DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

J.W. POWELL, DIRECTOR

GEOLOGIC ATLAS

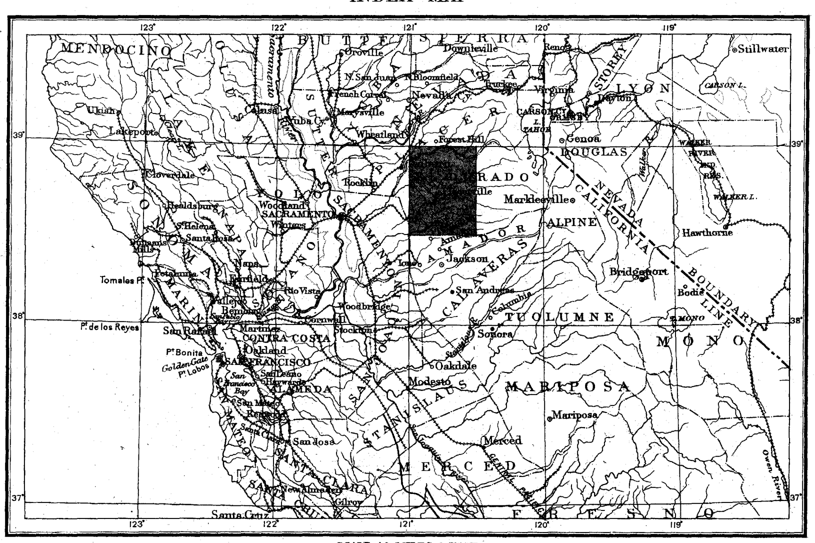
OF THE

UNITED STATES

PLACERVILLE FOLIO

CALIFORNIA

INDEX MAP



SCALE: 40 MILES-1 INCH

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FOLIO 3 | LIBRARY EDITION | PLACERVILLE

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EXPLANATION.

The Geological Survey is making a large topographic map and a large geologic map of the United States, which are being issued together in the form of a Geologic Atlas. The parts of the atlas are called folios. Each folio contains a topographic map and a geologic map of a small section of country, and is accompanied by explanatory and descriptive texts. The complete atlas will comprise several thousand folios.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, prairies, valleys, hills and mountains; (2) distribution of water, called *drainage*, as streams, ponds, lakes, swamps and canals; (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 printed in brown. It is desirable to show also the elevation of any part of a hill, ridge, slope or valley; to delineate the horizontal outline or contour of all slopes; and to indicate their degree of steepness. This is done by lines of constant elevation above mean sea level, which are drawn at regular vertical intervals. The lines are called *contours* and the constant vertical space between each two contours is called the *contour interval*. Contours are printed in brown.

The manner in which contours express the three conditions of relief (elevation, horizontal form and degree of slope) is shown in the following sketch and corresponding contour map:

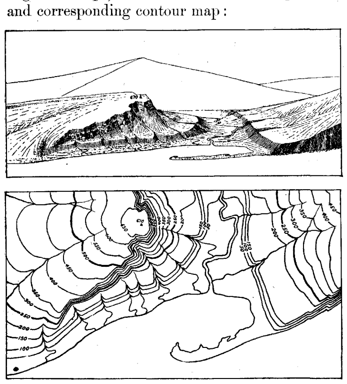

Fig. 1. The upper figure represents a sketch of a river valley, with terraces, and of a high hill encircled by a cliff. These features appear in the map beneath, the slopes and forms of the surface being shown by contours.

The sketch represents a valley between two hills. In the foreground is the sea with a bay which is partly closed by a hooked sand-bar. On either side of the valley is a terrace; from that on the right a hill rises gradually with rounded forms, whereas from that on the left the ground ascends steeply to a precipice which presents sharp corners. The western slope of the higher hill contrasts with the eastern by its gentle descent. 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 height, form and slope:

1. A contour indicates approximately a 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 on 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 are made heavy and are numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the horizontal 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 define all prominences. The relations of contour characters 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. Therefore contours are far apart on the gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is chosen; for a steep or mountainous country a large contour interval is necessary. The smallest contour interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for districts like the Mississippi delta and the Dismal Swamp region. In mapping great mountain masses like those in Colorado, on a scale of $\frac{1}{250,000}$ the contour interval may be 250 feet. For intermediate relief other contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—The water courses are indicated by blue lines, which are drawn unbroken where the stream flows the year round, and dotted where the channel is dry a part of the year. Where the stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Marshes and canals are also shown in blue.

Culture.—In the progress of the settlement of any region men establish many artificial features. These, such as roads, railroads and towns, together with names of natural and artificial details and boundaries of towns, counties and states, are printed in black.

As a region develops, culture changes and gradually comes to disagree with the map; hence the representation of culture needs to be revised from time to time. Each sheet bears on its margin the dates of survey and of revision.

Scales.—The area of the United States (without Alaska) is about 3,025,000 square miles. On a map 240 feet long and 180 feet high the area of the United States would cover 3,025,000 square inches. Each square mile of ground surface would be represented by a corresponding 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 "one mile to an inch." A map of the United States half as long and half as high would have a scale half as great; its scale would be "two miles to an inch," or four square miles to a square inch. Scale is also often expressed as 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 "one mile to one inch" is expressed by $\frac{1}{63,360}$.

Three different scales are used on the atlas sheets of the U. S. Geological Survey; the smallest is $\frac{1}{250,000}$, the second $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to four miles two miles, and one mile of natural length to one inch of map length. On the scale $\frac{1}{62,500}$ one square inch of map surface represents and corresponds nearly to one square mile; on the scale of $\frac{1}{125,000}$, to about four square miles; and on the scale of $\frac{1}{250,000}$, to about sixteen square miles. At the bottom of each atlas sheet the scale is expressed as a fraction, and it is further indicated by a "bar scale," a line divided into parts representing miles and parts of miles.

Atlas sheets.—A map of the United States on the smallest scale used by the Geological Survey would be 60 feet long and 45 feet high. If drawn on one of the larger scales it would be either two times or four times as long and high. To make it possible to use such a map it is divided into 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 (that is, represents an area one degree in extent in each direction); 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 4000, 1000 and 250 square miles.

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. At the sides and corners of each sheet the names of adjacent sheets are printed.

THE GEOLOGIC MAP.

A geologic map represents the distribution of rocks, and is based on a topographic map,—that is, to the topographic representation the geologic representation is added.

Rocks are of many kinds in origin, but they may be classed in four great groups: Superficial Rocks, Sedimentary Rocks, Igneous Rocks and Altered Rocks. The different kinds found within the area represented by a map are shown by devices printed in colors.

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. The materials composing them likewise vary with locality, for the conditions of their deposition at different times and places have not been alike, and accordingly the rocks show many variations. Where beds of sand were buried beneath beds of mud, sandstone may now occur under shale; where a flow of lava cooled and was overflowed by another bed of lava, the two may be distinguished. Each of these masses is limited in extent to the area over which it was deposited, and is bounded above and below by different rocks. It is convenient in geology to call such a mass a *formation*.

(1) *Superficial rocks.*—These are composed chiefly of clay, sand and gravel, disposed in heaps and irregular beds, usually unconsolidated.

Within a recent period of the earth's history, a thick and extensive ice sheet covered the northern portion of the United States and part of British America, as one now covers Greenland. The ice gathered slowly, moved forward and retreated as glaciers do with changes of climate, and after a long and varied existence melted away. The ice left peculiar heaps and ridges of gravel; it spread layers of sand and clay, and the water flowing from it distributed sediments of various kinds far and wide. These deposits from ice and flood, together with those made by water and winds on the land and shore after the glacier had melted, and those made by similar agencies where the ice sheet did not extend, are the superficial formations. This period of the earth's history, from the beginning of the glacial epoch to the present, is called the Pleistocene period.

The distribution of the superficial rocks is shown on the map by colors printed in patterns of dots and circles.

(2) *Sedimentary rocks.*—These are conglomerate, sandstone, shale and limestone, which have been deposited beneath seas or other large bodies of water and have usually become hard.

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 in the ocean, whose shore would traverse Wisconsin, Iowa, Kansas and Texas. More extensive changes than this have repeatedly occurred in the past. The shores of the North American continent have changed from age to age, and the sea has at times covered much that is now dry land. The earth's surface 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 oceans are changed.

The bottom of the sea is made of gravel, sand and mud, which are sorted and spread. As these sediments gather they bury others already deposited and the latter harden into layers of conglomerate, sandstone, shale or limestone. When the sea bottom is raised to dry land these rocks are exposed, and then we may learn from them many facts concerning the geography of the past.

As sedimentary strata accumulate the younger beds rest on those that are older and the relative ages of the deposits may be discovered by observing their relative positions. In any series of undisturbed beds the younger bed is above the older.

