PARTMENT OF THE INTERIOR
STATES GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

GEOLOGIC ATLAS
OF THE
UNITED STATES

BIDWELL BAR FOLIO
CALIFORNIA

INDEX MAP

SCALE: 40 MILES=1 INCH

AREA OF THE BIDWELL BAR FOLIO

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FOLIO 43

LIBRARY EDITION

BIDWELL BAR

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EXPLANATION

The Geological Survey is making a geologic map of the United States, which necessitates the preparation of a topographic base map. The two are being issued together in the form of an atlas, the parts of which are called folios. Each folio consists of a topographic base map and geologic maps of a small area of country, together with explanatory and descriptive texts.

THE TOPOGRAPHIC MAP.

The features represented on the topographic map are of three distinct kinds: (1) inequalities of surface, called *relief*, as plains, plateaus, valleys, hills, and mountains; (2) distribution of water, called *drainage*, as streams, lakes, and swamps; (3) the works of man, called *culture*, as roads, railroads, boundaries, villages, and cities.

Relief.—All elevations are measured from mean sea-level. The heights of many points are accurately determined, and those which are most important are given on the map in figures. It is desirable, however, to give the elevation of all parts of the area mapped, to delineate the horizontal outline, or contour, of all slopes, and to indicate their grade or degree of steepness. This is done by lines connecting points of equal elevation above mean sea-level, the lines being drawn at regular vertical intervals. These lines are called *contours*, and the uniform vertical space between each two contours is called the *contour interval*. Contours and elevations are printed in brown.

The manner in which contours express elevation, form, and grade is shown in the following sketch and corresponding contour map:

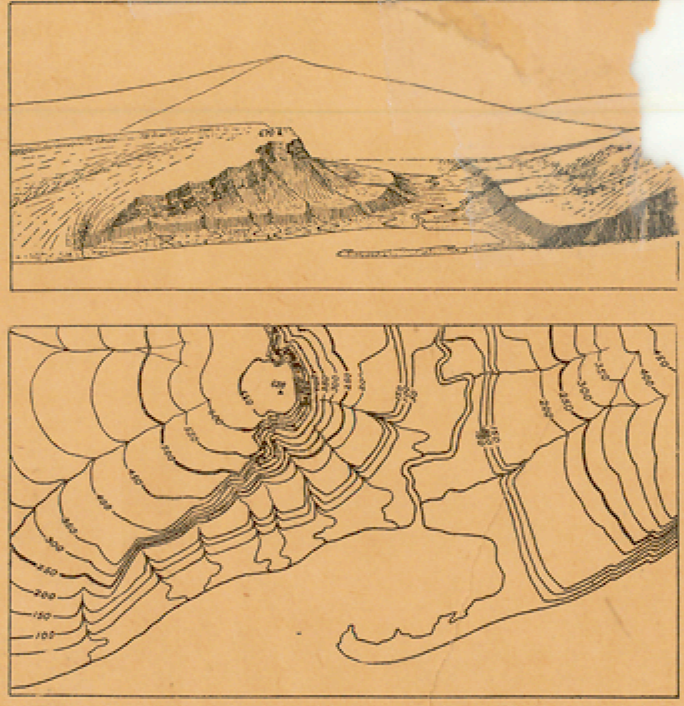


Fig 1.—Ideal sketch and corresponding contour map.

The sketch represents a river valley between two hills. In the foreground is the sea, with a bay which is partly closed by a hooked sand-bar. On each side of the valley is a terrace. From the terrace on the right a hill rises gradually, while from that on the left the ground ascends steeply in a precipice. Contrasted with this precipice is the gentle descent of the left-hand slope. In the map each of these features is indicated, directly beneath its position in the sketch, by contours. The following explanation may make clearer the manner in which contours delineate elevation, form, and grade:

1. A contour indicates approximately a certain height above sea-level. In this illustration the contour interval is 50 feet; therefore the contours are drawn at 50, 100, 150, 200 feet, and so on, above sea-level. Along the contour at 250 feet lie all points of the surface 250 feet above sea; and similarly with any other contour. In the space between any two contours are found all elevations above the lower and below the higher contour. Thus the contour at 150 feet falls just below the edge of the terrace, while that at 200 feet lies above the terrace; therefore all points on the terrace are shown to be more than 150 but less than 200 feet above sea. The summit of the higher hill is stated to be 670 feet above sea; accordingly the contour at 650 feet surrounds it. In this illustration nearly all the contours are numbered. Where this is not possible, certain contours—say every fifth one—are accentuated and numbered; the heights of others may then be ascertained by counting up or down from a numbered contour.

2. Contours define the forms of slopes. Since contours are continuous horizontal lines conforming to the surface of the ground, they wind smoothly about smooth surfaces, recede into all reentrant angles of ravines, and project in passing about prominences. The relations of contour curves and angles to forms of the landscape can be traced in the map and sketch.

3. Contours show the approximate grade of any slope. The vertical space between two contours is the same, whether they lie along a cliff or on a gentle slope; but to rise a given height on a gentle slope one must go farther than on a steep slope, and therefore contours are far apart on gentle slopes and near together on steep ones.

For a flat or gently undulating country a small contour interval is used; for a steep or mounta[illegible] ous country a large interval is necessary. T[illegible] smallest interval used on the atlas sheets of the Geological Survey is 5 feet. This is used for regions like the Mississippi delta and the Dismal Swamp. In mapping great mountain masses, like those in Colorado, the interval may be 250 feet. For intermediate relief contour intervals of 10, 20, 25, 50, and 100 feet are used.

Drainage.—Watercourses are indicated by blue lines. If the stream flows the year round the line is drawn unbroken, but if the channel is dry a part of the year the line is broken or dotted. Where a stream sinks and reappears at the surface, the supposed underground course is shown by a broken blue line. Lakes, marshes, and other bodies of water are also shown in blue, by appropriate conventional signs.

Culture.—The works of m[illegible] such as roads and tow[illegible] boundaries o[illegible] [illegible] and artificial [illegible] United States (exclud[illegible] [illegible],025,000 square miles. On a [illegible] scale of 1 mile to the inch this would cover 3,025,000 square inches, and to accommodate it the paper dimensions would need to be about 240 by 180 feet. Each square mile of ground surface would be represented by a square inch of map surface, and one linear mile on the ground would be represented by a linear inch on the map. This relation between distance in nature and corresponding distance on the map is called the scale of the map. In this case it is "1 mile to an inch." The scale may be expressed also by a fraction, of which the numerator is a length on the map and the denominator the corresponding length in nature expressed in the same unit. Thus, as there are 63,360 inches in a mile, the scale "1 mile to an inch" is expressed by $\frac{1}{63,360}$. Both of these methods are used on the maps of the Geological Survey.

Three scales are used on the atlas sheets of the Geological Survey; the smallest is $\frac{1}{250,000}$, the intermediate $\frac{1}{125,000}$, and the largest $\frac{1}{62,500}$. These correspond approximately to 4 miles, 2 miles, and 1 mile on the ground to an inch on the map. On the scale $\frac{1}{62,500}$ a square inch of map surface represents and corresponds nearly to 1 square mile; on the scale $\frac{1}{125,000}$, to about 4 square miles; and on the scale $\frac{1}{250,000}$, to about 16 square miles. At the bottom of each atlas sheet the scale is expressed in three different ways, one being a graduated line representing miles and parts of miles in English inches, another indicating distance in the metric system, and a third giving the fractional scale.

Atlas sheets and quadrangles.—The map is being published in atlas sheets of convenient size, which are bounded by parallels and meridians. The corresponding four-cornered portions of territory are called *quadrangles*. Each sheet on the scale of $\frac{1}{250,000}$ contains one square degree, i. e., a degree of latitude by a degree of longitude; each sheet on the scale of $\frac{1}{125,000}$ contains one-quarter of a square degree; each sheet on the scale of $\frac{1}{62,500}$ contains one-sixteenth of a square degree. The areas of the corresponding quadrangles are about 4000, 1000, and 250 square miles, respectively.

The atlas sheets, being only parts of one map of the United States, are laid out without regard to the boundary lines of the States, counties, or townships. To each sheet, and to the quadrangle it represents, is given the name of some well-known town or natural feature wit[illegible] [illegible]imits, and at the sides and corners of eac[illegible] [illegible]eet the names of adjacent sheets, if published, are printed.

Uses of the topographic sheet.—Within the limits of scale the topographic sheet is an accurate and characteristic delineation of the relief, drainage, and culture of the district represented. Viewing the landscape, map in hand, every characteristic feature of sufficient magnitude should be recognizable. It should guide the traveler; serve the investor or owner who desires to ascertain the position and surroundings of property to be bought or sold; save the engineer preliminary surveys in locating roads, railways, and irrigation ditches; provide educational material for schools and homes; and serve many of the purposes of a [illegible] for local reference.

THE GEOLOGIC MAP.

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

KINDS OF ROCKS.

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

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

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

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

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

Under the influence of dynamic and chemical forces an igneous rock may be metamorphosed. The alteration may involve only a rearrangement of its minute particles or it may be accompanied by a change in chemical and mineralogic composition. Further, the structure of the rock may be chan[illegible] [illegible]elo[illegible]ent of planes [illegible]sion, so that it splits in one direction more than in others. Thus a gr[illegible]ite may pass in gneiss, and from that int[illegible] [illegible]ca-schist.

Sedimentary rocks.—T[illegible] [illegible]omprise all rocks which have been deposi[illegible] [illegible]der water, whether in sea, lake, or stream. [illegible] form a very large part of the dry land.

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

Sedimentary rocks are usually made up of layers or beds which can be easily separated. These layers are called *strata*. Rocks deposited in successive layers are said to be stratified.

The surface of the earth is not fixed, as it seems to be; it very slowly rises or sinks over wide expanses, and as it rises or subsides the shore-lines of the ocean are changed: areas of deposition may rise above the water and become land areas, and land areas may sink below the water and become areas of deposition. If North America were gradually to sink a thousand feet the sea would flow over the Atlantic coast and the Mississippi and Ohio valleys from the Gulf of Mexico to the Great Lakes; the Appalachian Mountains would become an archipelago, and the ocean's shore would traverse Wisconsin, Iowa, and Kansas, and extend thence to Texas. More extensive changes than this have repeatedly occurred in the past.

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

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

Surficial rocks.—These embrace the soils, clays, sands, gravels, and bowlders that cover the surface, whether derived from the breaking up or disintegration of the underlying rocks by atmospheric agencies or from glacial action. Surficial rocks that are due to disintegration are produced chiefly by the action of air, water, frost, animals, and plants. They consist mainly of the least soluble parts of the rocks, which remain after the more soluble parts have been leached out, and hence are known as residual products. Soils and subsoils are the most important. Residual accumulations are often washed or blown into valleys or other depressions, where they lodge and form deposits that grade into the sedimentary class. Surficial rocks that are due to glacial action are formed of the products of disintegration, together with bowlders and fragments of rock rubbed from the surface and ground together. These are spread irregularly over the territory occupied by the ice, and form a mixture of clay, pebbles, and bowlders which is known as till. It may occur as a sheet or be bunched into hills and ridges, forming moraines, drumlins, and other special forms. Much of this mixed material was washed away from the ice, assorted by water, and redeposited as beds or trains of sand and clay, thus

DESCRIPTION OF THE BIDWELL BAR QUADRANGLE.

GEOGRAPHY.

Location.—The Bidwell Bar quadrangle comprises the territory lying between the meridians 121° 30′ and 121° west longitude and the parallels 39° 30′ and 40° north latitude. It is approximately 34.5 miles long and 26.5 miles wide, and contains about 918 square miles. The quadrangle forms a portion of the northern end of the Sierra Nevada and lies chiefly on its western slope. The larger part is in Butte and Plumas counties, but the southeast corner includes small portions of Sierra and Yuba counties.

Relief.—This quadrangle extends from the foothill region in the southwest corner, with an elevation in the canyon of the Feather River of only 200 feet, to the considerable ridges of the northern portion, where one point, Bucks Mountain, has an elevation of 7231 feet. The region is well wooded, and much of it is covered with thick brush, making exploration difficult. The river canyons are in general very rugged and deep, and in places impassable. There are few grander canyons in the Sierra Nevada than that of the North Fork of the Feather just west of Bucks Mountain, where it is about 5200 feet deep, as measured from the top of the mountain, and about 4300 as measured from the top of the high plateau west of the canyon, along the fortieth parallel.

