DESCRIPTION OF THE SAN FRANCISCO DISTRICT.

By Andrew C. Lawson.

GEOGRAPHY.

SITUATION AND GENERAL DIVISIONS OF THE AREA.

The five sheets of the San Francisco folio—the Tamalpais, San Francisco, Concord, San Mateo, and Hayward sheets—map a territory lying between latitude 37° 30' and 38° and longitude 122° and 127° 45'. Large parts of four of these sheets cover the waters of the Bay of San Francisco, in general are much lower. The culminating points in this part of the belt are Rocky Ridge (2000 feet) on the north, and the Briones Hills (1492 feet) on the north.

In the Hayward quadrangle there is a notable escarpment along the longitudinal profile of the range, and at Hayward there is a gap at the level of the alluvial plain, which here stands about 100 feet above sea level. This gap is the outlet of a remarkably open low valley known as Castro Valley.

Deposits. The drainage of the area includes several features worthy of special mention.

1. The dominant ridge of the hill belt does not form the divide that separates the streams flowing directly to the Bay of San Francisco from those flowing to Stevinson Bay by way of Walnut Creek, in San Ramon and Ygnacio valleys.

2. A second feature of drainage of especial interest is the depression of the slope to San Francisco Bay is of more recent origin than the naturally dissected hill country farther northeast—a suggestion which is more fully discussed in this text, under the heading "Structure." The only other notable feature of the drainage is the fact that the streams flowing in San Ramon Valley, the largest, most mature, and broadest valley in the Concord quadrangle, has cut through the alluvium on the valley floor at several places, particularly from Alamo to the village of Walnut Creek, where it runs on bedrock.

3. A third feature is the prevailing alluviation of the valley bottoms and the steep-sided stream trenches cut in the alluvium, which do not as a rule reach the bedrock, clearly indicating that the former conditions in this area favored more vigorous downward erosion by the streams, at a time when the canyons and valleys were deeper, and that with the passing of these conditions waters ceased which reduced the transporting power of the streams and ceased to drop their load of detritus in the bottom of the canyons and valleys, making them flat and broad, as well as helping to give the country its geomorphically mature aspect and aiding in its agricultural values. Since these flat-bottomed valleys were thus formed there seems to have been a slight but distinct tendency toward a recurrence of the older conditions, indicated by the trenching of the valley floors, but this trenching may be due, in part at least, to the disturbance of natural conditions caused by culture.

Attention may be called also to the rather noteworthy convergence of drainage in Castro Valley near Hayward. Most of this drainage is carried by San Lorenzo Creek through a pronounced break in the Berkeley Hills. The only other notable feature of the drainage is the fact that the streams flowing in San Ramon Valley, the largest, most mature, and broadest valley in the Concord quadrangle, has cut through the alluvium on the valley floor at several places, particularly from Alamo to the village of Walnut Creek, where it runs on bedrock.

AREA EAST OF SAN FRANCISCO BAY.

Elevation: The area east of San Francisco Bay embraces a belt of hilly country lying between the bay and the western flank of Mount Diablo. The ridges trend generally northwest and southeast. Formation of two wide valleys lie within this area. One of these is the valley of San Francisco Bay, whose shores stand the cities of Berkeley, Oakland, and Alameda; the other is Ygnacio Valley, which occupies the northeastern corner of the Concord quadrangle and extends with a very flat slope northeasterly beyond the limits of the quadrangle to the shores of Suisun Bay. The southern extension of this valley, up the drainage line of Walnut Creek, is the well-defined flat-bottomed San Ramon Valley, which separately separates the belts of hills above mentioned from Mount Diablo, the greater mass of which lies further east, in the adjacent quadrangle. The dominant range of hills is that which forms the southwestern limit of the belt and which immediately overtops the Bay of San Francisco. The culminating point on this range is Bald Peak, east of Berkeley, which stands at an altitude of 1300 feet above sea level. Other peaks whose altitudes afford us idea of the general height of the range are Crystal Peak, 1729 feet; Round Top, 1700 feet; and Redwood Peak, 1988 feet. This range is commonly referred to as the Berkeley Hills, although the area to which that term is applicable appears to be rather small. It is also often referred to as the Coastal Range, but this term apparently applies more properly to the broad group of hills between the Bay of San Francisco and Mount Diablo. A rather well defined line of valleys, including San Pablo and Moraga valleys, separates this dominant range from the more eastern portion of the hilly belt. The hills thus lying between the dominant range and Ygnacio and Ramon valleys show a less pronounced linear trend, are much more mature in their geographic expression, and in general are much lower. The culminating points in this part of the belt are Rocky Ridge (2000 feet) on the south, and the Briones Hills (1492 feet) on the north.

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Soil. The soils of the area may be divided into two classes. The soil on the hillsides and ridge tops above the level of the valley floors is sedentary—that is to say, it has been formed in place by the chemical and mechanical disintegration of the underlying rocks. This soil has been modified chiefly by the action of certain constituents which nourished the generations of plants that have grown upon the surface and by the addition of organic matter formed by the decay of the same vegetation. On these hills slopes surf­­worn are uncommon, probably because the soil is very dry and parched during the summer, so that they have not aided in turning over and mixing the soil and in thus making it more useful for agriculture. This work, however, has been performed, probably with equal efficiency, by several kinds of burrowing mammals, such as the gopher (Thomomys) and the ground squirrel (Spermophilus). These animals formerly infested the region in great numbers and have persisted there until very recently, in spite of the efforts of the farmers to destroy them, but during the last few years, by more systematic efforts, the health authorities have almost completely exterminated them, because they are regarded as a menace to the public health as propagators of the bubonic plague through the fleas which infest them.

These sedentary soils, having been formed from the immedi­ately underlying rocks, vary in character from place to place, and here and there the slopes are so steep that little or no soil can accumulate. The soils derived from the Cretaceous and Eocene formations are perhaps those best adapted to agricul­ture. This work, however, has been performed, probably with equal efficiency, by several kinds of burrowing mammals, such as the gopher (Thomomys) and the ground squirrel (Spermophilus). These animals formerly infested the region in great numbers and have persisted there until very recently, in spite of the efforts of the farmers to destroy them, but during the last few years, by more systematic efforts, the health authorities have almost completely exterminated them, because they are regarded as a menace to the public health as propagators of the bubonic plague through the fleas which infest them.

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that are underlain by the shale and chalk series, soil which, however, are almost entirely composed of sands and gravel and are underlain by the shales. The slope is a gentle one, and the area is underlain by the shales and limestones.
The dominant feature of the relief of the Marin Peninsula is a comparatively steep slope, which in part descends to the sea and in part to the west. The slope, which in part descends to the sea and in part to the west, is a prominent feature of the Marin Peninsula and is especially evident when viewed from the top of Mount Tamalpais. The slope is characterized by a gentle gradient, which increases as one approaches the crest of the ridge. The slope is flanked by two ridges, one to the north and one to the south, which rise steeply above the slope and provide a striking contrast to the gentle gradient of the slope itself.

The slope of the Marin Peninsula is dominated by a series of terraces and elevated deposits of marine shells of species that are characteristic of the area. These terraces and deposits are characterized by their alternating layers of sand and gravel, which have been deposited by the action of the sea over a long period of time. The terraces are well-developed and are especially evident along the coast and on the beaches of the Marin Peninsula.

The slope of the Marin Peninsula is also characterized by its extensive coastal cliffs, which are composed of a variety of sedimentary rocks. These cliffs are characterized by their steep gradients and their well-defined layers, which provide a clear indication of the geological history of the area. The cliffs are especially evident along the coast, where they provide a striking contrast to the gentle slope of the peninsula itself.

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The formations comprising the sedimentary rocks are graphically represented in the section on the columnar-section sheet. These rocks are certain quartzites, limestone, and crystalline schists, which are best exposed in the San Francisco coastal area, and in the ranges northward through Monterey County, the Santa Cruz Mountains, and the Point Reyes Peninsula, as far as Bodega Head.

Upon the eroded surface of the complex of plutonic and metamorphic rocks rest the Franciscan group, composed chiefly of sandstone, schists, gneiss, and various types of crystalline schists. These are widely distributed in the middle Coast Ranges, occurring notably in the Mount Hamilton and Mount Diablo ranges, about the Bay of San Francisco, and in areas south of the Monterey quadrangle.

Upon the Franciscan group the Shasta series (Lower Cretaceous) rests in unconformable relation, and upon this group lie the Chico formation (Upper Cretaceous). These Cretaceous rocks are widely distributed by the present Coast Ranges, and although removed by erosion over large areas where the Franciscan and older rocks now appear at the surface, they still constitute one of the largest elements in the stratigraphy of the region. They are composed chiefly of shales and sandstones, and in the ranges north of the Bay have a measured thickness of 5 and 6 miles. The Eocene rocks, which immediately follow the Cretaceous, are much less extensive, and their thickness is much uncertain, for in some places they rest directly upon Cretaceous or older rocks, either the Martires or the Tepiski intervening. The most characteristic feature of the group is its lithologic character; it consists largely of sandstones, and the names originally employed with which nearly all the oil of California is directly or indirectly associated. These shales alternate with sandstones, and the entire formation is of an extremely uniform character, with which the names employed for the various formations are associated.