Strata generally contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas. By studying these remains or fossils it has been found that the species of each epoch of the earth's history have to a great extent differed from those of other epochs. Rocks that contain the remains of life are called *fossiliferous*. Only the simpler forms of life are found in the oldest fossiliferous rocks. From time to time more complex forms of life developed and, as the simpler ones lived on in modified forms, the kinds of living creatures on the earth multiplied. But during each epoch 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.

Beds of rock do not always occur in the positions in which they were formed. When they have been disturbed it is often difficult to determine their relative ages from their positions; then fossils are a guide to show which of two or more formations is the oldest. 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 formed first. Fossil remains found in the rocks of different states, of different countries and of different continents afford the most important means for combining local histories into a general earth history.

Areas of sedimentary rocks are shown on the map by colors printed in patterns of parallel straight lines. To show the relative age of strata on the map, the history of the sedimentary rocks is divided into nine periods, to each of which a color is assigned. Each period is further distinguished by a letter-symbol, so that the areas may be known when the colors, on account of fading, color blindness or other cause, cannot be recognized. The names of the periods in proper order (from new to old), with the color and symbol assigned to each, are given below:

PERIOD.	SYMBOL.	COLOR—PRINTED IN PATTERNS OF PARALLEL LINES.
Neocene (youngest)	N	Yellowish buff.
Eocene	E	Olive-brown.
Cretaceous	K	Olive-green.
Juratrias	J	Gray-blue-green.
Carboniferous	C	Gray-blue.
Devonian	D	Gray-blue-purple.
Silurian	S	Gray-red-purple.
Cambrian	Ꞓ	Brown-red.
Algonkian (oldest)	A	Orange-brown.

In any district several periods may be represented, and the representation of each may include one or many formations. 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; and the formations of any one period are distinguished from one another by different patterns. Two tints of the period-color are used: a pale tint (the underprint) is printed evenly over the whole surface representing the period; a dark tint (the overprint) brings out the different patterns representing formations. Each formation is furthermore given a letter-symbol, which is printed on the map with the capital 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.

(3) *Igneous rocks.*—These are crystalline rocks, which have cooled from a molten condition.

Deep beneath the surface, rocks are often so hot as to melt and flow into crevices, where they congeal, forming dikes and sheets. Sometimes they pour out of cracks and volcanoes and flow over the surface as lava. Sometimes they are thrown from volcanoes as ashes and pumice, and are spread over the surface by winds and streams. Often lava flows are interbedded with ash beds.

It is thought that the first rocks of the earth, which formed during what is called the Archean period, were igneous. Igneous rocks have intruded among masses beneath the surface and have been thrown out from volcanoes at all periods of the earth's development. These rocks occur therefore with sedimentary formations of all periods, and their ages can sometimes be determined by the ages of the sediments with which they are associated.

Igneous formations are represented on the geologic maps by patterns of triangles or rhombs printed in any brilliant color. When the age of a formation is not known the letter-symbol consists of small letters which suggest the name of the rocks; when the age is known the letter-symbol has the initial letter of the appropriate period prefixed to it.

(4) *Altered rocks of crystalline texture.*—These are rocks which have been so changed by pressure, movement and chemical action that the mineral particles have recrystallized.

Both sedimentary and igneous rocks may change their character by the growth of crystals and the gradual development of new minerals from the original particles. Marble is limestone which has thus been crystallized. Mica is one of the common minerals which may thus grow. By this chemical alteration sedimentary rocks become crystalline, and igneous rocks change their composition to a greater or less extent. The process is called *metamorphism* and the resulting rocks are said to be metamorphic. Metamorphism is promoted by pressure, high temperature and water. When a mass of rock, under these conditions, is squeezed during movements in the earth's crust, it may divide into many very thin parallel layers. When sedimentary rocks are formed in thin layers by deposition they are called *shales;* but when rocks of any class are found in thin layers that are due to pressure they are called *slates.* When the cause of the thin layers of metamorphic rocks is not known, or is not simple, the rocks are called *schists,* a term which applies to both shaly and slaty structures.

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

Metamorphic crystalline formations 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 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 only.

USES OF THE MAPS.

Topography.—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 may guide the traveler, who can determine in advance or follow continuously on the map his route along strange highways and byways.

It may serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold.

It may save the engineer preliminary surveys in locating roads, railways and irrigation ditches.

It provides educational material for schools and homes, and serves all the purposes of a map for local reference.

Areal geology.—This sheet shows the areas occupied by the various rocks of the district. On the margin is a *legend,* which is the key to the map. To ascertain the meaning of any particular colored pattern on the map the reader should look for that color and pattern 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 colored 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 of the district. The formations are arranged in groups according to origin—superficial, sedimentary, igneous or crystalline; thus the processes by which the rocks were formed and the changes they have undergone are indicated. Within these groups the formations are placed in the order of age so far as known, the youngest at the top; thus the succession of processes and conditions which make up the history of the district is suggested.

The legend may also contain descriptions of formations or of groups of formations, statements of the occurrence of useful minerals, and qualifications of doubtful conclusions.

The sheet presents the facts of historical geology in strong colors with marked distinctions, and is adapted to use as a wall map as well as to closer study.

Economic geology.—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 geologic formations which appear on the map of areal geology are shown in this map also, but the distinctions between the colored patterns are less striking. 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 in this map, and it is accompanied at each occurrence by the name of the mineral mined or the stone quarried.

Structure sections.—This sheet exhibits the relations existing beneath the surface among the formations whose distribution on the surface is represented in the map of areal geology.

In any shaft or trench the rocks beneath the surface may be exposed, and in the vertical side of the trench the relations of different beds may be seen. A natural or artificial 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.*

Mines and tunnels yield some facts of underground structure, and streams carving canyons through rock masses cut sections. But the geologist is not limited to these opportunities of direct observation. 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. Thus it is possible to draw sections which represent the structure of the earth to a considerable depth and to construct a diagram exhibiting what would be seen in the side of a trench many miles long and several thousand feet deep. This is illustrated in the following figure:

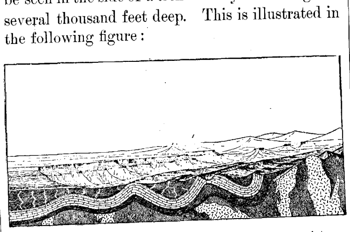

Fig. 2. Showing a vertical section in the front of the picture, with a landscape above.

The figure represents a landscape which is cut off sharply in the foreground by a vertical plane. The landscape exhibits an extended plateau on the left, a broad belt of lower land receding toward the right, and mountain peaks in the extreme right of the foreground as well as in the distance. The vertical plane cutting a section shows 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:

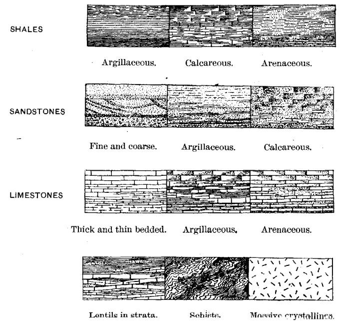

Fig. 3. Symbols used to represent different kinds of rocks.

The plateau in Fig. 2 presents toward the lower land an escarpment which is made up of cliffs and steep slopes. These elements of the plateau front correspond to horizontal beds of sandstone and sandy shale shown in the section at the extreme left, the sandstones forming the cliffs, the shales constituting the slopes.

The broad belt of lower land is traversed by several ridges, which, where they are cut off by the section, are seen to correspond to outcrops of sandstone that rise to the surface. The upturned edges of these harder 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 thicknesses 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. Where they are now bent they must, therefore, have been folded by a force of compression. The fact that strata are thus bent is taken as proof that a force exists which has from time to time caused the earth's surface to wrinkle along certain zones.

The mountain peaks on the right of the sketch are shown in the section to be composed of schists which are traversed by masses of igneous rock. The schists are much contorted and cut up by the intruded dikes. Their thickness cannot be measured; their arrangement underground cannot be inferred. Hence that portion of the section which shows the structure of the schists and igneous rocks beneath the surface delineates what may be true, but is not known by observation.

Structure sections afford a means of graphic statement of certain events of geologic history which are recorded in the relations of groups of formations. In Fig. 2 there are three groups of formations, which are distinguished by their subterranean relations.

The first of these, seen at the left of the section, is the group of sandstones and shales, which lie in a horizontal position. These sedimentary strata, which accumulated beneath water, are in themselves evidence that a sea once extended over their expanse. They are now high above the sea, forming a plateau, and their change of elevation shows that that portion of the earth's mass on which they rest swelled upward from a lower to a higher level. The strata of this group are parallel, a relation which is called *conformable.*

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

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second group on 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 or upon their upturned and eroded edges, the relation between the two is *unconformable,* and their surface of contact is an *unconformity.*

The third group of formations consist of crystalline schists and igneous rocks. At some period of their history the schists have been 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 group. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of strata of the second group. During this interval the schists suffered metamorphism and were the scene of eruptive activity. The contact between the second and third groups, marking an interval between two periods of rock formation, is an unconformity.

