PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

GEOLOGY

VOL. II

1902–1905

SAN FRANCISCO
PUBLISHED BY THE ACADEMY
1905

CONTENTS OF VOLUME II, THIRD SERIES, GEOLOGY.

PLATES I-XXXV.

December 30, 1914.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

GEOLOGY VOL. II, No. 1

CRETACEOUS DEPOSITS

OF THE

PACIFIC COAST

BY

FRANK M. ANDERSON

WITH TWELVE PLATES

Issued December 24, 1902

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1902

PUBLICATION COMMITTEE

Charles H. Gilbert, *Chairman*

Joseph W. Hobson

William A. Setchell

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

GEOLOGY VOL. II, NO. 1

CRETACEOUS DEPOSITS

OF THE

PACIFIC COAST

BY

FRANK M. ANDERSON

WITH TWELVE PLATES

Issued December 24, 1902

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1902

PREFACE.

This paper is the result of a study begun in 1894 upon an interesting collection of Upper Cretaceous fossils from a new locality in Southern Oregon, locally known as the "Forty-Nine Mine," but referred to here as the Phœnix Beds.

The special feature of interest in this collection is the large percentage of individuals and species of the genera *Schlœnbachia*, *Scaphites*, and the aberrant forms of cephalopods, types for the most part that were unfamiliar upon this Coast. The contents of this collection was referred to in the May–June number of the Journal of Geology, 1895.

Since the first visit to this locality almost every year has added new and important species from the same place, and from a quite similar locality on the opposite and southern slope of the Siskiyou Range, near the village of Henley, Siskiyou County, California. These two localities evidently belong to the same coastal basin of the Cretaceous, and are here included in what is called the Oregon Basin.

From this fauna the study was naturally led to the Chico deposits of the Sacramento Valley, and from these to the Horsetown and the whole of the Cretaceous.

In offering this paper for publication the author wishes to acknowledge the kindly interest and assistance of his instructors and co-workers, Drs. J. P. Smith, T. W. Stanton, J. C. Merriam, and others, who have shown not only professional courtesies, but have aided the work by a friendly appreciation and a coöperative spirit.

The conclusions that have been reached by this study, while they may not be final, are nevertheless believed to be important in the development of our knowledge of West Coast geology, and in the study of the Great Past and its biological and physical geography. F. M. A.

December 17, 1900.

CRETACEOUS DEPOSITS OF THE PACIFIC COAST.

BY FRANK M. ANDERSON.

CONTENTS.

Plates I–XII.

Part I.

Part II.

Part I.

I. Introduction.

The Cretaceous deposits of the Pacific Coast of North America, as already known to geologists, lie within a narrow continental border mainly to the west of the Great Basin and the northern Cordillera. In their north and south range the scattered and disconnected occurrences extend from Mexico to Alaska and the Arctic Ocean, although they do not territorially cover a large region. Represented upon a map with other formations, they might hardly be noticed except by one looking for them. They are but remnants, or even mere traces, of what was once a more extensive system of deposits, which in some places have been entirely removed, and in others covered by later sediments, and in some cases by volcanic flows. One of the largest and most noteworthy of these remnants occupies the Sacramento Valley in central-northern California, where it occurs in unconnected dashes along its borders, in low hills flanking the valley upon the east and west.

Southward in California, the Cretaceous rocks are sparingly distributed, occurring only at intervals in the Coast Ranges, where they either form some of the lesser ridges or protrude from beneath ridges of later sediments. In the extreme southern portion of the State, and in Lower California, they are confined to a narrow belt in the immediate neighborhood of the coast, buttressed against the older crystalline rocks of the interior.

Northward in California, and in Southern Oregon, the Cretaceous beds are restricted to the larger valleys lying among the Klamath Mountains or upon their eastern outskirts; and here, also, they rest upon the older crystalline or metamorphic rocks, and are overlaid by Tertiary or Neocene deposits largely of fresh-water origin, or by Neocene lavas.

Within the boundaries of the Great Basin, the only Cretaceous rocks that have been reported rest in a similar manner upon a complex of early Mesozoic and older rocks, in part crystalline, and in part metamorphic sediments, that make up the mass of the Blue Mountains in northeastern Oregon. Their limits have not been ascertained, but they appear to flank these mountains upon the west much as they do the Sierra Nevada in California; and here, also, they are in turn overlaid by fresh-water Tertiary deposits and Neocene lavas.

It would appear from what is known of the distribution of the Cretaceous sediments south of the Columbia River, and of the older basement series that in Cretaceous time formed the floor and margin of the sea, that the western coast-line of the Cordilleran continent in early Cretaceous time was roughly determined by the three older mountain groups,—the Sierra Nevada, the Klamath Mountains, and the Blue Mountain system in northeastern Oregon.

It is not yet proved that in later Cretaceous time the sea extended along the whole eastern base of the Klamath group, thus severing them wholly from the mainland, with which they had previously been connected.

Cretaceous rocks are not definitely known in the coast mountains of northwestern Oregon nor of Washington; yet certain beds are known along the Columbia River opposite Astoria, and in the Coast Ranges southward, that not improbably belong to this period. In the vicinity of Puget Sound, in British Columbia, and on the adjacent islands, the Cretaceous rocks have a distribution not less important than they have in California. They rest here upon a basement of earlier Mesozoic and older rocks, and extend eastward upon the flanks of the Cordilleran platform. As in Oregon and northern California, these beds are found occupying the chief valleys among a system of mountains composed essentially of pre-Cretaceous rocks. Farther north, on the southern coast of Alaska, Cretaceous beds are reported in the vicinity of Cook's Inlet, Kodiak Island, and on the Alaskan peninsula (Dall, 1895–96). They occur also at Rink Rapids, upon the Arctic border of the continent.

The fossil remains found in most of the Cretaceous deposits throughout this vast stretch of continental border show them to be for the most part of marine, and of littoral, rather than of deep-sea origin.

II. Historical Review.

No other series of rocks upon the Pacific Coast has received so much attention as those of the Cretaceous period. It is perhaps due to their easy accessibility, and to the extremely interesting character of their fauna, that so many able contributions have been made to the literature of West Coast Cretaceous. Yet we are far from knowing all that is desirable concerning the stratigraphy and fauna of this interesting period.

A brief review of the more important papers that have appeared from time to time, and accordingly a summary sketch of the development of our present knowledge of the subject, is here included for the benefit of readers who may not be familiar with what has already been done.

The first announcement of Cretaceous deposits in California was by Dr. Trask (1856), in which he reported the discovery of ammonites and baculites in "Tertiary strata."

Eight years later, in 1864, the first volume of the Paleontology of California appeared, in which Mr. Gabb published a large number of species from strata which he designated as Divisions *A.* and *B.* of the Cretaceous series. These are now known as distinct formations of Cretaceous and Tertiary age. Afterwards, in the second volume of the Paleontology of California, which appeared in 1869, Gabb distinguished four horizons of the Cretaceous, which he called respectively Shasta, Chico, Martinez and Tejon, the last two of which are now known to be Eocene, or only in part Cretaceous, as shown later.

The beds exposed at Horsetown, and along the North Fork of the Cottonwood Creek, Shasta County, constituted what was termed the Shasta Group. It was stated that it contained fossils representing the ages from the Gault to the Neocomian, inclusive, of the European Cretaceous.

The Chico Group was made to embrace all of the occurrences of Cretaceous on the eastern side of the Sacramento Valley, some important beds in the vicinity of Mount Diablo and Martinez, in Southern Oregon, and the coal-bearing deposits of Vancouver Island. It was correlated with the Chalk of England, though not definitely with either division.

The Martinez was believed to be distinct from the Chico, and was represented by beds at Mount Diablo, and near Martinez, Contra Costa County.

In 1887, in connection with the work of the United States Geological Survey upon the quicksilver deposits of the Pacific Coast, Becker (1888) and White (1888 and 1889) revised the classification of the California Cretaceous, recognizing essentially two divisions, the Lower and the Upper, separated by an unconformity.

The Upper Cretaceous was called the Chico-Tejon, to which were annexed, as probably confórmable with it, the Wallala Beds discovered by Becker on the coast of Sonoma and Mendocino counties, at San Diego, and in Lower California.

The Lower, or Shasta Group, was made to include not only what is now recognized as properly belonging to that division, but they placed in it also a great series of metamorphic rocks occurring in the Coast Ranges, as well as the Mariposa formation of the western Sierra Nevada, both of which are now known to be distinct from it. The lower portion of the Shasta Group was called the Knoxville, from its occurrence, with its typical fauna, at Knoxville in Napa County. The upper portion of the Shasta, or the Horsetown stage, was thought to be perhaps a portion of the same series, and involved with the Knoxville in the "pre-Wallala upheaval."

It was afterwards shown by A. Hyatt (1894), J. S. Diller (1894) and J. P. Smith (1894) that the former view held by Professor Whitney regarding an unconformity between the Mariposa and Cretaceous strata was correct; that after the folding and metamorphism of the Mariposa slates the Cretaceous subsidence of the region had been inaugurated. An unconformity was also established by paleontological evidence, and the confusion that existed in regard to the various species of *Aucella* was finally settled.

Paralleling in the Coast Ranges this separation of the Mariposa formation from the Cretaceous, the rocks that were thought to belong to the Shasta Group have been shown to consist of two unconformable series. It is due largely to the work of H. W. Fairbanks (1892, 1893, 1895, 1896), Diller and Stanton (1894) and J. S. Diller (1893) that certain metamorphic and semi-metamorphic rocks of the Coast Ranges and the Klamath Mountains are recognized as lying unconformably below the *Aucella*-bearing shales, which have been called Knoxville.

The Cretaceous series has been found to contain few, if any, rocks that have suffered a high degree of metamorphism. The older complex is composed of both igneous and stratified rocks that may eventually prove to include members of Paleozoic, as well as of Mesozoic age, embracing the Santa Lucia series of Willis (1900) and at least a portion of the Franciscan (Lawson, 1895), or Golden Gate (Fairbanks, 1895) series. The latter series was named from its important development in the vicinity of San Francisco Bay; it extends southward from the Klamath Mountains along the coast of California, and in the Coast Ranges forms the basement of many later deposits. The Franciscan series is generally believed to be in part Cretaceous; but much of it, including the Radiolarian cherts and some of the limestones and slates, is known to antedate the Cretaceous.

In the paper by Diller and Stanton (1894), referred to above, it is shown that in the upper Sacramento Valley, on the flanks of the Klamath Mountains, beds that have been called Knoxville overlie unconformably an older metamorphic series, partly sedimentary, and partly igneous and crystalline. The Cretaceous series was carefully studied in two more or less complete sections on the western side of the Sacramento Valley, ranging eastward from the Yallo Bally and Bally Choop mountains. The result has been a revision and reclassification of the Cretaceous deposits, and the publication of some surprising facts connected with their occurrence and deposition. The astonishing thickness of these sediments in their deepest section seems almost incredible, especially when one considers the limited dimensions of their basin, and the enormous movements necessary for their formation and subsequent folding. According to the estimates of these writers, about thirty thousand feet of sediments accumulated in the basin of the Sacramento without the intervention of any great disturbances, and during a period of continuous and prolonged subsidence. They have accordingly included in a continuous series all the strata of what is called the Shasta-Chico series, embracing the Chico, Horsetown, and Knoxville, and including rocks below the lowest *Aucella*-bearing horizon. They recognize faunal changes in the series, but no decided breaks.

Dr. T. W. Stanton (1895) published an extended list of Knoxville species, obtained from beds in the Shasta-Chico series below the upper limit of the range of the genus *Aucella*. More than fifty species are added by this contribution to the fauna previously known as belonging to this division. These species occur mainly in the upper portion of the Knoxville, within three thousand feet, stratigraphically, of what is believed to be the upper limit of the range of *Aucella*.

From a more recent paper by the same author (Stanton, 1897), it would appear that the Knoxville strata are to be correlated with the Comanche series of Hill, including the Trinity and Washita divisions. The Cretaceous series of California, south of Tehama County, has been less studied, but seems to be less simple than it is at the north.

Fairbanks has reported in the neighborhood of San Luis Obispo a distinct unconformity between *Aucella*-bearing and Chico strata.

It has also been shown by both Stanton (1895, 1895–96) and J. C. Merriam (1897) that the Martinez Group of Gabb consists of two parts, one indistinguishable from the Chico, and the other more nearly related to the Eocene. The upper division was designated the Martinez by Merriam. Between the typical Chico and the Martinez, as thus restricted, there is found to be neither a faunal nor a stratigraphic continuity, and the Martinez is provisionally classed with the Eocene.

A similar series of Cretaceous deposits has been found in British Columbia and the adjacent islands by the geologists of the Canadian Geological Survey (Whiteaves, 1893). On Queen Charlotte Islands and the Island of Vancouver a succession of strata has been shown to range from the Lower Cretaceous or even Jurassic, upward to horizons equivalent to the Chico of California. There is not, however, the apparent continuity in these beds that is claimed for the California series. But the fuller statement of their relations will be continued later.

In central Mexico, near Catorce (Nikitin, 1890), fossiliferous beds occur which have been referred to the Jurassic, but which Dr. Stanton thinks are probably to be correlated in part with the Knoxville of California (Stanton, 1895, p. 26, etc.). The *Aucellæ* and some of the ammonites are said to be very similar if not identical with California species.

Many important contributions to West Coast Cretaceous geology that are not here mentioned will be referred to later.

III. Purpose of the Paper.

The objects of the following discussion are primarily threefold. First, it is desirable to place in a more connected account the essential facts in regard to the Cretaceous deposits of the Pacific Coast, and particularly of California, with reference to their distribution, the physical conditions of their deposition, their disturbances, subsequent erosion, and other features of importance; and to add something as to the relations they bear to other formations with which they are territorially connected. Second, it is thought that a more complete classification of the series can be made, in which there shall appear its diversity and complexity, as well as its unity. It is accordingly the aim to give here what are thought to be the most natural divisions of the series, which shall recognize both its physical and faunal changes in their more important phases, and call attention also to the development of its fauna in geological time. Third, it is possible to correlate with more precision than has yet been done the various members of the California section with those of neighboring basins, neighboring American provinces, and other countries bordering the Pacific, if not also with the Atlantic and Indian oceans. Furthermore, many new and interesting fossil forms occur in the Cretaceous of California and Oregon, and many types whose close affinities with east Asiatic and Atlantic species have not yet been sufficiently recognized.

Probably no other formation is so favorable as the Cretaceous for the study of the distribution and historical development of the faunas embraced within its limits. The study of these problems may easily lead to the recognition of important changes that have taken place in the physical geography of North America and of the Pacific basin. In this connection it may be said that the limitations that are at present accepted for the different divisions of the Cretaceous series of California may be subject to some important alterations, and that the closer discrimination of horizons is both desirable and possible.

The physiography of California and Oregon, and perhaps of other West Coast regions during the Cretaceous, which ought to be connected with a study of this period, is not yet sufficiently recognized, although of more than ordinary interest. Not only is the general shore-line of the Cretaceous ocean approximately known, but the principal inlets that indented the shore of that time may be clearly shown. Something also of the drainage and configuration of the surface may be inferred.

IV. Stratigraphy of the Cretaceous.

1. Basement Complex.

In the foregoing review it was stated that the Cretaceous deposits of the West Coast are found, for the most part, occupying the present valleys, which are the results of a pre-Cretaceous folding, not yet obliterated. This fact is worthy of being further emphasized, since it is not yet sufficiently recognized. It can be shown in many ways that this distribution of the Cretaceous rocks is not to be attributed to erosion, but it represents the original conditions of Cretaceous and pre-Cretaceous physiography.

It has already been shown by Diller and Stanton (1894), by J. P. Smith (1894), and others, that the unconformity between the Knoxville beds and those of the older Mesozoic and pre-Mesozoic ages represents an uplift and period of land erosion prior to the Cretaceous deposition.

Dr. Smith places this period of folding, metamorphism, and erosion at the close of the Mariposa epoch, or in late Jurassic time. Indeed, it is now the opinion of most geologists that the prime movement (perhaps the intrusion) of the granitic core of the Sierra Nevada occurred at this period and was unquestionably the principal agent of both the folding and metamorphism of the pre-Cretaceous sedimentary rocks. Undoubtedly the diversification of the surface was considerable before the inauguration of the Cretaceous period, notwithstanding the subaërial reduction during the long land interval following the Mariposa epoch.

It is interesting to remember in this connection the two parallel granitic axes of the Pacific border, most noticeable in the central portion of California, between which most of the Cretaceous and later deposits lie. It might be better to refer them only to borders of the Great Valley region of California, were it not for the suggestiveness of well known facts outside of this latitude.

Nearly parallel to the granitic core of the Sierra Nevada, a similar granite massif follows the coast from Santa

Barbara County northward toward Sonoma. It is involved in a number of lesser ranges along the coast, among which are the Santa Lucia, Santa Cruz, and Montara ranges, and others on the coast north of San Francisco. The age of these granites is a matter of uncertainty, and it is conjectural to suppose that their movements have been contemporaneous with those of the Sierra Nevada; but this is immaterial so far as the Cretaceous deposits are concerned, which, as has been said, occupy a position for the most part intermediate between the two, and only occasionally touch the granites of either mass.

The components of the basement series upon which they rest are of various ages, and have roughly a concentric arrangement with reference to the Great Valley, forming a succession, inward, of Paleozoic and earlier Mesozoic rocks. The latest of these whose age is definitely known are the Mariposa slates of the Sierra foot-hills. In the Coast Ranges the unconformity of the Knoxville strata upon those of the Franciscan series, as at Mount Diablo, Santa Margarita, and other places, makes it apparent that this formation, which is probably also of Mesozoic age, forms a part of the basement of the Shasta-Chico series. Beyond the Mariposa slates on the east are the still older rocks of the Calaveras formation, while in the Coast Ranges, between the strata of the Franciscan series and the coastal granites, is found a series of ancient crystalline marbles and quartzites that can hardly be thought younger than the Paleozoic. Concentrically with these, tnough often overlapping them, are the later Mesozoic rocks of the Cretaceous, ranged along the borders of the Great Valley.

Northward, in the Klamath Mountains, the underlying rocks range down in age even to the Devonian and older. Near Yreka, in Siskiyou County, Cretaceous deposits are found resting upon a series of micaceous and quartz-schists of either Devonian or earlier age. Throughout the region these schists are mantled over by a series of slates, generally either silicious or calcareous, that remind one strongly of the slates and jaspers of the Franciscan series. The true relations of these slates to the Devonian rocks in the vicinity of Gazelle, in the same county, are not definitely known, though probably they include the strata of the Scott River Valley, referred to by Diller and Schuchert (1894) as probably Triassic.

In Southern Oregon the basement rocks are largely similar. Occasionally granitic rocks form the floor for Cretaceous sediments, as at Ashland, Oregon, in the vicinity of Horsetown, and on some of the tributaries of the Cottonwood Creek, Shasta County, and a stream of the same name in Siskiyou County, — California. But generally upon either margin of the Cretaceous basin there are found the folded and eroded older sediments. Thus both the situation and the distribution of the Cretaceous deposits are suggestive as to their period of folding; but the evidence is far from resting here. There are facts of erosion in the Klamath Mountains that furnish confirmatory evidence.

2. THE SACRAMENTO VALLEY.

The Shasta-Chico series, as represented in the upper Sacramento Valley, where it has been described by Diller, and afterward by Diller and Stanton, is said to consist of about thirty thousand feet of strata in which the sediments vary from conglomerates to sandstones and clay shales. The lower nineteen thousand nine hundred feet of the section along Elder Creek, Tehama County, is composed chiefly of shales with a subordinate amount of sandstone and of conglomerates, often of only local occurrence. Higher in the section, sandstones become more abundant, until at twenty-six thousand feet they give place to massive conglomerates and sandstones. The whole series has a varying dip to the eastward or southeastward, being near the base often nearly vertical, but generally not exceeding an inclination of thirty degrees. Toward the top it is sometimes but little disturbed.

The fossiliferous portion of this series has been divided into three divisions, mainly upon faunal characteristics. The lower nineteen thousand nine hundred feet contain an abundance of *Aucellæ*, of not more than two or three species, several species of Cephalopoda and other mollusks, also plant remains. This is the portion of the Cretaceous series to which the name Knoxville has been applied.

Stanton placed the upper limit of the Knoxville at the upper limit of the range of *Aucella*. Mr. Diller (1893, p. 211) at one time stated that in the lower nineteen thousand nine hundred feet of the Elder Creek section the only fossil found was *Aucella*; and in another paper Stanton says that they are often so abundant in the strata that it would seem they must have monopolized the bottom of the sea. Later, however, Stanton (1895, pp. 11–85) published a large number of species as belonging to the Knoxville, many of which have come from the strata of this section or near it. But it is to be noted that the entire list of molluscan and cephalopod species added to the fauna of the Knoxville from this section has been found almost if not entirely within three thousand feet of the upper limit of the Knoxville, or in other words, within this distance stratigraphically of the upper limit of the range of *Aucella*.

With the appearance of this new fauna at the top of the Knoxville, as then defined, the number of *Aucellæ* gradually diminishes. This fact will be referred to further on.

Above the upper limit of *Aucella* the shales continue uninterrupted, though becoming more sandy, for about six thousand feet, when they give place to conglomerates. It is the sandy and conglomeratic portion, confined to the uppermost four thousand feet of the series, that has been referred to the Chico division; while between this horizon and the Knoxville are the Horsetown strata.

The section along Cottonwood Creek, Shasta County, some fifteen or twenty miles north of Elder Creek, corresponds closely with that already described in so far as the series is represented. On the Cold Fork of the Cottonwood it consists of the Knoxville with the overlying Horsetown and Chico strata; while on the North Fork the base of the Horsetown rests directly upon the older metamorphic and granitic rocks.

Along the eastern side of the Sacramento Valley, in the foot-hills of the Sierra Nevada, only the upper portion of the series has been found, resting upon the metamorphic rocks of the "Gold Belt." Here the horizon, which perhaps should be considered as most typical Chico, is to be seen, though Gabb evidently included under that name more than is there represented. Diller states that the beds along the eastern side of the valley are much less disturbed than those on the west, being often nearly horizontal. The entire Cretaceous series, as has been shown by former writers, forms in the northern half of the Great Valley a geosyncline, which in its central portion passes below and is hidden by the accumulation of Tertiary and later strata, but which reaches the surface along both borders of the valley in the foot-hills of the Coast Ranges and Sierra Nevada.

In the papers already cited, Mr. Diller has shown that the Cretaceous series of the West Coast, as is illustrated by the deposits of the Sacramento Valley, was laid down under conditions of prolonged subsidence. A continuous though unequal settling of the sea-bottom from first to last is apparently demonstrated not only by the continuous and unbroken order of the series above described, all of which seems to indicate shallow water, but also by the successive overlapping and transgression outward of the younger portions of the series upon the border of older rocks that circumscribed the Cretaceous waters at each epoch. The differential action of this movement in the coast regions cannot be better stated than in Mr. Diller's words (Diller and Stanton, 1894, p. 456). He says: "The large extent of this subsidence, from Alaska on the north to Lower California on the south, makes it an epeirogenic movement. There is evidence, however, that the movement, although epeirogenic, was not uniform throughout the whole area. * * * and it appears that the subsidence was greater in the Sacramento Valley than in the region of the Coast Range and Sierra Nevada." And continuing the same topic he adds: "If the subsidence was uniform throughout the whole region it follows that what is now the western foot of the Sierra Nevada, as well as the corresponding portion of the Coast Range, where in both cases the Chico rests directly upon the folded pre-Cretaceous rocks, must have been at an elevation of twenty-five thousand feet above the sea when the basal portion of the Knoxville was deposited in the Sacramento Valley. This hardly seems possible, for we know of no such mountains in the country to-day. It seems much more probable that the subsidence was not uniform."

It is probable that at no time during the subsidence was the whole of either the Sierra Nevada or Klamath Mountains below the sea. Scattered areas of Cretaceous deposits occur among the Klamath Mountains west of the Sacramento Valley; but it is not necessary to suppose that the sea reached these localities across mountain summits. More likely it found its way into earlier basins through inlets from the open ocean at the west. This was undoubtedly the case in Southern Oregon, where portions of the same series are represented in different places.

3. The Oregon Basin.

In Rogue River Valley, beds of Upper Cretaceous age occur, following generally the western side of the valley, and resting upon the older metamorphic slates and crystalline rocks, with a fairly uniform dip toward the east. The strata consist for the most part of sandstones and conglomerates, with a subordinate amount of shales. The conglomerates predominate in the upper part of the section, while shales are common at and near the bottom. These beds are apparently equivalent to those of the Upper

Cretaceous of the Sacramento Valley, to which they will be compared in more detail in another section. Similar beds are found in northern California.

In Douglas County, near Riddles, is a syncline of Cretaceous strata folded between areas of older metamorphic and intrusive rocks. Lithologically it is a repetition of the equivalent portion of the Shasta-Chico series at the south, consisting of shales, sandstones, and conglomerates. The conglomerates are said by G. F. Becker (1891), who first described the section, to predominate in the upper part of the series, and to be very extensive. Only the middle portion of the Sacramento section is represented in these beds, which are in part Knoxville and in part belong to the Horsetown. Chico strata have not been reported for this immediate locality, but they occur at some distance to the southeast on tributaries of Rogue River.

These Oregon deposits, especially the lower strata, appear to belong to an embayment distinct from that of the Sacramento Valley; but they show a similar transgression of the later members of the series, only in this case the expansions were toward the southeast.

4. British Columbia.

Upon the mainland and islands of British Columbia the Cretaceous deposits form a series of considerable importance, which, while not so connected as that of California, is almost as complete, and is, perhaps, entirely comparable to it. *Aucella*-bearing strata which perhaps form the bottom of the series are found both upon the mainland and upon the Queen Charlotte Islands. The following tabular view after Dawson (1889, p. 127) represents the Cretaceous series of these islands, to which are annexed a few of the fossil species characteristic of each division.

Division.	Strata.	Thickness.	Important Species.
A.	Upper shales and sandstones	1500′	....*Inoceramus labiatus.*
B.	Coarse conglomerates.	2000′	....*Belemnites* sp.
C.	Lower shales and sandstones (with coal)	5000′	....{*Lytoceras sacya*, *L. timotheum*, *Desmoceras breweri*, *D. dawsoni*, and *D. planulatum*. *Aucella*, *Perisphinctes*, etc.
D.	Agglomerates.	3500′	....———————.
E.	Lower sandstones.	1000′	....*Pleuromya lævigata*, *Nemodon*, etc.

The lower portion of "Division *C*" perhaps ought not to be included in this part of the section, and may eventually prove to be equivalent to the *Aucella*-bearing beds of Tatlahcoh Lake, and to represent also a horizon considerably below the upper portion of *C*. Farther south, upon the northern end of Vancouver Island, in the vicinity of Quatsino Sound, the three upper members of this series are found. Here also *Aucella* and other species are reported which appear to belong to the Knoxville.

At the southern end of Vancouver's Island, near Comox and Nanaimo, strata occur that have been correlated with the Chico of California; they consist of shales and conglomerates, amounting in thickness to about five thousand feet. These deposits contain the coal-bearing beds of Vancouver's and the neighboring islands. Still further southward, on the borders of Puget Sound, is the coal-bearing Puget Group of White (1889), which has been compared to the Laramie, a series that is thought to be of Tertiary age, or at least later than the Chico.

The relative position of these deposits, all of which rest directly upon earlier Mesozoic or older rocks, suggests a Cretaceous basin extending southward, in which there was a continued subsidence and transgression of the sea similar to that already described for Oregon and California. This was the view held by Dawson (1890) prior to the recognition of the fact in Californian deposits. Similarly the Cretaceous deposits upon the mainland of British Columbia are said to occupy basins in older metamorphic rock.

South of Puget Sound massive beds of conglomerate occur along the Columbia River, which may belong with those of the upper portion of the Nanaimo Group. They contain few fossils; yet such as they are they may well be taken to support this view.

Aucella-bearing deposits are reported from different points along the Alaskan coast (Dall, 1895-96), as at Cook's Inlet, Kodiak Island, the Alaskan peninsula, etc. Whether they belong to the Cretaceous or Jurassic age has not been settled; yet undoubtedly some of the species are of Cretaceous type. Chico deposits are now known to occur near the mouth of the Yukon River, Alaska. Much of the rock is a shale, either clay or calcareous, but limestones, sandstones, and even conglomerates occur with Mesozoic fossils. *Aucella*-bearing rocks are also reported from Porcupine, Lewis, and Yukon rivers.

5. SOUTHERN OCCURRENCES.

Southward from California there are but few deposits known that can be classed as belonging to the Pacific province, which will be mentioned here.

Near Catorce, in the state of San Luis Potosi, Mexico, an *Aucella*-bearing formation has been described (Felix and Lenk, 1890), which Dr. Stanton (1895, pp. 25–27) thinks is equivalent in part to the Knoxville. Also in southern Mexico are beds that have been referred to the Lower Cretaceous, and are thought to represent a portion of the Knoxville; but too little is known of these deposits for exact correlation.

Upon the island of Quiriquina, off the west coast of Chili, Upper Cretaceous deposits occur resting upon schists of uncertain age, and in turn overlaid by Tertiary beds. The Cretaceous deposits consist of calcareous and glauconitic sandstone, with basal conglomerates, all of marine origin, and containing several fossil species common in the Upper Cretaceous of California. Besides the molluscan remains, these deposits contain several species of saurians and certain plants, some of which have been described by Steinmann (1895) and his associates.

6. Correlation.

But little can be done at correlating these widely separated deposits upon purely stratigraphical resemblances. In no one section is there a series that can find its exact parallel in any other, much less in all the others. It is to be noticed throughout, however, that the cycle of sedimentation in these deposits is the reverse of the normal order. Shales invariably are more abundant in the lower part of the sections, sandstones increase as one ascends the series, and conglomerates are more common in the upper portions. This is sometimes so, even where there is only a part of the entire series present, as in the vicinity of Medford and Ashland, in Rogue River Valley, Oregon. Yet this is not always so; at Horsetown and at Ono, Shasta County, the local base of the Cretaceous contains heavy beds of conglomerate. But little reliance can be placed in these conglomerates, however; for as Diller has stated, they are often of only local extent, and may merely show the position of some stream in mid-Cretaceous time. Their irregularity nevertheless affords some interesting suggestions.

The regional subsidence and the deposition of these beds could not have been quite so continuous as has been imagined, though the disturbances have been more or less local; still, there are some broad uniformities noticeable in the widely distributed deposits. Tawny or grayish sandstones and pebbly conglomerates characterize the Chico and Upper Horsetown; while dark or yellowish clay shales are more common in the Knoxville portion of the series. If the heavy beds of conglomerate in the vicinity of Riddles, Oregon, really belong, as Becker believed, at the top of the section, their apparent extensiveness would justify their being compared to the conglomerates of "Division *B*" of the Queen Charlotte Islands section; and they might also find their equivalents in the sections of California.

V. Faunal Changes of the Cretaceous.

1. Recognized Diversity.

The work of Diller and Stanton has demonstrated how little was previously known concerning the Cretaceous series of California. From their study of the Cretaceous deposits in the Sacramento Valley, they have felt compelled to abandon the views of earlier writers regarding the complexity of the series; while on the other hand, they have emphasized the evidence of unbroken stratigraphic succession from bottom to top. Less effort has been made to represent its actual diversification, either physical or faunal, whatever this may be; and accordingly it remains to be seen how far from simple were the conditions of deposition in the Pacific border province during Cretaceous time; yet it appears that sufficient has been known for arriving safely at conclusions somewhat different from those reached in the accepted summary of our knowledge.

It is entirely natural that the historical development of the subject should be as it has been. Early collectors working less thoroughly over the scattered deposits have noticed the more striking dissimilarities without being able to recognize connecting elements that a more detailed study has discovered. Attention has been called to the physical peculiarities of the Sacramento section of the Cretaceous, which shows on the whole a cycle of sedimentation somewhat the reverse of the normal. There is a certain evidence in this fact that leads one to suspect that the series as a whole is not altogether simple, and that in the closing epochs disturbances were both more numerous and more general. Similarly, when the series is made the subject of faunal study, a diversity that is still more significant is soon recognized. The faunal differences that are ordinarily seen have led to the distinctions hitherto made, and to the divisions of the series settled upon by the earlier writers; but these differences are real and not merely apparent. It is evident to one coming from the fossiliferous beds upon the eastern border of the valley, where gastropods and bivalves largely predominate, to the beds of the cottonwood, where cephalopods are so common, that one has reached an entirely different faunal horizon. So, also, when one proceeds to the more basal portions of the series in the foot-hills of the Coast Ranges, one finds again a complete faunal change. The cephalopods of the last horizon gave place to a fauna composed almost entirely of one or two species of *Aucella*. These facts led to the recognition of the three horizons commonly known as the Chico, Horsetown, and Knoxville, which, in spite of the connecting elements uniting them, have not yet been, and ought not to be, abandoned. Indeed, it is not improbable that upon further study additional reasons will be found for still further enforcing the distinctions, and even, as it now appears, of subdividing some of the principal divisions that are at present accepted as paleontological units.

Both Diller and Stanton have been convinced of the transitional character of the fauna from one level to another in different parts of the series. New forms appear successively and continue for unequal periods and disappear at different stages of the overlying series. Some forms are of short duration and some are very much more persistent. Many lists of species taken from different localities and representing different horizons have been published, which apparently show this; and undoubtedly within certain limits there is a more or less gradual change, and for some purposes these facts may well deserve attention. Yet the changes in the total faunas, as well as they can be known from the fragmentary collections that have been made and studied, do not seem to warrant the assertion of a uniformly transitional series, and perhaps this has not been claimed Yet the breaks that had previously been conceived to exist between the main divisions of the series were bridged over or minimized by the passage across them of many important forms. Thus it was left to be inferred that the transition from the Horsetown to the Lower Chico might not be different from that between different parts of the Horsetown itself, except perhaps locally. But our knowledge of the fauna as a whole, of each of the different horizons above named, has gradually become more complete by the continual contributions that have from time to time been made; and while it can not be called quite satisfactory, yet on the whole it may be regarded as sufficient for at least some general observations. It must be borne in mind, however, that the Cretaceous species of California need a revision before any final conclusions can be established or an entirely reliable correlation made, based upon paleontological evidence. Much confusion has undoubtedly existed in regard to the limits and range of certain species, that has often resulted from laxness in the identification of species.

In the subjoined portion of this paper attention is called to a few of the many corrections that are needed for a more satisfactory treatment of the subject, and which a successful treatment will demand. However, for the present there are some general facts that may be clearly established.

2. Horizons Distinguished.

The Chico Epoch.

Regarding each division of the Cretaceous separately, the fossil lists contributed by a number of its recognized localities may be massed together, and by this means a more complete idea of its general fauna can be gained than if but a few of its localities are taken independently. It is found in this way that there are recognizable elements apparent in each fauna, which may be safely depended upon, and that while there is more or less of a transitional character in the fauna of a given level, yet it does not depart from the main type to any considerable extent until the time arrives for an almost complete change. The Horsetown fauna, for example, consists of a large number of cephalopod forms, which is as great if not greater than the whole number of other mollusks combined. This can not be claimed for the Chico upon the eastern side of the valley, where the whole number of cephalopods known is not greater than one-eighth of the number of other mollusks, and even in the strata immediately overlying the Horsetown upon the west, which have been hitherto referred to the Chico, the proportion of cephalopods known is not more than one-third that of the others. The rapid increase in the number of gastropod and bivalve species in the Chico is, however, the noteworthy fact; while at the same time, the number of cephalopods as rapidly diminishes, except, perhaps, in more favored localities.

In the Great Valley basin of California the transition of faunas is more gradual than it has been in any other bȧsin of the Pacific border; and for that reason the faunas representative of the different horizons are not so easily distinguished. For purposes of correlation, therefore, it is safer to select for study, if possible, localities lying outside of the boundaries of the Great Valley, in which these distinctions can be more readily made. And for the Chico epoch this is both possible and especially desirable. The faunas of the Chico are therefore represented in the following lists, massed from a number of the more significant localities, as will be shown later. Each division of the Chico, the Upper and the Lower, is represented by four such localities, the lists being for the most part compiled, in a somewhat revised form, from others already published. For the Upper Chico the localities selected are in the Sacramento

Valley, and have been well described by Gabb, White, and others; while for the older division of the same epoch the localities are mostly new or have not yet become perfectly known. It seems to be especially important that the Lower Chico should be studied in such a manner.

Of the Lower Chico localities selected for study, two lie to the north and two to the south of the Great Valley basin, and are as follows: (*a*) near Phœnix, Jackson County, Oregon; (*b*) Henley, Siskiyou County, California; (*c*) Silverado Canyon (Bowers, 1890), Orange County, California; (*d*) near San Diego, San Diego County, California, including localities at Point Loma and La Jolla.

Locality (*c*), Silverado Canyon, is intended to represent the Lower Chico beds of the Santa Ana Mountains, Orange County. The fauna of this horizon has recently been reinforced by collections sent to the State University by Dr. Stephen Bowers of Los Angeles. Some of the localities from which his collections were made are very near the Silverado Canyon, and hence are included with it. Bowers' Canyon is thirty miles northwest of Los Angeles, and from the fossils furnished by this locality it belongs to the same horizon.

Species occur in the following lists that are referred to locality (*c*) by use of the letter "R," as explained in the foot-note.

LIST OF FOSSIL SPECIES FROM CHICO LOCALITIES.[1]

	Upper.				Lower.			
	Tuscan Spring.	Chico Creek.	Pence's Ranch.	Texas Flat	Phœnix.	Henley.	Silverado.	San Diego.
Acanthoceras compressum, sp. nov.							S	
Acanthoceras naviculare MANT.					*			
Acanthoceras rotomagense STOL.					*			
Ancyloceras lineatum GABB.			*					S
Ancyloceras (?) *quadratum* GABB.			*					
Bacutites chicoënsis TRASK	*	*					S	S
Baculites fairbanksi, sp. nov.							*	*
Baculites sp.					*		*	
Desmoceras ashlandicum, sp. nov.					*	*		
Desmoceras hoffmanni GABB.					*	*		*
Desmoceras sugatum FORBES.					*	*	S	
Hamites armatus, sp. nov						*		
Hamites cylindraceus DE FRANCE					*	*	*	
Hamites elliplicus, sp. nov.					*			
Hamites phœnixensis, sp. nov.					*			
Hamites vancouverensis								*
Helioceras breweri GABB.			*					
Helioceras declive GABB			*					
Helioceras sp.					*			
Heteroceras cooperi GABB								*
Heteroceras rel. *H. reussianum* D'ORB.					*			
Hoplites remondi GABB.		R						
Lytoceras batesi GABB		R						
Lytoceras jacksonense, sp. nov.					*		S	
Lytoceras jukesi (?) SHARPE					*			
Lytoceras sacya FORBES					?	?		*
Mortoniceras crenulatum, sp. nov.						*		
Nautilus danicus (?) SCHLOTH					*	S		
Nautilus sp.					*		R	
Pachydiscus newberryanus MEEK.			*			S		
Pachydiscus sp.						*		
Phylloceras ramosum MEEK					*	*		
Placenticeras californicum, sp. nov					*	*	*	

[1] In the following lists, R = reported, S = substituted from neighboring and equivalent deposits, ? = identity doubtful.

