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INCLUDING THE

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GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

The recent revival of interest in gold mining has centered much attention on the northern Sierra Nevada, and has caused a demand for reliable information on the geologic history of this famous gold-bearing region. Since the classic works of earlier geologists, Lindgren and others, are now difficult to obtain, having long been out of print, the Geologic Branch has prepared a general geologic map and report of the area. The principal rock formations are shown and described, the compilation of which has been made possible through use of material assembled during the preparation of the new State geologic map, a project now under way in cooperation with the United States Geological Survey. The colored overprint of the map has been largely compiled by Miss Mary Balch, Geological Clerk of the Geologic Branch, and shows the Tertiary gravel deposits, the former positions of the main Tertiary streams, and the area covered by the Mother Lode system of veins. Besides these features, a number of important gold mines are indicated.

Following this more general report on the Sierra Nevada, is a pertinent contribution by Dr. Ralph Chaney, entitled "Notes on occurrence and age of fossil plants found in the Auriferous Gravels of Sierra Nevada." The location of the collections discussed by him are shown on the geologic map, and therefore coordinated with the more general study. Determination of the geologic age of the fossils found in the interbedded shales of the auriferous gravels should throw considerable light on the correlation of the various ancient river channels. We wish to thank Dr. Chaney for permitting us to publish the results of progress made by him in this study.

Another study of special interest in the geology of the Sierra Nevada is that of glaciation. We highly appreciate, therefore, the contribution made by Dr. Eliot Blackwelder, who presents an instructive article on "Glacial and associated stream deposits of the Sierra Nevada." Although it is well known that the last great event in geologic history was that of glaciation, this is the first time that a map showing the distribution of the ancient glaciers throughout the Sierra Nevada has appeared.

The fourth geological paper appearing in this issue has been contributed by Dr. Frank M. Anderson, on the revision in interpretation of the "Jurassic and Cretaceous divisions in the Knoxville-Shasta succession of California." We are pleased to be able to publish this notable contribution to the sedimentary geology of the State, especially as it concerns a great thickness of strata exposed in northern California, where there has been much exploration made recently by oil geologists.

The fifth contribution, "Geology of a part of the Panamint Range, California," is by F. M. Murphy and represents the results of a very careful geologic investigation of an interesting region lying west of Death Valley in which considerable mining activity has lately been shown.

REPORT ACCOMPANYING GEOLOGIC MAP OF NORTHERN SIERRA NEVADA

By Olaf P. Jenkins, Chief Geologist, Geologic Branch

PURPOSE OF THE REPORT AND ACCOMPANYING MAP

The accompanying geologic map of northern Sierra Nevada has been prepared to meet the present demand for geological information of this important gold-producing region. The map (in pocket) shows four principal features:

(1) The surface areas covered by each of the principal groups of geologic formations.

(2) The principal exposed gravel deposits of the ancient gold-laden Tertiary streams and the general direction of their major channels. In addition, localities are indicated where fossils have been found associated with the auriferous gravels.

(3) The area covered by the Mother Lode system of veins.

(4) The location of some of the principal gold mines of the region.

A summary of the principal events in the geologic history of the region is presented in this brief report in order that the map may be more easily understood and the geologic features more readily interpreted.

PROJECT OF THE NEW STATE GEOLOGIC MAP

The geologic map of the northern Sierra Nevada, which this report accompanies, represents an advance sheet, subject to revision. It has been prepared in somewhat generalized form, traced from a part of the unpublished new State Geologic Map, which is one of the main projects of cooperative work between the U. S. Geological Survey and the Geologic Branch of the California State Division of Mines. When completed and published the State map will measure seven feet high, drawn on the scale of 1:500,000, or approximately eight miles to the inch. It will show, in various colors, patterns, and symbols, about 60 different geologic units or formations.

The first preliminary copy of the State map has been actually drawn in Washington, D. C., under the direction of G. W. Stose, map editor of the Federal Survey. Completion of the map as well as revision of various parts of it, however, will take several years of continued study, including much actual field work, and this part of the undertaking is being done by the State Geologic Branch.

The whole undertaking represents well-organized and carefully coordinated research. In its construction, care has been taken to make the map as easily understood as possible, and emphasis is laid on features which have a particular bearing on things of economic concern.

GENERAL FEATURES AND LOCATION OF THE AREA

The area covered by the geologic map which this report accompanies is located between meridians 37° 20′ and 40° 30′ and parallels 120° and 122°, and represents the northern part of the Sierra Nevada,

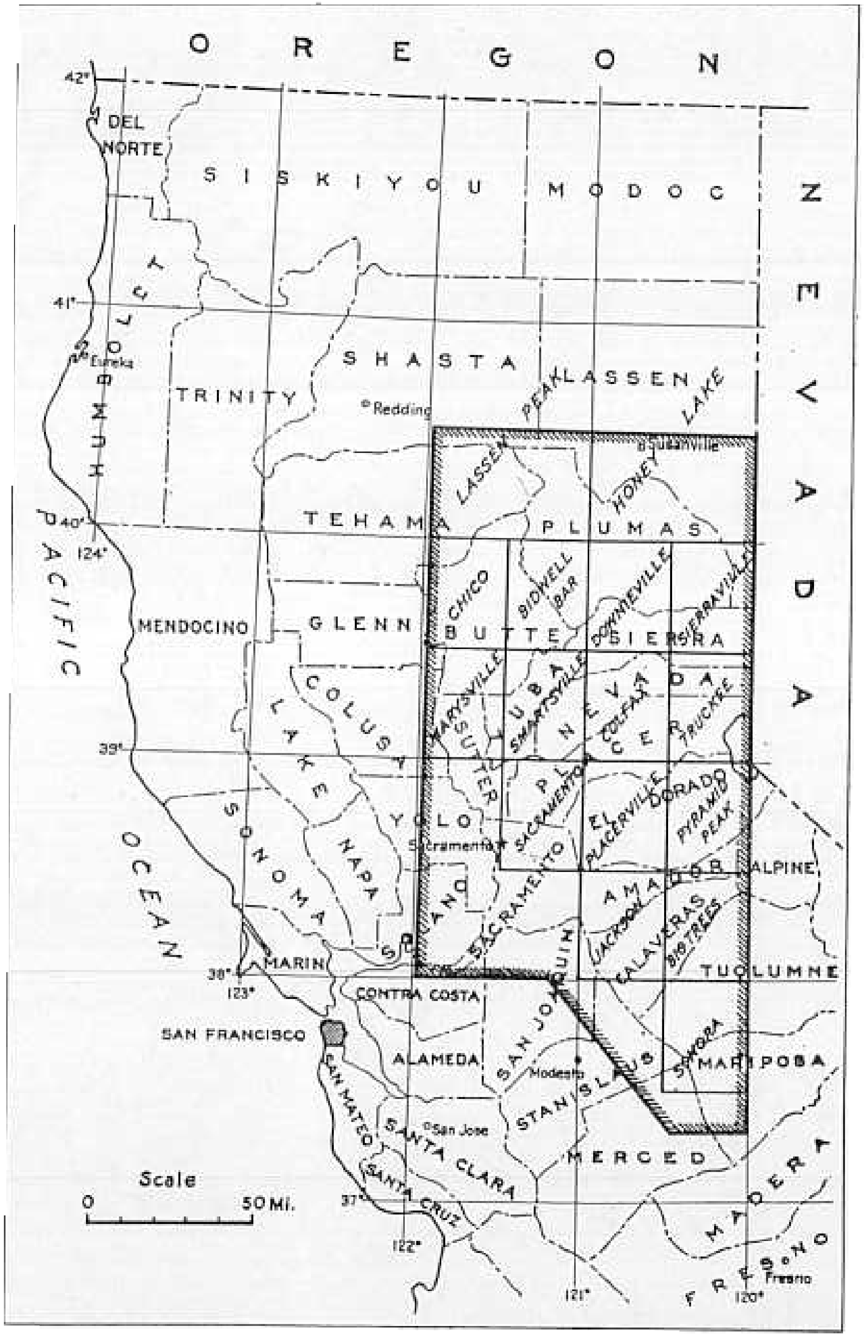

FIG. 1. Index map of northern California showing area covered by Geologic Map of Northern Sierra Nevada. The principal topographic quadrangles of the U. S. Geological Survey are also outlined and named. All of these, excepting the Chico, Sierraville, and Honey Lake, are covered by the geologic folios of the Federal Survey.

a major physiographic province of California. The rectangle under discussion is 200 miles long by 100 miles wide. Bordering this mountainous province on the north, is an extensive lava-covered region. To the east of the Sierra Nevada is the Great Basin province. On the west, lies the Great Valley of California, a plain through which the Sacramento River, flowing south, meets the San Joaquin River, flowing north; united they enter the waters of San Francisco Bay.