Some of the scenery is very picturesque, and there are a number of waterfalls, not exceeded in beauty by any others in the State. One of these is on Camp Creek, shortly before it joins the North Fork of the Feather, and about 2 miles above Big Bar. A portion of the canyon of the Middle Fork of the Feather, where it is bounded by bare granite walls, is known as Bald Rock Canyon, and about 2 miles downstream from the point called Bald Rock a stream known as Fall River joins the Middle Fork (see fig. 3, on the sheet of illustrations). About 1 mile above its mouth this stream leaps over a cliff perhaps 450 feet in height, forming a beautiful fall, below which is a series of cascades. The granite of the amphitheater about the base of the falls is much shattered, many of the fissures formed being nearly vertical, and this zone of fracturing has probably been the primary cause of the formation of the cliff over which the water pours. These falls are well worth a visit, but are at present difficult of access. There are also some picturesque cascades on Powell Creek, a branch of the South Fork of the Feather, and a small but beautiful fall on another branch of the South Fork near the road from Lumpkin to Little Grass Valley. The water here falls over a bluff of the older basalt. The point is about 7½ miles northeast of Lumpkin.

Scenic features.

As in other portions of the northern and central Sierra Nevada, the ridges as a rule have a comparatively gentle slope to the southwest. The heterogeneous character of the rocks of the quadrangle and the dislocations to which they have been subjected have, however, produced greater irregularity in the drainage system and consequently in the shape and trend of the ridges than in many other portions of the range. Thus the main ridges of the northern part of the quadrangle have an east-west trend and those of the southwest corner a north-south trend.

Trend of the ridges.

The comparatively level surface of the ridge tops is the result of the long-continued erosion to which the Sierra Nevada was subjected in Cretaceous and Tertiary time. At the close of the Tertiary the region was one of gentle relief, and the present rugged and deep canyons are the result of stream erosion in Pleistocene time.

Old surface of erosion.

Drainage.—Except a small area in the southwest corner, the region is drained entirely by the Feather River. While the general course of the main forks of this river and of their chief tributaries is southwest, parallel to the general slope of the surface, there are some marked exceptions. At many points the streams have a northwest or southeast course, as Fall River to the east of Quartz Hill, and the Middle Fork of the Feather just upstream from the mouth of Fall River. At both these points the rock is granite, and the course of the streams appears to have been determined by lines of weakness (joint or fault planes) in the massive rocks (see fig. 3, on the sheet of illustrations). Thus the structural features of the region have had an influence on the course of streams. It may likewise be noted that the fault zone of the northeast corner of the quadrangle has determined the trend of Dogwood and Bear creeks. The nearly south course of the North Feather to the south of Big Bend coincides with the trend of the schistosity that has been superinduced on the amphibolite which there forms the walls of the canyon.

Influence of structure on the course of streams.

GENERAL GEOLOGY.

BED-ROCK SERIES.

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

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

SEDIMENTARY ROCKS.

Calaveras formation.—The rocks of the Calaveras formation in the Bidwell Bar quadrangle consist largely of micaceous slates, with quartzite and some limestone lenses. In general the rocks of this formation are much more highly metamorphosed here than in most portions of the Gold Belt. This metamorphism is plainly the result of the extensive granitic intrusions, the sediments being most highly altered along the contact with the granite. Fossils indicating Carboniferous age have been found in limestone masses near Spanish Creek east of Spanish Ranch, and on the slope west of Onion Valley Creek, about 3½ miles southeasterly from the mouth of the creek. In the Diadem lode at Edmanton additional fossils have recently been found by Mr. J. A. Edman. These consist of rounded crinoid stems and little oval bodies which Mr. Schuchert, of the United States National Museum, has determined as being silicified tests of foraminifera (*Loftusia columbiana* Dawson). These fossils are likewise of Carboniferous age. In general, however, the sediments are referred to the Calaveras formation on the basis of stratigraphic continuity with the rocks of that formation in adjacent areas. There are, moreover, numerous isolated lenses of sediments presumed to belong to the Calaveras on lithologic grounds only.

Metamorphism.

Fossils in the Calaveras.

Cedar formation.—On the northern slope of the ridge north of Meadow Valley is an area of little-altered clay slates which is stratigraphically continuous with an area of the Cedar formation in the Lassen Peak quadrangle. In the latter area there are lenses of limestone which contain pentagonal crinoid stems. These indicate the Juratrias period. No other area that can be assigned to the Juratrias has been found in the Bidwell Bar quadrangle.

IGNEOUS ROCKS.

Amphibolite and amphibolite-schist, diorite, and porphyrite.—Under this head are grouped a variety of metamorphic igneous rocks. Some of these are massive amphibolites and amphibolite-schists, others contain much feldspar and are practically diorites. In many of these rocks, except when further metamorphosed, the hornblende is a finely fibrous uralite, and there are usually present epidote, chlorite, sometimes calcite, and often iron pyrite. These rocks are supposed to have been derived from massive igneous rocks and tuffs. The massive amphibolites are known in some cases to have been originally pyroxenites. The amphibolite-schists containing epidote and uralite can often be shown to be altered augitic tuffs. The dioritic rocks apparently represent in some cases massive lavas, as on the Forbestown ridge. Certain massive diorites which form a large area in the Slate Creek drainage east and southeast of Buckeye House may be original diorites. There are massive diorites containing free quartz on the ridge from 1 to 2 miles northwest of Flea Valley. There is also some porphyrite in the complex. All of these rocks are shown as a unit on the geologic map.

Original nature of the rocks

While thus differing in origin, and to a considerable extent in appearance, all of these rocks, except some of the porphyrites, are similar in containing a large amount of green aluminous hornblende. These diorites, amphibolites, amphibolite-schists, and porphyrites, containing epidote, uralite, calcite, chlorite, and other secondary minerals in minute particles, present under the microscope a confused appearance, due to the minute size and great abundance of the secondary minerals, and to the presence of more or less iron oxide and other substances, producing a discoloration of the various minerals. Rocks of this type have resulted chiefly from dynamic metamorphism and hydrous metamorphism. When the same rocks have been further altered by contact with intrusive granitic rocks this confused appearance often disappears and all of the elements become thoroughly recrystallized. The feldspars and quartz appear largely in clear grains, often forming a typical mosaic texture; the hornblende assumes its proper crystalline form; epidote, chlorite, and calcite usually disappear altogether, and the iron ore recrystallizes as magnetite or ilmenite. Such recrystallized amphibolitic rocks are very abundant in the Bidwell Bar district. They form zones about the areas of granite which comprise so large a portion of the quadrangle. Some of the massive amphibolites are metamorphosed pyroxenites, occasionally showing traces of the original pyroxene.

Secondary minerals.

Kind of metamorphism.

Recrystallization of the secondary minerals.

There are also some layers of lighter-colored altered lavas which contain little hornblende. A band of rock of this character forms a portion of Big Bend Mountain, crossing the North Fork of the Feather just east of the mouth of Berry Creek. The microscope shows that such rocks are altered andesites or porphyrites. In the canyon of the Middle Fork of Feather River, at the east edge of the quadrangle, is a mass of greenish rock which is an altered augitic lava.

Porphyrite or altered andesite.

Magnesian series.—Serpentine, talc, chlorite, colorless amphibole, and actinolite are in this district associated in an intimate manner and appear to be merely different alteration products of the same original rock mass. The rocks made up of these minerals are therefore grouped together under the head "Magnesian series," since magnesia is a prominent constituent of all of them. The colorless amphibole was at first supposed to be tremolite, which is a lime-magnesia amphibole. Chemical analyses and microscopic examinations, however, show that there are two colorless amphiboles present, one monoclinic, probably edenite, and the other orthorhombic, probably gedrite. These amphibole-schists are so intermingled with the serpentine and the talc-schists and chlorite-schists as to make their separation impracticable. At a number of points specimens collected show on microscopic examination that the original rock was a basic granular rock varying from pyroxenite to peridotite. In most cases the original pyroxene and olivine are entirely gone, but at a number of points they are still to be noted in thin sections of the rock.

Original nature of the magnesian series.

While, as above stated, the magnesian schists and serpentine are intermingled, certain of the large areas of the quadrangle are composed chiefly of serpentine, and others of the magnesian schists. Thus the area at Meadow Valley is almost entirely serpentine, and this is likewise true of the Grizzly Hill area, the area in the southeast corner extending north and south from North Star House, the small areas just east and north of Big Bend Mountain, and the larger portion of the area north and east of Mount Hope. The western portion of the area last noted, on the ridge north of Mount Hope House, and the extension of the same on the north side of the South Feather, contain a large amount of a diallage-feldspar rock, probably a gabbro, in which the feldspars are mostly too much decomposed for a microscopic determination. The long area extending from Hartman Bar, on the Middle Feather, to Big Bar Hill, is made up chiefly of the magnesian schists (composed of talc, chlorite, and amphibole), while the extension of the same area at Big Bar and on the west slope of Big Bar Hill is chiefly serpentine. The area at Soapstone Hill is almost entirely talc rock, and the same is true of the lenses in the amphibolite-schist area east and south of Bear Ranch Hill. In the areas west of Strawberry Valley, along Eagle and Owl gulches, both serpentine and the magnesian schists are well represented; and this is likewise true of the area west of Franklin Hill and that extending east and west from Brush Creek on the ridge west of the Middle Feather. Occurring as narrow dikes in the magnesian series in the Grizzly Hill area, about Meadow Valley, and near Big Bar Hill, are white dikes largely made up of albite feldspar, some of them containing in addition quartz and muscovite, forming soda-aplite or granite. These dikes appear to have a genetic connection with the basic rocks from which the magnesian series is derived.

Serpentine areas.

Gabbro?

Areas of magnesian schists.

Soda-feldspar dikes in the magnesian series.

Gabbro.—Rocks of the gabbro type—that is to say, granular rocks composed of labradorite or anorthite feldspars with pyroxene or amphibole and usually iron oxide—form few areas in the Bidwell Bar quadrangle. The largest mass is that forming the high, square-topped eminence known as Bucks Mountain. This mass is intersected by a system of horizontal and vertical partings which result in the formation of squarely outlined, picturesque bluffs. In the horizontal partings may be found the cause of the flat top of the mountain, which may also be a portion of the old eroded surface of Neocene time. This gabbro area is indicated on the geologic map, but no line of demarcation is drawn between it and the surrounding granodiorite, as it appeared to grade over into that rock. It should be stated, however, that no attempt was made to separate the two masses in the field. Small amounts of gabbro were found at various points in the areas of the magnesian series, and in a portion of the amphibolite series east of Granite Basin are coarsely granular rocks, perhaps in part metamorphosed gabbro. A considerable mass of an altered feldspathic rock, perhaps a gabbro, has been noted under "Magnesian series" as occurring to the north of Mount Hope House.

Definition of gabbro.

Gabbro grading into granodiorite.

By the road one-half mile west of Forbestown is a small mass of uralite-gabbro, and there is another small area on the ridge southeast of Brandy City.

Gabbro-diorite.—At the south edge of the quadrangle there are three areas of rocks called gabbro-diorite. Portions of these areas are made up of gabbro, and other portions of a hornblende-feldspar rock in which the feldspars are too much altered for microscopic determination. The name as here used does not designate a rock intermediate in composition between gabbro and diorite, but chiefly altered gabbro or uralite-gabbro, very probably with some coarse amphibole-diorite. The use of the term gabbro-diorite for such rocks is not a good one, but it is so used in this folio for the reason that it was so used in the Smartsville folio (No. 18, issued in 1895), describing the quadrangle just south, and certain areas of such rocks cover portions of both quadrangles.

Granite, granodiorite, and quartz-diorite.—Granite is a granular rock composed largely of quartz and feldspars rich in alkali. Granodiorite and quartz-diorite have in general the characteristic appearance of granite, and are commonly spoken of as such. The chief components are feldspar and quartz. The feldspar is chiefly soda-lime feldspar, with a smaller amount of potash feldspar. Usually biotite and hornblende are present. The feldspar varies from oligoclase to labradorite, with occasional microcline or orthoclase. All of these granitoid rocks show evidence, in their thoroughly crystalline texture, of having formed at some depth below the surface. The three granitoid rocks noted above are genetically related in this district, as at many other points, and are not separately shown on the geologic map.

Definition of the granitoid rocks.

Nearly all of the quartz-bearing granitoid rocks of the Bidwell Bar district may be correctly called granodiorite, although in many specimens in which little or no potash feldspar is present the rocks are more correctly called quartz-diorite. Usually there is both biotite and amphibole present in addition to the soda-lime feldspars, and often some orthoclase, which is occasionally so abundant that the rocks approach a granite in composition. This is the case with the rock about

Enterprise, on the South Fork of Feather River. The rock southeast of Merrimac is a typical quartz-mica-diorite. As noted under "Gabbro," the flat-topped eminence known as Bucks Mountain is formed of a true gabbro, which appears, however, to grade over into the surrounding granodiorite. So far as known, all of the granitoid rocks of the quadrangle are later in age than the inclosing sedimentary and igneous schists, which near the granite contact are often thoroughly recrystallized, at some points having a gneissoidal appearance. Definite evidence of the intrusive character of these granitoid rocks is the existence of a contact-breccia (see fig. 2, on the sheet of illustrations) along the borders of some areas, and occasional dikes clearly cutting the schist series.