Some strata referable to the Oligocene series have been observed and recorded, but the next great group of rocks is of Miocene age and is known as the Montara group. These formations comprise the great batholith of the Soledad-Santa Cruz quadrangle. The so-called "Montara granite" is a coarse-grained gray rock made up of quartzites, plagioclase, orthoclase, and biotite or hornblende. One common feature of the mass contains both biotite and hornblende. In an earlier paper the writer stated that the rock was a hornblende-biotite granite, but subsequent examinations have shown that a facies of the mass contains neither hornblende nor biotite, and that in this hornblende variety the rock is perhaps more widespread than that in which hornblende occurs either in or near the sea. The writer has found that by an increase in the proportion of plagioclase the rock at many places passes into quartz diorite, so that this designation is perhaps more appropriate. These rocks are found in areas where the term granite is justified only by popular usage. The rock is characterized by the presence of biotite, which is present in areas where the rock is exposed in large masses along the coast. The rock shows occasionally a foliated or gneissic structure, and the evidence of deformation appears in the microscopic structure of the rock even where no foliation is apparent.

The quartz diorite makes up the bulk of Montara Mountain, a bold ridge nearly 3000 feet high, which extends from north to southwest across the upper part of the Santa Cruz Range. The upper part of the group comprises only the lower part of the group, others only the upper part, and at least two of the latter parts are included in the Franciscan group. Some sections comprise only the lower part of the group, others only the upper part, but the examples are constant and several of the latter parts are included in the Franciscan group. Some sections comprise only the lower part of the group, others only the upper part, but the examples are constant and several of the latter parts are included in the Franciscan group.

The formations which by this mode of division constitute the Franciscan group are as follows, the series beginning at the top:

- Bonita sandstone.
- Ingleside chinle (radiolarian chert).
- Marin chert (radiolarian chert).
- Cobb sandstone (including Oeder limestone member and some volcanic rocks).

*Characteristics*: The Cobb sandstone is named from Cobb Ridge, in the San Mateo quadrangle, the Marin from Marin Peninsula, in the Santa Cruz quadrangle, and the Bonita from Bonita Point, on the north side of the Golden Gate. The three formations are petrographically very similar, and may therefore be described together. The prevailing rock in all three formations is a massive, commonly bedded sandstone of dark green-gray color and medium texture. Where it is coarse, or unweathered,
Bonita is about 1400 feet thick, though this estimate is less reliable on the Marin Peninsula is about 1000 feet thick and the stone member) with 500 feet of sandstone below and 2000 feet of chert lenses is located in the Cahil sandstone at a horizon several hundred feet above the base of the formation. These lenses are easy to separate from the limestone, which is very pure carbonate of lime with but little admixture of magnesia. The following analysis, made by W. L. Lawren, of samples of the limestone from Peninsular Canyon, San Mateo County, where it is quarried for use in the manufacture of beet sugar.


The Calera limestone is a belt of discontinuous outcrops that extend from the southern part of the San Mateo quadrangle. The thickness of the limestone in these outcrops vary greatly but averages about 60 feet.

Salayan and Eocene chert cherts.

General character.—These formations consist of radiolarian chert and are so much alike that one description will serve for both. The Sausalito chert, the lower of the two formations, is named from the town of Sausalito, in the Marin Peninsula, near which it is extensively exposed; the Inlandis chert takes its name from Inlandis, in the San Francisco Peninsula. The rocks of which these two formations are composed are the most remarkable of the Franciscan group. They are neither so thick nor so persistent as the sandstone, but their great hardness and their resistance to weathering make them the best exposed formations of the group, and they constitute the most rugged features of the relief. The interest which these rocks excite by their bold outlines is increased by the most curious impregnation of their structural and petrographic features. In color they are very uniform, being flesh-tinted and medium brown, though there are local variations in the texture and in the amount of impurities. In impurities the two cherts differ widely, but in general the Inlandis chert is richer in impurities than the Sausalito chert.

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surfaces that form the upper and lower limits of the chert beds. Some of these facies are lines of very evident voicing, and doubtless all of them would prove to be facies if examined in thin section. The vein matter is quartz, which is usually white or hyaline, whereas the chert is colored. None of these facies, flakes or veins pass through the shale partings, indicating of which has prevented their development, so that each thin sheet of chert has its own system of lenses.\[...

Thus the more consideration of the character of the formations listed in the fivefold subdivision of the Franciscan group, taken with their other minor motions, leads to the recognition of a remarkable series of vertical oscillations of the sea bottom and consequent horizontal migrations of the sea shore during the occupation by the deposition of the sediments of the group.\[...

The basal part of the Cahil sandstone was deposited upon the striking bottom of a transgressing sea. When the sediments had progressed far enough so that the land-dwelling animals failed to reach the deeper water, lateral deposition gave way to the formation of fossiliferous limestones on the bottom of a clear-water basin, which was not in a position to form a barrier to the passage of water. These are particularly noted in the San Francisco, Concord, and Hayward formations.\[...

The volcanic lavas which are interstratified with the sedimentary deposits in the Franciscan group are basaltic or andesitic rocks, which are generally vesicular or amygdaloidal and in which most of their fossils are greatly decomposed.\[...

Peridotite and serpentine—The intrusive rocks of the first class may be referred to generally as peridotite and serpentine, particularly at Hunter Point, there are stringers and masses of chalcedony, irregular masses of chert, and small veins of talc. The serpentine is nearly everywhere thoroughly altered by movements that have been set up within its mass, probably in connection with the gradual and irregular inward movement of an increasing amount upon serpentinization. This altered mass, which is traversed in all directions by slicken-faced surfaces, contains numerous subangular and rounded boulders as well as much larger masses of radiolarian chert, most of which are traversed superficially by a roughly rectangular network of minute veins of chrysolite. The altered serpentine of the Potrero and of Hunter Point includes many rather short, thick lenses of fresh fine-grained dihydrate, which are evidently detached fragments of dihydrate but were intruded into the peridotite before its serpentinization and which by this process became altered apart into discrete lenses. The intrusive lavas are very fine-grained and green in color, and are traversed by a few fractured veins of the altered serpentine, the edges of which are black. They are quite different in character from the altered serpentine, which is much smaller than that on Balboa Ridge and lies parallel.\[...

On the Marin Peninsula there are two well-defined belts of serpentinized peridotite. One of these extends southwestward from a point near the west end of Mount Tamalpais beyond the northern limit of the Tamalpais quadrangle. The serpentine here occurs in the form of a rather thin layered sheet, although partly exposed by erosion. The other consists of sheets and slabs of serpentine, which is smaller than that on Balboa Ridge but lies parallel.\[...

Another belt traverses the Tiburon Peninsula longitudinally and is also in the form of intrusive sheets and slabs, with glauconitic schists at the contact area, one of the most notable of which is that on Angel Island, described by F. L. Ransome.\[...

Still another belt of serpentine lies on the east side of the Bay of San Francisco, near the edge of the Franciscan group, where it grades over the underlying Knoxville formation. This belt extends through the San Francisco, Concord, and Hayward quadrangles, the sheet-like lenses of serpentine are interbedded with andesitic lavas, and are associated with metamorphic rock. The two rocks are in contact near the contact of the Franciscan with the overlying shales, and as both shales and serpentine are the exotic deposits of the Franciscan group, the twofold character of the intrusion being composed of slicken-faced, sheared and schistified serpentine. This belt traverses the Tiburon Peninsula longitudinally and is also in the form of intrusive sheets and slabs, with glauconitic schists at the contact area, one of the most notable of which is that on Angel Island, described by F. L. Ransome.\[...