	UPPER.				LOWER.			
	Tuscan Spring.	Chico Creek.	Pence's Ranch.	Texas Flat.	Phœnix.	Henley.	Silverado.	San Diego.
Placenticeras pacificum SMITH					*	*	S	
Prionotropis branneri, sp. nov..........					*			
Ptychoceras sp......					*		S	
Scaphites condoni, sp. nov					*			
Scaphites gillisi, sp. nov................						S		
Scaphites inermis, sp. nov..............					S			
Scaphites klamathensis, sp. nov..........						S		
Scaphites perrini, sp. nov					S			
Scaphites roguensis, sp. nov............					*			
Schlœnbachia bakeri, sp. nov............					*			
Schlœnbachia blanfordiana (?) STOL....					*			
Schlœnbachia buttensis, sp. nov..........			*					
Schlœnbachia chicoënsis TRASK..........	R	*	?					
Schlœnbachia gabbi, sp. nov.............		*	*					
Schlœnbachia knighteni, sp. nov.........					*		*	
Schlœnbachia multicosta, sp. nov........					*			
Schlœnbachia oregonensis, sp. nov.......					*	*	*	
Schlœnbachia propinqua STOL...........					*		?	
Schlœnbachia siskiyouensis, sp. nov......					*		*	
Schlœnbachia sp. undt.......					*			
Schlœnbachia sp. undt..................					*			
Actæon inornatus GABB			*					
Actæon pugilis STOL....................					*			
Actæonella oviformis GABB......							S	
Actæonina californica GABB............					*			
Actæonina pupoides GABB					*			*
Actæonina sp								*
Actæonina sp............					*			
Amauropsis alveata GABB						S	*	
Amauropsis oviformis GABB............	*							
Anchura californica GABB..............					*	*	*	
Anchura condoniana, sp. nov...........					*	*	?	
Anchura falciformis GABB..............	*	*	*	*				
Ancillaria elongata GABB...............								*
Angaria ornatissima GABB..............	*			*		*	S	

	Upper.				Lower.			
	Tuscan Spring.	Chico Creek.	Pence's Ranch.	Texas Flat.	Phenix.	Henley.	Silverado.	San Diego.
Architectonica inornata GABB	*							
Architectonica veatchi GABB	*							
Bulla sp.								*
Calliostoma sp.								*
Calliostoma radiata GABB				*				
Cerithium pilingi WHITE								*
Chemnitzia sp.					*			
Chemnitzia planulata GABB			*					
Cinulia obliqua GABB		*	*	*	*	*	*	*
Cominella lecontei WHITE			*				S	
Cylichna costata GABB			*	*	*	*		
Dentalium cooperi GABB							*	
Dentalinm stramineum GABB					*	S	*	
Discohelix leana GABB				*				
Emarginula radiata GABB				*				
Erato veraghoorensis (?)					S			
Eripachya ponderosa GABB	*		*					
Faunus maricidulus WHITE		S						
Fulgur hilgardi WHITE			*		*		*	
Fulguraria gabbi WHITE		*	*		*		*	
Fusus averilla GABB	*							
Globiconcha remondi GABB					*	*	*	
Gyrodes conradiana GABB					*	*	S	*
Gyrodes expansa GABB	*			*		*	S	
Gyrodes pansa STOL					*			
Haliotis lomaënsis, sp. nov.								*
Haydenia impressa GABB			*					
Helcyon dichotoma GABB				*				*
Littorina compacta GABB				*				
Lunatia pagoda FORBES					*			
Lysis duplicosta GABB				*				
Lysis oppansa WHITE			*					
Margaritella globosa GABB					*	*		
Mesalia obtusa GABB			*					
Nerita cuneata GABB	*							

	UPPER.				LOWER.			
	Tuscan Spring.	Chico Creek.	Pence's Ranch.	Texas Flat.	Phœnix.	Henley.	Silverado.	San Diego.
Patella traski GABB				*				R
Perissolax brevirostris GABB	*		*			S	S	
Phasionella sp.					*			
Potamides tenuis GABB			*				S	
Ringicula varia GABB		S						
Scobinella dilleri WHITE		S					*	*
Stomalia suciænsis WHITE			*					
Straparollus lens GABB				*				
Straparollus paucivolvus GABB				*				
Tritonium sp.						*		*
Trochus gemiferus WHITE			*					
Trophon condoni WHITE		S						
Turritella chicoënsis GABB		*						
Turritelta robusta GABB	*							
Turritella seriatim-granulata GABB	*					S	S	R
Turritella veatchi GABB	*							
Vasculum obliquum WHITE		*						
Anatina inequalateralis GABB						*		
Anomia sp.		*	*	*	*	*		
Anomia sp.					*			
Asaphis undulata GABB				*				
Astarte conradiana GABB				*				
Astarte matthewsoni GABB								*
Astarte tuscana GABB	*		*				*	
Avicula nitida FORBES					*			
Avicula pellucida GABB						*		*
Cardium remondianum GABB					*			
Chione varians GABB	*	*	*	*	*	*	*	*
Clisocolus dubius GABB	*	*		*				
Coralliochama orcutti WHITE							S	*
Corbula cultriformis GABB						?		
Corbula traski GABB	*		*		*			
Crassatella lomana COOPER							S	*
Cucullæa bowersiana COOPER						*	*	
Cucullæa decurtata GABB						*	*	

	Upper.				Lower.			
	Tuscan Spring.	Chico Creek.	Pence's Ranch.	Texas Flat.	Phœnix.	Henley.	Silverado.	San Diego.
Cucullæa truncata GABB	*			*	*	*		
Cyprimeria lens GABB	*				*	S	*	
Dosinia inflata GABB			*		*	*	*	
Dosinia pertenuis GABB						*		
Dosinia sp.					*		S	*
Eriphyla umbonata GABB		S						
Exogyra parasitica GABB				*	*	*		*
Exogyra sp.					*			
Exogyra sp.					*			
Goniomya borealis MEEK						*		
Gryphæa vesicularis LAMARK								R
Inoceramus adunca, sp. nov					*			
Inoceramus labiatus SCHLOTH					*	*		
Inoceramus multiplicatus (?) STOL					*			
Inoceramus vancouverensis MEEK								*
Inoceramus whitneyi GABB			*	S	*	*	S	
Lima appressa GABB					*			
Lima microtis GABB							*	*
Lima shastensis GABB							*	
Limopsis transversa				*				
Lithophagus oviformis GABB								*
Lucina postice-radiata GABB				*				
Lucina subcircularis GABB				*				
Lutraria truncata GABB			*	*				
Mactra ashburneri GABB	*	*	*	*	*	*	*	*
Mactra gabbiana, sp. nov					*	*	S	
Martesia clausa GABB	*		*	*		*		
Meekia navis GABB		*	*					
Meekia radiata GABB	*							
Meekia sella GABB	*							
Meretrix arata GABB						*		*
Meretrix longa GABB				*				
Meretrix nitida GABB		*			*			
Modiola cylindrica GABB	*		*					
Modiola siskiyouensis GABB					*	*		
Mytilus pauperculus GABB					*	*		*

	Upper.				Lower.			
	Tuscan Spring.	Chico Creek.	Pence's Ranch.	Texas Flat.	Phœnix.	Henley.	Silverado.	San Diego.
Mytilus quadratus GABB	*							
Nemodon vancouverensis MEEK	*					*	S	*
Nucula solitaria GABB				*				
Nucula truncata GABB	*			*	*			
Ostrea sp					*	*		
Panopæa concentrica GABB	*				*	*		
Pecten appressa						*		*
Pecten californica GABB								*
Pecten operculiformis GABB					S	*	*	
Pecten traski GABB				*		*	S	*
Pectunculus pacificus, sp. nov					*	*	*	
Pectunculus veatchi GABB	*		*	*	*		S	*
Pholadomya breweri GABB			*					*
Pholadomya anaäna, sp. nov							*	
Pinna breweri GABB					*	*		
Placosmilia sp					*	*		
Pleuromya lævigata WHITEAVES					*	*		
Protocardium placerensis GABB				?				*
Protocardium scitulum MEEK					*	*		
Tellina ashburneri GABB			*					
Tellina decurtata GABB			*					
Tellina hoffmanni GABB			*					
Tellina monilifera GABB								
Tellina oöides GABB			*					
Tellina paralis GABB					*			
Terebratella sp						?		*
Terebratella obesa GABB				*				
Thetis annulata GABB							S	
Trigonia evansana MEEK	*	*	*	*				
Trigonia rel. *T. evansana*					*	*	*	
Trigonia leana GABB			*		S	*		
Trigonia tryoniana GABB	*							
Trapezium carinatum				*				*
Venus veatchi	*							
Waldheimia imbricata COOPER								*

SUMMARY OF FACTS APPEARING IN THE LISTS.

CLASS.	Number of Species common to Upper and Lower Chico.	Number of Species common to the Chico, North and South.	Belonging to the Lower Chico.	Belonging to the Upper Chico.	Total Number.
CEPHALOPODS.	4—(2 doubtful).	12 species.	48	11	55
GASTROPODS..	11 { Some doubtful determinations.	16 species.	36	41	66
BIVALVES	17 { Hardy forms or not characteristic.	19 species.	58	47	88
TOTALS.....	32 species.	47 species.	142	99	209

An examination of the preceding tabulated lists makes it apparent that there are two distinct horizons in the Chico of California and Oregon, each having a fauna to a considerable extent peculiar to itself. A summary of the facts to be gathered from this list is presented. It will be observed also that the species belonging to the two divisions are supplementary rather than similar. In the Lower Chico there is shown a large number of cephalopods, several of which are common to both the northern and southern localities; only two of them, however, are certainly common to the upper and lower divisions. Similar facts will be noticed for the other classes. Also, as will be seen later, very few of the Chico forms are those of the Horsetown portion of West Coast Cretaceous. Some of the forms more characteristic for criteria of correlation are those of the following lists:—

CHARACTERISTIC FORMS OF THE CHICO.

LOWER CHICO FORMS.	UPPER CHICO FORMS.
Acanthoceras sp.	*Baculites chicoënsis*
Desmoceras hoffmanni	*Ancyloceras lineatum*
Desmoceras sugatum	*Helicoceras breweri*
Desmoceras ashlandicum	*Helicoceras declive*

Lower Chico Forms.	Upper Chico Forms.
Lytoceras sacya	*Pachydiscus newberryanus*
Lytoceras jacksonense	*Schlœnbachia chicoënsis*
Lytoceras jukesi	*Schlœnbachia gabbi*
Placenticeras pacificum	*Anchura falciformis*
Placenticeras californicum	*Eripachya ponderosa*
Phylloceras ramosum	*Fulgur hilgardi*
Nautilus sp.	*Fulguraria gabbi*
Prionotropis sp.	*Gyrodes expansa*
Scaphites sp.	*Perissolax brevirostris*
Schlœnbachia oregonensis	*Turritella chicoënsis*
Schlœnbachia multicosta	*Turritella robusta*
Schlœnbachia propinqua	*Tellina* sp.
Schlœnbachia siskiyouensis	*Meekia* sp.
Actæon pugilis	*Anomia* sp.
Actæonella oviformis	*Lutraria truncata*
Actæonina californica	*Lucina* sp.
Actæonina pupoides	*Trigonia evansana*
Amauropsis alveata	*Pectunculus veatchi*
Anchura californica	*Venus veatchi*
Anchura condoniana	
Inoceramus labiatus	
Inoceramus whitneyi	
Lima appressa	
Lima microtis	
Nemodon vancouverense	
Pecten operculiformis	
Pinna breweri	
Pleuromya lævigata	
Protocardium scitulum	
Trigonia rel. *T. evansana*	
Trigonia leana	
Thetis annulata	

Considering, then, the Lower and the Upper Chico, it will be seen not only that there is a quite noticeable development of gastropod and bivalve species in passing from Lower to Upper, but there is also a large omission of former species and genera and their replacement by others of usually different groups. For example, of the many species of cephalopods found in the Lower division, only four have been thus far reported from the Upper; and only two with certainty of identification. Among the gastropods only eleven have been reported as common to the two horizons and some of them are likewise doubtful. Others, as *Gyrodes expansa* and *Cinulia obliqua*, are forms that might easily be mistaken, or at best are not characteristic. One or two species of *Turritella* are found in the Lower Chico, and four in the Upper, only one of which is common to both.

Among bivalves a greater number of forms is found, continuing from the earlier to the later deposits; but this is perhaps to be expected, partly from their more simple habits, and partly from their greater numbers. But with these also a critical examination will result in lessening their apparent importance. Not more than twenty species are shown to have survived from the earlier to the later Chico, and among them are *Chione varians*, *Homomya concentrica*, *Exogyra parasitica*, *Meekia sella*, and perhaps *Inoceramus whitneyi*, none of which are of very decisive character. Of the others, *Pectunculus veatchi*, *Cucullæa truncata*, and *Trigonia evansana*, while they are more distinctive forms, have each near allies in the Cretaceous of the West Coast, among which there has not yet been a close discrimination. *Trigonia dawsoni*, from the Queen Charlotte Islands, is related to *Trigonia evansana* of the Comox beds. There are at least two varieties of *Pectunculus veatchi*, besides a new and nearly related species, while *Cucullæa truncata* from the Chico resembles superficially a *Trigonarca* from the Queen Charlotte Islands. One needs to be reassured by careful comparisons before yielding to first impressions. *Nucula truncata*, if not some of the others, has caused a similar confusion elsewhere by crossing a well established break from the Chico to the Tejon, and even into the Miocene, and ought not to be regarded seriously here.

But the distinction between Upper and Lower Chico does not appear to need this sort of defense. It could be properly made even if a much larger number of species was found to have crossed the interval. It may be true that a larger number will be found when the localities are more carefully searched; but even so, future explorations will probably also increase proportionally the number that have not crossed the line; so that it is safe to say the ratio of species that have survived from the earlier epoch will not be materially increased.

If the faunal dissimilarity that is apparent in the Lower and Upper Chico is to be taken as evidence of a discontinuity in the deposition of this member, it ought also to appear in deposits outside of the basin of the Sacramento, if the disturbance extended so far. And when the lists of Chico species from the different localities are examined with a view to discovering such evidence, it can only be said that the fragmentary collections that have been made at distant points thoughout the Coast Ranges toward the south are, as a rule, either prevailingly Upper or prevailingly Lower Chico for any given locality. The various papers by H. W. Fairbanks furnish a number of such lists that will be found interesting.

Upon the Eagle Ranch in northern San Luis Obispo County, the Chico beds that immediately overlie the *Aucella*-bearing shales have furnished the following species: *Baculites chicoënsis*, *Trigonia evansana* (?), *Pectunculus veatchi*, *Cucullæa* sp., and *Pentacrinus*. None of these species belong exclusively to the Lower Chico, while some of them have never been found there. *Baculites chicoënsis* is, perhaps, peculiar to the Upper division alone. The *Pectunculus* and *Pentacrinus* are probably undescribed species. Farther southward, in Santa Barbara County, a collection from the Sisquoc Canyon consists of the following:—

Inoceramus sp.	*Pectunculus veatchi*
Baculites chicoënsis	*Meekia sella*
Dentalium stramineum	*Cinulia obliqua*
Cylichna costata	*Tellina ashburneri*

The same evidence appears in this list as in the preceding, except that more of the species are those of the Upper Chico alone. Such evidence is, of course, only corroborative, and does not of itself establish the fact of different epochs for the Lower and Upper Chico. It shows, however, that the subsidence that attended or introduced the later portion of the Chico was not entirely local. Other occurrences of the Chico are represented in the following lists.

It is not claimed that the Upper and Lower divisions of the Chico are entirely distinct, but only that there is a sufficient difference between them to warrant their discrimination.

In widely separated localities both portions of the Chico seem to be represented together, though perhaps with more careful study the deposits might be found separable. In the vicinity of the Bay of San Francisco, four localities may be mentioned which will be found interesting. The connections between them are not known, except that they are not distant from each other geographically. It will be noticed that in two of these lists, Martinez and Pacheco Pass, the species are prevailingly those of the Upper Chico, though at Martinez a species of *Trigonia* occurs which has been supposed peculiar to the Lower Chico. In the list from Curry's, south of Mount Diablo, the species of the Upper and Lower horizons appear to be about equally mingled. A little farther south, in the Livermore Valley, Alameda County, fossils occur that are certainly below the Upper Chico, if not below the Lower; but this will be discussed later on.

PACHECO PASS.

Baculites chicoënsis TRASK
Gyrodes conradiana GABB
Lima appressa GABB
Lutraria truncata GABB
Meekia sella GABB
Perissolax brevirostris GABB
Pharella alta GABB
Tellina matthewsoni GABB

BENICIA.

Actæonina californica GABB
Chione varians GABB
Cucullæa truncata GABB
Desmoceras jugalis GABB
Eriphyla umbonata GABB
Fulguraria gabbi WHITE
Globiconcha remondi GABB
Inoceramus whitneyi GABB
Lytoceras batesi TRASK
Mactra ashburneri GABB
Margaritella globosa GABB
Meekia sella GABB
Pachydiscus newberryanus MEEK
(*Ammonites fraternus* GABB)
Pectunculus veatchi GABB
Pharella alta GABB
Trigonia evansana MEEK
Trigonia leana GABB
Turritella sp.

South of Mount Diablo.	Southwest of Martinez.
Acanthoceras turneri White	*Chione varians* Gabb
Anchura californica Gabb	*Cinulia obliqua* Gabb
Baculites chicoënsis Trask	*Corbula cultriformis* Gabb
Chione varians Gabb	*Cylindrites brevis* Gabb
Cucullæa truncata Gabb	*Dentalium cooperi* Gabb
Dentalium cooperi Gabb	*Gyrodes expansa* Gabb
Dentalium stramineum Gabb	*Gyrodes conradiana* Gabb
Eriphyla umbonata Gabb	*? Helicoceras vermiculare* Gabb
Lutraria alveata Gabb	*Meekia sella* Gabb
Lytoceras batesi Trask	*Meekia navis* Gabb
Mactra tenuissima Gabb	*Meretrix arata* Gabb
Meretrix nitida Gabb	*Mytilus pauperculus* Gabb
Nautilus sp.	*Nucula truncata* Gabb
Pachydiscus suciaënsis Meek	*Pachydiscus* sp.
Pecten operculiformis Gabb	*Pecten martinezensis* Gabb
Pinna breweri Gabb	*Perissolax brevirostris* Gabb
Schlutheria diabloënsis, sp. nov.	*Pectunculus veatchi* Gabb
Scobinella dilleri White	*Pugnellus hamulus* Gabb
Trigonia æquicostata Gabb	*Solarium inornatum* Gabb
Trigonia evansana Meek	*Tellina æqualis (?)* Gabb
	Tellina hoffmanni Gabb

List of Fossil Species from Todos Santos Bay, Lower California.

Actæonina pupoides Gabb	*Ledo translucida* Gabb
Ancyloceras lineatum Gabb	*Lunatia avellana* Gabb
Astarte matthewsoni Gabb	*Mactra ashburneri* Gabb
Baculites chicoënsis (?) Trask	*Nerita* sp.
Cerithium pilingi White	*Nucula truncata* Gabb
Cerithium totium-sanctorum White	*Ostrea* sp.
Chione varians Gabb	*Pectunculus veatchi* Gabb
Cinulia obliqua Gabb	*Pugnellus* sp.
Coralliochama orcutti White	*Tellina æqualis* Gabb
Fulguraria gabbi White	*Tellina öoides* Gabb
Fusus sp.	*Trochus eurystomus* White
Gyrodes expansa Gabb	*Turritella chicoënsis* Gabb

The horizon of Todos Santos Bay in Lower California is evidently that of the Lower Chico, and is supplementary to those of Orange and Los Angeles counties already given. Special weight has been attached by White, Stanton, and others to the occurrence of *Coralliochama orcutti*, and these beds have been generally correlated with those of Wallala, on the coast of Mendocino County, and with the lowermost Chico of the Sacramento Valley. At Wallala, *Coralliochama* occurs with *Solarium wallalaënse* White, *Ostrea*, *Inoceramus*, *Pecten*, *Cylichna*, and *Turritella*.

It appears that the disturbances of the West Coast have been to some extent local, though probably synchronous during the Chico epoch. Further evidence of this is also found in the deposits of Southern Oregon and Siskiyou County, California, where the fauna seems to indicate for these localities a different basin. The Oregon Basin was probably not directly connected with that of the Sacramento, at least until during the later Chico. Species that belong characteristically to the upper horizon are found plentifully common in the two basins, while in the lower horizon they are essentially different. There is a closer relationship between the deposits of Southern Oregon and Vancouver Island than between those of the latter and of the Sacramento Valley. There is also a representation of Upper Missouri—Colorado—forms in the fauna of Southern Oregon, as will be seen in the species of *Inoceramus* and *Scaphites*, and in some of the ammonites.

The cephalopods of these lists form one of the most striking features. The numerous species of *Schlœnbachia*,[1] alone, almost distinguish this basin from others of the Pacific Coast; while to these may be added six species of *Scaphites*, two species of *Acanthoceras*, two of *Lytoceras*, besides the aberrant forms, including *Hamites*, *Helicoceras*, and *Heteroceras*.

The Phœnix locality is regarded as representing stratigraphically the Lower Chico horizon of the Sacramento, yet the differences of the faunas are considerable.

Attention is also called to the occurrence in the Oregon Basin of such forms as *Desmoceras sugatum*, *Scaphites gillisi*, *Scaphites klamathensis*, *Goniomya borealis*, and *Protocardium scitulum*. Many others will also be noticed that seem to have special importance; these will be mentioned under the heading of correlation.

While there are fewer species of cephalopods that connect these beds directly with those of the Lower Chico in the Sacramento Valley, the large number of cephalopods,

---

[1] In the summer of 1899, Dr. J. P. Smith discovered in the Lower Chico of Silverado Canyon, Orange County, California, *Schlœnbachia oregonensis* and others of this genus like those of the Oregon Basin.

and especially the two species of *Acanthoceras*, the *Lytoceras* species, and others may be taken as evidence of a rather low position in the Chico. Moreover, beds of the same or of a little later age at Jacksonville, only a few miles to the west, contain Lower Chico forms, such as *Trigonia æquicostata*, *T. leana*, *Pecten operculiformis*, etc., which have not been found above the Lower Chico. Nor is there a single species among this collection that is characteristic of even the uppermost Horsetown beds.

The horizon of the Phœnix beds is almost identical with that of Cottonwood Creek and Shasta Valley, in Siskiyou County. Near the town of Hornbrook (Henley) the Cretaceous beds have a thickness approaching 2,500 feet, the lower two-thirds of which is fossiliferous. There are two well marked horizons, the lower one containing an abundance of trigonias and other bivalves and gasteropods, and the upper one containing a comparatively large number of cephalopods, among which are two species of *Placenticeras*, two of *Desmoceras*, a *Pachydiscus*, and two species of *Phylloceras*. On Willow Creek, a few miles south of the Klamath River, and in the strike of the Henley beds, the same horizons occur in the same relation. Here the upper zone contains also *Pachydiscus newberryanus*, *Desmoceras hoffmanni*, *Prionotropis crenulatum*, *Scaphites condoni*, *Hamites armatum*, *Desmoceras* sp., and many others of a Lower Chico aspect.

The Horsetown Epoch.

An examination of the Horsetown fauna shows it to consist in large part of abundant species of cephalopods, especially of the genera *Desmoceras* and *Lytoceras;* their relatives, *Hoplites* and *Acanthoceras* are also common; and there are, perhaps, three or four species of *Phylloceras*, one or two of *Olcostephanus*, at least two species of *Nautilus*, and two of *Belemnites*. One-half of the entire fauna of the Horsetown belongs to the class of cephalopods, and this proportion seems to be fairly constant throughout. Probably when the fauna of the Horsetown strata becomes more perfectly known, the proportion of cephalopods among the whole will be increased still more. In the basin of the Great Valley they are especially abundant and varied, some of them reaching very large dimensions. Among the very large forms are *Lytoceras argonautarum* and *Ancyloceras percostatum.* The following is a partial list of those already known from the Horsetown beds of the upper Sacramento Valley:—

List of Fossil Species from Horsetown Beds.

Acanthoceras dispar (?) (d'Orb.) Stol.
Actæon impressus Gabb
Anchura sp.
Ancyloceras lineatum Gabb
Ancyloceras remondi Gabb
Anisomyon meeki Gabb
Archomya undulata Gabb
Avicula mucronata Meek
Avicula whiteavesi Stanton
Belemnites impressus Gabb
Belemnites sp.
Chione varians Gabb
Crioceras latum Gabb
Crioceras percostatum Gabb
Cucullæa truncata Gabb
Cumlia sp.
Desmoceras beudanti Brong.
Desmoceras breweri Gabb
Desmoceras colusaënse, sp. nov.
Desmoceras dilleri, sp. nov.
Desmoceras haydeni Gabb
Desmoceras hoffmanni Gabb
Desmoceras lecontei, sp. nov.
Desmoceras merriami, sp. nov.
Desmoceras subquadratum, sp. nov.
Desmoceras voyi, sp. nov.
Diptychoceras læve Gabb
Douvilliceras mamillare Schloth.
Eriphyla sp.
Eripachya hoffmanni Gabb
Eripachya perforata Gabb
Exogyra parasitica Gabb
Fusus aratus Gabb
Helicancylus æquicostatus Gabb
Helicaulax bicarinata Gabb
Holcodiscus rel. *H. theobaldianus* Stol.
Hoplites remondi Gabb
Inoceramus sp.
Lima microtis Gabb
Lima shastensis Gabb
Liocium punctatum Gabb
Lunatia avellana Gabb
Lytoceras angulatum, sp. nov.
Lytoceras argonautarum, sp. nov.
Lytoceras batesi Trask.
Lytoceras sacya Forbes
Lytoceras rel. *L. sacya*
Lytoceras timotheanum May.
Meekia sella Gabb
Nautilus gabbi, sp. nov.
Nautilus suciaensis, sp. nov.
Neithea grandicosta Gabb
Nemodon vancouverense Meek
Nerinea dispar Gabb
Nerinea maudensis Whiteaves
Nerita deformis Gabb
Olcostephanus traski Gabb
Olcostephanus sp.
Ostrea sp.
Oxytoma mucronata Whiteaves
Pachydiscus sacramenticus, sp. nov.
Pecten operculiformis Gabb
Pinna sp.
Pleuromya lævigata Whiteaves
Pleuromya papyracea Gabb
Plicatula varia Gabb
Phylloceras onoënse Stanton
Phylloceras shastalense, sp. nov.
Potamides diadema Gabb
Ptiloteuthis foliatus Gabb
Ringinella polita Gabb
Scalaria albensis (?) d'Orb.
Schlœnbachia inflata Sowerby.
Sonnertia stantoni, sp. nov.
Thetis elongata Gabb
Trigonia æquicostata Gabb
Trigonia evansana Meek
Trigonia rel. *T. evansana* Stanton
Trigonia leana Gabb
Turnus plenus Gabb

Among the gasteropods of the Horsetown which may be mentioned are species of *Nerinea*, *Ringinella*, *Actæon*, *Anchura*, and *Helicaulax*. Bivalves are represented by such forms as *Avicula*, *Pleuromya* and *Lima*, two species each, along with others, as *Plicatula varia* and *Thetis elongata*. The following also are typical Horsetown species: *Crioceras latum*, *C. percostatum*, *Diptychoceras læve*, *Schlœnbachia inflata*, *Liocium punctatum*, *Potamides diadema* (?), *Oxytoma mucronata*, *Archomya undulata* and *Mithea grandicosta*. More than eighty species in all are at present known, though it is quite probable that this is not a large part of what will be known when the beds are more carefully searched.

The Horsetown fauna in its most typical development is of a tropical character, as has already been noticed by several writers. Many of its congeners are numerous in the fauna of Southern India. Both have evidently come essentially from the same source. The southern aspect of the Horsetown is seen in the numerous species of *Lytoceras*, *Phylloceras*, and many of the crioceran and nautilian forms. In this respect it contrasts strongly with the northern aspect of the fauna preceding it, in the upper portion of the Knoxville.

Comparatively few of the gasteropods and bivalve species occurring in this list continue above the Horsetown, though some have allies even in the Upper Chico. Probably when the Horsetown fauna becomes more completely known the transitional forms will appear even less significant, since the cephalopods form its ruling class. Perhaps, also, it will be possible to separate it into subdivisions, better characterized than those of the Chico. Diller and Stanton (1894, p. 445) mention as belonging to its upper portion only, *Lytoceras sacya*, *Desmoceras beudanti*, *Schlœnbachia inflata*, *Acanthoceras mamillare* and a few other forms. Likewise there are a few that belong especially to the lower portion of the Horsetown, among which are *Belemnites impressus*, *Crioceras percostatum*, *Olcostephanus traski*, and perhaps *Helicaulax bicarinata* and *Potamides diadema*. On the other hand, many important species run through the whole of the Horsetown, forming connecting links from bottom to top.

In the basin of the Sacramento the base of the Horsetown division of the Cretaceous has perhaps been well placed at the upper limit of the range of *Aucella*. Few if any of the species characteristic of the Horsetown appear to extend below this limit, and until this supposition shall be proved erroneous the boundary seems to be a practical one. It is stated by Diller and Stanton (1894, p. 446) that many well known and typical Horsetown species occur within a few hundred feet, stratigraphically, of the upper range of *Aucella*, near the Elder Creek section. Below this point, however, as one descends the series, they entirely disappear or have not been found. Or, with the exception of *Belemnites impressus*, *Lytoceras batesi*, *Crioceras latum*, and two or three others, there are perhaps no species connecting the Horsetown faunally with the strata containing *Aucella*, while on the other hand, the associates of this genus form a separate and distinct fauna.

The Paskenta Horizon.

The strata containing *Aucella*, that is, Knoxville, as originally understood, have been made the subject of a special faunal study by Dr. Stanton (1895) who has published a somewhat complete list, containing in all about seventy-seven species, fifty of which are described as new. He remarks that the majority of this number are rare; yet even so, this is an unexpectedly large number when contrasted with the few species that had formerly been known from the Knoxville. Yet had this assemblage of species been found distributed throughout the twenty thousand feet of strata that have been referred to the Knoxville, it would not have seemed surprising, for this thickness of strata is twice as great as the entire sum of the Horsetown and Chico strata combined. But the most interesting part of this discovery is not the large number of Knoxville species brought to light, but the fact that they were nearly all obtained, not from the entire range of twenty thousand feet of what was termed Knoxville strata, but from the uppermost four thousand feet of them. The seventy-seven species enumerated, all of which, with the exception of two or three species of *Aucella*, are apparently confined to this relatively small stratigraphical range, are almost equal in number to the eighty or more species that are thus far known from the six thousand feet of Horsetown strata, where the individuals are far more abundant. In fact, the actual thickness of strata through which this new and distinct fauna ranges is not yet definitely known, though from the statements made in regard to the locality and position of the different species, we learn that the great majority of them have been found in or near the sections studied in the Sacramento Valley, and that the stratigraphical range is rarely if ever given as greater than three thousand feet below the upper limit of the *Aucella* range. With the introduction of this new fauna at that horizon the *Aucellæ* gradually diminish, until at the next immigration of species they entirely disappear. Stanton says of this fauna: "All but seven of the species are mollusca, including thirty-three species of Pelecypoda, one species of Scaphopoda, eighteen species of Gasteropoda, and eighteen species of Cephalopoda, of which fifteen are Ammonoids, and three are Belemnites. The other seven species include five Brachiopods and two Echinoderms." So far as known, the cephalopods contain a single species each of *Desmoceras*, *Lytoceras*, and *Phylloceras*, forms which are so numerous in the Horsetown, while *Hoplites* is represented by five species and *Perisphinctes* by one.

The two species of *Olcostephanus* are both new and have not been found in the Horsetown. An important feature of the Gasteropoda is the large number of *Turbo* species, six species of this shell being described. Two species of *Hypsipleura*, and three of *Cerithium* are known. Nothing particularly characteristic is to be noticed with reference to the bivalves, most of which, with the exception of *Aucella*, have allies among the fauna of the Horsetown. The Brachiopoda, however, deserve mention, the five species being, perhaps, peculiar to this fauna alone.

The fauna here described is especially well represented in the vicinity of Paskenta, Tehama County, where a few localities have yielded most of the described species. Other localities that have furnished a number of the species which have been included in this list appear to belong to the same horizon. One is a locality of white limestone along Sulphur Creek, Colusa County, from which the following species have been obtained: *Rhynchonella whitneyi*, *Modiola major*, *Pecten complexicosta*, *Lucina colusaënsis*, *Atresius liratus*, and *Turbo colusaënsis*. Other species from evidently the same horizon in the near neighborhood may be added, as *Astarte trapezoidalis*, *Turbo morganensis*, and *Turbo wilburensis*.

The exact position of this limestone in the series of *Aucella*-bearing strata has not been determined, but it appears to be interstratified with shales containing *Aucella;* and since many of the same species have been found near Paskenta, in thin layers and lenses of limestone, it seems pretty evident that the same horizon is represented in both localities, and that the strata of both belong near the top of the upward range of *Aucella*.

Southward of the Sacramento Valley scattered occurrences of *Aucella*-bearing rocks are found of which but little is yet known. One mile north of Berkeley, Alameda County, *Aucella* and *Belemnites* have been found in dark, sandy shales, and near by is a bed of light colored limestone having a fetid odor, from which Dr. J. C. Merriam and Charles Palache obtained *Modiola major*, *Lucina colusaënsis*, *Pecten complexicosta*, *Cardinia* (?), *Myoconcha* (?), *Turbo*, *Atresius liratus*, and other forms resembling Paskenta species. At the eastern edge of the town, almost in the strike of these rocks, are sandy beds that will be referred to again, and which Dr. Merriam regards as undoubtedly of Chico age.

Farther south, in the vicinity of Haywards, fossiliferous shales occur from which was obtained a specimen of *Crioceras percostatum*, which is now in the collection of the California Academy of Sciences. This locality is classed as probably of the Knoxville (Paskenta) epoch.

In the Alum Rock canyon, a few miles east of San Jose, Dr. J. P. Smith has found *Aucella piochi* associated with *Belemnites;* and in the canyon of Stephens Creek, a few miles west of the same town, he has reported a similar bed of dark, siliceous shale containing *Aucella piochi.*

Still farther south, near Gilroy, on the road from San Jose to Santa Cruz, *Aucella crassicollis* has been found by Dr. Smith and others, along with an *Olcostephanus*, and other undetermined species.

The most southern locality in which *Aucella* has yet been discovered in California is a few miles north of San Luis Obispo. Dark, *Aucella*-bearing shales occur in the hills to the west of Santa Margarita, where in one exposure of them on the Eagle Ranch the slender form of *Aucella piochi* is very abundant. An ammonite, probably an *Hoplites*, was also obtained at this locality.

While not exactly demonstrable from our present knowledge, it yet seems evident that a more or less connected line of deposits of Knoxville (Paskenta) age can be traced along the eastern border of the basin of San Francisco Bay from beyond San Jose northward. This line of deposits will be be seen to include Gilroy, Alum Rock, Haywards, and the exposures near Berkeley. The topography of the country suggests also that it might even be extended by a little exploration to connect with deposits of the same age in Napa Valley, at Sulphur Creek, and even to Knoxville itself.

One other isolated locality deserves to be mentioned; that upon the northern flank of Mount Diablo. Mr. Turner discovered here *Aucella*-bearing shales in contact with metamorphic rocks of a still older series. The fauna of these shales consists of *Aucella* which he refers to the type, *A. mosquensis*, *Belemnites*, *Inoceramus*, and a few species of gasteropods.

It has already been noticed that in the strata referred to the Paskenta horizon beds and lenses of limestone are common; and as usual, according to Turner, here, too, all the fossils with the exception of *Aucella* are found in layers of limestone. It seems most probable, therefore, from the foregoing statements, that all of these scattered localities contain strata entirely equivalent to that of Paskenta, since below this horizon in the sections of the Sacramento Valley no ammonites have thus far been discovered. This horizon, moreover, represents exactly and completely all that should be included in the Knoxville as it was first described by White (1885).

Three things should be noticed regarding the Knoxville horizon as thus understood, showing its faunal relations to that of the Horsetown. First, it is characterized by an almost distinct fauna, very few species of which appear to have been found in the Horsetown portion of the series, while in each the total number of species is rather large. Second, the typical and varied Horsetown fauna occurs very near, though above, the upward limit of the Knoxville, and appears there in a somewhat striking contrast with it. The transition is sudden. Third, the Horsetown fauna, with the exception of three or four species already mentioned, does not seem to have been, and hardly could have been derived from that of the Knoxville. The types are entirely different. Dr. White believed the Knoxville fauna to be decidedly boreal in character, and referred particularly to the genus *Aucella* in support of this view. The same opinion has been held by others, and Dr. J. P. Smith states that some of the ammonites have their nearest allies in the north of Europe. Reference has already been made to the equally manifest tropical aspect of the fauna of the Horsetown.

Another circumstance that appears to coincide with this faunal demarcation, and which forms a strong corroborative testimony in support of the conclusions to be drawn therefrom, will be discussed later in connection with the distribution of the Horsetown beds and the general occurrences of intrusive peridotites.

The Sub-Knoxville Horizon.

One of the most important contributions made by Diller and Stanton to our knowledge of West Coast geology was in the discovery of an immense thickness of strata below the horizon of the true Knoxville, which for lack of a better name is here designated as the sub-Knoxville. Below the Knoxville (Paskenta) horizon in the Tehama and Shasta sections there are at least 15,000 feet of conformable strata from which but few organic remains other than *Aucella* have been obtained. It is not yet possible to say where the exact limits between this and the Knoxville horizon may be drawn, and indeed it may not be possible to establish one more than theoretically in these sections. Still there appears to be quite sufficient evidence that the Knoxville, as here restricted, was inaugurated by some profound movements, felt elsewhere, if not in this basin itself.

The sub-Knoxville horizon, that here forms at least one-half of the entire conformable series, has not yet been clearly recognized outside of the Sacramento Valley, either in California or Oregon. Nearly, if not quite all the occurrences of *Aucella*-bearing rocks in the Coast Ranges have shown themselves by their fossil remains, other than *Aucella*, to belong wholly to the Knoxville (Paskenta) horizon, and have not been shown to exceed it either in thickness of strata or in faunal contents. If the sub-Knoxville horizon has really any equivalent in other portions of the State, they ought to be found outside of the borders of the Great Valley, beyond the margins of recognized Cretaceous deposits; and it is not unlikely that some of the stratified rocks of the Klamath Mountains will prove to be their complete contemporaries.

VI. DISTURBANCES OF THE PERIOD.

1. DISTRIBUTION OF THE HORSETOWN BEDS.

In dealing with the two horizons of the Chico an attempt was made to show the wide-spread disturbance that had intervened and which was locally accentuated. The evidence for this was first a considerable faunal change in passing from Lower to Upper Chico, and second a general lack of coincidence in the distribution of Upper and Lower

Chico deposits. It might also be said that the Lower Chico has a wider transgressional expansion than the other.

Quite similar relations exist also between strata of the Lower Chico and Horsetown epochs, with the difference, however, that in California the Horsetown is but little known outside of the Sacramento Valley, or to express it more accurately, outside of the immediate borders of the Great Valley. Its distribution is apparently restricted, just as are the deposits of the sub-Knoxville, almost entirely to this basin, where it builds with the strata of the lower and upper horizons of the Cretaceous a more or less continuous series. The fact is a remarkable one, that throughout the Coast Ranges west and south of the Great Valley, few if any deposits of Horsetown age are found. Those that have been satisfactorily shown to belong to this epoch lie upon the immediate borders of the Great Valley, and they have yet to be found south of the latitude of Benicia and the junction of the two great rivers of this basin.

There is no assignable reason why deposits of the Horsetown should not be found within the boundaries of the San Joaquin Valley, but as yet the nearest approach to this fauna that has been discovered south of the latitude named is from a locality lying about eight miles east of the town of Livermore, at Arroyo del Vallé, some miles southeast of Mount Diablo. This is a locality discovered many years ago by Dr. Lorenzo G. Yates of Santa Barbara, who obtained from this place a large number of ammonites now in the collections of Stanford University. Among them are the following species as determined by Dr. J. P. Smith:—

Baculites chicoënsis
Belemnites sp.
Cinulia obliqua
Desmoceras hoffmanni
Desmoceras cf. *D. selwynanum*
Hoplites remondi
Lytoceras alamedense
Lytoceras batesi
Lytoceras cf. *L. timotheanum*
Pachydiscus cf. *P. newberryanus*
Pachydiscus cf. *P. suciaënsis*
Phylloceras onoënse
Phylloceras ramosum
Placenticeras californicum, sp. nov.
Placenticeras pacificum

It can not be denied that the fauna of this locality shows a strong intermingling of Horsetown and Lower Chico species. In this respect it resembles other localities within the borders of the Great Valley. The succession of disturbances inaugurating the Chico was here so little felt as to allow pre-existing species to survive locally. The Chico faceies of this locality, is, however, represented by such forms as *Pachydiscus newberryanus*, *P. suciaënsis*, *Baculites chicoënsis*, *Cinulia obliqua*, and also *Placenticeras californicum* and *P. pacificum* have been found elsewhere in undoubted Chico deposits, and they have been found in no other deposits. The former occurs in the Lower Chico beds of the Forty-nine Mine, Jackson County, Oregon, and in exactly the same horizon at Henley, Siskiyou County, California, along with *P. pacificum;* while Dr. J. P. Smith states that *P. californicum* has been found in the Lower Chico of the San Fernando Mountains, Los Angeles County, California, and that Mr. F. Rolfe has found in the Lower Chico of Silverado Canyon, Orange County, California, *P. pacificum* associated with typical fossils of this epoch.

2. The Chico-Knoxville Unconformity.

This occurrence of Lower Chico strata seems the more important because upon the northern flanks of Mount Diablo, only a few miles away, Chico beds are found apparently conformable upon *Aucella*-bearing shales forming a series of several thousand feet in thickness. These Mount Diablo deposits were first described by H. W. Turner (1891) and afterward discussed by Stanton (1895, p. 21, etc.). Mr. Turner believed that a portion of this conformable series represented the Horsetown, but was unable to prove it to his own satisfaction. The upper portion of the series has yielded *Baculites chicoënsis* and a few other Chico forms, and the lower portion is the horizon of the Knoxville discussed a few pages back. Stanton estimated that the intervening strata had a thickness of about five thousand feet, in regard to which he says: "If the horizons are all represented, then sedimentation was here very much less rapid during a part of the Cretaceous than it was one hundred and fifty miles north, in Tehama County; while if the Horsetown and a part of the Knoxville beds are really lacking, there must have been a local uplift in the Mount Diablo region which did not involve the Coast Ranges farther north." The Chico beds are here the Upper Chico and much of the five thousand feet of strata intervening between this and the *Aucella* beds must evidently belong to the Chico group, since on the south side of the mountain the Lower Chico occurs. One is forced, then, to accept Mr. Stanton's second alternative, with the amendment, however, that the uplift, while local, was only a local accentuation of a disturbing influence much more general throughout the Coast region.

It will be interesting to remember here the cases of unconformity discovered by Fairbanks (1895, p. 426, etc.) between Chico and Knoxville beds in San Luis Obispo County, in reference to which he says: "The Knoxville (Paskenta) is bordered on the west by a great dike of serpentine, while on the east a nearly hidden axis belonging to the Golden Gate (Franciscan) series projects through it in numerous places. The Knoxville presents a very much disturbed condition, partly due to the dikes of serpentine. The Chico, consisting almost wholly of heavy bedded sandstone, rises on the eastern slope, overlapping the Knoxville shales and capping portions of the first line of hills." Points at which this unconformity is particularly clear he has discussed more in detail. One was found upon the Eagle Ranch, west of Santa Margarita, and another a few miles to the northwest, where almost undisturbed Chico sandstones rest upon highly tilted Knoxville shales with *Aucella piochi*. Concerning this region Dr. Fairbanks (1898, p. 560) says in a later paper, speaking of the Chico: "Fossils are not abundant but they were found in sufficient numbers in the Santa Lucia Mountains to demonstrate the age of the formation. In the latter locality the sandstone terminates downward in a conglomerate which is in places one hundred feet thick, resting either upon the Knoxville shales or the Golden Gate series. The relation to the Knoxville shales was carefully examined at many points along the northern slope of the Santa Lucia Mountains and a conclusion was reached which is in accord with one already published, namely, that the Lower and Upper Cretaceous are, in this region at least, separated by an unconformity. This is shown by a marked discordance in the dip between the two and the extension of the upper across the strike of the lower, etc." The Chico here described is that of the upper horizon as previously shown. And what has been so clearly demonstrated in the region south of the Great Valley is exactly paralleled beyond its boundaries northward in California.

In a former paragraph mention was made of *Aucella* beds occurring at the base of the Cretaceous section in the Siskiyou Mountains. In the collections of the State Mining Bureau in San Francisco is a specimen of calcareous rock about two pounds in weight, consisting of a compacted mass of *Aucella piochi* shells, and bearing upon its label, "from Siskiyou County, California." Miss M. Hearn of Yreka, from whom this specimen was obtained, states that it came from the south side of the Siskiyou Mountains, and from a locality from which many Chico fossils have often been collected, and one which is included in the preceding lists of Chico fossils from that region. Much of the Cretaceous series along Cottonwood Creek, Siskiyou County, has the appearance of the soft clay shales of the Knoxville beds on Cottonwood Creek, Shasta County; and to one familiar with these shales, and with the unconformity between Chico and Knoxville found far southward, it is not surprising that *Aucella* beds should be found here also unconformably related to the Chico. How extensive this unconformable relation may be throughout the coast region is not yet known; but from the observations of Dr. J. C. Merriam (1901) in the basin of the John Day River, it appears to have a wide range in the Oregon Cretaceous basin. He says: "In the valley of Bridge Creek a great thickness of conglomerates, sandstones and shales is exposed at Mitchell, eighteen miles northwest of Spanish Gulch. The upper portion of this section much resembles the Cretaceous at Spanish Gulch, while the lower part, consisting of soft dark shales with an occasional thin, hard stratum, is an exact duplicate of the Knoxville, as it is usually developed in California and Southern Oregon. The total thickness of the section is hardly less than 3,500 to 4,000 feet, of which the shales probably make up more than one-half. At the lower end of the Mitchell Knoxville section the shales dip westerly for a short distance, but the west side of the anticline is covered by Tertiary formations." The fossils of the upper portion of the section show it to be of Lower Chico age.

3. THE PERIDOTITE INTRUSIONS.

The relations of the serpentines of the Coast Ranges to both the Knoxville (Paskenta) and the Chico strata form another convincing proof of the unconformity of the Chico upon the former. It is well known that the peridotites from which the serpentines have been derived have been intruded into the Knoxville beds at many places in the Coast Ranges, and that this has happened especially, also, throughout the very region from which the Horsetown strata are entirely missing. A few of these cases may be given, though an extended and complete list of them, that have from time to time been noticed, would be superfluous for the purpose of this paper.