Granitic metamorphism.

The granodiorite is often intersected by systems of partings, or joints, as in other districts. This is particularly to be seen in the amphitheater at the base of the Fall River falls, and the vertical partings here appear to be the cause of the formation of the scarp over which the water is precipitated. Where the granite is more massive, as in the vicinity of the point known as Bald Rock, there is a tendency to weather in dome-shaped forms. Near the contact with other rock masses the granodiorite is often schistose, as by the stage road west of Berry Creek House and on Spanish Peak ridge. At many points the granite series is cut by fine-grained, light-colored granitoid rocks, containing as a rule ferromagnesian minerals in small amount. These are called aplite or granulite, and appear to represent the acid residual material of the granitic magma, squeezed up into cracks which have formed after the main mass of the magma has consolidated. As noted later under "Diorite and diorite-porphyry," there are also numerous dikes of fine-grained diorite-porphyry at many points.

Joints in the granitic rocks.

Granitic domes.

Dikes of aplite or granulite.

Microgranite-porphyry.—Fine-grained granitic rocks with porphyritic crystals may be called microgranite-porphyry. Numerous dikes of such rocks were noted in the canyon of the Middle Feather, just at the mouth of Onion Valley Creek and farther east, cutting the rocks of the Calaveras formation. Similar dikes were also seen in the canyon of Onion Valley Creek. The largest of these dikes, at the mouth of the creek, is shown on the map. This contains numerous anastomosing veins of white quartz, and there are grains of iron disulphide scattered through the rock. Calcite is also present. This dike has evidently been changed by the action of mineral waters.

Porphyry dikes.

About a mile east of Enterprise, on the north side of the South Feather, a dike of fine-grained granite-porphyry containing both white and black mica occurs in the granodiorite. Certain white, fine- and even grained rocks in a decomposed and friable condition were noted by the side of the Quincy road about 1½ miles north of Buckeye House, to the north of the Walker Plain basalt area. These rocks, while showing no porphyritic constituents, are doubtless closely related to granite-porphyry, and may be called microgranite.

Quartz-porphyry (rhyolite-porphyry).—Altered rhyolitic rocks (highly siliceous volcanic rocks rich in alkali) containing porphyritic crystals of quartz, usually in a fine-grained crystalline groundmass, are generally known as quartz-porphyry. Sometimes this groundmass is the result of the crystallization of an amorphous paste or glass which formed part of the rock when it first cooled. Such rocks are sometimes called devitrified rhyolites (aporhyolites). The crystalline character of such a groundmass is thus secondary. In other cases this finely crystalline groundmass is the original groundmass. While such porphyritic rocks are ordinarily known as quartz-porphyry, a better name for them, and one that may become general, is rhyolite-porphyry.

Definition of quartz-porphyry.

No considerable masses of quartz-porphyry were found in the Bidwell Bar district, but in the amphibolite-schists 1¾ miles northeast of Miners Ranch is a dike, with strike to the east of north, about a mile in length and but a few feet in diameter. This is shown on the map, as is also another dike on Big Bend Mountain. Doubtless other dikes occur at other points, and some of the dike rocks noted under the head "Microgranite-porphyry" which were found in the canyon of the Middle Feather would by some investigators be called quartz-porphyry.

Dike of quartz-porphyry.

Diorite and diorite-porphyry.—Granular rocks composed chiefly of soda-lime feldspar (oligoclase-andesine), with usually some amphibole, mica, or pyroxene, may be called diorite. Cutting the granodiorite at many points are dark-gray, fine-grained rocks showing minute needles of brown amphibole to the unaided eye. These are abundant in the Merrimac granodiorite area, and are sometimes found along the gold-quartz veins. In specimens collected by the road to Quincy, about 2 miles southeast of Merrimac, the amphibole occurs in ragged grains and fibers, but as a rule the needles show their crystal form clearly. Similar dikes may be noted in the Spanish Peak granodiorite area, and they are also found cutting the Auriferous slate series and associated greenstones. Several such dikes were noted in the canyon of the Middle Feather about 2 miles upstream from the mouth of Onion Valley Creek. These small dikes, often only a few inches in width, are among the latest of the pre-Cretaceous intrusives, for they cut nearly all of the pre-Cretaceous rocks. Under this head may also be noted a peculiar quartz-diorite which occurs as a dike-like mass in the granodiorite by the trail to North Valley in the northwest corner of the quadrangle. This contains a large amount of a green amphibole, which a chemical analysis shows to be an aluminous amphibole unusually rich in silica. Rutile is rather abundant in this peculiar diorite.

Diorite-porphyry dikes.

Diorite dike.

SUPERJACENT SERIES.

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

NEOCENE PERIOD.

During the Neocene period the Bidwell Bar quadrangle was a country of low relief, as were other portions of the Gold Belt. At some points the old eroded Neocene surface is still perfectly preserved under the later lava flows, and at other points is approximately shown by the level tops of the ridges. Some of these ridges are lava-capped, and their present level surface is due to the flat lava-tables, but that the underlying surface was likewise approximately level is shown by the nearly level lines of contact on the canyon sides between the lavas and the underlying older surface.

Old surface of erosion.

Since the Neocene period the present river system has cut canyons which are in places more than 3000 feet deep. This is well shown by the canyon of the North Feather to the west of Bucks Mountain. In the neighborhood of Hartman Bar, where the Middle Feather has an altitude of about 2500 feet, the Neocene surface preserved on the ridge tops to the north and south is 5000 feet or more in elevation. That the ridge tops at this point represent accurately the Neocene surface is shown by the presence of river gravels of that period resting on them.

Measure of erosion since the Neocene period.

As noted later in the discussion of faulting, the present relief of the country is, however, by no means wholly due to erosion. Thus, along the east slope of the level lava-capped ridge of Spanish Peak is a zone of faulting, and the low position of the basin to the east is due more to subsidence than to erosion. The old Neocene surface may be finely seen on the spur south of the North Yuba to the west of Slate Range, and on the level-topped wooded ridge 2 miles west of Strawberry Valley, as well as at many other points.

Auriferous river gravels.—It is safe to assert that in Neocene time, as now, an extensive system of rivers existed in the Bidwell Bar quadrangle and that the Auriferous gravels were deposited by them. The great subsequent erosion, however, has removed the larger part of the gravels, and the preservation of many of the remnants of the old river deposits is due to their being capped with volcanic material which flooded the river valleys during and at the close of the Tertiary period. As in other portions of the Sierra Nevada, evidence of two or more systems of rivers of different age may be found.

In the Bidwell Bar quadrangle the oldest river system of which there are records formed deposits composed chiefly of white quartz pebbles. Deposits belonging to this earlier period are to be seen at Union Hill, Council Hill, Brandy City, and Grizzly Hill, these being remnants of one river deposit, the same shown in the Downieville folio at Scales, Poverty Hill, and other points. Nearly all of these gravels have been washed by the hydraulic method and have been found to be rich in gold. The Brandy City–Council Hill channel is capped with andesite-tuffs and -breccia.

Oldest Neocene river system.

There is white quartz gravel also at the American House, on the road from Strawberry Valley to Laporte. This is not covered with lava, although there is an area of basalt immediately to the east. The abundance of white quartz veins near this gravel mass suggests a local origin for a portion of it. At the head of Dogwood Creek there is some river gravel capped by the older black basalt. The camp was known as Sweet Oil diggings. Some of the gravel from a shaft sunk through basalt was examined. Most of the pebbles are of white quartz, but there are also some of quartzite, siliceous argillite, and variegated breccia. The latter pebbles probably came from the breccia beds of the Milton formation, which would indicate that the deposits containing them were formed by rivers originating in the southeast portion of the Downieville quadrangle, where are located the nearest known areas of the Milton formation.

Three and one-half miles southwest of Franklin Hill there is a remnant of a gravel channel that has been mined by the hydraulic method. It lies at the edge of a ridge of the older basalt. Some white quartz gravel has been exposed in shallow shafts about 1¾ miles southwest of Franklin Hill, near the road. These two deposits on Franklin Hill ridge may easily have been connected at one time with the Sweet Oil channel, if, as elsewhere suggested, there is a fault at the head of Dogwood Creek along which the Franklin Hill ridge has been differentially elevated. At Davis Point, in a ravine draining into Fall River from the south, about 1½ miles southeast of Cammel Peak, there is gravel composed mostly of white quartz pebbles, but with some volcanic pebbles also. The bed rock is amphibolite-schist. This gravel has been hydraulicked.

Gravels on Franklin Hill ridge.

Davis Point gravels.

There is also an area of old river gravel, known as Fales Hill, at the west edge of the lava area that caps Chaparral Hill. The extensive gravel deposits at Gopher Hill, Badger Hill, and Shores Hill, east of Spanish Ranch, are noted later under the heading "Pleistocene period."

There are also at many points evidences of river deposits under the older basalt, and those now to be noted appear to be later than the deposits containing the pebbles of white quartz above described.

The Dodson gravel mine lies about 3¼ miles northwesterly from Strawberry Valley, at the south border of the basalt flow that caps Mooreville Ridge. The gravel is from 30 to 100 feet thick and is largely coarse, but there is also some fine material. The pebbles are of granite, andesite, basalt, quartz, and metamorphic rocks. They vary in size from small pebbles to large bowlders, all well waterworn. A considerable amount of finely preserved silicified wood is found here. Professor Knowlton determined this as being coniferous wood (Araucarioxylon). The basalt capping the mine is from 15 to 30 feet thick, and shows a columnar structure in places. Some of the basalt pebbles contain crystal of chabazite in cavities. The bed rock is granite.

Dodson gravel mine.

Ludlam's hydraulic mine is, without much doubt, on the same channel as Dodson's. It lies on the north edge of the basalt area of Mooreville Ridge, about 4 miles a little west of north from Strawberry Valley. It differs in no essential particulars from the Dodson mine. The bed rock is granite. The gravel attains a thickness of about 90 feet, and the basalt capping a thickness of about 150 feet. The lower gravel is made up chiefly of the older sedimentary and associated igneous rocks of the Auriferous slate series, and the upper part of Tertiary lava pebbles. Fine silicified wood occurs here also. There is gravel on Mooreville Ridge 2 miles northeast of Ludlam's mine. Under the basalt of Kanaka Peak there are well-rounded pebbles of the kind noted at the Dodson mine. At Walker Plain there are gravel beds under the basalt. The gravel of this channel as seen at Buckeye House is much like that at Kanaka Peak and the Dodson mine, so far as examined. While it is not probable that all of the gravel deposits under the older basalt belong to the same period, most of them are similar in containing some pebbles of Neocene volcanic rocks and of the older rocks of the Auriferous slate series, and without doubt were formed by rivers of later age than those of the white quartz gravel period.

The small area of gravel 1½ miles north of Lexington Hill by the road to Little Grass Valley appears to rest on andesitic tuff. The pebbles are chiefly quartzite, siliceous argillite, quartz-porphyry, a few of vein quartz, and one a soft white pebble resembling a Neocene lava, possibly a rhyolite-tuff. Gravel of this kind is often locally called by the miners "bastard gravel," inasmuch as it seldom contains gold in paying quantity. On the east slope of Cammel Peak there is a little river gravel containing the same variegated breccia pebbles noted at Sweet Oil diggings and other points. On the summit of the ridge south of the Middle Fork of the Feather, at a point about 2 miles north of Lava Top, is a remnant of a former gravel deposit capped by the older basalt, a mere point of which still remains on the gravel. This deposit contains pebbles of quartz-porphyry, granite, and various other igneous rocks, and of some metamorphic rocks.

"Bastard" gravel.

The Spanish Peak gravel channel has been described by Professor Whitney.* The gravel is capped by andesite-breccia. It is made up of pebbles of pre-Cretaceous rocks and contains also pebbles of pyroxene-andesite. The deposit was mined by a tunnel at the Monte Cristo claim, at the south edge of the deposit. The layers of pipe clay here contain leaves of fossil plants, which are said to indicate an upper Miocene age for the finer beds. Scattered over the level top of Spanish Peak itself are well-waterworn pebbles, including many of white quartz. The Spanish Peak ridge deposit is also exposed 1½ miles west of Spanish Peak, and pebbles of metamorphic and igneous rocks were noted at numerous places in the andesitic conglomerate and breccia that caps the channel.

Monte Cristo gravel mine.

A small patch of gravel, with pebbles like those at the Monte Cristo mine, was noted on the ridge south of Bucks Creek, associated with andesitic tuff. There is also a little of the older basalt in place here. At one point a shaft has been sunk through andesite-tuff and has struck fine white quartz gravel. The pebbles on the gravel flat 6 miles southeast of Spanish Peak are mainly of quartzite and other siliceous rocks. Overlying this gravel is andesite-breccia. About 3½ miles south of Grizzly Hill, north of the point called Gravel Range on the topographic map, well-worn pebbles were noted scattered along the ridge, testifying to the former existence of a river deposit. Pebbles have also been found scattered along the ridge forming the northwest extension of Big Bend Mountain.