Two distinct sheets of serpentine, which are intrusive in the Franciscan group and are separated by a moderate thickness of Franciscan sandstone, have been described as the intrusion being very evident in the excellent exposures at Hunter Point, the Potrero, and Fort Point. These sheets lie nearly flat but are traversed by small veins tending to be rounded in the form of chalcedony or hyaline material. These smaller veins are composed of small veins traversing an aggregate of carbonates of...
iron, magnesia, and lime. Under the weather the carbonates are dissolved out at the surface, leaving the siliceous, prominent, as well as rock which is firmly embedded. The most notable occurrence of the rock is found north of Berkeley, in the valley of Tassajara Creek, and at San Bruno Point, but many other smaller bodies may be seen in the environs of San Francisco. Spherical basalt and diabase.—The second class of intrusive involving the Franciscan rocks are the variolitic and aphrically-structured formations. These have been called the Franciscan group; they are not found in later formations. They entered the formations by which they invaded the somewhat different rocks which are present in each, and not in the manner of the intrusive rocks in the Sierra Nevada, where the granite is clearly shown to be continuous in all areas the igneous rocks occur. They are of irregular shape, they include no clean-cut dikes or intrusive sills, and their exposed contacts with the rocks they intrude are generally irregular and jagged. (See PI. V.) Fragments of the intruding rocks, especially of the radiation dikes, are abundant at the contacts, where the sheet is usually broken into a block of different reds and its structure is in some places also greatly changed. Some inclinations show evidence of pressure or deformation. The spherical structure of these intrusive rocks is clearly revealed only on sea cliffs, as at Hunter Point and Point Bonita (see PI. VII), but may also be detected in numerous road cuttings and in natural exposures on hilltops. On sea-cliff exposures the rock presents the appearance of an irregular pile of rolled rocks, each rock having its rounded form modified by contact with its neighbor. The average dimensions of these spherulites or spheroidal masses are about 5 feet in the largest diameter and about 1 feet in their smallest. In the general mass of these spherulites and spheroidal masses are scattered small amounts of glassy rock or spicules. In the white sheet the dominant constituent is feldspar, which is accompanied by subordinate amounts of quartz and mica. In these spherulites of course contain numerous accessory minerals, and some of them include large amounts of tourmaline. The fact that they are derived from various kinds of rocks, both sedimentary and igneous, and yet have common features, such as their content of feldspar, shows a common origin and influence on the development of these rocks. The fact that the rocks of this kind of rocks do not differ significantly from the rocks of the same kind of rocks in the same general area is a sign that the agencies of metamorphism have been changed so that they are in the rocks that intrude the Franciscan area. 5. The pre-granitic rocks are generally metamorphosed and consist chiefly of connate crystalline rocks (which are locally graphitic), quartzites, and various crystalline schists, none of which resemble the Franciscan schists. The Franciscan rocks have not been subjected to the same dynamic metamorphism, but has generally affected the rocks into which the granite was intruded. The pre-granitic rocks are generally metamorphosed and consist chiefly of connate crystalline rocks, which are locally graphitic, quartzites, and various crystalline schists, none of which resemble the Franciscan schists. The Franciscan rocks have not been subjected to the same dynamic metamorphism, but has generally affected the rocks into which the granite was intruded. The nature of the Franciscan schists is at present obscure, but it is highly probable that the latter assembly is post-granitic. Considering this, the fact that the Franciscan is post-granitic, and the fact that the granitic rocks of the Coast Range are continuous with and of the same age as the granites of the Sierra Nevada, we must conclude that the Franciscan group is post-Jurassic. This conclusion is clearly in conflict with that drawn from the fact that the Franciscan lie unconformably below the Sierra (Lower Cretaceous). At present there appears to be no way of harmonizing the conflict without (1) either extending the geologic time at the interval between the recognized Cretaceous and the Jurassic, or (2) assuming a period of batholithic development in the Coast Range that was distinct from and older than that in the Sierra Nevada, on assumption that should not be made without further and fuller investigation. It is hoped that this statement of the difficulty of determining the age of the Franciscan group may stimulate California geologists to make further field studies directed to the solution of the problem. Cretaceous System. DISTRIBUTION. The Cretaceous formations constitute an important feature of the geology of the region mapped but are confined to the eastern side of the Bay of San Francisco. Their chief outcrops lie in a belt that extends through the San Francisco Concord, and Hayward quadrangles, widening toward the southeast. A series of the upper part of the Cretaceous coal measures also in the southern part of the Concord quadrangle. The Cretaceous rocks lie unconformably upon those of the Franciscan group along the west front of the Berkeley...
Hills and are the dominant rocks of that range. They strike northwest and dip steeply generally to the northwestern part of the range. The upper formation of the Cretaceous rocks is unconformably overlain by Tertiary strata that occupy a great trough in the central part of the range. The Cretaceous formation is the bed of the formation south of the town of Martinez, and also, more extensively, in the Mount Diablo quadrangle, which adjoins the Concord quadrangle on the east. Of these two strata of Cretaceous rocks, that of the Berkeley Hills is stratigraphically the more important, for it offers complete sections of the system from the Franciscan to the Tertiary, and it will therefore be described in greater detail.

The system as represented in these quadrangles comprises two distinct formations, which, named in ascending sequence, are designated the Knoxvile and the Chico formation.

**KNOXVILLE FORMATION.**

The Knoxville formation, named for Knoxville, in Napa County, is exposed in a practically continuous belt along the southwest slope of the Berkeley Hills, being confined to the lower part of the slope in the northwestern part of the range but reaching the limit of the Cretaceous system in the southeast part and disappearing to the foot of the slopes beyond the Haywards. The belt widens notably from northwest to southeast across the Concord quadrangle, the belt of Knoxville rock at the northern boundary of the quadrangle is smaller. The rocks are in part mantled over by sand, and are covered in some places by a boulder clay which is in part mantled over by sand, and are covered in some places by a boulder clay which is perhaps as much as 1000 feet thick. As the formation thin out rapidly northwest of Berkeley and at its northeastern extremity it is usually only 100 feet thick, and may be as much as 1000 feet. This thickness is due in large part to erosion in Tertiary times, for these remnants are unconformably overlain by Pliocene and Pleistocene formations.

Knoxville being the basal formation of a series that rests unconformably upon the Franciscan rocks, might reasonably be expected to consist of the coarser detritus that is characteristic of transgressive beds—that is, it should be in large measure conglomeratic. This, however, is not the case, and the pebbles are generally small and the coarsest stones are not much larger than pebbles. The conglomerate is well cemented, and has a bluish-gray color. Under weathering, it becomes reddish brown and crumbly, taking on a texured appearance, and affords an abundant soil, so that fields are found on its surface.

Fossils.—Numerous characteristic Chico fossils have been found in these beds. The locality within the area here described that is most abundantly and possibly the most abundantly in the upper part of the section exposed on the east side of the Arroyo del Habano, about three-quarters of a mile south of the northern boundary of the Concord quadrangle and a short distance southeast of the point where the strata near the base of the Chico formation. The more important fossils found here have been determined by Prof. J. C. Merriam, and are as follows:

**Fossils of the Chico formation.**

<table>
<thead>
<tr>
<th>Fossil</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrella caurina</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Perissolax brevirostris</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Meekia navis</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Meekia utahae</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Meekia saras</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Meekia sp.</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Tellina hoffmanniana</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Tellina sp.</td>
<td>Upper Cretaceous Series</td>
</tr>
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<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Tellina sp.</td>
<td>Upper Cretaceous Series</td>
</tr>
</tbody>
</table>

**TERTIARY SYSTEM.**

**BACCARE SERIES.**

As Prof. J. C. Merriam has clearly shown, the Eocene rocks of the California Coast Ranges may be divided into two paleontologically well-defined formations—the Martinez and the Topal. The line of stratigraphic separation between these two formations is not well marked, and so, as the section of the second formation consists of the upper part of the section exposed on the east side of the Arroyo del Habano, about three-quarters of a mile south of the northern boundary of the Concord quadrangle and a short distance southeast of the point where the strata near the base of the Chico formation. The more important fossils found here have been determined by Prof. J. C. Merriam, and are as follows:

**Fossils of the Eocene formation.**

<table>
<thead>
<tr>
<th>Fossil</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrella caurina</td>
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<td>Perissolax brevirostris</td>
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<tr>
<td>Tellina sp.</td>
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</tr>
<tr>
<td>Perissolax brevirostris</td>
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</tr>
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<td>Meekia sp.</td>
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</tr>
<tr>
<td>Tellina hoffmanniana</td>
<td>Upper Cretaceous Series</td>
</tr>
<tr>
<td>Tellina sp.</td>
<td>Upper Cretaceous Series</td>
</tr>
</tbody>
</table>

**Upper Cretaceous Series.**

The Eocene Hills were the principal part of the Chico formation—the part that conformably overlies the Knoxvill formation. The upper part of the Knoxvill formation may be divided into two paleontologically well-defined formations—the Martinez and the Topal. The line of stratigraphic separation between these two formations is not well marked, and so, as the section of the second formation consists of the upper part of the section exposed on the east side of the Arroyo del Habano, about three-quarters of a mile south of the northern boundary of the Concord quadrangle and a short distance southeast of the point where the strata near the base of the Chico formation. The more important fossils found here have been determined by Prof. J. C. Merriam, and are as follows:

**Fossils of the Eocene formation.**

<table>
<thead>
<tr>
<th>Fossil</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrella caurina</td>
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</tr>
<tr>
<td>Tellina sp.</td>
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</tr>
</tbody>
</table>
named the Franklin antclines, from Franklin Creek, which run almost across it. Here beds the Martinez and Tejon formations form important elements of the stratigraphy. The Tejon appears also in the core of a large antcline northeast of Shell Ridge, which has not been described, but which reveals the underlying formations. It also occurs on Shell Ridge and Lime Ridge, two northwestern spurs of Mount Diablo, although the paleontologic section, although it is not so satisfactory, as well as northeast of Pacheco, where the underlying Martinez outcrops at the north border of the quadrangle.

Maritime formation.

Character and distribution.—The Martinez formation, named from the town of Martinez, in Contra Costa County, is, in its typical form, composed of heavily bedded sandstones in which much chalcedony occurs, giving the rocks a greenish-gray color. The formation includes also some reddish sandstones and interbedded shales. Both sandstones and shales break down readily under the weather. A thick lens of rather coarse, well-cemented conglomerate also occurs in the southwestern extension of the terrane, south of Grayson Creek. These strata dip away from the Chico and apparently form a tongue of the Martinez rocks into the center of the Chico area northeasterly. The Franklin anticline is a broad syncline of Martinez strata, which is flanked on both sides by strata of Monte­

Distribution and character.—The beds of the Tejon forma­tion are best exposed for study in the neighborhood of the Franklin antclines, where they lie in a steeply dipping syncline and where their thickness is not less than 300 feet. The rocks are typically a massive grayish sandstone composed of more closely cemented sand than that formed of the shales. The Martinez strata are either of a very light gray or are stained red with oxide of iron. They are also much more strongly cemented and more resistant to degradation than the Martinez rocks. The beds of Tejon represented by the two limbs of this syncline run on the southeast side of Ygnacio Valley in the two spurs of Mount Diablo that enclose the lower part of Pine Canyon. On the southern slopes the Tejon rocks rest upon and dip away from younger (Mountjoy) rocks on the limbs of an overturned syncline. On the northernmost slope the strata dip a steeper angle in the northwest. The rocks are sandstones that are generally less than 100 feet thick, whereas those of the Tejon, which are formed of some of the heavy-bedded sandstones southeast of Concord, which are highly calcareous and softer. The only other locality at which the Tejon appears is in the heart of the Solano antcline, where it is flanked on both sides by strata of Monte­

Fossils.—Fossils occur at many places in the Martinez formation, most abundantly on the southwest limb of the Franklin antclines. These fossils have been studied by Dickerson, Roy B., and Dickerson has kindly supplied the following list as a result of his recent studies of this fossil fauna:

