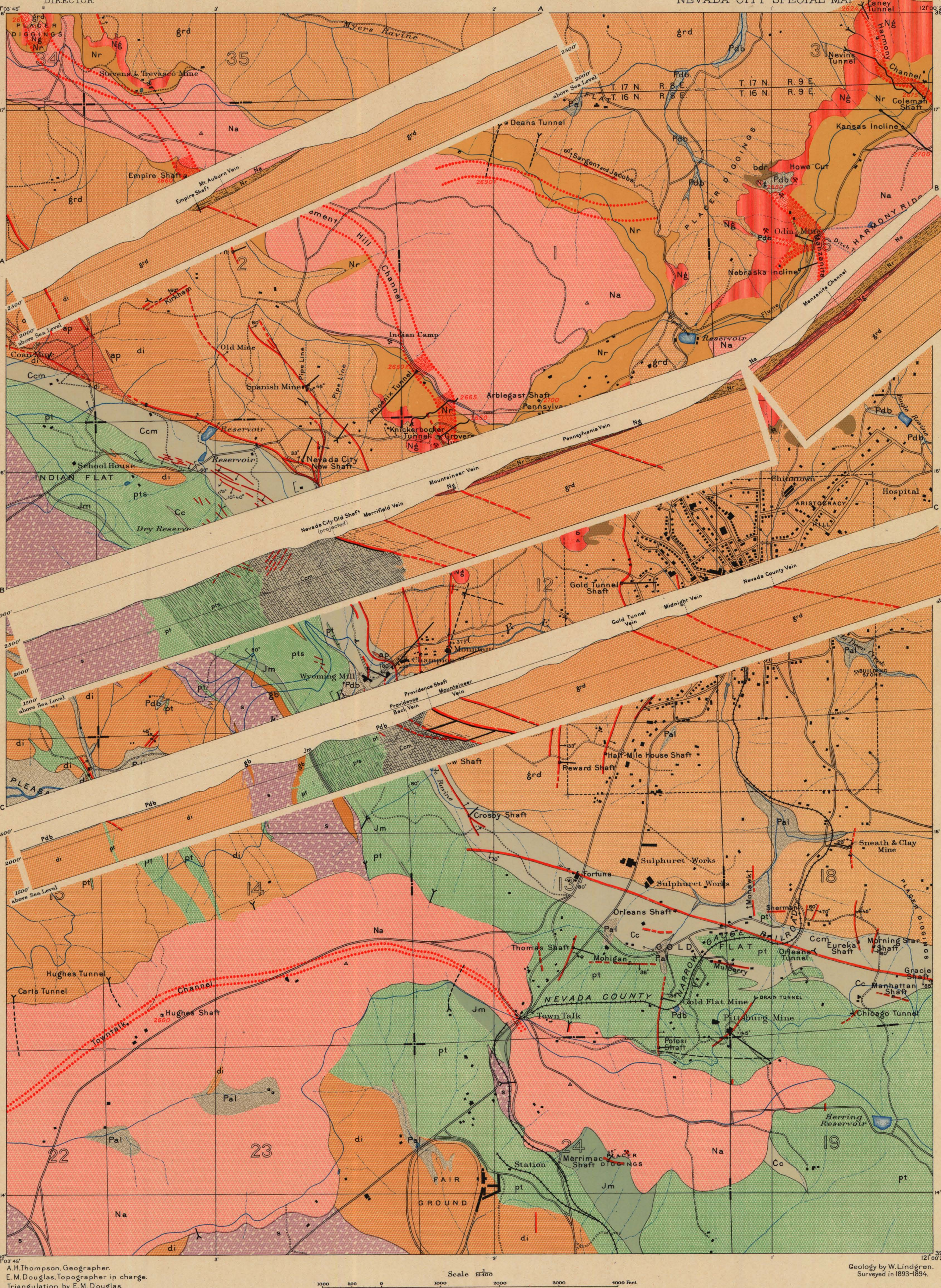
STRUCTURE SECTIONS

CALIFORNIA
(NEVADA CO.)
NEVADA CITY SPECIAL MAP



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1000 500 0 1000 2000 3000 4000 Feet

0 ½ 1 Kilometer

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Surveyed in 1893-1894.