The northern Sierra Nevada differs materially from the southern part of the range. The former is comprised of a large number of different sedimentary and metamorphic rocks, intruded by granites, veined with quartz, traversed by a system of ancient river channels, and capped by lava; while the more southern part of this stately mountain range with snow-capped peaks is composed almost exclusively of massive granite of scenic grandeur. Geologically the northern part is more complex; economically it has produced the most mineral wealth, particularly gold; and historically it is known throughout the world, especially by the writings of Bret Harte and Mark Twain.

The range as a whole is a west-tilted, up-raised block of the earth's crust. Its crestline follows in close proximity to its eastern front, scarped by prominent faults of recent geologic date.

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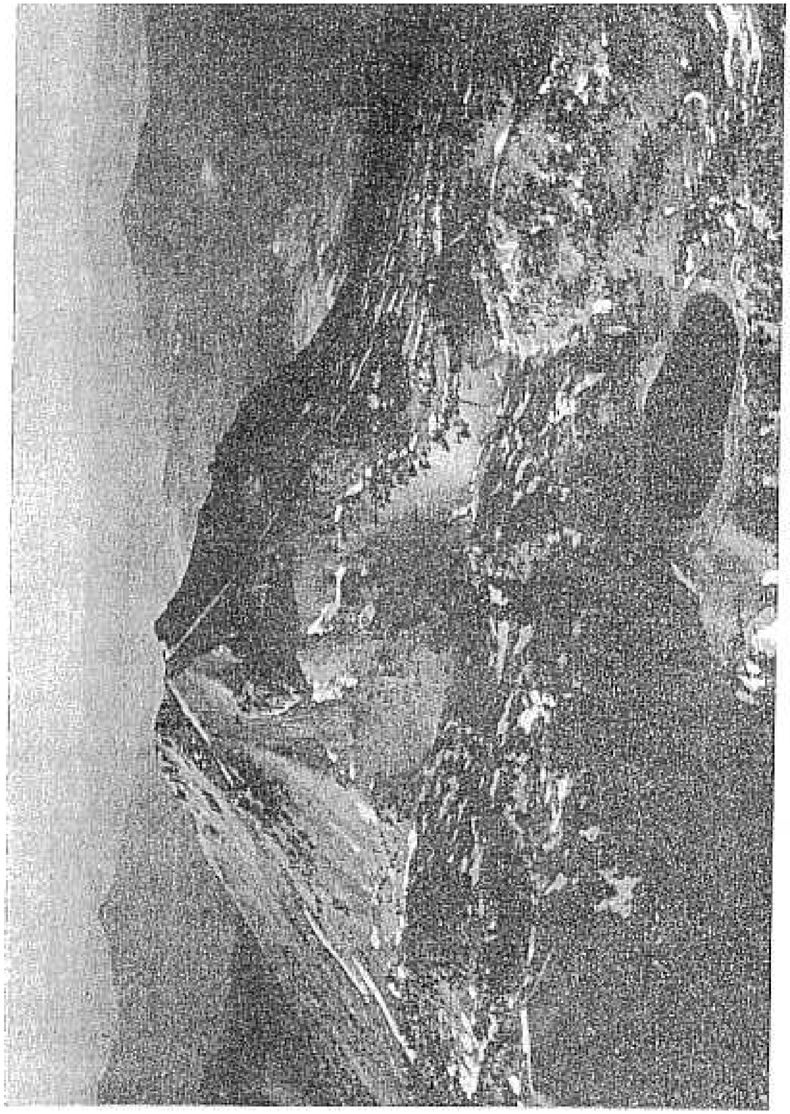

FIG. 2. Airplane view of Lassen Peak, looking NW. Helen Lake in foreground. Volcanic country in the distance. This region belongs properly to the Cascade Mountains province and not to that of the Sierra Nevada, which adjoins it on the south. The extruded volcanic rocks overlie the older granites and metamorphic formations of the Sierra Nevada. *Photograph by courtesy of G. E. Russell.*

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In addition to these sources, unpublished data have also been used in the preparation of the map. One item in particular is a "Reconnaissance geologic map of a portion of northern California compiled from various sources with additional field data'' by R. Dana Russell.

GEOLOGIC UNITS SHOWN ON THE MAP

A legend is shown on the Geologic Map of Northern Sierra Nevada which indicates the meaning of the various symbols used on the map. Each symbol represents a distinct geological formation or group of formations and the whole series is arranged chronologically. That is, the youngest appears at the head of the list, while the group names of the older rocks are indicated below it in descending order. The rocks of each group have been described in published literature elsewhere. In most cases they have been indicated on maps of larger scale in a more detailed manner than shown here.

The name 'Bedrock series' has often been employed to include all the older rocks, comprising both the metamorphic series and the igneous rocks which intrude it, while the name 'Superjacent series' has been applied to the gravel deposits together with the Tertiary volcanic materials. The quartz veins were formed prior to the 'Superjacent series,' while the placer gold belongs to this later series.

EXPLANATION OF GEOLOGIC LEGEND

QUATERNARY

Qal *Alluvium*
Deposits by recent streams, consisting principally of gravel and sand covering areas of considerable extent.

Ql *Lacustrine and playa deposits*
Deposits in recent lakes, generally of fine-grained silt.

Qt *Terrace alluvial deposits*
Stream gravel and sand found in the older benches and terraces.

Qg *Glacial deposits*
Only the more extensive glacial deposits (moraines, etc.) are shown in this unit; unsorted boulders, gravel, sand, clay, etc.

Qv *Chiefly Pleistocene volcanics*
Lavas, chiefly basalt, extruded later than Tertiary but earlier than Recent flows.

QP *Quaternary and Pliocene sediments (chiefly nonmarine deposits)*
Clay, sand and gravel, in general of a red-brown color and in places more or less consolidated; for the most part, the material is of the old alluvial fans; in some places the gravels are auriferous.

TERTIARY

Pliocene

Tlb *Late Tertiary lake beds*
Areas covered by these local deposits are rather limited in size.

TPu *Upper Pliocene nonmarine deposits (Tuscan tuff, etc.)*
This formation consists of sandstone, conglomerate, volcanic tuff, breccia, and agglomerate.

TPv *Pliocene volcanics (chiefly basalt)*
Some of these rocks represented by this unit have been considered to be of Quaternary age.

Miocene

TMv *Miocene volcanics and continental deposits (lava flows and tuffs of rhyolite, basalt, latite, and andesite)*
These rocks constitute the main mass of Tertiary volcanic material. The intervolcanic Tertiary river channels, shown on the overprint, are interbedded and a part of this series of Tertiary volcanics.

Eocene

TEm *Eocene marine deposits (Ione formation)*
These sediments are for the most part marine. The older Tertiary river gravels, composed largely of white quartz pebbles and the gravel deposits mapped on the overprint as Tg, are probably of the same age as the Ione formation. The early Tertiary streams apparently emptied into bodies of water in which the Ione formation was deposited.

CRETACEOUS

K *Cretaceous marine deposits (chiefly upper Cretaceous or Chico formation)*
These beds consist of shales, sandstones, and conglomerates, containing characteristic Chico fossils. Exposures of lower Cretaceous (Knoxville and Horsetown) are entirely lacking in this area.

JURASSIC

Jai *Acidic intrusives (granite, granodiorite, gabbro, etc.)*
This massive series of rocks represents the main body of the great granite batholith of Sierra Nevada. The time of intrusion was probably late in the Jurassic.

