DEPARTMENT OF THE INTERIOR

UNITED STATES GEOLOGICAL SURVEY

J. W. POWELL, DIRECTOR

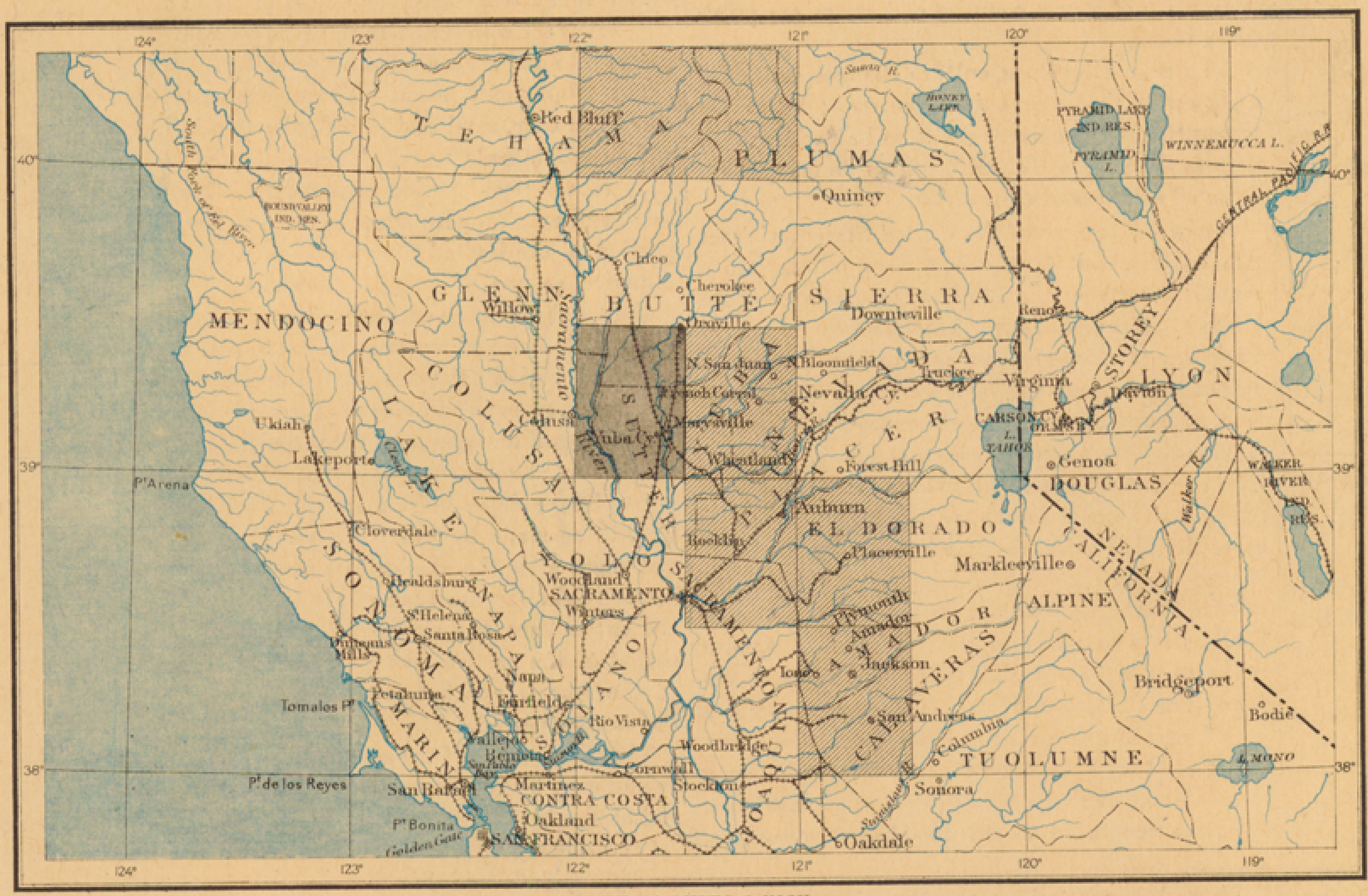
17

GEOLOGIC ATLAS OF THE UNITED STATES

MARYSVILLE FOLIO

CALIFORNIA

INDEX MAP



SCALE: 40 MILES - 1 INCH

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FOLIO 17

LIBRARY EDITION

MARYSVILLE

WASHINGTON, D. C.

ENGRAVED AND PRINTED BY THE U. S. GEOLOGICAL SURVEY

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

1895

EXPLANATION.

The Ge gical 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:

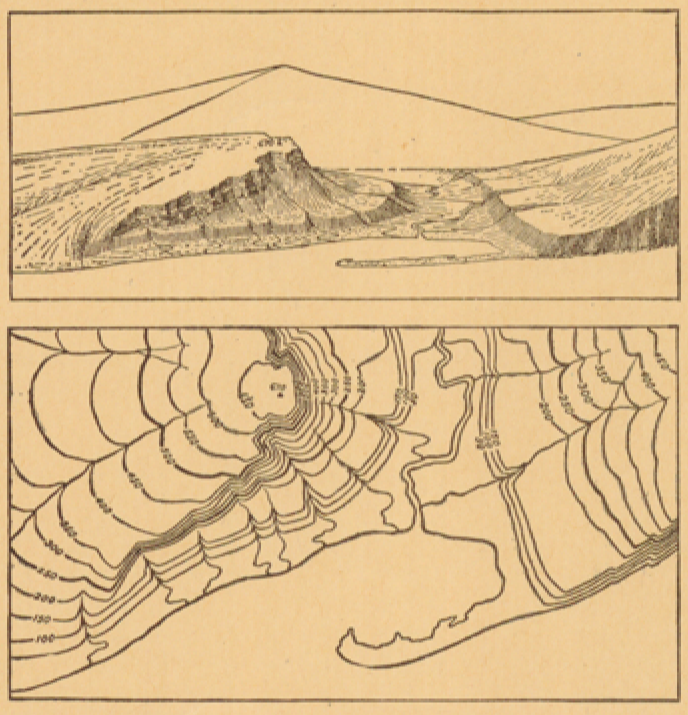


Fig. 1. The upper figure represents a sketch of a river valley, with terraces, and of a high hill encircled by a cliff. These features appear in the map beneath, the slopes and forms of the surface being shown by contours.

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' his v, a thick and extensive ice portion of the Unite itish America, as one 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 wh n 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	Є	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

DESCRIPTION OF THE GOLD BELT.*

GEOGRAPHIC RELATIONS.