LEGEND

(continued)

Known productive formations

- *Quartz veins* (direction and dip of known outcrops)
- *Quartz veins* (probable outcrop)
- *Cross-seams* (usually without quartz and barren)
- *Known course* (of auriferous, Neocene, drainage channels under volcanic capping)
- *Probable course* (of auriferous, Neocene, drainage channels under volcanic capping)
- *Auriferous gravels*
- bdr — *Bed-rock* (exposed by hydraulic mining. Letter symbols placed in parenthesis indicate the formation thus exposed)

LEGEND

SURFICIAL ROCKS

SUPERJACENT SERIES

PLEISTOCENE

- Pal — Alluvium (sand and gravel)
- Pdb — Debris (from hydraulic gravel mines)

SEDIMENTARY ROCKS

NEOCENE

- Nr — Rhyolite-tuff (sandy or clayey, interstratified with gravel)
- Ng — Auriferous river gravels (with beds of clay, sand, and some rhyolitic tuff)

BED-ROCK SERIES

JURATRIAS

- Jm — Mariposa formation (clay-slate with tuff)

CARBONIFEROUS

- Cc — Calaveras formation (siliceous clay-slate and black chert)
- Ccm — Calaveras formation (micaceous and quartzose schists metamorphosed by contact with granodiorite)

IGNEOUS ROCKS

SUPERJACENT SERIES

NEOCENE

- Na — Andesite (tuff and breccia)

BED-ROCK SERIES

EARLIER THAN THE LATE CRETACEOUS (CHICO FORMATION)

- grd — Granodiorite
- ap — Aplite (granitic facies of granodiorite)
- di — Diorite (sometimes containing pyroxene; in part facies of granodiorite)
- gb — Gabbro
- pt — Porphyrite (augitic and hornblendic, with diabase and tuff; extensively altered to amphibolitic rocks)
- s — Serpentine (derived from gabbro, pyroxenite, and peridotite)
- pts — Amphibolitic schist (derived from diabase and porphyrite)

SPECIAL SYMBOLS

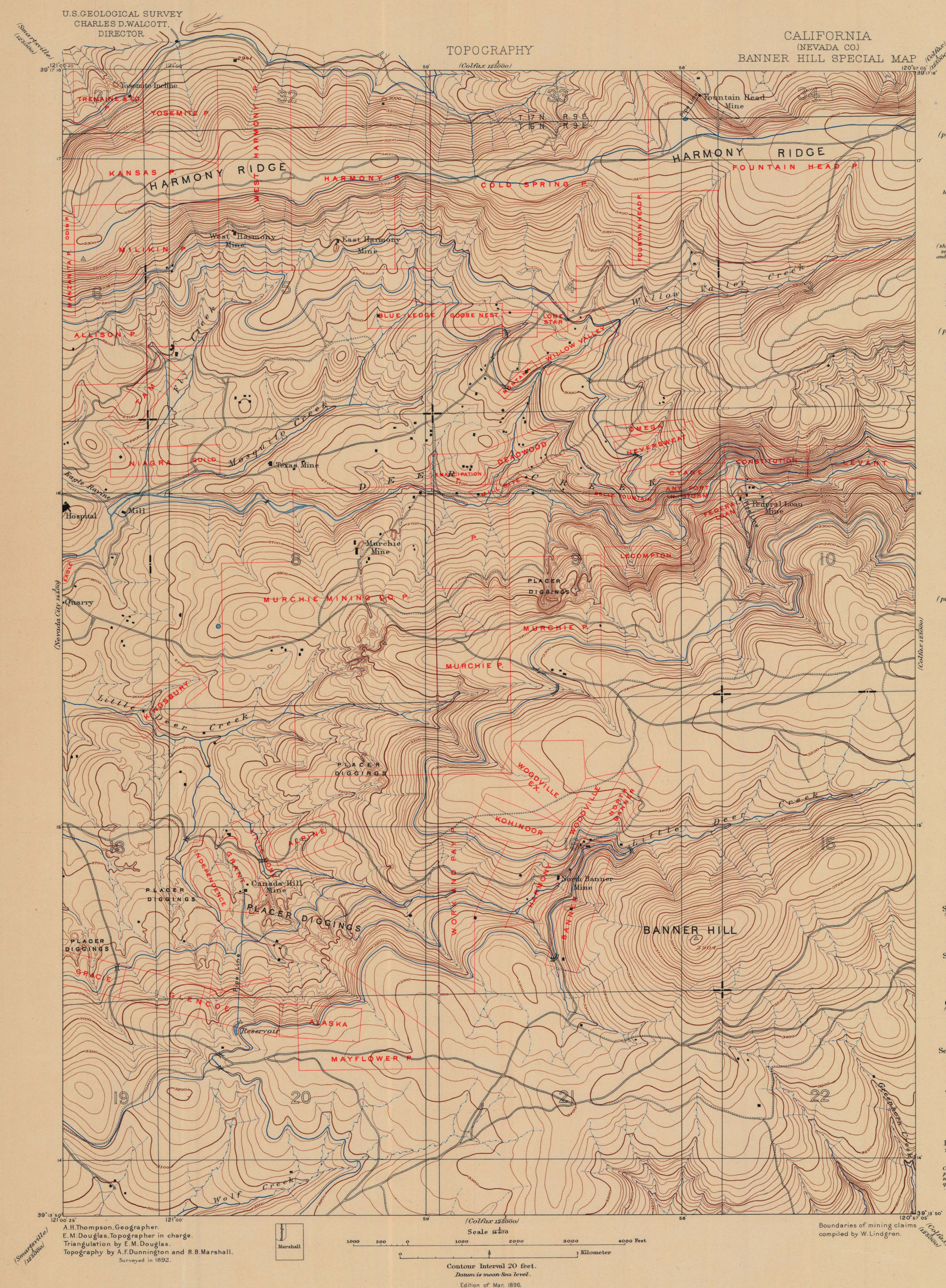
- 20° *Dip and strike of stratified rocks*
- *Vertical dip and strike of stratified rocks*
- 80° *Dip and strike of schistosity*
- *Vertical dip and strike of schistosity*
- *Pits of hydraulic mines*
- *Quarries*
- *Vertical shafts*
- *Inclined shafts*
- *Tunnels*
- *Tunnels of known length but direction doubtful*
- 2850 *Elevation of the Neocene surface under volcanic capping (bed-rock)*