Jbi *Basic intrusive (diabase, amphibolite, and hornblende schist)*
The age of the intrusion of these rocks is post-Calaveras. They may be in part of Mariposa age but largely pre-Mariposa. Their association with the Mother Lode belt give them an economic significance.

Late Jurassic

Jub *Ultra-basic intrusives (peridotite, pyroxene, serpentine, etc.)*
These rocks represent the oldest of the post-Mariposa intrusives. The serpentines are hydrothermally altered products of such rocks as peridotite. They are of economic interest because of their prevalence in the Mother Lode belt.

Upper Jurassic

Ju *Upper Jurassic marine deposits (chiefly Mariposa formation)*
A metamorphic sedimentary series, consisting largely of black slate and graywacke with greenstone, a prominent associated formation in the Mother Lode belt.

JURASSIC AND TRIASSIC

JTR *Jurassic and Triassic volcanic and sedimentary rocks (includes about 16 individual formations)*
In the northern end of Sierra Nevada this group is represented by various formations which have been differentiated elsewhere on geologic maps of larger scale accompanying the original reports of the U. S. Geological Survey.

CARBONIFEROUS

Pennsylvanian and Mississippian sedimentary and igneous rocks (includes the Robinson formation, Calaveras group and other rocks of the Carboniferous period)
This series of metamorphic sediments includes rocks older than the Mariposa slate. Though usually considered to be of Carboniferous age, the Calaveras formation may include both older and younger rocks. In the Mother Lode

belt this formation consists chiefly of black phyllite with subordinate fine-grained quartzite, limestone and chert.

DEVONIAN AND SILURIAN

DS *Devonian and Silurian marine deposits (Taylorsville, Grizzly, and Montgomery formations)*

These sedimentary rocks exposed in the northern end of Sierra Nevada, are the oldest known of the Paleozoic section in this region. They consist of quartzite, slate, and some limestone.

AGE UNKNOWN

pK *Pre-Cretaceous metamorphic sedimentary complex.*

pS *Pre-Silurian meta-rhyolite*

These rocks are shown by the same map symbol, located in the northern end of Sierra Nevada; they represent undifferentiated metamorphic series the age of which has not been determined.

GEOLOGIC HISTORY OF THE REGION MAPPED

As seen by the chronologically arranged list of geologic units used on the map of the region under discussion, the record of past events in geologic history is nearly complete, being well represented by rocks of various ages, from a time before the Paleozoic to the present. The three main classes of rocks are found, i.e., sedimentary, igneous, and metamorphic.

A detailed account of the geologic history of the Sierra Nevada as it may be interpreted from known facts, would be a very long story. Briefly, the principal events may be summarized as follows:

The events of pre-Paleozoic time are very indefinite and the record is hardly recognizable. Some of the older schists and metamorphic igneous rocks may be of this very ancient period. It is possible that in Cambrian time, the beginning of the Paleozoic era, a mountain range stood where the Sierra Nevada now is located.

The Paleozoic (comprising the Cambrian, Ordovician, Silurian, Devonian, and Carboniferous) is represented for the most part by several geological formations considered to be of Carboniferous age. In the northern end of the Sierra Nevada, however, the presence of a number of marine sedimentary formations show that the sea covered part of this area during the Silurian and Devonian. Unconformities between formations show that there were elevations and submergences of the land which caused frequent fluctuations in the relative position of land and sea.

The beginning of the Carboniferous shows evidence of marine deposition, but this was followed by intrusive igneous activity. Though it subsided, and widespread marine limestones were again formed, another period of igneous activity was repeated and a general uplift of the Sierra Nevada was initiated. Later, metamorphic action became very intense, especially in the southern part of the region, where the individual formations of this series can not now be differentiated, and the name Calaveras formation is used, even though the unit may include formations of both older and younger periods. In the north, however, metamorphic action was not so great and a number of separate formations are recognized and shown on the larger-scale published maps.

Of the rocks representing the Mesozoic era (which includes Triassic, Jurassic, and Cretaceous) the Jurassic is the most complete. In the Triassic, marine deposition was prominent though some igneous activity occurred. In the Jurassic not only were sediments formed, but much igneous activity prevailed, especially during the latter part of that period, when an enormous series of intrusive magmas invaded the formations.

The earliest intrusions are represented by igneous rocks which are considerably metamorphosed. Basic magmas were followed by the more acidic. The greatest of intruders was the granite batholith, comprised of granite, diorite, granodiorite, gabbro, and other such holocrystalline deep-seated igneous rocks. The emplacement of this acidic magma which extended far beyond the bounds of the Sierra Nevada, the metamorphic action it had on the previously formed and deformed rocks which it intruded, and the release of accompanying mineralizing solutions which invaded crushed zones of the surrounding rocks to form ore deposits, were events of such importance that they have had an everlasting effect upon civilization.

On the map under discussion, a large number of formations, of both Triassic and Jurassic age are grouped together, though elsewhere on large-scale maps they are separated. One undifferentiated metamorphic series, of Upper Jurassic age, known as the Mariposa formation, is so intimately associated with the Mother Lode system that it has been shown as a single unit on the State map.

Since the granite invasion followed the deformation and uplifting that began in late Carboniferous time, it is thought that the two actions—uplift and intrusion—were in some way genetically related. After the intrusion had apparently ceased, a different kind of earth movement was initiated. Where folding and igneous invasion typified the orogenic actions preceding the Cretaceous period, faulting and extensive movements of solid blocks or segments of the earth's crust have marked the type of active mountain building that has since taken place. Block movements of this sort have continued down to the present time.

During early Cretaceous, the region was greatly eroded and reduced to a surface in places gently undulating, though on the whole still mountainous. The geologic structure, marked by long northwest-southeast folds and faults, controlled the topographic relief, so that the mountain range may have appeared somewhat similar to the Appalachians of today. Subsidence in parts farther to the northwest and west allowed deposition of sandstone and conglomerate in the west-bordering Chico sea (Upper Cretaceous). Beginning at this same time and continuing during the epochs that followed, the Sierra Nevada was uplifted, breaking away from the Great Basin region along huge faults that are still found active along the eastern front of the range. The total erosion that took place during the Cretaceous and Eocene removed a cover the thickness of which varied, but probably averaged about two miles, measured vertically.

There has not yet been completed sufficient stratigraphic work to differentiate in mapping the representatives of all of the various epochs of the Tertiary (Eocene, Oligocene, Miocene, and Pliocene). In general, however, the significant historical events of the Tertiary seem to