On the map of the Great Western Quicksilver Mine, Napa County, published by Becker (1888, p. 358), tongues of serpentine are shown penetrating the "Neocomian" shales. Such occurrences are said to be abundant, and so closely and generally are serpentine and Knoxville shales associated in that region as to suggest to Becker the derivation of the serpentine from sedimentary rocks. He (Becker, 1888, p. 121) says: "Highly inclined strata strike into serpentine areas in such a manner as to wholly preclude the supposition that the serpentine represents an earlier mass." At Mount Diablo, also, Mr. Turner (1891) has shown similar dikes of serpentine cutting the Knoxville shales. In Tehama County, the shales are said to dip steeply away from a mass of serpentine at their base, which has evidently been a disturbing agent. H. W. Fairbanks has repeatedly spoken of serpentine cutting the Knoxville shales in the southern Coast Ranges, as near San Luis Obispo and other neighboring points. Dr. J. P. Smith states that he has observed serpentine intrusive in the *Aucella*-bearing shales on the Whitney ranch, some miles southwest of Gilroy, Santa Clara County.

Exactly similar relations are found in connection with strata of the same age at Riddles, Oregon, where a belt of Cretaceous rocks five miles in length is bordered on the west by serpentine and peridotite. It is thus seen that from San Luis Obispo County northward far into Oregon the Knoxville is everywhere penetrated and disturbed by dikes and masses of serpentine and accompanying peridotites; and it is exactly from this Coast Range region in which serpentine is common that the Horsetown strata are entirely absent. (Turner, 1891, map opposite p. 383.)

At many places in this same region Chico beds are also found in contact with the serpentine; but it has not been stated that they have ever shown evidences of having been even slightly altered or disturbed by the peridotites. Indeed, quite the contrary is usually the case, as Fairbanks has already stated.

4. THE CHICO OVERLAP.

This serpentine intruded country does not form a narrow strip bordering the basin of the Great Valley, but it extends from that basin westward, frequently to the ocean. It is many miles in width, and extends from the southern portion of California northward far into Oregon. In the latitude of southern Mendocino County this intrusion has thrown the Horsetown entirely out of the series in the Coast Ranges west of the Great Valley, while Chico strata are found upon both sides of the peridotite belt, at Wallala, upon the seaboard and in the Sacramento Valley. The position of these Wallala beds, which have been classed as

Lower Chico, lying as they do near the low coastal border of a large area of Knoxville which has been uplifted by this intrusion, accords well with the unconformity which elsewhere exists between them.

On the other hand, the Chico beds, representing the great overlap succeeding these intrusions, are known in many cases to rest directly upon masses of serpentine in an undisturbed position. This is particularly true in northern California. Near Yreka, Siskiyou County, a belt of serpentine and peridotite crosses the country in a southwesterly direction, passing beneath the town. At a distance of one to three miles on either side of the town are to be seen the fossiliferous and unaltered beds of the Lower Chico, resting in nearly a horizontal position upon the serpentine. Other similar occurrences have also been noticed. South of Weaverville, in Trinity County, the Lower Chico occurs, and appears to have some similar relation to the serpentines lying to the north. Similar facts have also been noticed in the southern Coast Ranges.

Thus every class of evidence required to fully demonstrate the post-Knoxville disturbance seems to have been satisfactorily shown to exist. Not only have the Chico deposits been found resting unconformably upon the Knoxville, but the Horsetown is evidently absent from wide regions in which both of the other members occur; and at the same time copious masses of eruptive rocks are found exactly in the position to coincide with the intervening disturbance and accordingly with the unconformity between them; and it has also been shown that beds of the Lower Chico rest in an undisturbed position directly upon areas of the same intrusion.

VII. Correlation of Deposits.

Without attempting to settle the difficult problems of correlation, there are a few observations that may be made relative to results that are not beyond the range of data already known. For distant and unrelated provinces possibly no correlation will ever be attained that is entirely satisfactory; and that is not the aim of this paper.

1. The Sacramento Sections.

The Sacramento sections, on account of their completeness and simple stratigraphic succession may well become standards of great value for the correlation of other Cretaceous deposits of the greater Pacific province; but only when they themselves become very much better known. For the present, criteria must be sought by means of which these sections may be studied. It is evident, too, that the greater stratigraphic range of species in this basin will always be a perplexing element in using any of these sections as a standard for comparison. For that reason, the plan of selecting deposits beyond the limits of this basin, in which there are clear evidences of disturbance, has here been attempted.

For the Chico epoch this method is reasonably satisfactory, and with our increasing knowledge of the Cretaceous deposits of the Pacific Coast, it will become more so. Possibly when the Horsetown faunas of California and Oregon become better known the same method will be found equally applicable.

In correlating widely separated deposits by purely paleontological means, the safest conclusions are reached by considering whole faunas, or the ruling classes, and supplementing such evidence by the more direct comparison of species, some of which have a wide geographical range.

It is a surprising fact that the cephalopod faunas of the Pacific Coast basins of America are not more closely related, while some of them have comparatively strong affinities with those upon the opposite side of the Pacific, namely, of eastern and southern Asia. Already there are many species known, either identically or representatively common to the Cretaceous of Southern India, and to one or more of the basins of the Pacific Coast of America; and the same is true of the Cretaceous deposits of Japan.

2. Equivalents of the Chico.

It has been the custom of most writers upon the subject to regard the Upper Cretaceous rocks of Vancouver and the neighboring islands as homotaxial equivalents of the

Chico of California. Mr. J. F. Whiteaves (1876–84, p. 179) has published an extended list of species from the fossiliferous beds of the Nanaimo and Comox sections, in which he indicates the horizon of each, and its occurrence, when known, in the Chico beds of the Sacramento Valley.

Of the fifteen species of cephalopods occurring in these lists, only three are known to occur also in the Chico. Nearly one-half of the gasteropods and almost the same proportion of the lamellibranchs are abundant or common in the Chico of California. The occurrence of the interesting species, *Inoceramus labiatus*, in the Lower Chico of California, and in "Division *A*" of the Queen Charlotte Islands section, perhaps shows the equivalence not only of these horizons, but also indirectly the equivalence of the Nanaimo beds, and the uppermost beds of Queen Charlotte Islands. It is an unusually interesting point, and one that can furthermore be considerably strengthened by evidence that is not quite so direct but entirely conclusive. It serves also to correlate more satisfactorily the deposits of the Pacific border with those of the interior basin.

Inoceramus labiatus is abundant in the upper portion of the Colorado group, but is rare outside of that horizon. In the deposits of the Pacific border it is apparently confined to the Lower Chico and to beds homotaxially equivalent.

The upper beds of the Oregon Basin, including those that have been referred to as the Phœnix and Henley beds, having a stratigraphic position equivalent to that of the Chico, contain not only *Inoceramus labiatus*, but also other forms still more trustworthy for purposes of correlation.

In the three basins, therefore, of the West Coast, the Chico, the Nanaimo, and the Phœnix and Henley beds may be shown to be homotaxially equivalent, and equivalent also to the beds of the Colorado group in the interior basin.

The faunal elements that appear to connect these horizons in the Pacific border basins contain not only a general parallelism of the broad classes of mollusks, but also representative genera, and not a few species in common. The proportion of cephalopods is essentially the same in each. Although in the case of the Phœnix beds it seems somewhat large, this is due rather to the neglect of the lower orders than to their absence. It is not far from the truth to say that the ratio of the cephalopods to the others is, in general, one to five. The genera most commonly present in this class are *Pachydiscus*, *Baculites*, *Hamites*, and others of the aberrant types. A few species of *Desmoceras*, *Lytoceras*, and at least one species of *Phylloceras* are known to occur. *Phylloceras ramosum* (Meek) is common to the three basins, occurring at Mount Diablo, the "Forty-nine Mine," and in the Nanaimo beds. *Baculites chicoënsis* is reported from the Chico and Nanaimo groups along with *Pachydiscus newberryanus*, and possibly *P. suciaënsis;* while the Nanaimo and the Phœnix beds are further connected by *Lytoceras jukesi*, and by representative species of *Hamites* and *Baculites*. Similarly the connection between the Chico and the Phœnix beds is reinforced by the occurrence in each of *Schlœnbachia chicoënsis* (Trask), and an *Acanthoceras* related to *A. rotomagense*. Undoubtedly, however, the strongest connections between the three basins are shown by the large proportions of gasteropods and bivalves, very many of which are specifically common to all of them. In addition to *Inoceramus labiatus*, which is common to all the basins, there is also *I. crippsi*, which is probably identical with *I. whitneyi*. Two species of *Trigonia*,—*T. tryoniana* and *T. evansana*,—are found alike in each of the three basins. But the true relations can only be fully presented by comparative lists of species, such as the one published by Whiteaves, which cannot here be reproduced. Of the thirty or more species there listed as common to the Nanaimo and the Chico beds, more than half are found in the Phœnix (and later) beds of the Oregon Basin. Others, common only to the Phœnix and Nanaimo beds, and others, occurring only in the Phœnix and Chico beds, still further augment this number; and this is exactly what would be expected in beds synchronously deposited in different basins.

It has been pointed out by Whiteaves and others that the overlap of the Nanaimo strata in the Vancouver basin accompanied a subsidence of the Cordilleran region which resulted in the final connection of the Pacific and interior waters. This has been conclusively established not only by the presence of *Inoceramus labiatus*, a form very abundant in the upper portion of the Colorado group, occurring also in the upper beds of the Queen Charlotte Islands, but by others.

Whiteaves (1876–84, p. 188) has published a list of related species, occurring in the upper beds of Vancouver and in the Cretaceous of upper Missouri, which are intended to show the commingling of faunas of this period. To these lists may now be added other important forms from the later Cretaceous beds of Southern Oregon. No less than six species of *Scaphites*, eight species of *Schlœnbachia*, two species of *Placenticeras*, five species of *Inoceramus*, and many other forms, have been found here that strongly recall the fauna of the Colorado group. Nor is the resemblance one of only general groups and genera. Many of the species are either very closely related or are identical. Besides *Inoceramus labiatus*, the list includes a species resembling *I. mytiloides* Con., *Prionocyclus branneri* (very close to *P. woolgari* (Mant.) Meek), *Scaphites gillisi* (still more closely related to *S. warreni* M. & H.), and *S. klamathensis*, which may be an equivalent of *S. larvæformis* M. & H. from the lower portion of the Colorado. Other members of the genus *Schlœnbachia* resemble *Prionocyclus wyomingensis*. These species have been given other specific names; yet the very close affinities with those of the Colorado group can hardly be doubted.

The close resemblances in the faunas of the more northern Pacific border basins and those of eastern Asia are shown in the following parallel lists from the Upper Cretaceous of the Oregon Basin and that from the Island of Ezo (Jokoyama, 1889):—

Island of Ezo.		Oregon Basin.
Desmoceras gaudama (pars),	rel.	*Desmoceras hoffmanni* Gabb
Desmoceras sugatum	=	*Desmoceras sugatum* Forbes
Lytoceras sacya (pars)	=	*Lytoceras sacya* Forbes
Lytoceras sacya (pars)	cf.	*Lytoceras jukesi* Sharpe
Pachydiscus arrialoörensis	cf.	*Pachydiscus henleyensis*, sp. nov.
Phylloceras villedæ,	near rel.	*Phylloceras ramosum* Meek
Inoceramus naumanni	rel.	*Inoceramus klamathensis*, sp. nov.
Inoceramus sp.,	rel.	*Inoceramus whitneyi* Gabb
Cucullæa sachalinense (?),	cf.	*Cucullæa truncata* Gabb
Nucula picturata,	cf.	*Nucula truncata* Gabb

The Turonian aspect of at least the upper portion of the Chico is very clear, as has already been pointed out by different writers. It is further emphasized by some of the above forms, which are known for the first time from the Pacific border province in the Phœnix beds of Southern Oregon. And to these may be added the great development of the gasteropod and bivalve classes and many aberrant forms of *Helicoceras* and *Hamites*, among which is to be noticed an *Helicoceras* related to *H. reusianum* d'Orb., while the Turonian species, *Inoceramus labiatus*, and many others ally these beds to the Turonian of European Cretaceous. But there are also contained in them many forms that belong to a higher, as well as a lower, horizon. *Baculites chicoënsis* and *B. fairbanksi* are both closely akin to *B. vagina* Forbes, which is thought to be a Senonian species. Numerous forms of *Pachydiscus* are found in the Chico and its equivalents which would be expected in Senonian equivalents; while the large development of gasteropods and lamellibranchs shows a late period of the Cretaceous. On the other hand, there are not a few undoubted Cenomanian forms in the Lower Chico beds which incline one to refer them to a lower position than the Turonian. Among such forms are certain species of *Acanthoceras* and some of the forms of *Schlœnbachia*.

In this connection also it ought to be said that the closest relationship seems to exist between some of the forms of the Lower Chico and some from the Ootatoor beds of Southern India. *Inoceramus labiatus* is associated with *Acanthoceras* *naviculare* Mant., both in the Phœnix beds and in the Ootatoor; but the Ootatoor beds have been correlated with the Cenomanian, and both these forms are likewise found in rocks of that period in Europe. On the whole, however, the strongest affinities are undoubtedly with the Turonian; and if one remembers the great stratigraphical range of some of the species of the Sacramento Valley, it does not seem remarkable that Cenomanian or even Gault types are found occasionally in the Chico.

Mention might be made here of the Upper Cretaceous beds occurring on the west coast of Chile. Whether these beds are to be correlated more closely with the Upper or Lower Chico has not been very satisfactorily ascertained, but a few of the species found there indicate a rather low horizon. *Phylloceras ramosum* occurs in the lower part of the Chico in all of the more northern localities; *Desmoceras (Puzosia) darwini* has a close ally in *D. ashlandicum* of the Phœnix beds; *Lytoceras varuna* is found in the Ootatoor beds of India; and the *Hamites*, resembling *H. cylindraceus* de France, is also in accord with the lower horizon.

The exact position of *Lytoceras kayei* in the Californian beds has unfortunately not been learned. It is only known to come from the Chico of Mount Diablo. It appears, therefore, that along the Pacific Coast of America from British Columbia southward to Chile the overlap of the later Cretaceous, including the Lower Chico and its equivalents, is satisfactorily seen in most, if not all, of the widely separated localities of southern Vancouver, Rogue River and Sacramento valleys, Southern California, Todos Santos Bay, and Quiriquina Island, on the coast of Chile.

It seems hardly probable that a movement of so great north and south range should be unaccompanied by parallel disturbances in regions lying so nearly contiguous as that of the interior basin; and there appears to be both faunal and stratigraphical evidence that contemporaneous movements occurred in the two regions on opposite sides of the Cordilleras.

Sacramento Valley.		Oregon Basin.	British Columbia.	Southern California.	South America and Mexico.	Interior Basin.	Southern India.	Europe.
								Danian
Chico	Upper					Montana	Arrialoor	Senonian
Chico	Lower	Phœnix and Henley beds	Nanaimo and "Div. *A*," Q. C. I.	Silverado and San Diego	Quiriquina Island	Ft. Benton	Trichinopoly	Turonian
Conglomerates			Conglomerates			Dakota	Ootatoor	Cenomanian
Horsetown	Upper		"Div. *C*" (in part)		"No. 3," ?			
Horsetown	Lower	Riddles				Comanche: Washita, Fredericks-burg		Gault
Knoxville		Riddles	"Div. *C*" (in part)	San Luis Obispo, etc.	"No. 2" (in part) / Catorce, Mexico	Comanche: Trinity		Neocomian
Sub-Knoxville		Folded Slates			"No. 2" (in part) / Catorce, Mexico			Portlandian
Franciscan (?)					"No. 1," ?			

3. EQUIVALENTS OF THE HORSETOWN.

There are fewer known deposits of the Horsetown epoch upon the borders of the Pacific, and they have thus far been less studied than either the lower or upper horizons; yet its equivalents are recognized in each of the Pacific border basins, although in the Oregon Basin the typical cephalopod fauna of the Upper Horsetown has not been shown to exist. The close relationship, however, of the Horsetown and at least a portion of the Queen Charlotte Islands section is very much more clearly seen. Several species of the Upper Horsetown fauna occur in a portion of "Division *C*" of this section, and leave us accordingly but little room to doubt their equivalence.

Among the connecting elements may be noticed the general abundance of cephalopods, and especially those of the genera *Lytoceras* and *Desmoceras*. Both these deposits have many of the species and general cephalopod fauna of the Ootatoor, as has been more especially emphasized by Kossmat (1895), though previously recognized by others. Among the forms common to the three regions, California, British Columbia, and India, are *Lytoceras timotheanum*, *L. sacya*, *Desmoceras beudanti*, *D. planulatum*, *Schlœnbachia inflata*, and others apparently identical. As in the Chico, so here additional species are found still more closely connecting either two of these basins. *Lytoceras batesi*, *Desmoceras breweri*, *Nautilus suciaënsis*, *Ancyloceras remondi*, species of *Belemnites*, and many other molluscan forms are common to both the Sacramento and the Queen Charlotte Islands sections. *Schlœnbachia propinqua* is reported from the Queen Charlotte Islands and occurs in the Ootatoor beds. Forms connecting the Ootatoor and the Horsetown are still more numerous. Among them are probably the following: *Phylloceras velledæ* (?=*P. onoënse* Stanton), *Stoliczkaia dispar*, *Lytoceras cala*, *Holcodiscus*, aff. *H. theobaldianus* Stol., *Desmoceras voyi*, aff. *D. latidorsatus*, and perhaps others.

Kossmat correlates the Ootatoor horizon and its equivalents on the West Coast of America with the Cenomanian, and there can be no doubt that many of the species do favor that determination. At the same time, however, it must be admitted that many of them are also more closely allied to forms of the Gault.

It has been stated by R. T. Hill (1893), that in the Cretaceous deposits on the eastern border of the Cordilleras a distinct unconformity exists between the strata of the Comanche series and those of the Upper Cretaceous. Rocks of the Dakota epoch are absent from large areas, indeed, from the whole region extending from eastern Texas to Wyoming and westward; while, at the same time, there is evidence of a land-mass covering this belt from which have been derived the littoral conglomerates of the Dakota lying to the eastward. Furthermore, there is a marked difference, both lithological and faunal, between the deposits of the Comanche and those of the Colorado and later groups, which extend far beyond the boundaries of the Lower Cretaceous, reaching northward beyond the region of the Upper Missouri. The rocks of the Comanche series, consisting largely of marls and limestones, indicating deep water conditions, are followed by clays and shales and coarser detrital material, such as could only have been deposited in shallow water.

The faunal differences are very great, although they cannot be more than referred to here; yet it is worth while recalling the comparisons that have been made between these faunas and their contemporaries upon the Pacific border. Stanton has especially emphasized the contrast which is apparent between the faunas of the Comanche and the Shasta groups. It is not certain to what extent his epitomized diagnosis is applicable for this purpose, since he has included in the Shasta formation the whole of the Horsetown, which evidently has, in large part, no marine representatives upon the eastern border of the Cordilleran continent. The Dakota group, which is the equivalent to at least a portion of the Horsetown, is either absent or is a non-marine, plant-bearing series, but which, moreover, in any case is omitted from any part of the comparison.

Accordingly, almost the whole class of cephalopods listed in his scheme have neither complementary elements nor even contemporaries in the Comanche series. The contrast is therefore evidently less than it would appear to be; but in so far as it is strictly applicable, it is quite complete.

On the other hand, as has been already shown, when the fauna of the Colorado group is compared to that of the Chico, particularly as represented in the basin of Southern Oregon, a strong resemblance is apparent, and there is promise of a still closer relationship being recognized when the fauna has become better known. In the paper by Hill already referred to, the Dakota beds are given a position equivalent to the Cenomanian, and the facts made use of in the present paper are entirely in accord with that correlation. It appears, therefore, that the hiatus which has been here described as existing between the Knoxville (Paskenta) and the Chico beds over so large a part of the Coast Range region of the West, has its parallel and contemporary phenomenon in the deposits of the interior; and the subsidence that followed the lateral extension of land conditions on both sides of the Cordilleran continent, was, therefore, epeirogenic; that is, it was synchronous on both borders of that continent.

4. EQUIVALENTS OF THE KNOXVILLE.

The earlier Cretaceous deposits of the Pacific border and of Texas are more or less indirectly correlated, since there is little or no faunal resemblance between them, and they are too remote from each other to warrant a lithological comparison. Still, it is not amiss to recall the facts that the most calcareous portions of the California Cretaceous are those of the true Knoxville (or Paskenta) strata, which are often not unlike the limestones of the Comanche. It is these horizons between which Mr. Stanton (1897, p. 608) has pointed out such striking faunal contrasts, but of which he says: "The two faunas are complements of each other, and both must be taken together to make up a really representative Lower Cretaceous fauna." Of their synchrony he apparently has no doubt.

In his summary of the deposits of San Luis Potosi, Mexico (Stanton, 1895, p. 26), he recognizes therein equivalents not only of the Knoxville, but apparently also of the Upper Cretaceous, possibly of the Horsetown; while below these is the lower division of group No. 2, which he refers to the Jurassic. It shows a general resemblance to the fauna of the Mariposa beds in the large number of species of *Perisphinctes*, and in the presence of *Olcostephanus*, *Belemnites*, and *Aucella*.

The equivalents of the lowest portion of the Sacramento section have not yet been clearly recognized. As to whether the group which has been termed the Sub-Knoxville should really be classed with the Cretaceous or with the Jurassic, there has been a difference of opinion. C. A. White was convinced that but a single species of *Aucella* was known from the Knoxville and from the Mariposa beds; and the separation of these groups was not determined by a distinction of the species of this doubtful genus. J. P. Smith (1895, p. 381) has expressed views strongly favoring the Jurassic determination not only of the Sub-Knoxville fauna with *Aucella piochi*, but he also points out the very close relationship between certain members of the Knoxville fauna and the Volga stage of Russia. Quite similarly, the lowest beds of the Queen Charlotte Islands section, a portion of "Division *C*" of J. F. Whiteaves (1876-84), has been compared to the same horizon of Russia. The Knoxville horizon, as here restricted, has not been shown to occur either upon the Queen Charlotte Islands or upon the mainland of British Columbia. The relationship between these beds and the Russian deposits appears most strongly in some of the ammonites, which have not been found in any of the Californian beds. If this observation proves to be trustworthy, then the Sub-Knoxville of the Sacramento basin is perhaps the equivalent of the lowest member of the Queen Charlotte Islands group, or of

"Division *C*," and both may be compared to the Volga stage and similar deposits.

Among the authors whose opinions are of more than ordinary weight upon this topic may be mentioned the name of Emil Haug (1898, p. 226). While conceding the Neocomian equivalency of the upper portion of the Knoxville (evidently the Paskenta), he plainly states that the lower portion of the "Knoxville beds" undoubtedly corresponds to the upper Portlandian of the Mediterranean region, which he correlates with the upper Volgian, the Tithonian and the Purbeck beds, and to the same horizon he refers the Jurassic portion of the series found at Catorce in the State of San Luis Potosi, Mexico. This seems to be on the whole the most satisfactory correlation of these beds yet suggested.

5. CORDILLERAN OSCILLATIONS.

The subsidence recognized independently for the regions of Texas and California was synchronous throughout the Cordilleras. It culminated with the close of the Comanche-Knoxville epoch, attaining, probably, as great a depression in these regions during the Cretaceous period as has since been reached. The sea extended over western Texas and eastern Mexico nearly, if not quite, to meet the waters of the Pacific, which covered western Mexico.

Following this period of depression was an epeirogenic uplift of the Cordilleran continent, which threw the shore-lines seaward upon both of its borders and thus correspondingly expanded the terrestrial areas, and excluded accordingly from the territory thus added to the continental margins the contemporaneous deposits of the Dakota and the Horsetown groups.

Following the uplift of the Cordilleras were the disturbances that resulted in the contemporaneous overlaps of the Chico and of the Colorado, and the continued subsidence of the region until marine communications were established between the interior basin and the Pacific Ocean, which enabled species to pass from one to the other unobstructed.

The return of the sea upon the continental borders resulted in the deposition of Cenomanian equivalents upon the older Cretaceous deposits unconformably, as is seen on the one hand, between the Knoxville and the Chico, and on the other, between the Comanche and the Colorado.

How widely spread this unconformable relation may appear to be remains to be discovered, but judging from the almost continuous series of the Cretaceous deposits in favorable localities, it can hardly be expected that unconformities will always be found where Comanche and Colorado rocks are present. The double character of the Chico group reminds one alike of the Trichinopoly and Arrialoor of the Indian Cretaceous, of the later subdivisions of the Rocky Mountain section, and of the Turonian and Senonian overlap upon the European continent. It therefore appears that disturbances of a similar character occurred in very remote regions during the closing epochs of the Cretaceous period.

VIII. Summary and Conclusions.

The foregoing discussion of the Cretaceous deposits of the Pacific border is designed to contain a statement of our present knowledge of the subject, and particularly of the Cretaceous deposits of California and Oregon. An attempt has been made to revive the earlier views regarding the complexity of the series, which have been to a considerable extent suppressed. The view more recently maintained, that the series is one of comparative simplicity, even in its most complete developments, has proved to be misleading when applied to districts outside of a rather restricted basin. The series at its best cannot be called simple, its continuity having been frequently disturbed even when deposition was most uniform in the basin of the Great Valley. While the disturbances have not always been sufficiently great to destroy all existing marine species, and thus obliterate faunal connections between deposits of succeeding epochs, yet it is evident that only the most persistent forms have survived from one epoch to the next. The faunal evidence of such disturbances is reïnforced by the abundance of conglomerates which are interstratified with sandy and shaly beds, especially in the upper portion of the series. Coincident with the evidence of these facts is that of the territorial distribution of different members of the series in California and Oregon.

The Cretaceous series of the Sacramento basin and of the whole Pacific border (excluding the Sub-Knoxville, which is probably of pre-Cretaceous age), is divisible into the following well defined members: (1) The Knoxville horizon, including several thousand feet of strata extending upward to the upper limit of the present known species of *Aucella*, embracing what has been shown to be essentially a boreal fauna; (2) the Horsetown horizon, beginning with the close of the Knoxville and the substitution of a typical subtropical fauna for one of boreal character, and continuing to the horizon representing the great Chico overlap; (3) the Chico, or uppermost member of the series, as represented in the Phœnix beds and the beds of Wallala, Silverado Cañon, Point Loma, and Todos Santos Bay, Lower California.

The fauna of the Chico is characterized in its later portions by a large development of gasteropods and lamellibranchs. It is divisible into two horizons, at least in the Sacramento basin, and perhaps elsewhere. The movements that have affected the region are to be inferred from the relations thus recognized. Their general order, particularly in the basin of the Great Valley, has been downward from the first, but not continuously so. With the close of the Knoxville epoch, an interval of epeirogenic uplift prevailed, which withdrew a large amount of territory from oceanic submergence, but which in favored places may have caused only a cessation of deposition, as in the Great Valley basin. The extent of this disturbance, and the duration of the interval, may be inferred from the great faunal change which was introduced with the Horsetown epoch. This was the most important disturbance of the period, and was accompanied by extensive intrusions of peridotite in the Coast Range region of California and Oregon.

Succeeding the post-Knoxville elevation, the next great movement was that inaugurating the Dakota and later Horsetown disturbances, which later were followed by the great overlaps, extending along the Pacific border of both North and South America, from the coast of Chile to British Columbia, and in the interior basin, carrying the Upper Cretaceous far northward along the flanks of the Cordilleras. It was therefore of an epeirogenic nature, extending in longitude as well as latitude over great inland areas.

The close of the Chico epoch is not yet sufficiently well understood for any final statements; but the faunal difference between this epoch and that of the Martinez, as restricted by J. C. Merriam, shows a hiatus, probably between the Chico and the Eocene deposits of the Pacific border.

The different members of the Cretaceous series of California find their counterparts in other portions of the Pacific border, in British Columbia, Mexico and Chile, and are to be closely correlated with the recognized members of the interior basin deposits, with those of Asia and of Europe. This is shown not only by the parallelism of their developments, but also by their faunal resemblances, amounting often to close specific affinities, and even specific identity.

The crustal movements that have affected the Pacific border of America have been much more general than has been commonly believed. Simultaneous disturbances of the same tendency may be traced in many of the great Cretaceous series of the world.

Part II.

Description of Species.

In the following descriptions of fossil species, it has been the endeavor, whenever possible, to recognize from previously published figures and descriptions the forms that have been found by others and listed as authentic species. There are among the collections of the University of California many type-specimens from which Gabb's original descriptions were made, and considerable other material which was labeled by Mr. Gabb and turned over by the State Survey to the State University. Such material has proved to be of great service in the identification of species described in the publications of the State Geological Survey. Much kindly interest has been shown, and great assistance given in the preparation of this paper, by those chiefly interested in extending our knowledge of West Coast geology, and especially of Pacific Coast Cretaceous deposits.

It is not improbable that when the Cretaceous fauna of California becomes better known many of the species that have been described as new will prove to be either identical with, or very closely allied to, Atlantic or to other Pacific forms. It is with this feeling that many of the names are proposed in the present descriptions; but an identification of this kind will not be retarded by the attachment of mere names, while the published descriptions of these forms will, it is hoped, stimulate closer comparison.

It is evident to any one familiar with the different types of the genera *Lytoceras* and *Desmoceras* that too much laxness has been allowed in the determination of species. Forms that have barely more than a general resemblance have been included under a common name. Note, for example, *Desmoceras jugalis*, *Desmoceras hoffmanni*, *Lytoceras batesi*, and many others.

BRACHIOPODA

1. Rhynchonella densleonis, sp. nov.

PLATE VII, FIGS. 157 AND 158.

Shell of medium size, attaining a diameter of 11-12 mm.; trigonal; gibbous; when full grown, the greatest convexity being near the middle; posterior lateral margins straight, sloping from the beak at an angle of about 90 degrees; anterior margin somewhat broadly rounded; dorsal valve more convex than the ventral, nearly globose; ventral valve flattened, though bearing a deep sinus; anterior half of each valve bearing strong, rounded or angular plications which disappear on the posterior portion of the shell; surface of both valves bearing fine striations most plainly seen on the posterior half of the shell. The sinus of the ventral valve bears three or four plications, while the corresponding prominence on the dorsal valve bears four or more; beak not very prominent and only slightly curved; deltidium small; width of shell greater than length.

This species seems to be very closely related to *Rhynchonella gnathophora* Meek.[1] Whiteaves states that *R. maudensis* Whiteaves[2] also resembles Meek's species, and it is therefore not unlikely that the two Cretaceous species are identical.

Occurrence.—This species is not uncommon at Horsetown, Shasta County, California, in the uppermost beds of this division. In this respect it may also agree with *R. maudensis*.

2. Rhynchonella whiteana, sp. nov.

PLATE VII, FIGS. 160 AND 161.

Associated with the former species is another somewhat related form, with a finer and more subdued sculpture. The ventral sinus bears about nine or ten plications of uniform size and none of the strong folds of the other. The shell is rather circular in outline. The dorsal valve is crossed by two diverging ridges meeting on the anterior margin the borders of the ventral sinus.

---

[1] Pal. Cal., Vol. I, p. 39, Pl. VIII.

[2] Mes. Foss., Vol. I, p. 252.

LAMELLIBRANCHIATA

3. Inoceramus adunca, sp. nov.

PLATE IX, FIGS. 188 AND 189.

Shell equivalve or nearly so, narrowly oval; margin elliptical; anterior side short, rounded, sloping rapidly from the beaks; base forming a broad curve; posterior side longer than high, meeting the basal margin in a rounded point; beaks high, very prominent and full, forming a strongly curved hook; surface having moderately strong concentric ridges, not regularly disposed.

Length of shell 5.8 cm.; height 3.15 cm.; thickness of each valve 2.25 cm.

This shell recalls by its strongly curved beaks some of the species of the Colorado group of the Upper Missouri section.

Occurrence.—A single specimen of this shell was found at the Forty-nine Mine, near Phœnix, Oregon, associated with species of *Schlœnbachia*, *Scaphites*, *Lytoceras*, and *Desmoceras*. It apparently belongs to the horizon of the Lower Chico.

4. Inoceramus klamathensis, sp. nov.

PLATE IX, FIGS. 185 AND 186.

Shell small, not attaining a size much above that shown in the figures, inequivalve, the left valve being much more strongly arched, the right being somewhat flattened, or compressed; left valve showing a tendency to form an umbonal angle and depression at mature age; hinge line short, and forming an angle of 60 degrees with the anterior margin.

In the largest specimen found the length of the shell from the point of the long, narrow beak to the extreme border is about 40 mm., width 25 mm.; curvature of the left valve about 15 mm.

Occurrence.—This species was found in the Lower Chico beds of Willow Creek, Siskiyou County, California, and at the Forty-nine Mine in Southern Oregon.

5. Pholadomya anaäna, sp. nov.

PLATE VII, FIG. 151.

Shell gibbous, oval, rounded on the anterior and lower margins, narrowing rapidly behind; beaks subcentral, but a little in advance of the middle, high and incurved; surface marked with fine, regular, concentric lines; radiating ridges, usually six in number, crossing the posterior surface, the last and heaviest one followed by a groove extending from the beak to the margin; hinge not distinct.

Length of shell, 2.5 cm. or more; height, 2 cm.; thickness, 1.6 cm.

Occurrence.—The species is known from five or six specimens obtained by Dr. Fairbanks from the Santiago and the Silverado canyons of the Santa Ana range in Orange County, California. It was associated with *Pectunculus pacificus*, *Schlœnbachia gabbi*, and other species known only in the Lower Chico. The same, or a very similar species, is reported by Dr. Smith from the Lower Chico of the San Fernando Mountains, Los Angeles County, California.

6. **Pectunculus pacificus**, sp. nov.

PLATE VII, FIG. 159.

cf. *Pectunculus subplanatus* STOL., Pal. Ind., Vol. III, p. 347, Pls. XVII and XLIX.

Shell subcircular, compressed; beaks central, low, sometimes a little prominent; surface nearly smooth, yet marked with fine radiating striæ and a few faint lines of growth; thickness of shell two-thirds the vertical diameter; hinge-margin angularly truncated in some specimens, both anteriorly and posteriorly; diameter generally 1.5 to 3 cm.

Occurrence.—The type of this species was obtained by H. W. Fairbanks from the Santiago Canyon of Orange County, California, where it is associated with *Schlœnbachia gabbi*, *Baculites fairbanksi*, and other species that are known only from the lower portion of the Chico. It occurs also in the lower Chico beds of Southern Oregon, at the Forty-nine Mine, and the Smith ranch.

The type of this species is the property of Dr. H. W. Fairbanks, Berkeley, California.

7. **Mactra gabbiana**, sp. nov.

PLATE VII, FIG. 156.

Shell moderate in size, somewhat resembling *M. ashburneri* Gabb, but generally with a heavier shell, and more strongly grooved concentrically; umbonal angle strongly marked, especially near the base; anterior surface flattened but not excavated.

Gabb appears to have seen this species in the Chico beds of California, but did not distinguish it from *M. ashburneri* Gabb.

Occurrence.—This species occurs in the Lower Chico beds of Henley and Willow Creek, in Siskiyou County, and in the Santa Ana and Temescal mountains of Los Angeles and Riverside counties, in California.

GASTEROPODA

8. Haliotis lomaënsis, sp. nov.

PLATE IX, FIG. 183.

Shell small, length 1.3 cm., oval, the two lateral margins nearly equally curved; convex, the back angled at the row of perforations; spire low, indistinct, not terminal; lips continuous around the spire end, expanded along both sides, forming a thin margin; muscle-impression central, oval, slightly roughened; perforations four, preceded by a slight marginal notch, and produced ridge behind; surface marked by concentric lines extending around the entire body-whorl near the margin; radial lines also seen; convexity of shell about one-fourth the length; width five-sixths the length.

This shell appears to resemble in many respects Tryon's group of *H. iris.*

Occurrence.—The type of this interesting species, which is in the collections of the State Mining Bureau, San Francisco, was obtained by H. W. Fairbanks from the Lower Chico of San Diego County, California. A single specimen was found in the beds at Point Loma, associated with *Pecten californicus*, *Actæonina pupoides*, and Upper Chico forms; but below the beds contain *Coralliochama orcutti*, according to the statements of Dr. Fairbanks. It is doubtless the oldest *Haliotis* known, being somewhat lower in position than the *H. antiqua* Bink. of the Maëstricht beds.

9. Erato veraghoörensis (?) *Stol.*

PLATE IX, FIGS. 181 AND 182.

Erato (?) veraghoörensis STOL., Paleont. Ind., Vol. II, p. 59, Pl. IV, fig. 14, etc.

Shell ovate, more inflated posteriorly; spire low though distinct, about one-eighth of the entire length of the shell; outer lips thickened and reflexed, broadly rounded, denticulate with fine ridges on the inner margin; aperture narrow, somewhat S-shaped, a little wider at anterior end; shell notched both before and behind; inner lip rounded, not known to be toothed; surface smooth and polished. The outer lip is slightly expanded posteriorly in an ear-like elevation that rises to a level with the low spire. The anterior end of the inner lip is bent a little downward just before reaching the forward notch. Both notches are somewhat shallow, the posterior one showing an upward curve or groove between the spire and the ear-like expansion of the outer lip.

Occurrence.—One good specimen of this shell was found at the Smith ranch, Oregon.

10. **Gyrodes siskiyouensis**, sp. nov.

PLATE VIII, FIGS. 167 AND 168.

Shell moderate in size, subglobose, though a little compressed, spire low; upper surface a little flattened near the suture, forming a narrow ledge and angle; the whole surface plainly marked by revolving lines, most developed near the angle above; umbilicus open and slightly angled; no lines of growth visible, except on perfectly preserved shells.

Occurrence.—This shell is common on the north slope of the Siskiyou Mountains, in the Chico beds. It occurs with *Desmoceras ashlandicum*, and *Cucullæa truncata*, and many other gasteropods and bivalves that belong to the Chico.

11. **Anchura condoniana**, sp. nov.

PLATE VIII, FIG. 179.

Shell large, robust, with high spire; whorls about eight in number, moderately rounded; surface of spire ornamented by twenty or more longitudinal ridges; body-whorl entirely covered by longitudinal and revolving ridges equally developed; lip long and falcate, extending laterally, but bearing a spur-like process near the spire; lip strongly angled along the back, with angle extending upon the body-whorl; lip also bearing an angle on its outer margin.

Occurrence.—This species was found in the Lower Chico beds of the Forty-nine Mine, near Phœnix, Oregon, associated with many species of *Schlœnbachia* and *Scaphites*.

CEPHALOPODA

NAUTILOIDEA

12. **Nautilus gabbi,** sp. nov.

Nautilus texanus (?) (SHUM.) GABB, Pal. Cal., Vol. I, p. 59, Pl. IX.

There is in *N. gabbi* about the same number of septa that Stoliczka states commonly occurs with *N. kayeanus*; the umbilicus is similarly small, though not closed, the position of the siphuncle is subcentral, a little nearer the base of the septa, and the ornamentation of the shell is the same in so far as the flexuous radial markings are concerned. There is the same backward curve upon the ventral surface. Small specimens of the Shasta species show in addition to this some fine revolving striæ that give a beautiful cross-hatched sculpture that is not seen in any of the older specimens.

This species of *Nautilus*, which Gabb doubtfully referred to the Texan species, has recently been collected upon Cottonwood Creek, by Dr. J. P. Smith. It agrees in all respects with Gabb's figures, and it seems probable that it was from one of the specimens obtained from Shasta County that the figures were made. Gabb reports the species also from Mount Diablo, but the identity of the two species ought to be accepted with hesitation. It resembles in some respects *N. campbelli* Meek from Comox, Vancouver Island, and might be mistaken for this species.

Nautilus gabbi is closely related to *N. kayeanus* Stol. from the Ootatoor beds of Southern India. Stoliczka considers his species a representative of a group of associated forms, one of which he identifies with *N. pseudo-elegans* d'Orbigny.

Occurrence.—*Nautilus gabbi* is found in the Upper Horsetown beds of Shasta County, California, though its range has not yet been ascertained.

Two specimens of a *Nautilus* labeled "Claytons, Contra Costa County" are among the Pioche collection at the University of California. They apparently belong to a distinct species, in which the umbilicus is entirely covered by a thick callous, and which has a characteristic ornamentation of surface. The dark coloration is preserved upon the portion covered by the body-whorl in one of the specimens, and the outermost layer is marked by minute granulations that have a systematic arrangement in rows parallel to the median plane.

13. Nautilus charlottensis *Whiteaves*.

Nautilus suciaënsis WHITEAVES, Mes. Foss., Vol. I, 1876-84, p. 197, Pl. XXI.
Nautilus charlottensis WHITEAVES, Mes. Foss., Vol. I, p. 269.

A fine example of this species was found at Horsetown, Shasta County, California; it is in the museum of Stanford University. Whiteaves reports it from the Upper Cretaceous of the Queen Charlotte Islands. In the Horsetown examples the siphonal tube is perhaps a little lower in its position than in the northern specimens. It appears to be very similar to *N. pseudo-elegans* d'Orbigny,[1] although the position of the siphonal tube is a little higher than in d'Orbigny's figure. There is a relationship between *N. gabbi* and *N. charlottensis*, similar Indian species mentioned in the preceding description.

14. Nautilus sp.

Among the collections obtained by Dr. Bowers from the Santa Ana Mountains are two imperfect specimens of *Nautilus* that appear to be related to *N. gabbi* and *N. charlottensis*, though not identical with either. It forms, perhaps, a third member of this group belonging to the Pacific border province.

AMMONOIDEA.

15. Placenticeras californicum, sp. nov.

PLATE VIII, FIGS. 173-177.

The shell is discoidal, compressed, narrowing regularly from the umbilical region outward; inclined to be rough or with coarse ribs; costæ flexuous, extending to the umbilicus, and terminating outward in tubercles upon the

[1] Pal. Franc. Terr. Cret., Vol. I, Pls. IX and XIX.

peripheral angle; tubercles elongated and narrow, standing in single rows on either side of the ventral surface, and opposite one another. The ribs are low and rounded, and about equal in width to the intervening furrows. On old shells they reach the number of about forty on an entire whorl, while on younger shells the number is generally less. The ribs incline strongly forward on leaving the umbilicus, but about the middle of the shell describe a sharp curve backward, followed by a more gentle forward curve on approaching the marginal tubercles. Upon the periphery the space between the rows of tubercles is flattened and band-like, being equal in width to one-third the thickness of the shell. The early stages of this shell have been described by Dr. J. P. Smith,[1] and its relations to the next species stated.

Hitherto the genus *Placenticeras* has been but little known in the Cretaceous of the Pacific border. Two allied species have recently been recognized in the Lower Chico beds in widely separated districts in California and Oregon. In the above named species the shell is of moderate size, the largest specimen having the following dimensions:—

Diameter	120 mm.
Height of last coil	58 mm.
Width of last coil	30.5 mm.
Width of umbilicus	23 mm.
Involution	13 mm.

Occurrence.—This shell is known from the Lower Chico of Phœnix, Henley, Arroyo del Vallé, and the San Fernando Mountains.

The type is in the collections of the University of California.

16. Placenticeras pacificum *Smith.*

PLATE VIII, FIGS. 162–164 AND 171–172; PLATE IX, FIG. 180.

Placenticeras pacificum SMITH, Proc. Cal. Acad. Sci., 3d Ser., Geol., Vol. I, pp. 207–210, Pls. XXV–XXVIII.

Shell discoidal, involute, compressed, and moderately smooth; size of largest shell about 16.5 cm. in greatest diameter. The species is related to the preceding and superficially differs from it chiefly in being smoother and more graceful in its ornamentation. As shown in the figures and description (l. c.), in its younger stages it is characterized by its smooth form, without ribs or tubercles. The development of the two species is entirely different.