The section and landscape in Fig. 2 are hypothetical, but they illustrate only 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 sections.—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 characters of the rocks, to the thicknesses of sedimentary formations and to the order of accumulation of successive deposits.

The characters of the rocks are described under the corresponding heading, and they are indicated in the columnar diagrams by appropriate symbols, such as are used in the structure sections.

The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest thicknesses. 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 of the descriptions and of the lithologic symbols in the diagram. The oldest formation is placed at the bottom of the column, the youngest at the top. The strata are drawn in a horizontal position, as they were deposited, and igneous rocks or other formations which are associated with any particular stratum are indicated in their proper relations.

The strata are divided into groups, which correspond with the great periods of geologic history. Thus the ages of the rocks are shown and also the total thickness of deposits representing any geologic period.

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, not only by the description of its character, but by its name, its letter-symbol as used in the maps and their legends, and a concise account of the topographic features, soils, or other facts related to it.

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Director.

DESCRIPTION OF THE GOLD BELT.

GEOGRAPHIC RELATIONS.

The Gold Belt of California includes that portion of the Sierra Nevada lying between the parallels of 37° 30′ and 40°. This area is bounded on the east by the Great Basin and on the west by the Great Valley of California, comprising about 17,000 square miles. The Sierra Nevada here forms a single range sloping somewhat abruptly towards the Great Basin and gradually towards the Great Valley of California. Within this area lie the chief gold deposits of the state, though by no means all of the area is auriferous. At the northern limit the deposits are scattered over nearly the entire width of the range, while to the south the productive region narrows down to small dimensions. The mass of the range south of Alpine county is comparatively barren. North of the 40th parallel the range is probably not without deposits, but the country is flooded with lavas which effectually bury them.

GENERAL GEOLOGY.

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

The southern portion of the range is composed of granite. The central and northern part, west of longitude 120° 30′, consists prevailingly of schists which have been produced by intense metamorphism of both ancient sediments and igneous rocks, and it is chiefly but not solely in these schists that the auriferous quartz veins occur. The trend of the bands of altered sediments and of the schistose structure is generally from northwest to southeast, parallel to the trend of the range, but great masses of granite and other igneous rocks have been intruded among these schists, forming irregular bodies which interrupt the regular structure and which are generally bordered each by a zone of greater metamorphism. These schists with their associated igneous masses form the older of two great groups of rocks recognized in the Sierra Nevada. This group is generally called the "Bedrock series."

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

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

The history of the Sierra Nevada, even so far as it is recorded in the rocks, has not yet been fully made out; but the events of certain epochs are recognized, and these can be stated in a brief summary in the order in which they occurred.

THE PALEOZOIC ERA.

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

At the close of the Carboniferous the Paleozoic land area of western Nevada subsided, and during a portion or all of the Juratrias period it was at least partly covered by the sea. At the close of the Juratrias (according to the latest paleontological determinations) the Sierra Nevada was upheaved as a great mountain range, the disturbance being accompanied by the intrusion of large amounts of granite.

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

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

The Paleozoic sediments of the Gold Belt consist of quartzite, mica-schist and clay-slate with limestone lentils. Rounded crinoid stems, *Lithostrotion*, *Fusulina*, *Clisiophyllum*, *Spirifera* and other genera have been found, chiefly in the limestone, and indicate that the age of the rocks is lower Carboniferous. The Paleozoic sediments are finely exposed in Calaveras county and they will be designated on the Gold Belt sheets as the Calaveras formation. It is probable that some areas mapped as Calaveras may contain strata earlier or later than the Carboniferous.

During an epoch of upheaval some time after the close of the Carboniferous period, these sedimentary strata were raised, forming part of a mountain range. The beds were folded and compressed, rendering them schistose. Granite and other igneous rocks were intruded among them, and they assumed somewhat the relations which they now exhibit in the Sierra Nevada. But those masses which now form the surface were then deeply buried in the foundations of the range. They have been brought to the present surface by subsequent uplifts and prolonged erosion.

JURATRIAS PERIOD.

The areas of land and sea which existed during the earlier part of this period are scarcely known. Strata showing the former presence of the sea have been recognized in the southeastern portion of the range at Mineral King, where the sediments are imbedded in eruptive granite, and at Sailor canyon, a tributary of American river. Rocks of this age occur generally throughout the Great Basin and the Rocky mountains, but the interior sea or archipelago, in which they were deposited, was apparently separated from the Pacific by a land mass stretching the length of the Sierra Nevada. This land probably originated in the upheaval some time after the close of the Carboniferous, and toward the end of the Juratrias period its area became so extensive that the waters of the Pacific seem to have been completely separated from the interior seas. This conclusion is based upon the fact that fossils of Jurassic age in California, so far as known, have closer relations with those of Russia than with those of eastern America of the same age.

The genus *Aucella*, whose shell occurs in Russia, flourished on the Pacific coast until well into the Cretaceous and is distributed from Alaska to Mexico. In the Juratrias strata it is associated with ammonites of the genera *Perisphinctes*, *Cardioceras* and *Amaltheus*, closely related to forms of the European upper Jurassic age.

The strata in which these fossils occur are prevailingly clay slates which are locally sandy and contain pebbles of rocks from the Calaveras formation. Thus it is evident that they were deposited near the shore of a land composed of the ancient schists, and the generally fine character of the sediment shows that the land which occupied the area of the Sierra Nevada can not have been very mountainous. These strata now occur in two narrow bands along the western base of the range and are called the Mariposa formation, from the fact that they are well exposed near that place.

Soon after the Mariposa formation had been deposited the region underwent uplift and compression. The result of uplift was the development of a mountain range along the line of the Sierra Nevada. The Coast Range also was probably raised at this time. The action of the forces was such as to turn the Mariposa strata into a vertical position, shattering the rock and deforming it, and producing some metamorphism. The clay shales now have a slaty structure, produced by pressure, which appears to coincide usually with the bedding.

The Mariposa beds carry numerous gold veins, the most important group of which constitutes the famous "Mother lode." It is believed that a great part of the gold veins were formed after this upheaval and as a consequence of it, occupying fissures opened during the uplift. It was a time of intense eruptive activity. The Mariposa beds were injected with granite, and vast masses of diabase, associated with other basic igneous rocks, date from this time. There is evidence that igneous rocks were intruded in varying quantities at different times, but that the great mass of the intrusive igneous rocks accompanied or immediately followed the upheavals.

The epoch of disturbance following the deposition of the Mariposa beds was the last of those which produced the vertical arrangement of the Auriferous slate series. The strata of succeeding epochs are sediments and tuffs. Lying nearly horizontally or at low angles they prove that since they were accumulated the rock mass of the Sierra Nevada has not undergone much compression. But the fact that they now occur high above sea level is evidence that the range has been raised in more recent time.

CRETACEOUS PERIOD.

By the close of the Juratrias the interior sea of North America had receded from the eastern base of the Sierra Nevada eastward beyond the Rocky mountains. From the western part of the continent the waters of the Pacific had retired in consequence of the Juratrias uplift. The valley of California was then partly under water and the Coast Ranges seem to have been represented by a group of islands, but during the later Cretaceous the region subsided and the sea substantially overflowed it. Through gradual changes of level the areas of deposition of marine sediments were shifted during the Cretaceous and Neocene periods, and late in the Neocene the sea once more retreated west of the Coast Range. The deposits laid down during this last occupation of the valley of California belong to the "Superjacent series."

The advance of the sea spread a conglomerate over the eastern part of the valley in later Cretaceous time, and sandstone and shale were subsequently deposited. This formation is well developed near Chico, California, and at Folsom on the Sacramento sheet. It has been called the Chico formation.

EOCENE PERIOD.

In consequence of slow changes of level without marked disturbance of the Chico formation, a later deposit formed, differing from it somewhat in extent and character. The formation has been called the Tejon (Tahone). It appears in the Gold Belt region only at the Marysville buttes, but it is extensively developed in the southern and western portions of the valley of California.

NEOCENE PERIOD.

The Miocene and Pliocene ages, forming the later part of the Tertiary era, have here been united under the name of the Neocene period. During the whole of the Neocene the great valley of California seems to have been under water, forming a gulf connected with the sea by one or more sounds across the Coast Range. Along the eastern side of this gulf was deposited during the earlier part of the Neocene period a series of clays and sands to which the name Ione formation has been given. It follows the Tejon and appears to have been laid down in sensible conformity to it. Marine deposits of the age of the Ione formation appear within the Gold Belt only in the Marysville buttes. Along the eastern shore of the gulf the Sierra Nevada, at least south of the 40th parallel, during the whole of the Neocene, and probably also during the Eocene and latest Cretaceous, formed a land area drained by numerous rivers. The shore line at its highest position was several hundred feet above the present level of the sea, but it may have fluctuated somewhat during the Neocene period. The Ione formation appears along this shore line as brackish water deposits of clays and sands, and frequently it contains beds of lignite.