Legend is continued on the left margin.

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

TOPOGRAPHY

CALIFORNIA
(NEVADA CO.)
BANNER HILL SPECIAL MAP



LEGEND

RELIEF (printed in brown)

- 3904 — Figures (showing exact heights above mean sea-level)
- Contours (showing height above sea, horizontal form, and steepness of slope of the surface)
- Mine dumps

DRAINAGE (printed in blue)

- Creeks
- Intermittent streams
- Ponds and reservoirs
- Ditches and pipe lines
- Flumes

CULTURE (printed in black)

- Buildings
- Main roads
- Roads
- Trails
- Bridges
- Fords
- Section corners (found and located)
- Section corners (not found)
- Quarter posts (found and located)
- 22 — Section numbers
- Triangulation stations
- Boundaries of mining claims

Claims marked P are placer claims; those not so marked are quartz claims.

A.H.Thompson, Geographer.
E.M.Douglas, Topographer in charge.
Triangulation by E.M.Douglas.
Topography by A.F.Dunnington and R.B.Marshall.
Surveyed in 1892.

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Boundaries of mining claims compiled by W. Lindgren.

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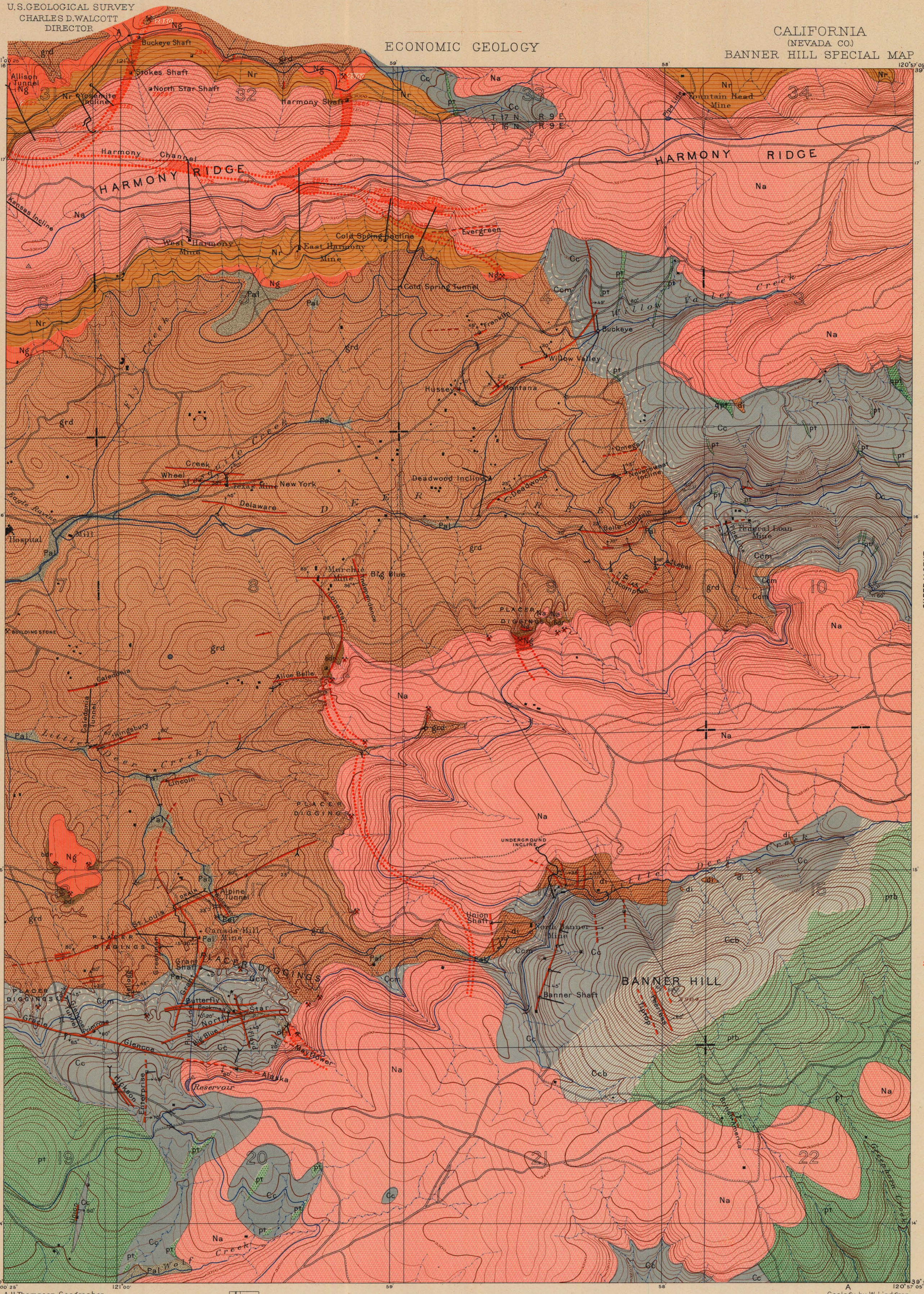
ECONOMIC GEOLOGY

CALIFORNIA
(NEVADA CO.)
BANNER HILL SPECIAL MAP



39°13'50" 121°00'25" | 121°00' | 59' | 58' | A | 120°57'05" 39°13'50"

A.H. Thompson, Geographer.
E.M. Douglas, Topographer in charge.
Triangulation by E.M. Douglas.
Topography by A.F. Dunnington and R.B. Marshall.
Surveyed in 1892.

Dunnington
Marshall

Scale $\frac{1}{14400}$
1000 500 0 1000 2000 3000 4000 Feet