---

[1] Proc. Cal. Acad. Sci., 3d Ser. Geol., Vol. I, p. 181.

Occurrence.—The species occurs with the preceding at Phœnix, Henley, and Arroyo del Vallé, and Dr. Smith states that he has found it in the Lower Chico beds of the Silverado Canyon, Orange County, California.

17. **Phylloceras shastalense,** sp. nov.

Plate IV, Figs. 112-115.

Shell small, inflated, not globose, rapidly increasing in width; section of body-whorl nearly circular, but in younger stages elliptical; umbilicus closed, or not showing any of the earlier whorls, except in minute specimens; surface crossed by transverse ribs that are tolerably coarse compared with those of other species lower in the series. The ribs begin at the umbilical depression and run transversely over the ventral surface, making only slight curves. The diameter of the largest specimen found is 3 cm., from which most of the body-chamber is missing. The suture is clearly that of a *Phylloceras*. It does not appear to be closely related to either of the previously known forms of this genus from the Pacific Coast. It is more nearly allied to *Ammonites rouyanus* d'Orbigny[2] though less flattened ventrally than this species, as represented in the figure.

Occurrence.—This species is quite common at Horsetown, Shasta County, California, where four or five good specimens were recently collected.

The type is in the collection of the University of California.

18. **Schlüteria diabloënsis,** sp. nov.

Plate III, Figs. 105-106.

Among the ammonites labeled by Gabb "*Am. jugalis*" is an undescribed species of *Schlüteria* for which the name *S. diabloënsis* is here proposed.

The greatest diameter of the largest specimen is 2.5 cm., with a thickness near the umbilicus of 1.2 cm. The umbilicus is small, with sides that become very abrupt at this diameter, though the younger portion of the shell shows more gentle slopes. The sides are apparently smooth or marked with a few faint transverse grooves, and are flattened and gently converge outward. The fine lines of growth curve a little backward after crossing the umbilical shoulder. The suture is that of a *Desmoceras*, though in shape and general appearance the species might be considered a *Phylloceras*.

---

[2] Pal. Franc. Terr. Cret., Vol. I, Pl. CX, figs. 3-5.

Occurrence.—The specimen from which the figures have been drawn is labeled "Mt. Diablo," and being in a collection with several others of the same species from Curry's is probably also from that locality. Other species from this locality, as stated elsewhere, show a low horizon of the Chico.

The type is in the collection of the University of California.

19. Lytoceras rel. duvalianum *d'Orb.*

PLATE VI, FIGS. 140-143.

Ammonites duvalianus D'ORB., Pal. Franc. Terr., Vol. I, Pl. L.

Among the close allies to European forms found in the Cretaceous of the Pacific Coast, there are few that seem more truly identical than this one. If d'Orbigny's figure represents the suture of this species correctly, both lobes and saddles are relatively narrower in the California types, otherwise there is but little difference, unless it is in the less equal division of the lobes. The form of the shell and its surface markings are too nearly like d'Orbigny's species to justify any other name being applied at present. There are certainly greater ranges of variation recognized in nearly all Californian types than there appear to be between the specimens from California and the European form as figured by d'Orbigny.

In the young shell from the Shasta beds the constrictions are scarcely noticeable but begin to appear upon the sides, without crossing the ventral surface, at a diameter of 3 cm. They reach their clearest development at 4 or 5 cm., and then again diminish. At first they form upon the sides only broad, undulatory ridges, between which the constrictions become more sharply defined with growth, becoming deeper upon their posterior margin and diminishing in depth forward. Between the constrictions, which are about twenty in number, the surface is covered by fine transverse lines, yet the shell has an almost polished appearance. The section of the whorl is quadrate in the adult but is more rounded upon the ventral side in youth. The walls of the umbilicus are abrupt, and the involution covers about one-half of the width of the whorl.

Occurrence.—Two good specimens of this species, one of which is the type, were found near the mouth of Hulen

Creek, and three were obtained at Horsetown, Shasta County, California. *Lytoceras duvalianum* d'Orbigny is found in the Neocomian of Europe.

The types of this species are among the collections of the University of California.

20. Lytoceras (Tetragonites) jacksonense, sp. nov.

Plate V, Figs. 124-125.

Shell moderately compressed, rounded, smooth; size of type 6.33 cm. in diameter; umbilicus rather narrow, walls steep, rounded on the shoulders; involution covering the larger part of the preceding coil; section subcircular, somewhat quadrate, slightly thicker near the umbilical shoulder, from which zone the sides slope gently toward the periphery. Faint grooves are to be seen obliquely crossing the sides and inclining forward, and forming upon the ventral surface a wide, backward curve, very much as is seen in the next species, to which this one is somewhat related. Faint lines of growth are barely perceptible upon the portions of test yet remaining, which are parallel to the grooves. The suture consists of four or five very much divided saddles, narrow, and unequally bifid, the outer branch of which is the smaller. The lobes are relatively wider, with branches terminating in pointed denticles. The division of the lobes is more equally bifid than that of the saddles. Both lobes and saddles diminish uniformly in size from the external side inward to the umbilicus. The small siphonal saddle is narrow and denticulate.

Occurrence.—A single specimen of this shell was obtained from the Forty-nine Mine, near Phœnix, Oregon. The locality has been referred to the Lower Chico beds in the body of this paper.

The type of the species is in the California Academy of Sciences.

21. Lytoceras (Gaudryceras) sacya *Forbes.*

Ammonites sacya Forbes, Trans. Geol. Soc. Lond., Ser. II, Vol. VII, 1845-56, p. 113.
Ammonites sacya (Forbes) Stol., Pal. Ind., Vol. I, p. 154, Pl. LXXV.
Ammonites whitneyi Gabb, Pal. Cal., Vol. II, p. 134, Pl. XXII, 1869.
Lytoceras sacya Whiteaves, Mes. Foss., Vol. I, 1876-84, Pt. I, p. 43, etc.
Lytoceras (Gaudryceras) sacya Whiteaves, Mes. Foss., Vol. I, 1876-84, Pt. IV, p. 270.

In the upper portion of the Horsetown beds this species is fairly abundant and generally takes the place of

Lytoceras batesi, occurring lower in the series. *Ammonites whitneyi* has not yet been clearly recognized as a distinct species, and to any one familiar with the fauna of this horizon there can hardly be a doubt that Gabb's species and *Lytoceras sacya* are the same. Gabb's figure is apparently defective, showing too deep and too early constrictions on the shell. On older specimens of *Lytoceras sacya* these appear to be constant, but are lacking on shells below a diameter of 6.33 centimeters.

Occurrence.—*Lytoceras sacya* occurs in the Upper Horsetown beds of California, and the Lower Chico beds of California and Oregon, and in beds equivalent to the Upper Horsetown on Queen Charlotte Islands.

22. Lytoceras (Gaudryceras) kayei *Forbes.*

Ammonites kayei FORBES, Trans. Geol. Soc. Lond., Ser. II, Vol. VII, 1845–56, p. 101.

Ammonites kayei (?) (FORBES) STOL., Pal. Ind., Vol. I, p. 156, Pl. LXXVII, fig. 1.

Lytoceras kayei FORBES, STEIN., Jahrb. f. Min., etc., Beil.-Bd. X, 1895–96, p. 86.

Shell discoidal, thin, increasing very slowly in diameter; section of the whorls transversely elliptical; umbilicus wide and shallow, coils small, ornamentation simple, surface crossed by oblique lines and a few moderately deep grooves. Septation well represented by Steinman's figure (l. c., p. 87).

There are few more interesting discoveries here noted than the identification of this characteristic Upper Cretaceous species from the Chico beds of California. The shell in all of its details of ornamentation and sutures is almost the exact facsimile of the species from the west coast of Chile and from the Pondicherri District of Southern India, as well as can be judged from the figures.

Occurrence.—A single well preserved specimen from Mount Diablo is in the collections of the University of California.

23. Lytoceras (Tetragonites) cala (?) *(Forbes) Stoliczka.*

cf. *Ammonites cala* FORBES, Trans. Geol. Soc. Lond., Ser. II, Vol. VII, 1845-56, p. 204.
Ammonites cala (?) (FORBES) STOL., Pal. Ind., Vol. I, p. 153, Pl. LXXV.

In the collections of Lorenzo G. Yates, temporarily deposited at Stanford University, are several specimens of a *Lytoceras* of the genus *Tetragonites*, which appear to be referable to *L. cala*, as described by Stoliczka. They have been compared with both Forbes' and Stoliczka's figures, but so far as can be ascertained by this means they agree more nearly with the latter. They are from the Arroyo del Vallé, eight miles southeast of Livermore, Alameda County, California.

In all respects they agree perfectly with Stoliczka's description. The shell is evidently a close relative of Forbes' species, which could be distinguished from it only by a comparison of types.

Shell discoidal, flattened on the sides, and of a diameter not exceeding 7.6 cm.; umbilicus wide and shallow, with abrupt walls; involution very little, clasping little more than the flattened ventral surface; shell increasing slowly in size with growth; section of whorls tetragonal; suture consists of three lobes on each side, with auxiliary lobes much reduced, upon the umbilical surface. The siphonal lobe is broad, divided by a denticulated tongue-shaped siphonal saddle.

Occurrence.—There are in the Yates collection four or five specimens of this shell, all of which have been obtained from the Jordan ranch on the Arroyo del Vallé, eight miles southeast of Livermore, Alameda County, California. The horizon is that of the Lower Chico. Stoliczka says *L. cala* is from the Ootatoor beds of India.

24. Lytoceras batesi *(Trask) Gabb.*

Under the specific title of *Ammonites batesi* Gabb included three quite clearly marked species which he recognized as only varieties. In all the larger collections of Cretaceous fossils in California there are numerous specimens of related forms bearing this name. The confusion is the result of Gabb's failure to recognize the true differences in these forms. The various representatives of the species, as understood by Gabb, for the most part may be easily separated into this and the two following types: *Lytoceras batesi* TRASK (s. s.), Proc. Cal. Acad. Sci., Vol. I (2d Ed.) 1855, p. 39; Pal. Cal., Vol. I, p. 67, pars., Pl. XIII.

The most striking difference between this species and the next one is in the rate at which they increase in diameter with growth. In Trask's original type this increase was relatively slow. According to his description, at a diameter of 14 cm. the width of the aperture measured 3 cm. Gabb's figure[1] was probably drawn from Trask's type specimen. According to Trask, the section of the whorl is about circular ("convolutions nearly round"). Both these characteristics were overlooked by Gabb, who included with it two species very different in both these respects.

Occurrence.—It is not easy to decide the exact range of this species from the statements of Gabb. Evidently, though, it is found well toward the bottom of the Horsetown, and seems to have a wide stratigraphical range.

25. **Lytoceras argonautarum**, sp. nov.

PLATE VII, FIGS. 154–155.

Ammonites batesi (pars.) GABB, Pal. Cal., Vols. I and II, 1863.

Shell discoidal, somewhat inflated, increasing rapidly in size; section of whorls not quite circular, flattened slightly on sides and ventrum; umbilicus deep, walls rapidly becoming steeper outwardly; involution slight, like that of the preceding species; suture similar to that of *Lytoceras batesi*, but correspondingly heavier and less regular; lateral lobes not equally bipartite, small siphonal saddle lanceolate, with minute denticulations; surface ornamented with rounded, evenly spaced ridges, separated by wide, smooth, and shallow grooves, and in this respect unlike *L. batesi.*

The type from which the figure was drawn was obtained by Dr. J. P. Smith, one and one-half miles east of Ono, Shasta County, California. Its greatest diameter is 17.1 cm.,

[1] Pal. Cal., Vol. I, Pl. XIII.

while the corresponding width of the umbilicus is 5.7 cm. The specimen is the inner coil of a much larger shell, 30 cm. in diameter. The aperture is not circular, but has a width of 8.4 cm., and a depth of 7 cm. In this specimen the removal of one complete volution would reduce the diameter to 3.3 cm. Another specimen of the same species in the collections of the University of California, measuring a little over 40 cm. in diameter, would, by the removal of two complete volutions, be reduced to almost the same dimensions, 3.3 cm. The aperture of this gigantic specimen measures 15 cm. in diameter. It does not contain the whole of the body-chamber, which would have considerably increased its diameter. This is evidently the species represented by the specimen to which Gabb has alluded[1] as the "largest known species of California." It is not very difficult to recognize even the young shells of this species when compared with typical specimens of *L. batesi* of the same diameter, or of the same number of coils. A specimen of this shell in the collections of the University of California measures sixteen inches in greatest diameter.

Occurrence.—This species is found in the upper portion of the Horsetown, though its downward range is not known. Dr. Smith states that he has found what is probably the young of this species associated with *Phylloceras ramosum* Meek and *P. onoënse* Stanton in the Lower Chico beds of Arroyo del Vallé, Alameda County, California.

Lytoceras argonautarum, as Gabb has stated, is the largest ammonite known from the Cretaceous of California. The name is proposed in honor of the "argonauts" and gold-seekers of the pioneer days of California and the Pacific Coast. This gigantic cephalopod appropriately commemorates the motive and heroic spirit of these sturdy and brave adventurers who so often struggled with hardships even greater than those described in traditionary history.

---

[1] Pal. Cal., Vol. I, p. 67; Vol. II, p. 132.

26. Lytoceras (Gabbioceras) angulatum, sp. nov.

PLATE VI, FIG. 139.

Ammonites batesi (pars.) GABB, Pal. Cal., Vol. II, p. 132, Pls. XX and XXI, figs. 9 and 10, 1863.
Gabbioceras batesi HYATT, Phylogeny of an Acquired Characteristic.

One of the species which was believed by Gabb to be only a variety of *Ammonites batesi* has below the diameter of 3.8 cm. a strongly angular section. There are few who will maintain the identity of these species even upon an inspection of Gabb's figures.

In the collections of the University of California are three well preserved examples of this shell, from which the drawing (fig. 139) was made. One of the specimens has the aperture complete, though crushed. It has been restored in the figure. The shell does not apparently attain a large size. Two of the specimens seem to be mature and are less than three inches in diameter.

The involution of the shell is considerably greater than either of the preceding species which Gabb included under the name *Ammonites batesi*. The body-chamber, which in these specimens occupies almost a complete whorl, is crossed superficially by a few moderately strong, transverse, sinuous grooves not evenly distributed. The shell between these is polished, though marked with a few fine lines which bend gently backward within the umbilicus.

The shell increases rapidly in size after losing its angular character at a diameter of one inch or less.

Occurrence.—The stratigraphical position of this species can not be given with certainty. The specimens are all labeled "Cottonwood Creek, Shasta County." They are probably from the Horsetown beds of that region.

27. Hamites ellipticus, sp. nov.

PLATE III, FIGS. 102–103; PLATE X, FIG. 191.

Shell compressed, elliptical in section, more narrowly rounded upon the ventral or siphonal side than upon the dorsal; surface ornamented with simple and narrow transverse ribs separated by wider, rounded grooves; no nodes or tubercles shown; suture line complex, consisting of six lobes and six saddles, each bifid, and showing the same tendency in all of the smaller divisions; both lobes and saddles widely branching, the former terminating in sharp denticular points, while the latter become more rounded in their terminations. The siphonal lobe is bipartite, with diverging branches, each of which is further divided, and above which is a smaller, secondary spur or branch. The antisiphonal lobe is more simple, consisting of an elongated and irregularly toothed neck, tripartite in its termination. The first lateral lobe is wider, though not quite so long as the second, and more regularly divided. The second lateral saddle is both broader and higher than the first one, and in its location occupies the middle of the rounded side. A single constriction is to be seen upon the fragment found, though it is not clear that this is not accidental. It consists of a broad and flattened depression (7.5 mm. in width) upon the sides and ventral edge, which is not altogether regular in its form. In front it is bordered by an oblique, rounded constriction one millimeter wide, against the posterior side of which terminate four or five of the preceding ribs. The succeeding ribs are thus set at an angle which places them not quite parallel with those preceding this broad depression of the sides.

Occurrence.—Forty-nine Mine, near Phœnix, Oregon.

The type is in the California Academy of Sciences.

28. **Hamites phœnixensis,** sp. nov.

Plate III, Fig. 104.

Shell small, cylindrical in section, bent in one plane into a hook-like curve; surface ornamented with slightly oblique, transverse ribs inclining a little forward in passing from the inner to the ventral side of the whorl; ribs a little stronger on the ventral than upon the dorsal side, some rising considerably above the rest in approaching the ventral surface; whorls crossed at intervals by small rounded constrictions, not distinctly shown in the figure. The ribbing is not quite regular in the vicinity of the reflex curve, and there seems to be a slight deviation from a true plane in this portion; and this seems to be still further indicated by the ribbing, which is not quite symmetrical at this point.

The septation of this species is not known. In its form and sculpture, except for its lack of tubercular ornamentation, it resembles *Hamites royerianus* d'Orbigny, which is said to come from the Neocomian of Europe; and in all respects except size it resembles *H. cylindraceus*, as figured by Whiteaves, from the Sucia Islands. It may be a small representative of this western species.

Occurrence.—This species is from the Lower Chico beds of the Forty-nine Mine, near Phœnix, Oregon.

The type is in the California Academy of Sciences.

29. Hamites cylindraceus *de France.*

Hamites cylindraceus (D'ORB.) DE FRANCE, Pal. Franc., Vol. I, Pl. CXXXVI. SCHLÜTER, Paleontographica, Vol. XXI, p. 103, Pl. XXXI. ? not *H. cylindraceus* (DE FRANCE) WHITEAVES, Canada Geol. Sur., Mes. Foss., Vol. I, 1876–84, p. 113, Pl. XIV.

Among the fossil cephalopods collected in Southern Oregon is one that closely resembles *H. cylindraceus*, as figured by Schlüter (l. c.), belonging to the Upper Cretaceous of Europe. The suture line is not visible on any of the specimens collected, but in their superficial features they agree too nearly with the European species to justify any other determination.

Shell not large, nearly cylindrical in section; elongated in the later portion, straightened and recurved into a hook-like bend with two parallel arms; surface crossed by simple annular ribs which are usually oblique to the axis, without nodes or noticeable irregularities, except in direction. Some of the ribs show a tendency to arrange themselves in planes perpendicular to the axis of the shell, but the inclination is generally forward on the siphonal side. The ribs are narrow and ridge-like, and separated by furrows which are rounded on the bottom and at least twice as wide as the ribs themselves. The diameter of the body-chamber in the largest specimen obtained is about 1.7 centimeters. All the specimens lack the band-like constrictions seen on the species described by Whiteaves from the Sucia Islands.

30. Hamites armatus, sp. nov.

PLATE V, FIGS. 130–132.

Shell of medium size, attaining a greater diameter of about 20 mm.; elliptical in cross-section; surface ornamented with regular rounded ribs inclining obliquely forward; body-whorl crossed by strong constrictions about 30 mm. apart, between which there are about twelve or thirteen parallel ribs; every fifth or sixth rib armed near the siphonal line with two widely diverging spines, attaining a length of 6 or 7 mm.; the intervening ribs also armed but with shorter spines. The area between each pair of longer spines is somewhat flattened, and marked by a narrow oval, especially when two of the ribs coalesce to form the spine-like tubercles. The septum of this extraordinary species is not yet known, but it is probably sufficiently well characterized.

Occurrence.—This shell was found in the Lower Chico beds near Henley, Siskiyou County, California. It was found associated with *Pachydiscus henleyensis, Desmoceras* *sugatum*, *Placenticeras californicum*, *P. pacificum*, and other Lower Chico forms.

31. Hamites (Ptychoceras) æquicostatum *Gabb.*

Ptychoceras æquicostatum GABB, Pal. Cal., Vol. I, p. 74, Pl. XIII, fig. 20; Vol. II, Pl. XXV, figs. 20, *e* and *f*. Not *Helicancytus æquicostatus* GABB, Pal. Cal., Vol. II, p. 141, Pl. XXV, figs. 20, *a–d*.

Ptychoceras æquicostatum, as originally described by Gabb, is a true representative of this genus, and usually not difficult to recognize as such; it is not uncommon in the Upper Cretaceous beds of Shasta County.

On the larger branch of the shell the transverse ribbing is rather heavy, and without ornamentation; the ribs themselves are high and narrow, the intervening spaces rather broad and concave. On the smaller branch the ribs are much less prominent, and the intervening spaces correspondingly shallow; many of the ribs, at least, are ornamented with lateral, mammillary tubercles. Between the ribs which are so ornamented there are subordinate ridges that appear to be simple; and with these there are also subordinate striations.

These markings can be detected on Gabb's types and on other examples which are among the collections of the University of California.

In Gabb's revised description of this species[1] quite another genus (which Zittel refers to *Lindigia*, with some doubt) has been confused with this species, and both are placed in the genus *Helicancylus*.

32. Hamites (Ptychoceras) solanoënse, sp. nov.

PLATE IX, FIG. 184.

Shell of moderate size; smaller branch of the type 15.5 cm. in length, with an average diameter of 14 mm.; tapering very gradually from small end to the recurved portion; surface marked by regular, simple, and rounded transverse ribs which are almost without ornamentation. There are seventy-five of these ribs on the whole length of the small branch, evenly distributed throughout. The only ornamentation noticed on these ribs are rows of very faint tubercules on the ventral surface, on either side of the median plane, most noticeable near the curve. On the dorsal side, which is somewhat flattened, the ribs are nearly suppressed. On the recurved portion they are also apparently less prominent.

[1] Pal. Cal., Vol. II, 1863, p. 141. See also *Lindigia ? nodosum*, this paper, page 92.

Occurrence.—The type of this species is in the collection of the University of California. It was obtained from the Cretaceous beds near Vacaville, Solano County, California, by Mr. F. A. Steiger.

33. Helicoceras indicum (?) *Stol.*

PLATE III, FIGS. 96-97.

cf. *Helicoceras indicum* STOL., Pal. Ind., Vol. I, p. 184, Pl. LXXXVI.

Shell small, coiled in a spiral, first to the right to a diameter of .7 cm. and then reversed; section of whorls at first nearly circular, but afterward elliptical; surface marked by oblique transverse ridges not quite evenly spaced, also by three or four constrictions. Diameter of spiral, 2 cm.; septation unknown.

Occurrence.—A single specimen was obtained from the Smith ranch, two and one-half miles southwest of Phœnix, Oregon, and belongs to the horizon of the Lower Chico.

The type here described is in the collection of the California Academy of Sciences.

34. Heteroceras ceratopse, sp. nov.

PLATE III, FIGS. 100-101.

Shell elliptical, or subcircular in section, very helicoid, forming widely open coils in mature age; coiled sometimes toward the right and sometimes toward the left, and therefore neither in one plane nor in a regular spiral; surface ornamented with numerous transverse striations intervening between much larger and elevated ridges that rise abruptly from the surface of the shell at intervals of a few millimeters. These ridge-like ribs begin upon the dorsal side in elevations hardly distinguishable from the intervening striations, and as they pass downward on the sides they become more and more elevated, until on the siphonal side they are often 1 mm. in height. They are rarely well enough preserved to show their exact character, but appear to be pointed or tuberculated along their thin blade-like summits.

The average diameter of the specimens collected ranges from .5 cm. to 1 cm. The largest fragment has a length of 7 cm. All the fragments show a tendency to curve irregularly and to depart from a simple spiral. The suture line is complex, consisting of bifid lobes and saddles; the lateral saddles show a tendency to tripartite division in their main branches, while the lobes retain their bipartite character throughout. In general form and ornamentation this species resembles very closely *Heteroceras reussianum* d'Orbigny, as figured by Schlüter in "Paleontographia" (Vol. XXI, Pl. XXXII), to which it may be related.

Occurrence.—Found at the Smith ranch, east of Phœnix, Oregon.

Type in the California Academy of Sciences.

35. **Lindigia ? nodosum,** sp. nov.

Helicancylus æquicostatus GABB, Pal. Cal., Vol. II, p. 141, Pl. XXV, figs. 20, *a–g*.

Zittle refers this species doubtfully to the genus above given, which he has placed as a subgenus under *Turrilites*. Gabb figured the type of this species under the name *Helicancylus*. His description needs no special revision, except that the tuberculation is not sufficiently pronounced either in his figures or his description. On the larger coils of the spiral portion these tubercles are large and circular in section, or slightly elongated, and abruptly truncated at the top.

Occurrence.—The type in the collection of the University of California is labeled, "Cottonwood Creek, Shasta County, California."

36. **Baculites fairbanksi,** sp. nov.

PLATE VII, FIGS. 152–153; PLATE X, FIG. 194.

cf. *Baculites vagina* FORBES, Trans. Geol. Soc. Lond., 2d Ser., Vol. VII, 1845-56, p. 114.

cf. *Baculites vagina* FORBES, in STEIN., Neu. Jahrb. f. Min., etc., Beil.-Bd. X, 1895–96, p. 89.

The largest specimen is a fragment about 11.5 cm. in length, and in largest diameter 1.5 cm. It is coarsely ribbed with strongly bent costæ, and shows distinct lines of growth. The section is ovate but does not show the narrow ridge along the siphonal edge as the figures of *B. vagina* appear to require. There is a depression a little below the middle of the side which may represent it, however. There is a much closer resemblance found in the suture, which is composed of broad, bifid saddles and narrow lobes, also somewhat equally divided. The bifid or bipartite character is noticeable even in the smaller divisions of both lobes and saddles.

This species is only distantly related to *B. chicoënsis* Trask, but shows more affinity with the form described by

Meek under that name; yet Meek's species is smooth while this one is costate, and there are some differences to be seen in the septation. Neither does it agree with the costate variety of Gabb, which is that usually found near Martinez.

It appears remarkable that the widely distributed species of cephalopod, *Baculites vagina*, has not been recognized in the California Cretaceous deposits. It occurs both in Southern India and on the west coast of Chile, and ought to be found in the rich deposits of California, Oregon, and British Columbia. Perhaps the nearest approach to it is the above named species, brought from Orange County, California, by Dr. H. W. Fairbanks. There is certainly a very near relationship between the forms from Quiriquina Island and the Santa Ana Mountains of Orange County.

Occurrence.—This species is found associated with many Lower Chico fossils near Silverado Canyon, in the Santa Ana Mountains of Orange County, California. It occurs along with *Anchura californica*, *Actæonella oviformis*, *Pholadomya anaäna*, and *Chione varians*.

Desmoceras.

In the middle Cretaceous of California, forms of *Desmoceras* belonging to the group *D. planulatum* are numerous. Four or five types have been recognized that are capable of specific discrimination, some of them having very strong resemblances to Atlantic forms, such as *D. mayorianum* d'Orbigny.

Among the members of this group is *Desmoceras hoffmanni* Gabb.[1] Gabb seems not to have recognized evident differences among them and accordingly classed all under one species, which does not appear to be justified. More than twenty fairly well preserved specimens of this group in the collections of Stanford University and the University of California may easily be divided into three subgroups. There can hardly be a doubt as to the distinctness of two

[1] Pal. Cal., Vol. I, Pl. XI, not Vol. II, Pl. XX.

of these types, and probably the other is as deserving of recognition. All of them range in diameter below 12.7 cm., while some of them are considerably smaller, ranging down to the diameter of 2.5 cm. Some of the specimens in the collections of the University of California still retain the original labels attached to them by Gabb or other members of the State Geological Survey.

The four succeeding types belong to the group *D. planulatum*.

37. Desmoceras hoffmanni *Gabb*.[1]

PLATE V, FIGS. 120-123; PLATE X, FIGURE 203.

It is not easy to determine which of the several forms of this group should bear the name proposed by Gabb. The species described in Vol. II of the Paleontology of California, and figured on Plate XX, which seems to belong to another type, has not been thus far identified.

In the collections of the University of California are several specimens of a comparatively compressed shell, some of which bear the name *D. hoffmanni*, and appear to be referable to this species, except that the umbilicus is somewhat narrower. Gabb states that in *D. hoffmanni* the umbilicus has a diameter nearly equal to half that of the coil. The six specimens here referred to this species have a quite constant ratio between these measurements of 3.1 : 1, the umbilicus being measured just inside the angles, or shoulders. In the cross-section of the whorl they agree in the main with Gabb's figure,[2] though some of them are relatively thicker. The number of constrictions does not exceed seven or eight, though they are not regularly disposed. The suture agrees in only a general way with Gabb's figure, which is evidently defective. His description of the suture seems better, though it also is unsatisfactory. The suture line consists of a siphonal and several

---

[1] NOTE.—This species has been selected by Alpheus Hyatt for the type of a new genus, *Pleuropachydiscus* of the family *Silestidæ* (Eastman's Translation of Zittel's Paleontology), but there is no apparent reason for such a classification, and paleontologists who are most familiar with this species will probably accept it with hesitation.

[2] Pal. Cal., Vol. I, Pl. II, figs. 13-13*a*.

lateral lobes, diminishing quite regularly in size from without inward. On whorls of a diameter of 10.2 cm. there are five of these lateral lobes which are unequally tripartite, so much so, in fact, that they might almost as appropriately be called unequally bipartite. The saddles are bifid, though they have not the terminations shown in Gabb's figure. Both lobes and saddles are moderately broad in their trunk portions, the lobes regularly so; the terminations of the lobes are digitiform, those of the saddles more or less broadly scolloped. The involution of the whorls is more than one-half and is, in one specimen, nearly two-thirds.

Occurrence.—This species is found in abundance along Cottonwood Creek, Shasta County, California, in the upper portion of the Horsetown. It occurs also at Horsetown itself.

38. **Desmoceras lecontei,** sp. nov.

PLATE III, FIGS. 94 AND 95; PLATE X, FIG. 190.

Shell moderate in size, discoidal, flat, and rather involute; diameter of the largest specimen found, 8.5 cm.; greatest thickness, 2.75 cm.; ratio of the diameter of umbilicus to height of coil, 1:4; section of the whorl quadrate, narrowing slightly toward the periphery; umbilicus narrow, but not deep, the walls abrupt on each whorl, the inner coil forming a flattened ledge; ventral surface rounded or slightly flattened; sides and surface of shell ornamented with radiating, flexuous ribs which bifurcate a little above the middle of the side on some specimens, and branch into three or more divisions on others; ribs at first inclining forward, then backward, and finally forward upon approaching the ventral region. In the more finely sculptured specimens of this species the ribs are rather closely crowded together, while in others they are as much as 2 mm. apart. Both ribs and interspaces are rounded. The ribs do not continue across the ventral surface as a rule, but there are occasional thickened ridges, probably of the nature of varices, upon this surface, occupying the position of about each eighth or tenth rib.

In Gabb's species, as figured in Pal. Cal., Vol. II, Pl. XX, the ratio of the width of umbilicus to height of coil is 1 : 3, the umbilicus being relatively wider than in *D. lecontei*. The figure shown in Pal. Cal., Vol. I, Pl. X, has even a wider umbilicus, and truthfully represents the specimen from which it was drawn. In Gabb's species, furthermore, the ribs are coarser, and the specimens do not show the varices on the ventral surface, clearly seen in *D. lecontei*.

Some specimens collected at Horsetown that are possibly referable to this species have a diameter of 15 centimeters or more.

Occurrence.—The type of this species was found in the Horsetown beds a little to the east of Hulen Creek, Shasta County, California. It is in the collections of the University of California.

39. Desmoceras subquadratum, sp. nov.

PLATE IV, FIGS. 118-119; PLATE X, FIG. 193.

Shell only moderately compressed; width of whorl nearly equal to depth; umbilicus not so wide as in last species, ratio of whole diameter to umbilicus, 3.5:1; section of whorl subquadrate; umbilical wall abrupt, broadly rounded on the back; surface of the cast nearly smooth, showing none or only faint constrictions; surface of shell marked by fine lines of growth and occasional varex-like ridges that form the flexures commonly seen on the shells of this group, bending more strongly forward in crossing the periphery; suture characterized by stout lobes and saddles, lateral lobes four or five in number on shells 7.5 cm. in diameter, decreasing uniformly in size toward the interior; first lateral lobe nearly equally tripartite, the others less so; saddles nearly equally bifid, with rounded terminations; width of shell increases with growth more rapidly than the depth.

This species is possibly one figured by Gabb in the Paleontology of California (Vol. II, Pl. XX) as *Desmoceras hoffmanni* (Pal. Cal., Vol. II, Pl. XX).

Occurrence.—This shell is not uncommon in the upper portion of the Horsetown of Cottonwood Creek, Shasta County, California, near the mouth of Hulen Creek. Four of five good specimens were obtained at this place, some of which are in the collections of the University of California.

The types of this and the preceding species, as here described, are in the collections of the University of California.

40. Desmoceras colusaënse, sp. nov.

PLATE V, FIGS. 128-129; PLATE X, FIG. 200.

In the collections of the State Mining Bureau in San Francisco is a magnificent example of a *Desmoceras* of the group *D. planulatum*, nearly one foot in diameter. It is in perfect state of preservation though broken so that it can be taken apart, revealing the inner coils.

The shell is discoidal and somewhat compressed when small, but increases in thickness very rapidly with growth; width of full grown whorl somewhat less than the depth; ratio of diameter to width of umbilicus, 3.3:1; walls of umbilicus rounded and sloping; section of whorl oval, sloping on the sides toward the periphery; surface ornamented by transverse, rounded ridges with the customary flexure, bending sharply backward within the umbilicus, and forward in crossing the ventral surface. On the younger coils about ten or eleven grooves are to be seen extending parallel to the lines of growth, and are plainest upon the ventral surface. The involution covers nearly two-thirds of the inner coils. The distinguishing features of this species are: (1) the oval section of the whorl; (2) the rapidly increasing thickness of the shell after attaining a diameter of three or four inches; (3) the absence of constrictions which appear on most of the species of this group; and (4) sutural characters. The suture of this species resembles in most points that of *Desmoceras hoffmanni*, yet there is at least a specific difference which only a comparison will make clear. These differences are to be seen in the siphonal saddle, the divisions of the lateral lobes, and in the regularity of the small digitations on the lobes. There is less uniformity in the forward terminal limits of the saddles than appears in the figures.

Occurrence. — This species evidently belongs to the Horsetown horizon. It was obtained from the Peterson ranch, in the vicinity of Sites, Colusa County, California, a locality not yet very well known, and was found associated with *Lytoceras batesi* and other Horsetown species.

41. **Desmoceras dilleri**, sp. nov.

Plate IV, Figs. 116-117; Plate X, Fig. 192.

Shell discoidal, but not compressed; umbilicus wide and shallow, walls rounded but abrupt, broadly rounded on ventral surface; ratio of greater diameter to width of umbilicus 2.5:1; width of whorls equal to depth; involution a little less than one-half, that is covering less than one-half of the inner coils; surface marked by slightly flexuous lines of growth and about six shallow, transverse grooves which bend but little forward in crossing the ventral surface; sides of whorl slope somewhat rapidly toward the periphery. Suture line not minutely divided; both lobes and saddles rather broad; lobes not equally tripartite, saddles bifid.

Occurrence. — Specimens of this species were obtained from near the mouth of Hulen Creek, Shasta County, California. It belongs, therefore, in the upper part of the Horsetown horizon.

The type is in the collections of the University of California.

42. Desmoceras sugatum *Forbes.*

PLATE III, FIGS. 98-99.

Ammonites sugata FORBES, Trans. Geol. Soc. Lond., 2nd Ser., Vol. VII, 1845-56, p. 113, Pl. X. STOLICZKA, Paleont. Ind., Vol. I, p. 60, Pl. XXXII.

Desmoceras sugata YOKOYAMA, Paleontographica 34, p. 185, Pl. XX.

Among the interesting species comprising a small collection of fossils from Shasta Valley is an undoubted representative of *Ammonites sugata,* as described and figured by Stoliczka. The author had not access to the original description of Forbes, and can only judge of its identity with the Indian species, trusting to the accuracy of Stoliczka's determination. The well preserved specimens from Siskiyou County show clearly all the characteristics of the Indian type, and leave no room to doubt the essential identity.

The shell is discoidal, very involute, smooth, flattened upon the sides, keeled, and with narrow and deep umbilicus; the keel is less noticeable upon the younger portion of the coil; one or two faint flexuous grooves are seen near the aperture, bending considerably forward upon the ventral side. The suture line consists of many lobes and saddles, six of each being visible upon one side of the whorl and showing well their peculiarities; saddles bifid, with ultimate divisions rounded; lobes trifid, with numerous pointed denticles. The greatest diameter of the type specimen, which is probably not an old one, is 2.7 cm. On a portion of the outer whorl, in which the test is preserved, are faint lines of growth which curve strongly forward in crossing the keel, indicating that the aperture had upon its ventral margin a long projection or rostrum. These lines show also upon the cast of the shell, but more faintly.

Occurrence.—According to Stoliczka, *Ammonites sugata* occurs in both the Arrialoor and Trichinopoly groups of Southern India; Yokoyama reports it from a similar horizon of Japan; and in California it occurs in the Lower Chico beds of Siskiyou County, from which the present specimens were obtained. At Henley, four specimens of this species were obtained along with *Placenticeras californicum*, *P. pacificum*, and very many others of the Lower Chico.

The type is in the collections of the California Academy of Sciences.

43. Desmoceras jugalis *Gabb.*

Ammonites jugalis Gabb (in part), Pal. Cal., Vol. II, p. 133, Pl. XXII, figs. 12, 12*a* and 12*b*; not figs. 13 and 13*a*, same plate.

Perhaps no other California species has caused so much perplexity as *Ammonites jugalis* Gabb. In the Paleontology of California, three species are figured and referred to *Ammonites jugalis.* In the collections of the University of California were found eight small specimens in one tray labeled "*Am. jugalis* Gabb," each with a label indicating its locality. One, the type of fig. 5, Plate X, Vol. I, is a typical *Phylloceras ramosum* Meek from the north side of Mount Diablo. Another, labeled "Pioche's Coal Mine," perhaps near Mount Diablo, is clearly a crushed specimen of sea-urchin, and has been recognized by Dr. J. C. Merriam as an example of a species recently discovered in the Martinez Group, and to which he has given the name *Schizaster lecontei.* This is apparently the specimen from which Gabb[1] claimed to have drawn figs. 5 and 6*b*,[2] which doubtless represent two distinct species of *Ammonites.* Of the other specimens, five are perhaps from Curry's, on the south side of Mount Diablo, and belong to a distinct genus, *Schluteria*, mentioned in another part of this paper, and the remaining one is a small crushed specimen of perhaps the same genus from Martinez. The species figured in the Paleontology of California (Vol. II, Pl. XXII, figs. 12, 12*a*, 12*b*), should be selected as representing the type of *Ammonites jugalis*, and this is apparently the conclusion arrived at by Stanton (1895–96, p. 1031), who has studied the species carefully. There can be little doubt that figs. 13 and 13*a*[3] are from a species not yet recognized, which is distinct from *Ammonites jugalis.* This is plainly seen in the sections and surface markings, as shown in the figures.

---

[1] Pal. Cal., Vol. II, p. 134.
[2] Pal. Cal., Vol. I, Pl. X.
[3] Pal. Cal., Vol. II, Pl. XXII.

44. Desmoceras voyi, sp. nov.

PLATE III, FIGS. 89-90.

In the collections of the University of California are three specimens of a *Desmoceras*, each of a diameter of about 5 cm., two of which belong to the "Voy collection," and are labeled "Cottonwood"; the third is from the North Fork of Cottonwood, near Ono, Shasta County, California, where it was obtained by the writer.

The general form is discoidal, though somewhat inflated; thickness of the specimens, about 2.5 cm., umbilicus narrow and deep, rounded on the ventral surface, toward which the sides gently converge; surface marked by many fine lines of growth which are flexuous and parallel to the six transverse grooves. These grooves are bordered behind by a ridge upon the shell, while they themselves are to be seen only, or ordinarily, upon the cast. The ridges become more prominent upon the periphery, where they bend strongly forward, forming a projection at the border of the aperture. The section of the whorl is elliptical in specimens of this diameter, though in the younger shells it is more nearly circular. The involution is deep, embracing more than three-fourths of the preceding whorl. The suture is a true *Desmoceras* suture, similar to that represented by d'Orbigny[1] for *Ammonites latidorsatus*, to which this species seems to be related. The sectional aspect, however, of *D. voyi* is much narrower than that of d'Orbigny's figures. There are also some resemblances between this species and *D. jugalis* Gabb;[2] yet the differences will be seen to be greater than could be admissible for an identity without unusual evidence.

Occurrence.—Desmoceras voyi belongs to the lower or central portion of the Horsetown beds of the Cottonwood section. *Ammonites latidorsatus* Mich. is a species belonging to the Gault, though it has also been found in the Ootatoor beds of Southern India, which are thought to be of Cenomanian age.

45. Desmoceras ashlandicum, sp. nov.

PLATE IV, FIGS. 107-109; PLATE X, FIG. 196.

Shell discoidal, compressed, not small, moderately involute, and coarsely ribbed; section of the whorl elliptical, narrowing gradually toward the periphery; umbilicus moderately large, and increasing more rapidly with

---

[1] Pal. Franc., Vol. I, Pl. LXXX.

[2] Pal. Cal., Vol. II, Pl. XXII, figs. 12, 12*a* and 12*b*.

age; in young adult shells the walls of the umbilicus are abrupt, but are more sloping in younger, and more rounded in older shells; the involution is moderate, one-half of each earlier whorl being covered. The ribs are mostly simple, only a few showing a disposition to bifurcate near the umbilical shoulders. Two-thirds or more of the ribs do not extend to the umbilicus, but arise from the middle of the side, or near the periphery, and cross the ventral surface, curving forward so as to produce an angle on the median plane. In age the ribs mainly disappear, or are reduced to about ten or twelve rounded ridges that are confined to the umbilical side of the whorl. The external side is then rounded and smooth. The diameter of the two largest shells found was about 25 cm.

This species seems to be somewhat related to *Puzosia darwini*, as figured by Steinmann, from the Island of Quiriquina. The constrictions that are shown upon Chilean species, however, do not appear upon the casts of the one from Oregon.

Occurrence.—Several specimens of this shell, one of which is the type, were found four miles southeast of Ashland, Oregon. A similar shell that may belong to the same species was found at the Forty-nine Mine in Southern Oregon.

The type of this species is in the collections of the California Academy of Sciences.

46. Holcodiscus, cf. H. theoboldianus *Stol.*

PLATE V, FIGS. 126–127; PLATE X, FIG. 197.

In the Voy Collection at the University of California is a beautiful, well preserved specimen of an *Holcodiscus* that very closely resembles the above species from the Trichinopoly group of Southern India. It belongs to the type of *Ammonites incertus* d'Orbigny, which comes from the Lower Cretaceous of Europe. Its sculpture exactly agrees with *Haploceras cumshewaënse* Whiteaves, though its form is rather thicker. In this specimen the ratio of width of the whorl to height is about nine to one; in *H. cumshewaënse* the ratio is said to be little more than five to one.