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

GENERAL GEOLOGY.

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

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

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

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

BED-ROCK SERIES.

PALEOZOIC ERA.

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

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

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

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

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

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

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

POST-CARBONIFEROUS UPHEAVAL.

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

JURATRIAS PERIOD.

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

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

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

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

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

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

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

THE POST-JURATRIAS UPHEAVAL.

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

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

THE GOLD-QUARTZ VEINS.

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

SUPERJACENT SERIES.

CRETACEOUS PERIOD.

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

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

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

EOCENE PERIOD.

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

NEOCENE PERIOD.

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

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

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

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

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

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

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

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

THE NEOCENE UPHEAVAL.

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

PLEISTOCENE PERIOD.

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

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

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

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

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

IGNEOUS ROCKS.

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

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

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

GLOSSARY OF ROCK NAMES.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

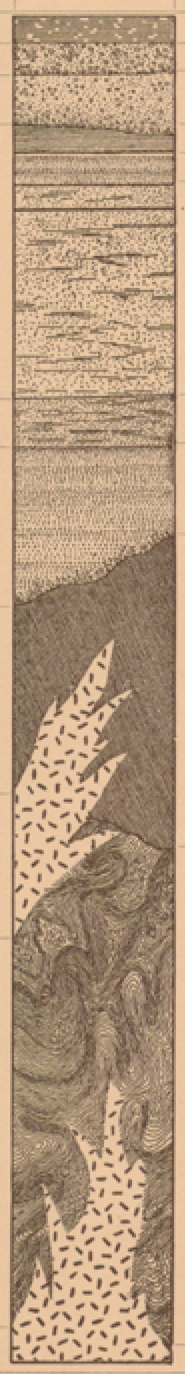
Rhyolite.—An effusive rock of Tertiary or later age. The essential constituents are alkali feldspars and quartz, usually with a small amount of biotite or hornblende in a groundmass, which is often glassy.

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

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

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

GENERALIZED SECTION OF THE FORMATIONS OF THE GOLD BELT.



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

DESCRIPTION OF THE MARYSVILLE SHEET.

TOPOGRAPHY.

The Marysville atlas sheet includes the territory between the meridians 121° 30′ and 122°, and the parallels 39° and 39° 30′. The area is 34.5 miles long and 27 miles wide, and contains 925 square miles. It includes portions of Butte, Yuba, Sutter, and Colusa counties, California.

The broad alluvial plains of the Sacramento and Feather rivers occupy the larger part of the area. These rivers pursue a winding course on low ridges. This elevated channel is characteristic of streams which wander through flood-plains, the banks being built up by sediments deposited during high water. The tributaries, as a consequence, before reaching the main stream are usually turned aside and converted into stagnant sloughs, overflowing large areas during the wet season. Extensive tracts of land must, therefore, to be available for agriculture, be protected by levees. On both sides of the Sacramento River there are broad belts of swamp lands, which are annually overflowed, and are usually covered by a dense growth of tule (*Scirpus lacustris*). There are also in these areas several lake-like depressions in which the water remains the whole year. Minor sloughs and swamps occur on both sides of the Feather River. A considerable area north-northeast of Marysville is also of a marshy character, though usually dry during the summer. The elevation of Marysville is 66 feet above the sea. The channel of the Yuba River has, during the last decade, been choked by an excessive amount of fine débris brought down from the hydraulic gravel mines of the Sierra Nevada, and, as a consequence, the townsite of Marysville, formerly high and dry, is now considerably lower than the river at high-water mark. The sandy flood-plain of this river is now from 1½ to 3 miles wide, and the channel shifts every season.

In the northeastern corner of the area the outlying foothills of the Sierra Nevada reach an elevation of 500 feet. The first hills appear as broad, low, flat-topped elevations. The bed-rock series appears east of these as a low ridge with north-northwest direction.

In pronounced contrast to these monotonous plains and low rolling hills, there rise, in the center of the area, between the two principal rivers, the Marysville Buttes, the central peaks of which attain an elevation of about 2,000 feet. They form a nearly circular group of mountains, with a diameter of 10 miles. Their topography can better be described in connection with the geology.

The plains and the lowest, rolling foothills are, on the whole, destitute of arboreal vegetation, though in places scattered oak trees impart a park-like character to the landscape. The tule-covered areas on both sides of the Sacramento River have been mentioned above. The river banks usually support a dense vegetation of brush and willows, and in the dryest places, of oaks also. The higher foothills in the northeast corner, as well as the Marysville Buttes, are covered by white and black oak, live oak, digger pine, and underbrush—largely *Ceanothus*.

The Marysville Buttes and the higher foothills in the northeast corner are utilized as pastures, as are also to a certain extent the first low rolling foothills. When irrigated, however, the latter are in many places adapted to horticulture; oranges, lemons, olives, peaches, and other semi-tropical fruits growing well. Where the foothills gradually change to the level, richer bottom-lands, wheat fields replace the pasture lands, though fruit trees of all kinds also succeed wonderfully well, except where the hardpan is near the surface.

The climate is of a subtropical character, which prevails everywhere in the Great Valley of California. Snow hardly ever falls; the lowest temperature recorded is 18° F., the highest being about 115° F. The average rainfall, comprised in the winter months between October and May, is 18 inches at Marysville.

GEOLOGY.

The geologic formations of the Marysville sheet form two very distinct groups of rocks, which occur in areas that may be described separately, the first being the district of the alluvial plains and the foothills of the Sierra Nevada, the second consisting of the Marysville Buttes and representing an isolated, extinct volcano.

BED-ROCK SERIES.

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

JURATRIAS AND OLDER.

Diabase and porphyrite.—The foothills of the Sierra extending into this area are formed of representatives of the bed-rock series or the compact pre-Cretaceous rocks of the mass of the Sierra Nevada. They are diabases and augite-porphyrites—green, massive, and hard rocks, composed principally of feldspar and augite. These rocks are of igneous origin, and were probably extruded during the Juratrias period.

SUPERJACENT SERIES.

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

NEOCENE AND PLEISTOCENE.

The level plains of the Sacramento Valley are composed of deposits of Neocene and Pleistocene age.

Auriferous gravels (fluviatile).—The Neocene area south and east of Lava Beds is composed of fine shale, with sandy layers, and fine gravel. These deposits are of the age of the fluviatile Auriferous gravels on the slope of the Sierra Nevada, and are therefore described as such, although the material does not contain gold enough to be worked profitably. Some of the tuff to the south of Lava Beds seems to contain andesitic detritus. These Neocene deposits evidently represent the flood-plain of an ancient stream of the Sierra Nevada near the point where it débouched into the gulf which then occupied the present Great Valley of California.