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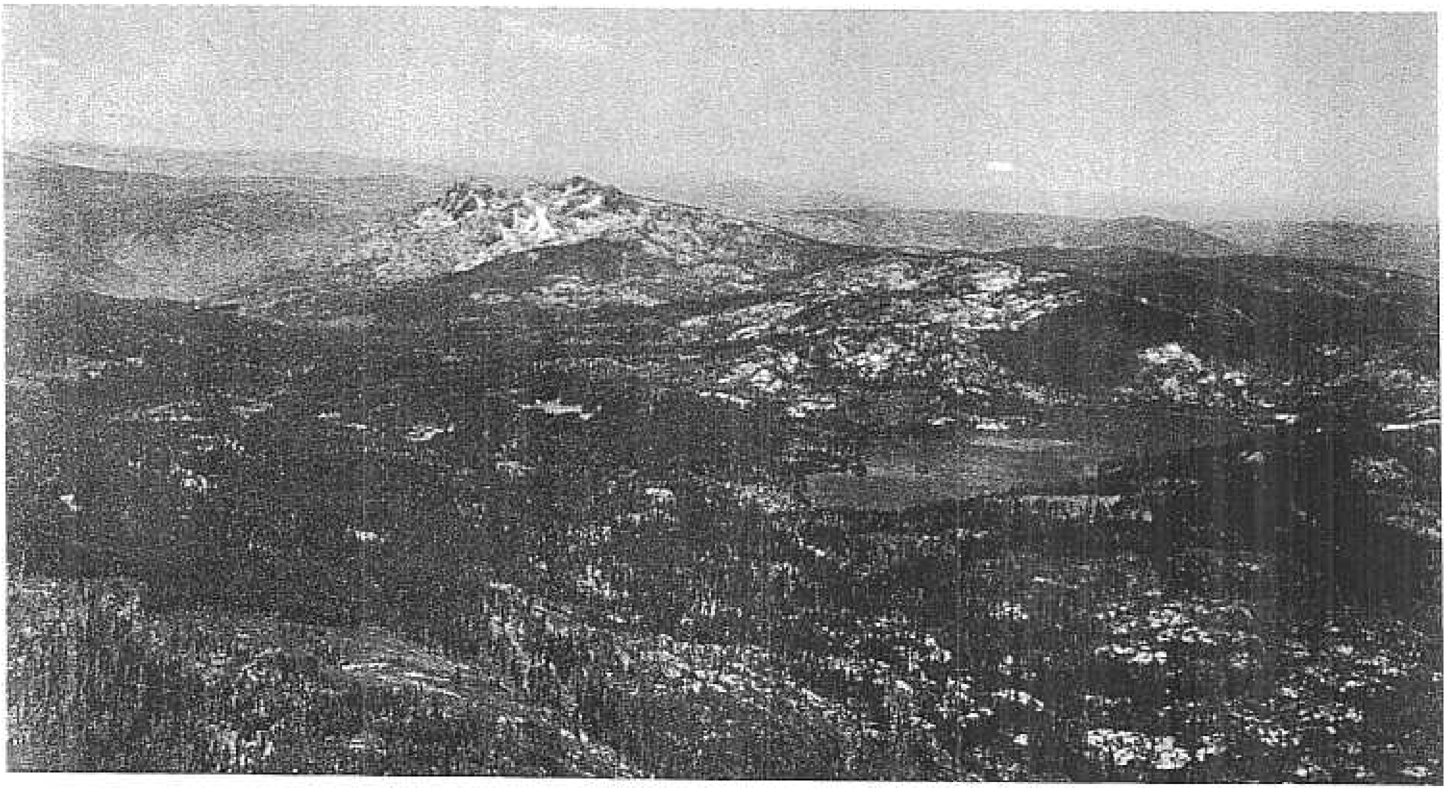
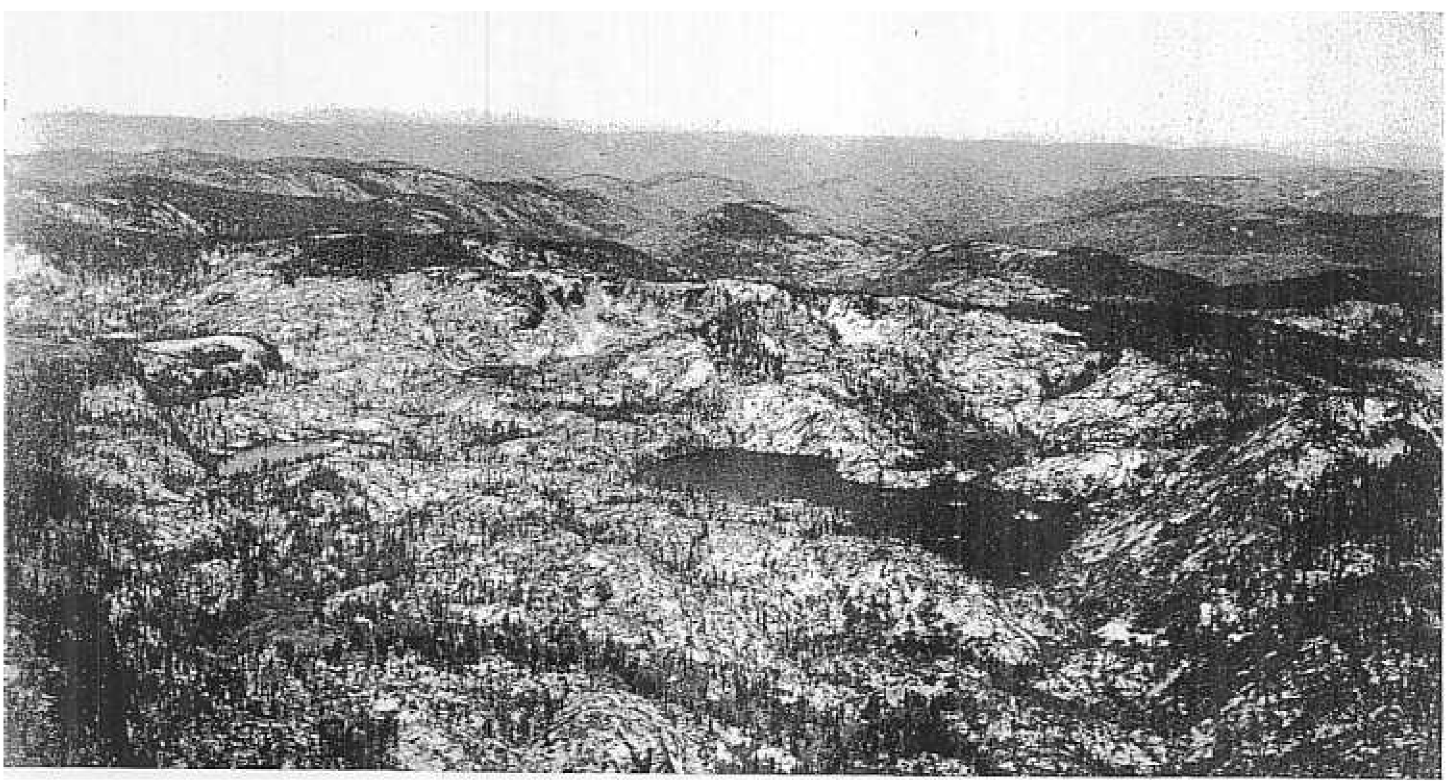


Photograph by courtesy of G. E. Russell.

Airplane view in northern Sierra Nevada north of Sierra City, looking SW. across the old evenly sloping surface (now dissected by stream-canyons) on which auriferous gravels were deposited by the ancient Tertiary streams, and later buried by volcanic materials. Upper Salmon Lake, to the right; Sierra Buttes, to the left beyond representing a vestige of Lindgren's pre-Tertiary divide, a fragmentary record suggesting the topography of greater antiquity.



Photograph by courtesy of G. E. Russell.

Airplane view, forming with Figure 3, to the left, a panorama. Gold Lake, and the glaciated region about it, are in the foreground, while the canyon of North Fork of Yuba River may be seen in the distance, cutting through the sloping Tertiary 'peneplain.'

have been as follows: Before the eastern scarps were developed, the mountain range was nearly symmetrical in shape, but the western slope was somewhat steeper than the eastern. Evidence of a long northern-flowing stream shows that a slope extended in that direction also. The western Eocene streams, cutting the deeper channels, apparently diverted some of the drainage of the eastern-flowing streams, causing the older rugged Cretaceous crest line (shown by Lindgren to have passed through Sierra Buttes southeastward to Pyramid Peak) to be abandoned and a new Tertiary divide to hold a position farther to the east.

The Tertiary streams flowing down the western and northern flanks of the ever-moving mountain range, found it necessary to be continually adjusting their courses. Then came the Miocene outpourings of lava and volcanic breccia which covered much of the older river system, entombing their gravel deposits, filling in the valleys and producing a broad plain-like surface relief. New systems of streams then developed and new outpourings of lava came, resulting in the formation of intervolcanic streams the gravel deposits of which now lie intercalated with the volcanic rocks. The courses of the ancient streams which ran westward somewhat resembled in general direction the streams which are flowing there today, though the positions of their courses differ greatly. One northern early Tertiary stream channel, however, known to geologists as the old Jura River now lies at right angles to the present major drainage system. Its old course now stands deformed, rising and falling in a peculiar manner. The cutting down of the more recent streams has formed deep canyons in bedrock, while remnants of the Tertiary river gravels have been left high above, on the crests of the intervening ridges.