**Fossils in the bed of the San Polo Point.**

<table>
<thead>
<tr>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pholadomya nasuta Gabb.</td>
</tr>
<tr>
<td>Urosyca robusta Weaver.</td>
</tr>
<tr>
<td>ActiBon lawsoni Weaver.</td>
</tr>
<tr>
<td>Macrocallista (?) packi n. sp.</td>
</tr>
<tr>
<td>Meretrix stantoni n. sp.</td>
</tr>
<tr>
<td>Semele (?) sp.</td>
</tr>
<tr>
<td>Paracyathus (?) sp.</td>
</tr>
<tr>
<td>Cidaris sp.</td>
</tr>
<tr>
<td>Tapes (?) quadrata Gabb.</td>
</tr>
<tr>
<td>Venericardia planicosta var. hornii</td>
</tr>
<tr>
<td>Amauropsis alveata (Conrad).</td>
</tr>
<tr>
<td>Ammonites (?) sp.</td>
</tr>
<tr>
<td>Radiolaria ? sp.</td>
</tr>
<tr>
<td>Turritella cf. pachecoensis Stanton.</td>
</tr>
<tr>
<td>Dentalium cooperi Gabb.</td>
</tr>
<tr>
<td>Helcionella cf. striata Gabb.</td>
</tr>
<tr>
<td>Tellina martinezensis Weaver.</td>
</tr>
<tr>
<td>Telluridae sp.</td>
</tr>
<tr>
<td>Telluridae sp.</td>
</tr>
</tbody>
</table>

The chalcy fossils of the bituminous shale may occur either in thinly and evenly laminated beds or in rather massive thick beds that are traversed by numerous irregular soft shales. Localities where the chalcy fossils are best seen are those in an open slide, which is dense and compact but may be easily weathered with a steel point.

These nonclastic rocks, which were undoubtedly deposited far from the continental margin, grade into clayey and finely stratified terrigenous or volcano-siltstone varieties. Some are of a clayey shale, but some are of a thinner, less clayey character, and grade into varieties in which this constituent seems to predominate. Though still remaining somewhat soft and chalky, this white bituminous shale grades into a soft, tough, or breccia variety. The color appears to be due wholly to organic matter, for it can be burnt out, the rock becoming white or assuming a slightly reddish tint, due to the volatiles and inorganic matter remaining. These varieties are usually of a very light color, but may grade into varieties in which this constituent seems to predominate. Though still remaining somewhat soft and chalky, this white bituminous shale grades into a soft, tough, or breccia variety. The color appears to be due wholly to organic matter, for it can be burnt out, the rock becoming white or assuming a slightly reddish tint, due to the volatiles and inorganic matter remaining. These varieties are usually of a very light color, but may grade into varieties in which this constituent seems to predominate.
zone in the Monterey group, but in some places one grade into the other. A bituminous shale at one horizon may be persistently cherty over a wide area, whereas a shale at another horizon in the same vicinity may be essentially detrital. In the Condor quadrangle, where the bituminous shale is separated into distinct formations by intervening formations of sandstone, one of the shale formations may consist typically of an alternation of thin beds of sandstone, each bed being there represented largely by sandy littoral deposits, while the underlying beds may be nearly 100 feet in thickness, as in the vicinity of San Martin in the Condor quadrangle.

The limestone is generally magnesian and is usually devoid of fossils. Specimens of rock taken from certain of its beds, however, contain a small percentage of phosphoric acid, and the limestone is generally rich in lime, containing more lime than is usual in such rocks. In the Eocene-Miocene interval is that this part of the Monterey group is made up of sandstones and bituminous shales, including an alternation of beds of sandstone, each bed being there represented largely by sandy littoral deposits, and of beds of bituminous shale, which is generally 60 feet in thickness, as in the vicinity of San Martin in the Condor quadrangle.

In the Contra Costa quadrangle, where the bituminous shale is separated into distinct formations by intervening formations of sandstone, one of the shale formations may consist typically of an alternation of thin beds of sandstone, each bed being there represented largely by sandy littoral deposits, while the underlying beds may be nearly 100 feet in thickness, as in the vicinity of San Martin in the Condor quadrangle. In the Contra Costa quadrangle, where the bituminous shale is separated into distinct formations by intervening formations of sandstone, one of the shale formations may consist typically of an alternation of thin beds of sandstone, each bed being there represented largely by sandy littoral deposits, while the underlying beds may be nearly 100 feet in thickness, as in the vicinity of San Martin in the Condor quadrangle.

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discordance, for the exposures of the underlying Tejon do not fully reveal the strata that underlie these rocks.

**CLAREMONT SHALE.**

The Clermont shale, which is named from Clermont Creek, in the Concord quadrangle, represents the earliest appearance of the bituminous shale in the Monterey group. It occurs not only in the Sobrante and Pinole Valley anticlines but appears to hold more or less continuous and to dip toward the southeast along the crest and northeastern edge of the Berkeley Hills. In the Sobrante anticline it is in part soft and distinctly shaly or chalky and in places contains a large mixture of fine detrital matter, but in the Berkeley Hills it is notably cobby, consisting of beds of hard, flinty chalk alternating at irregular intervals with layers of shale. (See P. V.) This belt in the Berkeley Hills extends in unbroken continuity across the southwestern part of the Concord quadrangle and the northeastern corner of the Hayward quadrangle. The bituminous Clermont shale in the Berkeley Hills rests upon the Chico formation, no Eocene strata existing, and the Tice has a thickness of about 1000 feet. The Sobrante anticline, if present, is represented only by a thin bed of yellowish friable shale, difficult to observe in the field and too slight a feature of the stratigraphy to be represented on the map. The stratigraphic relations indicate a well-marked unconformity between the Monterey in general and the older rocks.

**OCRAN SANDSTONE.**

The Orcran sandstone, named from Orcran Ridge, in the Concord quadrangle, is a rather fine grained rock. It outcrops parallel to the Clermont shale in the Pinole Valley anticlines and flanks the Clermont belt in the southern part of the Berkeley Hills, having been removed by erosion from the northern part prior to the deposition of the Orcran quartzites. It forms an indistinctly well marked unconformity that extends from the Clermont into the San Francisco quartzite on the northeastern flank of the Berkeley Hills.

**TICE SHALE.**

The bituminous shale to which the name Tice shale is here applied occurs in a well-marked stratigraphic belt in the northwestern part of the Concord quadrangle, the most widely distributed formation of the Monterey group. It is prevailingly a light-colored to white, well-annealed, bituminous shale, in some places poorly consolidating and in general of coarser texture than the lower sandstones. Many of its strata are abnormally fissile and some are even broken into easy to handle flat flakes. It is a more or less evenly cobby shale, with some uncertainty across the northeast corner of the Hayward quadrangle. In its northeastern exposures it flanks the anticline that extends from the Clermont into the San Francisco quartzite on the northwestern flank of the Berkeley Hills.

**HAMBORNE SHALE.**

The Hamborne sandstone, named from the Arroyo del Hamborner, in the Concord quadrangle, has a wider distribution. Besides flanking the Sobrante and Pinole Valley anticlines in parallel outcrop to the lower formations, it has an extensive outcrop along the southern flank of the Franciscan, where it forms the lowermost formation of the Monterey group and lies next to the Hamborne and Tice formations. The Hamborne sandstone appears also in the belt of the sharply appraised anticline of Las Trampas Ridge and in the east of an anticline that lies north of Lafayette Ridge. It also occurs in the Walnut Creek syncline. The formation everywhere consists of medium-to-fine grained, slightly ferruginous sandstones with some sandy shales.

**ERDO SHALE.**

The bituminous shale to which the name Redo shale is here applied occurs at a strongly marked stratigraphic belt in the northwest quarter of the Concord quadrangle and is also exposed in the adjoining part of the San Francisco quadrangle. The formation is named from Redo Creek, in the Concord quadrangle. The shale is mostly chalky and more or less stained with oxide of iron but is locally cherty. Its chief exposure is on the flanks of the Sobrante and Pinole Valley anticlines and on the southwest limb of the Frankfurt anticline. It occurs also in a narrow belt, difficult to trace continuously, which includes the Hamborne sandstone in the Las Trampas Ridge and of the Franklin anticline. The beds collected in this belt indicate that it includes both upper and lower Monterey. The lower and upper quartzites are well represented, but the middle zone is represented only by a comparatively thin sandy bituminous shale, which may be the equivalent of the entire fivefold alternation of sandstones and bituminous shales found a few miles further west or any part of it which is mapped as the Tice shale (Pleistocene, or Lower Pliocene).

**Family Reproduced—Western Mollusca Shells of the Eocene Quadrangle.**

In the northwestern part of the Concord quadrangle there are two other belts of strata which belong to the Monterey group and which appear to represent more nearly persistent shallow-water deposition. The bituminous shale in these belts is younger in age and prevailingly sandy, as shown here in the area, and the group cannot be subdivided into formations by its petrographic character as a whole, or any other part of its character.

**POLYPOLEPSY.**

<table>
<thead>
<tr>
<th>Genus</th>
<th>doggeni Conrad, 1890</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species</td>
<td>doggeni Conrad, 1890</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
</tbody>
</table>
Although the structural discordance indicated is apparent at Dr. Bruce Clark, who refers the fauna to the Miocene and con­by him. It is interesting to note that he found twice as many San Pablo formation lies is sharply appressed and overturned, practically the same fauna and its stratigraphic relations are

so that the San Pablo strata on the northeastern limb of the syncline are practically free from pyrite. Chemically it closely resembles the Northbrae rhyolite, to be described under the next heading, but reasons are there given why it is regarded as a separate lava flow.