The Neocene area described probably extends much farther to the south than is indicated on the map, but is overlain by Pleistocene hardpan and gravel to a greater or less depth. The line separating the earlier Pleistocene from the Neocene area must be taken as an approximate one.

Earlier Pleistocene.—There are large tracts of deposits of earlier Pleistocene age along the eastern border of the area, evidently formed along the shore of the shallow gulf that occupied the Great Valley during that epoch. As a rule, they form tables gently rising eastward, and, beginning at an elevation of 70 or 80 feet, extend up to about 350 feet above the sea, where they meet the more abrupt rocky foothills of the Sierra Nevada. The strata consist of clays, hardpan, sands, and gravel which is chiefly siliceous and grows coarser near the old shore-line. This gravel is made up of pebbles probably largely derived from Neocene deposits which have been worked over by waves. By the sorting process the finer sediments have been removed and the pebbles of softer igneous rocks decomposed and washed away, leaving the pebbles of quartzite and other quartzose rocks, which better resist the action of water. In a general way, the earlier Pleistocene may be distinguished by the red soil from the later, dark alluvial areas. Scattered Pleistocene gravel occurs on the Neocene area to the south of Oroville and Lava Beds. The general character of the soil is that of a gravelly or sandy reddish loam.

Exposures made by Honcut Creek, about a mile east of Moore's Station, show 20 feet of gravel mixed with coarse sand, conformably underlain by 4 feet of white or yellowish hardpan, which in some places has a tuffaceous aspect. This rests directly on diabasic rocks, showing that at this place the Ione formation (Neocene), which was certainly deposited all along the border of the valley, had already been eroded when the earlier Pleistocene beds were deposited. The whole area between Moore's Station, Palermo, and a line drawn a mile or two east of Feather River, presents this same section, being covered by gravel and underlain by a stratum of more or less sandy hardpan.

Between the Honcut and the Yuba, the gently rolling, gravelly lands begin near the boundary line of the sheet, and one low isolated hill has been preserved near the Honcut on the west side of the railroad. These hills are made up of yellowish clays, hardpan, and sand, covered by a stratum of gravel of varying thickness.

South of the Yuba the alluvial sands are heavy near the rivers, while a couple of miles away from them the hardpan and gravel come closer to the surface. At Reed's Station the wells show a section of 1 to 6 feet of red soil, 1 foot of clay, 3 feet of hardpan, below which is a stratum of sandy gravel. Southwest and south of Reed's the hardpan is covered by only a shallow layer of adobe or red soil.

Alluvium.—Under alluvium are here classed the fluviatile deposits of clays, sands, and gravels, formed by the steady erosion of the older formations by the shifting streams since the Great Valley became dry land. The alluvium has been formed very largely by the working over and the redeposition of the earlier Pleistocene and Neocene strata covering the valley. There is excellent reason to believe that these alluvial beds are relatively shallow, probably in few places deeper than 100 feet, and that they rest on a very deep series of estuarine and marine strata of early Pleistocene, Neocene, Eocene, and Cretaceous age.

The soil of the alluvial plains is usually of dark color, owing to abundant humus, and is, as a rule, of great fertility. On the eastern side of the Feather River a reddish color frequently shows the influence of the adjoining areas of earlier Pleistocene beds derived from the ferruginous rocks of the Sierra Nevada.

On this side the alluvium is much thinner than over the rest of the plains; it rests as a shallow mantle on the earlier Pleistocene, which is sometimes exposed in the creek beds, and the boundary between the two formations is usually very indistinct. Some of the thin alluvial areas overlying the earlier Pleistocene north of Moore's Station are not noted on the map.

Near Yuba and Feather rivers this thin mantle becomes heavier and consists largely of sand, which, at a depth of 50 feet or less, is underlain by hardpan and gravel. At Marysville the Buckeye Mill well has been bored to a depth of 218 feet in clay, sand, and gravels; between the depth of 80 and 140 feet, clay containing impressions of shells was penetrated. These strata may without doubt be regarded as older than the alluvium. In Yuba City wells were bored through sandy soil 20 feet; quicksand, 6 to 20 feet; and blue clay, 40 feet; but in other places south of the town the sand is much deeper. Five miles southeast of Marysville about 30 feet of sand generally overlies well-washed gravel. The former is regarded as alluvial. A little farther southeast, near Reed's Station, the early Pleistocene comes much closer to the surface.

A well bored in the tule lands south of the Marysville Buttes to a depth of nearly 400 feet showed the following section:

	Feet.
Surface soil (rotten tule and loam) . .	12
Hardpan	1
Alternate strata of blue clay and white sand	195
Blue and white quartz gravel	a few
Sand and blue clay alternating . . .	183

In this section it is of course impossible to indicate the lower limit of the alluvium.

In the northern part of Sutter County, near the Feather River, the surface section is about as follows:

	Feet.
Sandy clay	3
Hardpan	3
Yellow clay . . . . at least	25
Gravel	

Near Colusa, on the banks of the Sacramento River, there are, as a rule: sandy loam, 18 feet; then clay and sand, 27 feet, underlain by gravel. North of Marysville, up to the Honcut, about 30 feet of sand and clay, sometimes with hardpan, overlies gravel. It is probable that only 10 or 15 feet of this belongs to the alluvial series.

The recent river gravels of the Feather River below Oroville cover an area of several square miles. As may be seen at the numerous shafts sunk in them for gold, they are 20 feet or more in depth. About two miles to the west of Lava Beds these river gravels give place to more sandy deposits, and gradually merge into the finer alluvium of the valley.

The high isolated mountain group of the Marysville Buttes, rising with serrate and fantastic outlines from the monotonous plains of the Sacramento Valley, is in more than one respect an object of interest. On the western side the overflowed lands of the Sacramento River encircle it, while toward the east and north a gentle slope leads up from the Feather River to the base of the buttes, which may be assumed to coincide with the 100-foot contour line.

The detailed topography and the geology of this mountain group are so intimately connected that they may best be described together.

In general, it may be said that the Marysville Buttes are an extinct volcano of probably late Neocene age, the internal structure of which is to a certain extent laid bare by erosion.