The last period in the geologic history of California is quite as eventful as any previous period. In the earliest Quaternary or in the latest part of the Pliocene, the Sierra Nevada may be pictured first as a mountain range, not half so high as it is now, with the main streams flowing westward through broad mountain valleys while tributaries entered from southeast and northwest directions following along courses which once marked the trend of the old Cretaceous structure. Then, as the Quaternary proceeded, the mountain range was upheaved by a succession of movements to a great altitude. It was tilted southwestward, breaking along faults that traversed its eastern side, becoming displaced from the adjoining more depressed Great Basin area and forming a series of prominent east-slope scarps. In several places the eastern front of the Sierra Nevada is today a spectacular topographic as well as structural feature.

Those streams, the courses of which were directed westward down the slope of the newly tilted block, were thus enormously accelerated so that they cut very deep and rugged canyons, though the remaining intervening ridges, when viewed from above or along their edges appear as a nearly level plain or as a low, broad, undulating surface tilted slightly westward. The period of canyon-cutting was especially effective in the southern Sierra Nevada, for example, in the Yosemite Valley and Kings River Canyon. The tributary streams of these major canyons, running in a longitudinal direction to the range as a whole, did not

have their beds so tilted nor their water-flow so accelerated; thus they were left "hanging" high above the bottom of the newly-made canyons and have been obliged to pitch into the latter often by a series of high waterfalls. The Quaternary upheaval of the Sierra Nevada thus caused such drastic stream adjustment that the old Tertiary drainage system was completely discarded. The new rivers even cut through the lavas and underlying channels that had been entombed since the Miocene volcanic activity.

In the higher Sierra, snow accumulated and glaciers crept down the valleys for a short way, modifying their stream-cut V-shape to U-shaped troughs. Such is the case of Yosemite Valley. Morainal deposits were formed and little lakes were left as the ice retreated. Outwash streams, derived from the melting glaciers, built gravel bars at the foot of the mountains, where the streams entered the Great Valley.

The closing of the period of glaciation brings us to the present surface form of the mountains.

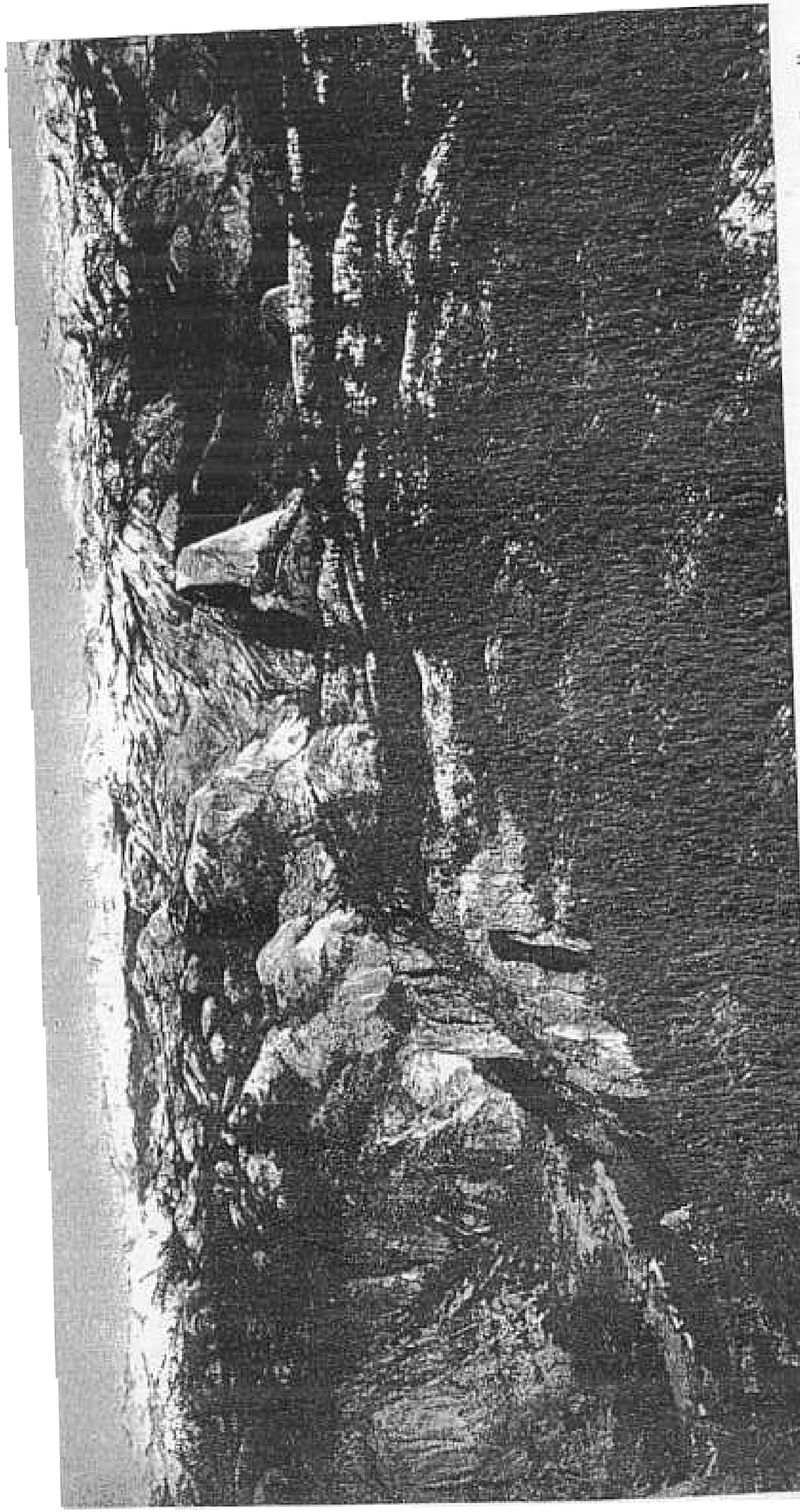
MOTHER LODE BELT

Lying in a general northwest-southeast direction in the central foothill region of the Sierra Nevada, is a strip of country, about one mile wide by 120 miles long, which is one of the most famous gold-mining districts of the world—the Mother Lode belt. Mining started in 1849 near its south end and has continued to the present day. The deepest gold mines of North America are in this region and reach depths of nearly a mile, vertically from the surface. To the end of 1931 the total gold output amounted to about $225,000,000, one-half of this coming from a ten-mile portion of the belt from Plymouth to Jackson.

In the pioneer days it was thought that the Mother Lode was one continuous vein, the sharp ridges of white quartz marking its course. Now it is known that the Mother Lode is a belt or system of quartz veins which carry varying amounts of gold. They all occur in a more or less fissured zone of faulting (specifically a zone of reverse faulting) and are not continuous.

The ores were deposited at the end of the great period of igneous intrusion, and since that time combined upheaval of the range plus erosion has brought the veins to the surface or comparatively near to it. Many gold-bearing veins were completely eroded away. The origin of the gold, found in the veins, is believed to be from deep-seated sources, associated with the intrusive magmas that have solidified to form the igneous rocks which are now exposed through long-continued erosion. Some of the gold, however, may also have been derived from the intruded rocks, and carried in solution by water to points of concentration. For the most part the gold ores are of low or moderate grade.

The gold-laden quartz veins are not confined to the Mother Lode belt. Paralleling it on either side and lying farther to the north of it are other systems of veins and other kinds of mineral deposits. For the most part these are also genetically related to the disturbances and internal activities that accompanied or followed the period of wide-spread late-Jurassic igneous intrusion.



Photograph by courtesy of G. E. Russell.

FIG. 5. Airplane view of Yosemite Valley and Half Dome, looking to the north with the snow-capped even-crest line of the High Sierra in the distance. The higher and more rugged character of the southern Sierra Nevada is thus contrasted with the northern (Figures 3 and 4). The western slope is cut by mighty canyons, the upper courses of which have been reshaped by Pleistocene glaciers.

TERTIARY RIVER CHANNELS

The first extensive erosion that brought the Sierra Nevada down to a region of moderate relief was in Cretaceous time. Sand and gravel were washed to the sea, which then occupied the position of the Great Valley, and were deposited in a thick series of marine sandstones and conglomerates. No appreciable amount of gold was gathered and concentrated at this time.