The drainage system during the Neocene had its sources near the modern crest of the range, but the channels by no means coincided with those of the present time. The auriferous gravels for the most part accumulated in the beds of these Tertiary rivers, the gold being derived from the croppings of veins. Such gravels could accumulate only where the slope of the channel and the volume of water were sufficient to remove the silt while allowing the coarser or heavier masses to sink to the bottom with the gold.

The climate of the late Neocene was warm and humid, much wetter than it would have been if the great valley had been above water, and erosion was correspondingly rapid.

A mountain-building disturbance occurred during the Neocene period. This was caused by pressure acting from the S.-SW. toward the N.-NE. with a downward inclination. One effect of this pressure was to induce movements on a network of fissures, often of striking regularity, intersecting large portions of the range. It is not improbable that this fissure system originated at this time, but there are fissures of greater age. This disturbance also initiated an epoch of volcanic activity accompanied by floods of lavas* consisting of rhyolite, andesite and basalt, which continued to the end of the Neocene. These lavas occupy small and scattered areas to the south, increasing in volume to the north until, near the 40th parallel, they cover almost the entire country. They were extruded mainly along the crest of the range and often followed fissures belonging to the system mentioned above. The recurrent movements on the fissures were probably accompanied by an increase in the development of the fissure system. An addition to the gold deposits of the range attended this period of volcanic activity.

When the lavas burst out they flowed down the river channels. Sometimes they were not sufficient to fill the streams, and are now represented by layers of "pipe clay" or similar beds in the gravels. These minor flows were chiefly rhyolite. The later andesitic and basaltic eruptions were of great volume, and for the most part completely choked the channels into which they flowed. The rivers were thus obliged to seek new channels—substantially those in which they now flow.

Fossil leaves have been found in the pipe clay and other fine sediments at numerous points. Magnolias, laurels, figs, poplars and oaks are represented. The general facies of the flora is thought to indicate a low elevation and has been compared with that of the flora of the South Atlantic coast of to-day.

PLEISTOCENE PERIOD.

During Cretaceous and Tertiary time the older Sierra Nevada mountains had been reduced by erosion to a range with gentle slopes. An elevation of the range doubtless attended the Neocene disturbance above referred to, and minor dislocations probably recurred at intervals; but at the close of the Tertiary occurred a greater uplift which was accompanied by the formation of normal faults widely distributed through the range, particularly along the eastern escarpment, where they form a well marked zone to the west of Mono lake and Owen lake. As a consequence of this

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

elevation, the streams, having greater fall, cut new and deep canyons in the hard but shattered base of the preexisting mountains.

A period of considerable duration elapsed between the emission of the lava flows which displaced many of the rivers and the time at which the higher Sierra was covered by glaciers. In the interval most of the deep canyons of the range were cut out. Such, for example, are the Yosemite valley on the Merced river, the great canyon of the Tuolumne and the canyon of the Mokelumne. The erosion of these gorges was often facilitated by the fissure system referred to above, and many of the rivers of the range follow one or other set of parallel fissures for a long distance.

It is a question at what point the limit between the Neocene and Pleistocene should be drawn. In the eastern United States it has become usual to regard the beginning of the Glacial Epoch as the close of the Neocene. If it could be shown that the glaciation of the Sierra was coeval with that of northeastern America a corresponding division would be adopted. It is believed, however, that glaciation was a much later event in California than in New England, and that the close of the Neocene can not be put later than the great andesitic flows.

The Sierra, from an elevation of about 5000 feet upwards, was long buried under ice. The ice did not to any notable extent erode the solid rock in the area which it covered. It seems rather to have protected it from erosion while intensifying erosion at the lower elevations, just as the lava cap would do. Small glaciers still exist in the Sierra.

There is no valid reason to believe that the Sierra has undergone any great or important dynamic disturbances since the beginning of glaciation. The whole mass, however, has risen bodily a few hundred feet during that time, as is shown by the raised beaches along the coast line of California, recent shells in the Contra Costa hills, and other significant indications.

IGNEOUS ROCKS.

Rocks of igneous origin form a considerable part of the Sierra Nevada. The most abundant igneous rock in the Sierra Nevada is granite, embracing under this term both granodiorite and granite-porphyry. Rocks of the granitic series are believed to have consolidated under great pressure and to have been largely intruded into overlying formations at the time of great upheavals. Thus granite is a deep seated rock and is exposed only after great erosion has taken place.

The rocks called diabase and augite-porphyrite on the Gold Belt maps are not always intrusive, but to some extent they represent surface lavas and correspond to modern basalt and augite-andesites. In like manner some of the hornblende-porphyrites correspond to hornblende-andesites.

GLOSSARY OF ROCK NAMES.

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

Gabbro.—A granular intrusive rock consisting principally of diallage, or allied monoclinic pyroxene, or a rhombic pyroxene, together with soda-lime and lime feldspars.

Gabbro-diorite.—This term has been used to indicate areas of gabbro containing primary and secondary hornblende, and for areas containing intimate mixtures of gabbro and diorite.

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

Peridotite.—An intrusive granular rock generally composed principally of olivine and pyroxene; frequently of olivine alone.

Serpentine.—This is composed of the mineral serpentine, and often contains unaltered remains of feldspar, pyroxene or olivine; serpentine is frequently a decomposition product of rocks of the peridotite and pyroxenite series.

Diorite.—A granular intrusive rock consisting principally of soda-lime feldspars and hornblende.

Granodiorite (quartz-mica-diorite).—A granular intrusive rock having the habitus of granite, and carrying feldspar, quartz, biotite and hornblende. The soda-lime feldspars usually are considerably and to a variable extent in excess of the alkaline feldspars. The granitic rock might be called quartz-mica-diorite, but this term, besides being awkward, does not sufficiently suggest its close relationship with granite. It has therefore been decided to name it "granodiorite."

Granite-porphyry.—A granite with large porphyritic potash-feldspars.

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

Diabase.—An intrusive or effusive granular rock composed of augite and soda-lime feldspars. The augite is often partly or wholly converted into green fibrous hornblende or uralite.

Augite-porphyrite.—A more or less fine grained rock of the diabase series, with porphyritic crystals of augite and sometimes soda-lime feldspars.

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

Quartz-porphyrite.—An intrusive or effusive porphyritic rock consisting of quartz and soda-lime feldspar, together with a small amount of hornblende or biotite. It is connected by transitions with granodiorite and with the following:

Quartz-augite-porphyrite.—This is the same as the above excepting that it contains augite. It is connected by transitions with augite-porphyrites and with quartz-porphyrites.

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

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

Andesite.—An effusive porphyritic rock of Tertiary or later age. The essential constituents are soda-lime feldspars and ferro-magnesian silicates. The silica is usually above 56 per cent.

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

DESCRIPTION OF THE PLACERVILLE SHEET.

TOPOGRAPHY.

The Placerville sheet comprises a part of the middle slope of the Sierra Nevada in Placer, Eldorado and Amador counties. The elevations above sea level range from 300 feet in the southwest corner to 5,400 feet in the northeast. The prevailing character of the topography between the rivers is that of irregular and undulating plateaus cut by steep ravines and gulches; in the higher eastern parts gently sloping tables are formed by the surfaces of the Neocene volcanic flows. The high bedrock ridges of the Slate mountains rise above these flows in the northeastern part of the sheet. The three forks of the American river and the three forks of the Cosumnes have cut precipitous canyons through this table land. These canyons attain a maximum depth of 2,500 feet and their slopes are inclined at a maximum angle of about 40°.

GEOLOGY.

BED-ROCK SERIES.

[This series consists of the sedimentary rocks which were driven into a nearly vertical position at or before the post-Mariposa upheaval, together with the associated igneous masses.]

AURIFEROUS SLATES.

Calaveras formation.—This group, which includes the oldest strata in the region, consists of two belts of rocks, one lying to the east and one to the west of the main belt of Mariposa slates. The series to the west consists of highly compressed black slates and black sandstones, and fine grained siliceous rocks (pthanites), the latter at least in many cases intimately connected with and derived from limestone; the black slates are not very fissile, but weather into irregular fragments. In the northwestern corner of the sheet there are a few isolated limestone masses. The one crossing the north fork of the American river is about 300 feet wide and about two miles long. Fossils indicating Carboniferous age have been found in the limestone masses southeast of Applegate's near the Central Pacific railroad, and also in the limestone mass exposed in the middle fork of the American river, two miles above Mammoth bar. In both places the characteristic forms are corals. This western belt of the Calaveras formation contains areas of fragmental volcanics and dikes and massifs of basic igneous rocks, chiefly diabase and hornblende-porphyrites. The Calaveras formation east of the Mariposa beds consists of a succession of clay slate, sandstones and quartzites with lentils of limestone, and along the south fork of the Cosumnes river there is a good deal of mica-schist. The clay slate is, when fresh, very black and fissile, weathering into smooth fragments with sometimes almost a silvery luster. The basic igneous rocks, so abundant in the western belt, occur to a minor extent in the rocks of the Calaveras formation east of the Mariposa beds.