At the point called Clipper Mill, on the road to Strawberry Valley, is a long streak of Neocene river gravel about 600 feet wide. The pebbles are chiefly of the older siliceous rocks. There is no volcanic material associated with this area. At the west end of the andesite-breccia area, or about 1¾ miles east of Clipper Mill, is a small deposit of gravel, known as the Pratt drift mine. About 1½ miles north of Clipper Mill is the Gentle Anna drift gravel mine. The tunnel had evidently cut the olivine-basalt that caps the deposit before it struck the gravel, which is half rounded and does not appear to represent a large channel.

The high plateau of the northwest corner of the district, about Table Mountain and the Campbell Lakes, is known locally as Gravel Range, from the occurrence of gravel at numerous points. Some of the so-called gravel is merely morainal material and will be noted under the heading "Evidences of glacial action." The white quartz gravel at Lotts diggings, just north of the fortieth parallel, is undoubtedly a remnant of the oldest river system of this plateau. Like the gravel at Lotts diggings, the other river gravels are at nearly all points capped by olivine-basalt, which appears to be part of the extensive flow forming the bluffs on the north side of Chipps Creek (Lassen Peak quadrangle). The gravels at the Butte King and Butte Queen mines belong to this series, but they are north of the Bidwell Bar district.

Gravels of the plateau west of the North Feather.

The Reese-Jones drift gravel mine is under a spur of olivine-basalt 1¼ miles northwest of Table Mountain. The gravel appears to be part of a thin sheet spread over the ground at the time the basalt flow took place. Some of the gravel is

*Auriferous Gravels of the Sierra Nevada, 1879, p. 216.

well rounded, but there is also a considerable amount of subangular material of local origin. Rather abundant are pebbles of hematite, and of chromic iron. The basalt sometimes lies immediately on the bed rock, cutting off the gravel.

Morainal gravel.

The material mined at Snow's gravel mine will be described later, under "Evidences of glacial action," as being morainal, but there is also some river gravel here, well exposed at a hydraulic washing located at about the point where the house is shown on the map. The houses of the miners are perhaps one-half mile southeasterly from this point, and morainal material was being mined near these houses, by hydraulicking underground, in 1895. The altitude of the house shown on the map is about 5200 feet. Here may be seen the mouths of tunnels which have been run in on the channel toward Table Mountain. At the base of the exposure at the hydraulic washing are about 20 feet of sand and well-washed gravel. The pebbles of the bottom part of this are of chert, hornblende-schist, slate, granite, and quartz. Overlying the well-worn gravel and sand is a mass of volcanic rubble, with some granite, plainly of later origin (morainal material). Mr. Snow supposes this channel to extend under the lava of Table Mountain; and this is not unlikely, for the bed rock is granite, and the pebbles of hornblende-schist, slate, etc., were very likely derived from areas of these rocks north of Table Mountain. Pebbles of iron ore similar to those noted at the Reese-Jones mine occur here.

Some of the gravel above referred to were doubtless deposited by rivers which occupied the same channel for a long space of time. Thus at Sweet Oil diggings the white quartz gravels may belong to the oldest gravels, and the darker gravels to a much later period. It is obvious that much remains to be done before the course of any of the Neocene rivers of the district can be indicated, except that represented by the Brandy City deposits.

THE NEOCENE AND LATER VOLCANIC ROCKS.

Source of the lavas.

While volcanic rocks are very abundant in the Bidwell Bar quadrangle, there appear to have been but few volcanoes in the district. The lavas came largely from volcanic vents located in the Downieville quadrangle. This is not true, however, of the lavas of the plateau west of the North Fork of the Feather. The lavas of this portion of the quadrangle originated in the Lassen Peak volcanic area. At a few places flows of basalt appear to have issued from points near where they are now found, and west of Franklin Hill, as hereafter noted, is the base of a former volcano.

The Superjacent volcanic rocks in the district may be grouped under the following heads:

Basalt:
- Older basalt with little olivine.
- Late coarse-grained basalts or dolerite.
- Late basalt, dark colored, and rich in olivine.

Andesite:
- Hornblende-pyroxene-andesite tuff or breccia.
- Fine-grained massive hypersthene-andesite.

Basalt.—Basalts are lavas that are usually fine grained and dark in color. They are composed chiefly of basic lime-soda feldspars, with usually pyroxene, olivine, and magnetite. On the geologic map the basalts are grouped under two heads, "Older basalt" and "Late basalt," which comprise all the other kinds described.

Older basalt.

The older basalt is a dark, fine- and even-grained rock, containing much magnetite and little determinable olivine. Although it has been clearly shown that the older basalt is at many points covered with fragmental andesite, and therefore older, there is evidence in andesite pebbles found under the flows of the basalt that some andesitic eruptions antedate the basalt. The most extensive flows cap the ridges drained by Fall River and the South Fork of the Feather. These can be traced into the Downieville quadrangle, to the vicinity of Little Grass Valley. Smaller areas are to be found at Walker Plain, Kanaka Peak, and other points. There is a series of benches of the older basalt on the south slope of the ridge north of the South Fork of the Feather, a little west of Little Grass Valley (see fig. 4, on sheet of illustrations). These benches present the appearance of successive flows. The entire thickness of the basalt is here not less than 500 feet.

There is a small mass of columnar basalt on the southwest spur of Big Bend Mountain, just one-half mile west of Island Bar. This mass is perhaps to be correlated with the older basalt, although it differs somewhat in appearance.

Doleritic basalt.

The late coarse-grained doleritic basalt is found in smaller areas than in the Downieville quadrangle. It appears to have issued approximately at the points where it is now found. It is distinctly later in age than the andesitic breccias, on which it often rests, and may be of very early Pleistocene age, and is therefore represented without the Neocene symbol on the map. It forms part of the level top of Mount Ararat, where it rests on andesitic breccia, and is here much finer grained than usual. There is a considerable flow north of Fall River, of which Cammel Peak is the culminating point.

Basalt of the Lassen Peak area.

The basalt of the plateau in the northwest corner of the district forms a portion of the Lassen Peak volcanic area. It is of the coarse olivinic type, much of it having a marked porphyritic development. The flow may be older than the somewhat similar rocks of the Mount Ararat and Cammel Peak areas. This basalt forms the bed of the upper part of Rock Creek at one point where the elevation, according to the topographic map, is 6200 feet, the older pre-Cretaceous rocks (here chiefly granodiorite) rising to a greater elevation both north and south, indicating that the basalt flowed over a very uneven surface, or that it came out in a fissure at this point, or that there have been some displacements of the old Neocene surface. Some of this basalt resembles pyroxene-andesite in texture. It usually contains olivine, and always pyroxene. Hornblende was not noted. A chemical analysis of a specimen from the flow about 1 mile west of the Campbell Lakes shows a silica content of 52 per cent and a lime content of 9 per cent.

The late olivine-rich dark basalt grouped under the third head is represented by two little buttes of columnar lava southeast of China Gulch, on the ridge west of Mount Ararat. The lava appears to have issued at these points. While it is regarded as later than the older basalt before described, no positive evidence on this point has been obtained in this region.

Old volcanic vent.

About $1\frac{1}{2}$ miles due west of Franklin Hill is a small basin formed in the older rocks. The rim is cut through on the north side, where the drainage of the basin escapes. An examination of the bottom of this basin shows that it is underlain by a stratified tuff, some of which dips south and southwest at angles varying from 30° to 70°. An examination of the specimens collected shows that the tuff contains abundant olivine and is of a basaltic nature. Moreover, a massive dark olivine-basalt occurs on the west slope of the basin, and is presumed to have come from the same source as the material of the tuff. This basalt is darker in color and finer grained than the doleritic basalt of Cammel Peak, and presumably represents a distinct eruption from a different subterranean reservoir. It differs from the fine-grained basalt of the little buttes above noted in having a resinous look, such as is seen in some augite-andesites. Fragments of serpentine, which forms the walls of the basin, are plentiful in the tuff. It is probable that this represents an old volcanic vent.

Andesite.—The andesitic lavas differ from basalts chiefly in containing a more acid soda-lime feldspar, with usually no olivine and less magnetite.

Andesite-tuff and -breccia.

By far the larger part of the andesitic material of the Bidwell Bar district occurs in a fragmental or pyroclastic form, and may be called andesitic tuff, breccia, conglomerate, or agglomerate, according to the shape and size of the components. As in other portions of the Sierra Nevada, foreign material occurs, mixed with that of volcanic origin. This fragmental andesite attains a thickness of more than 700 feet on the plateau east of the head of Bear Creek, and about the same thickness on the northeast part of Mooreville Ridge, where it distinctly overlies the older basalt.

Dike of andesite-breccia.

About $1\frac{1}{4}$ miles south of Cammel Peak, in the canyon of Fall River, is a dike-like mass of fragmental andesite. The stream has cut into this dike of andesite-breccia to the depth of about 500 feet, and in the dike material in the bed of the river are embedded numerous fragments of fossil wood, as well as pebbles of pre-Cretaceous rocks and pebbles and fragments of hornblende-andesite and of the older basalt. The specimens of wood collected were referred to Prof. F. H. Knowlton, who reports that "it is a sequoia of the redwood, or *S. sempervirens*, type. The wood is not well enough preserved to enable me to say that it is the same as the living redwood, although it is undoubtedly near it." This dike-like mass is about 1500 feet in width where crossed by Fall River. The wall rock is granite. The dike-like mass represents a fissure opened by an earthquake and filled in from above. In this way the fragments of wood found embedded in the dike are readily accounted for.

Hypersthene-andesite.

The fine-grained hypersthene-andesite is found in the Bidwell Bar district, so far as known, only at Franklin Hill and at one other point. At Franklin Hill it forms a cap having a maximum thickness of 300 or more feet on the north slope. The characteristic slaty structure of this lava is well brought out at this place, and a photograph was taken to show this feature, which is reproduced on the sheet of illustrations (fig. 5). The second locality is the little butte six-tenths of a mile south of west from the highest point of Mount Ararat.

PLEISTOCENE PERIOD.

Pleistocene river bars.

Pleistocene river gravels.—The old river gravels found above high-water level, chiefly at the bends of the streams, are referred to the Pleistocene period. Such are the deposits at Bidwell Bar and those along the South Fork of the Feather near Stringtown, at Island Bar, Hamilton Bar, and Big Bar on the North Fork, and at Hartman Bar and Butte Bar on the Middle Fork. In fact, there is scarcely a stream of any size in the area along which such bars may not be found. Some of them are still being mined for gold.

Just east of the mouth of a branch of the North Fork of the Yuba called Slate Creek is a nearly level-bottomed ravine, separated from the creek by a hill. This ravine is called the Race Track, and investigation showed it to be a bit of a former bed of the creek. The gravel of this former channel is still being mined for gold.

Pleistocene lake gravels.—The gravel beds about Meadow Valley, as may be seen by referring to the geologic map, underlie the valley and form terraces about it, some of which attain an altitude of more than 4000 feet, the lowest part of the valley having an altitude of about 3700 feet. As has been before intimated, this valley appears to have been formed by orographic causes, probably in early Pleistocene time. The gravel beds that form the terraces about it plainly show that it was occupied for a long time by a body of water, and the topography indicates that this lake must have drained easterly—that is, into the American Valley, itself an old lake bed, although apparently a shallow one.

Gopher Hill gravel mine.

The Meadow Valley gravels have been mined very extensively by the hydraulic method at Gopher Hill, $1\frac{1}{2}$ miles east of Spanish Ranch. The banks now exposed show the character of the material finely. On the south side of the flume is a vertical bank about 150 feet high in which are two layers, of a light-buff color, from 1 to 5 feet in thickness. The lower layer is perhaps from 40 to 60 feet above the bed rock, and the upper layer 50 feet higher. The same material is exposed in a bank north of the flume, and a specimen was taken there. Microscopic examination shows this to be composed of isotropic, translucent grains, often reddish by discoloration, and doubly refracting grains and angular particles, some of which are probably quartz. The isotropic material is volcanic glass, perhaps from the Lassen Peak volcanic vents. The material is very light and friable.

The general color of the Gopher Hill gravel is reddish, a dark red near the surface. The pebbles are usually small, from 1 to 4 inches in diameter, and by far the greater number of them are flattened. Decomposed lava pebbles were noted, but the pebbles are mostly composed of rocks of the pre-Cretaceous formations, quartzite, greenstone, and siliceous argillite being represented. Pebbles of white quartz occur, but are not abundant. There is a large amount of silt and sand, perhaps one-half of the entire material. Lying about over the area that had been washed by the hydraulic method were noted many well-worn bowlders about a foot in diameter, but there were very few of these to be seen in place in the banks.