Later, during the Tertiary, as the mountain range was gradually raised and tilted westward, streams coursed down the mountain flanks and deposited white quartz gravels carrying much gold. It was from the gold-bearing quartz veins and other gold-impregnated rocks brought to light during Cretaceous erosion, that these Eocene streams first gathered their wealth and concentrated it in their channels.

The Eocene quartz gravels were then buried by Miocene lavas and new systems of streams were developed; many of these were also buried by volcanic extrusions. Boulders of volcanic rock, tuff, and breccia are to be found in the intervolcanic stream deposits. Except where these streams eroded through the lava beds and washed out the gold from the older white gravels, they are barren of gold values.

The westward tilting of the Sierra Nevada progressed throughout the Tertiary and Quaternary ages. The old Eocene surface and its systems of streams were tilted along with the mountain block so that they now slope westward more steeply than they did during the time when these ancient river courses drained the area. The present streams have now cut through this older surface, cutting deeper canyons toward the east where the older surface now stands highest. Therefore, the steeper-sloping older surface, now to be seen along the intervening crests, converges westward to meet the present slope of the mountain valleys as it flattens out towards the Great Valley. The Tertiary gravel deposits for this reason are found at increasingly higher altitudes eastward and on ridge crests far above the present rivers.

On the geologic map the positions of the principal Tertiary stream courses are shown. The data for this have been drawn principally from reports issued by the U. S. Geological Survey and listed in this paper. The names of the geologists preëminent in this particular study of the Tertiary channels are listed as follows: J. D. Whitney, J. S. Diller, H. W. Turner, and Waldemar Lindgren.

It must be understood, however, that the geologic record on which this interpretation is based is only fragmental at the best. Many Tertiary channels have undoubtedly been omitted and others which are shown may be somewhat inaccurately located or in part nonexistent.

It has been estimated that the Tertiary gravels have produced \$300,000,000 in gold but that \$600,000,000 worth still remains. This last estimate, however, may be rather high, and the gold content of the gravel is for the most part of low grade. Hydraulic mining was responsible for the extraction of most of this Tertiary placer gold, but since the court injunctions of 1884, which restricted the dumping of the vast amounts of gravel tailings into the present streams, this great industry has all but ceased.

Photograph by courtesy of Fairchild Aerial Surveys, Inc.

FIG. 6. Aerial map, a mosaic of vertical photographs, of a region, $6\frac{1}{2} \times 4$ miles in size, lying between Sonora and Angel's Camp, showing the meandering shape of both Table Mountain, a lava flow which entombed an ancient Tertiary stream channel, and Stanislaus River, which is partly flooded by an

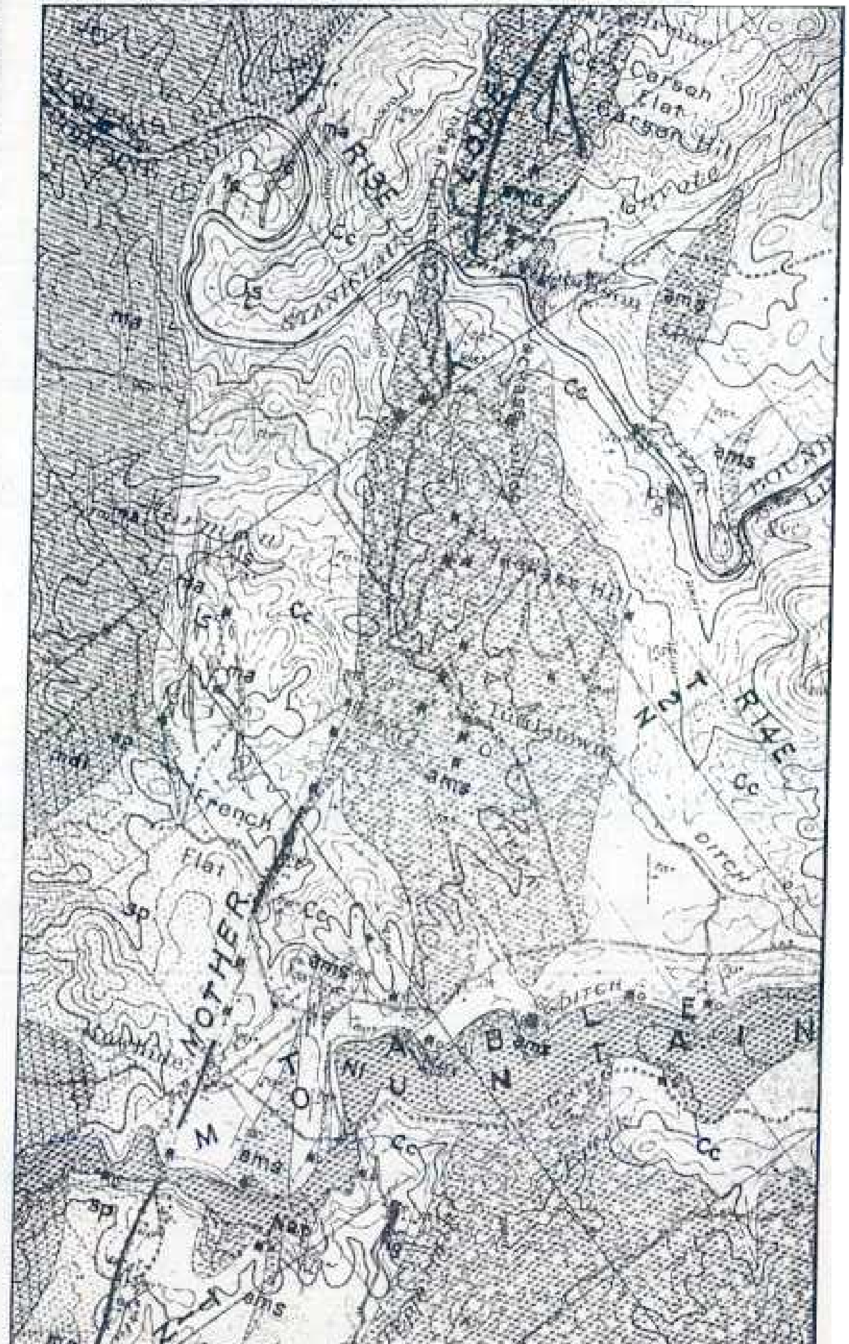


FIG. 7. Geologic map, which may serve as an index, of the area shown in Fig. 6. Surveyed in 1898 by Becker and Ransome, and reprinted from U. S. G. S. Folio 63 in Prof. Paper 157, Pl. 3. The squares indicate sections. The geological formations are shown by patterns, with symbols as follows Pgv, auriferous river gravel; Jm, Mariposa formation; Cc, Calaveras formation; ls, limestone; Nl, latite; Nat, andesite tuff; mdl, metadiorite; sp serpentine; ma, meta-andesite; ams, amphibolite schis

The well-recognized major drainage system of the Tertiary may be listed as follows:

Jura River, which rose in the high Sierra, flowed for 50 miles in a direction a little west of north. Its terminus is now concealed under the lava which covers the northern end of this great mountain range;

Photograph by courtesy of Fairchild Aerial Surveys, Inc.

FIG. 8. Vertical airplane view, showing in greater detail the point at which the Table Mountain lava flow crosses the Mother Lode.

but it is thought that this ancient stream entered at this point a large body of water.

Magalia Channel, of minor extent, located northeast of Chico.

Tertiary Yuba River, located in the same general region as the present Yuba River.

Tertiary American River, located in the same general region as the present American River and its three main forks. In this region is also located the Intervolcanic American River.

Tertiary Mokelumne River, located in the general district of the Cosumnes and upper Mokelumne rivers.

Tertiary Calaveras River, located in general region of the Mokelumne, Calaveras, and South Fork of the Stanislaus rivers. Along the latter is also located the course of the Intervolcanic Cataract Channel.

Tertiary Tuolumne River, which follows the same general trend of the present Tuolumne River.

QUATERNARY GRAVELS

Since Tertiary time, the streams of the Quaternary period, including those of today, have rewashed and reconcentrated the gold carried from the older channels. To this store have been added new particles of gold, washed from the original quartz veins of the bedrock. It is interesting to note that the discovery of gold in California by John Marshall, January 24, 1848, was made in the recent stream gravels of the South Fork of the American River, near Coloma, El Dorado County.