All of the limestone masses are more or less crystalline and the fossils are very poorly preserved. In the limestone area, four miles southeast of Placerville, frequently occur crinoid stems which by their rounded forms indicate Paleozoic age.

The whole series up to the eastern margin has a steep easterly dip. Although differing in details the series is essentially similar in character throughout and might be described as the siliceous series. The strike of this siliceous series is north and northwest, except in the region southwest of Grizzly Flat, where the strike for a considerable distance is northeast. This change of strike appears to be due to the intrusion of the granodiorite.

Mariposa slates.—The Mariposa beds consist almost entirely of black slates not so much altered as those of the Calaveras formation. When fresh they are of a deep black, but weathering changes them quickly to a light rusty brown. A little south of the Mile Hill toll-house in the northwest corner of the sheet appears a series of dark, partly volcanic sandstones and breccias, intercalated among the slates. This series continues up towards Colfax. It is well exposed along the canyon of the north fork of the American river, where it enters from the Colfax sheet adjoining at the north. The belt of the Mariposa slates contains numerous highly auriferous quartz veins. Ammonites and belemnites are found in these slates in Eldorado county. These fossils are similar to upper Jurassic forms of Europe. Another belt of Mariposa slates occurs in the lower foot-hills, extending southeast from Folsom. There are small patches belonging to this belt on the southwest corner of the sheet. The quartz veins in this western belt seldom contain gold in paying quantities.

IGNEOUS ROCKS.

Diabase and amphibolite-schist.—In the Carboniferous of the northwestern corner of the sheet are numerous dike-like masses of a fine grained dark green diabase usually partly or wholly uralitized (that is, with the pyroxene converted into hornblende).

The amphibolites of the large area near the western margin of the sheet are dark green rocks, medium to fine grained, sometimes consisting almost entirely of amphibole, and are usually distinctly schistose with steep eastern dip. A part of them, especially north of Latrobe, are quite coarse grained. Although the larger part of them have been derived from diabase, it is not improbable that in many cases the original rock was gabbro. The two areas of light colored amphibole and talc rocks crossed by the road from Oleta to Bridgeport were probably pyroxenite originally. Some specimens contain pyroxene altering to tremolite and serpentine.

The long dike of diabase which follows the western contact between the western belt of the Calaveras formation and the Mariposa slates is quite variable in composition; the southern part, up to the granodiorite area of Coloma, is principally composed of a massive, dark green diabase-breccia; while to the north of this area of granodiorite it is roughly schistose and consists partly of massive dark green diabase and diabase-porphyrite with large white feldspar crystals, and partly of breccia of varying fineness made up of these rocks. The large area of amphibolite-schist north of Greenwood which is inclosed in the black Mesozoic slates is derived from diabase and diabase-porphyrite by dynamo-metamorphism, that is, metamorphism induced by intense pressure and movement. Near Greenwood there is altered diabase-porphyrite going over into normal amphibolite-schist. The Mesozoic slates contain a great number of similar smaller streaks and masses of amphibolitic rocks.

Gabbro-diorite.—West of Shingle Springs occurs an area of coarse grained gabbro, the pyroxene in which is partly converted into uralite; it is a compact and hard rock presenting great resistance to weathering. Large parts of this area are occupied by rough and rocky hills covered with grease wood (*Adenostoma*). Along the contacts with the amphibolite it is plain that the gabbro-diorite is the younger rock and intrusive in the former.

Serpentine, pyroxenite, peridotite, gabbro and garnet-pyroxene rock.—The Carboniferous slates north of Coloma contain several areas of serpentine in many places intimately mixed with amphibolite-schists. Smaller masses of pyroxenite and peridotite occur in them, and from these rocks the serpentine has probably been derived. The Coloma area of granodiorite cuts off the serpentine masses in the same manner as it has cut off the diabase dike near Placerville. South of that area the serpentine continues as lenticular and dike-shaped masses in the amphibolite with which it is intimately connected; so much so, indeed, that frequently it is difficult to outline the areas. East of Shingle Springs the serpentine contains small masses of a dark colored gabbro as well as a dike of quartz-porphyrite. A small mass of garnet-pyroxene rock occurs four miles southeast of Latrobe.

The large dike in the slates of the Calaveras formation entering the Placerville sheet near Volcanoville is in many respects interesting and complex. It is usually referred to as the "serpentine belt," and is continuous for about forty miles north of this sheet. The primary rock of this dike varies from gabbro or diorite to pyroxenite and peridotite, although on this sheet no considerable areas of either of the two latter rocks are present. Masses of serpentine and amphibolite-schist, often very difficult to separate from the gabbro, occur at frequent intervals along the belt. Both must be considered as alteration products of the rocks mentioned above. Near the mouth of Rock creek on the south fork of the American river the dike is cut off by granodiorite; south of that area it appears again somewhat narrower and principally composed of serpentine, although along with it occur small masses of peridotite and gabbro. The serpentine area that lies just southwest of Bridgeport may perhaps be considered as part of this serpentine belt.

Granodiorite, quartz-porphyrite and hornblende-porphyrite.—Intrusive in the slates of the Calaveras formation on the eastern part of the sheet are several large isolated areas of granodiorite. This rock usually metamorphoses the surrounding slates into micaceous and quartzitic schists; the width of the contact zone varies from several hundred feet up to three-quarters of a mile, or in some cases even more; near Grizzly Flat the contact metamorphics frequently carry andalusite. At Grizzly Flat there are near the granodiorite contact small masses of a gabbroitic rock going over into granodiorite. The Coloma area of granodiorite is similar to the others in most respects, except that in some places the black mica is absent, and it has a tendency to grade into quartz-porphyrite. There is without doubt a gradual transition between the two rocks, as shown in the long projecting offshoots or apophyses at the southern end of the area.

The quartz-porphyrite is a light colored rock with porphyritic feldspars and quartz crystals in a groundmass of grayish or greenish color and of somewhat variable texture, though it is usually fine grained. The quartz-porphyrite, as well as the granodiorite, here contains much more sodium than potassium.

Closely connected with the granodiorite is the hornblende-porphyrite; it is a medium grained rock with porphyritic feldspars and hornblendes in a groundmass of the same composition. It occurs at several places along the contacts, going over into normal granodiorite; it also occurs as dikes and isolated massifs in the serpentines and other rocks of the vicinity. The hornblende-porphyrite massifs and dikes of Big Sugar Loaf and vicinity in places contain augite and grade into rocks of the diabase series containing no hornblende.

SUPERJACENT SERIES.

[This series consists of late Cretaceous, Eocene, Neocene and Pleistocene sediments lying unconformably upon the Bed-rock series, together with the igneous rocks of the same periods.]

NEOCENE.

Auriferous gravels.—During the Neocene period the general topography of this sheet was that of a sloping table land, relieved by hills of moderate elevation. This area was drained by two river systems, one more or less closely corresponding to the forks of the present American river, and the other representing the branches of the present Cosumnes. The gravels accumulated in them are now largely covered by volcanic material. The general direction of the Neocene drainage was as follows:

The old channel of the south fork of the American river enters the eastern margin of the sheet north of Pacific House and, crossing over, passes under the lava flow at Pacific House; from there it runs under the masses of Neocene andesite for about ten miles in a west-southwest direction down to a point between the two forks of Webber creek, northeast of Newtown; crossing the south fork of Webber creek it follows the present course of that creek for a considerable distance. The center of the old channel is here eroded, but there are numerous benches remaining to indicate its approximate course. In the vicinity of Placerville there is a complicated system of channels running south or southwest and tributary to the main fork. From a point between Placerville and Diamond Springs the channel was cut in a northwesterly direction, touching Granite Hill and entering the Sacramento sheet near Pilot Hill.

In Neocene time, the north fork of the American river followed a course which is now represented for a short distance by the divide north of Long canyon. The old channel again enters the sheet under the volcanic flow somewhere west of Todd valley and emerges from beneath the southern end of the volcanic area. Its course below this point is somewhat uncertain, but must have followed the present canyon of the middle fork pretty closely. Tributary to this former course are the Neocene channels north of Georgetown and between Volcanoville and Kentucky Flat. These tributaries flowed in a general north and northwest direction. In Neocene time, as now, the Georgetown divide formed a ridge between the two forks.

The course followed by the Cosumnes during the Neocene period is not perfectly known. It is certain, however, that one of the Neocene branches corresponding to the present Cosumnes headed near Grizzly Flat, and, flowing in a southwesterly direction across the present drainage, passed Henry diggings, Omo House and Indian diggings.