Field relations.—This rhyolite is a lava which lies inffer­rently on the surface of the Franciscan group, on the rocks intruded into it, and on the Knoxville formation. It is less resistant to degra­
dation, so that its profiles present a contrast to those of the formations with which it is associated. Under the weather the rock disintegrates both mechanically and chemically. The mechanical alteration yields a soil changed with small, sharply

angular fragments; the chemical alteration is due to the oxida­tion of the pyrite to limonite and hematite and to the decom­position of the alluvium of the rock by hydrochloric acid formed by this oxidation. The general result is that the soil and rock are reddish or yellowish brown, but in many prominent outcrops where the soil oxide has been leached out the rock is yellowish white. A microscopic examination of typical spec­imens of the decomposed facies of the rock shows that it consists of a micracrystalline aggregate of quartz and feldspar in which are embedded a few small pyconysts of orthoclase, oligoclase and andesine, and, more rarely, corroded phenocrysts of quartz. It also includes some polyomastic quartz that grades into and interlocks with the groundmass, but this may be sec­ondary. It is not impossible that these feldspars and crystals of sanidin and, in addition to the pyrite, some small crystals of magnetite.

The composition of the rock forms a field with, white, nearly opaque earthy material in the groundmass, through which chlorite is usually disseminated. This material is prob­ably residual semiporous siliceous. The chlorite is not derived from place to place from ferromagnesian alluviums, but has been lightened through the rock southeast of Mount Diablo, olivine, and chloride fill minute cracks. The abundant chlorite makes the rock dark. The feldspars are clearly and in part eliphitic. Many of the crystals of pyrite, both the cubes and the pentagonal-
dodecahedrons, are surrounded by the white earthy mate­rial above mentioned. Some of the pyrite occurs partly in the feldspar, which bear allotriomorphic relations to them, indicating that the pyrite may perhaps be an original constitu­ent of the rock. Other occurrences of pyrite are, however, probably of secondary origin.

The high content of silts, the low content of lime, and the proportion of sands to pachyderm indicate clearly that the rock is a soda rhyolite; but the fact that all the material is more or less altered precludes the possibility that these analyses may repre­sent a true composition of the original rock. Some of the ferric oxide in samples 2 and 3 is doubtless contained in limonite produced by the oxidation of pyrite. Sample 1 was practically free from pyrite. Chemically it closely resembles the Northbrae rhyolite, to be described under the next heading, but reasons are there given why it is regarded as a separate lava flow.

Field relations.—This rhyolite is a lava which lies inferrer­rently on the surface of the Franciscan group, on the rocks intruded into it, and on the Knoxville formation. It is less resistant to degra­
dation, so that its profiles present a contrast to those of the formations with which it is associated. Under the weather the rock disintegrates both mechanically and chemically. The mechanical alteration yields a soil changed with small, sharply

angular fragments; the chemical alteration is due to the oxida­tion of the pyrite to limonite and hematite and to the decom­position of the alluvium of the rock by hydrochloric acid formed by this oxidation. The general result is that the soil and rock are reddish or yellowish brown, but in many prominent outcrops where the soil oxide has been leached out the rock is yellowish white. A microscopic examination of typical spec­imens of the decomposed facies of the rock shows that it consists of a micracrystalline aggregate of quartz and feldspar in which are embedded a few small pyconysts of orthoclase, oligoclase and andesine, and, more rarely, corroded phenocrysts of quartz. It also includes some polyomastic quartz that grades into and interlocks with the groundmass, but this may be sec­ondary. It is not impossible that these feldspars and crystals of sanidin and, in addition to the pyrite, some small crystals of magnetite.

The composition of the rock forms a field with, white, nearly opaque earthy material in the groundmass, through which chlorite is usually disseminated. This material is prob­ably residual semiporous siliceous. The chlorite is not derived from place to place from ferromagnesian alluviums, but has been lightened through the rock southeast of Mount Diablo, olivine, and chloride fill minute cracks. The abundant chlorite makes the rock dark. The feldspars are clearly and in part eliphitic. Many of the crystals of pyrite, both the cubes and the pentagonal-
dodecahedrons, are surrounded by the white earthy mate­rial above mentioned. Some of the pyrite occurs partly in the feldspar, which bear allotriomorphic relations to them, indicating that the pyrite may perhaps be an original constitu­ent of the rock. Other occurrences of pyrite are, however, probably of secondary origin.
The introduction does not support the suggestion afforded by stratigraphic considerations.

Petrographic character. The Northborne rhyolite has been studied and described in detail by Pohle. In some places it shows pronounced flow structure, locally marked by vesiculation and in other places containing hollow spherical cavities, the largest several inches in diameter, which make up a considerable part of the otherwise glassy rock. The texture of the rhyolite is holocrystalline and porphyritic. The groundmass is a fine aggregate of quartz and feldspar, with occasional augellite, orthoclase, and adularia. The rock contains no ferromagnesian alteration of which can be observed only by means of the light-yellowish pumice, partly in fragments ranging in size from Bay, in the San Francisco and Concord quadrangles, its volume is not so persistent as either of these formations. On San Pablo tuff persisted into the early part of the Orinda epoch. The tuff shows pronounced flow structure, locally marked by vesiculation; in other places containing hollow spherical cavities, the largest several inches in diameter, which make up a considerable part of the otherwise glassy rock. The texture of the rhyolite is holocrystalline and porphyritic. The groundmass is a fine aggregate of quartz and feldspar, with occasional augellite, orthoclase, and adularia. The rock contains no ferromagnesian alteration of which can be observed only by means of the light-yellowish pumice, partly in fragments ranging in size from Bay, in the San Francisco and Concord quadrangles, its volume is not so persistent as either of these formations. On San Pablo tuff persisted into the early part of the Orinda epoch. The tuff shows pronounced flow structure, locally marked by vesiculation; in other places containing hollow spherical cavities, the largest several inches in diameter, which make up a considerable part of the otherwise glassy rock. The texture of the rhyolite is holocrystalline and porphyritic. The groundmass is a fine aggregate of quartz and feldspar, with occasional augellite, orthoclase, and adularia. The rock contains no ferromagnesian alteration of which can be observed only by means of the light-yellowish pumice, partly in fragments ranging in size from
Stratigraphic relations.—The basement upon which the Mesozoic rocks rest in the vicinity of Muscle Rock is the worn surface of volcanic rocks of the Franciscan group. Between the basement sandstone and the basalt beds of the Morro is a wedge of post-Franciscan and pre-Morro alluvium, now firmly cemented, composed almost wholly of fragments derived from the underlying volcanic rock. Upon this ancient alluvium lies a layer of forest material, less than a foot thick, consisting of carbonized wood, bark, mast, leaves, and pine cones of the species Pinus longaeva, and above this are the marine beds. Cores of the same species have been found in the marine beds a few hundred feet higher in the section, just north of the lenticular near Muscle Rock. Still higher are cores of Paradoxylon douglasii. In one of the cores east of Muscle Rock, where a small stream has cut down into the formation, several trunks of coniferous trees are exposed, the wood and bark being excellently preserved. These trunks lie in the Morro formation, and a sandstone bed a little above them contains numerous remains of marine mollusks. This lignitic forest lies under beds and there is probably no great distance. It ranges in thickness from a few inches to perhaps 2 feet. On the cliffs north of Muscle Rock the actual exposure of the inclined beds measures about 30 miles along the shore, or obliquely across the strike. From the cliffs the beds strike southeastward along the southwest side of Muscle Valley and have been traced nearly as far as San Mateo. The breadth of the outcrop along this belt decreases strongly from the southwest to the southeast. In the formation there lies a long, winding stream which drains eastward into the ocean. Everywhere, however, the base of the Morro rests upon the Franciscan. As a large part of the formation is composed of soft beds it is exposed for at least 50 miles along the northwest side of the belt, and it can with difficulty be distinguished from the soft alluvial Franciscan formations and the sand dunes that occupy the adjoining territory. The belt of Morro is limited on the northeast by a fault that drops the formation nearly vertical. At the north end of the belt, near Seaside, the basal beds of the Morro formation rest directly upon the granite rocks that form the shores further north. Here all the phenomena of a breccialy beach may be seen at the base of the section.

North of the Golden Gable, at Raines, in the Tampalique quadrangle, another mass of the same formation, consisting of typical Morro beds, rests unconformably upon much disturbed beds of the Montery group and dips outward beneath these beds. The Santa Cruz formation has been referred in part on very bad evidence to the Morro and its beds in the Santa Cruz quadrangles are regarded as a terrestrial equivalent of the Morro. The correlation with the Morro and the Morro of the Santa Cruz region is uncertain, but the Santa Cruz formation is probably of Tertiary age. The Morro formation has been referred in part on evidences of a fault, as has the Santa Cruz formation, to the San Pedro line, and its age is probably Tertiary.

Fossils.—The rocks of this formation are rich in Brachiopod and Echinodermata.

1. Echinodermata:
   - Pecten sp.
   - Paphia tenerrima Carpenter.
   - Mytilus edulis Linne.
   - Paphia staleyi Conrad.
   - Modiola recta Conrad.
   - Macoma nasuta Conrad.
   - Cardium centifilosum Carpenter.
   - Mya japonica Jay.
   - Chione succincta Valenciennes.
   - Scutella interlineata Stimpson.
   - Cardium inekeianum Gabb.