A large surface of the lower gravel beds at Grub Flat and vicinity has been mined over. Underlying the well-rounded gravel northwest of Grub Flat is some decomposed "cement" gravel, made up largely of small round, red, brown, and white particles, between which there has been deposited an opaque white secondary substance in concentric layers. Under the microscope this is seen to be a distinct tuff, but decomposed. It is made up of microlitic and glassy fragments in which the outlines of the feldspars are still to be seen. Some fragments contain fresh augite and hornblende grains, and there are also grains of serpentine present. Some of the particles are thoroughly rounded.

Along Wapanse Creek some of the lake gravel is subangular. Three and a fourth miles east of Meadow Valley post-office, on a branch of Slate Creek, at an altitude of over 4000 feet above sea, is some gravel with angular blocks of the late doleritic basalt like that capping Clermont Hill. Some of these gravels were formerly mined. The camp was probably the one called Hungarian Hill. Four miles southeast of Meadow Valley post-office, on the ridge west of Deer Creek, is some Pleistocene gravel extending to an altitude of 4700 feet, and a gravel area west of the South Fork of Rock Creek attains an altitude of 4500 feet. There are also gravel beds that have been mined by the hydraulic method on the ridges east and west of Whitlock Ravine. These mines were known as Badger Hill and Shores Hill. The gravels may represent portions of a deposit formed at a former outlet of the Meadow Valley Pleistocene lake. They are like those at Gopher Hill. There is little doubt that all of these isolated gravel patches were originally connected with the large Meadow Valley area of lake gravel, although some of them may have been formed by Pleistocene streams draining into the lake, and some of them may have attained their present altitude by displacement subsequent to the lake period. The rocky barrier between Meadow Valley and the American Valley has been cut through by Spanish Creek in late Pleistocene time, and thus the lake was drained.

Moraines.

Evidences of glacial action.—On the north and east slope of the Spanish Peak ridge is a series of fine moraines which together form an area more than 4 miles long. Between these deposits and the steep north slope of the granite ridge are several small but picturesque lakes. On the north slope of the Bucks Mountain ridge are moraines and morainal lakes, and at a point about 2 miles southeast of the summit is a little lake or pond that has been formed by a terminal moraine. The moraines west of Haskins Valley are on the north slope of the serpentine ridge of which Grizzly Hill is the highest point. The road from Buckeye House to Spanish Ranch passes over some of this glacial débris. The rock of this north slope is polished and some scratched bowlders were found in the morainal material. Some granitic bowlders were seen here on the serpentine in very perplexing situations if regarded as transported by ice, since there is no granite about the névé region of this former glacier. On close examination, however, this granite was found to contain muscovite and to be unlike that of any of the large granite areas of the district. A more careful search showed that these granitic bowlders had weathered out from dikes in the serpentine, and are not far from in place. These dikes are, in fact, soda-granulites or aplites, and are briefly described under "Magnesian series."

The elevation of the serpentine ridge just south of this morainal area is only about 6000 feet, and this is remarkable as being the lowest elevation in the Sierra Nevada, so far as my observations go, that sheltered a glacier during the Glacial epoch, with possibly one exception. What appears to be a minute moraine may be seen on the granite ridge southwest of Bucks Valley, forming the north side of a little pond. The top of the ridge south of this pond has an elevation of only 5800 feet.

On the east slope of the Dogwood Peak ridge, about $1\frac{1}{2}$ miles southeast of the peak, is a small bank of loose material, apparently a terminal moraine. It lies about 500 feet below the top of the ridge. At the head of the ravine which contains this moraine there was a bank of snow in August, 1894. The rocks below the snow bank were smoothed, but no striæ were noted. The elevation of the ridge top is more than 6000 feet. As a general rule, it may be said that in the Sierra Nevada all those slopes which now shelter snow banks during the entire season nourished glaciers during the Glacial period.

Glaciated plateau west of the North Feather.

On the high plateau of the northwest section of the district, to the west of the North Fork of Feather River, is another glaciated region. There is more or less morainal material scattered over nearly the whole of this plateau, and definite moraines are to be seen at the head of Chambers Creek, near the mouth of North Valley Creek, and about Crane Valley. The granite of the drainage above (north of) Crane Valley is finely polished and grooved in places.

There are also extensive moraines south of Table Mountain at the head of Little Kimshew Creek. These materials, which contain water-worn pebbles, have been mined for many years for the gold they contain. The camp was formerly known as Little Kimshew. Snow's mine, $1\frac{1}{2}$ miles south of Table Mountain, is still being operated. This mine is further referred to under the heading "Auriferous river gravels." Morainal deposits were formerly extensively washed for gold at Big Kimshew, $2\frac{1}{2}$ miles southwest of Table Mountain, and at a point east of Rock Creek, by the trail from North Valley to Lotts diggings. At the time of my visit (1894) some morainal material was also being mined for gold at a point $4\frac{3}{4}$ miles due east of Table Mountain.

At North Valley, and at several points southwest of the valley, by the trail, are patches of well-worn gravel. These deposits may have been formerly continuous, and may have been formed by the damming of North Creek by a moraine, which the creek has since cut through. Pebbles of granitoid rocks, pyroxenite (?), and amphibolite were noted in these deposits, and in addition rounded fragments of the Tertiary basalt of the ridge to the north. The amphibolite pebbles presumably came from near the Campbell Lakes.

SCHISTOSITY AND BEDDING.

The sedimentary rocks in the Bidwell Bar quadrangle are chiefly argillite, mica-schist, and quartzite, with limestone lenses, and the original bedding, where it can be determined, coincides roughly with the planes of schistosity developed later. However, a careful study of the district would probably show numerous minor discordances. The igneous schists comprise amphibolite-schists, which are chiefly altered augitic tuffs, and the schists of the magnesian series, composed of talc, chlorite and colorless amphibole. These sedimentary and igneous rocks have been subjected to pressure, resulting in the development of schistosity.

An interesting phenomenon of structure is represented in the accompanying figure (fig. 1).

FIG. 1.—Diagrammatic map of the massive and schistose rocks of the Bidwell Bar quadrangle, showing the manner in which the lines of schistosity are, as a rule, parallel to the contact of the massive granitic areas, which are represented in white with divergent hachures.

The schistose areas here include the sediments of the Calaveras formation and the various igneous schists above noted. The massive areas represented by close-fitting divergent hachures are serpentine, peridotite, pyroxenite, diorite, and massive amphibolite and massive talc rock. The white areas with divergent hachures are granite, granodiorite, quartz-diorite, and gabbro. It will be observed that at nearly all points the lines of schistosity, which are also largely coincident with the bedding of the sedimentary rocks, are parallel to the outlines of the granitoid areas. To this, however, there are abundant minor exceptions, as where narrow tongues of granite cut across the lines of schistosity, and it would appear that the schistosity in the main was developed at a period antecedent to the granitic intrusions, and that the parallelism of the lines of schistosity to the contacts of the entering granite is due to these masses being forced aside by the intrusive rock.

Schistosity older than the granitic intrusions.

FAULTING AND LANDSLIDES.

On the steep slopes of the canyons one may often note benches, which appear to have been formed by landslides. They may be seen along the new lower road to Forbestown from Robinson Mill, where there are slight depressions in the benches, which after rains contain water.

A considerable landslide or fault appears to have occurred on the northwest slope of Bloomer Hill. There is a high northwest spur with gentle top slope extending more than a mile from the summit of the hill, and on the north side of the northwest end of this spur is a precipitous face perhaps 400 feet high, the dropped-down area to the north forming an irregular series of flats, on which the old road to Island Bar runs.

Fault scarp at head of Dogwood Creek.

A still better example of a post-Neocene displacement may be seen west of the head of Dogwood Creek. This fault scarp is shown on the illustrations sheet (fig. 6). The wooded flat lying below and east of this scarp appears to represent a downthrown area, and the probability of this is heightened by the occurrence of Neocene river gravels and lavas on this area and their recurrence on the top of the ridge west of the fault scarp.

Meadow Valley a depressed basin.

Meadow Valley seems likewise to represent a depressed area, with a zone of faulting along the east side of the Spanish Peak ridge. The Tertiary andesitic tuffs to the north and south of Meadow Valley continue down to the level of the valley; and similar tuffs overlying river gravels cap the Spanish Peak ridge, 3000 feet vertically above the valley. This displacement appears to have taken place after the last andesitic eruptions, either at the end of the Neocene or early in the Pleistocene, for the valley was the bed of a lake during a part of Pleistocene time. The broad plateau 7 miles southeast of Spanish Peak likewise may be regarded as a downthrown block, and the steep slope west of Bear Creek as a zone of faulting. There are river gravels on this plateau, which is mainly covered by andesitic tuffs. That the underlying surface of the older rocks is likewise nearly level may be seen from the level line of contact between this old surface and the overlying volcanic material, as shown on the geologic map. The displacement of this plateau is thought to be comparatively slight. There is evidence of faulting along the Diadem lode at Edmanton, $2\frac{1}{2}$ miles southeast of Spanish Peak, and this is in the same general fault zone as that along Dogwood and Bear creeks and the east slope of Spanish Peak. Faults have likewise been noted in the Auriferous gravels at Brandy City and elsewhere.

Microscopic evidence of faulting.

In the bed of the Middle Fork of Feather River, just above the mouth of Onion Valley Creek, the Paleozoic clay slates are cut by numerous dikes. One of these was noted which had been faulted, the displacement amounting to about 15 inches. Careful observations will probably show that similar small faults exist at many points. The same sort of evidence may be noted under the microscope in thin sections. The faulting is particularly well shown in crushed rocks in which there are triclinic feldspars showing lamellar twinning.

ECONOMIC GEOLOGY.

GOLD GRAVELS.

The gold-bearing gravels formed by a preexisting system of rivers of Tertiary age have been treated of under the head of Neocene "Auriferous river gravels." At a number of points morainal material or accumulations of loose rock due to ice action have been found to be auriferous. These localities are noted under "Evidences of glacial action." The auriferous gravels of the Pleistocene lake that formerly filled Meadow Valley are noted in the description of that deposit. No detailed description of the Pleistocene gravels seems necessary; they are found along nearly all the streams forming the so-called "bars."

Big Bend mine.

Among the notable efforts to mine the river beds themselves is that which proved unremunerative at Big Bend. A tunnel was constructed at a point on the North Fork of the Feather where the river turns sharply to the east. The river then flows south for some distance, and then bends again to the west, making a magnificent horseshoe bend, having a length, following the course of the river, of perhaps 12 miles. The tunnel is about 2 miles in length and opens into the head of a ravine on the west of Big Bend Mountain, known as Dark Canyon. A dam was built at the northeast end of the tunnel, by which, at low water, the river was diverted into the tunnel. The abundance of large bowlders in the bed of the stream, and consequently the expense of getting out the gold, is said to have been one reason why the undertaking failed to be profitable.

Horseshoe mine.

An extremely pretty example of a horseshoe bend on a diminutive scale may be seen on the Little North Fork of the Middle Fork of the Feather, 3 miles southeast of Merrimac, where the river is joined by a branch creek known as Bear Gulch. In this case, however, the horseshoe itself is not mined. There is here a narrow gorge in the granite bed rock containing potholes from 5 to 20 feet in diameter. A dam built across the Little North Fork just upstream turns the water into a flume, leaving the bed of the stream exposed for mining. The gravel is sluiced into the narrow gorge of the horseshoe and allowed to accumulate there during the summer, to be carried off by the winter floods. This mine is known as the Horseshoe mine.

GOLD-VEIN DEPOSITS.

In the Bidwell Bar quadrangle the gold-bearing veins are, as in other districts, composed chiefly of quartz; but there are some notable exceptions; namely, the auriferous barite veins of Big Bend Mountain and the Diadem lode deposit. The richest mines are those in the neighborhood of Forbestown. For information concerning the production of these and other mines the reader is referred to the reports of the State mineralogist of California and to the columns of the Mining and Scientific Press (published at San Francisco).

Forbestown mining district.

The mines of the Forbestown district are chiefly in fine-grained diorite or greenstone, although the Shakespeare is close to an area of a granitic rock, and the diorite that forms the country rock of this mine is coarser than usual. Several of them are noted on the economic sheet, but the Denver mine was the only one entered. This is on the north slope of the Forbestown ridge, about $1\frac{1}{2}$ miles west of Forbestown. The strike of the vein is about S. 65° W., and the dip 70° to 80° NW. The vein matter is quartz of the kind called ribbon quartz, and the vein has a width of from 5 to 10 feet. As at Forbestown, the country rock is fine-grained diorite.