The auriferous gravels in this sheet consist of strata of quartzose and metamorphic gravel resting on the bed rock and usually overlain by finer sediments, such as clay and sand. The maximum thickness is not more than one hundred feet; usually it is much less.

The accumulation of auriferous gravels probably went on throughout the Tertiary, and may have begun even earlier.

Rhyolitic beds.—The first volcanic flows which during the Neocene period came down the slopes of the Sierra from the volcanoes near the summit were rhyolitic in character. The rhyolitic beds directly overlie the auriferous gravels and are composed of white or light colored tuff usually fine grained and occasionally containing scales of black mica. This volcanic fragmentary material doubtless came down in the form of many successive mud flows. Intercalated in the tuffs are beds of quartzose and metamorphic gravel and of light colored clays and sands partly of volcanic origin. The gravels are usually somewhat auriferous. The total thickness of the rhyolitic beds is about 300 feet on the divide north of Long canyon and 400 feet in the vicinity of Newtown. Unlike the subsequent volcanic flows, the rhyolite did not spread over large areas, but only filled the valleys of the principal streams. During the interval between the rhyolitic and the subsequent andesitic eruption the former beds were considerably eroded and in places new channels were worn down to the bed rock. These, usually referred to as "cement channels," occur both north of the middle fork of the American river and in the vicinity of Placerville; in them the andesitic breccia ordinarily rests directly on shallow but rich gravel.

Andesite.—The andesitic eruptions in the high Sierra flooded the larger part of the lower slopes with volcanic mud. Substantially the whole of the area of the Placerville sheet must have been thus covered, excepting the high bed-rock ridges of the Slate mountains and, probably, the hills in the southwestern corner.

The andesitic beds, which are entirely fragmental in character, attain a maximum thickness of 700 feet on the divide north of Long canyon; in the vicinity of Placerville the thickness does not exceed 400 feet, while east of Placerville it again increases to 700. The lower part consists of heavy volcanic gravel, frequently somewhat auriferous, together with volcanic sands and tuffs; the upper part consists of a hard andesitic breccia and usually contains angular or subangular bowlders of andesite often more than a foot in diameter. The andesite is dark gray to dark brown and contains porphyritic crystals of pyroxene and hornblende, the latter slightly prevailing; the cement uniting the bowlders is light gray to light brown and consists of finely comminuted volcanic material. Nearly all of this rock has the rough and porous character which has been called asperitic.

PLEISTOCENE.

Earlier Pleistocene.—Along the rivers, and especially in the vicinity of Coloma, there are patches of gravel, from twenty to sixty feet above the present channel, which have been referred to the earlier Pleistocene. Along their upper courses below the limit of glaciation the canyons of the rivers usually are so narrow and steep that there is no room for these deposits.

Moraines resulting from Pleistocene glaciers are found in the extreme northeastern corner of the sheet. The morainal deposit here consists of a thin layer of angular fragments of granite and other rocks covering the surface of the Neocene volcanic flows, and partly the slopes of the canyons.

Alluvium.—There is but little alluvium on the Placerville sheet. Very shallow alluvial soil covers some of the valleys of the plateaus.

MINERAL RESOURCES.

Gold-bearing gravels.—J. W. Marshall's discovery of gold in 1848 was made at Coloma, on this sheet. The alluvial accumulations of gold-bearing gravels in the present rivers and creeks were the first deposits worked. They were soon exhausted and the attention of the miners was turned to the gold in older deposits. A few bars along the American and Cosumnes rivers are still washed. The Pleistocene gravel benches along the present rivers have been and are now in part worked by sluicing and hydraulic mining. The hydraulic process is applied to the Tertiary auriferous gravels near Todd valley, on the divide north of Long canyon, near Placerville and Newtown, and at several places in the neighborhood of Georgetown, as well as at Mendon, Henry diggings and Indian diggings. The largest part of these gravels is, however, covered by volcanic flows, and is usually mined by drifting along the bed rock. Drift mines are at present worked in several places near Placerville, and also near Indian diggings.

Gold-quartz veins.—By far the most important mines on the Placerville sheet are located along the so-called Mother lode in the area of the Mariposa slates, traversing the sheet from north to south. The Mother lode, which must not be considered as a continuous vein, but rather as a belt of parallel though sometimes interrupted quartz-filled fissures, can be traced continuously as far north as the St. Lawrence mine on the Georgetown divide, and along it are found many celebrated mines, such as the Church Union, the Pacific and the Gopher-Boulder. The veins run parallel to the strike of the slates or cut them at a very acute angle. The dip is nearly always to the east and usually at a somewhat less steep angle than that of the surrounding slates. Along the veins of the Mother lode frequently run narrow streaks of amphibolite-schist and serpentine. The eastward bend in the strata caused by the intrusive granodiorite in the vicinity of Placerville is closely followed by the veins.

North of the St. Lawrence mine the Mother lode is not well defined. The quartz veins are more frequently interrupted and are replaced by a peculiar kind of deposit, the seam diggings. In these a certain belt of slate is impregnated with minute irregular quartz veins, frequently very rich in gold. Such seam diggings occur at Georgia Slide, Spanish Dry Diggings, Greenwood and other places. From the St. Lawrence one branch of auriferous quartz deposits runs up towards Georgetown and Georgia Slide. Another belt begins by the Esperanza mine, north of the St. Lawrence, and continues with frequent interruptions to the Sliger vein and Oregon bar, both on the middle fork of the American river. The quartz mines near Butcher ranch, and the seam diggings in Codfish canyon on the north side of the north fork of the American river, may be considered as belonging to the same belt, but it is not possible to trace the auriferous veins of the Mother lode further.

On both sides of the great serpentine belt running from Volcanoville to the Cosumnes granodiorite area, there are near the contact numerous small quartz veins, very rich in scattered bunches and pockets of gold. Few permanent mines are found, however, along these contacts.

The only important mining district in the eastern part of the sheet is that of Grizzly Flat. A long stretch of the contact of slates and granodiorite, from the middle fork of the Cosumnes to the "Buttes," is mineralized and accompanied by a great many auriferous quartz veins, the most prominent of which is that of the Mount Pleasant mine.

Copper deposits.—Copper ores are found in very few places on the Placerville sheet, and nowhere in any considerable quantity. They occur as vein deposits along the granodiorite in the zone of contact metamorphics, and one prospect lies south of Deer creek in the amphibolite-schist. Small masses of copper pyrites occur in serpentine and amphibolite about two miles west of Greenwood.

Quicksilver deposits.—Quicksilver was formerly mined near Fanny creek, south of Big Sugar Loaf. Traces of Cinnabar are said to occur near the mouth of Hastings creek and in Clark's creek ravine one mile north from its mouth.

Chrome iron.—Deposits of chrome iron occur in California only in serpentine. On the sheet showing the economic geology two deposits are noted. Along the area described above as the "serpentine belt" many small pockets have been found.

Building-stones.—When massive, the granodiorite makes very good building-stone and is used in many places. Certain kinds of more massive rhyolitic tuffs, found at Smith's Flat and other places near Placerville, make a most excellent and easily dressed building-stone.

Black clay roofing slates are quarried at Chili bar, 4 miles north of Placerville, in the canyon of the south fork of the American river. There are at present several quarries, and the slate, which is of excellent quality, is used in many places in California. Good roofing slate could doubtless be obtained at other points in the Mariposa beds.

Militating against the development of the quarry industry is the lack of cheap transportation.

SOILS.

As previously stated, there is very little bottom land (alluvium) on the Placerville sheet.

The soil of the hills and ridges formed by secular disintegration of the underlying rock, is deep only on some slopes and lava plateaus. Many of the ridges have but a thin coating of soil. The soils formed by secular disintegration may be classed under three general heads, as red, granitic and slate soils.

Red soil.—In part derived from diabase, gabbro-diorite and amphibolite, and in part from the andesitic lavas. The two kinds differ somewhat, but both are rich in plant food and admirably adapted to horticulture.

Granitic soil.—Derived from granodiorite. This soil is somewhat poorer than the red soil, but being usually deeper, warmer and easier to work, it is often preferred.

Slate soil.—Derived from the sedimentary slates. It is usually shallow and the poorest of the three.

WALDEMAR LINDGREN,
H. W. TURNER,
Geologists.