In any view from a distance two distinct features of the mountain group are always noted; first, the peripheral slopes, reaching up to 600 or 700 feet in a long, gentle curve; second, the abrupt and jagged interior peaks and domes, of which the South Butte and the North Butte are the most prominent. It is probable that when the volcano was in active eruption it formed one great cone, such as that of Vesuvius, Etna, or Fuji-yama, and that its original form can be reconstructed with considerable accuracy by carrying up the curves of the lower slopes, with gradually increased declivity, until they culminate in a summit, high above the present peaks. The drainage is radial, the creeks and ravines originating in the central mass and flowing thence north, east, south, and west.

There are three divisions of the buttes, which are topographically and geologically distinct. They are: 1. The peripheral tuff ring. 2. The interior ring of upturned sedimentary rocks. 3. The central core of igneous rocks.

1. *The tuff ring.*—The first subdivision corresponds to the gentle slopes mentioned above, and is made up of a successive series of beds of mud lava poured out from the vents of the volcano. These flows form grassy slopes covered with rough bowlders of eruptive rocks, and sustain a scant, brushy vegetation. In its typical development this mud lava consists of finely ground up detritus in which lie imbedded angular fragments of andesite, or more rarely rhyolite, of all sizes. The color of this tuff is gray or brownish-gray. Very frequently, however, there is more or less sedimentary material—clay, sand, or gravel—mixed with these mud lavas, or tuffaceous breccias, as they might be called. The abundance of this sedimentary material is explained by the loose character of the beds through which the eruptive masses must have forced their way. These mud lavas show a close analogy with similar enormous masses largely covering the flank of the Sierra Nevada. They probably poured out as a semi-fluid, hot mud, and were only to a less extent the result of ash showers. Narrow gulches or defiles have been cut through this ring of mud-flows, leading from crater-like valleys with level bottoms, which are often of roughly circular shape and surrounded by steep walls of tuff or massive andesite. Such craters are the two valleys 3 miles south of Pennington, that south of the North Butte, and the South Butte Valley. There can hardly be any doubt that from these lateral craters a great deal, if not all, of the tuffs and breccias were ejected.

The tuff slopes emerge from the Pleistocene of the Great Valley at an elevation of about 150 feet, but scattered well-washed pebbles of quartzose, metamorphic, volcanic, and Neocene rocks occur up to an elevation of 300 or 400 feet, or to about the height reached by the Pleistocene sediments on the flank of the Sierra. No indications of terraces or shore-lines are, however, visible; they are also absent on the Sierra Nevada side.

At the base of the buttes the Pleistocene formations covering the tuffs consist of clayey and sandy beds, which at Sutter City are 55 feet deep and overlie a bed of gravel with volcanic pebbles.

2. *The upturned sediments.*—Between the exterior mud-flows and the massive core, and strongly contrasting with them, there often occur a series of smooth, rounded hills forming a frequently interrupted ring a mile or less in width. These hills are not volcanic, but consist of a series of sandstones (usually soft), white or dark clays, and gravelly beds. The beds are very much disturbed and dip at all angles and in all directions. As a rule, however, they dip away from the central core, and when near it stand at high angles, sometimes vertical. At the immediate contact with the massive volcanic rocks these sediments are usually hardened. No volcanic detritus of the same rocks of which the buttes are made up is found in them, and it may be regarded as certain that they were laid down before the period of volcanic activity.

The oldest of these formations belongs to the Tejon formation (Eocene); it has thus far been identified only in the sedimentary area northeast of the village of West Butte. It is here composed of greenish sandstones and shales, adjoining the volcanic masses and dipping at high angles east or west. A thickness of several hundred feet of sediments is exposed. Some of the beds contain abundant marine fossils, characteristic of the Tejon, among which a small coral (*Trochosmilia striata* Gabb) is most abundant. *Cardita planicosta*, a form eminently characteristic of the Tejon, is also found.

Overlying these beds are light-colored, soft sandstones and clays, dipping west at an angle of about 20°, which have been referred to the Ione formation. The other sedimentary areas consist largely, if not entirely, of these soft, light-colored beds. Near the tuffs they dip southward at 15° to 20°; approaching the central volcanic mass they usually stand almost vertical. In many places the beds are greatly disturbed and dip in various directions within short distances. The character of the beds makes it often difficult to ascertain strike and dip accurately. In the clays of these areas, in carbonaceous strata, impressions of leaves were collected. At two places marine fossils were found. The first is about 2 miles east of the South Butte; the second, 2½ miles north-northwest of the South Butte. The fossils, while not abundant, point to an early Neocene (Miocene) age; though it is not impossible that they are later Neocene (Pliocene). There is every probability that these beds are the exact equivalent of the Ione formation exposed along the foothills of the Sierra Nevada. Their aggregate thickness is very considerable, 1,000 feet being a fair minimum estimate. There are no dikes of massive volcanic rocks in the tuff mantle or in the upturned sediments; in fact, they appear to be entirely absent from the whole group. Instead, there are, both in the tuffs and in the sediments, a few eruptive masses having the form of chimneys or necks, appearing in horizontal sections with rounded or oblong outline. These necks, as a rule, protrude above the more easily eroded tuffs and sediments as dome-shaped hills. They consist of a porphyritic rock, intermediate between a rhyolite and a dacite.

3. *The central core.*—The central mass of the buttes consists principally of massive volcanic rocks, mixed with some breccias of the same materials. Most prominent, and occupying the largest area, are rough and jagged peaks and ridges of dark color, often showing beautiful columnar and laminated structures. They are made up of a normal hornblende-mica-andesite of very rough, trachytic appearance. Both the North Butte and the South Butte are formed of this material. The rock type does not correspond to any found on the western flank of the Sierra Nevada, but shows the closest analogy with the latest effusive masses from the Comstock and Bodie. Between these rough ridges are some smoother hills, consisting of mixed andesite and andesite-breccia. Besides these there are a few areas — west of the North Butte and on the south slope of the South Butte — of a white, fine-grained, normal rhyolite. Along the periphery of the central mass there are several rounded necks of a rhyolite approaching a dacite in composition. It is a light-colored — brown, gray, or purplish — compact rock with small white feldspars and abundant mica foils. The succession of these rocks is not established beyond doubt, but the acid, dacitic rhyolites appear to be later than the andesite. Small masses of enclosed sediments occur in a few places in the massive volcanic rocks; the clays are altered to a hard, dark, and brittle metamorphic rock. The absence of dikes and flows of molten material in this volcano is very remarkable. The eruptions took the form of large masses or necks, forced upwards through the loose sediments. The mass and the energy of the ascending lavas were so great that the surrounding sediments were uplifted more than 1,000 feet and bent upwards on all sides of the necks. It is probable that the ascending lavas were very viscid and comparatively cool, so that they, in some measure, acted as a plastic solid mass. The surrounding sediments, of which now a large part is probably eroded, prevented them from breaking out and forming lava-flows. It is also probable that the peripheral craters were formed during the later eruptions, and that the breaking out of the tuff-flows closed the period of volcanic activity. The Marysville Buttes represent a very unusual type of volcano, and many of their phenomena are difficult of explanation.