0 ½ 1 Kilometer
Contour Interval 20 feet.
Datum is mean Sea level.
Edition of Mar. 1896.

Geology by W. Lindgren.
Surveyed in 1893-94.

LEGEND

SURFICIAL ROCKS

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

SUPERJACENT SERIES

PLEISTOCENE

Pal — Alluvium *(mostly debris from hydraulic gravel mines)*

SEDIMENTARY ROCKS

(Areas of Sedimentary rocks are shown by patterns of parallel lines. Metamorphism is indicated by short dashes combined with the parallel lines)

NEOCENE

Ng — Auriferous river gravels *(with beds of clay, sand, and some rhyolitic tuff)*

Nr — Rhyolite-tuff *(sandy or clayey, interstratified with gravel)*

BED-ROCK SERIES

CARBONIFEROUS

Cc — Calaveras formation *(black chert and clay-slate)*

Ccb — Calaveras formation *(contact breccia with some porphyrite-tuff)*

Ccm — Calaveras formation *(micaceous and quartzose schists metamorphosed by contact with granodiorite)*

IGNEOUS ROCKS

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

SUPERJACENT SERIES

NEOCENE

Na — Andesite *(tuff and breccia)*

BED-ROCK SERIES

EARLIER THAN THE LATE CRETACEOUS

grd — Granodiorite

di — Diorite

pt — Porphyrite *(hornblendic or augitic with some diabase)*

ptb — Porphyrite-breccia

qpt — Quartz-porphyrite

SPECIAL SYMBOLS

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
70° *Dip and strike of joint structure*
Pits of hydraulic mines
Quarries
Vertical shafts
Inclined shafts
Tunnels
Tunnels of known length but direction doubtful
2850 *Elevation of the Neocene surface under volcanic capping (bed-rock)*