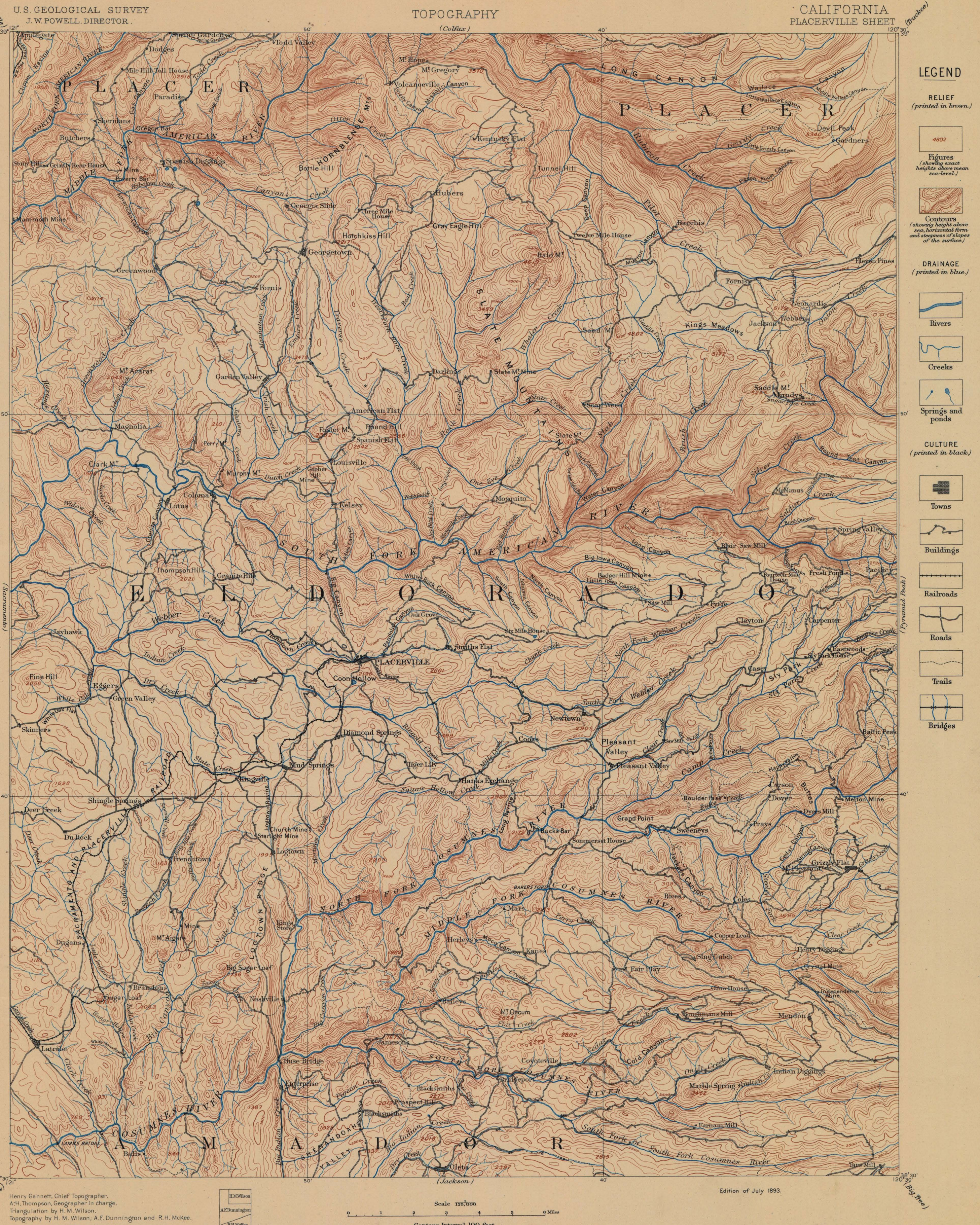
GEORGE F. BECKER,
Geologist in charge.

December, 1892.

U.S. GEOLOGICAL SURVEY
J.W. POWELL, DIRECTOR.

TOPOGRAPHY

CALIFORNIA
PLACERVILLE SHEET



Henry Gannett, Chief Topographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by H.M. Wilson, A.F. Dunnington and R.H. McKee.
Surveyed in 1887.

Scale 1/125,000

Contour Interval 100 feet

Edition of July 1893.

(Smartsville) U.S. GEOLOGICAL SURVEY
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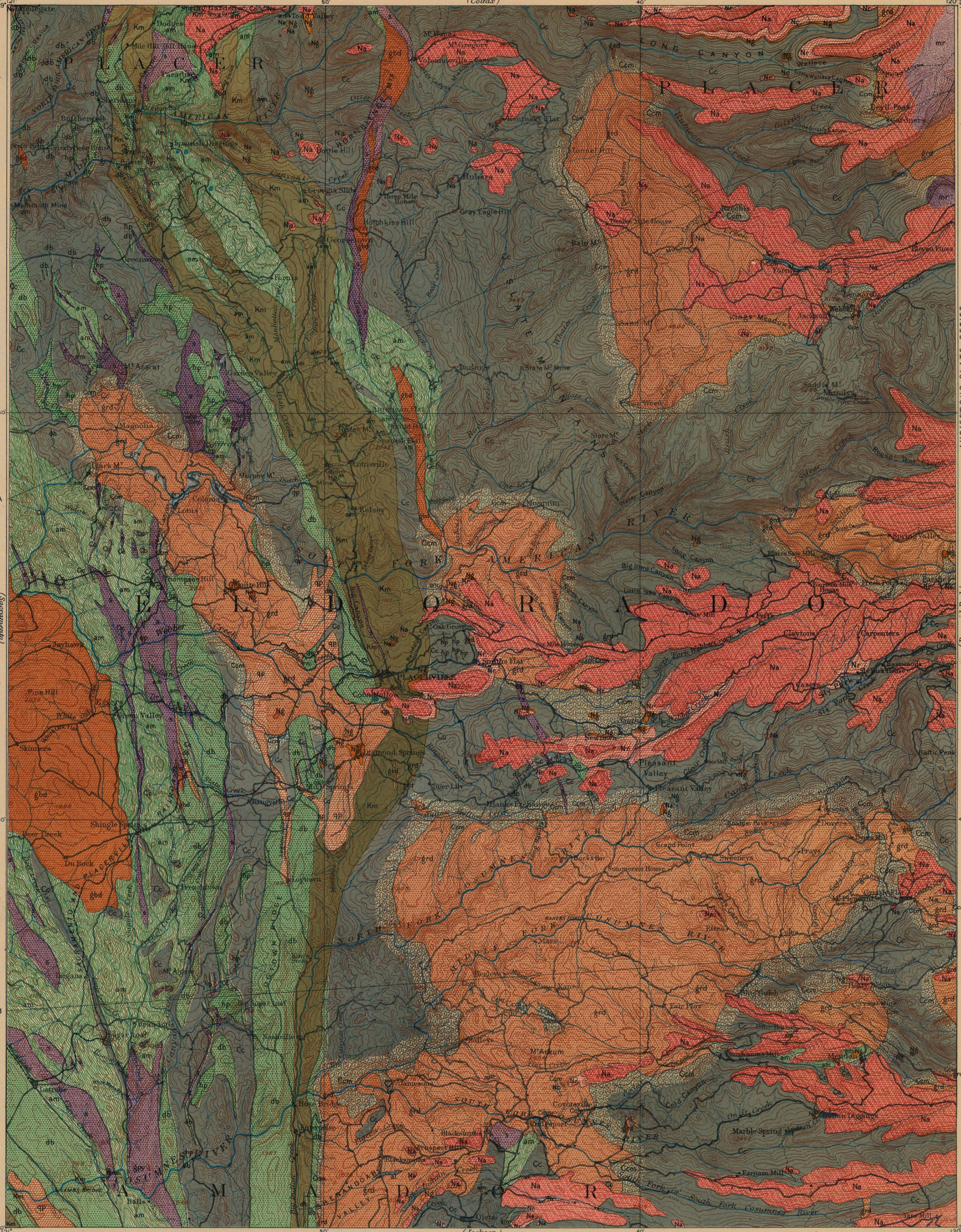
AREAL GEOLOGY

CALIFORNIA
PLACERVILLE SHEET (Truckee)

(Colfax)

39° 121° 50' 40' 120°30' 39°



38°30' 121° 50' (Jackson) 40' 120°30' 38°30'

(Sacramento) (Pyramid Peak) (Lodi) (Big Tree)

LEGEND

SUPERFICIAL

PLEISTOCENE

LATE

al — Alluvium (bottom lands)

EARLIER

grv — River gravels (containing gold)

mr — Moraines

SEDIMENTARY

NEOCENE

Ng — Auriferous river gravels

SEDIMENTARY (metamorphic)

AURIFEROUS SLATE SERIES

CRETACEOUS

Km — Mariposa slates. (black clay slates either early Cretaceous or late Jurassic containing numerous rich gold veins. Roofing slates)

CARBONIFEROUS

Cc — Calaveras formation (Slate, quartzite, limestone and mica-schist of Carboniferous age and possibly in part early Mesozoic as well as older Paleozoic. Contains gold quartz veins)

Ccm — Contact metamorphic rock (of same age as Calaveras formation. Mica-schist and quartz-schist containing some copper deposits)