The Bee Hive mine, on the west slope of Mount Hope, near the stage road, is on the west edge of an area of coarse quartz-diorite which forms the hanging wall of the vein. The course of the vein, which is from 3 to 6 feet in thickness, is about N. 8° E., and the dip 45° E. The quartz contains free gold, some galena, and sulphide of iron. There is more or less sericite mixed with the vein material, and this may cause the loss of some of the fine gold, the sericite adhering to the gold particles and preventing amalgamation. West of the Bee Hive vein the country rock is clay slate. It is therefore a contact vein.

Rocks of Big Bend Mountain.

A considerable part of Big Bend Mountain, as exposed along the road from the bridge over the West Branch of the North Fork of Feather River to the abandoned village of Big Bend, is made up of clay slates, probably Paleozoic in age, with layers of greenstone-schists, representing original augitic tuffs. The rocks along the east and south base of the mountain, as seen along the river (the North Fork of the Feather), are almost entirely greenstones, with one or two layers of sedimentary mica-schists. These greenstones are largely amphibolitic rocks representing original surface lavas and tuffs, probably augitic andesites, but now containing little or no augite. There are a number of quartz veins in the schistose rocks above described that deserve prospecting. Mullen's vein strikes north-south; the Bohanan veins strike northwesterly. Near the latter veins is a dike of granitoid rock, the relation of which to the veins was not determined.

Gold in heavy spar.

By far the most interesting feature, however, was the occurrence of a vein of barite, or heavy spar, containing gold. The deposit is known as the Pinkstown ledge. It is located about half a mile due south of the highest point of Big Bend Mountain. The ledge strikes N. 13° W. and dips at a high angle (about 80°). It is from 2 to 3 feet wide where best exposed at the north end, and is composed of a soft, heavy mineral which was proved by chemical tests to be barite, or heavy spar. This was found to contain gold in small amount. There is said, however, to be enough in the deposit to pay for working it.

Quartz veins rare in serpentine.

In the Bidwell Bar district quartz veins are very rare in the serpentine areas, and not common in the granite or quartz-diorite areas, with some exceptions to be mentioned later. They are common, however, in the talc-schists, as may be seen at Quartz Hill, north of Lumpkin, but in no case noted have the veins in the last-named rock warranted the erection of a stamp mill.

Near Merrimac, in the granitoid quartz-diorite, some quartz veins have been found to contain considerable gold. One of these, the Reynolds mine, was worked for some time.

Granite Basin mines.

In the small granite area the erosion of which has formed the depression known as Granite Basin* there are gold-bearing quartz veins which have been worked with profit. The veins are said to have a general northeast-southwest trend. Standing vertical or at a high angle, they are narrow, seldom running over 2 feet in width. The walls are generally well defined. The ore contains auriferous iron sulphide, as well as galena and zinc blende, and is said to average $20 to the ton.

Diadem lode.

Quartz veins in clay slate are numerous in the Bidwell Bar quadrangle as elsewhere. One of the most interesting lodes in this rock is south of Meadow Valley. It is known as the Diadem lode. The strike of the lode is N. 37° W., dipping 60° NE., and its average width is 60 feet. The vein matter is a highly ferruginous mass of material consisting of chalcedony, quartz, oxide of iron, and manganese. Large masses of siliceous dolomite appear in the lower levels in all stages of alteration. This mine has been exploited to a depth of 300 feet. Rich selenides of gold and silver combined with lead and copper, and rhodonite or silicate of manganese, are found as a rarity. Tourmaline is also present in minute crystals. The Diadem lode may have been originally dolomite, in part replaced by quartz, chalcedony, and other vein material. This view is strengthened by the occurrence of little elliptical bodies now composed of silica, but which were originally calcareous shells of foraminifera. It is thus certain that silica has replaced limecarbonate in part of the lode. This vein deposit may be called a replacement vein.

Quartz veins abundant.

In the Willow Creek drainage, south and southeast of Grizzly Hill, the gravels along the stream bed have been worked for many years with considerable profit, pointing to the existence of auriferous quartz veins in the older rocks. No large veins have, however, been yet developed in the vicinity. Quartz veins are abundant on the ridge west of Willow Creek and south of Gravel Range, and in the vicinity of Sky High, 4 miles southeast of Merrimac. They were also noted on the south spur of Mount Ararat.

MANGANESE.

There is a vein of oxide of manganese near the Diadem lode, and another deposit about three-fourths of a mile due south, known as the Penrose lode. It has been traced northwesterly as far as Eagle Gulch. The manganese occurs in the form of pyrolusite and psilomelane.

IRON ORE.

There is said to be a well-defined vein of hematite and magnetite parallel with the Diadem lode and distant 400 feet westerly, conforming to it in dip and strike. It may be traced for more than 2 miles and runs from 6 inches to 3 feet in width.

CHROMITE.

Bodies of chromic iron in place are noted on the economic sheet in the serpentine belt about 2 miles west of Spanish Ranch post-office and about three-fourths of a mile southwest of Meadow Valley, to the south of Clear Creek. Pebbles of chromic iron are abundant in the Meadow Valley Pleistocene conglomerate, and some were also found in the Auriferous river gravels of the northwest corner of the quadrangle.

LIMESTONE AND MARBLE.

The limestone lenses have been noted on the geologic map, from which their location can best be determined. Certain of these masses have been converted into marble, some of which is massive and even-grained and will probably answer for ornamental and building purposes. Such a mass is Marble Cone, on the north side of the canyon of the Middle Fork of the Feather, east of the mouth of Willow Creek.

H. W. TURNER,
Geologist.

May, 1898.

*The information about the Granite Basin and Diadem lode deposits was obtained from Mr. J. A. Edman, as well as the notes on iron ore, manganese, and chromite.

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

TOPOGRAPHIC SHEET

CALIFORNIA
BIDWELL BAR QUADRANGLE

(Lassen Peak $\frac{1}{250000}$)

(Honey Lake $\frac{1}{250000}$)

LEGEND

RELIEF
(printed in brown)

Figures
(showing heights above mean sea level instrumentally determined)

Contours
(showing height above sea, horizontal form, and steepness of slope of the surface)

DRAINAGE
(printed in blue)

Rivers

Creeks

Aqueduct tunnels

Lakes and ponds

CULTURE
(printed in black)

Roads and buildings

Trails

Bridges

Fords

Dams

County boundary lines

Names of adjoining published sheets are printed on the margin.

(Marysville $\frac{1}{125000}$)

Henry Gannett, Chief Geographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by R.H. Mc. Kee.
Surveyed in 1885-6-8.

(Smartsville $\frac{1}{125000}$)

Scale $\frac{1}{125000}$

1 ½ 0 1 2 3 4 5 Miles

1 ½ 0 1 2 3 4 5 Kilometers

Contour Interval 100 feet

Datum is mean Sea level

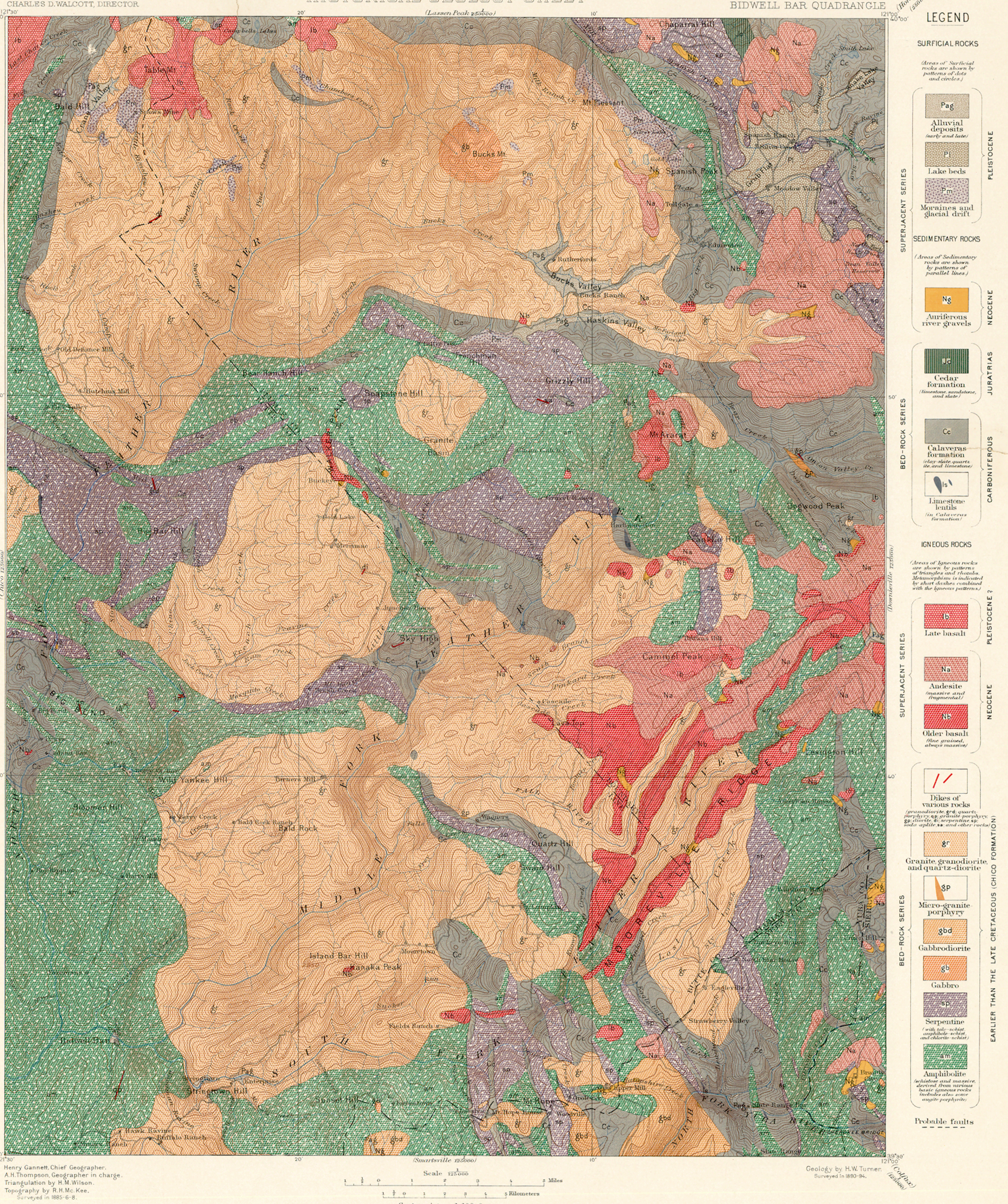
Edition of June 1897.

(Colfax $\frac{1}{125000}$)

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

HISTORICAL GEOLOGY SHEET

CALIFORNIA
BIDWELL BAR QUADRANGLE



Henry Gannett, Chief Geographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by R.H. Mc.Kee.
Surveyed in 1885-6-8.

Scale $\frac{1}{125000}$

Contour interval 100 feet.
Datum is mean sea level.
Edition of April 1898.

Geology by H.W. Turner.
Surveyed in 1880-94.

