DESCRIPTION OF THE GOLD BELT.*

GEOGRAPHIC RELATIONS.

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

GENERAL GEOLOGY.

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

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

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

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

BED-ROCK SERIES.

PALEOZOIC ERA.

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

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

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

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

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

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

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

POST-CARBONIFEROUS UPHEAVAL.

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

JURATRIAS PERIOD.

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

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

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

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

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

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

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

THE POST-JURATRIAS UPHEAVAL.

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

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

THE GOLD-QUARTZ VEINS.

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

SUPERJACENT SERIES.

CRETACEOUS PERIOD.

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

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

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

EOCENE PERIOD.

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

NEOCENE PERIOD.

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

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

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

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

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

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

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

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

THE NEOCENE UPHEAVAL.

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

PLEISTOCENE PERIOD.

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

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

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

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

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

IGNEOUS ROCKS.

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

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

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

GLOSSARY OF ROCK NAMES.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

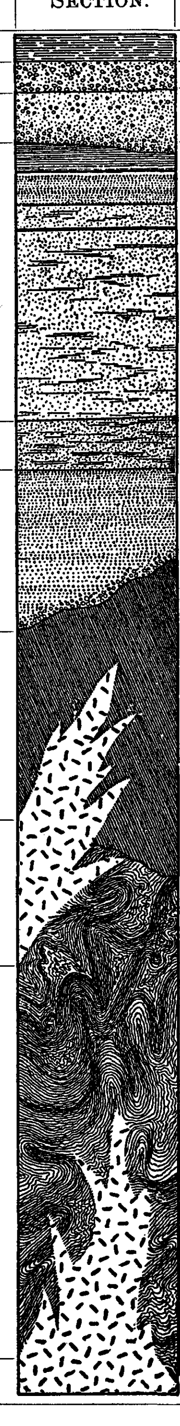
Rhyolite.—An effusive rock of Tertiary or later age. The essential constituents are alkali feldspars and quartz, usually with a small amount of biotite or hornblende in a groundmass, which is often glassy.

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

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

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

GENERALIZED SECTION OF THE FORMATIONS OF THE GOLD BELT.



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

DESCRIPTION OF THE 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 crystal-line 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 $1\frac{1}{2}$ 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 $1\frac{3}{4}$ 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 $1\frac{3}{4}$ 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 $1\frac{1}{2}$ 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 $3\frac{1}{4}$ 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 $1\frac{1}{4}$ 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 $1\frac{1}{2}$ 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 $3\frac{1}{2}$ 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 $1\frac{3}{4}$ miles east of Clipper Mill, is a small deposit of gravel, known as the Pratt drift mine. About $1\frac{1}{2}$ 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 $1\frac{1}{2}$ 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 $1\frac{1}{4}$ 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, $1\frac{1}{4}$ 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, 1½ 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, 2½ 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 4¾ 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).

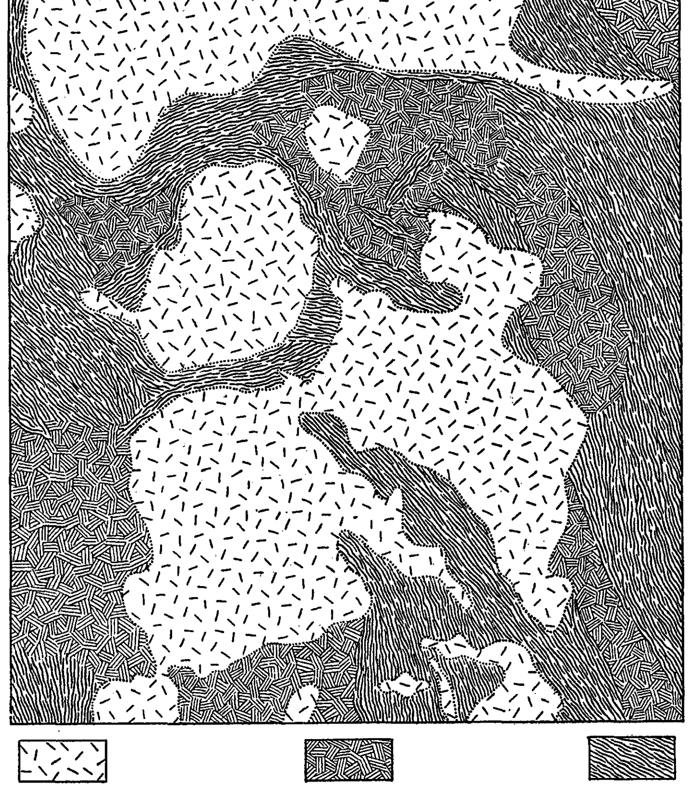


FIG. 1.—Diagrammatic map of the massive and schistose rocks of the Bidwell Bar quadrangle, showing the manner in which the lines of schistosity are, as a rule, parallel to the contact of the massive granitic areas, which are represented in white with divergent hachures.

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.

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.

Fault scarp at head of Dogwood Creek.

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, 2½ 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.

Meadow Valley a depressed basin.

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.

Microscopic evidence of faulting.

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."

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.

Big Bend 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.

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). 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 1½ 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.

Forbestown mining district.

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.

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 veins strike 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. 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.

Rocks of Big Bend Mountain.

Gold in heavy spar.

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.

Quartz veins rare in serpentine.

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.

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.

Granite Basin mines.

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 lime-carbonate in part of the lode. This vein deposit may be called a replacement vein.

Diadem lode.

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.

Quartz veins abundant.

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.