Known productive formations

80° *Quartz veins (direction and dip of known outcrops)*

Quartz veins (probable outcrop)

Known course (of auriferous, Neocene, drainage channels under volcanic capping)

Probable course (of auriferous, Neocene, drainage channels under volcanic capping)

Auriferous gravels

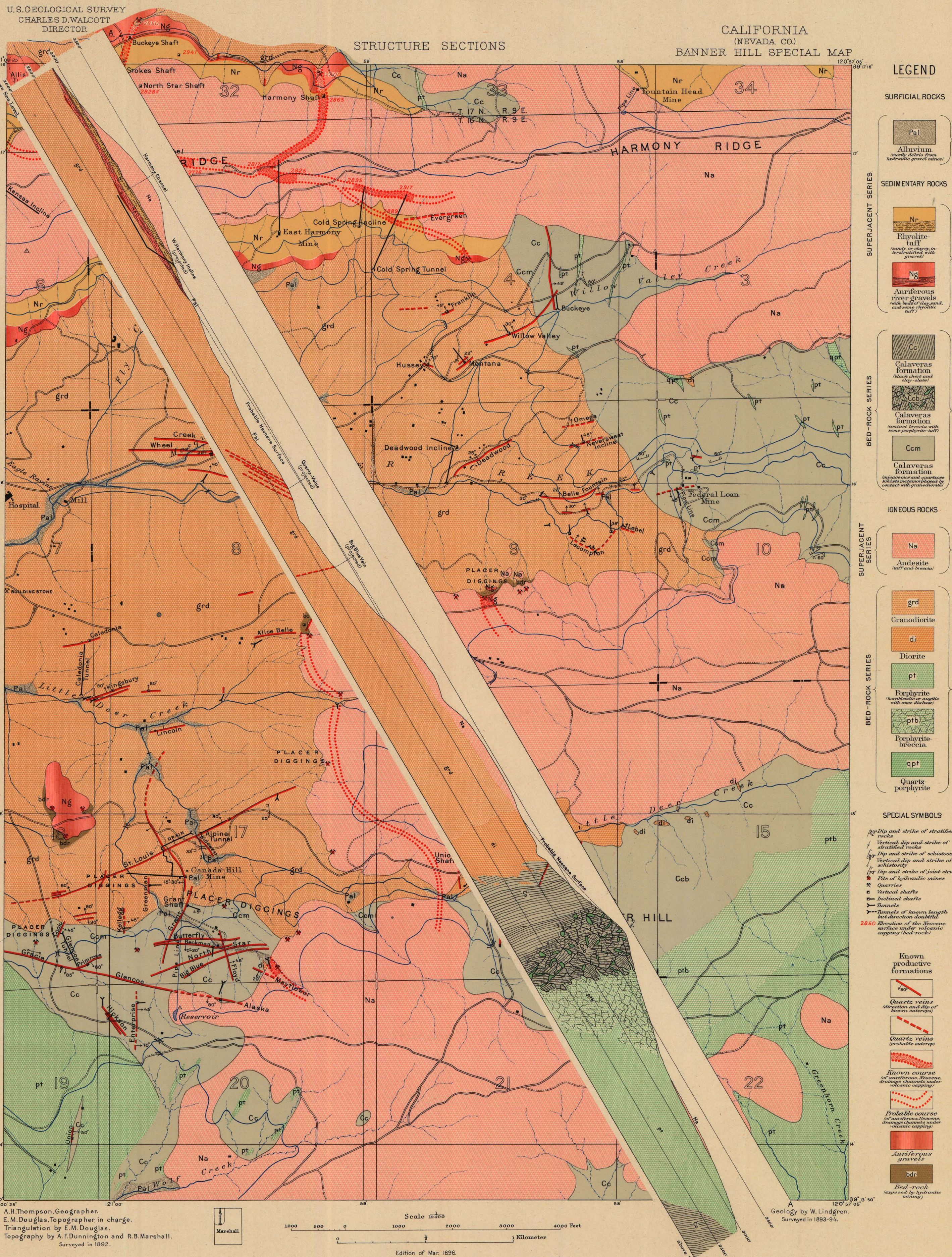
bdr — *Bed-rock (exposed by hydraulic mining)*

Section

A — A

U.S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT
DIRECTOR

CALIFORNIA
(NEVADA CO.)
BANNER HILL SPECIAL MAP



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Scale 1/14400
Kilometer

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