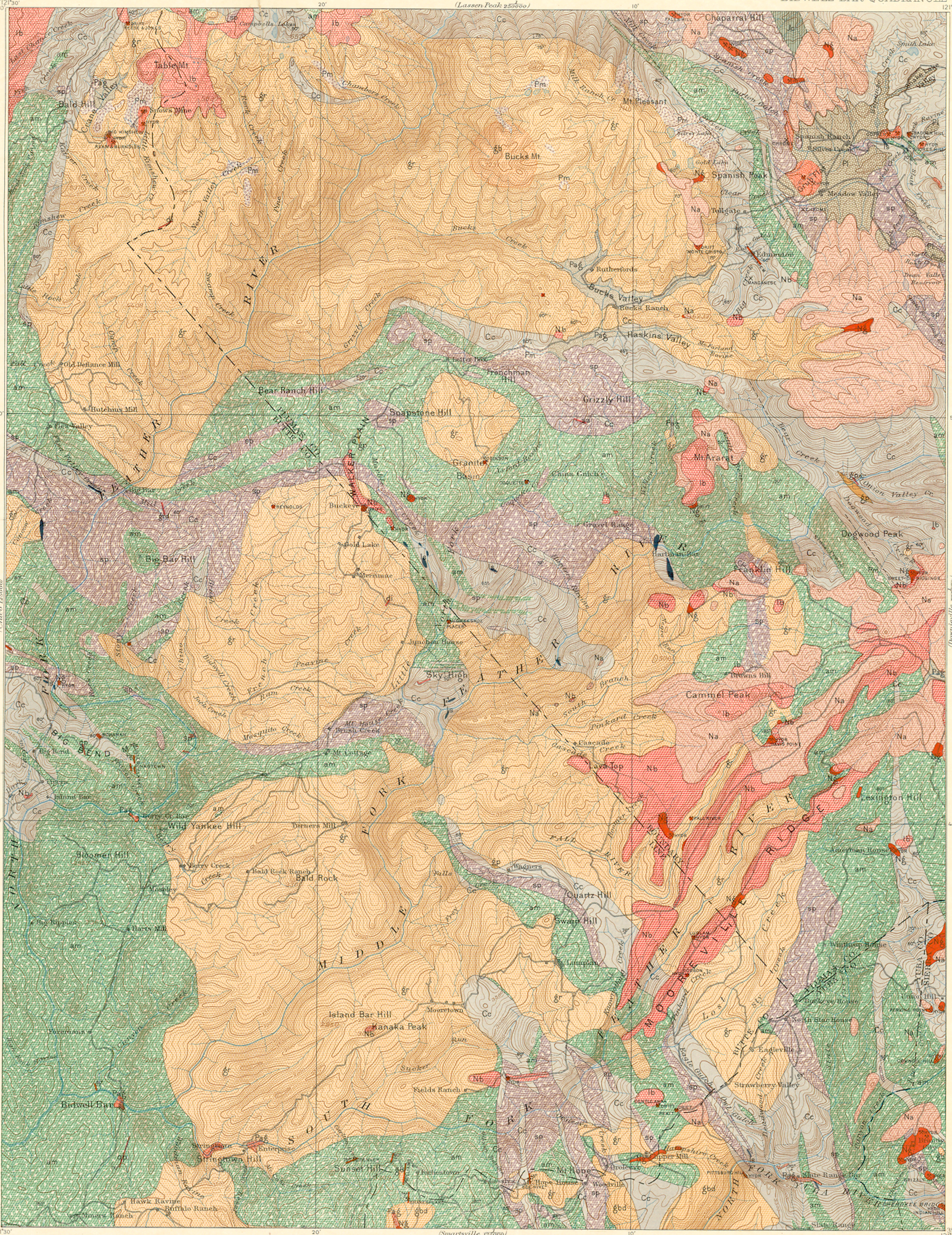
U. S. GEOLOGICAL SURVEY
CHARLES D. WALCOTT, DIRECTOR

ECONOMIC GEOLOGY SHEET

CALIFORNIA
BIDWELL BAR QUADRANGLE

(Lassen Peak) (1/250000)

(Honey Lake) (1/250000)



Henry Gannett, Chief Geographer.
A.H. Thompson, Geographer in charge.
Triangulation by H.M. Wilson.
Topography by R.H. Mc. Kee.
Surveyed in 1885-6-8.

(Marysville) (1/125000)

Scale 1/125000

Miles: 1, ½, 0, 1, 2, 3, 4, 5

Kilometers: 1, ½, 0, 1, 2, 3, 4, 5

Contour interval 100 feet.

Datum is mean sea level.

Edition of April 1898.

Geology by H.W. Turner.
Surveyed in 1890-94.

(Colfax) (1/125000)

LEGEND

(continued)

- 20° *Dip and strike of stratified rocks*
- *Vertical dip and strike of stratified rocks*
- 80° *Dip and strike of schistosity*
- *Vertical dip and strike of schistosity*
- *Gold quartz veins*
- DRIFT *Drift mines in auriferous gravels*
- HYDR. *Hydraulic gold mines*
- *Gold quartz mines*
- *Gold quartz prospects*
- × *Chrome and manganese prospects*

Known productive formations

Auriferous gravels

Limestone

LEGEND

SUPERJACENT SERIES

SURFICIAL ROCKS

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

PLEISTOCENE

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

SEDIMENTARY ROCKS

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

NEOCENE

- Ng — Auriferous river gravels

BED-ROCK SERIES

JURATRIAS

- Jc — Cedar formation *(limestone, sandstone, and slate.)*

CARBONIFEROUS

- Cc — Calaveras formation *(clay-slate, quartzite, and limestone)*
- ls — Limestone lentils *(in Calaveras formation)*

IGNEOUS ROCKS

(Areas of Igneous rocks are shown by patterns of triangles and rhombs. Metamorphism is indicated by short dashes combined with the Igneous patterns.)

SUPERJACENT SERIES

PLEISTOCENE ?

- lb — Late basalt

NEOCENE

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

BED-ROCK SERIES

EARLIER THAN THE LATE CRETACEOUS (CHICO FORMATION)

- Dikes of various rocks *(granodiorite, grd; quartz-porphyry, qp; granite-porphyry, gp; diorite, di; serpentine, sp; soda-aplite, sa; and other rocks)*
- gr — Granite, granodiorite, and quartz-diorite
- gp — Micro-granite-porphyry
- gbd — Gabbrodiorite
- gb — Gabbro
- sp — Serpentine *(with talc-schist, amphibole-schist, and chlorite-schist)*
- am — Amphibolite *(schistose and massive, derived from various basic igneous rocks includes also some augite-porphyrite)*

Probable faults

Legend is continued on the left margin.

SPECIAL ILLUSTRATION SHEET

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

FIG. 2.—GRANITIC CONTACT BRECCIA.

Showing dark fragments of schist inclosed in the intrusive quartz-diorite. The specimen was collected from the border of a mass of quartz-diorite four miles northeast of Mount Hope.

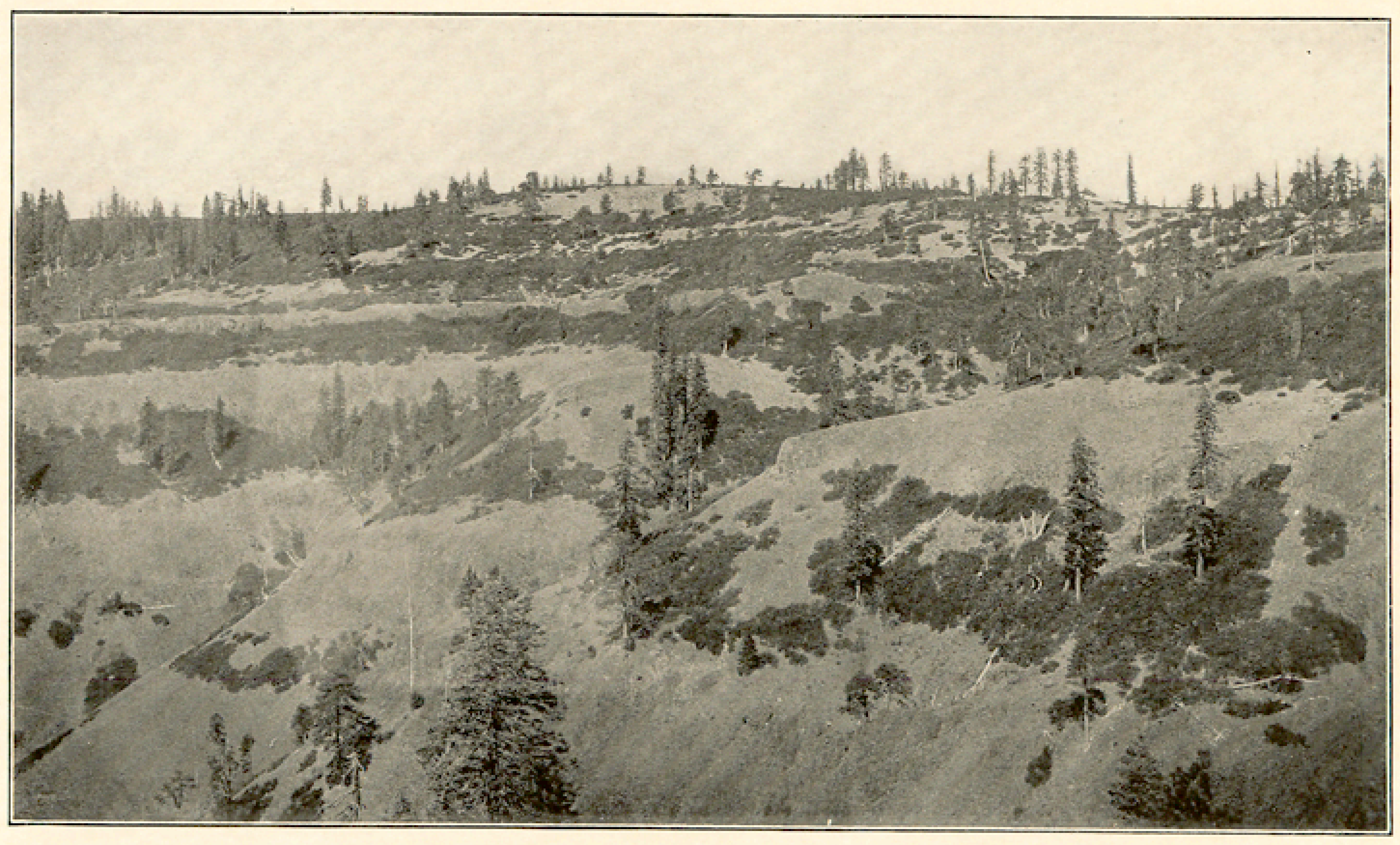


FIG. 4.—RIDGE NORTH OF SOUTH FEATHER RIVER, NEAR EAST BORDER OF QUADRANGLE.

Showing lava terraces emphasized by lines of vegetation. These terraces are due to the unequal erosion of successive flows of the older basalt. The lighter colored lava capping the ridge is andesite-breccia.

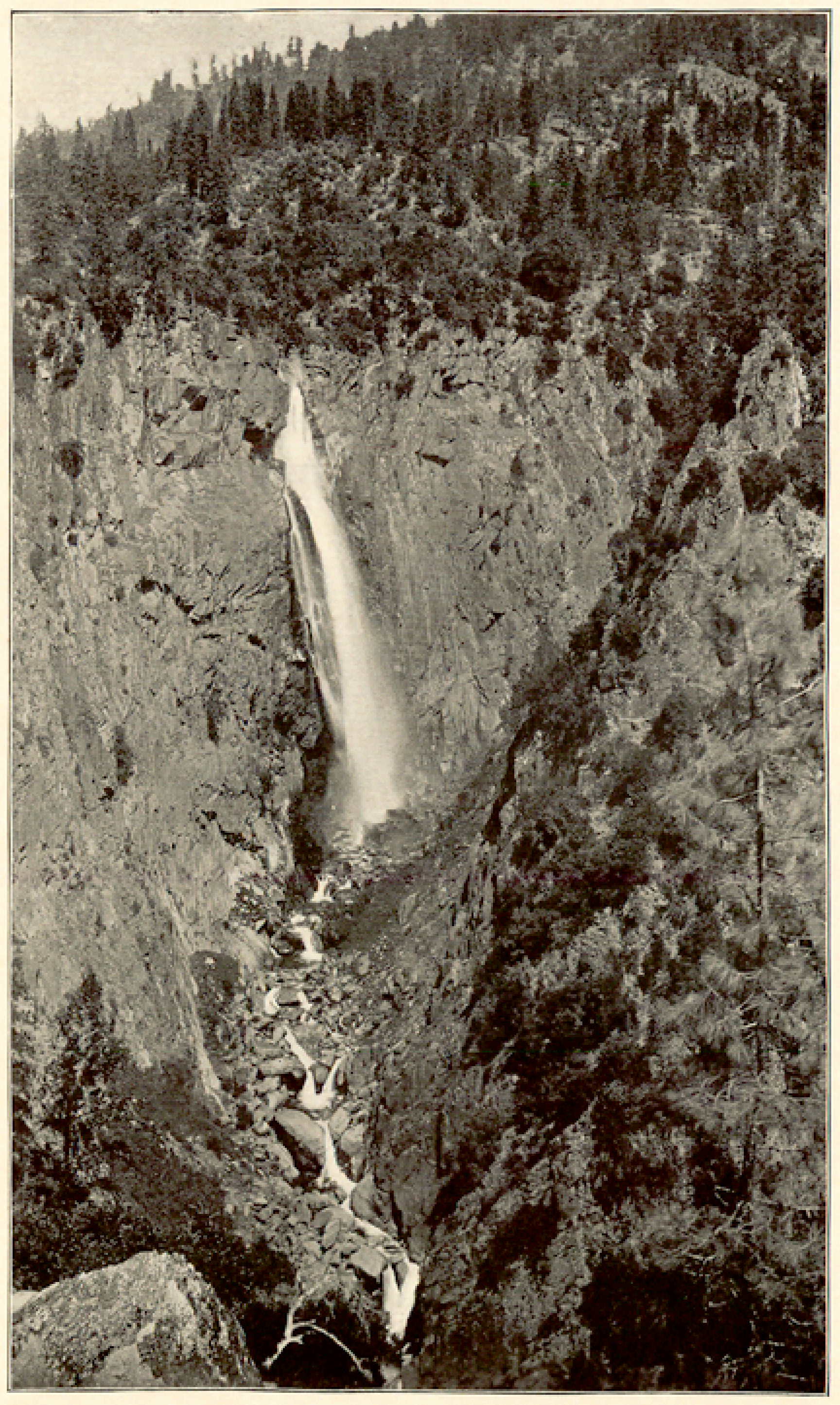


FIG. 3.—FALLS OF FALL RIVER AND THE CANYON INTO WHICH IT DESCENDS.