The time at which the volcano was active can, without much doubt, be fixed at the close of the Neocene or the beginning of the Pleistocene. It was probably a little later than the volcanoes which began their eruptions in the Sierra Nevada at the close of the Neocene. Since the time when the eruptions ceased, erosion has been actively engaged in destroying what the volcanic agencies builded, and the rate of the degradation can almost be measured as rock after rock falls from the lofty pinnacles and as the winter floods break down and sweep away the soft tuffs and sediments.

ECONOMIC GEOLOGY.

Gold-bearing gravels.—The gravelly bottomlands of the Feather River below Oroville have been extensively mined for gold by means of shafts. The gold seems to have been found in the bottom layers of the recent river gravel. Numerous old shafts may still be seen near Lava Beds.

The shore gravels of early Pleistocene age that cover so much of the country between the Feather River at Oroville and Honcut Creek are frequently auriferous, and have been washed for gold over considerable areas. The little heaps of washed-over gravel may still be seen in some of the fields that have not yet been brought under cultivation.

Among the Neocene beds of the Marysville Buttes there are gravels of varying degrees of coarseness, some of the pebbles being 5 inches or more in diameter. All of the pebbles are well washed, and consist of quartz, siliceous sedimentary rock, diabase, granite, and serpentine. All of this gravel, as well as the volcanic mud-flows whenever containing a considerable mixture of gravel, are slightly auriferous, and the gulches and ravines in such areas have often been washed during the wet season with some profit. The gold is well rounded and, as a rule, is moderately fine. A few exceptionally large pieces, up to a value of five dollars, are reported to have been found. In some places these deposits might be profitably washed by the hydraulic process if it were possible to obtain sufficient water.

These coarse auriferous gravels are certainly a most interesting feature, occurring as they do so far removed from their source in the Sierra Nevada. There are no indications of quartz veins in the buttes.

Coal.—The Ione formation contains in places thin seams of an inferior lignite and carbonaceous clay. Prospecting has been carried on at various places in the South Butte Valley, and also 3 miles south of Pennington. Nothing of value has been found, nor is it very likely that any important deposit will be. Coal is also said to have been struck in a well 35 feet deep, 1 mile south of Sutter City; below the gravelly soil clayey strata were found overlain by coal.

Natural gas.—Gas in small quantities has been struck at Marysville at a depth of 200 feet, and at a less depth at Yuba City. It occurs also in the Marysville Buttes. It is not unlikely that deep wells would disclose enough gas to be of some economic importance.

About 1 mile southwest of the South Butte, in Neocene clay and sandstone, a well was sunk about 1864 to a depth of 20 feet, from which a small flow of natural gas issued. This well is still flowing. A well put down in 1892 close to the first one struck no gas, but ran into massive eruptive rock. On account of the very disturbed condition of the strata it seems extremely doubtful whether a large supply may ever be obtained.

Clay.—As usual, a large amount of clays is found in the Ione formation, some of which may be available for the manufacture of pottery.

Limestone.—An impure gray limestone occurs in the nearly vertical Neocene beds directly south of the South Butte. In the area of the volcanic tuffs, about 1,000 feet south of the South Pass road, 1½ miles south-southeast of the South Butte, is a spring deposit consisting mainly of calcite.

Building stones.—The rhyolite, being easily dressed, is locally used as a building stone. There is a quarry in the rhyolite area 3 miles northwest of Sutter City.

Soils.—The soils of the volcanic area are very shallow and, as a rule, not available for anything but pasture. The Neocene areas produce an extremely clayey soil of little strength. On the other hand, several of the crater valleys, as well as all of the level land surrounding the buttes, are covered with a deep and fertile soil, composed principally of wash from the volcanic areas.

Water supply.—On the banks of the Sacramento River good water is obtained at about 50 feet. Marysville and Colusa pump water from deep wells. The stratum carrying most water is at Marysville, 153 feet below the surface, and the water rises to within a few feet of the surface.

In the tule lands the water in the wells is apt to be brackish. Near Sutter City, south of the Marysville Buttes, the water plane is found 60 feet below the surface, in a gravel bed underlying clayey strata. South and east of Sutter City the water plane is higher. Near Pennington, water is found from 6 to 20 feet below the surface, clayey and sandy beds alternating. The water obtained in the wells is generally good, though somewhat hard. The deeper wells bored in the Sacramento Valley have, with few exceptions, failed to yield potable water, the water containing, as a rule, much carbonates and sulphates. The deepest well bored within the area of the sheet appears to be the one, mentioned above, in the tule lands south of Marysville Buttes. Deeper wells, if bored, are likely to strike artesian water, but whether it would be potable or not is doubtful.

Between the Yuba and the Honcut rivers the stratum of gravel underlying the hardpan carries potable water 10 or 12 feet below the surface. On the gravel hills along the eastern boundary the water plane is considerably deeper, the depth near Seven Mile House being 28 feet. South of Marysville the wells are generally about 30 feet deep. Near Reed's Station abundant water for irrigation is obtained at 50 feet, the water rising to within 12 feet of the surface.

All of the creeks issuing from the Marysville Buttes are dry during the summer, so that there is practically no water available for irrigation from this source. In the sedimentary areas there are, however, many strong springs flowing during the dryest seasons, and these are in some places utilized. The water is slightly alkaline.

WALDEMAR LINDGREN,
H. W. TURNER,
Geologists.