IGNEOUS

NEOCENE

Na — Andesite (fragmental)

Nr — Rhyolite (fragmental with some clays and gravels)

AGE OF MARIPOSA SLATES AND OLDER

grd — Granodiorite

gbd — Gabbrodiorite

qp — Quartz-porphyrite

hp — Hornblende-porphyrite

db — Diabase (in part diabase-porphyrite and diabase-tuff)

pr — Peridotite

py — Pyroxenite

gpy — Garnet-pyroxene Rock

s — Serpentine (containing chrome iron deposits)

DYNAMOMETAMORPHIC

am — Amphibolite (derived from diabase, gabbro etc; containing some copper deposits and gold quartz veins)

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H.M.Wilson | A.F.Dunnington | R.H.McKee

Scale $\frac{1}{125,000}$

0 1 2 3 4 5 6 Miles

Contour Interval 100 feet

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Lindgren | Turner

Geo.F. Becker Geologist in Charge.
Geology by W. Lindgren and H.W. Turner.
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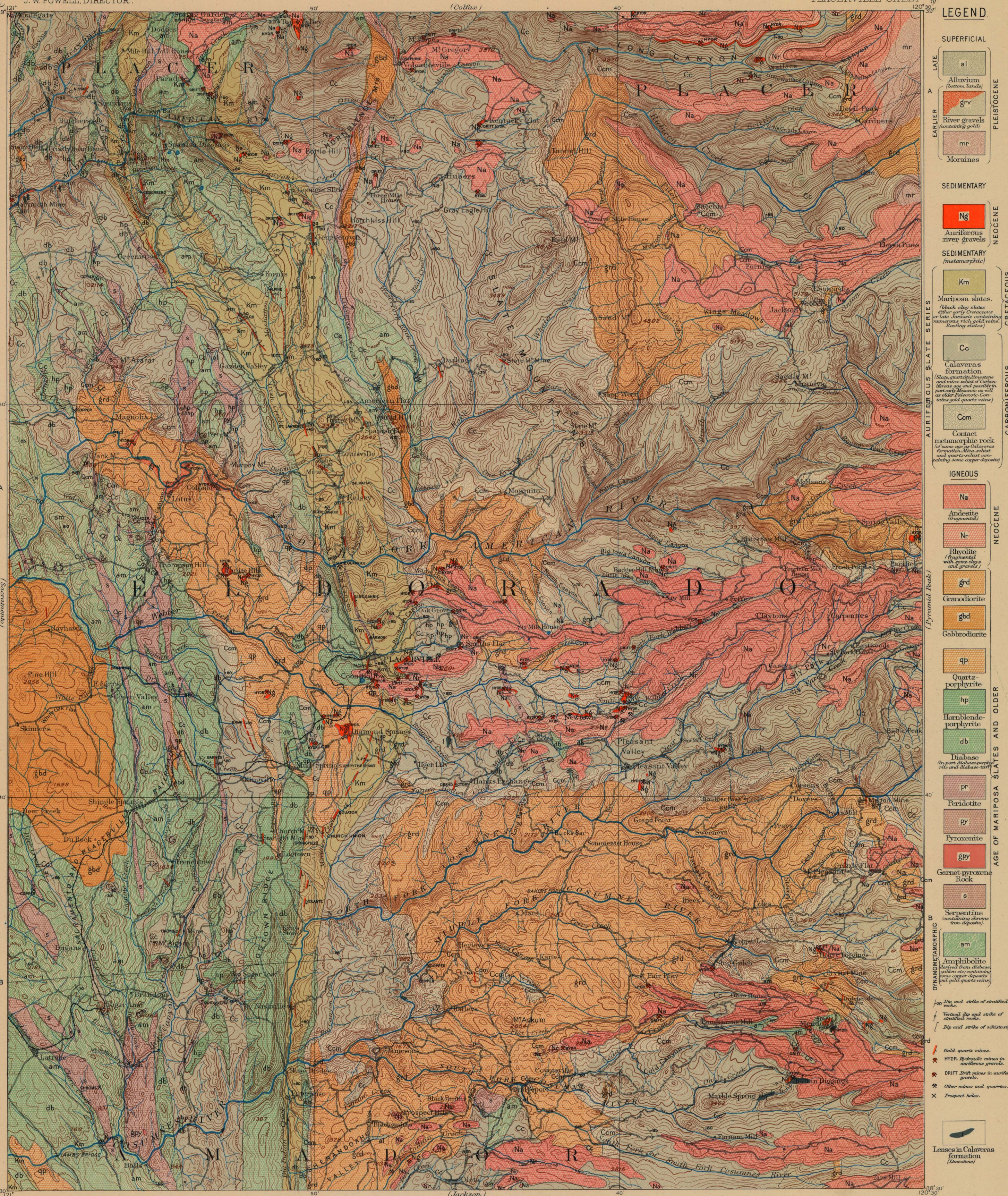
ECONOMIC GEOLOGY

CALIFORNIA
PLACERVILLE SHEET



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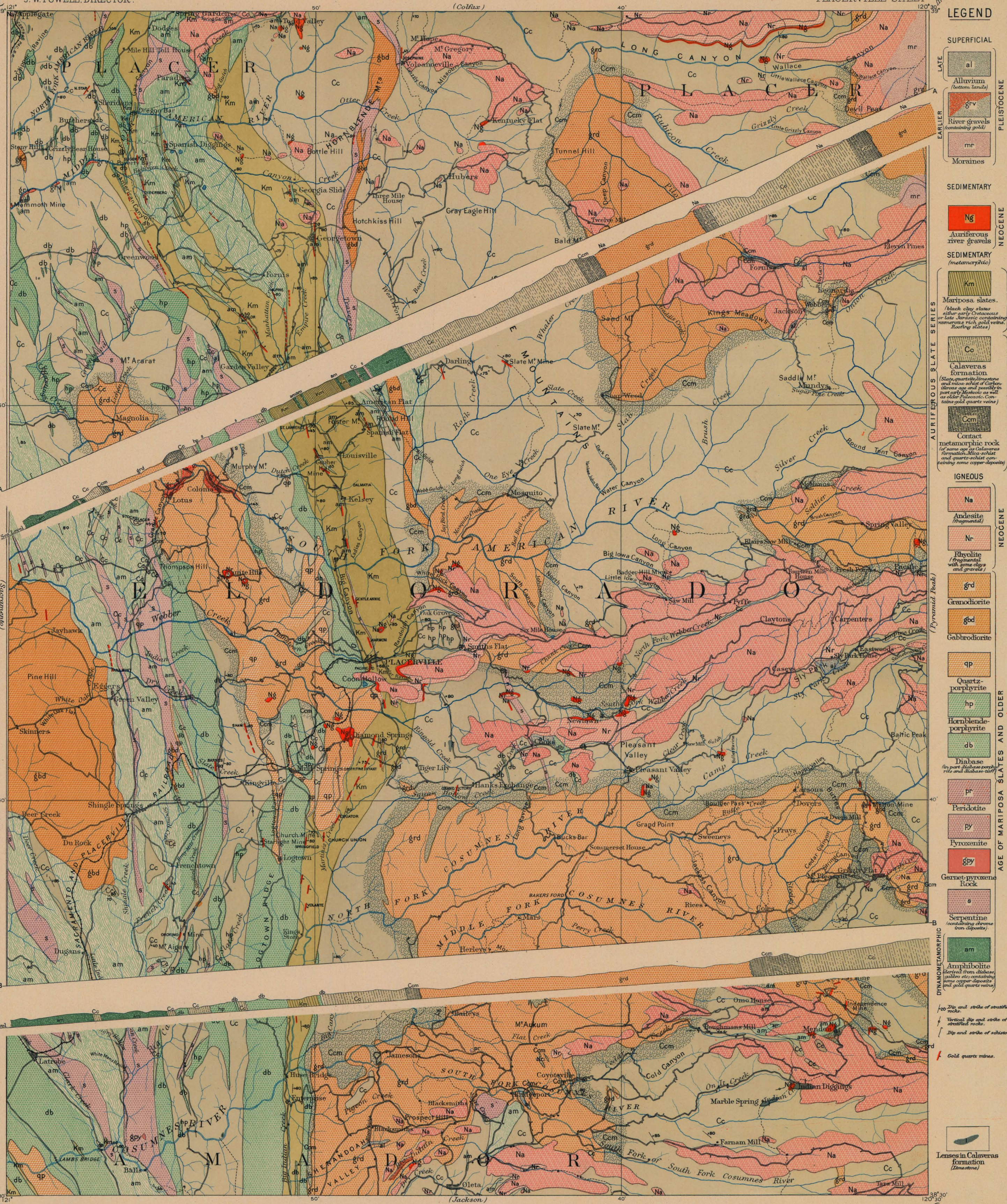
STRUCTURE SECTIONS

CALIFORNIA
PLACERVILLE SHEET



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