It has been estimated that some $900,000,000 in gold values have been extracted from Quaternary gravels. Today large dredges are still working in the old alluvial cones, formed in part by recent stream deposition and in part by the outwash of glacial streams which, after a torrential course down the canyons of the Sierra Nevada, deposited their loads along the border of the Great Valley.

List of Gold Mines and Districts as Shown by Numbers on Geologic Map of Northern Sierra Nevada

No.	*Name of mine or district*	*Quartz*	*Placer*	*Dredge*
	MARIPOSA COUNTY			
1	Princeton Mine	x	-	-
2	Josephine Mine	x	-	-
3	Virginia Mine	x	-	-
	TUOLUMNE COUNTY			
4	Eagle Shawmut Mine	x	-	-
5	App-Heslep Mine	x	-	-
6	Rawhide Mine	x	-	-
7	Confidence Mine	x	-	-
	CALAVERAS COUNTY			
8	Carson Hill Mine (Melones Mine)	x	-	-
9	Utica Mine	x	-	-
10	Sheep Ranch Mine	x	-	-
11	Gwin Mine	x	-	-
	AMADOR COUNTY			
12	Argonaut and Kennedy Mines	x	-	-
13	Central Eureka Mine	x	-	-
14	Keystone Mine	x	-	-
15	Bunker Hill Mine	x	-	-
16	Plymouth Mine	x	-	-
	EL DORADO COUNTY			
17	Church Union Mine	x	-	-
18	Kelsey Mine	x	-	-
	PLACER COUNTY			
19	Forest Hill District	-	x	-
20	Iowa Hill District	-	x	-
21	Dutch Flat District	-	x	-

NEVADA COUNTY

22	Allison Ranch Mine	x
23	North Star Mine	x
24	Empire Mine	x
25	Idaho Maryland Mine	x
26	Empress (Newtown) Mine	x
27	Champion Mine	x
28	Hoge Mine	x
29	Murchie Mine	x
30	Relief Hill District	-
31	North Bloomfield District	-

SIERRA COUNTY

32	Sixteen-to-One Mine	x
33	Forest City District	-
34	Brush Creek Mine	x
35	Sierra Buttes Mine	x
36	Howland Flat District	-

PLUMAS COUNTY

37	Bellevue Mine	-
38	Plumas Eureka Mine	x

BUTTE COUNTY

39	Cherokee Mine	-
40	Magalia Mine	-
41	Genii Mine	-
42	Oroville District	-

YUBA COUNTY

43	Yuba River District	-

SACRAMENTO COUNTY

44	Folsom District	-

STANISLAUS COUNTY

45	La Grange District	-

NOTES ON OCCURRENCE AND AGE OF FOSSIL PLANTS FOUND IN THE AURIFEROUS GRAVELS OF SIERRA NEVADA

By Ralph W. Chaney [1]

INTRODUCTION

The first comprehensive study of the fossil plants of the Auriferous Gravels of the Sierra Nevada, California, was made by Lesquereux and published in 1878.[2] Many years later Lesquereux's type specimens were examined by Knowlton, who in 1911, revised the descriptions of them in connection with his own study of additional fossil material.[3] Few collections have been made subsequently until the past ten years, during which several new and critical fossil localities have been discovered. At the present time, the floras from these and certain of the old localities are receiving detailed study by the writer and his associates at the University of California. This statement is written for the purpose of placing on record the location and approximate age of the floras of the Auriferous Gravels as now known. It is hoped that the present mining activity on the west slope of the Sierra Nevada may result in the discovery of additional material which may be placed at our disposal for study.

While the floras of the Auriferous Gravels have commonly been considered of Miocene age on the basis of Knowlton's studies, it has been apparent for a number of years that some of them are older; Knowlton himself considered the possibility that certain of the floras which occur in gold-bearing gravels are as old as Eocene.[4] Our studies in recent years definitely establish the fact that the term *Auriferous Gravels* can not properly be applied as indicating a definite stratigraphic unit, since the floras range in age from Eocene to Miocene.

The statement which follows, in which the floras are considered separately on the basis of their occurrence, includes suggestions regarding their age and the physical conditions under which they lived.

FOSSIL LOCALITIES [5]

Locality 92. Buchanan Tunnel, Table Mountain, Tuolumne County.

Leaf impressions occur in the tuffaceous shale at the roof of the tunnel, a total of 14 species being represented. Of these, 12 have been previously recorded in Miocene deposits elsewhere in the State and in Oregon, Washington, Idaho and Nevada.[6] Teeth of *Hipparion* (extinct species of ass) have been found in associated gravels in the Springfield Mine. The upper Miocene age of these deposits seems clearly established. The flora assemblage indicates a climate characterized by temperature not unlike that in the region today, and by a slightly higher

[1] Chairman, Department of Paleontology, University of California, and Research Associate, Carnegie Institution of Washington.

[2] Mus. Comp. Zool. Mem., vol. 6, No. 2, 1878, pp. 1–62, pl. 1–10.

[3] In Lindgren, U. S. Geol. Surv. Prof. Paper 73, 1911, pp. 57–64.

[4] *Op. cit.*, p. 61 and p. 63.

[5] Locality numbers (also shown on Geologic Map of Northern Sierra Nevada prepared by Olaf P. Jenkins, and appearing in this issue of Mining in California) refer to collections in the University of California.

[6] Chaney, Carn. Inst. Wash., Pub. 349, 1925, p. 33.

MAPS

Register of Mines With Maps.

Asterisks (**) indicate the publication is out of print.

	Price
Register of Mines, with Map, Amador County	$0.25
Register of Mines, with Map, Butte County	.25
**Register of Mines, with Map, Calaveras County	----
**Register of Mines, with Map, El Dorado County	----
**Register of Mines, with Map, Inyo County	----
**Register of Mines, with Map, Kern County	----
**Register of Mines, with Map, Lake County	----
**Register of Mines, with Map, Mariposa County	----
**Register of Mines, with Map, Nevada County	----
**Register of Mines, with Map, Placer County	----
**Register of Mines, with Map, Plumas County	----
**Register of Mines, with Map, San Bernardino County	----
**Register of Mines, with Map, San Diego County	----
Register of Mines, with Map, Santa Barbara County (1906)	.25
**Register of Mines, with Map, Shasta County	----
**Register of Mines, with Map, Sierra County	----
**Register of Mines, with Map, Siskiyou County	----
**Register of Mines, with Map, Trinity County	----
**Register of Mines, with Map, Tuolumne County	----
Register of Mines, with Map, Yuba County (1905)	.25
Register of Oil Wells, with Map, Los Angeles City (1906)	.35

OTHER MAPS

**Map of California, Showing Mineral Deposits (50 x 60 in.)	----
**Map of Forest Reserves in California	----
**Mineral and Relief Map of California	----
**Map of El Dorado County, Showing Boundaries, National Forests	----
**Map of Madera County, Showing Boundaries, National Forests	----
**Map of Placer County, Showing Boundaries, National Forests	----
**Map of Shasta County, Showing Boundaries, National Forests	----
**Map of Sierra County, Showing Boundaries, National Forests	----
**Map of Siskiyou County, Showing Boundaries, National Forests	----
**Map of Tuolumne County, Showing Boundaries, National Forests	----
**Map of Mother Lode Region	----
**Map of Desert Region of Southern California	----
Map of Minaret District, Madera County	.20
Map of Copper Deposits in California	.05
**Map of Calaveras County	----
**Map of Plumas County	----
**Map of Trinity County	----
**Map of Tuolumne County	----
Geological Map of Inyo County. Scale 1 inch equals 4 miles	.60
**Map of California accompanying Bulletin No. 89, showing generalized classification of land with regard to oil possibilities. Map only, without Bulletin	----
Geological Map of California, 1916. Scale 1 inch equals 12 miles. As accurate and up-to-date as available data will permit as regards topography and geography. Shows railroads, highways, post offices and other towns. First geological map that has been available since 1892, and shows geology of entire state as no other map does. Geological details lithographed in 23 colors. Unmounted	.75
Mounted	2.00
**Topographic Map of Sierra Nevada Gold Belt, showing distribution of auriferous gravels, accompanying Bulletin No. 92 (also sold singly) In 4 colors	----
Geologic Map of Northern Sierra Nevada, showing Tertiary River Channels and Mother Lode Belt, accompanying July-October Chapter of Report XXVIII of the State Mineralogist. (Sold singly.)	.25

OIL FIELD MAPS

These maps are revised from time to time as development work advances and ownerships change.