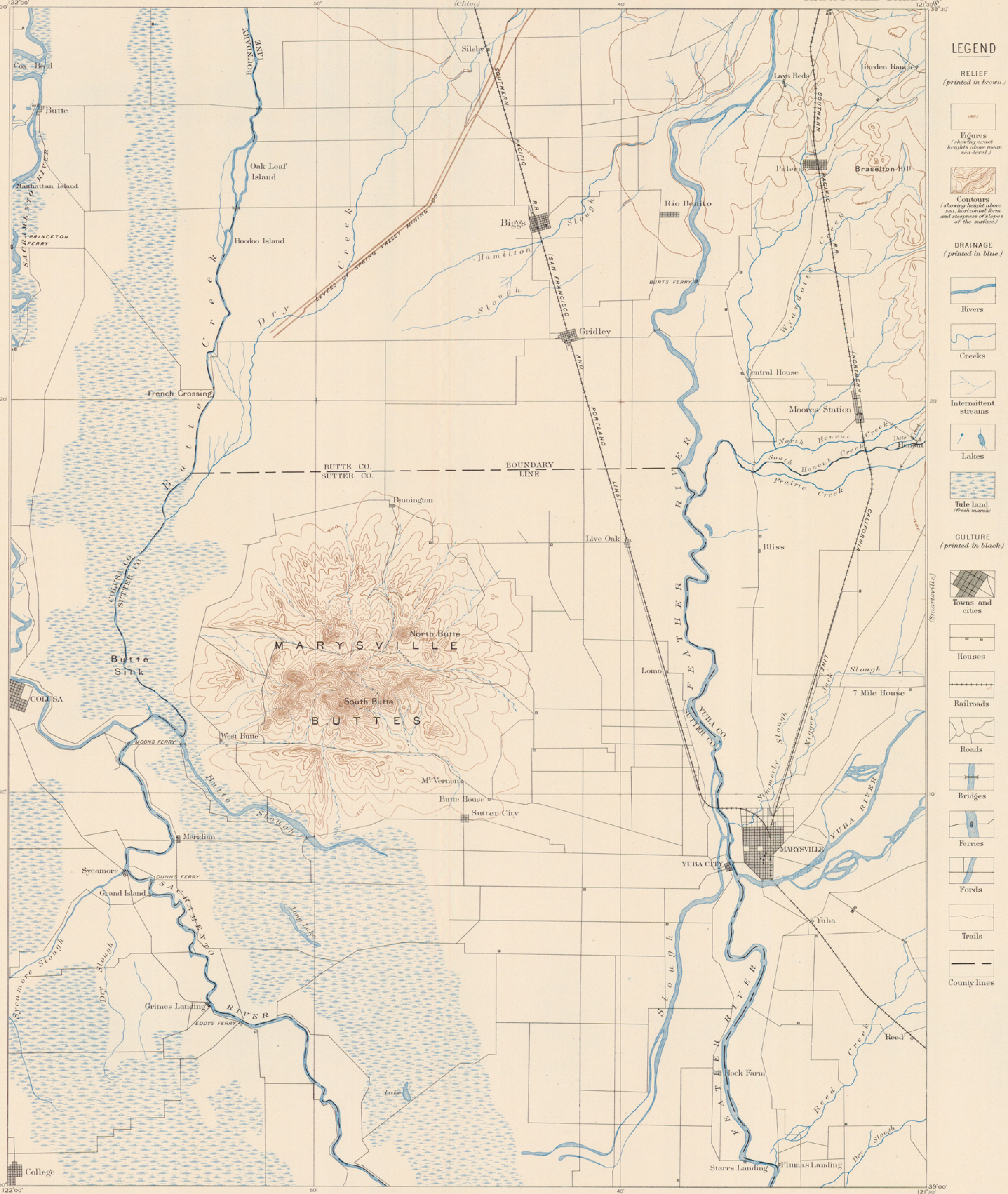
G. F. BECKER,
Geologist in charge.

April, 1895.

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

TOPOGRAPHY

CALIFORNIA
MARYSVILLE SHEET



Henry Gannett, Chief Geographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by H.M. Wilson.
Surveyed in 1886.

Scale 1:125000
1 ½ 0 1 2 3 4 5 Miles

Contour Interval 100 feet
Datum is mean Sea level

Edition of Jan. 1895

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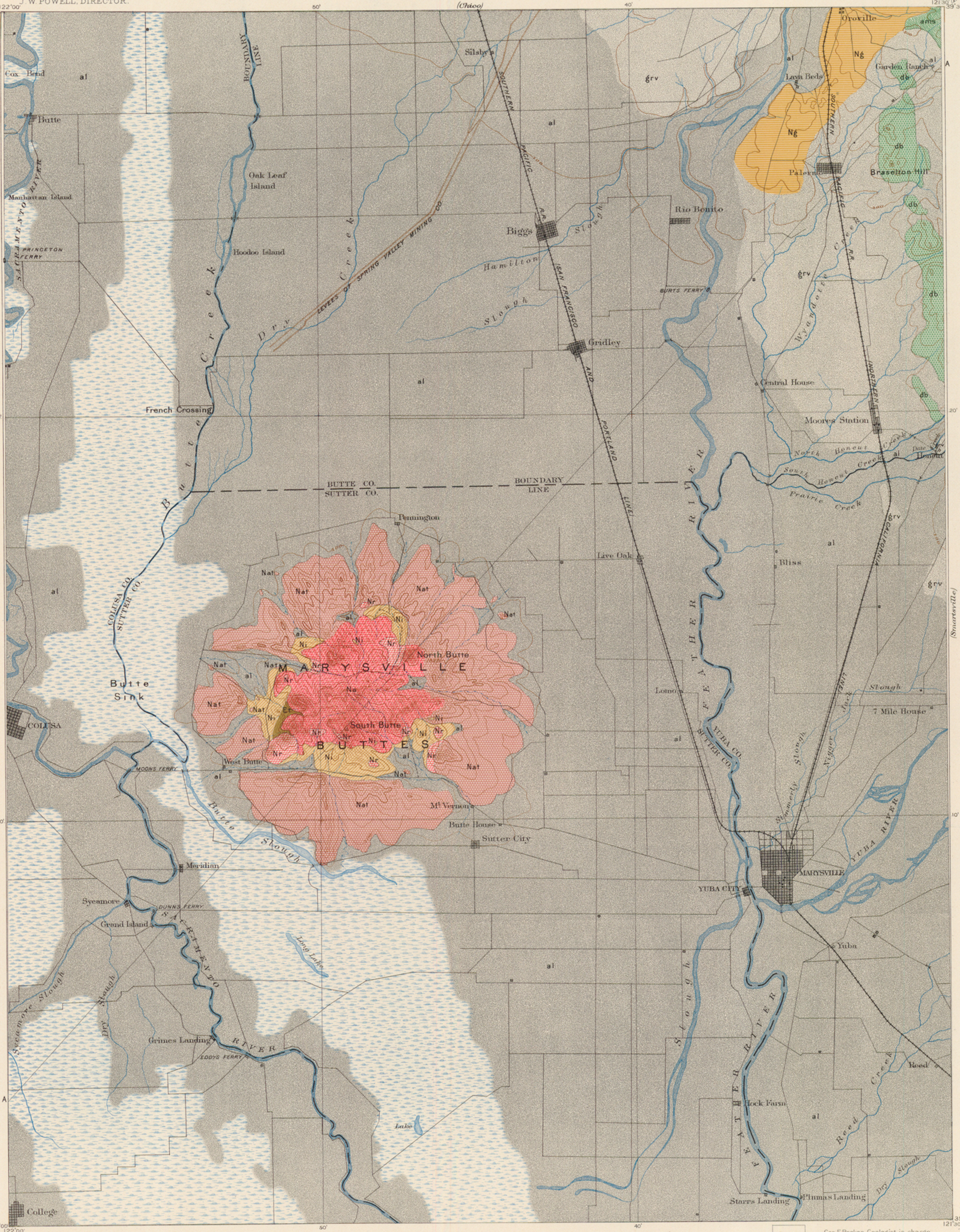
AREAL GEOLOGY