The gorge was eroded along a vertically sheeted zone in the granodiorite
The falls are about 450 feet in height.

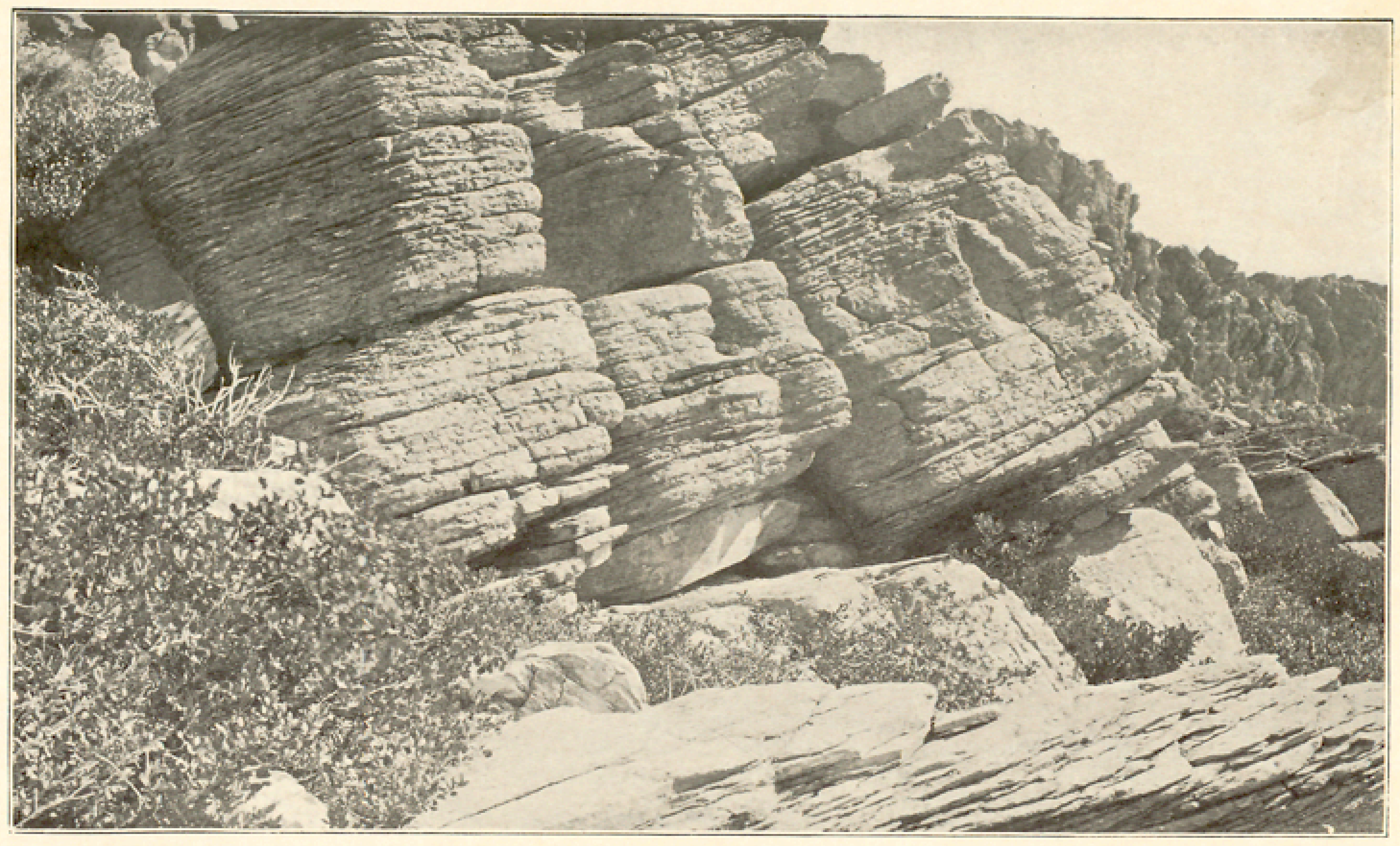


FIG. 5.—HYPERSTHENE-ANDESITE ON FRANKLIN HILL.

Shows the slaty structure of the lava.

FIG. 6.—FAULT SCARP AT HEAD OF DOGWOOD CREEK.

The wooded flat to the right of the scarp is capped with Tertiary lavas, and represents a downthrown block.

forming another gradation into sedimentary deposits. Some of this glacial wash was deposited in tunnels and channels in the ice, and forms characteristic ridges and mounds of sand and gravel, known as osars, or eskers, and kames. The material deposited by the ice is called glacial drift; that washed from the ice onto the adjacent land is called modified drift. It is usual also to class as surficial rocks the deposits of the sea and of lakes and rivers that were made at the same time as the ice deposit.

AGES OF ROCKS.

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

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

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

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

Strata often contain the remains of plants and animals which lived in the sea or were washed from the land into lakes or seas or were buried in surficial deposits on the land. Rocks that contain the remains of life are called fossiliferous. By studying these remains, or fossils, it has been found that the species of each period of the earth's history have to a great extent differed from those of other periods. Only the simpler kinds of marine life existed when the oldest fossiliferous rocks were deposited. From time to time more complex kinds developed, and as the simpler ones lived on in modified forms life became more varied. But during each period there lived peculiar forms, which did not exist in earlier times and have not existed since; these are characteristic types, and they define the age of any bed of rock in which they are found. Other types passed on from period to period, and thus linked the systems together, forming a chain of life from the time of the oldest fossiliferous rocks to the present.

When two formations are remote one from the other and it is impossible to observe their relative positions, the characteristic fossil types found in them may determine which was deposited first.

Fossil remains found in the rocks of different areas, provinces, and continents, afford the most important means for combining local histories into a general earth history.

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

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

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

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

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

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

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

THE VARIOUS GEOLOGIC SHEETS.

Historical geology sheet.—This sheet shows the areas occupied by the various formations. On the margin is a *legend*, which is the key to the map. To ascertain the meaning of any particular colored pattern and its letter-symbol on the map the reader should look for that color, pattern, and symbol in the legend, where he will find the name and description of the formation. If it is desired to find any given formation, its name should be sought in the legend and its color and pattern noted, when the areas on the map corresponding in color and pattern may be traced out.

The legend is also a partial statement of the geologic history. In it the symbols and names are arranged, in columnar form, according to the origin of the formations—surficial, sedimentary, and igneous—and within each group they are placed in the order of age, so far as known, the youngest at the top.

Economic geology sheet.—This sheet represents the distribution of useful minerals, the occurrence of artesian water, or other facts of economic interest, showing their relations to the features of topography and to the geologic formations. All the formations which appear on the historical geology sheet are shown on this sheet by fainter color-patterns. The areal geology, thus printed, affords a subdued background upon which the areas of productive formations may be emphasized by strong colors. A symbol for mines is introduced at each occurrence, accompanied by the name of the principal mineral mined or of the stone quarried.

Structure-section sheet.—This sheet exhibits the relations of the formations beneath the surface. In cliffs, canyons, shafts, and other natural and artificial cuttings, the relations of different beds to one another may be seen. Any cutting which exhibits those relations is called a *section*, and the same name is applied to a diagram representing the relations. The arrangement of rocks in the earth is the earth's *structure*, and a section exhibiting this arrangement is called a *structure section*.

The geologist is not limited, however, to the natural and artificial cuttings for his information concerning the earth's structure. Knowing the manner of the formation of rocks, and having traced out the relations among beds on the surface, he can infer their relative positions after they pass beneath the surface, draw sections which represent the structure of the earth to a considerable depth, and construct a diagram exhibiting what would be seen in the side of a cutting many miles long and several thousand feet deep. This is illustrated in the following figure:

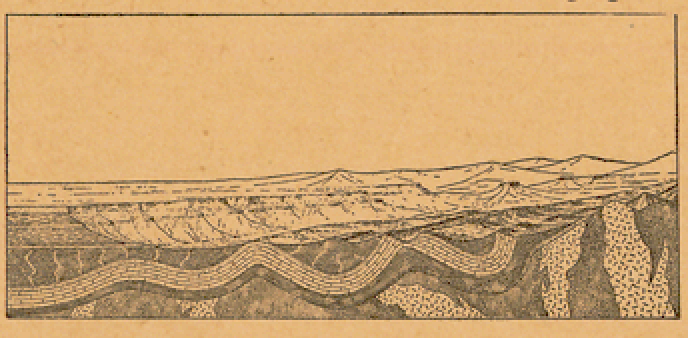


Fig. 2.—Sketch showing a vertical section in the front of the picture, with a landscape beyond.

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

The kinds of rock are indicated in the section by appropriate symbols of lines, dots, and dashes. These symbols admit of much variation, but the following are generally used in sections to represent the commoner kinds of rock:

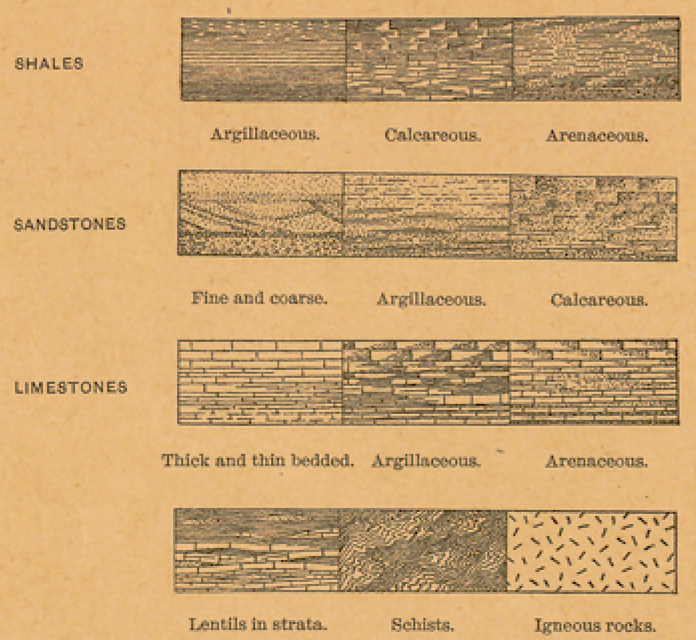


Fig. 3.—Symbols used to represent different kinds of rock.

The plateau in fig. 2 presents toward the lower land an escarpment, or front, which is made up of sandstones, forming the cliffs, and shales, constituting the slopes, as shown at the extreme left of the section.

The broad belt of lower land is traversed by several ridges, which are seen in the section to correspond to beds of sandstone that rise to the surface. The upturned edges of these beds form the ridges, and the intermediate valleys follow the outcrops of limestone and calcareous shales.

Where the edges of the strata appear at the surface their thickness can be measured and the angles at which they dip below the surface can be observed. Thus their positions underground can be inferred.

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

On the right of the sketch the section is composed of schists which are traversed by masses of igneous rock. The schists are much contorted and their arrangement underground can not be inferred. Hence that portion of the section delineates what is probably true but is not known by observation or well-founded inference.

In fig. 2 there are three sets of formations, distinguished by their underground relations. The first of these, seen at the left of the section, is the set of sandstones and shales, which lie in a horizontal position. These sedimentary strata are now high above the sea, forming a plateau, and their change of elevation shows that a portion of the earth's mass has swelled upward from a lower to a higher level. The strata of this set are parallel, a relation which is called *conformable*.

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

The horizontal strata of the plateau rest upon the upturned, eroded edges of the beds of the second set at the left of the section. The overlying deposits are, from their positions, evidently younger than the underlying formations, and the bending and degradation of the older strata must have occurred between the deposition of the older beds and the accumulation of the younger. When younger strata thus rest upon an eroded surface of older strata the relation between the two is an *unconformable* one, and their surface of contact is an *unconformity*.

The third set of formations consists of crystalline schists and igneous rocks. At some period of their history the schists were plicated by pressure and traversed by eruptions of molten rock. But this pressure and intrusion of igneous rocks have not affected the overlying strata of the second set. Thus it is evident that an interval of considerable duration elapsed between the formation of the schists and the beginning of deposition of the strata of the second set. During this interval the schists suffered metamorphism; they were the scene of eruptive activity; and they were deeply eroded. The contact between the second and third sets, marking a time interval between two periods of rock formation, is another unconformity.

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

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

The rocks are described under the corresponding heading, and their characters are indicated in the columnar diagrams by appropriate symbols. The thicknesses of formations are given under the heading "Thickness in feet," in figures which state the least and greatest measurements. The average thickness of each formation is shown in the column, which is drawn to a scale—usually 1000 feet to 1 inch. The order of accumulation of the sediments is shown in the columnar arrangement: the oldest formation is placed at the bottom of the column, the youngest at the top, and igneous rocks or other formations, when present, are indicated in their proper relations.

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

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

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

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Director.

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