	Price
Map No. 1—Sargent, Santa Clara County	$0.50
Map No. 2—Santa Maria, including Cat Canyon and Los Alamos	.75
Map No. 3—Santa Maria, including Casmalia and Lompoc	.75
Map No. 4—Whittier-Fullerton, including Olinda, Brea Canyon, Pueute Hills, East Coyote and Richfield	.75
Map No. 5—Whittier-Fullerton, including Whittier, West Coyote and Montebello	.75
Map No. 6—Salt Lake, Los Angeles County	.75
Map No. 7—Sunset and San Emidio and Kern County	.75
Map No. 8—South Midway and Buena Vista Hills, Kern County	.75
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Map No. 10—Belridge and McKittrick, Kern County	.75
Map No. 11—Lost Hills and North Belridge, Kern County	.75
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Map No. 18—Piru-Simi-Newhall Oil Fields	.75
Map No. 19—Arroyo Grande, San Luis Obispo County	.75
Map No. 20—Long Beach Oil Field	1.25
Map No. 21—Portion of District 4, Showing Boundaries of Oil Fields, Kern and Kings counties	.75
Map No. 21A—Portion Kern and Kings counties	.75
Map No. 22—Portion of District 3, Showing Oil Fields, Santa Barbara County	.75
Map No. 23—Portion of District 2, Showing Boundaries of Oil Fields, Ventura County	.75
Map No. 24—Portion of District 1, Showing Boundaries of Oil Fields, Los Angeles and Orange counties	.75
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Map No. 27—Santa Fe Springs Oil Field	.75
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Map No. 29—Dominguez, Los Angeles County	.75
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Map No. 32—Seal Beach, Los Angeles and Orange counties	.75
Map No. 33—Rincon, Ventura County	.75
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Map No. 39—West Coyote, Los Angeles and Orange counties	.75
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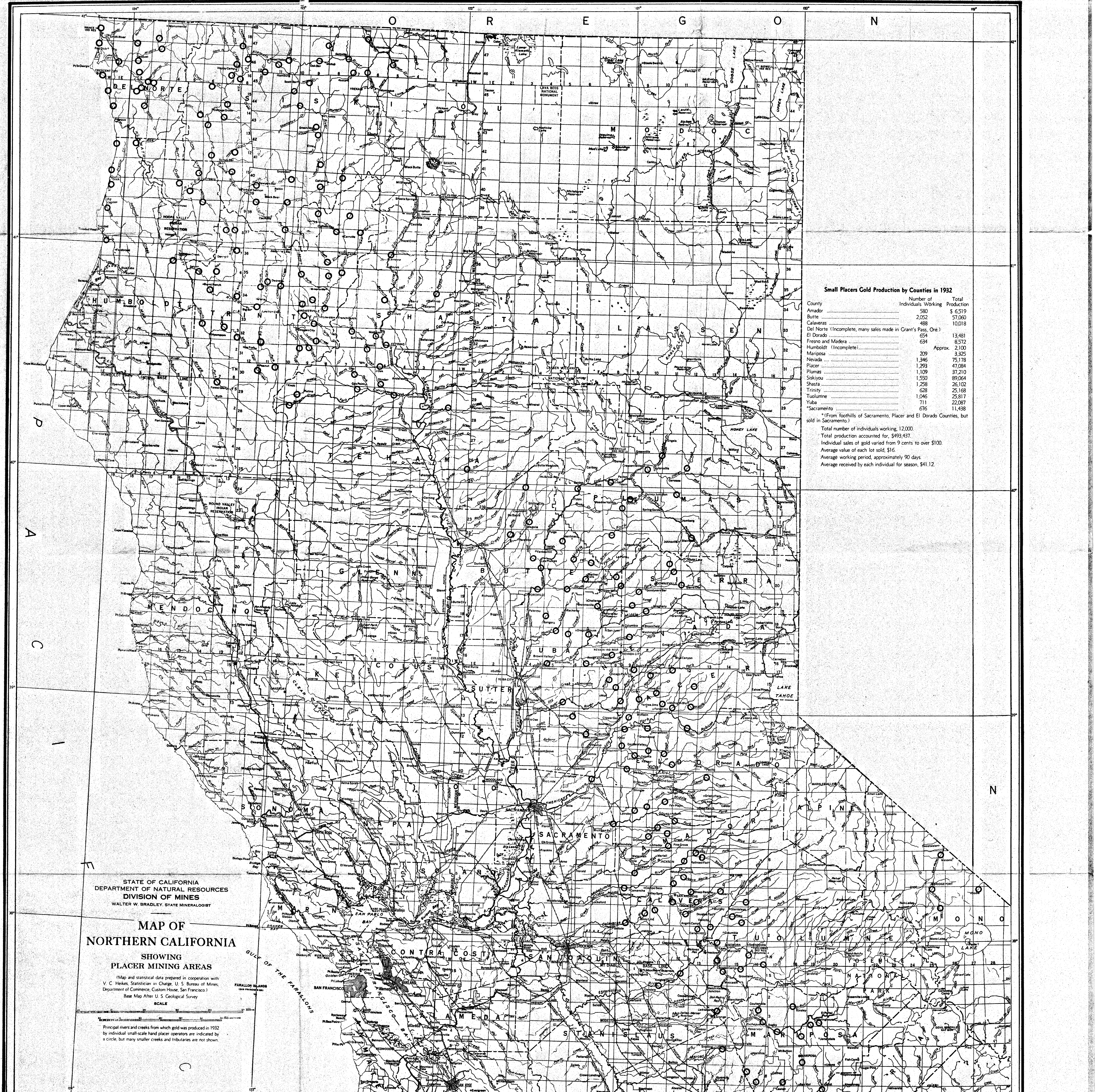
Map No. 41—Potrero, Los Angeles County	.75
Map No. 42—Playa Del Rey, Los Angeles County	.75
Map. No. 43—Capitan, Santa Barbara County	.75
Map No. 44—Mesa, Santa Barbara County	.75



Small Placers Gold Production by Counties in 1932

County	Number of Individuals Working	Total Production
Amador	580	$ 6,519
Butte	2,052	57,060
Calaveras	488	10,018
Del Norte (Incomplete, many sales made in Grant's Pass, Ore.)		
El Dorado	654	13,481
Fresno and Madera	634	8,572
Humboldt (Incomplete)		Approx. 2,100
Mariposa	209	3,325
Nevada	1,346	75,178
Placer	1,293	47,084
Plumas	1,109	37,210
Siskiyou	1,550	89,064
Shasta	1,258	26,102
Trinity	628	25,168
Tuolumne	1,046	25,817
Yuba	711	22,087
*Sacramento	676	11,438

*(From foothills of Sacramento, Placer and El Dorado Counties, but sold in Sacramento.)

Total number of individuals working, 12,000.
Total production accounted for, $493,437.
Individual sales of gold varied from 9 cents to over $100.
Average value of each lot sold, $16.
Average working period, approximately 90 days.
Average received by each individual for season, $41.12.

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST

MAP OF NORTHERN CALIFORNIA

SHOWING PLACER MINING AREAS

(Map and statistical data prepared in cooperation with V. C. Heikes, Statistician in Charge, U. S. Bureau of Mines, Department of Commerce, Custom House, San Francisco.)

Base Map After U. S. Geological Survey

SCALE

Principal rivers and creeks from which gold was produced in 1932 by individual small-scale hand placer operators are indicated by a circle, but many smaller creeks and tributaries are not shown.

Accompanying July-October 1932 quarterly chapter State Mineralogist's Report XXVIII.