2. Gastropoda:
   - Cerithidea californica Hinds.
   - Bittium asperum Gabb.
   - Astyris richthofeni Gabb.
   - Spisula catilliformis Conrad.
   - Tellina bodegensis Hinds.
   - Saxidomus nuttalli Conrad.
   - Saxidomus giganteus Deshayes.
   - Solen sicarius Gould.
   - Saxidomus nuttalli Conrad.

TERTIARY AND QUATERNARY DEPOSITS.

SIESTA FORMATION.

The Siesta formation, as named from Siesta Valley, in the Concord quadrangle, consists chiefly of beds of sandstone and conglomerate, with which are associated some basic tuffs and beds of well-cemented rhyolite tuff. Between these volcanic rocks lie horizontal beds of conglomerate, clay, and limestone. One of these limestone horizons, 10 feet thick, consists of well-cemented radiolarian limestone. The total thickness of the formation is 1000 to 1200 feet. The Siesta formation is divided into a lower and an upper part.

1. Lower Siesta Formation.
   - Scutella interlineata Stimpson.
   - Cerithidea californica Hinds.
   - Bittium asperum Gabb.
   - Astyris richthofeni Gabb.
   - Spisula catilliformis Conrad.
   - Tellina bodegensis Hinds.
   - Saxidomus nuttalli Conrad.
   - Saxidomus giganteus Deshayes.
   - Solen sicarius Gould.
   - Saxidomus nuttalli Conrad.

2. Upper Siesta Formation.
   - Scutella interlineata Stimpson.
   - Cerithidea californica Hinds.
   - Bittium asperum Gabb.
   - Astyris richthofeni Gabb.
   - Spisula catilliformis Conrad.
   - Tellina bodegensis Hinds.
   - Saxidomus nuttalli Conrad.

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   - Scutella interlineata Stimpson.
   - Cerithidea californica Hinds.
   - Bittium asperum Gabb.
   - Astyris richthofeni Gabb.
   - Spisula catilliformis Conrad.
   - Tellina bodegensis Hinds.
   - Saxidomus nuttalli Conrad.
   - Saxidomus giganteus Deshayes.
   - Solen sicarius Gould.
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basalt. Above these beds is a thick series of basalt flows, and lastly, resting on the basalt, there are remnants of a once extensive series of alluvial fans, or sedimentary and igneous rocks, now well cemented.

The formation occupies a trough which trends northward and which has an older syncline of the Berkeley group—a trough that is filled in part by a synclinal fold and in part by faults, the fault having dibuted the northeastern side of the trough against formations of the Berkeley and Monterey groups. This faulting uppers on, however, to have affected only the upper portion of the Campus formation, since the volcanic rocks of the upper part of the formation are spread out over the traces of the fault in the upper part of Wildcat Canyon, in the Concord quadrangle, and the displacement must have occurred during the deposition of the formation. The fault in general, how­ever, determines the northeastern boundary of the trough.

On its southeastern boundary the basal beds of the Campus formation are faulted down against the Chico Knob Thrust, of the Franciscan, and the Orinda. Although the lower part of the Campus formation is faulted down against the Berkeley group, it is apparent from the map that the Berkeley strata had been folded and in large measure degraded before the fresh-water basin in the Berkeley group was formed, and so the unconformity therefore exists between the Berkeley and the Campus. At the northeastern end of the trough the elongations of the Campus rest on the Orinda, and as both formations are of much the same character and have been correlated in time with the deposits of the San Francisco formation, from the township of that name.

The alluvium is divisible into two parts, an older and a younger syncline of the Berkeley group a trough that is formed northwest and which lies athwart the northwest end of the Diamond Creek. Without much change in character it passes into the conglomerates of the Campus formation and the overlying alluvium indicates an important change in the character of the stream gravels. This formation is faulted down against the Berkeley group, and as both formations are of much the same character and have been folded and in large measure degraded before the fresh-water basin in the Berkeley group was formed, and that an unconformity therefore exists between the Berkeley and the Campus. At the northeastern end of the trough the elongations of the Campus rest on the Orinda, and as both formations are of much the same character and have been correlated in time with the deposits of the San Francisco formation, from the township of that name.

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steeply inclined against the massive plutonic rock, suggests that accompanied by earthquakes. The importance of giving due con­

panied Sawyer Ridge on one side and Cahil and Fifield ridges on

lives that gave the block its present profile. From the crest of Mount Mount Mount, or to the southeast of Montara Mountain, which is the de­

ground a large mass of bituminous shales of the Monterey group. This is a long, straight, narrow valley, which trends about

positions. It is traceable over Whiting Ridge to the head of Pilar­

The entire Merced formation, which occupies the northeastern part of the Montara block, is only about one mile wide and

sawyer ridge appears to be a flat, long, straight, narrow valley, which trends about

its northeastern part. This area of Eocene beds that flank the north side of the mountain.

This is a long, straight, narrow valley, which trends about

The entire Merced formation, which occupies the northeastern part of the Montara block, is only about one mile wide and

The southwest limb of this syncline is well exposed in the

The southwest and southeastern parts of the Santa Cruz quadrangle

The Merced strata are similarly preserved in the same

The San Bruno fault is shown in Plate X.

The fault blocks of the San Bruno fault on the west side of San Francisco Bay. The San Bruno fault, a large footwall block, its present profile.

The fault which parallels the San Bruno fault on the west side of San Francisco Bay. The San Bruno fault, a large footwall block, its present profile.

This area of Eocene rocks is in the vicinity of Pilarcitos Lake.

Another notable fold within the Montara block is a syncline on its northwest margin, which involves the Merced formation.

The southwest limb of this syncline is well exposed in the

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By this fault a band of radiolarian chert of the Franciscan group (probably Ingleside) is brought against sandstones of the same group (probably Mata). The fault doubtless extends southeastward across the city of San Francisco, along the main portion of the Franciscan group, however, where the rocks are very felsic and the strata are not so numerous, similar faults are difficult to detect, and even if a fault is observed at one place it is difficult to follow and map. The region therefore probably contains many more faults than are indicated on the geologic maps.

In general, the faults of the Franciscan rocks in the San Francisco-Marin block show remarkably little appression, particularly in their larger features, but in parts of the Franciscan terrane where the rocks are thin bedded and therefore incompetent to transmit pressure they show the results of crushing, the beds having been broken and crumbled. The strike of the folded beds is in general constant, even where the strata are highly inclined, and the axes of such folds as can be made out are also very diverse in direction. This irregularity in strike is due in part to the local tectonics of the small upwarpings and downwarpings of the pre-Franciscan reaches. The folding that results from careful mapping reveals different directions. The irregular folding in the Franciscan strata presents a striking contrast to the folding in the later sedimentary beds of the Coast Ranges, which is simpler and more the Appalachian type.

The prevailing dip of the Franciscan rocks on the San Francisco Peninsula is to the northeast. The San Miguel Hills, on the southwest edge of the city, lie in an undulating syncline, the undulations of the southwest flank of the hills being under the streets of the summit at a low angle. The undulations are of great importance in the Marin Headlands and San Francisco Bay, and in the San Francisco Bay region, as the undulations of the Franciscan and may possibly belong to the Cretaceous system. The structure northeast of the San Miguel syncline is obscured by bodies of sedimentary and by an extensive layer of sand. The sandstones south of Fort Point are very unevenly stratified and dip to the northeast, and as those on the south side of the Nicasio Platte, although intensely contorted, appear to have the same general dip, their attitude suggests that they lie in the northwestern part of the San Francisco Peninsula. On Rincon Point, southwest of the city, the prevailing dip is similarly to the northeast. In the San Miguel Hills and in the neighboring hills the sequence of the Franciscan formations and their structural relations may be seen. The folding can be made out fairly well, but the structure elsewhere in the city of San Francisco is obscure. As many exposures in street cuts and other excavations even the local dip can not be determined, owing to the masking of the softer strata, the varying rocks, the depth of rock decomposition, and the surface creep. The general structure across the southwestern part of the city, however, is shown in section E-F.

On the Marin and Tiburon peninsulas certain broad features of the folding can be made out, but a detailed interpretation of the structure is possible only locally. On the northeast side of Tiburon Peninsula and Angel Island the dips are southeast, but at Belvedere and on the Mount Tamalpais quadrangle the dips are northwest. The structure of the Tiburon Peninsula and Angel Island is therefore synclinal, though complicated by numerous small faults. (See section B-C.) In the Berkeley Hills the strata of the summit of Sobrante Ridge, which it follows, is marked by abundant coarse fault breccia in a silicified sandstone, and the depth of rock decomposition, and the surface creep. The general structure across the southwestern part of the city, however, is shown in section E-F.

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At this point toward Haywards, however, the trace of the Haywards fault may be followed southwestward through a line of sinks, and south and southward in the hills west of Lake Chabot, until, at a point beyond the town of Strawberry Point, it passes out to the base of the hills. The faults here show the effects of the fault and the edge of the quadrangle, east of Donato, and that shown in the vicinity of Lake Chabot are features of the general zone of deformation that bounds the Berkeley Hills on the southwest and probably represent the earlier movement, which defined the Berkeley Hills block, rather than that which produced the Haywards fault.