The shell in the Voy Collection has a diameter of about 6 cm., which is a little more than three times the width of the umbilicus. The umbilicus has abrupt though not vertical walls, the involution exposes about one-half the side of the earlier whorls, the surface is ornamented with numerous fine transverse ribs which bifurcate about the middle of the side, or more often one-third of the distance from the umbilicus to the periphery. The ribs extend downward on the walls of the umbilicus, are only slightly inclined forward, and but little flexuous. The last whorl is crossed by five rather deep and rounded grooves, marking former positions of the mouth. These grooves follow the direction of the ribs, yet from their posterior margin three or four ribs arise at intervals and cross the periphery. This gives the constrictions an oblique appearance, yet on their anterior side they are exactly parallel to the next succeeding ribs. The grooves are bordered by ridges a very little stronger than the ribs ordinarily, and the anterior one forms a sharp prominence where it crosses the umbilical shoulder. The suture line is quite complex, consisting of four or more bifid saddles, very finely divided, terminating in rounded denticles, and diminishing regularly in size toward the umbilicus. The trunk and branches of the trifid lobes are relatively wider than the corresponding parts of the saddles, and terminate in pointed, fingerlike teeth. The auxiliary lobes have an oblique direction, and are relatively wider than the main, or first lateral lobe. The suture line agrees very well with Stoliczka's figure in the main, but the dissection of the saddle is more complete.

Occurrence.—It is unfortunate that this interesting species cannot be more definitely located than a general reference to Cottonwood Creek, Shasta County, California. The sandy character of the matrix, however, suggests that it probably comes from an upper horizon of the Cretaceous section of that place.

47. Pachydiscus newberryanus *Meek* (not *Gabb*).

Ammonites newberryanus MEEK. Trans. Albany Inst., Vol. IV, 1857, p. 47; Bull. Geol. Sur. Terr., Vol. II, 1876, p. 367, Pl. IV, figs. 3, 3*a*, 3*b*. WHITEAVES, Mes. Foss., Vol. I, 1879, p. 109, Pl. XIV.
Ammonites fraternus GABB, Pal. Cal., Vol. II, Pl. XXIII.

In the collections of the University of California are two or three specimens of this species from Pence's ranch, Butte County, California. These were carefully compared with a typical specimen from the Sucia Islands, in the Straits of Georgia, British Columbia, borrowed from the collections at Stanford University.

The normal development of this shell is characteristic. In youth, at a diameter of three to four centimeters, the section of the shell is almost circular, though involute to the extent of covering nearly one-half the earlier whorl. The ribs are simple or obscurely bifurcated in part; half of them arise from within the umbilicus and pass outward to the ventral side, while some of them arise from tubercles upon the umbilical shoulders. About six constrictions cross the outer whorl transversely, bordered by ridge-like ribs behind. As the shell increases in diameter it becomes rapidly more discoidal, narrowing toward the ventral edge. The ribs curve more strongly forward in approaching the siphonal margin, the tubercles upon the umbilical shoulder become obsolete or indistinct, and the height of the whorl increases considerably. The more inflated form of the young shell of this species is probably represented by Gabb's species, *Ammonites fraternus*.[1]

Occurrence.—The species belongs to the upper portion of the Chico beds, having a wide distribution in this horizon.

48. **Pachydiscus merriami**, sp. nov.

PLATE VI, FIGS. 135–138.

cf. *Ammonites suciaënsis* GABB (not MEEK), Pal. Cal., Vol. I, Pl. XXVII.

Shell robust, but little compressed, rounded on the abdomen, and with small umbilicus; walls of umbilicus abrupt within, rounded upon the shoulders, deep and somewhat funnel form; width of umbilicus less than one-fifth the whole diameter of the shell; somewhat flattened upon the sides, rounded broadly over the ventral surface, and very thick; surface marked with about eight transverse, shallow grooves, which are seen only upon the casts, while upon the shell itself there are as many rounded ridges that border these grooves in front; ridges more prominent upon the ventral surface and almost disappearing upon the sides; lines of growth distinct between the ridges.

The measurements of the largest specimen found are: diameter, 9.7 cm.; greatest thickness, 4.7 cm.; width of umbilicus, 1.7 cm.; depth of involution, 1.7 cm.; height of last whorl from umbilicus, 4.8 cm. The suture consists of two principal and three smaller auxiliary lobes, diminishing rapidly in size. Both lobes and saddles are much divided, the saddles consisting in their final divisions of broadly denticulated digitations that are somewhat spatulate in form. The terminal branches of the lobes are narrowly acuminate. Shells of this species are nearly spherical at a diameter of 1 cm., with a reniform section; the depth of whorl becoming proportionately greater with age. In crossing the sides of the whorl the grooves curve at first gently backward and then forward, and approach the median plane obliquely.

This species is probably the one which Gabb found upon the Cottonwood, in Shasta County, California, and referred to as *A. suciaënsis* Meek. The figure in the Paleontology of California,[2] however, was drawn from a speci-

---

[1] Pal. Cal., Vol. II, p. 137, Pl. XXIII.

[2] Vol. I, Pl. XXVII.

men brought from Vancouver Island, and represents neither *A. suciaënsis* nor *A. merriami;* yet perhaps they are related.

The type represented by Gabb's figure, however, has actually been found in the Lower Chico beds of the Oregon basin, at Henley, Siskiyou County, and is described in the following pages as *Pachydiscus henleyensis.*

Occurrence.—*Pachydiscus merriami* belongs near the top of the Horsetown horizon. Three samples, representing successive stages in its growth, were obtained from the Upper Horsetown beds of Hulen Creek, Shasta County, California.

The types are in the collection of the University of California.

49. **Pachydiscus henleyensis,** sp. nov.

PLATE VIII, FIGS. 165–166.

Ammonites suciaënsis GABB (in part). Pal. Cal., Vol. I, Pls. XXVII and XXVIII.

Shell robust, inflated, section of whorl broader than high, being reniform, the ratio approximately nine to five; the umbilicus narrow, with rounded shoulders; surface crossed by low, rounded ridges flattening and growing in number toward the ventral side; sides of young shell moderately even, and rounded in section, but flattening with age and breaking up into broad undulations which appear to arise with growth from heavier ribs placed at intervals, hardly noticeable on shells below a diameter of 15 centimeters. The suture line is well represented by Gabb's figure, the lobes being narrow and exceedingly divided.

Gabb's figure of this species is from a specimen about five and one-half inches in diameter, a size intermediate between the two that are represented in the sections given for *P. henleyensis.* The section published by Gabb is evidently not accurately drawn, showing too great an involution. A correction of this error shows the section of Gabb's specimen to be intermediate to those given here, which were both drawn from one specimen at different ages.

Occurrence.—Two specimens of this shell were found at Henley, Siskiyou County, California, in the Lower

Chico beds of that place, the larger one being about thirty-two centimeters in diameter, but not altogether perfect.

The types of this species are in the collections of the California Academy of Sciences.

50. Pachydiscus sacramenticus, sp. nov.

PLATE VI, FIGS. 133-134; PLATE X, FIG. 195.

Shell discoidal, not compressed, of moderate size; section of whorl sub-elliptical, truncated at umbilicus, rounded sides sloping very gently to meet rounded ventrum; umbilicus wide, walls sloping steeply, involution covering one-half of inner whorls; surface marked by narrow, sinuous ribs curving gracefully forward in crossing ventral surface, most prominent at two-thirds distance from umbilicus to siphonal plane; ribs separated by wide grooves, which do not extend to umbilicus, and diminish on ventral surface; minor lines abundant between larger ribs; body chamber occupying two-thirds of entire outer whorl, increases but gradually in size with age; ratio of umbilical dimension to diameter thirty-three one hundredths; width of whorl eighty-four one hundredths of depth; suture of large whorl not seen.

This shell Dr. Stanton thinks is a *Pachydiscus*, and the suture, so far as it can be seen, agrees with that determination.

Occurrence.—The species belongs apparently to the upper portion of the Horsetown. The type was obtained upon an east branch of Hulen Creek, Shasta County, California. Another smaller specimen, thought to be identical with this one, was found at Horsetown.

The type of the species is in the collections of the University of California.

51. Sonneratia stantoni, sp. nov.

PLATE III, FIGS. 91-93. PLATE X, FIG. 198.

Shell small, not often above a diameter of 3.5 cm., discoidal, laterally compressed and flattened; sides converging gently toward the periphery; ventral surface rounded or subquadrate; umbilicus not large, less than one-third the total diameter, generally funnel-form, owing to its sloping sides and the increasing thickness of the shell; surface ornamented with about thirty transverse flexuous ribs which usually cross the ventral surface and terminate in about half as many distinct tubercules upon the shoulder of the umbilicus. The ribs show a tendency to bifurcate from these ridge-like tubercules, become considerably depressed upon the sides of the shell, curve gently backward, and become more prominent and wider near the outer margin, where the curve is again decidedly forward. The surface of the shell, both on the ribs and in the intervening rounded hollows, shows fine striations which are parallel always to the ribs. The suture line is simple, consisting of a few broadly-rounded saddles and wide lobes having very short branches. The saddles are but little indented, and are bifid with rounded denticles and incisions. Lobes unequally tripartite.

There appears to be considerable variation in the shells of this species, some of them being much more compressed and nearly without ribs, while others simply lack the ribs and retain their normal thickness. One specimen in which this variation is extreme, in addition to being almost without ribs or tubercules, has its septa so crowded together as to render them nearly indistinguishable, which does not seem to be true of the great majority of specimens. Dr. T. W. Stanton, to whom some specimens of this species were submitted, thinks it probably belongs to the genus *Sonneratia* Bailey; and in recognition of the valuable contributions he has made to the study of West Coast Cretaceous, the above name for this abundant and interesting species is proposed.

Occurrence.—This shell is common in the vicinity of Horsetown, Shasta County, California, though it has not been reported from corresponding horizons elsewhere. It belongs, therefore, to the upper portion of the Horsetown division of the Cretaceous.

The type of the species is in the collections of the University of California.

52. Stoliczkia dispar *(d'Orb.) Stoliczka.*

cf. *Ammonites dispar* D'ORB., Pal. Franc. Terr. Cret., I, Pl. XLV.
Ammonites dispar (D'ORB.) STOL., Pal. Ind., Vol. I, p. 85, Pl. XLV.

The many descriptions of d'Orbigny's species referred to by Stoliczka have not been accessible for comparison, but the identity of the Indian species with one in the collections of the University of California from the Shasta beds cannot be doubted. There is so close an agreement in every particular that little hesitation is felt in stating the identification. A quotation from Stoliczka's description is applicable to the California species exactly. He says: "The small tubercles on the edge of the back of the young shell, the unequally longer and shorter ribs, the nodular ribs on the back of the body chamber, the irregular evolution of this last chamber, the division of the septa,"—all these characters which have been recognized in the Indian examples are clearly seen also in those from California.

Occurrence.—This species comes from the Horsetown beds of Cottonwood Creek, Shasta County, California.

53. **Acanthoceras compressum**, sp. nov.

PLATE IX, FIG. 187.

Shell small, compressed or discoidal; average diameter of adult shell about 4.5 cm., greatest thickness 1.5 cm.; height of whorl about twice the width of umbilicus, which is about one-fourth the diameter of the coil; surface marked by flattened and rather flexuous ribs, of which there are about thirty-two in a complete adult whorl; ribs often considerably reduced in strength, especially on the sides of the shell, and ornamented at each extremity with rows of prominent nodes. Along the margin of the umbilicus these tubercles are rather high and narrow, inclining forward, while at the ventral termination of the ribs the prominent linear nodes are often parallel to the median plane in their arrangement. A secondary row of tubercles, less pronounced in appearance, occupies a position inside the marginal row, each one forming a point from which the rib bends rather sharply forward. The ventral surface is flattened or only slightly convex between the marginal nodes, and is generally crossed by faint undulations which are the continuations of the ribs. The median row of nodes sometimes noticed in species of this genus does not appear on any of the specimens of this shell.

A. compressum is no doubt very closely related to *Am. rhotomagensis* (var. *compressus*) Stoliczka, and perhaps might be included in that species with no greater stretch of Stoliczka's definition; but there does not seem to be sufficient reason to include all of his four varieties in a single species, while at the same time other forms are excluded. *A. compressum* has a near ally in a species from the Lower Chico beds of Southern Oregon, referred to *Acanthoceras rhotomagense*, which very probably belongs to the variety showing a median row of nodes upon the abdominal surface, as shown in d'Orbigny's figures[1] and in some of Stoliczka's.[2]

Occurrence.—*Acanthoceras compressum* is found in the Lower Chico beds of the Santa Ana Mountains, Silverado Cañon, and at Bowers Cañon, in Los Angeles County, California.

The type was obtained from the latter locality by Dr. Stephen Bowers of Los Angeles. It is at present in the collections of the University of California.

54. Douvilliceras mamillare *Schloth.*

Acanthoceras mamillare SCHLOTH, Pal. Franc. Terr. Cretac., T. I, Pl. LXXIII.

Acanthoceras mamillare (?) (SCHLOTH) STANTON, Bul. Geol. Soc. Am., Vol. V, 1894, p. 445.

cf. *Ammonites mantelli* (SOW.) STOLICZKA, Pal. Ind., Vol. I, p. 81, Pl. XLII, figs. 1 and 1*a*.

Ammonites stoliczkanus (?) GABB, Pal. Cal., Vol. II, p. 135, Pl. XXIII.

In the upper Cretaceous beds of Clear Creek and the Cottonwood Creek, Shasta County, California, this species is somewhat common. It occurs here in beds evidently quite similar to the Cenomanian, being found both in the Lower Chico and the uppermost Horsetown.

Among the collections at the University of California are a number of specimens of *Ammonites mamillare* from France, and a comparison of these with several well preserved types from Shasta County shows few differences, and the very strongest resemblances, between them. There is the same general form and ornamentation; the same width and depth of umbilicus, and involution of whorls; the tuberculation on both is identical, and goes through a cycle of development the same in both cases.

At a diameter of 2–3 centimeters (in the Shasta specimens) the ornamentation of the ribs consists of spinose tubercles in three rows. One of these rows is upon the umbilical shoulder, one upon the ventral surface upon each side of the median plane, and a third upon the middle of the side, where it

---

[1] Pal. Franc. Terr. Cret., I, Pl. CV.

[2] Pal. Ind., Vol. I, Pl. XXXIV.

forms a sort of angle. These tubercles are not generally found upon all the ribs, but are often upon only alternate ones. As the growth of the shell proceeds, these rows become series by the development of other secondary tubercules that cause a doubling or trebling of the rows. This is more particularly so with the external row. At the diameter of 5 or 6 centimeters, these tubercules appear to reach their maximum development and form almost a continuous series from the umbilicus outward, which has its greatest height upon the ventral side. Above this diameter they gradually decline in prominence and at the diameter of 12 centimeters they become obsolete. The form of the shell also changes with age and becomes less angular and more rounded in section. The suture line consists of three saddles and two lateral lobes with one or two auxiliary lobes and saddles within the umbilical angle. The first lateral saddle is very prominent. The saddles are broad and are not deeply incised, the lobes are unequally bifid, the longer division terminating in a long, narrow digit with short branches and denticles. D'Orbigny's figure represents this form quite perfectly.

The figures and description of *Acanthoceras spiniferum*[1] Whiteaves agree with this species perfectly as it occurs in the California beds, and the differences between the Queen Charlotte Island specimen sent to Kossmat and the European species seem to be unimportant. In fact, the features upon which the distinction is founded do not seem to be constant for either the European samples, or those obtained from California.

This shell is not uncommon at Horsetown and at Hulen Creek, a few miles to the west.

Scaphites.

Until now the genus *Scaphites* has been all but unknown in the Pacific border province of America, though it is well represented both in the Cretaceous of Southern India and in that of the upper Missouri, from either or from both of which sources it may have been derived. It is therefore of some interest to find at last within the limits of the West Coast Cretaceous no less that six species of this shell so characteristic of many marine Upper Cretaceous deposits.

In the rich fossil beds of Southern India this genus is most abundant in the lower horizon, the Ootatoor, which has been correlated with the Cenomanian of Europe. In

[1] Mes. Foss., Vol. I, Pt. IV, p. 273, Pl. XXXV.

the upper Missouri beds it belongs to beds that are regarded as Turonian in age. The members of the genus that have been found in the Oregon basin are, at least in two or three cases, closely allied to those of the upper Missouri, with which they may have probably genetic relation.

55. Scaphites gillisi, sp. nov.

PLATE III, FIGS. 85-88.

It is only after considerable study and comparison that this fine little Scaphite has appeared to be entitled to a distinct specific name. There are in the collections of the University of California five perfect examples of *S. warreni* M. & H. from the Upper Cretaceous of Dakota.

In form and ornamentation the above species agrees so closely with that from the upper Missouri that at first it seemed indistinguishable from it except by its smaller size and generally smoother shell. The transverse costæ of *S. warreni* are not only sharper and stronger, but the lateral ridge-like nodes are also more numerous and more prominent. In form *S. gillisi* is more quadrate in outline, being at the same time proportionately longer and narrower than the species of M. & H. As to the sutures in *S. gillisi*, the lateral lobes are relatively wider and more developed; the first lateral saddle is more deeply divided, and the siphonal lobe and its subdivisions are both deeper and more strongly incised. While in general the form of the suture is very similar to that of *S. warreni*, it is at the same time more complex in detail.

There will hardly be a doubt as to the near relation of the species *S. gillisi* and *S. warreni*, and whether identical or not it serves to strengthen the connection between the deposits of the Oregon basin and those of the Colorado group, in which the latter is found, and to ally them both to the Cenomanian. *S. gillisi* is more distantly related to *S. æqualis* Sowerby, and agrees fairly well with some of the types figured by Stoliczka,[1] except that the shell is thicker in transverse section, is more quadrate in outline, and has simpler sutures. It lacks the peculiar ventricose development of the body-chamber seen in d'Orbigny's figures, though in other respects there is considerable

[1] Pal. Ind., Vol. I, Pl. LXXXI, figs. 4 and 6.

agreement. Meek also states a similar relationship for *S. warreni.*

The type is in the collections of the California Academy of Sciences.

Occurrence.—This species, with its associates, is from the Upper Cretaceous beds of Shasta Valley, which in their stratigraphic position correspond very nearly to the fossiliferous beds of the Forty-nine Mine, near Phœnix, in Rogue River Valley, Oregon, and to the Lower Chico beds of Shasta County and the upper Sacramento Valley, California. The name is proposed in recognition of the general and intelligent interest taken in geological science by the donor, Mrs. H. B. Gillis of Yreka, who has contributed materially to the present study.

56. Scaphites condoni, sp. nov.

PLATE II, FIGS. 58-63.

Shell small, type specimen 2.5 cm. in length, 1.6 cm. in width, moderately inflated, especially at the recurved portion, where the section of the body-chamber is almost circular; outline of shell subquadrate, inclining to oval; surface ornamented by both ribs and nodes. The body-chamber is crossed just behind the deflected portion by thick transverse ridges with intervening constrictions, which are, however, confined to the sides of the shell and are most prominent upon the middle zone, though extending to the umbilicus and to the row of small tubercules bordering the ventral area. The posterior part of the body-chamber is flattened upon the sides and forms a dorsal expansion which almost covers the otherwise open umbilicus. The coiled portion of the shell is crossed by numerous transverse, slightly curved ribs extending from the umbilical border and branching a little below into two or more divisions. Each of these branches terminates in a node upon the ventral margin of the side, from which arise two or more finer ribs crossing the ventral area. Upon the sides of the body-chamber these ribs do not appear, except in the most posterior portion. The nodes upon the ventral shoulder of the whorl first appear at a diameter of near 1 cm., becoming most prominent upon the body-chamber. Along the ventral margin of its sides these nodes show a tendency to become pointed or spinose tubercules which incline outwards, forming a flattened ventral surface. From these tubercules, which are triangular in form, originate small ridges, scarcely noticeable, which cross the ventral portion of the body-chamber. Neither nodes nor ridges, however, are found upon the recurved portion of the shell. Back of the aperture, which is partly closed by a strong constriction, is a conspicuous expansion or thickening of the shell, forming a lip-like ridge surrounding the mouth. The umbilicus in the younger coils is wide, the whorls being little involute and almost circular in section. With increasing age the whorls become more clasping, until at maturity the umbilicus is almost, though never entirely, closed. The ribs form at a diameter of about .8 cm.

The suture line is simple, consisting of but few bifid lobes and saddles, the latter of which are rounded in their smaller divisions, and in general outline, while the former are narrow and pointed.

Occurrence.—This species was collected with the following at the Forty-nine Mine, near Phœnix, Oregon. Its horizon is equivalent to that of the Lower Chico of the Sacramento basin.

The type is in the collections of the California Academy of Sciences.

The species is named in honor of Professor Thomas Condon of the University of Oregon. It is with pleasure that a tribute of recognition is thus offered for the deep interest and devotion to geological study which has so often been a source of inspiration alike to students and acquaintances.

57. **Scaphites condoni** var. **appressus,** sp. et var. nov.

PLATE II, FIGS. 64–66.

This shell is quite evidently a variety of the preceding, and it will be only necessary to mention here its points of difference.

In general it has a thinner and more compressed form. The transverse ridges and constrictions upon the body-chamber are farther forward than those upon the type of the species, and have, moreover, a decidedly oblique tendency. The transverse ribs upon the coiled portion of the shell are scarcely to be seen. The suture line seems to be a little more developed, or complex, in its details, but otherwise is identical with that of the type.

Occurrence.—The position and occurrence of this shell is the same as that of the preceding.

The type is in the collections of the California Academy of Sciences.

58. **Scaphites roguensis,** sp. nov.

PLATE II, FIGS. 67–70.

Shell small, discoidal, flattened on sides, quadrate in section; umbilicus small in adult shell, relatively wider when young; surface of shell nearly smooth on body-chamber, coiled portion crossed by many transverse costæ; ventral shoulders of body-whorl ornamented by small, oblique tubercules; dorsal edge of body-chamber expanded over the umbilicus.

Length of shell, 2 cm.; width, 1.5 cm.; greatest thickness, .6 cm. Septation unknown.

This shell is apparently related to the preceding, though it has not the characteristic constrictions of that species, and is more flattened on the sides.

Occurrence.—Found with the preceding in the Lower Chico beds of the Forty-nine Mine, near Phœnix, Oregon.

The type of this species is in the collections of the California Academy of Sciences.

59. **Scaphites inermis**, sp. nov.

Plate III, Figs. 74–77.

Shell small, compressed, elliptical in outline, smooth, and almost without ornamentation. Umbilicus open and wholly uncovered; whorls little involute, never clasping one-half the preceding whorl, and subcircular in section throughout; body-chamber, however, a little deeper than wide though quadrate; squared or truncated on the dorsal side. The sides of the body-chamber are obliquely crossed by faint transverse, and apparently bifurcating ribs, which continue uninterrupted across the ventral surface. On both the umbilical and ventral shoulders of the body-whorl there are small linear nodes that are almost obsolete on some specimens and hardly appear at all upon the coiled portion of the shell; aperture having a ridge-like rim, hardly a lip, surrounding it, behind which is a shallow constriction, both of which curve backwards at the inner angle of the whorl. On each side of the aperture a small auricular expansion extends forward from near the dorsal edge of the mouth, forming a small triangular surface showing faint concentric striæ.

It is thought worth while to note that upon one specimen, which was accidentally broken, the "impressed zone" of the body-chamber was well exposed. Although the body-volution was entirely free from the earlier coil, this dorsal zone, which had appeared to be squared or truncated, yet contained, as far as the margin of the aperture, a shallow, though distinct groove.

Occurrence.—This species is abundant at the Smith ranch, and has been found also at the Forty-nine Mine, near Phœnix, Oregon.

60. Scaphites perrini, sp. nov.

PLATE II, FIGS. 71-73.

The most remarkable species of *Scaphites* that has been discovered at localities in Southern Oregon was collected recently by Dr. James Perrin Smith, in whose honor the above name is proposed.

Unlike other known types of this genus, most of which are inclined to be discoidal, at least in some stages, *S. perrini* seems to be at no stage either discoidal or merely gibbous or inflated.

The shell is small, being little over 1.2. cm. in length, .9 cm. in greatest width, and .65 cm. in greatest thickness.

The section of the whorls, though not entirely visible, seems to be transversely elliptical, or "digonal" with each "lateral angle" forming the margin of a funnel-form umbilicus. The ventral surface is broad, extending to the umbilical angle, rounded, and nearly smooth. The aperture is reduced by a strong, rounded constriction which extends a little beyond the umbilical angles, and is bordered in front by a sharp elevation or ridge. From each side of the aperture large lateral ears extend forward, almost touching the lateral angles of the preceding whorl, and reducing the form of the aperture to subquadrate. The surface ornamentation of this species consists of small, simple ribs, which do not appear to cross the wide ventral surface, or else cross it only as fine lines, not visible upon the cast. These ribs are most conspicuous upon the lateral angles of the whorl, which they cross, forming small nodes, from which they incline obliquely backward on both the umbilical and the external surfaces.

The suture line, which can be traced only across the rounded ventral surface, is simple, consisting of broad saddles and narrow lobes, both of which are bifid in their subdivisions. The siphonal lobe is simple, being almost as wide as long, having one lateral and one terminal branch. The first lateral saddle is quadrate in outline, and subdivided into two unequal portions, which are again indented or divided in a similar manner.

Occurrence.—*S. perrini* is known only from a single, though nearly perfect, specimen, obtained recently from the Smith ranch, near Phœnix, Oregon, by Dr. J. P. Smith, through whose courtesy the author has been permitted to describe it. It is from beds that are equivalent in their horizon to those of the Lower Chico of the Sacramento basin.

The type is in the collections of the Leland Stanford Jr. University.

61. **Scaphites klamathensis**, sp. nov.

PLATE III, FIGS. 78-81.

Shell small, compressed, ovate in outline, measuring only 1.3 cm. in length, .9 cm. in width, and .35 cm. in greatest thickness. Umbilicus not wide; whorls clasping generally about one-half of the preceding volution in youth and apparently suppressing the umbilicus in age; section of whorls subcircular or subquadrate, flattened on the dorsal side of the body-whorl, which is somewhat inflated in the region of the bend. The surface is ornamented with fine ribs or striations, which cross the ventral surface and converge toward small nodes near the umbilical margin of the whorl. These ribs are seen only upon the body-chamber, and the nodes appear only upon the last two-thirds of the same. The suture is simple, consisting of a large siphonal lobe and a very much smaller lateral one, with one or two secondary lobes. There is one lateral saddle upon the inner side of which is an indentation that might pass for an auxiliary saddle.

The aperture of this species deserves special notice. It is bordered by a distinct lip which is immediately preceded by a rather wide and shallow constriction which extends upward toward the dorsum without apparently reaching it; from each side of the aperture a wing-like expansion extends to the preceding coil, against which it rests, thus reducing the aperture to an oval opening upon the ventral side of the shell. The surface of these expansions are ornamented with concentric undulations that begin at the middle of the mouth-border, *i. e.*, at the middle of the side of the aperture.

In all respects except as to size and form of aperture, *S. klamathensis* exactly agrees with *S. larvæformis* M. & H. from the lower portion of the Colorado group of the upper Missouri. Meek and Hayden's figures do not show the buccal border, and apparently it was not known. There is reason to believe that *S. klamathensis* is only a small form of *S. larvæformis*, but until this can be more satisfactorily shown, it seems preferable to designate the Shasta Valley species by a separate name. It is also related to *S. inermis*.

Occurrence.—This species is one from the small collection presented to the author by Mrs. H. B. Gillis of Yreka, and comes from the northern border of Shasta Valley, to the south of the Klamath River.

The type is in the collections of the California Academy of Sciences.

An important addition to the number of species of *Schlœnbachia*[1] hitherto known from the West Coast will be recognized in this paper. No less than ten distinct forms have been found in the Chico beds of Northern California and Southern Oregon. It is possible that with further searching still others will be discovered, since each new collection of them contains some new species not met with before.

In the Lower Horsetown beds representatives of this genus have not been found, but in the Upper Horsetown is the Cenomanian species, *S. inflata*. In the Upper Chico are *S. chicoënsis* Trask, *S. gabbi*, sp. nov. and *S. buttensis*, sp. nov. By far the larger number, however, are found in the Lower Chico beds, and principally in the Oregon basin. With the exception of a single species, *S. chicoënsis*, there is but little resemblance between those of the two adjoining basins.

Most of the species described in this paper fall without much question into the genera recognized by Zittel in his later work.[2] Four of the genera are represented by two or more species each. There are other forms, however, that admit of such grouping with more difficulty. In some of them the keel entirely disappears in old age, or even before mature age is reached.

62. Schlœnbachia chicoënsis *Trask.*

PLATE I, FIGS. 21–22; PLATE II, FIGS. 23–25.

Ammonites chicoënsis TRASK, Proc. Cal. Acad. Sci., Vol. I, 1856, p. ~~92~~ 85, Pl. II.

From a careful study of this species with others nearly related, it is evident that there has been a confusion entertained by some of the earlier writers upon the paleontology of California. The figures and description of this species

[1] *Schlœnbachia* is used in this paper in the broad sense origially defined by Zittel in his "Traité de Paleontologie," 1887.

[2] "Grundzüge der Palæontologie," 1895.

by Gabb can hardly be made to agree with those of Trask (l. c.). The description of neither species can be considered satisfactory; yet enough is shown and told to make it evident that two species, and not one, have been described under this name.

In Trask's species there are about twenty-four distinct and simple ribs, bearing a double row of tubercules near the outer margin of the coil. The ribs do not bifurcate upon the sides, but seem to consist of two kinds, primary and auxiliary. The latter do not extend to the umbilicus, but disappear a little above the middle of the sides, and extend to the outer margin. No statement is made as to the relative size of the umbilicus, but in Trask's figure it appears to be more than one-third the diameter of the entire coil. The section of the whorl is oval rather than flattened, as in Gabb's species.

The specimen figured by Trask was probably an immature one, and there is room for a considerable change in these features during a more complete growth; yet the changes would hardly be of the nature which Gabb's figures indicate. There is in the collections at Berkeley a small specimen, labeled as coming from Trask's original locality, which agrees tolerably well with his description except in the number of ribs, which is slightly greater. Trask's species also seems to be much less common than Gabb's, or it has not been definitely recognized.

Occurrence.—Trask's specimens came from the Upper Chico, on the eastern side of the Sacramento Valley, and from the locality of Chico Creek, and Pence's ranch, California.

63. Schlœnbachia gabbi, sp. nov.

Ammonites chicoënsis GABB (not TRASK). Paleontology Cal., Vol. I. p. 68, Pls. XVIII-XIX.

In the collections of the University of California are several well-preserved casts of Gabb's species of this shell from the original localities of both Trask and Gabb. They are identifiable without great difficulty from Gabb's figures and description, with which they agree fairly well in most points.

The larger shells are almost squarely truncated at the ventral margin, the keel often being very slight, though always visible. The sides are flattened or gently convex, and ornamented with about forty-five to fifty ribs counted along the ventral margin, where they terminate in flat, transverse tubercules. On the umbilical margin of the whorl there is a prominent row of tubercules not shown in Gabb's figure, though mentioned in the text, from which the umbilical wall makes a perpendicular descent. The costal nodes are not always very conspicuous upon the casts, though three or four rows can be distinctly made out.

The young shells of this species, unlike those of Trask's species, are almost perfectly smooth, showing neither ribs nor costal nodes until they attain a diameter of more than 2 cm. Gabb seemed to have noticed this fact, though without attaching to it the importance which it deserves. The specimen figured by Trask had a diameter of 1.5 cm., yet distinctly showed twenty-four strong ribs. In the young shell of Gabb's species the umbilicus has a diameter of less than one-fourth that of the entire coil, and the section of the whorl is narrow and elongated, and rather squarely truncated on both dorsal and ventral margins.

The largest specimens of *S. gabbi* in the collections of the University of California have a diameter of 10 cm., and at that size the ribs have almost disappeared, together with the nodes upon the sides of the shell.

The above name is proposed to distinguish this species from that for which it has evidently been mistaken. There are some varieties of the species that deserve mention, one, especially, in which the sides are more than ordinarily convex, and in which the ventral truncation is somewhat rounded.

64. **Schlœnbachia buttensis**, sp. nov.

PLATE IV, FIGS. 110, 111.

This species is related to *S. gabbi*, though it is evidently a distinct form. The ribs, about fourteen in number, counted along the umbilical shoulders, are nodose and bifurcating. The nodes are in five rows upon the sides of the shell, and in this respect it resembles its congener, *S. gabbi*, but the umbilical row is much more elevated and narrow, and the ribs are more disposed to bifurcate. This takes place from either of the three inner rows of nodes. The nodes of the outer row are sharp and ridge-like, forming upon the periphery a flattened, ventral surface, as shown upon the cast. The keel is low and apparently entire; septation not well known. *S. buttensis* is also related to *S. varians* Sowerby.

The figure was drawn from an imperfect specimen, immature in size, yet sufficiently large to show the specific characters.

Occurrence.—The species is an associate of the preceding one, *S. gabbi*, and belongs to the Upper Chico of Pence's ranch, Butte County, California.

The type is in the collections of the University of California.

65. Schlœnbachia siskiyouensis, sp. nov.

PLATE I, FIGS. 19-20.

Shell discoidal and compressed; umbilicus of young coils about one-third the whole diameter, becoming relatively narrower with increasing age; keel at first simple, but at a diameter of 1 cm. begins to break up into nodes, which at 3 cm. become entirely separated by moderately wide intervals. On the older shells the segments of the keel form high and narrow tubercules which have a definite and regular position with reference to the ribs. The ribs are simple, about twenty-five in number, and are of two orders. The first originate in the prominent tubercules along the umbilical margin of the whorl, and, bifurcating from that point, terminate in the outer row of tubercles along the ventral margin. The ribs of the second order make their appearance between the pairs of the first. Thus, about every third rib arises from a little above the middle of the side, without extending to the umbilicus, and terminates as do the others, in the external row of tubercules. This outer row of tubercules forms a series of distinct and pointed prominences that diverge slightly from the plane of the keel. A little above these, upon each rib, is developed a distinct prominence which forms the thickest portion of the rib, and which is separated from the outer, or marginal node, by a shallow though visible depression. The ribs are inclined to be straight, except where on approaching the outer margin they curve slightly forward. The tubercules of the keel stand a little forward of the marginal nodes in a position to meet exactly the forward curving of the ribs.

This, together with the following species, appears to be referable to the genus *Barroisiceras* Gross. It seems to have no close ally either in the deposits of Southern India or in the Interior Basin of the United States.

66. Schlœnbachia knighteni, sp. nov.

PLATE I, FIGS. 1-4; PLATE II, FIGS. 39-40.

Shell discoidal, compressed; sides flattened in young adult smaller coils, but becoming more inflated in old age, attaining a diameter of 10 cm.; surface characterized by the possession of about thirty simple and almost straight ribs, most of which originate at the umbilical margin of the whorl; one-third of the whole number beginning there in prominent tubercules, the others arising below this line upon the sides of the whorl, but all extending to ventral margin, where they terminate in equally prominent tubercules. This outer row of tubercules shows a tendency to doubling, which can be detected upon all shells above a diameter of 1.5 cm., though shown most clearly upon coils above a diameter of 4 cm. and below 7 cm. The ribs bend more obliquely forward at the inner node of this double row, which is considerably less conspicuous than the outer one.

The ventral and dorsal margins have an abrupt truncation at maturity, and above a diameter of 2 cm., but lose this character and become rounded in old age, as they are in the very young stages.

The keel and ribs seem to appear together just below the diameter of 3 mm., the ribs appearing first in the ventral region. The keel, which is at first simple, begins to show crenulations at a diameter of 1.5 cm., which gradually increase in prominence until maturity. In the older portions of the shell these again decline.

The umbilicus of this shell is wide and shallow, occupying about one-third of the entire diameter of the coil. Within the umbilicus the thin, sharp ribs and dorsal tubercules of the younger whorls are noticeable.

The sutures consist of a ventral and one lateral lobe, supplemented by two auxiliary lobes near and within the umbilicus. The saddles show a tendency to become bifid, though this division has actually been seen on only the first lateral saddle. The lateral lobe is simple and elongated, with relatively small subdivisions, amounting merely to short teeth.

The name, *S. knighteni*, is proposed in recognition of the kindly interest taken in this study by Mr. E. Knighten Anderson, from whose property the larger part of this interesting collection was obtained, and to whom the author is indebted for first calling his attention to this important locality.

The type is in the collections of the California Academy of Sciences.

67. **Schlœnbachia multicosta**, sp. nov.

PLATE II, FIGS. 41–47.

Shell discoidal and compressed, umbilicus wide and shallow; moderately involute, the outer whorl embracing about one-third, or less, of the inner one; sides of whorl flattened, giving a narrow quadrangular outline to the shell when viewed from behind; the sides ornamented with about fifty oblique, flexuous ribs, which tend to bifurcate from tubercules occurring along the inner margin of the whorl. The ribs curve forward in approaching the outer margin of the whorl, and like the preceding species this one has a double row of inconspicuous tubercules upon the ventral shoulders. The ribs are generally rounded; the keel, which is simple and entire, lacks the grooves noticed in the preceding species. In development this species is very similar to the preceding, but differs from it considerably in the adult shells. The essential differences are: (1) the narrower umbilicus of *S. multicosta;* (2) the flexuous ribs, which have a greater tendency to form tubercules upon the umbilical shoulders from which bifurcate the ribs; and (3) the absence of the grooves along the sides of the keel. The whorls are, furthermore, usually inflated in the younger forms.

Occurrence.—This species occurs abundantly at the Smith Ranch, about two miles west of Phœnix, Oregon. The horizon is that of the Forty-nine Mine, and is the equivalent of the Lower Chico of the Sacramento Valley.

The types are in the collections of the California Academy of Sciences.

68. **Schlœnbachia bakeri,** sp. nov.

PLATE II, FIGS. 26–33.

Shell discoidal, compressed, quadrilateral in section; umbilicus wide and shallow, with rounded sides; keel prominent and entire, with slight grooves along the sides; involution covering about one-third the inner whorl; sides ornamented by about thirty-eight to forty-four simple, oblique ribs, which are narrow and sharply angular, each extending from the inner margin of the whorl to the keel.

The ribs form only small tubercules upon the umbilical margin of the whorl, though a few of them become a little more prominent here, while near the periphery a double row of inconspicuous nodes occurs. The ribs bend sharply forward as they approach the keel, while seen from the side they appear straight for the greater part of their length. They begin to form uniformly at 3½ whorls at a diameter of 3 mm.

Keel high and thin, with only faint undulations along its summit, sometimes not to be seen at all. The smallest coils of the shell are smooth, without keel, and almost circular in section except for the impressed zone. The keel begins to appear upon the third whorl at a diameter of between 2 and 3 mm.

The diameter of the largest specimen found is a little more than 3 cm., and this is probably the average diameter of adult shells. The body-chamber occupies about two-thirds of the last whorl.

Although a number of otherwise perfect specimens of this species were found, the suture of an adult shell was not seen. As far as could be ascertained, it is similar to that of the following species, *S. oregonensis*, to which it is related.

The name proposed for this species is borrowed from the frontier history of Southern Oregon, old Fort Baker having stood within a short distance of the locality from which the type was collected.

Occurrence.—This shell is tolerably abundant at the locality of the Forty-nine Mine, near Phœnix, Oregon, on the horizon of the Lower Chico beds.

The type is in the collections of the California Academy of Sciences.

69. Schlœnbachia oregonensis, sp. nov.

PLATE II, FIGS. 48-57; PLATE VI, FIG. 144; PLATE VII, FIG. 149.

Schlœnbachia oregonensis ANDERSON (M. S.), J. P. SMITH, Jour. Morph., Vol. XVI, 1899, p. 10, Pls. *A-E.*

Shell discoidal and compressed, increasing in thickness with age; involution embracing about two-fifths of the depth of the whorl; umbilicus wide and shallow, with walls not always abrupt; keel reduced, but distinct, generally consisting of an obtuse angle surmounted by a low, thin keel, not serrated; surface ornamented with about forty-eight to fifty-two simple flexuous ribs, usually arising in pairs from the small, rounded, umbilical tubercules, and crossing the sides of the whorl obliquely forward. There are also a few subordinate ribs that do not extend above the middle of the sides. There is a single row of inconspicuous tubercules along the ventral margin of the whorl that forms an angle between the flattened sides and the beveled ventral surface. On the older shells these tubercules become almost obsolete, as they are also upon young shells. Upon approaching these tubercules the ribs bend more obliquely forward, and in the old shell appear to cross the ventral surface, forming on the keel a faint crenulation. On coils with a diameter of less than .8 cm. the ribs are not often seen, the shell being almost smooth. The keel first makes its appearance, at a diameter of .3 cm., as a faint line upon the ventral margin of the whorl. The section of the whorl at this diameter is almost circular. The ribbing begins with the development of the tubercules upon the outer margin, which is followed by the extension of the ribs upward, and later, by the appearance of the umbilical row of tubercules and a downward extension of the ribs from them.

The largest example of this species collected has a diameter of 4.3 cm., though fragments of still larger coils were found which may belong to it.

S. oregonensis is related to *S. propinqua* Stoliczka, though easily separable from it.

A variety of *S. oregonensis*, of which a few small specimens were collected, has considerably finer ribs, the number being about seventy-two, most of which belong to the secondary class, not passing above the middle of the sides.

Occurrence.—This species was found abundant at both the Forty-nine Mine and at Smith's ranch, two miles to the northwest, near Phœnix, Oregon. It belongs to a horizon equivalent to the Lower Chico of the Sacramento Valley.

The types are in the collections of the California Academy of Sciences.

70. Schlœnbachia propinqua *Stol.*

PLATE II, FIGS. 34-38.

Ammonites propinquus STOL., Pal. Ind., Vol. I, p. 53, Pl. XXXI.

The species of *Schlœnbachia* which is believed to be identical with the Indian form agrees so well in its measurements and surface markings with Stoliczka's figures and description, that were it found in the same region there would be no hesitation as to its specific determination. In sutural features, however, there seems to be a slight difference, though not sufficient to warrant a specific distinction. The suture represented in the figure is from a younger whorl than that of Stoliczka's figure, having a diameter of only 3.5 cm.

The shell is discoidal and flattened at a diameter of 2 or 3 cm., but becomes thicker with increasing growth. At the diameter of 4 cm. the section of the whorl is elliptical. The ribs of a single whorl number from forty to forty-four, showing a tendency to bifurcate a little below the dorsal, or umbilical margin. The keel, at first simple, becomes at a diameter of about 2 cm. broken up in slight undulations.

This species is distinguished from *S. oregonensis* not only by the smaller number of ribs, but by a number of important and minor differences. *S. oregonensis* lacks the prominent umbilical tubercules of the former; its sides are also more flattened, the keel less conspicuous in older and in young shells, and the abdominal area is more angular. Moreover, in *S. oregonensis* this abdominal area is distinctly crossed by the ribs at the diameter of a little over 3 cm., which does not appear to be the case either in Stoliczka's figures or in the specimens from Southern Oregon. The sutures show still more important differences, which only a comparison of the types or the figures will make apparent.

In *S. oregonensis* the ventral lobe has only slight subdivisions or none; the lateral saddles are simple and rounded, the smaller divisions amounting to only shallow scallops. The lateral lobe also shows a corresponding simplicity of detail. This contrasts considerably with the more deeply cut lobes and saddles of *S. propinqua*.

In *S. propinqua* the ventral lobe is divided by a siphonal indentation of noticeable depth.

Both of these species appear to belong to Neumayer's genus *Schlœnbachia*, which probably includes the following species.

71. Schlœnbachia blanfordiana *Stol. (?)*

PLATE I, FIGS. 5-10.