CALIFORNIA
MARYSVILLE SHEET



Henry Gannett, Chief Geographer.
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Triangulation by H. M. Wilson.
Topography by H. M. Wilson.
Surveyed in 1886.

Scale $\frac{1}{125000}$
Contour Interval 100 feet
Datum is mean Sea level
Edition of Jan. 1895.

Turner
Lindgren

Geo. F. Becker, Geologist in charge.
Geology by H. W. Turner and W. Lindgren.
Surveyed in 1892.

LEGEND

SUPERFICIAL ROCKS

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

PLEISTOCENE
- LATE — al — Alluvium *(bottom lands)*
- EARLIER — grv — Shore and river gravels, sand and hardpan *(Gravels locally auriferous)*

SEDIMENTARY ROCKS

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

NEOCENE
- Ng — River gravels, sand and fine tuffs *(Gravels are auriferous)*
- Ni — Ione formation *(Clays, sandstone, and gravels locally auriferous. In part marine)*

EOCENE
- Et — Tejon formation *(Marine clays and sandstone.)*

IGNEOUS ROCKS

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

NEOCENE
- Na — Andesite
- Nat — Andesitic tuffs and breccias
- Nr — Rhyolite

JURATRIAS OR EARLIER
- db — Diabase and diabase-porphyrite

ALTERED ROCKS

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

- ams — Amphibolite-schist

Section

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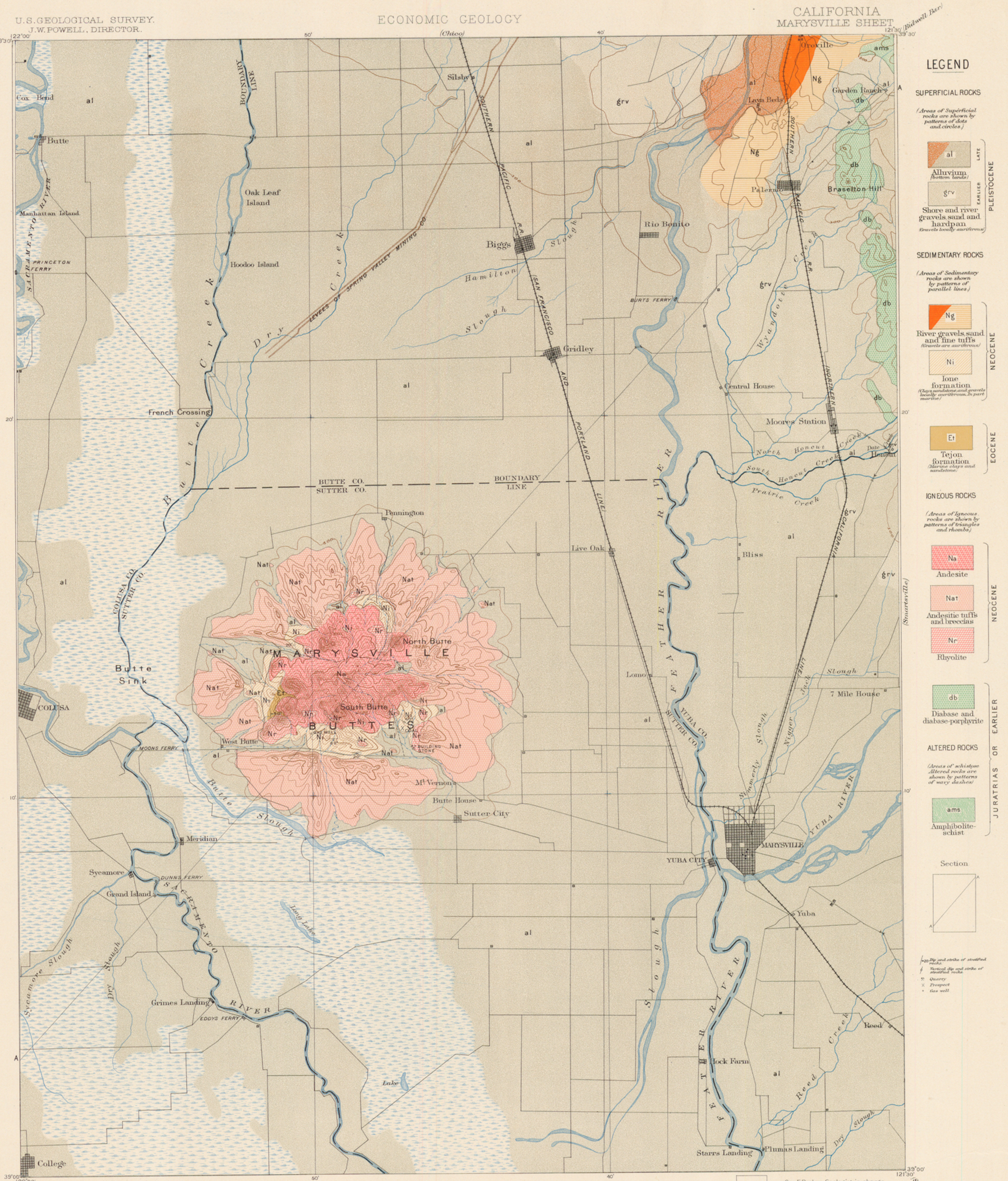
ECONOMIC GEOLOGY