The zone of deformation on the southwest flank of the Berkeley Hills is marked in the San Francisco quadrangle by a series of step faults, the effects of which are still clearly defined in the profile of the slope between Strawberry Creek and Cordones Creek. Beyond Cordones Creek similar faults are indicated by topographic displacements, although they are only faintly expressed in the geologic profile. In the district known as Cordonices, east of Northbrae, one of the faults is marked by abundant coarse fault breccia in a silicified sandstone of the Santa Cruz Beds, which have a drainage on the slope. On the crest of the San Andreas fault west of the San Andreas fault, a similar stream flows through a notch in the ridge, the strata are prevailingly sandstone, similar faults are dis­

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Ramon Valley. It brings several horizons of the Monterey fault, with larger throw, the trace of which lies in the line of Farther south, at the end of the ridge, is another transverse flat-lying plane, involving a slight rotation of the overthrust parallel transverse faults are cut at nearly right angles by the and its strike is in general parallel to that of the strata of the overthrust block. For the movement caused by the compressive forces. The most important of the folds is the synclinal trough in which a broad syncline of Monterey formations, in the center of which lies the Monterey rocks of the crest of Rocky Ridge overlie thrust the Monterey group and the San Pablo formation. Its strike is the same as that of the strata of the overthrust block. For the movement caused by the compressive forces. 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probable that the pre-Ordisian folding was post-San Pablo. There is also little evidence of uplift and erosion prior to the post-Ordisian period, and it appears that the region experienced a period of relative stability during this time. It is likely that the post-Ordisian period was a time of widespread denudation and erosion, as suggested by the widespread occurrence of tillites and glacial erratics in the region.

GEOLGY.

The geology of the area described in this folio begins with the term "Franciscan" and is well suited to the subject. The term "Franciscan" is commonly used to describe a group of rocks that includes the most extensive series of rocks in the region. These rocks are typically characterized by a combination of metamorphic and intrusive rocks, and they are generally considered to be of late Cretaceous age. The Franciscan rocks are typically characterized by a high degree of metamorphism, and they are often associated with a variety of other rock types, including granitic and gabbroic rocks. The Franciscan rocks are typically characterized by a high degree of metamorphism, and they are often associated with a variety of other rock types, including granitic and gabbroic rocks.

The Franciscan epoch of sedimentation was succeeded by the Oakridge conglomerate member of the Chico formation. This formation represents a maximum thickness of about 1000 feet and consists of a series of alternating layers of sandstone and shale. The sandstones are predominantly fine-grained, and they are typically characterised by a high degree of cross-stratification. The shales are typically characterised by a high degree of fine-grained texture, and they are often associated with a variety of other rock types, including siltstone and mudstone.

The fact that the Chico formation represents a maximum thickness of about 1000 feet and consists of a series of alternating layers of sandstone and shale is significant in that it suggests that the region experienced a significant period of subsidence and erosion during the Franciscan epoch. The subsidence and erosion were likely driven by a variety of factors, including tectonic activity, climate change, and sea-level changes.

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of Monterey County. The second condition—that of continuous littoral sedimentation—is in some measure fulfilled in the Monterey. The beach is a single, comparatively thin and impermeable formation of bituminous sands.

SAN PABLO EPOCH.

Monterey time was brought to a close by uplift and disturbance of the Coast Ranges. The disturbance was great in Santa Cruz County, where, as W. F. Jones has shown, the San Pablo formation rests upon the upper edges of the nearby vertical Monterey strata and, moreover, has a basal conglomerate. The discordance, though not so pronounced, is still well marked in the Mount Diablo quadrangle. There is also a distinct indication of discordance between the San Pablo and Monterey in the distribution of the San Pablo along the middle of the northeastern part of the Concord quadrangle. Elsewhere in the Concord quadrangle, however, the San Pablo follows the Monterey without appreciable discordance. The substratum that permitted the deposition of the San Pablo beds appears to have formed a much smaller basin than the one that existed during Monterey time. The present valley bed is probably the result of erosion and the removal of coarse sandstone of the San Pablo and their general blue color tend to mask off this formation from the underlying commonly light-colored or rusty-yellow sandstone of the Monterey and indicate a change in the conditions of deposition. The absence of the bituminous sands probably characterizes the Monterey also to some extent.

MERCED EPOCH.

The superposition of the Merced formation upon the San Pablo has nowhere been seen in the area here mapped, but such superposition, with evidence of unconformity, occurs near Chilitenon, in Santa Cruz County, and has been described by W. F. Jones. The absence of the San Pablo below the Merced in the Sunol and Tumalpais quadrangles itself suggests an unconformity between the two, unless the San Pablo was so much eroded as not to cover this part of the field.

The depression which permitted the accumulation of Merced strata to the thickness of over a mile on the site of the present San Francisco Peninsula appears to have been local and to have formed a sinking trough in which accumulated marine clays, sands, and conglomerates. The land surface that was thus gradually depressed more than a mile below sea level had supported a forest growth, represented by abundant pine cones, which are represented by the San Pablo and Tertiary periods.

BERKELEY EPOCH.

At the close of Orinda time a slight depression probably occurred on the southwest side of the structural trough in which the fresh-water sediments of that epoch accumulated, and into this depression there was poured a succession of alluvial and deltaic beds and occasional showings of沙子. Between these volcanic flows and showings there were times when fluvial and lacustrine conditions occurred and other times in which the lake was exposed to atmospheric oxidation or to erosion. The beds of tuff or ash that are intercalated with the lavas indicate periods of formation of the Pleistocene. This accumulation of volcanic and interstratified fresh-water beds forms the Berkeley group.

FORMATION OF COAST OF TERTIARY PERIOD.

At the close of the Tertiary period, which marked also the end of the Tertiary period, the Merced, Orinda, and Berkeley strata became involved with all the older rocks in the great earth movements which deformed the region. The basement upon which the Merced had been deposited and which, as we have seen, had been lifted to a level far above sea level, was lifted far above sea level, as may be plainly seen at the exposure near Mussel Rock, in the San Mateo quadrangle. The extent to which the Merced, Orinda, and Berkeley strata were uplifted during this time can best be described by the following analogy. Suppose the basin of the bay were filled with water, and then let the whole block be raised on dry land, their present position indicates very recent subsidence.**

RECENT UPLIFT AND DEPRESSION.

The record of the Monterey formation is replete with the history of the Bay of San Francisco. Monterey, which is read in the Quaternary deposits of the east side of the Bay of San Francisco and in its drainage is not matched on the west side. The Alluvium which extends from the base of the steep slopes to the edge of the salt marshes of the bay is the equivalent of the Temescal formation, and the Alameda, San Antonio, and Merritt formations are absent. The deltaic outwash of the shore—a series of embayments separated by rocky promontories—which characterizes the bay sides of the Marin Peninsula and of the San Francisco Peninsula as far south as San Bruno Point clearly points to a subsidence much more pronounced than that which occurs on the east side of the bay. If the mounding formations were ever deposited on the west shore, it needs to be explained that some of them were so far submerged by the greater elevation of this part of the bay.

The luxuriant flora of alluvium of the west side of Crystal Springs Lagoon, at the southern border of the San Mateo quadrangle, which is the northern extension of the San Clara formation of the San Francisco quadrangle, is the product of deposition and fluvial and torrential deposition during a period whose eolian age is in doubt.

Outside of the Golden Gate the striking wave-cut terrace at Bolinas affords unequivocal evidence of uplift, the minimum measurement of which is the elevation of the terrace where it abuts upon its formerly degraded sea cliff. This structure is about 200 feet above sea level. The uplift thus clearly indicated is extremely interesting in view of the absence of evidence of uplift on the shores of the Marin Peninsula northeast of the San Andreas rift and in view of the positive evidence of depression and the entire absence of evidence of uplift on the southern side of the Marin Peninsula. Similarly uplifted shore lines are absent on the Pacific side of the San Francisco Peninsulas between the Golden Gate and Point San Pedro. South of this point, however, particularly south of Half Moon Bay as far as Santa Cruz, alluvial strata are present, features of the coastal profile. It is noteworthy also that on the coast north of Tomales Bay elevated terraces again become conspicuous, and on the east side of Tomales Bay itself there are raised shell beds, which stand 20 to 30 feet above the present shore line. Since the uplift of the Bolinas terrace there has been a slight depression of the Point Reyes Peninsula, as may be easily inferred from the drowning of the small stream flowing into Drake's Bay, near Point Reyes Light. The evidence thus presented shows that the eluvial movements of the region about the Bay of San Francisco in Quaternary time have been complex and uncertain. The evidence that Bell and others have given of uplift of the San Francisco Peninsula is based upon the fact that the dentate contour of the San Francisco Peninsula as far south as San Bruno Point is identified with the dentate contour of the Bay of San Francisco. This suggests a possible origin from either the position of the land surface that was uplifted or a possible origin from the existence of uplift on the shores of the Marin Peninsula. The evidence, however, is not so clear as that presented on the Marin Peninsula, indicative subsidence in late Quaternary time.**

CHANGES IN DRAINAGE.

The courses of many of the streams in these quadrangles were modified during Quaternary time, and it would be interesting to trace their history in detail, but only a few of the more important changes will be mentioned.

The most notable event in the modification of the drainage of the region was the conversion of the valley lying between the Berkeley Hills and the higher part of the San Francisco—Marin Mountain block into an inlet of the ocean by the sinking of the coast. The drainage of the Great Valley of California and from the Coast Ranges north and south of San Francisco mountain range was drained to the north by a short transverse canyon at the Golden Gate. The submarine admitted the sea to the valley and so created the great harbor of San Francisco Bay. By this change the mouth of the bay was made more accessible to deep water and the significant feature of the profile of the bay was established.
flow from Livermore Valley through San Ramon and Ygnacio valleys to Suisun Bay. The divide between the head of San Ramon Creek and the hydrographic basin of Alamedas Creek, in the country east of the Concord quadrangle, is situated on the nearly level floor of Livermore Valley, which was the floor of the broad plain of the much larger flow of the bay. This plain was laid waste by the retreat of the sea, and the present narrow coastal strip is all that remains of the old bay.