Ammonites blanfordianus STOL., Pal. Ind., Vol. I, p. 46, Pl. XXVI.

Among the collections made at the Forty-nine Mine, in Southern Oregon, are several specimens of a shell plainly of the type of Stoliczka's species, and at least very closely related to it, if not identical.

The shell is flat and discoidal, with moderately wide umbilicus surrounded by about fourteen or more elevated tubercules; sides ornamented with about forty ribs, which are clearly distinguishable on shells below a diameter of 3 cm., but becoming obsolete with age. The sides of the older whorls are smooth, with the exception of the tubercules bordering the umbilicus and the ventral margin. The ribs when they appear are flexuous, and show on one specimen a tendency to form nodes considerably below the umbilical row. The shell becomes a little more involute with age and finally clasps about one-half of the preceding whorl. The keel is never prominent and with increasing growth becomes, at a diameter of 3 cm., undulating and apparently obtuse at 4.5 cm., or reduced to an obtuse ventral angle. The suture, as far as it can be seen, agrees reasonably well with that of Stoliczka's figure, showing the same general character of lobes and saddles.

The ribs of the Oregon species seem to become lost at an earlier age than in the Indian form, and the number of umbilical tubercules is not so great. On the young shells the ribs first make their appearance at a diameter of 1 cm., beginning at the ventral margin in small tubercules.

Occurrence.—This shell was found at the Forty-nine Mine, near Phœnix, Oregon. It belongs to a horizon equivalent to that of the Lower Chico beds of California.

72. Mortoniceras crenulatum, sp. nov.

PLATE I, FIGS. 17–18.

Shell small, not above a diameter of 5 or 6 cm.; umbilicus wide and shallow, with rounded and sloping shoulders; section of whorl quadrate, a little higher than broad; surface ornamented by strong ribs, inclined forward and nearly straight, with broad, round interspaces extending from within the umbilicus to the keel; ribs bearing tubercules at the umbilical shoulder and at the ventral shoulder, the latter extending laterally into thorn-like spines. The keel is not apparently developed on the youngest whorls, which are elliptical in section, but becomes visible at a diameter of about 4 or 5 mm. The keel, at first simple, becomes very soon finely crenulated, but apparently not deeply serrate at a diameter of 5 cm. The shell is smooth up to a diameter of 2 or 3 mm. Septa not well shown.

This shell evidently belongs to Meek's genus *Mortoniceras*, but is not closely related to any other found on the Pacific Coast.

Occurrence.—Found in the lowest horizon of the Chico, at Willow Creek, Siskiyou County, California. It was associated with *Trigonia leana* and other forms of the Lower Chico below the horizon of *Pachydiscus newberryanus*.

73. Prionotropis branneri, sp. nov.

PLATE I, FIGS. 11–16.

cf. *Prionocyclus woolgari* MEEK. Geol. Sur. Terr., Vol. IX, p. 455, Pl. VII.

Among the species that should be regarded as "representative" from the Interior Basin and the Pacific Border none are more worthy of prominence than the above.

In form and ornamentation *P. branneri* strongly recalls Meek's species from the Upper Missouri, but it is more inflated.

Shell more or less discoidal, but not compressed; greatest diameter of largest specimen found 12 cm., though fragments of larger specimens were collected; thickness at this diameter, 3.5 cm. Keel simple at first, appearing at a diameter of 2 mm., showing faint undulations at 1 cm., and in old age breaking up into a median row of nodes with rounded outline and with rounded intervening depressions; umbilicus relatively wide, equal to about three-eighths of entire diameter of coil, having abrupt walls, especially at the diameter of 3 or 4 cm. Ribs twenty-five in number, simple at first, appearing at a diameter of 2 mm. or earlier. At 5 cm. tubercules begin to develop upon the external or ventral shoulder of the whorl in a double row; those of the inner row have a greater lateral prominence, while the outer incline more toward the plane of the keel. In shells of 3 or 4 cm. diameter these tubercules have often a triangular appearance that is lost in older whorls. The umbilical tubercules are more prominent upon alternate ribs, and are thin and ridge-like in form. Above a diameter of 3 or 4 cm. the ribs become depressed in their middle portion, forming only a bare connection of external and umbilical tubercules in old age.

The suture line is simple; siphonal lobe long and relatively narrow, with short, narrow teeth upon the side, parallel and equal; terminal teeth longer and divided; first lateral saddle broad, bifid, and having either sharp or rounded, small digitations; lateral lobe broad and tapering evenly in general outline, indistinctly trifid, having sharp and narrow digitations; second lateral saddle high and little cleft, scalloped at margin; second lobe and succeeding saddle small and narrow. The digitations of the suture are not always regular, different septa of the same specimen showing considerable variation. On the whole, however, they agree with the septa figured by Meek for his species. Meek seems to have noticed in the Dakota types the same irregularity. The furrows along the keel of the Oregon type are comparatively shallow, as seen upon the casts. Aside from this there is no other difference in the two types, unless it be a little greater thickness for those from Oregon.

Occurrence.—This species was found on the Smith ranch, near Phœnix, Oregon, at which place several good specimens were obtained, though from its abundance there it should be expected at the other localities. It belongs to a horizon equivalent to that of the Lower Chico beds of the Sacramento Valley.

The types are in the collections of the California Academy of Sciences.

LITERATURE CITED.

1893. AQUILERA and ORDONEZ. Datos para la Geologia de Mexico.

1885. BECKER, GEO. F. Notes on the Stratigraphy of California. *Bull. U. S. Geol. Sur.*, No. 19, pp. 1–25. (In Vol. III, p. 197.)

1888. ———Descriptive Geology of the Oathill, Great Western, and Great Eastern Districts.—Geology of the Quicksilver Deposits of the Pacific Slope. *U. S. Geol. Sur.*, Monog. XIII, pp. 1–486.

1891. ———Notes on the Early Cretaceous of California and Oregon. *Bull. Geol. Soc. Am.*, Vol. II, pp. 201–208.

1890. BOWERS, DR. STEPHEN. Orange County. *Tenth Report State Mineralogist, Calif. State Mining Bureau*, pp. 399–409.

1895–96. DALL, W. H. Report on Coal and Lignite of Alaska.—Notes on the Paleontology of Alaska. *Seventeenth Ann. Rept. U. S. Geol. Sur.*, Pt. I, pp. 865–872.

1889. DAWSON, GEORGE M. On the Earlier Cretaceous Rocks of the Northwestern Portion of the Dominion of Canada. *Am. Journ. Sci.*, 3rd Ser., Vol. XXXVIII, pp. 120–127.

1890. ———Notes on the Cretaceous of the British Columbia Region.—The Nanaimo Group. *Am. Journ. Sci.*, 3rd Ser., Vol. XXXIX, pp. 180–183.

1893. DILLER, J. S. Cretaceous and Early Tertiary of Northern California and Oregon. *Bull. Geol. Soc. Am.*, Vol. IV, pp. 205–224.

1894. DILLER, J. S., and CHAS. SCHUCHERT. Discovery of Devonian Rocks in California. *Am. Journ. Sci.*, 3rd Ser., Vol. XLVII, pp. 416–422.

1894. DILLER, J. S., and T. W. STANTON. The Shasta-Chico Series. *Bull. Geol. Soc. Am.*, Vol. V. pp. 434–464.

1892. FAIRBANKS, HAROLD W. The Pre-Cretaceous Age of the Metamorphic Rocks of the California Coast Ranges. *Am. Geol.*, Vol. IX, pp. 153–166.

1893. ———Notes on a Farther Study of the Pre-Cretaceous Rocks of the California Coast Ranges. *Am. Geol.*, Vol. XI, pp. 69–84.

1894. ———Geology of Northern Ventura, Santa Barbara, San Luis Obispo, Monterey and San Benito Counties. *Twelfth Rept. State Mineralogist, Calif. State Mining Bureau*, pp. 493–526.

1895. ———The Stratigraphy of the California Coast Ranges. *Journ. Geol.*, Vol. III, pp. 415–433.

1896. ———Stratigraphy at Slate's Springs, with some Farther Notes on the Relation of the Golden Gate Series to the Knoxville. *Am. Geol.*, Vol. XVIII, pp. 350–356.

1898. ———Geology of a Portion of the Southern Coast Ranges. *Journ. Geol.*, Vol. VI, pp. 551–576.

1890. FELIX, J., and H. LENK. Beiträge zur Geologie und Palæontologie der Republik Mexico. *Palæontographica*, Bd. XXXVII, pp. 180–189.

1898. HAUG, ÉMILE. Portlandien, Tithonique, et Volgien. *Bull. Geol. Soc. France*, 3rd Ser., Vol. XXVI, pp. 197–228.

1893. HILL, ROBERT T. The Cretaceous Formations of Mexico and their Relations to North American Geographic Development. *Am. Journ. Sci.*, 3rd Ser., Vol. XLV, pp. 307-324.

1894. HYATT, ALPHEUS. Trias and Jura in the Western States. *Bull. Geol. Soc. Am.*, Vol. V, pp. 395-434.

1889. JOKOYAMA, M. Versteinerungen aus der Japanischen Kreide. *Palæontographica*, Vol. XXXVI, pp. 159-200.

1895. KOSSMAT, FRANZ. On the Importance of the Cretaceous Rocks of Southern India in estimating the Geographical Conditions during Later Cretaceous Times. *Rec. Geol. Sur. India*, Vol. XXVIII, Part II, pp. 39-55.

1895*a*. ——Untersuchungen über die Südindische Kreideformation. *Beitr. Pal. und Geol. Oesterreich-Ungarns und des Orients*, Bd. IX, Hefte 3 and 4.

1895. LAWSON, A. C. A Contribution to the Geology of the Coast Ranges. *Amer. Geol.*, Vol. XV, pp. 342-356.

1897. MERRIAM, JOHN C. The Geologic Relations of the Martinez Group of California at the Typical Locality. *Journ. Geol.*, Vol. V, pp. 767-775.

1901. ——A Contribution to the Geology of the John Day Basin. *Bull. Geol. Dept. Univ. Calif.*, Vol. II, pp. 269-314.

1890. NIKITIN, S. Einiges über den Jura in Mexico und Centralasien. *Neues Jahr. f. Min.*, 1890, Bd. II, pp. 272-275.

1894. SMITH, JAS. P. Age of the Auriferous Slates of the Sierra Nevada. *Bull. Geol. Soc. Am.*, Vol. V, pp. 245-258.

1895. ——Mesozoic Changes in the Faunal Geography of California. *Journ. Geol.*, Vol. III, pp. 369-384.

1899. ——The Larval Stages of Schlœnbachia. *Journal Morphology*, Vol. XVI, No. 1, pp. 237-268.

1901. ——The Larval Coil of Baculites. *Amer. Naturalist*, Vol. XXXV, pp. 39-49.

1895. STANTON, T. W. Contributions to the Cretaceous Paleontology of the Pacific Coast.—The Fauna of the Knoxville Beds. *Bull. U. S. Geol. Sur.*, No. 133, pp. 1-132.

1895-96. ——The Faunal Relations of the Eocene and Upper Cretaceous on the Pacific Coast. *Seventeenth Ann. Repl. U. S. Geol. Sur.*, Pt. I, pp. 1011-1048.

1897. ——A Comparative Study of the Lower Cretaceous Formations and Faunas of the United States. *Journ. Geol.*, Vol. V, pp. 579-624.

1895. STEINMANN, G. Beiträge zur Geologie und Palæontologie von Sudamerika. *N. Jahrb. f. Min.*, Beilage-Bd. X, pp. 1-118.

1865-73. STOLICZKA, F. Cretaceous Fossils of India. *Paleontologia Indica. Mem. Geol. Sur. India*, Vols. I, III, IV.

1856. TRASK, JOHN B. Description of a New Species of Ammonite and Baculite from the Tertiary Rocks of Chico Creek. *Proc. Cal. Acad. Sci.*, Vol. I (1st Ed., pp. 85-86, Pl. II; 2nd Ed., p. 92, Pl. II).

1891. TURNER, H. W. The Geology of Mount Diablo, California. *Bull. Geol. Soc. Am.*, Vol. II, pp. 383-402.

1885. WHITE, CHAS. A. On the Mesozoic and Cenozoic Paleontology of California. *Bull. U. S. Geol. Sur.*, No. 15.

1885*a*. ———On New Cretaceous Fossils from California. *Bull. U. S. Geol. Sur.*, No. 22, pp 1–14. (In Vol. III, p. 349.)

1889. ———On Invertebrate Fossils from the Pacific Coast. (Invertebrate Fossils from California, Oregon, Washington, and Alaska.) *Bull. U. S. Geol. Sur.*, No. 51, pp. 1–102. (In Vol. VIII, 1889, pp. 441–532.)

1891. ———Correlation Papers.—Cretaceous. *Bull. U. S. Geol. Sur.*, No. 82.

1888. ———Remarks on the Genus Aucella, etc, (in Becker's Monograph XIII, *U. S. Geol. Survey*).

1876–84. WHITEAVES, J. F. *Geol. Sur. Canada.* Mesozoic Fossils. Vol. 1

Part I, 1876: On Some Invertebrates from the Coal-Bearing Rocks of the Queen Charlotte Islands, collected by Mr. James Richardson in 1872.

Part II, 1879: On the Fossils of the Cretaceous Rocks of Vancouver and Adjacent Islands in the Strait of Georgia.

Part III, 1884: On the Fossils of the Coal-Bearing Deposits of the Queen Charlotte Islands, collected by Dr. G. M. Dawson in 1878.

1893. ———The Cretaceous System in Canada. *Trans. Roy. Soc. Canada*, Vol. XI, Sec. 4, pp. 1–19.

1900. WILLIS, BAILEY. Some Coast Migrations, Santa Lucia Range, California. *Bull. Geol. Soc. Amer.*, Vol. XI, pp. 417–432.

INDEX OF SPECIES

CRETACEOUS DEPOSITS OF THE PACIFIC COAST.

New species in **heavy face**, synonyms in *italics*.

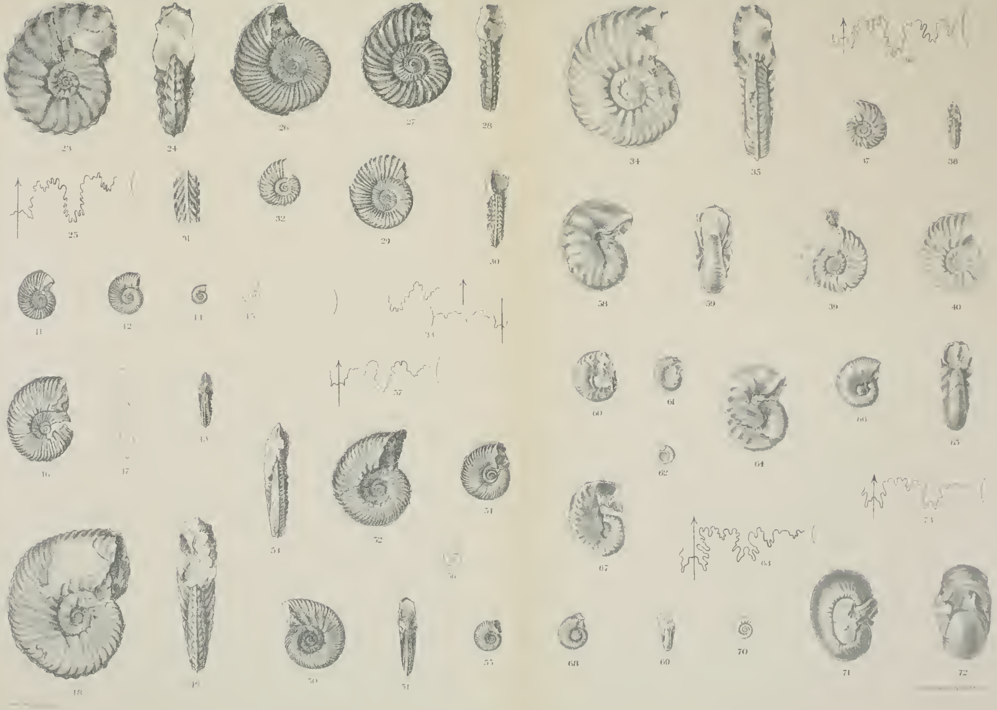
EXPLANATION OF PLATE I.

	PAGE.
Schlœnbachia knighteni, sp. nov.	119
Fig. 1. Adult specimen.	
Figs. 2-3. Young shells.	
Fig. 4. Enlarged suture of young shell.	
Schlœnbachia blanfordiana ? STOL.	124
Figs. 5-6. Adult shells.	
Figs. 7-9. Young shells.	
Fig. 10. Very young shell; ×2.	
Prionotropis branneri, sp. nov.	125
Figs. 11-12. Adult shells.	
Figs. 13, 14, 15, 16. Young shells.	
Mortoniceras crenulatum, sp. nov.	125
Figs. 17-18. Ventral and side views of adult shell with spines.	
Schlœnbachia siskiyouensis, sp. nov.	119
Figs. 19-20. Side and front views of adult shells; natural size.	
Schlœnbachia chicoënsis TRASK.	116
Figs. 21-22. Side and front views of young shells.	


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22

EXPLANATION OF PLATE II.

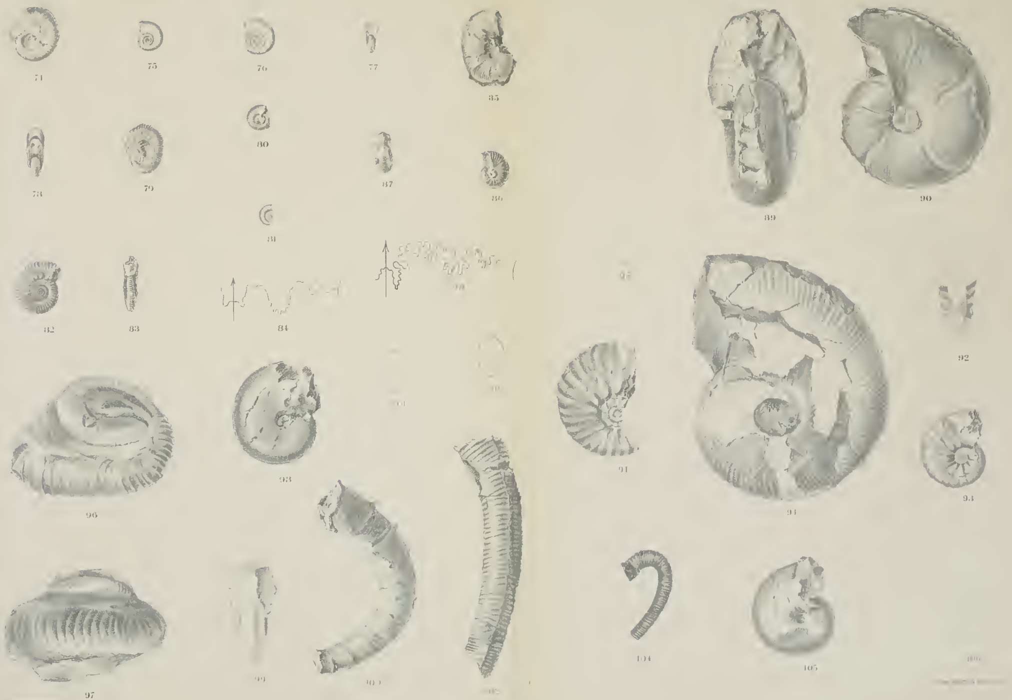
			PAGE.
Schlœnbachia chicoënsis TRASK.			116
	Figs. 23–24.	Mature shells.	
	Fig. 25.	Suture line of same.	
Schlœnbachia bakeri, sp. nov.			121
	Figs. 26–30.	Mature shells.	
	Fig. 31.	Enlarged view of ventral surface.	
	Fig. 32.	Young shell.	
	Fig. 33.	Enlarged suture of young shell.	
Schlœnbachia propinqua STOL.			123
	Figs. 34–35.	Mature shells.	
	Fig. 36.	Suture line of same.	
	Figs. 37–38.	Young shells.	
Schlœnbachia knighteni, sp. nov.			119
	Figs. 39–40.	Young shells.	
Schlœnbachia multicosta, sp. nov.			120
	Figs. 41–43.	Young shells.	
	Fig. 44.	Very young stage.	
	Fig. 45.	Very young shell; $\times 2$.	
	Figs. 46–47.	Mature shells.	
Schlœnbachia oregonensis, sp. nov.			122
	Figs. 48–49.	Adult shells.	
	Figs. 50–54.	Young shells.	
	Figs. 55–56.	Very young shells; $\times 2$.	
	Fig. 57.	Suture of young shell.	
Scaphites condoni, sp. nov.			111
	Figs. 58–59.	Mature shells.	
	Figs. 60–62.	Young shells.	
	Fig. 63.	Suture line.	
Scaphites condoni var. *appressus*, var. nov.			112
	Figs. 64–65.	Mature shells.	
	Fig. 66.	Young of same.	
Scaphites roguensis, sp. nov.			112
	Fig. 67.	Mature shell.	
	Figs. 68–70.	Young shells of same.	
Scaphites perrini, sp. nov.			114
	Figs. 71–72.	Mature shells; $\times 2$.	
	Fig. 73.	Suture of same.	



23
24
26
27
28
25
31
32
29
30
12
33
57
13
53
52
54
18
19
50
51
34
35
38
58
59
39
40
60
61
64
66
65
62
67
68
69
70
71
72

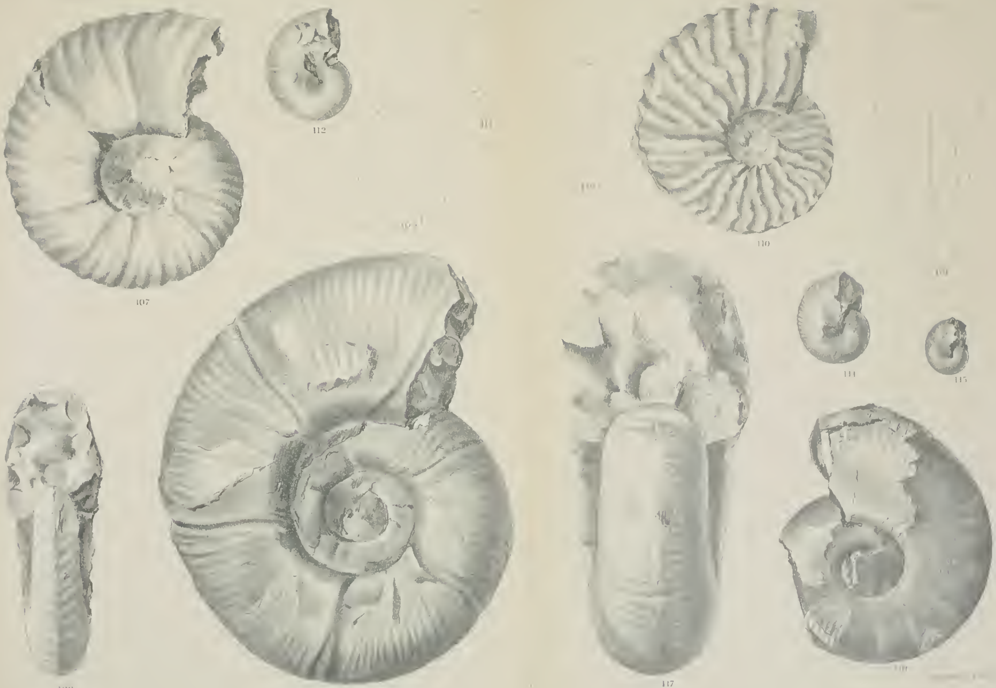
EXPLANATION OF PLATE III.

	PAGE.
Scaphites inermis, sp. nov.	113
Fig. 74. Mature shell.	
Figs. 75-77. Young shells.	
Scaphites klamathensis, sp. nov.	115
Figs. 78-79. Mature shells.	
Figs. 80-81. Young of same.	
Hoplites parva, sp. nov.	
Figs. 82-83. Natural size.	
Fig. 84. Suture of same.	
Scaphites gittisi, sp. nov.	110
Fig. 85. Mature shell.	
Figs. 86-87. Young coils.	
Fig. 88. Suture line.	
Desmoceras voyi, sp. nov.	100
Figs. 89-90. Shell natural size.	
Sonneratia stantoni, sp. nov.	105
Figs. 91-93. Mature and young shells.	
Desmoceras lecontei, sp. nov.	95
Figs. 94-95. Adult, but not full grown shell.	
Heticoceras indicum ? STOL.	91
Figs. 96-97. Coiled portion; ×4.	
Desmoceras sugatum FORBES.	98
Figs. 98-99. Mature shells.	
Heteroceras ceratopse, sp. nov.	91
Fig. 100. Portion of coil; natural size.	
Fig. 101. Section of same.	
Hamites ellipticus, sp. nov.	87
Fig. 102. Side view; natural size.	
Fig. 103. Section of whorl.	
Hamites phœnixensis, sp. nov.	88
Fig. 104. Body chamber; natural size.	
Schlüteria diabloënsis, sp. nov.	80
Figs. 105-106. Shell natural size.	


71
75
76
77
85
78
79
80
87
86
89
90
81
82
83
84
92
91
93
94
95
96
97
99
101
104
105

EXPLANATION OF PLATE IV.

	PAGE.
Desmoceras ashlandicum, sp. nov.	100
Figs. 107–109. Young adult shells.	
Schlœnbachia buttensis, sp. nov.	118
Fig. 110. Full grown shell.	
Fig. 111. Section of whorl.	
Phylloceras shastalense, sp. nov.	80
Figs. 112–113. Mature shells.	
Figs. 114–115. Younger shells.	
Desmoceras dilleri, sp. nov.	97
Figs. 116–117. Mature shells.	
Desmoceras subquadratum, sp. nov.	96
Figs. 118–119. Young adult shells.	


112
110
107
111
115
108
116
117

EXPLANATION OF PLATE V.

	PAGE.
Desmoceras hoffmanni GABB.	97
Figs. 120–121. Young adult shells.	
Figs. 122–123. Younger shells.	
Lytoceras (Tetragonites) jacksonense, sp. nov	82
Figs. 124–125. Adult shells, without body-chamber.	
Holcodiscus, cf. *H. theobaldianus* STOL.	101
Figs. 126–127. Young adult shells; natural size.	
Desmoceras colusaense, sp. nov.	96
Figs. 128–129. Adult shell; one-half natural size.	
Hamites armatum, sp. nov.	89
Fig. 130. Side view, body-whorl.	
Fig. 131. Ventral surface, showing spines.	
Fig. 132. Cross-section of same.	


120
124
126
127
132
121
122
128
129
131
130

EXPLANATION OF PLATE VI.

	PAGE.
Pachydiscus sacramenticus, sp. nov.	105
Fig. 133. Full grown shell.	
Fig. 134. Young shell.	
Pachydiscus merriami, sp. nov.	103
Figs. 135–136. Full grown shells.	
Figs. 137–138. Younger coils.	
Lytoceras (*Gabbioceras*) *angulatum* (GABB'S var.), sp. nov.	87
Fig. 139. Partial restoration of an adult shell.	
Lytoceras rel. *duvalianum* D'ORB.	81
Figs. 140–143. Partly grown shells.	
Schlœnbachia oregonensis, sp. nov.	122
Fig. 144. Cross-section of whorls; 22.25 mm. diameter. After J. P. SMITH.	


133
134
135
136
137
138
139
140
141
142
143

EXPLANATION OF PLATE VII.

PAGE.

Lytoceras timotheanum MAYOR. 63

Figs. 145–148. Young adult shells.

Schlœnbachia oregonensis, sp. nov. 122

Fig. 149. Very young shell; diameter 5.6 mm.

Fig. 150. Very young shell; diameter 1.65 mm.

After J. P. SMITH.

(For cross-section see Fig. 144, Plate VI.)

Pholadomya anaäna, sp. nov. 73

Fig. 151. Shell; natural size.

Baculites fairbanksi, sp. nov. 92

Fig. 152. Adult; natural size.

Fig. 153. Cross-section of same.

Lytoceras argonautarum, sp. nov. 85

Figs. 154–155. Young shells; two-thirds natural size.

Mactra gabbiana, sp. nov. 74

Fig. 156. Shell; natural size.

Rhynchonella densleonis, sp. nov. 72

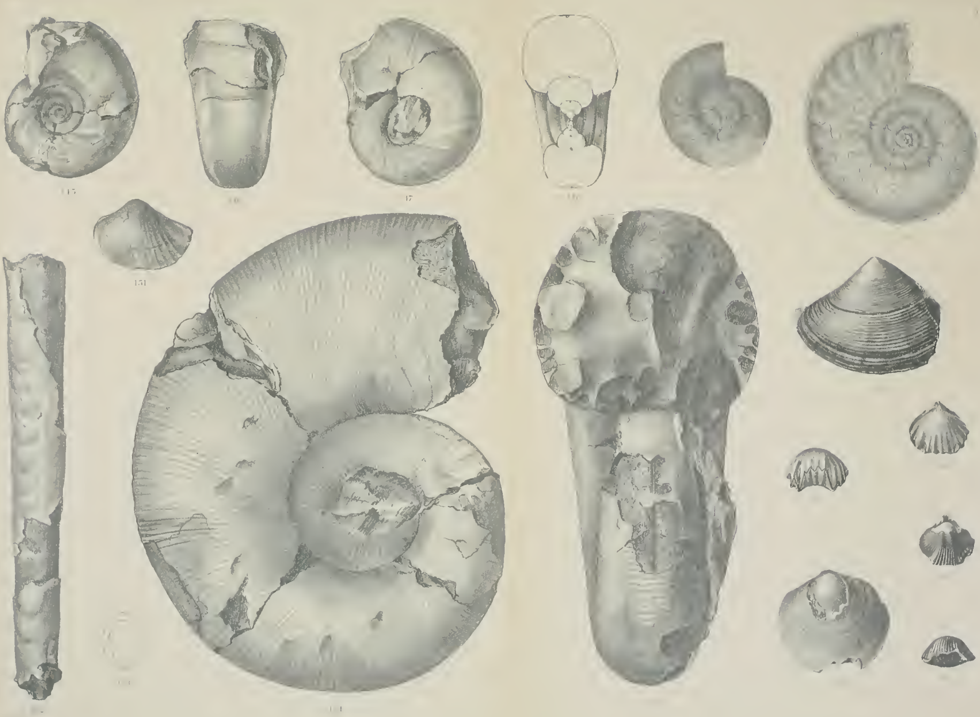
Figs. 157–158. Top and front views.

Pectunculus pacificus, sp. nov. 74

Fig. 159. Shell; natural size.

Rhynchonella whiteana, sp. nov. 72

Figs. 160–161. Top and front views; natural size.


151

EXPLANATION OF PLATE VIII.

PAGE.

Placenticeras pacificum SMITH. 79

(After J. P. Smith, Proc. Cal. Acad. Sci., 3d Ser., Geol., Vol. I, Plate XXV.)

Figs. 162–163. Four coils; diameter 20.5 mm.; ×2.7. Arroyo del Vallé, Alameda County, California.

Fig. 164. Four and five-sixths coils; diameter 47 mm.; natural size. Henley, California.

Pachydiscus henleyensis, sp. nov. 104

Fig. 165. Section of whorl reduced, at fourteen inches.

Fig. 166. Section of whorl at a diameter of three and one-half inches.

Gyrodes siskiyouensis, sp. nov. 76

Fig. 167. Front view; natural size.

Fig. 168. Top view of same.

Belemnites, sp. Texas Flat, Shasta County, California. 40

Fig. 169. Shell partly restored; natural size.

Fig. 170. Enlarged view, showing protoconch.

Placenticeras pacificum SMITH. 79

Figs. 171–172. Adolescent stage; two and five-sixteenths coil; diameter 2.32 mm.; ×10. Henley, California.

Placenticeras californicum, sp. nov. 78

(After J. P. Smith, Proc. Cal. Acad. Sci., 3d Ser. Geol., Vol. I, Plate XXV.)

Fig. 173. Three coils; diameter 8 mm.; ×2.7. Henley, California.

Figs. 174–175. Adolescent stage; three and five-eighths coils; diameter 14 mm.; ×2. Henley, California.

Figs. 176–177. Adolescent stage; four coils; diameter 22 mm.; ×2. Arroyo del Vallé, Alameda County, California.

Fig. 178. Four and one-half coils; diameter 34.5 mm.; ×2. Henley, California.

Anchura condoniana, sp. nov. 76

Fig. 179. Full grown shell; natural size.

170
168
178
179

EXPLANATION OF PLATE IX.

	PAGE.
Placenticeras pacificum SMITH.	79
(After J. P. Smith, Proc. Cal. Acad. Sci., 3d Ser., Geol., Vol. I, Plate XXVI; figure redrawn.)	
Fig. 180. Adult shell, diameter 172 mm., six and one-sixth coils; natural size. Henley, California.	
Erato veraghoorensis (?) STOL.	75
Figs. 181–182. Shell, natural size.	
Haliotis lomaënsis, sp. nov.	75
Fig. 183. Shell; natural size.	
Hamites (Ptychoceras) solanoënse, sp. nov.	90
Fig. 184. Rear view of body-chamber; natural size.	
Inoceramus klamathensis, sp. nov.	73
Fig. 185. View of left valve.	
Fig. 186. Left valve with hinge; natural size.	
Acanthoceras compressum, sp. nov.	107
Fig. 187. Shell; natural size.	
Inoceramus adunca, sp. nov.	73
Figs. 188–189. Front and rear views of adult shell.	

EXPLANATION OF PLATE X.

Suture lines of new species.

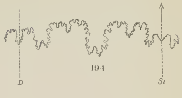
		PAGE.
Fig. 190.	*Desmoceras lecontei.*	95
Fig. 191.	*Hamites ellipticus.*	87
Fig. 192.	*Desmoceras dilleri.*	97
Fig. 193.	*Desmoceras subquadratum.*	96
Fig. 194.	*Baculites fairbanksi.*	92
Fig. 195.	*Pachydiscus sacramenticus.*	105
Fig. 196.	*Desmoceras ashlandicum.*	100
Fig. 197.	*Holcodiscus*, cf. *H. theobaldianus.*	101
Fig. 198.	*Sonneratia stantoni.*	105
Fig. 199.	*Schlüteria diabloënsis.*	80
Fig. 200.	*Desmoceras colusaënse.*	96
Fig. 201.	*Heteroceras ceratopse.*	91
Fig. 202.	*Prionotropis branneri.*	125
Fig. 203.	*Desmoceras hoffmanni.*	94


190

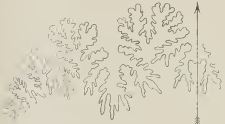

191


192


193

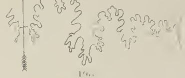


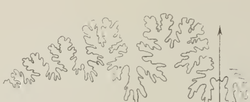
194


195

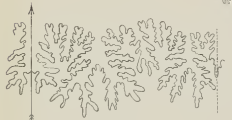

196


197

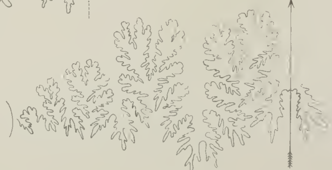

198


199


200


201


202


203

EXPLANATION OF PLATE XI.

PAGE.

Schlœnbachia oregonensis, sp. nov. 122

After J. P. Smith, Journ. Morph. Vol. XVI, 1899, Plates A and B.

Figs. 204–206. Protoconch, phylembryonic to ananepionic. $\frac{40}{1}$.

Figs. 207–208. Phylembryonic to paranepionic; diameter 0.58 mm.; one-half whorl, first eight septa, glyphioceran stage at the sixth. $\frac{40}{1}$.

Fig. 209. Paranepionic, glyphioceran substage; diameter 0.64 mm.; third to tenth septa, five-eighths of a whorl. $\frac{40}{1}$.

Figs. 210–211. Phylembryonic to paranepionic, glyphioceran substage; diameter 0.68 mm.; three-quarters of a whorl, nine septa. $\frac{40}{1}$.

Figs. 212–213. Paranepionic, paralegoceran substage; diameter 2.25 mm.; two and three-eighths whorls. $\frac{20}{1}$.

Figs. 214–215. Ananeanic, *Parastyrites* stage; diameter 3.70 mm.; three and one-fourth whorls. $\frac{13}{1}$.

Fig. 216. Paranepionic, glyphioceran substage; diameter 0.74 mm.; seven-eighths of a whorl. $\frac{40}{1}$.

Figs. 217–218. Paranepionic, transition from glyphioceran to gastrioceran substages; diameter 1.20 mm.; one and three-eighths whorls. $\frac{20}{1}$.

Figs. 219–220. Paranepionic, transition from glyphioceran to gastrioceran substage; diameter 1.33 mm.; one and five-eighths whorls. $\frac{20}{1}$.

Figs. 221–222. Paranepionic, gastrioceran substage; diameter 1.65 mm.; one and seven-eighths whorls. $\frac{20}{1}$.

Figs. 223–224. Ananeanic, *Styrites* stage; diameter 3.10 mm.; two and seven-eighths whorls. $\frac{20}{1}$.

Fig. 225. Metaneanic, advanced adolescent stage; diameter 5.60 mm.; three and three-quarters whorls, show-beginning of ribs at a diameter of 4.70 mm. $\frac{10}{1}$.


204
205
206
209
212
213
214
207
208
210
223
215
216
217
218
211
219
220
221
222
224
225

EXPLANATION OF PLATE XII.

The Development of *Baculites chicoënsis* TRASK.[1]

Upper cretaceous, Chico beds, Jordan ranch, Arroyo del Vallé, eight miles southeast of Livermore, Alameda County, California.

Fig. 226. Protoconch, front view, diameter 0.48 mm.; enlarged 15 times.

Fig. 227. First septum, showing siphonal cæcum.

Fig. 228. Second septum, at diameter 0.58 mm.

Fig. 229. Larval shell, at one-fourth of a revolution, diameter 0.58 mm.; 15 times enlarged.

Fig. 230. Sixth septum, at one-half revolution.

Figs. 231–232. Larval shell, showing the embryonic constriction, and the first larval body-chamber; 15 times enlarged.

Figs. 233–234. Larval shell at three-quarters of a revolution, diameter 0.83 mm.; enlarged 15 times.

Fig. 235. Larval shell, showing the ornamentation of the embryonic and early larval stage, and the ananepionic body-chamber; enlarged 15 times.

Figs. 236–237. Shell at end of the second larval stage, diameter 1.6 mm.; 15 times enlarged.

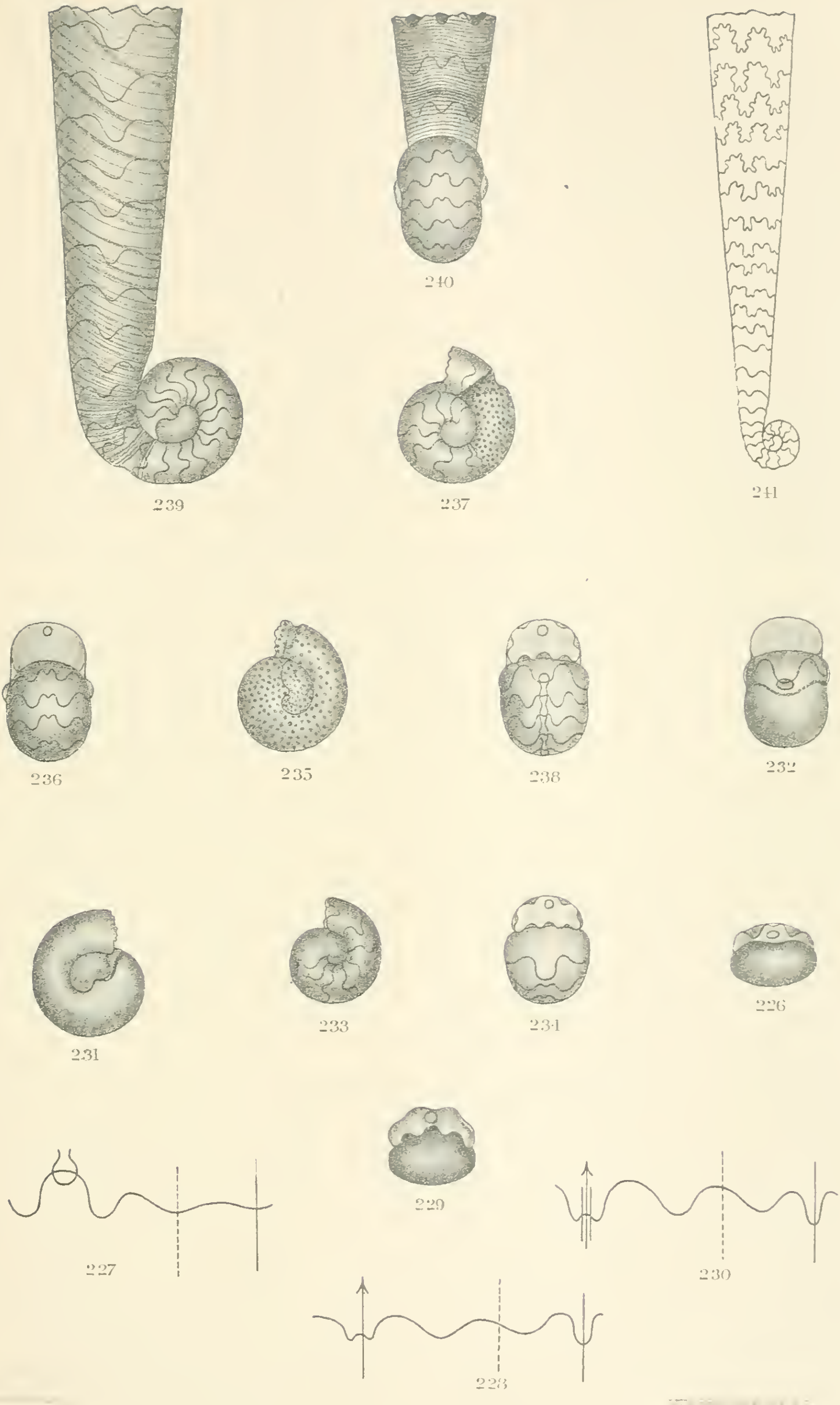
Fig. 238. Larval shell, showing the periodic swelling of the siphuncle. Diameter 1.00 mm.; enlarged 15 times.

Figs. 239–240. Early adolescent stage, showing the unsymmetric shape of the larval coil, and the contraction of the shell at the beginning of this stage; enlarged 15 times.

Fig. 241. Composite drawing from several specimens, showing the development of the septa from the embryonic into the adolescent stage; enlarged 5 times.

---

[1] These drawings are copied from a paper by J. P. Smith, "The Larval Coil of Baculites," *American Naturalist*, Vol. XXXV, p. 39, Jan., 1901. The numbers on this plate do not correspond to the originals of Smith's plates, since not all his figures are reproduced here.


240
239
237
241
236
235
238
232
231
233
234
226
229
227
230
228

PROCEEDINGS OF THE ACADEMY.

(Octavo.)

Third Series.

GEOLOGY.

Vol. I.