CALIFORNIA
MARYSVILLE SHEET



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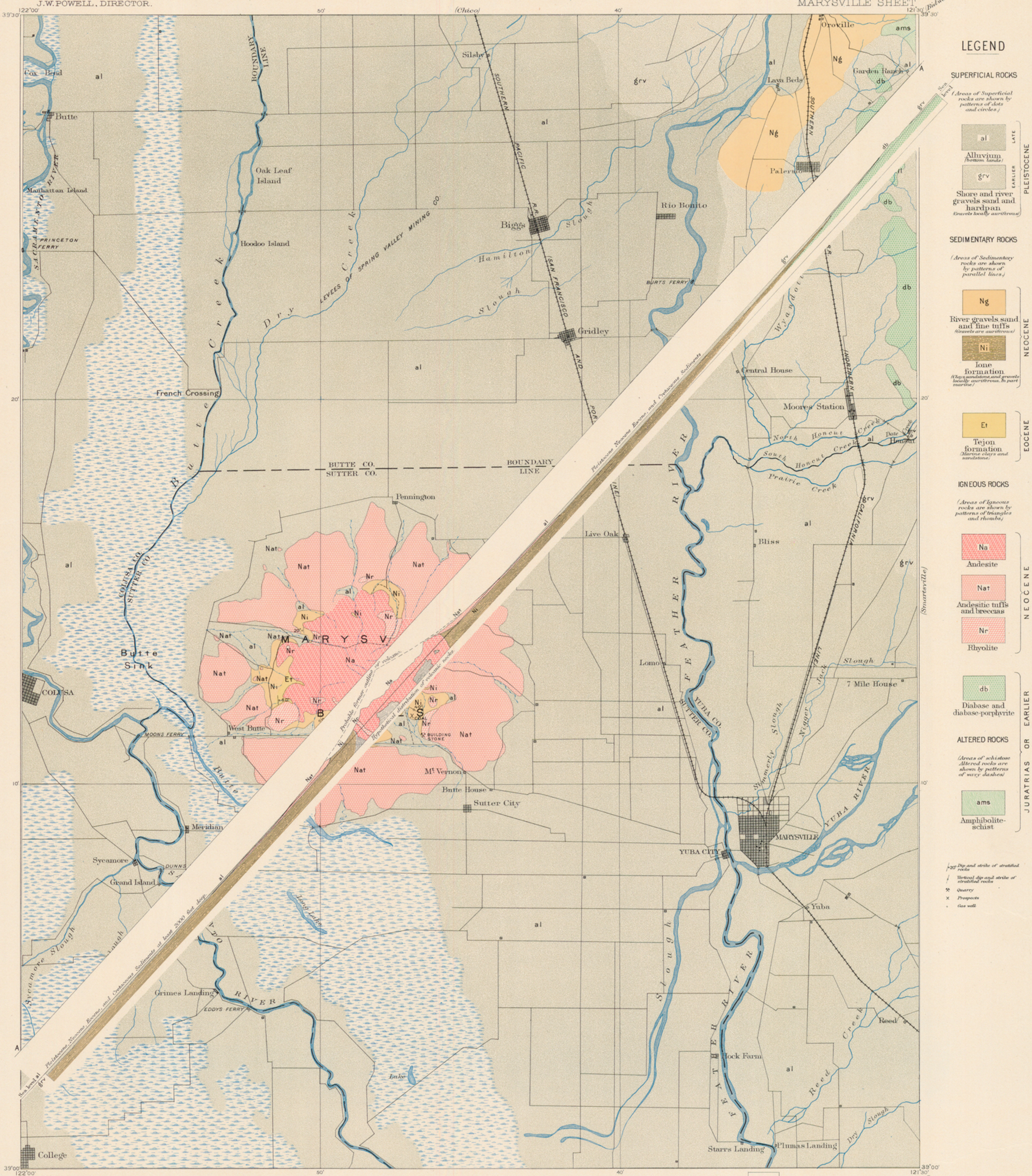
STRUCTURE SECTIONS

CALIFORNIA
MARYSVILLE SHEET



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Scale 1:125000

Contour Interval 100 feet
Datum is mean Sea level

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Surveyed in 1892.

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:

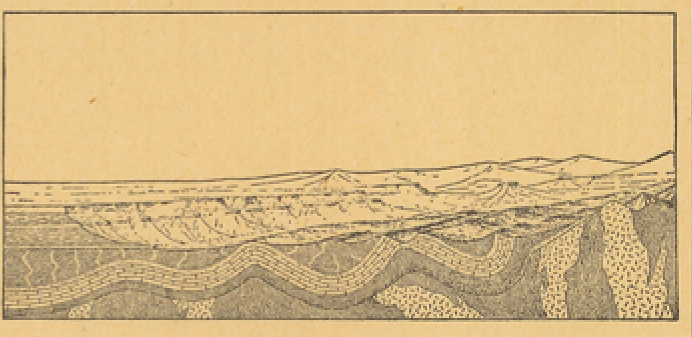

Fig. 2. Showing a vertical section in the front of the picture, with a landscape above.

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:

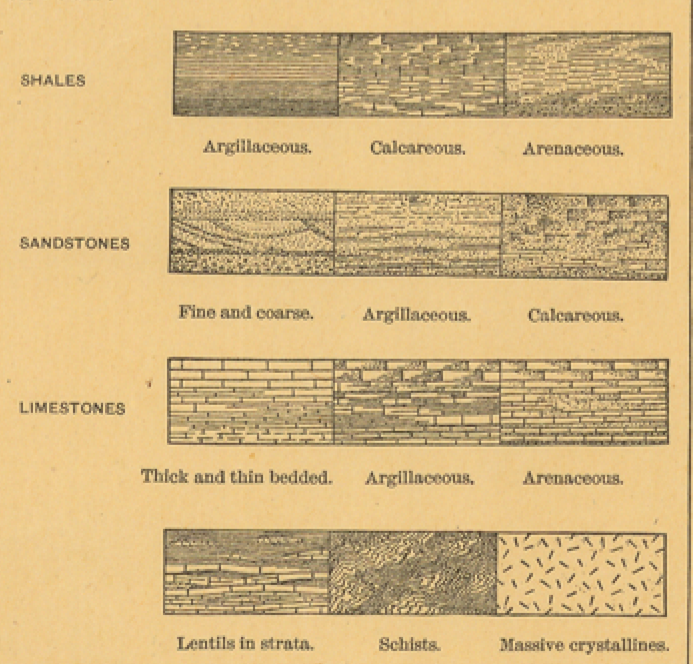

Fig. 3. Symbols used to represent different kinds of rocks.

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.

J. W. POWELL,

Director.