The surface of the bay constitutes one large artesian basin. The numerous successful wells that have been sunk in it, particularly around the southern end of the bay, show that the conditions favorable to the storage of water are nearly constant over the whole area of the valley and that gravel beds containing water lie at many levels. The conditions at the north end of the valley, on the south side of San Pablo Bay, are somewhat similar to those at the south end. A number of wells recently sunk near San Pablo have obtained a supply of water from gravelly and sandy strata alternating with clays, which have an aggregate thickness of about 100 feet. The situation of the deposit indicates that their superficial parts are the outwash dunes of San Pablo and Wildcat creeks, but the wells doubtless pierce these deposits and penetrate the underlying, slightly inclined strata of alternating gravels and clays of the Orinda formation.

The artesian basin of San Francisco Bay is probably susceptible of still more extended exploitation, and measures might possibly be taken to insure the permanence of this supply by directing surface drainage into the gravel beds that hold the water.

Another small but similar artesian basin, which, however, has been but little exploited, lies beneath Ygnacio Valley, in the Concord quadrangle, and its extension northward to Suisun Bay.

BRECCIA FORMATION

Orinda formation.—The Orinda formation, a heterogeneous accumulation of fluvial and lacustrine deposits with local beds of volcanic ash, includes valuable beds of clay, the most important of which may be briefly indicated.

A large deposit lies near Oyster Point and Bryant, in the Concord quadrangle. Midway between these two places the beds are about 75 feet thick, but they include a few layers of sandy clay and sandstone. The clay outcrops continuously for nearly a mile along the north shore of the bay, but beyond this point it is masked by soil. The deposit occurs also farther north, just beyond Bryant and north of Orinda. Throughout its known extent the deposit averages probably 40 feet in thickness, but its boundaries are obscure and this estimate is therefore not exact. At Bryant a second set of clay beds outcrops on the hillside west of the railroad bridge, which aggregates about 30 feet in thickness but in places includes considerable layers of sand.

At the northeast end of Pleasant Valley, near Lafayette, in the Concord quadrangle, there is an exposure of sandy clays, which extend more than a mile eastward. In its eastern...
exposures the clay appears on the south side of the valley, where its estimated thickness is about 20 feet.

South of Larkspur, on the road leading eastward from Larkspur to San Anselmo, there is a deposit of clay of good quality, about 12 to 15 feet thick as exposed at the base of a hillside. The clay beds extend from Larkspur to San Anselmo, but for so far as they are now exposed they appear to be thin and to grade into clayey sandstones and conglomerates.

Near Danville several beds of good clay are exposed in the creek beds, their total thickness being about 20 feet. The greatest thickness of a single bed is 6 feet. There is also considerable sandy clay at the same locality.

Several other deposits of impure or sandy clay suitable for brickmaking occur in the Orinda area, and much of the Orinda soil in places where outcrop of the strata is apparent is so clayey as to be available for brickmaking. Some of these clayey soils probably lie upon clays of good grade.

**Sample formation.**—The Siesta formation is composed largely of clays, which extend from the head of Wildcat Creek in the Concord quadrangle, southward to the end of Morgan Valley. The most extensive exposure of these clays is in Morgan Valley, where the belt of clay has a maximum width of about 1200 feet. The formation throughout its extent lies in a synclinal trough, and the width just given probably represents more than double the thickness of the clays. The clay beds are flanked on the east by conglomerate and on the west by sandstone. The clay beds outcrop for about a quarter of a mile on each side of the creek. Below these slopes, in the salt marshes around the bay, there are at many places extensive deposits of good clay, which could be obtained by dredging with a mudboat.

**Sample formation.**—In the Orinda area, along the Berkeley Hills, is available for making bricks and possibly also, in its purer forms, which contain little or no sand, for making cement. Most of this clay, however, is not as suitable as indicated by its outcrop, in more or less sandy clays.

**Sample formation.**—In the Knoxville formation, its outcrop along the Berkeley Hills, is available for making bricks and possibly also, in its purer forms, which contain little or no sand, for making cement. Most of this clay, however, is not as indicated by its outcrop, in more or less sandy clays.

**Sample formation.**—The deposits of limestone large and pure enough to be of commercial value are two in the region about the Bay of San Francisco. The oldest limestone (Cevilla limestone) is older than the quartz diorite. Within the quadrangles here described this rock occurs apparently only as inclusions in the quartz diorite. One of these inclusions, on the west side of Piedmont Canyon, is a hard block of limestone that is about 100 feet thick and is of good grade. Another deposit of limestone is that at the base of the Cretaceous beds in the Gaviota formation. This limestone is of good quality and the supply is very large. The clay beds are flanked on the east by conglomerate and on the west by sandstone.

**Sample formation.**—In the Franciscan group the foraminiferal limestone (the Gavilan limestone) is older than the quartz diorite. Within the quadrangles here described this rock occurs apparently only as inclusions in the quartz diorite. One of these inclusions, on the west side of Piedmont Canyon, is a hard block of limestone that is about 100 feet thick and is of good grade. Another deposit of limestone is that at the base of the Cretaceous beds in the Gaviota formation. This limestone is of good quality and the supply is very large. The clay beds are flanked on the east by conglomerate and on the west by sandstone.

**Sample formation.**—In the Franciscan group the foraminiferal limestone (the Cevilla limestone member of the Cretaceous) is a deposit large and pure enough to be of commercial value. This deposit is located in the north-central part of the California coast, near the Point Reyes station, just beyond the northern limit of the Tamalpais quadrangle. The most extensive exposure of these clays is in Morgan Valley, where the belt of clay has a maximum width of about 1200 feet. The formation throughout its extent lies in a synclinal trough, and the width just given probably represents more than double the thickness of the clays. The clay beds are flanked on the east by conglomerate and on the west by sandstone. The clay beds outcrop for about a quarter of a mile on each side of the creek. Below these slopes, in the salt marshes around the bay, there are at many places extensive deposits of good clay, which could be obtained by dredging with a mudboat.

**Sample formation.**—The deposits of limestone large and pure enough to be of commercial value are two in the region about the Bay of San Francisco. The oldest limestone (Cevilla limestone) is older than the quartz diorite. Within the quadrangles here described this rock occurs apparently only as inclusions in the quartz diorite. One of these inclusions, on the west side of Piedmont Canyon, is a hard block of limestone that is about 100 feet thick and is of good grade. Another deposit of limestone is that at the base of the Cretaceous beds in the Gaviota formation. This limestone is of good quality and the supply is very large. The clay beds are flanked on the east by conglomerate and on the west by sandstone.

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mining on a small scale. The only occurrence worthy of mention is one discovered in this fall on Red Rock Island, in the Bay of San Francisco, and near Fort Baker, on the north side of the Golden Gate, in the San Francisco quadrangle. At the locality first named the ore occurs on the southwest side of the island as an integral part of the chert formation. The ore here has a west-southwest strike and a nearly vertical dip, and consists of the usual rhomboidal alteration of thin beds of hard, flinty chert, containing always the whole host rock. Locally, however, the chert layers are abnormally bent and contorted, and bent from the shore at this place the prevailing dip is nearly at high angles. A belt parallel to the strike of the chert adjoining these layers of psilomelane are but in places the psilomelane is much thicker. Some of the psilomelane occur are not sharply defined, but the mineral has been mined in open cuts from 2 to 6 feet wide. The ore appears to be composed of a primary deposit, contemporaneous with the deposition of the siliceous partings that form the chert, although it has some of the psilomelane has since migrated into the adjoining beds. It is probably related in its genesis to the concretionary manganese nodules now accumulating on the sea floor in association with manganese oxides, as shown by deep-sea dredging.

Near Fort Baker, in a road cut, the manganese ore is well exposed as a stratified deposit of hard, black manganese at about 18 inches thick, grading off in its upper part into a lens of black and highly charged with the black manganese by being mined. There is no definite boundary between the layer of manganese and the normal chert formation, for the proportion of the psilomelane simply decreases till it ceases to color the rock. The thickness of the psilomelane varies from a few feet of an intense contrast of elliptical bands, with the chert, the contact plane being parallel to the bedding, and may be traced for 90 feet on the outcrop of the formation, which is a bluish gray sand-clay. The manganese oxides near the surface are not sharply defined, but are contained in a belt parallel to the strike of the chert adjoining these layers of psilomelane are but in places the psilomelane is much thicker. Some of the psilomelane occur are not sharply defined, but the mineral has been mined in open cuts from 2 to 6 feet wide. The ore appears to be composed of a primary deposit, contemporaneous with the deposition of the siliceous partings that form the chert, although it has some of the psilomelane has since migrated into the adjoining beds. It is probably related in its genesis to the concretionary manganese nodules now accumulating on the sea floor in association with manganese oxides, as shown by deep-sea dredging.

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The chert here has a west-northwest strike and is southerly, at high angles. A belt parallel to the strike of the chert adjoining these layers of psilomelane are but in places the psilomelane is much thicker. Some of the psilomelane occur are not sharply defined, but the mineral has been mined in open cuts from 2 to 6 feet wide. The ore appears to be composed of a primary deposit, contemporaneous with the deposition of the siliceous partings that form the chert, although it has some of the psilomelane has since migrated into the adjoining beds. It is probably related in its genesis to the concretionary manganese nodules now accumulating on the sea floor in association with manganese oxides, as shown by deep-sea dredging.

Where Eucled Avenue crosses Cordesons Creek in the city of Berkeley lumps of coarse crystalline gneiss have been found, some with a measure shows that these beds of psilomelane is not known, but they may have been derived from deposits in the Franciscan group.