No. 1—The Geology of Santa Catalina Island. By William Sidney Tangier Smith		$ .50
No. 2—The Submerged Valleys of the Coast of California, U. S. A., and of Lower California, Mexico. By George Davidson		.50
No. 3—The Development of Glyphioceras and the Phylogeny of the Glyphioceratidæ. By James Perrin Smith		.35
No. 4—The Development of Lytoceras and Phylloceras. By James Perrin Smith		.35
No. 5—The Tertiary Sea-Urchins of Middle California. By John C. Merriam	}	.25
No. 6—The Fauna of the Sooke Beds of Vancouver Island. By John C. Merriam	}	
No. 7—The Development and Phylogeny of Placenticeras. By James Perrin Smith		.50
No. 8—Foraminifera from the Tertiary of California. By Frederick Chapman		.25
No. 9—The Pleistocene Geology of the South Central Sierra Nevada with Especial Reference to the Origin of Yosemite Valley. By Henry Ward Turner		.50

Vol. II

No. 1—Cretaceous Deposits of the Pacific Coast. By Frank M. Anderson	$1.75

All subscriptions, applications for exchanges, and inquiries concerning the publications should be addressed to

The Corresponding Secretary,
California Academy of Sciences,
San Francisco, California

3205

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

GEOLOGY VOL. II, No. 2

A Stratigraphic Study in the Mount Diablo Range of California

BY

FRANK M. ANDERSON

Curator of the Department of Invertebrate Paleontology

WITH TWENTY-THREE PLATES

Issued December 4, 1905

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1905

COMMITTEE ON PUBLICATION

LEVERETT MILLS LOOMIS, *Chairman*

ALPHEUS BULL JOSEPH W. HOBSON

THE HICKS-JUDD PRESS
SAN FRANCISCO

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

GEOLOGY VOL. II, No. 2

Issued December 4, 1905

A STRATIGRAPHIC STUDY IN THE MOUNT DIABLO RANGE OF CALIFORNIA

BY FRANK M. ANDERSON

Curator of the Department of Invertebrate Paleontology

CONTENTS

PLATES XIII–XXXV

 November 28, 1905

Preface.

The systematic study of the field covered by this paper, and its stratigraphy, was begun for purely economic and private purposes and not for publication; nevertheless, so much data and material of a scientific interest have been gathered, and so much information has been acquired, part of which, though of a practical nature, it is permissible to make public, that some of the more general facts are here offered as a contribution to the geological literature of California.

The matter and conclusions set forth are the result of a field-study extending over a period of more than two years, made partly alone, and partly with the coöperation and aid of Mr. Josiah Owen, whose knowledge of the field is both extensive and practical to a high degree, and to whom are due many of the stratigraphic observations here presented.

The advantages for a statigraphic and faunal study offered by this field are in most respects unsurpassed anywhere. The aridity of the climate, and the soft and crumbling nature of the younger sediments, together with the action of the wind, combine to give excellent and accessible exposures of rock, while in many cases the almost perfect preservation of the shells and other fossils renders the task of identification satisfactory. The structure of the rocks, moreover, is generally simple, and strata are readily followed to almost any extent, particularly along the eastern flanks of the range, to which most of the field-work was naturally confined.

In this connection it is proper to mention the generous interest taken in this work by Professor E. T. Dumble and the many facilities afforded through his kind coöperation.

The fossils collected during the field explorations, aggregating several thousand in number, were donated to, and have become the property of the California Academy of Sciences.

INTRODUCTION.

In order that one of the main purposes of this paper may be understood, it is necessary, at the outset, to make the following statement. It is believed that during the Neocene periods, if not throughout the Tertiary, there were a number of more or less separated basins, or minor faunal provinces, along the Pacific border, two of which are represented within the confines of California.

The California *interior basin* was bounded approximately by the outer Coast Range, the Tehachapi Range, and the Sierra Nevada. At the south the barrier described a broad curve, following the axis of the Santa Cruz and Santa Lucia ranges along the present coast, thence turning eastward to Pine Mountain and the Tehachapi Range, which united it to the Sierra Nevada. The interior basin thus occupied the region of the Great Valley of California and the intermontane valleys between that and the coast.

The basin thus bounded and outlined is clearly distinguished from that of the open ocean of the time, the littoral deposits of which form a narrow fringe at intervals along the present coast, or fill the narrow coastal valleys, especially at the south.

The present paper is concerned especially with the deposits of the interior basin of California, which are believed to be typically represented in the Mount Diablo Range and in a few other localities within the Great Valley.

The Mount Diablo Range, as defined by Whitney,[1] extends along the southwestern border of the Great Valley of California, from Mount Diablo, near the Straits of Carquinez, southeasterly to Pine Mountain, where it unites with the Tehachapi Range, which links it with the Sierras. Thus the valley of the San Joaquin is surrounded by a continuous barrier of ranges on the east, south, and west, while it is separated by the Mount Diablo Range from the rest of the interior basin occupied by the Salinas and the Carisa valleys. In other words the Mount Diablo Range divides the basin of

[1] Geol. Surv. Calif. Geol. v. 1, pp. 8-60.

the California interior somewhat centrally, presenting at the same time magnificent stratigraphic sections that are unsurpassed anywhere in the West in their exposures.

DIVISIONS OF THE MOUNT DIABLO RANGE.

Whitney divided the Mount Diablo Range into six more or less distinct sections separated by certain low passes, some of which at least are notable breaks in the range, and though the region was not so well known then as now, it is still useful to observe some of these divisions.

The San Carlos Division of Whitney embraced that portion of the range between the Panoche Pass on the north and the Estrella (or Cottonwood) Pass on the south, thus including most of the western border of Kings and Fresno counties, or the territory adjacent to the Devil's Den, Coalinga, and "Oil City" petroleum districts. It is this division of the range which is chiefly the subject of the present paper, the various features of which will serve to illustrate the facts and conditions prevailing throughout the range.

Rocks of various kinds are found among the formations of this section ranging in age from Paleozoic to Recent, and embracing both sedimentary and igneous elements, though the latter are of only minor importance. For the most part the formations are arranged in roughly concentric fashion about the two principal centers of this division, one of which lies to the south and the other to the northwest of the Coalinga district. On the eastern slope of the range the structure is usually monoclinal, the strata dipping at varying angles toward the Great Valley, generally toward the east or north. The Cretaceous and early Tertiary beds stand at a high angle, while the younger strata often have a much gentler inclination.

The general topographic features of the Mount Carlos Division of the range are similar to those of other portions, and vary according to the underlying formations. The concentric arrangement of the rocks above referred to gives rise to similarly concentric series of hills and dales that have developed in accordance with the character and hardness of the rocks affected. The higher portions of the range are rocky and rugged, while the lower eastern slopes are often formed of gently undulating hills extending in parallel ranks and gradually sinking below the plain to the eastward.

The principal streams of this section, flowing toward the Great Valley, are the Panoche, San Carlos, Cantua, Los Gatos, and Alcalde creeks, each of which cuts deep canyons into the softer formations near the valley, but heads high up on the rocky ridges in the central parts of the range. Farther south are the Sunflower and Antelope valleys with converging streams.

Stratigraphic Series.

Franciscan and Associated Rocks.

The oldest rocks met with in the San Carlos Division of the range are those generally referred to the Franciscan series, including not only the well known sedimentary factors, but also certain basaltic and other igneous rocks closely connected or involved with them. It is perhaps sufficient to say that the entire series, including the eruptives, are in point of age pre-Cretaceous, though they have been variously assigned by different authors, wholly or in part, to the Paleozoic, Jurassic, or Cretaceous periods.

The sedimentary members of the Franciscan series represented in this field include the rocks ordinarily found associated in this formation, such as radiolarian jaspers, sandstones, slates, and schists, and perhaps certain conglomerates.

Closely connected with the Franciscan rocks territorially are the serpentines of the range. While it is not likely that the connection is anything more than territorial, as in point of age the serpentines are of more recent origin and therefore more closely connected with the succeeding series, still, as their association with the Franciscan rocks is habitual even outside this district, they may be better classed with these than with any other formations.

The geologic and topographic features of the series are the same as everywhere in the coast ranges both north and south of the Bay of San Francisco. In this field the series is confined in its occurrence to the axis of the chief range extending west of the Coalinga district, or, more accurately, to a few prominent areas within that range.

There are two or three principal areas of Franciscan and serpentine rocks, separated to a considerable extent by an area of Cretaceous strata. One of these lies to the south of the upper tributaries of Alcalde Creek (or Warthan Canyon), and extends from there southeasterly to Cottonwood Pass; another extends from the upper branches of Los Gatos Creek northward toward the Panoche Valley and the tributaries of the San Benito River, and therefore includes the New Idria quicksilver district and the San Carlos and San Benito peaks.

The most extensive formation in this area is undoubtedly serpentine. To the south and west of New Idria, serpentine is almost the only rock to be seen for many miles. The sedimentary rocks of the Franciscan series are mostly confined to the southern and western borders of the area.

CRETACEOUS STRATA.

Lying along the eastern margins of the Franciscan areas and filling wide spaces between, are Cretaceous rocks, forming a stratified series of great thickness and dipping steeply toward the Great Valley. An important area of Cretaceous rocks is that between the Alcalde and Los Gatos creeks near Coalinga.

The Cretaceous strata include both the Knoxville and Chico divisions, with the intervening Horsetown Beds apparently omitted. The usual nonconformity between these members has not been proved in this field directly, though there are abundant grounds for believing that it exists.

The Knoxville consists of a thick series of dark clay shales and thin-bedded sandstones, lying next to the Franciscan rocks. They have been particularly noted along the head waters of Alcalde Creek, near the Fresno Hot Springs, on the head of the Jacalitos Creek, and at the Devil's Den, south of the Sunflower Valley. The Cretaceous rocks in the vicinity of the New Idria quicksilver mines have long been known. From there they extend southeasterly to Coalinga. In the Knoxville portion the only fossils so far discovered are species of *Ammonites*, (*Hoplites*), *Belemnites*, and imperfect plant remains.

The Chico rocks, which are chiefly in evidence north of Alcalde Creek, and still more so north of Los Gatos Creek, form a thick series of yellow clay shales and tawny colored sandstones. To the north of Los Gatos Creek they extend high up on the range and constitute the most conspicuous formation of the mountain as seen from the south and east. The sandstones predominate, and make up two quite distinct members of the upper part of the Chico, with thick beds of yellow clay shales between. The upper sands of the Chico are characterized by large sandy concretions of a brown color, which have a tendency to split horizontally or to fall apart in concentric shells or laminae.

Thus far species of *Inoceramus* are the only fossils found in these concretionary rocks, but *Baculites* have been found in close connection with them near the coal mine west of Coalinga. The concretionary sandstone has a maximum thickness of some four hundred feet where it is exposed nine miles north of Coalinga. The yellow shales below the concretionary sandstones contain masses of nodular limestone from which were obtained at different points the following species:

Baculites chicoënsis Gabb	*Inoceramus whitneyi* Gabb
Baculites sp.	*Perissolax brevirostris* Gabb
Lytoceras sacya Forbes	*Architectonica* sp.
Desmoceras (rel. *D. hoffmanni* Gabb)	*Gyrodes* sp.
Pectunculus veatchi Gabb	*Cinulia obliqua* Gabb. etc., etc.

The Chico rocks stand at a high angle all along the range, and vary in strike to conform to the underlying Franciscan and other rocks. For the most part all the Cretaceous rocks strike northwesterly or a little north of west. Perhaps the average strike of the Cretaceous rocks is N. 60° W. However, there are two structural ox-bow curves, one on either side of Coalinga at a distance of some ten or more miles, in which the Cretaceous rocks are carried well toward the valley, forming the foundation upon which the Tertiary oil yielding strata are deposited.

Attention should be directed to these curves as structural features of the range as a whole, but too little is yet known of them to warrant more than a suggestion. It appears that their repetition along the eastern part of the range forms the axes of local anticlines in the later strata which plunge respectively below the level of the valley bottom. No less than six such folds are known between the Sunset district and the Big Panoche Creek north of Coalinga, but their fuller discussion must be left for another time.

Eocene Formations.

The Eocene strata of the Coalinga district and vicinity lie in detached belts along the eastern and northeastern flanks of the range. One of the more extensive belts of Eocene rocks extends from the northern border of the Sunflower Valley westerly to the head of Alcalde Creek. Another begins in the hills west of Coalinga and extends northerly for two miles or more and includes the coal mines of that district. A third belt begins north of Los Gatos Creek, extends northeasterly along the foothills, and can be traced north and northwesterly in a fairly well marked band for twelve or fifteen miles to Salt Creek, and thence westerly to Silver Creek and the Panoche Valley. Northward from Los Gatos Creek the Eocene forms a fairly uniform and continuous series as far as it has been followed.

Still another area occurs on the northern border of the Antelope Valley near the Devil's Den, and includes the massive sandstones at the place locally termed the Point of Rocks. A fifth and more southerly area of Eocene occurs in the near vicinity of Temblor and at Canara Springs and northward toward the Antelope Valley. At Canara Springs the massive sandstones of the Eocene form conspicuous and picturesque cliffs, over which lie the more regular beds of the Lower Miocene. These massive sandstones present many curious and striking examples of atmospheric erosion, among which are the natural cisterns often developed on the summits of the most conspicuous pyramids of rock.

Along the Eocene belt extending westerly from Tar Springs the rocks stand at a high angle dipping to the north at an angle of 75° to 80°. In the Coalinga belt they likewise stand at a high angle dipping toward the east, while farther north the inclination is less and the strike carries them in a broad curve around the outer flanks of San Benito Mountain. The dip naturally varies in its direction with the strike, but in its inclination it is commonly between 25° and 35°.

While the stratigraphic divisions of the Eocene do not continue regularly throughout, there is at least one member that is fairly well characterized along the whole extent of the series as far as followed. This member is the middle one, and consists of brown bituminous or carbonaceous shale, more or less sandy in the lower portion, and with a maximum thickness of six hundred feet as exposed on the hills a few miles north of Coalinga. Farther to the south and southeast it varies considerably, attaining at the Kreyenhagen wells a thickness of about nine hundred feet, while on the head of the Jacalitos and on the Zapata Chino there are not more than two hundred fifty or three hundred feet of strata. On account of its development at the Kreyenhagen wells this member of the Eocene has been termed the *Kreyenhagen Shales*. The lithological character of these shales is not constant, as the proportions of the chief elements vary from point to point. Sands, clay, and organic matter, both calcareous and carbonaceous, make up the mass of the beds, which at some points become sandy and at others argillaceous, while the percentage of lime or carbonaceous matter also varies.

Nodular masses of calcareous rock and nodules of barites ($Ba\ SO_4$) are common in many places, and these form a characteristic feature of the shales.

The calcareous masses occurring in the shales often contain foraminifera in great numbers, not unlike certain rocks of the Miocene. The brown color of these shales is probably due in large part to bituminous matter contained therein; but this will be referred to later.

Both above and below the Kreyenhagen Shales are sands, which at some points are sufficiently consolidated to form hard rock.

South of the Kreyenhagen wells there is a great thickness of sandstone exposed along the canyon of Canoes Creek with a thin basal bed of conglomerate resting upon the Lower Cretaceous shales. The strata stand almost vertical with a dip of 75° or 80° toward the north and an east-west strike.

At least the upper four hundred feet of this sandstone, and possibly all of it, is to be referred to the Eocene. A few miles to the east, at Tar Springs, the lower portion of the Eocene consists of about four hundred feet of concretionary sandstones which are very fossiliferous. The concretions occupy a place immediately below the Kreyenhagen Shales, while lower down are thin beds of sandstone, and at the base a bed of pebbly conglomerate six to ten feet in thickness, resting upon strata of Cretaceous age. The Avenal wells at Tar Springs are drilled to penetrate these sands. These basal and concretionary sandstones can be followed for several miles both east and west from Kreyenhagen's, being exposed at Tar Springs on the east and at the Sulphur Springs on the Zapata Chino Creek to the west. On account of their development at the Avenal wells (Tar Springs) they may be conveniently termed the *Avenal Sandstones*.

The species of invertebrate fossils obtained from these sandstones include the following:

Cardita horni Gabb (*C. planicosta* Conrad)
Cardium cooperi Gabb
Cardita sp.
Corbula paralis Gabb
Solen paralellus Gabb
Meretrix horni Gabb
Amauropsis alveata Gabb
Architectonica horni Gabb
Ancellaria elongata Gabb
Dentalium cooperi Gabb
Fusus martinez Gabb
Fusus diaboli Gabb
Turritella uvasana Gabb
Turritella pachecoënsis Stanton
Neverita globosa Gabb

A stratigraphic section of the rocks at Tar Springs is shown in the accompanying sketch (Pl. xxxiv, fig. 1).

At the sulphur spring in one of the canyons of Zapata Chino Creek the Eocene is represented by the following members:

	ft.
Kreyenhagen Shales	250
Avenal Sandstones	500
Basal conglomerate	15

It will be seen that the Kreyenhagen Shales are considerably reduced in thickness while the Avenal Sandstones are somewhat thickened, but the latter was proved by the concretionary masses, by the basal conglomerate, and by fossils. The entire series stands at a high angle with a westerly strike and a dip to the north.

The Eocene could not be traced westerly beyond the Sulphur Springs on the Jacalitos Creek.

At the Point of Rocks on the northern border of the Antelope Valley there are about twenty-four hundred feet of Eocene strata exposed, the lowest beds of which contain the following species:

Neverita globosa
Turritella uvasana
Discohelix
Meretrix uvasana
Ostrea idriaënsis
Spondylus carlosensis n. sp.
Cardita
Terebratella
Sea urchins

These beds dip northeasterly at an angle of near 30°, and to the eastward are overlain by the sandy beds of the Lower Miocene. The upper one-third of the Eocene consists of sands which include exposures like that shown on Plate XXVII. Between the fossiliferous concretionary sandstones forming the lowest beds exposed and the massive sand beds above, there are softer and less resistant beds that perhaps represent the shales which form elsewhere the intermediate member.

At Temblor and Canara Springs the massive sands are exposed, but the shales and fossiliferous beds below were not identified. The unconformity of the Lower Miocene beds upon these massive sands of the Eocene is well shown on Plate XXV.

In the areas extending northward from Coalinga the Avenal Sandstones have been only indirectly proved. At the coal mines the basal portion of the Eocene is occupied by thin beds of conglomerate, sand, and coal-bearing sandy shale. The following stratigraphic section fairly represents the Eocene at the coal mines:

	ft.
Kreyenhagen Shales	400
Echinoderm conglomerate	8
Carbonaceous sands	140

Two fossil horizons are to be noted in this section: (a) that of the pebbly conglomerate containing species of Echinoderms; (b) that of the carbonaceous sands. The thin bed of conglomerate has afforded the following species:

Cassidulus californicus n. sp.
Scutella sp. A.
Echinoderms (genus not det.)
Ostrea aviculiformis n. sp.
Cardium cooperi Gabb
Mactra sp.
Meretrix horni Gabb
Ostrea (2 sp.)
Spondylus carlosensis n. sp.
Tellina sp.
Galerus excentricus Gabb
Turritella uvasana Gabb
Terebratella sp.
Crustaceans (Cancer, etc.)
Nodules of barites

From the sandy beds more closely connected with the coal and carbonaceous strata were obtained:

Modiola ornata Gabb
Meretrix uvasana Gabb
Meretrix horni Gabb
Cardium cooperi Gabb
Mactra sp.
Arca (*Barbatia*) *morsei* Gabb
Cardita sp.
Placuanomia inornata Gabb
Ostrea idriaënsis Gabb
Lunatia horni Gabb
Nerita triangulata Gabb
Neverita globosa Gabb
Galerus excentricus Gabb
Fusus martinez Gabb
Turritella pachecoënsis Stanton

North of Los Gatos Creek a pebbly conglomerate, six to ten feet thick, near the top of the Kreyenhagen Shales, has been followed almost continuously for a distance of four miles. It has yielded the following species:

Ostrea aviculiformis n. sp.
Cardita horni Gabb
Dosinia sp.
Gari texta (?) Gabb
Cardium cooperi Gabb
Pecten sp.
Meretrix horni Gabb
Ostrea (2 sp.)
Spondylus carlosensis n. sp.
Amauropsis alveata Gabb
Morio tuberculatus Gabb
Turritella uvasana Gabb
Turritella pachecoënsis Stanton
Trochosmilia striata Gabb
Ellipsosmilia granulifera Gabb
Terebratella sp.
Echinoderms (2 sp. undet.)
Sharks' teeth
Teleost. vertebrae
Nodules of barites

On the N. E. ¼ of Sec. 17, north of Coalinga, similar pebbly beds just above the top of the Kreyenhagen Shales contain a few of the foregoing species along with species of Foraminifera and nodules of barites.

This horizon of the Eocene begins its greater development at this point and increases in thickness as it is followed to the northwest. On the east side of Section 17 it has a thickness of not more than three hundred fifty feet, while eight miles to the northwest it has a thickness of something like twelve hundred feet, where it is exposed in the vicinity of the Kimball wells.

It consists chiefly of yellow sands, which, as far as they have been followed, are but little consolidated, and under the meager rainfall of the region readily disintegrate, forming loose sandy slopes. Its great development in the vicinity of the Domijean ranch affords grounds for its designation as the *Domijean Sands*.

On the west side of Section 17 the sandy beds at the base of the Eocene aggregate somewhat more than at the coal mine, but they are also more distributed stratigraphically, with shales intervening between their several layers.

They are partially represented on Plate XXXIV, figure 3. Their correlation with the Avenal Sands is based chiefly upon their stratigraphic position, as they are undoubtedly basal and rest directly upon the concretionary Chico sandstones.

In the vicinity of New Idria and along the southern side of the Big Panoche Valley the Eocene rocks present the stratigraphy characteristic of the series north of Coalinga. Three members are clearly distinguishable, though their aggregate thickness can hardly exceed twelve hundred feet. The beds may be divided as follows:

	ft.
Loose ash-colored sandstones	300
Carbonaceous clay shales	300
Sandstones (ash-colored)	600
Total	1200

The Eocene age of these beds appears to have been at least suspected by Gabb, as shown in Whitney's[1] discussion of the region.

The stratigraphic members of the Eocene, then, are the following:

Domijean Sands
Kreyenhagen Shales
Avenal Sandstone

The lack of continuity of these members along the entire range is to be attributed partly to their nature and manner of origin, and partly to their degradation previous to the laying down of the succeeding Miocene or Pliocene strata; naturally, therefore, this lack affects chiefly the lower and upper members, while the intermediate member is more uniform in its character and at the same time more persistent in its occurrence.

The preceding lists of fossils contain representative Eocene species such as indicate that the beds are to be correlated rather with the Tejon than with the Martinez division of the Eocene, and this accords with the fact that the latter horizon has been considered local in its occurrence, or extending only northward from the latitude of Mount Diablo, and also with the fact that the Tejon Beds are found at New Idria and other points only a few miles north of the limits of our own observations.

Miocene Formations.

Rocks of the Miocene period do not enter extensively into the stratigraphy of the San Carlos Division of the range north of Alcalde Creek, but south and east of this stream they are more in evidence. Miocene strata occur in somewhat disconnected belts running parallel with the Eocene, and to some extent parallel with the Cretaceous. The greatest thickness of Miocene rocks found in any part of the range is near McKittrick and Temblor, although thicker aggregations of strata are found elsewhere, as on the western border of the Carisa Valley.

---

[1] Geol. Surv. Calif. Geol. v. 1, p. 57.

The most representative section of the Miocene that has been observed anywhere in the range south of the Cantua Creek is to be seen at Temblor and Canara Springs in western Kern County. Though no detailed study of these strata was undertaken, a general statement will be found interesting and instructive. The most conspicuous member of the Miocene in this section is the Monterey Shales, which have here an aggregate thickness of more than five thousand feet. For the most part this member consists of light colored shaly strata, the material of which is evidently largely organic, but in which three or more elements are easily recognizable; viz., foraminiferal limestone, siliceous organic beds, clay shales, and supposedly volcanic dust and ash. The limestone occurs in thin lenticular bands, gray or yellowish in color, in which Foraminifera are readily seen through a good lens. These yellow or light gray bands occur in groups or singly, scattered through the entire thickness. The siliceous portion of the Monterey Shales predominates, and generally shows remains of Diatomaceae and other siliceous organisms, with bones and scales of fishes.

Near the top of the series the strata become more chalky and softer. *Pecten peckhami* has been found at both the top and bottom of this member at Canara Springs and eastward. The Monterey Shales, apparently, in undiminished thickness, make up the mass of the main range west of McKittrick, but they have not been traced easterly much beyond the Sunset district.

Underlying the Monterey Shales at Canara Springs and Temblor are sandstones and sandy shales which make up an additional thickness of fifteen hundred feet. The entire series of Miocene rocks at this point is about as follows:

	ft.
Monterey Shales	5500
Sandstones with *Astrodapsis*	100
Siliceous and clay shales with interstratified sandstone	600
Sandstones with numerous fossil species	800
Total thickness	7000

The sandstone with *Astrodapsis* contains in addition *Pecten nevadensis*, *Pecten discus*, and a few fragments of oysters and barnacles. The lower fossiliferous sandstones yielded the following species of invertebrates:

Lucina borealis Linn.	*Pecten* sp.
Lucina richthofeni Gabb	*Solen* sp.
Yoldia cooperi Gabb	*Tapes* sp.
Mytilus mathewsoni Gabb	*Macoma* sp.
Chione mathewsoni Gabb	*Ballanus* sp.
Dosinia mathewsoni (?) Gabb	*Neverita callosa* Gabb

In the light of stratigraphic studies farther north it is evident that the entire series of sands and shales below the Monterey Shales should be regarded as a distinct member of the Miocene, and the name *Temblor Beds* is suggested to embrace this aggregate of strata, while for the first sandy beds below the Monterey at Temblor the name "Button beds" has been used on account of the great numbers of small discoidal sea urchins (*Astrodapsis*) which characterize them here and elsewhere.

The Temblor Beds are often characterized by sands, more or less distinctly stratified, which are usually rendered highly calcareous by great numbers of fossil invertebrates. Echinoderms are sometimes so abundant that certain beds become almost a limestone. Occasionally pebbly layers are encountered, and at other points the sandstones become noticeably shaly.

As will be noticed further on, it is not rarely that the Monterey Shales are found resting on older rocks without any appearance of the Temblor Beds intervening. In some places there is a distinct overlapping of the Monterey Shales beyond the borders of the Temblor Beds.

North of the Canara Springs there is no similar thickness of Miocene strata anywhere in the Mount Diablo Range as far as known to the writer. In the vicinity of the Devil's Den and northward the section is materially reduced, chiefly by the reduction of the Monterey Shales.

Nowhere north of the Antelope Valley have these shales been found to exceed one thousand feet in thickness, though otherwise they are identical and appear to represent the basal portion of the shales occurring in the Canara Springs section.

Miocene strata describe a broad curve around the eastern side of the Sunflower Valley, but at most points only the Monterey Shales are visible. On the northern border of the Sunflower Valley, at Tar Springs, the Miocene section is about as follows:

	ft.
Monterey Shales	900
Temblor Sandstones with fossils	800
White sandy shales	400
Total	2100

This section is representative of the Miocene occurrences at most points between the Antelope Valley and Alcalde Creek. The Miocene rocks rest indiscriminately upon the Eocene, the Cretaceous, or older rocks as the case may be, though not always with an appearance of unconformity. The dip is always toward the Great Valley at some angle between 20° and 90°. At Tar Springs the dip is above 75°. At the Devil's Den on the south side of the Sunflower Valley the dip is in some places anticlinal, and to the west of the valley the Monterey Shales rise upon the flanks of the main range, overlying the Cretaceous without any appearance of the Temblor Beds.

The topographic aspect of the Temblor Beds is striking. They stand out in bold relief along the whole range from McKittrick northwestward to near Coalinga, and form a species of serrated wall along the front of the hills through which the canyons emerging into the Great Valley have cut their ways. This is particularly noticeable along the northern border of the hills extending west from Tar Springs, and in many other parts of the country. This feature is shown in some degree on plates XXVIII and XXIX.

The following fossil species have been collected from the Temblor Beds at different points:

Tar Springs.

Scutella sp.
Astrodapsis merriami n. sp.
Pecten discus Conrad
Pecten crassicardo Conrad
Turritella ocoyana Conrad
Neverita callosa Gabb
Dosinia mathewsoni (?) Gabb
Crepidula praerupta Conrad
Ballanus sp.

Kreyenhagen Wells.

Astrodapsis merriami n. sp.
Pecten discus Conrad
Pecten estrellanus Conrad
Turritella ocoyana Conrad
Agasoma gravidum Gabb
Neverita callosa Gabb
Mactra densata Conrad
Venus (Chione) temblorensis n. sp. (rel. *C. guidia.*)
Zirphaea sp.
Natica sp.
Mactra (Spisula) sp.
Ostrea sp.
Hemifusus wilkesana n. sp.
Lucina acutilineata Conrad
Arca montereyana Osmont
Ballanus sp.

Sulphur Springs, Zapata Chino Creek.

Mactra densata Conrad
Mactra sp.
Arca montereyana Osmont
Tapes sp.
Lucina sp.
Venus (Chione) temblorensis n. sp.
Astrodapsis merriami n. sp.

The species given in the preceding lists are characteristic of the Lower Miocene as it occurs in the Great Valley of California, and perhaps that of all the interior valleys of the State.

The more northerly belt of Miocene rocks in the Coalinga district begins a few miles to the northwest of Coalinga, on the north side of Sec. 2, T. 20 S., R. 14 E., and extends in a broad curve northeasterly, northerly, and northwesterly for many miles, or quite beyond the Cantua Creek.

It is fairly well shown on the Coalinga geologic map prepared for this paper (Pl. XXXV). The dip of the strata is always toward the Great Valley at angles varying from 20° to 35°, and in directions normal to the strike. In a few cases only, and notably in one or two cases, is the structure complicated. In the main the structure of all the Tertiary rocks is monoclinal. But on the S. E. ¼ of Sec. 20, T. 19 S., R. 15 E., the Miocene rocks are exceedingly crushed and distorted by compression, and to some extent this distortion extends also to the Eocene and the Pliocene rocks.

Two members of the Miocene have been detected in the Coalinga district proper, but possibly others occur a few miles to the northwest. For the most part the Temblor Beds are not present, and the following members only are in evidence, as in the vicinity of the Kimball wells, where the following members occur:

	ft.
(?) Contra Costa Beds	—
Monterey Shales	800
Domijean Sands (Eocene)	1200

Ashy beds near the top of the Miocene resemble both lithologically and faunally beds on the bay-shore north of Pinole Station, Contra Costa County. The following species were collected from these Miocene beds on the west side of Sec. 19, T. 18 S., R. 14 E.:

Ashy beds.	Monterey Shales.
Leda oregona (?)	*Pecten peckhami* Gabb
Tellina congesta (?)	*Callista* (?) sp.

The Miocene rocks show little evidence of being bituminous as they are followed northward toward the Cantua Creek, and in fact there is but slight direct evidence that they are bituminous at any point between Coalinga and the Cantua.

The noteworthy facts about the Miocene series north of Coalinga as far as followed are the absence of the Temblor Beds and the greatly reduced thickness of the Monterey Shales. Strata of apparently the horizon of the Temblor Beds occur in the Walnut Creek Valley west of Mount Diablo, as described by Dr. Merriam.[1]

Later Neocene Beds.

By far the most important series of strata in the Mount Diablo Range from the view-point of economic geology are the late Tertiary strata, including the probable equivalents of the San Pablo Beds and others with which they are unconformably related. In this collection of strata the following members are distinguishable, either stratigraphically or faunally:

[1] Bull. Dept. Geol. Univ. Calif. v. 3, pp. 377-381.

Etchegoin Beds (San Pablo Beds ?)	San Joaquin Clays Etchegoin Sands
Coalinga Beds	Oyster Sands, etc. Reef Beds, etc.

Each of these divisions could be again subdivided with greater or less success within specified limits, but it would be difficult to discover features characteristic enough for such purposes that would have a wide application. In other words, the materials of the strata change more or less from point to point along their strike, passing from coarser to finer, etc., according to local conditions during the period of their deposition, such as the presence of streams, currents, etc.

The most constant feature of the lower two-thirds of the combined series is its sandy character, while the upper portion is clay or fine sand and clay, in which the clays are variegated in color, being alternately white, red, gray, or yellow.

Coalinga Beds.

An interesting stratigraphic unit is that here described as the Coalinga Beds. So far they have been found only locally, and throughout a stretch of more than fifty miles along the Mount Diablo Range they were not recognized at all. They occur, however, in both the Coalinga and McKittrick districts, and in each case sufficiently individualized to be regarded as distinct from both the Monterey and the Etchegoin Beds.

In the Coalinga district, as shown on the map (Pl. xxxv), the formation occurs in two separate areas, the more northern of which can be followed far beyond the limits of the map, or at least to the Cantua Creek if not to Mount Diablo.

West of Coalinga these beds are sandy with a minor part of shale, which at one place north of the coal mine appears to be soft and marly if not diatomaceous. At the artesian water well on Section 35 these marly beds do not appear, but the basal beds are composed of sands which are locally bituminous. Six miles north, on the E. ½ of Sec. 36 marly beds crop out very near the base and present also a strongly bituminous appearance in their yellow red, and brown discolorations. The stratigraphic position of these white marly beds can be well observed at many points, as on the south side of Sec. 20, T. 19 S., R. 15 E., where a conspicuous *reef* of sandstone crosses the ravine, with marly beds both above and below. This sandy stratum, on account of its disposition to protrude here into a sort of wall, and from the fact of its being fossiliferous, was during our field-study termed the *Reef Bed*, and it proved a useful name in further exploration. The accompanying sections show the principal stratigraphic features of the Coalinga Beds at two or more points:

		ft.
Coalinga Beds ten miles north of Coalinga	Yellow sands, etc.	1300
	Tamiosoma Bed with oysters, pectens, etc.	20
	Yellow sands	550
	White shale (marly)	20
	Dark sands	50
	Reef Bed	40
	White shale with oysters	20
	Basal sands, etc.	180
Coalinga Beds twenty miles northwest of Coalinga	Yellow sands.	1000
	Sands with oysters	6
	Sandy white shales	80
	Tamiosoma Bed with oysters, pectens, etc.	15
	Yellowish sands, gravels, etc.	320
	Reef Bed (sandy)	15
	Basal sands and conglomerate	120
Coalinga Beds three miles west of Coalinga	Blue sands, gravels, etc.	2400
	Pecten beds	40
	Sands, gravels, etc.	700
	Sands and yellow gravels	1000
	Dark sands with *Diplodonta harfordi*	50
	Reef Bed (sand stone)	50
	Gray sands, unconsolidated	200
	Basal gravels	50

It will be seen by an inspection of these sections that there is throughout the field but little continuity to any of the lithologic features that seem locally to be significant, as gravels give place to sands, and both become locally calcareous, or the reverse.

A somewhat more satisfactory means of correlating or identifying strata is found in the faunal contents as illustrated in the case of the Reef Bed, from which the following species have been obtained where the bed can be traced continuously for two or three miles through Sec. 16, 21, and 20; T. 19 S., R. 15 E.

Reef Bed, Sec. 20 and Sec. 21:

**Astrodapsis tumidus* Remond	**Tapes tenerrima* Cpr.
**Arca montereyana* (?) Osmont	*Lucina borealis* Linn.
**Dosinia ponderosa Gabb*	**Pseudocardium* sp.
**Mactra* (*Spisula*) *falcata* (?) Gould	**Neverita recluziana* Desh.
Macoma inquinata (?) Desh.	*Hemifusus* sp.
Mytilus californianus Conrad	**Trophon gabbiana* n. sp.
**Pecten discus* Conrad	*Trochita* sp.
Pecten estrellanus Conrad	Sharks' teeth

The more characteristic of these species were found in the Reef Bed of Sec. 20, T. 18 S., R. 14 E., including:

**Pecten discus* Conrad	**Dosinia ponderosa* Gabb
**Astrodapsis tumidus* Remond	

A stratum in the last section immediately above the white shales, four hundred feet above the Reef Bed, contained the following species and genera:

Cytherea (*Callista*) sp.	*Solen* sp.
Chione (rel. *C. guidia*)	*Ostrea* sp.
Macoma nasuta Cpr.	*Agasoma kernianum* Cooper
Pecten estrellanus Conrad	*Turritella* sp.
Zirphaea dentata Gabb	*Cancellaria* sp.
Lucina borealis Linn.	*Trophon* sp.
Diplodonta harfordi n. sp.	

It is apparent that not only are the characteristic Reef Bed fossils absent from this list, but there are some forms introduced, as for instance the first two and nearly all of the gasteropod species.

The Oyster sands, with their associated gigantic *Tamiosoma*, *Pecten*, etc. are well developed on the N. E. ¼ of Sec. 19, T. 18 S., R. 14 E., and can be easily followed toward the southeast to the vicinity of the wells of the California Limited Oil Company.

Another feature of the basal portion of the Coalinga Beds between Salt Creek on the north and the wells of the Cali-

NOTE. In the above and following lists important or characteristic species are marked with an asterisk.

fornia Limited Oil Company is the rather local development of heavy beds of conglomerate. These are best seen in the "Rainbow beds" on Sec. 4 and 10; T. 19 S., R. 15 E. and in the conglomerates crossing Salt Creek, Sec. 10, 11, and 14; T. 18 S., R. 13 E.

These conglomerates vary considerably in thickness, having their maximum development on Salt Creek, where there are above the Reef Beds about twelve hundred feet of heavy serpentine conglomerate. The conglomerates, including the "Rainbow beds," lie between the Reef Bed below and the Tamiosoma bed above, and as far as they have been followed they hold this relation, but at intervals give place to sandy beds, as in the case south and west of the California Limited Oil Company's wells.

West of Coalinga the Reef Bed is not a prominent topographic feature, but it can be recognized by its faunal contents, which contains the following species:

**Dosinia ponderosa* Gabb
**Cyrena californica* Gabb
Crepidula excavata (?)
**Cytherea* (*Callista*) sp. (rel. *C. callosa*)
Mytilus californianus Conrad
Lucina borealis Linn.
**Metis* (*Lutricola*) *alta* Conrad
Macoma nasuta Cpr.
Cytherea (*Callista*) *diabloënsis* n. sp.
**Tapes tenerrima* Cpr.
Diplodonta harfordi n. sp.
**Pecten discus* Conrad
Pecten estrellanus Conrad
Zirphaea dentata Gabb
**Mactra* (*Spisula*) *catilliformis* Dall
**Mactra* (*Spisula*) *falcata* Gould
**Neverita recluziana* Desh.
**Chrysodomus recurva* Gabb
Purpura sp.
Galerus sp.
Cancellaria vespertina n. sp.
Nassa sp.
**Trophon* sp.
**Astrodapsis* sp.

Vertebrates
- *Oxyrhina tumula* Agz.
- *Lamna clavata* Agz.
- *Zygobates* sp. Agz.

It is not unlikely, and is perhaps even probable, that the Coalinga Beds as here described will be found to be the equivalent of the Contra Costa Beds described by Merriam[1] as belonging to the uppermost Miocene. Their nonconformity with both the Monterey Shales below and the characteristic Etchegoin Beds above is clearly shown, as pointed

[1] Bull. Dept. Geol. Univ. Calif. v. 3, no. 16.

out by Mr. Owen, in the foothills directly north of Coalinga. It is also a significant fact that for more than sixty miles along the eastern side of the range, between Coalinga and McKittrick, they do not appear, though the Monterey Shales and the Etchegoin Beds are continually in evidence. Throughout the Salinas and other intermontane valleys to the west, the Coalinga Beds appear to be present in considerable thickness.

Etchegoin Beds.

No other formation in the Mount Diablo Range has so great an areal extent and so great a thickness and continuity as the Etchegoin Beds, which overlie in turn all of the older formations of the region, resting upon each respectively with a distinct nonconformity. The relations of this formation to the others in the Coalinga field are shown in the accompanying map (Pl. XXXV) and sections (Pl. XXIV).

The maximum stratigraphic thickness of the Etchegoin Beds in their greatest development is certainly not less than seventy-five hundred feet, while at other points they do not exceed five thousand feet. In some sections they have the appearance of aggregating the incredible thickness of nine thousand feet, but such a development is probably local.

Sands, usually but little consolidated, form the predominating element and make up locally three-fourths of the entire series, occurring chiefly at the bottom or in the lower portions.

The name of this formation has been derived from its characteristic development in the vicinity of the Etchegoin ranch, some twenty miles northeast of Coalinga.

A detailed description of the divisions of the Etchegoin Beds is hardly possible from our present knowledge of them, but a general statement will perhaps be useful in identifying them in the field and in correlating them with similar formations elsewhere.

Etchegoin Sands.—Occupying a stratigraphic position at the base of the Etchegoin and forming almost two-thirds of its mass, are unconsolidated sands or gravels in which a characteristic blue or bluish gray color predominates, at least in certain localities. In the vicinity of the Etchegoin ranch, some twenty miles northeast of Coalinga, these blue sands are distributed in three prominent horizons including about twelve hundred feet of strata. They can be traced with more or less continuity throughout the field from the Cantua southward to the Sunflower Valley.

The blue color has been generally found to be a safe index to the identity of the beds and has been recognized in the vicinity of Mount Diablo and on San Pablo Bay. It is not claimed, however, that it is constant or characterizes any particular strata within this division. In thickness the Etchegoin Sands vary considerably. Near the Cantua the thickness appears to be less than on the Etchegoin ranch, while south of Alcalde the thickness is considerably greater.

In the vicinity of Kreyenhagen's where the Etchegoin has its greatest development, the strata included within the limits of the blue sands are twenty-five hundred feet, of which ordinary gray sand and gravels form the larger portion. Many of the pebbles are jet black in color.

The Etchegoin Sands are commonly coarse in texture and often pebbly, forming beds of conglomerate. There is an appearance of volcanic ash or Kaolin-like matter throughout the colored zones, and their characteristic color may be partly due to this material, but the exact nature of the coloring matter has not been determined.

One or two fossil horizons are to be recognized in the Etchegoin Sands, one near their bottom and another some distance above, but whether persistent or not cannot be stated. The more characteristic horizon is that near the bottom of this division and includes the following species:

Pseudocardium gabbi Remond	*Scutella* sp.
Arca trilineata Conrad	*Mytilus* (large sp.)
Mya arenaria Linn.	*Ostrea attwoodi* Gabb
Pectunculus septentrionalis Midd.	*Cardium meekianum* Gabb

The second fossil horizon occurs higher up in the beds, nearer their top, and contains the following:

Arca trilineata Conrad
Saxidomus aratus Gould
Pecten coalingaënsis Arnold
Pecten wattsi Arnold
Pecten etchegoini n. sp.
Chama sp.
Ostrea sp.
Tellina sp.
Ballanus sp.
Neverita recluziana Desh.
Nassa californica Conrad
Terebratella sp.
Clypeaster (*Scutella*) *breweriana* Remond
Scutella gibbsi Remond
Astrodapsis tumidus Remond
Sharks' teeth, etc.

Southward on the Jacalitos Creek similar beds near the base of the Etchegoin series contains the following species:

**Mactra* (*Mulinia*) *densata* Conrad
**Mactra* (*Spisula*) *falcata* Gould
**Metis* (*Lutricola*) *alta* Conrad
Macoma nasuta Cpr.
Pectunculus septentrionalis Midd.
Saxidomus aratus Gould
Pecten crassicardo Conrad
**Hinnites* sp.
**Trophon ponderosum* Gabb
**Chrysodomis* sp.
Nassa sp.
Natica sp.

West of Coalinga where the Etchegoin Beds are well exposed and fossiliferous, they contain:

Mactra (*Spisula*) *falcata* Gould
Metis (*Lutricola*) *alta* Conrad
Saxidomus aratus Gould
Tapes staleyi Gabb
Pecten oweni Arnold
Arca trilineata Conrad
Pectunculus septentrionalis Midd.
Cardium meekianum Gabb
Diplodonta harfordi n. sp.
Macoma secta Conrad
Pseudocardium sp.
Nassa californica Conrad
Neverita recluziana Desh.
Pleurotoma (*Surcula*) sp.
Scutella gibbsi Remond, etc.

A comparison of these lists with the lists published by Whitney[1] and others for the Pliocene occurring at Kirker's Pass, Contra Costa County, makes it evident that faunally they are of the same group of strata. Furthermore a few days spent by the writer in studying and collecting from the beds occurring on the east shore of San Pablo Bay, Contra Costa County, led to the conclusion that the two thousand or more feet of Pliocene strata occurring there on the southern side of the syncline is the equivalent of the Etchegoin Sands and represents only the basal portion of the Etchegoin Beds in their full development. The same fauna can be recognized also a little to the north of Walnut Creek Station on the railroad running to San Ramon. The lowest faunal

Geol. Surv. Calif. Geol. v. 1, p. 32.

horizon on San Pablo Bay is equivalent to that of the lowest horizon described in the Etchegoin Sands. Among the more characteristic species are the following, from the bay-shore north of Pinole:

Astrodopsis tumidus Remond	*Mactra falcata* Gould
Pecten pabloënsis Conrad	*Pectunculus septentrionalis* Midd.
Pecten crassicardo Conrad	*Saxidomus aratus* Gould

San Joaquin Clays.—The clays at the upper part of the Etchegoin, from Coalinga northward, occupy at least a third of the entire series, or about fifteen hundred feet in stratigraphic thickness. At a distance these clays present a banded appearance from the zones of color seen in the different strata, some of which have a width of two hundred or three hundred feet. These clays are overlain by fresh water deposits in the vicinity of Tulare Lake and the Kettleman Hills to the depth of one thousand feet or more.

No fossils have been found in them north of Coalinga, but north of Tar Springs, Kings County, specimens of *Scutella gibbsi* and teeth of sharks have been found.

TULARE FORMATION.

Overlying the San Joaquin Clays of the Etchegoin series there are thick strata of gypsiferous sands and clays exposed at intervals along the western border of the Great Valley. In the Kettleman Hills, ten to fifteen miles southeast of Coalinga and near the western shore of Tulare Lake, these beds aggregate fully one thousand feet in thickness, though no attempt was made to measure them accurately. They lie conformably upon the San Joaquin Clays and in some respects resemble them, so that it is not always possible to discriminate accurately between them. Where the Tulare beds are exposed in the Kettleman Hills they have been noted by W. L. Watts[1], who gives a sectional view of the Pliocene beds with which he classes these. Some of the beds contain an abundance of fresh-water mollusks, and

[1] Bull. no. 3, Calif. State Min. Bur. 1894, p. 55.

among those collected by Watts the following species were identified by Dr. J. G. Cooper:

Anodonta decurtata Conrad	*Margaritana subangulata* Cooper
Anodonta nuttaliana Lea	*Physa costata* Newcomb
Amnicola turbiniformis Tryon	*Planorbis tumens* Carpenter
Carinifex newberryi Lea	*Sphaerium dentatum* Hold.
Goniobasis occata Hinds	

Their classification as Pliocene is perhaps supported only by their conformable position on the Etchegoin clays, but in view of the fact of their fresh-water origin, the determination is not conclusive.

Similar beds are also described by Watts[1] from the vicinity of McKittrick (Sec. 34, T. 30 S., R. 22 E.) where the following species were obtained:

Anodonta nuttatiana Lea
Carinifex newberryi Lea
Pomatiopsis intermedia Tryon

It has been suggested that these beds might be correlated in part or whole with the Orindan beds described by Dr. Lawson[2] from the Berkeley Hills and other points in Contra Costa County. If such be the case their occurrence is probably continuous along the whole western border of the Great Valley, and probably also to the north of the Straits of Carquinez.

STRATIGRAPHIC RELATIONS.

With few exceptions, notably that of the later sedimentary beds designated as the Tulare Formation, the entire collection of stratified rocks described in the foregoing pages is essentially marine. While the coal beds of the Eocene may represent a condition somewhat different, it is evident that these beds are local and have not a great stratigraphic range.

In the case of all the later series, beginning with the Cretaceous, there is a considerable uniformity of strike and dip in many parts of the range. From stratigraphic evidence alone

1 Bull. no. 3, Calif. State Min. Bur. 1894, p. 49.
2 Bull. Dept. Geol. Univ. Calif. v. 2, pp. 371 *et seq.*

it is often impossible to discriminate between the rocks of the several periods. In most places there is an apparent stratigraphic conformity between Cretaceous and Eocene, and between the latter and Miocene strata. And in most sections, likewise, the Pliocene (Etchegoin) rocks rest conformably upon the older series. Dr. Becker and C. A. White[1] believed that the entire collection of Cretaceous, Eocene, and Miocene strata formed a continuous and conformable series, and this opinion was held after observations had extended over a considerable portion of the Mount Diablo Range.

The lithological variation of the rocks is considerably greater, and characteristic types are the rule in all of the principal epochs. It is often possible to recognize without the aid of fossils many of the typical members of the stratigraphic groups. Probably the most trustworthy guide for the identification of strata in all cases is that afforded by paleontology, but in the later formations the persistence of some of the fossil forms from the earliest Miocene to the Present makes it necessary to use them with caution. Without the aid of other stratigraphic data and the recognition of lithologic peculiarities it would often be difficult to distinguish between the Lower Miocene and the Coalinga Beds, while both of these series contain forms that are still living along the west coast. However, there are a few forms that have been found to be sufficiently trustworthy within provincial limits, but it is doubtful if many of them would support extensive generalizations.

Dr. Merriam has pointed out[2] that *Agasoma gravidum*, *Turritella ocoyana*, and *T. hoffmanni* are characteristic of the lower Miocene, and all of these have been found in the Temblor Beds of the Mount Diablo Range, along with many other forms occurring in the typical Lower Miocene beds of Kern River.

Similarly certain forms of *Pecten*, *Mactra*, *Scutella*, and *Astrodopsis* are believed to belong only to the Etchegoin Beds, but it will require at least a reasonable degree of

1 Bull. no. 15, U. S. Geol. Surv. pp. 14, 15 *et seq.*
2 Bull. Dept. Geol. Univ. Calif. v. 3, pp. 377-381.

specific discrimination to maintain this generally, as several forms of each occur at intervals from the early Miocene to the Present. *Pseudocardium gabbi* of the Pliocene resembles *Mulinia densata*, occurring in both the Upper and Lower Miocene, and in like manner closely allied species of *Scutella* and *Astrodopsis* occur in both the early Miocene and the San Pablo.

There is evidence of nonconformity between the rocks of all of the successive periodic series, and in some cases between the different members of the same series. The nonconformity between the Chico and Eocene is well shown by a detailed study of the field north of Alcalde Creek. The nonconformity is both stratigraphic and faunal, but the evidence of either class becomes more convincing only as it becomes better known. In the case of the Eocene and Miocene nonconformity the evidence is also both faunal and stratigraphic, the latter appearing more satisfactory from the fact that the Lower Miocene rests in turn upon the Eocene, the Cretaceous, and the Franciscan rocks.

The relations of the Pliocene (Etchegoin) formation to the earlier ones has been shown in the preceding pages and on the map of the Coalinga district (Pl. xxxv), but the evidence shown there is only partial.

What evidence the field might afford as to the relation of the Etchegoin to later rocks has not been ascertained, beyond the fact of a transition from marine to fresh-water conditions. It is conceivable that such a transition might be effected so gradually by normal causes that no stratigraphic nonconformity would exist, but such a transition in this case requires to be shown. In the Berkeley Hills the Orindan Formation rests unconformably upon the Monterey Shales, and their basal portion is pebbly conglomerate. If the Tulare Beds are to be correlated with the Orindan, the individuality in each case would be the same.

There is, however, a stratigraphic member still to be considered, whose exact relationship is less evident, though probably not so difficult as it might appear. This remark concerns the Coalinga Beds. They have been followed throughout a distance of twenty miles along their outcrop, where they are almost entirely uncovered, regularly stratified, and quite fossiliferous. Where they rest upon the Monterey Shales, which for the greater part of the distance they do, there is but little appearance of stratigraphic divergence, except an abrupt transition from fine to coarse sediment. In their dip and strike there is considerable uniformity, at most points at least, though there is at some points a sudden change from the hard shales of the Monterey to the soft coarse sands and conglomerates of the Coalinga Beds. As they are followed along their contact, however, as they can be easily for many miles, the Coalinga Beds are not only found resting upon different portions of the Monterey at different points, but toward the south they rest in turn upon Monterey Shales, the Eocene, and the Chico.

The nonconformity therefore of the Coalinga Beds with all of these older series may be considered equally clear.

The stratigraphic nonconformity of the Coalinga Beds, on the other hand, with the Etchegoin Beds is also equally clear.

This is best shown near the northeast corner of the map of the Coalinga field, or about seven miles north of Coalinga. As the basal beds of the Etchegoin are followed westward through the field, they rest upon, and then close out successively lower and lower strata of the Coalinga Beds until finally the latter disappear from the stratigraphic section entirely, and the Etchegoin Beds are found resting upon the Monterey Shales. A similar occurrence may perhaps also be seen west of Coalinga, where the Etchegoin Beds are found passing from the Coalinga Beds to the underlying Chico.

A faunal study of the Coalinga Beds shows them more closely related to the Temblor than to any later or living faunas. Notice for example in the basal Coalinga—that is in the Reef Beds—the occurrence of *Agasoma kernianum*, *Arca montereyana*, and *Pecten discus*, besides many other forms closely allied to those of the Temblor Beds.

Other Occurrences of Lower Miocene within the Interior Basin.

For purposes of comparison and for a more complete understanding of the Lower Miocene fauna within the interior basin of California, brief descriptions of other occurrences are here given. In a short paper recently published by Dr. Merriam[1] the Lower Miocene beds of Contra Costa County are described, including a partial list of fossils. The beds are said to rest directly upon the Tejon, and to be overlain by beds of Monterey Shale. The most characteristic species are:

Agasoma gravidum Gabb	*Chione mathewsoni* Gabb
Dosinia mathewsoni Gabb	*Mytitus mathewsoni* Gabb

The stratigraphic thickness of these beds was not given, but it is probably commensurate with that of the Temblor Sandstone.

San Emidio Section.

An instructive section of the rocks of the San Emidio Canyon is to be found in Whitney's[2] description. In referring to this illustration, however, it is necessary to remember that Eocene rocks were classed by him as Cretaceous.

Overlying the Eocene beds are beds of Lower Miocene age with a fauna similar to that already described for the Temblor Beds.

The dip is toward the north at a high angle, and the strike is conformable to that of the Eocene and later rocks. The Monterey Shales are missing from this section, or if present were not recognized. The beds may be traced westerly and northwesterly toward the Carisa, toward McKittrick and Temblor, and perhaps easterly toward the Tejon ranch.

Beds of the Carisa Ranch.

Near the Carisa ranch house, along the San Juan River, San Luis Obispo County, an enormous thickness of Miocene

---

[1] Bull. Dept. Geol. Univ. Calif. v. 3, pp. 377-381.

[2] Geol. Surv. Calif. Geol. v. 1, p. 189.

rocks is exposed with a dip of 40° to 60° to the northeast. The series consists of alternating horizons of sandstone and siliceous shales, the former of which greatly preponderate.

The lowest fossil horizon near the base of the series, and the second one some thirteen hundred feet above the base contained very nearly the same fauna, from the latter of which the following species were collected:

Turritella ocoyana Conrad
Trochita filosa Gabb
Agasoma gravidum Gabb
Crepidula grandis Conrad
Crepidula praerupta Conrad
Neverita callosa Gabb
Fusus (*Hemifusus*) *wilkesana* n. sp.
Scaphander jugularis Conrad
Cytherea (*Callista*) *mathewsoni* Gabb
Dosinia mathewsoni Gabb
Mytilus mathewsoni Gabb
Lucina richthofeni Gabb
Pecten estrellanus Conrad
Pecten sp.
Glycimeris estrellanus Conrad

A third fossiliferous horizon within twenty-five hundred feet of the top of the Miocene series yielded essentially the same fauna with one or two additional forms, as *Pecten nevadensis*, *Oliva californica* n. sp., and an undescribed species of *Dosinia*. etc. This horizon is well exposed about four miles southeast of La Panza Springs on the east side of the San Juan River. It is overlain by shaly beds with a fauna resembling that of the Monterey Shales.

KERN RIVER BEDS.

Although this locality was not specially studied, and lies without the Mount Diablo Range, still it has long been known. and lies within the interior basin of California. The locality is on Kern River, two to six miles east of Oil City, Kern County. The strata are mainly sands and sandy clays. dipping gently toward the west. The entire thickness of the strata exposed along the river aggregates about three thousand feet, of which the lower two-thirds belongs to the Miocene. Toward the base they become very fossiliferous. containing numerous species of invertebrates, teeth of sharks, and bones of fishes and other marine vertebrates.

The following species were collected in the vicinity of Barber's ranch, chiefly north of the river:

Agasoma gravidum Gabb
Agasoma kernianum Cooper
Agasoma sinuatum (?) Gabb
Conus oweniana n. sp.
Neverita callosa Gabb
Turritella ocoyana Conrad
Cuma biplicosta Gabb
Oliva californicus n. sp.
Scaphander jugularis Conrad
Trophon kernensis n. sp.
Dentalium substriatum Conrad
Dentalium sp.
Pleurotoma (*Clathurella*) *dumbleana* n. sp.
Nassa arnoldi n. sp.
Trochita filosa Gabb
Crepidula praerupta Conrad
Purpura lima Martyn
Sigaretus scopulosus Conrad
Terebra cooperi n. sp.
Bullia (*Molopophorus*) *anglonana* n. sp.
Cancellaria pacificus n. sp.
Cancellaria joaquinensis n. sp.
Cancellaria condoni n. sp.
Cancellaria simplex n. sp.
Cancellaria dalliana n. sp.
Cytherea (*Callista*) *mathewsoni* Gabb
Venus (*Mercenaria*) *pertenuis* Gabb
Venus (*Chione*) *temblorensis* n. sp.
Dosinia mathewsoni Gabb
Dosinia sp.
Mactra (*Spisula*) *falcata* Gould
Mactra sp.
Pachydesma inezana Conrad
Pecten discus Conrad
Solen sicarius Gould
Solen sp.
Tellina ocoyana Conrad
Tellina sp.
Yoldia impressa Gabb
Lucina richthofeni Gabb
Arca montereyana Osmont
Corbicula dumbleana n. sp.
Leda oregona Shumard
Cytherea sp.
Homomya sp.
Pectunculus sp.

Many yet undescribed species occur in this collection, and the locality is well worth a more exhaustive study. On the whole it probably better represents the Lower Miocene fauna of the California interior than any other locality that has been described.

CORRELATIONS.

It is not at present possible to correlate with much accuracy the Tertiary beds of the Mount Diablo Range with others occurring in distant parts of the Coast or of the State. For the Pliocene, and perhaps also the Miocene periods, a number of minor provinces must be recognized along the Pacific border, corresponding to the physical geography of the time. North of the Klamath Mountains the Miocene and Pliocene faunas are in a measure specifically different from those of Central California, while these are in turn somewhat unlike those of the southern coast of California.

The exact line of separation between the Californian provinces of the later Neocene appears to follow very nearly the line of the outer Coast Ranges as far south as the head waters of the Salinas Valley drainage, and follows in turn the axis of the Santa Cruz and the Santa Lucia ranges, turning eastward to Pine Mountain and the Tehachapi Range at the latitude of Moro Bay. The Pliocene beds of the coastal valleys south of the Santa Lucia Range are faunally more closely related than any of them are with the Pliocene of the interior valleys. The interior basin of the Pliocene includes not only the Great Valley, but the Salinas and Carisa valleys and other small valleys of the Coast Ranges, probably extending as far north as Lake and Tehama counties.

Within these provincial limits a faunal and stratigraphic correlation of Pliocene deposits, at least, is likely to be more successful than are present attempts at a detailed correlation of deposits within two or more provincial basins.

In the Salinas Valley occur late Tertiary beds that can be satisfactorily compared and correlated with those of the Mount Diablo Range. At Santa Margarita and on the Nacimiento River, at La Panza Springs, and on the Estrella and San Lorenzo rivers, are beds that are entirely similar. At Santa Margarita these beds have been mapped and described by H. W. Fairbanks[1] as the Santa Margarita Formation.

It is quite likely that a correlation of the Miocene beds, or at least of some of them, will have to be restricted within the same territorial limits. The Vaquero sandstones described by Dr. H. W. Fairbanks as occurring within the drainage of the Salinas River lack thus far any faunal description, and his correlation of these with beds occurring south of the Santa Lucia Range is not supported by any faunal evidence. On the other hand the fauna occurring at the base of the Miocene near San Luis Obispo is characteristic over the whole extent of the coast border, especially south of that point.

1 San Luis Folio, U. S. Geol. Surv. no. 101.

CONCLUSIONS.

The conclusions to be arrived at from the stratigraphic study of this field are not at variance with, but are mainly confirmatory of much that has been written during the last decade. The Tertiary formations of California have thus far been too little studied and analyzed, though for general scientific as well as for economic reasons they richly deserve attention. In the present contribution to the literature it is believed that the following points are either made clear or are at least clearly indicated:

1. Stratigraphic nonconformities exist in the Mount Diablo Range between all of the chief periodic series, and in some instances between different members of the same series.

2. The Eocene strata are capable of being divided into several distinct members, of which the Tejon portion contains, at least locally, two sandy members separated by one of shale.

3. The Neocene deposits of California can be separated into two or more basins or minor provinces, those of the Mount Diablo Range belonging to the California interior basin and being characteristic of the same.

4. In the Mount Diablo Range two clear stratigraphic nonconformities exist within the Neocene, dividing these deposits into three groups, lower, middle, and upper. The lower and older of these groups contains the well recognized Miocene strata of Central California; the later and younger group, the strata which have been described as Etchegoin or San Pablo, and which are believed to be of Pliocene age; while the intervening or middle group, on account of its faunal resemblance to the older Miocene, is more logically classed in this period than in the period following.

5. In the older Miocene two distinct members are to be recognized; viz., the Monterey Shale and the Temblor Sandstone.

6. The most complete and therefore the most typical fauna of the Lower Miocene of the California interior is that

of the Kern River Beds on the southeastern border of the San Joaquin Valley.

7. The most complete and typical development of the San Pablo strata is not found in the locality from which it takes its name, but along the northeastern flanks of the Mount Diablo Range, as in western Fresno County, where the series attains more than four times the thickness stated in its original description.

8. The Etchegoin series is capable of being subdivided, at least locally, into two or more separate members, each of which has a greater stratigraphic thickness than was originally given for the entire body of similar beds occurring on San Pablo Bay, which are altogether embraced in the lower division, the Etchegoin Sands.

9. The uppermost stratigraphic unit of the Mount Diablo Range is one of fresh-water origin, and is perhaps equivalent to the Orindan Formation of the Berkeley Hills, as described by Dr. Lawson.

10. The Neocene faunas of California are far from being completely known; they offer a rich field for study, and it is believed that such study would yield results of great value to students of stratigraphic geology.

DESCRIPTIONS OF SPECIES.

Among the many fossils collected in the Mount Diablo Range and the California interior during the field-study represented in the foregoing paper, many new species have been discovered, some of which are here described.

While undescribed forms have been obtained from both Cretaceous and Tertiary strata, the latter only are illustrated in the following pages. The list of new forms from each of the Tertiary horizons might be considerably extended by the use of fragmentary and imperfect materials, but the description of such material is not only unsatisfactory but results in much harm to paleontologic science.

Many of the California Tertiary invertebrates were originally described in literature that has become inaccessible, and some of the accessible literature contains only unsatisfactory figures and descriptions; therefore it is highly desirable to have re-descriptions and better drawings made when authentic material can be obtained and properly identified. The species figured and described by Conrad in the Pacific Railroad Reports can rarely be identified except from the type localities, and then only by the utmost care and reservation; the same is often true of the species described by Gabb in the Paleontology of California. Much of the confusion and uncertainty in stratigraphic determination in the Pacific Coast Tertiary originates in such faulty descriptions. Correct specific determinations cannot be made from much of the literature upon California paleontology that is accessible to students of the subject, and until these can be made, trustworthy determinations of faunal horizons are likewise impossible.

Where any departure has been made from the current paleontological nomenclature it has been with deference to the classification proposed by Zittel in his *Handbuch der Palæontologie*, and it must be confessed that such a standard should have been adopted throughout. An attempt to do this would, however, involve a considerable amount of work in revising the Pacific Coast nomenclature, and that is beyond the purpose of this paper.

The paleontological materials that form the basis of this study have been largely collected by the writer; they have become the property of the California Academy of Sciences, and are a part of its permanent collections.

FORAMINIFERA.

EOCENE.

PLATE XIII, FIGS. 9–29.

For the purpose of calling attention to the many well preserved forms of Foraminifera in the Eocene rocks of the Mount Diablo Range, and to illustrate some of the more common genera, a few have been figured without any attempt at specific identification, along with other Eocene species occurring in very nearly the same horizon. These Foraminifera are as follows:

Nodosaria	*Cyclammina*
Lagena (?)	*Pulvulina*
Sagrina	*Polymorphina* (?)
Vaginulina	

Some of the species of Foraminifera are very large, and can be easily seen with the unaided eye. Some species of *Nodosaria* attain a length of three-fourths of an inch, and all of them are easily distinguished with a good lens. Most of the forms are found in calcareous concretionary masses, occurring as lenses in the argillaceous beds described in this paper as the Kreyenhagen Shales.

ECHINODERMATA.

EOCENE AND MIOCENE.

Scutella sp. A. n. sp.

PLATE XIII, FIG. 8.

Test small, thin, disk-like, oval or sub-pentagonal; anal pore supermarginal; apical star symmetrical, but not central; calyx open.

The numerous specimens of this species which were found, are immature and cannot yet be satisfactorily described. Most of them are laterally convex and small.

Occurrence.—The species is not rare in the Avenal Sands west of Coalinga.

Astrodapsis merriami n. sp.

PLATE XIV, FIGS. 33 AND 34.

Disk small, circular, depressed; margin only slightly notched at the ambulacral extremities; apex central, only slightly elevated, star symmetrical, petals equal but not reaching the margin of the disk, and slightly elevated; anal pore marginal; ambulacral furrows of inferior surface straight and simple. The largest specimens have a diameter of 1½ inches, though the usual size is ¾ of an inch. The disk is thin and flattened but shows a decided tendency to form elevated stars on the upper surface.

Occurrence.—This form is extremely abundant locally in the Temblor Beds of the Mount Diablo Range, at Tar Springs, Kreyenhagen's, and Temblor.

Cassidulus californicus n. sp.

PLATE XIII, FIGS. 6 AND 7.

Test small, elliptical, robust and often somewhat globular; lower surface flattened, or concave, upper surface convex; mouth not central, round, and occupying a position ⅗ of the distance from the anal margin; anal pore terminal; apical star nearly symmetrical, central on dorsal surface; tuberculation distinct, the tubercules lying within rounded pits. There is a tendency to form shoulder-like expansions on the periphery behind the position of the mouth.

Occurrence.—This species is not rare in the Avenal Sands west of Coalinga.

LAMELLIBRANCHIATA.

EOCENE.

Spondylus carlosensis n. sp.

PLATE XIII, FIG. 1.

Shell of medium size, sub-circular or obliquely ovate, radially ribbed, convex; costae granulated or obscurely spinose; ears and hinge rather broad. The costae radiate in graceful, sinuous lines from the beak to the margins, and occur in pairs or triplets, every second or third rib being more elevated than the others.

Occurrence.—This species occurs only rarely in the Avenal Sands west and north of Coalinga.

Ostrea aviculiformis n. sp.

PLATE XIII, FIGS. 3-5.

Shell small, very inequivalve, quadrate, oblique, laminated; inferior valve convex and strongly arched; superior valve thin, often concave, and sharply laminated in thin concentric folds; hinge broad and somewhat straight. The surface of the convex valve is marked only by concentric lines of growth. The margin is more or less ragged or irregular.

This species bears some resemblance to *Ostrea sellaeformis* Conrad, from the Eocene of Alabama.

Occurrence.—This species is found only occasionally in the Avenal Sands west and north of Coalinga.

MIOCENE.

Cyrena (Corbicula) dumblei n. sp.

PLATE XIV, FIGS. 30–32.

Shell moderate in size, or large, 3 inches in greater diameter; sub-circular in outline; beaks central, not greatly elevated, incurved; surface marked by heavy and irregular concentric ridges, or smooth in young shells; teeth sharp and prominent; lateral tooth long and slightly curved and finely crenulated.

This species differs from *C. californica* Gabb in being larger and more circular in outline and in having generally a more robust form.

Occurrence.—This species is not rare in the lower Miocene beds of Kern River.

Venus (Chione) pertenuis *Gabb.*

Venus pertenuis Gabb, Pal. Calif. v. 2, pp. 22 and 55, pl. v, fig. 37.

In Gabb's description of this species there is some doubt expressed as to its proper sub-generic determination, though he says it very probably may prove to be a *Chione.* Several specimens have been obtained from the Lower Miocene beds of Kern River, some of them showing the hinge from which Gabb's judgment is readily confirmed.

Venus (Chione) conradiana n. sp.

PLATE XIV, FIG. 35.

Shell large, rather thick, cordate, broadly rounded below, and much produced behind; beak prominent, anterior, incurved; lunule large; surface marked by concentric ridges, strongest in the umbonal region; margin thin and not crenulated.

This shell is related to *Chione pertennis* Gabb, but has not the triangular outline of that species, is more produced posteriorily, and less produced before. The hinge is fairly well exposed showing its generic features unmistakably.

Occurrence.—This species occurs with *C. pertennis* in the Lower Miocene beds three miles east of La Panza Springs, San Luis Obispo County.

Venus (Chione) temblorensis n. sp.

PLATE XIV, FIGS. 36–38.

Shell moderate in size, 2½ inches in larger diameter, 1½ inches thick; sub-triangular in outline; beaks slightly anterior; incurved; lower margin rounded, crenulated within, produced to an angle posteriorly; hinge margin straight; surface ornamented with concentric ridges and radiating ribs. The concentric ridges rise in gently fluted and ruffled folds. The radiating ribs occur singly from beak to margin.

This species is undoubtedly related to *C. guidia* Brod. & Sow. but is ornamented with single instead of double ribs or riblets, less prominent concentric folds, and generally different outline. It is perhaps ancestral to the latter species.

Occurrence.—Lower Miocene beds of Kern River and Temblor.

Cytherea (Callista) diabloënsis n. sp.

PLATE XVII, FIGS. 83–85.

Shell large, thick, obliquely cordate in outline; beaks prominent, anterior, incurved; margin broadly rounded below, produced in front; cardinal region widely excavated; lunule large, impressed; surface ornamented by smooth concentric ridges, more or less interrupted as in *C. callosa* Conrad; inner margins not crenulated.

This species resembles specimens of *C. callosa* from the California coast, but is shorter and has a greater lateral thickness. Moreover it does not show the internal thickening of the valves as in *C. callosa*.

Occurrence.—This species is not uncommon in the Coalinga Beds west of Coalinga, Fresno County.

Pectunculus septentrionalis *Middendorf.*

Plate XVII, Figs. 86 and 87.

Pectunculus septentrionalis (Midd.) Carpenter, Brit. Assn. Rept. 1856, p. 219.
Glycymeris septentrionalis (Midd.) Arnold, Mem. Calif. Acad. Sci. v. 3, p. 101, pl. xviii, fig. 10.

This species is well described by Arnold, though the sculpture of the shell is not shown in his figure. It will be noticed upon a comparison of the figures that the form from San Pedro has a smaller ligamental area and a somewhat higher beak than the form here represented.

Occurrence.—This species is abundant in the Etchegoin Beds both north and south of Coalinga, and is identical with or closely related to a similar species occurring in the San Pablo Beds on San Pablo Bay, Contra Costa County.

Diplodonta harfordi n. sp.

Plate XVII, Figs. 88 and 89.

Shell not large, rotund, sub-quadrate in outline; beaks nearly central, low, closely approaching each other; cardinal margin straight, excavated; anterior margin sometimes a little produced, but generally rounded; surface marked only by concentric lines.

This shell is allied to *D. orbella* Gould, but has a less prominent beak and a straight hinge margin.

Occurrence.—This shell occurs abundantly in the Coalinga Beds west of Coalinga.

Pecten coalingaënsis Arnold.

Plate XVIII, Figs. 94–98.

Pecten (*Pecten*) *coalingaënsis* Arnold.

Shell moderate in size, the largest having a diameter of 2¼ inches; inequivalve, radially ribbed; lower valve convex, upper concave.

Arnold's description of this species is not yet published, but as the specimens here figured are from his type locality and have been identified by Dr. Arnold, there is no doubt about the correctness of the determination. They have been referred by Arnold to the Miocene of the Kreyenhagen ranch, but the true horizon is that of the Etchegoin Beds, which are probably Pliocene.

Occurrence.—This species is common in the Etchegoin Beds of the Mount Diablo Range, at the Kreyenhagen ranch on Zapata Chino Creek.

Pecten wattsi *Arnold.*

Pecten wattsi Arnold, Tert. and Recent Pectens of Calif., Profess. Paper no. —, U. S. Geol. Surv. ——.

Occurrence.—This species occurs with the preceding.

Pecten etchegoini n. sp.

Plate XVIII, Figs. 92 and 93.

Shell rather large, thick, and ovate in outline; ears nearly equal, costate; ribs strong and grouped in sets of 3 or 4, forming radial undulations in the shell, seen both within and without; margin of valve fluted within. The grouping of the ribs is a variable feature of the shell. In some specimens the depressions are wider, in others narrower than in the one figured. Concentric lines are usually visible on the shell.

Occurrence.—The species occurs with the two preceding in the Etchegoin Beds of the Kreyenhagen ranch on Zapata Chino Creek.

GASTEROPODA.

Eocene.

Cypraea fresnoënsis n. sp.

Plate XIII, Fig. 2.

Shell of medium size, 1½ inches long, 1 inch in diameter, robust or subglobose; spire covered; canal produced a little in front. The epidermis covers the spire in adult age, though in the figured specimen it has been removed. The aperture is narrow and curved. The dentition is not shown.

Occurrence.—This species is rare in the Avenal Sands northwest of Coalinga, western Fresno County.

Miocene.

Cancellaria dalliana n. sp.

Plate XV, Figs. 39–42.

Shell of moderate size, fusiform; spire high and angular; whorls angular and spinose; columella thickly crusted within in old specimens; surface marked with strong varical ridges and lines, the ridges rising in thin edges on the upper surface of the body whorl. The lower part of the body whorl is ornamented with strong revolving lines with wide interspaces in which there are usually 1–3 secondary lines. The canal notch is not shown.

Occurrence.—This species occurs with the succeeding in the Lower Miocene beds of Barker's ranch, on Kern River.

Cancellaria pacifica n. sp.

Plate XV, Figs. 43–45.

Shell moderate in size, ¾–1½ inches in length, width ½ as great; spire moderately elevated; mouth oval in outline; whorls angulated, bearing small nodes on the upper angles; surface ornamented with revolving lines, heavier and lighter lines occurring alternately on the body whorl, crossed by vertical ridges.

This shell seems to be somewhat closely related to *C. granosa* Sowerby, described from Van Dieman's Land.

Occurrence.—This shell occurs with the preceding species in the Lower Miocene beds of Kern River.

Cancellaria joaquinensis n. sp.

Plate XV, Figs. 46–48.

Shell of moderate size, stout, and ovate; 1 inch or more in length and nearly as broad; spire medium or low, sloping evenly without conspicuous angles; shell thick; inner lip crusted; surface ornamented chiefly by revolving lines and interspaces, with finer secondary lines within; varical ridges weak, but forming on the upper angle of the body whorl a single circle of nodes.

This species is related only distantly to any other described form occurring on the Pacific Coast.

Occurrence.—Lower Miocene beds of Kern River, where four or more well preserved specimens were obtained.

Cancellaria condoni n. sp.

PLATE XV, FIGS. 49 AND 50.

Shell of moderate size, 1-1½ inches in length, ½-¾ inch wide; spire high; whorls angular, slightly sloping above; surface ornamented with strong revolving lines, with wide interspaces, crossed by strong varical ridges forming tubercular nodes on the upper angle of the whorls; inner lip crusted, bearing 2 spiral folds on the columella.

This species is apparently related to the *C. oregonensis* Conrad described from the Astoria beds of Oregon.

Occurrence.—This species is represented by four specimens from the Lower Miocene beds of Kern River.

Cancellaria simplex n. sp.

PLATE XV, FIGS. 51 AND 52.

Shell moderate in size, simple and inconspicuously marked, resembling *C. pacifica*, but having a less elevated spire, and generally shorter whorls. The spiral lines and longitudinal ridges are both more reduced and the width of the shell is greater. The inner lip is well crusted. The length of the largest shell found is nearly 2 inches.

Occurrence.—Lower Miocene beds of Kern River, with the preceding.

Cancellaria vespertina n. sp.

PLATE XVI, FIGS. 77 AND 78.

Shell not large, fusiform, angulated, bearing tubercules, longitudinally ribbed; spire elevated, but not high; whorls slightly sloping above; aperture ovate, inner lip crusted; canal short; surface ornamented more conspicuously with vertical ridges, crossed by faint spiral lines, seen more plainly on the lower portion of last whorl.

The species resembles somewhat *C. urceolata* Hds. but is less robust, with a higher spire and less prominent spiral ridges on the columella, besides having strong tubercules on the angles of the whorls.

Occurrence.—The species is not abundant, but occurs in the Coalinga Beds west of Coalinga, Mount Diablo Range.

Scaphander jugularis *Conrad.*

PLATE XV, FIGS. 56 AND 57.

Bulla jugularis Conrad, Pac. R. R. Rept. v. 5, p. 328, pl. VII, figs. 62 *a* and *b*.

Shell not large, 1–1½ inches in length, width ½ as great; contracted toward the posterior end; aperture wide, ovate; inner lip crusted; whorl loosely convolute, narrowing behind; surface ornamented by revolving lines crossed by oblique lines of growth. The revolving lines consist of flattened ridges and rounded grooves of equal width.

Conrad's figure lacks sufficient description to make absolute identification possible, but as the localities are contiguous and the horizon practically the same, there can be little doubt as to identity.

Occurrence.—Lower Miocene beds on Kern River, a few miles south of Ocoya Creek.

Oliva californica n. sp.

PLATE XV, FIGS. 54 AND 55.

Shell moderate in size, 1–1½ inches long, width more than half as great, ovate, narrowing below; spire low and rounded; aperture narrow, inner lip somewhat crusted; columella bearing 2 principal spiral plications, with finer lines both above and below; suture impressed and sharply defined on adolescent and mature shells; surface marked only by lines of growth.

Occurrence.—Lower Miocene beds of Kern River, Barker's ranch, etc.

Oliva futheyana n. sp.

PLATE XV, FIG. 53.

Shell similar in many respects to the preceding, but narrower, and having a more elevated spire, and more graceful outline.

Occurrence.—This shell occurs with the preceding.

Conus oweniana n. sp.

PLATE XV, FIGS. 58 AND 59.

Shell small, conical; spire moderate, conical; whorls flattened, or concave above; suture impressed on young shells; aperture narrow, and straight; surface marked by distant, fine revolving lines.

This species is unlike *C. californica* Gabb in having a lower and less rounded spire, a less ovate outline, and a narrow straight aperture.

Occurrence.—This shell occurs in the Lower Miocene beds of Kern River.

Purpura lima *Martyn.*

PLATE XV, FIGS. 62 AND 63.

Purpura lima Martyn, Conch. fig. 47.
Purpura lima (Mart.) Tryon, Man. Conch. v. 2, p. 175, pl. LIII, figs. 156, 158, 159, and 161.

Among the many molluscan species originally described in obscure or inaccessible literature is the above. Authentic samples of this shell are in the collections of the California Academy of Sciences, and the identification of the fossil species is from a comparison with these. The fossil specimens are a little shorter, with a less elevated spire, but the difference seems to be insignificant.

Occurrence.—The four or five samples of this species that have been found fossil are from the Lower Miocene beds of Kern River.

Trophon kernensis n. sp.

PLATE XVI, FIGS. 64 AND 65.

Shell rather large, length from 2–3 inches, width 1½ inches; graceful in outline, narrowing rapidly before; spire rather short, conical, and angular, but sloping above, bearing tubercules, or very short spines on the angles, more prominent on very young shells; surface ornamented chiefly by lines of growth, but bearing faint spiral lines on the lower part of the whorl, noticeable especially in young shells; aperture pear-shaped, and narrowing to a long canal; inner lip crusted; canal long and narrow.

This species is only distantly related to *T. ponderosum* Gabb, but more nearly related forms are found in the Pliocene of California.

Occurrence.—This shell is from the Lower Miocene beds of Kern River.

Trophon gabbiana n. sp.

PLATE XVI, FIGS. 79 AND 80.

Shell not large, laminate, spinose on the angles; canal short, recurved; spire high, sloping above; body whorl tapering below. The mouth narrows regularly toward the canal. The spines are often considerably suppressed on the angles, and on the lower part of the last whorl there are numerous spiral lines.

The shell differs from *T. ponderosum* Gabb in having a recurved columella, spiral lines below, and less prominent spines.

Occurrence.—This shell occurs in the Coalinga Beds of the Mount Diablo Range, nine miles north of Coalinga.

Terebra cooperi n. sp.

PLATE XVI, FIGS. 66 AND 67.

Shell of moderate size, tapering regularly; length 1½–2 inches, width of body whorl ½ inch or less; aperture narrow and elongated, with simple outer lip; surface ornamented with slightly sinuous vertical ribs or lines closely set on the whorls; inner lip only slightly crusted; columella with a narrow oblique fold on the outer side; the upper ⅓ of the whorls bearing a constricted band, not clearly shown in the figures.

This species is undoubtedly related to *Terebra wattsiana* Cooper,[1] but is characterized by two or more distinguishing marks, the depressed zone on the upper part of the whorls and the narrow fold on the columella. A similar species is found in the late Pliocene beds of San Diego, California.

Occurrence.—This species is found in the Lower Miocene beds of Kern River, but it is not abundant.

Sigaretus scopulosus *Conrad.*

PLATE XVI, FIGS. 72 AND 73.

Sigaretus scopulosus Conrad, U. S. Expl. Exped. (Wilkes) pl. XIX, figs. 6 and 6*a;* text p. 727.

Sinum scopulosum Conrad (Gabb), Pal. Calif. v. 2, p. 114, etc.

Shell moderate in size, obliquely oval, slightly flattened above, hollowed below; surface marked with revolving lines, equal in width with the inter-

[1] Bull. no. 4, Calif. State Min. Bur. 1894, p. 39.

spaces, and flattened above; spire very small, but with distinct suture; spiral lines not showing within.

Three specimens in the collections of the California Academy of Sciences are apparently referable to this northern species, and this determination is supported by other evidence and faunal resemblances.

The species has a near relative in the Pliocene of San Fernando as seen in *S. planicostum* Gabb, but the form of the shell is evidently different.

Occurrence.—Lower Miocene beds of Kern River.

Nassa arnoldi n. sp.

PLATE XVI, FIGS. 70 AND 71.

Shell small, acutely ovate; spire moderately elevated, bearing 5 whorls; aperture circular, outer lip always bordered by a thickened varex; columella short, bearing only a slight, or no sulcus; surface ornamented by spiral and longitudinal ridges forming a reticulation as in the young of *N. perpenguis* Hds.

This species differs from *N. perpenguis* in its smaller size, more regular and symmetrical form, shorter columella, the absent, or much reduced sulcus, and the bucal border which appears on all of the specimens that have been found.

Occurrence.—This species occurs with the preceding in the Lower Miocene beds of Kern River.

Crepidula praerupta Conrad.

PLATE XVI, FIGS. 68 AND 69.

C. praerupta Conrad, U. S. Expl. Exped. (Wilkes) pl. XIX, figs. 9, 9*a*, 10*a*, 10*b;* text p. 727.

Shell of medium size, 1–1½ inches long; strongly curved; aperture elliptical, or ovate; surface marked by irregular lines of growth.

Occurrence.—The species is found abundantly in the Lower Miocene beds of Kern River.

Pleurotoma (Clathurella) dumblei n. sp.

PLATE XV, FIGS. 60 AND 61.

Shell small or medium in size, 1–1¼ inches long; spire high; whorls 6 or more, convex; aperture simple, ovate, inner lip uncalloused; canal very short; surface ornamented by strong spiral and longitudinal lines, giving a cancellated sculpture.

Occurrence.—This species occurs abundantly in the Lower Miocene beds of Kern River.

Bullia (Molopophorus) anglonana n. sp.

Plate XVI, Figs. 74–76.

Shell moderate in size, 1 inch in length, ¾ inch in width; spire moderately elevated; aperture broad, lip simple, notched above; columella crusted, whorls angulated, bearing tubercular, or spinose nodes above, and on lower part of body whorl; surface ornamented with lines of growth, and with revolving lines, strongest on the lower portion of the body whorl. The anterior notch is deep, and bordered by 2 strong folds which extend upward, revolving obliquely around the columella, forming a wide canal, shown only in figure 74.

This species is somewhat related to *B. striata* Gabb, from the Tejon Beds, but more nearly related to undescribed species occurring in the so-called *Oligocene Beds* of Oregon.

Occurrence.—This species occurs not rarely in the Lower Miocene beds of Kern River.

Fusus (Hemifusus) wilkesana n. sp.

Plate XVI, Figs. 81 and 82.

Shell moderate in size, robust, tapering rapidly below; spire moderately elevated, angulated, with tubercular nodes on the angles of the whorls; surface strongly marked by spiral lines and longitudinal ridges, especially prominent at and below the angles of the whorls; canal only moderately prolonged; open; columella somewhat curved.

This species seems to be related to, and is possibly identical with *Fusus corpulentus* Conrad, from the Miocene beds of Astoria, Oregon; but as Conrad's figure was drawn from a cast, it is not possible to establish its identity with the species described here.

Occurrence.—The Lower Miocene beds (Temblor Beds) at the Kreyenhagen oil wells, Kings County.

Chorus carisaënsis n. sp.

Plate XVII, Figs. 90 and 91.

Shell rather large and thick, strongly spinose, and oblique; spire moderately high, sloping above; body whorl narrowing rapidly below; aperture large, triangular, bearing a stout tooth on the outer lip near the upper end of the canal; canal narrow, short, and strongly recurved; columella crusted and strongly recurved; surface marked only by strong lines of growth. There are about 8 strong spines on the angles of each whorl, excavated in front and convex behind.

Occurrence.—This shell is common, though not plentiful in the lower Etchegoin Beds of the Mount Diablo Range, near La Panza Springs, San Luis Obispo County.

California Academy of Sciences,
July 31, 1905.

EXPLANATION OF PLATE XIII.

Foraminifera.

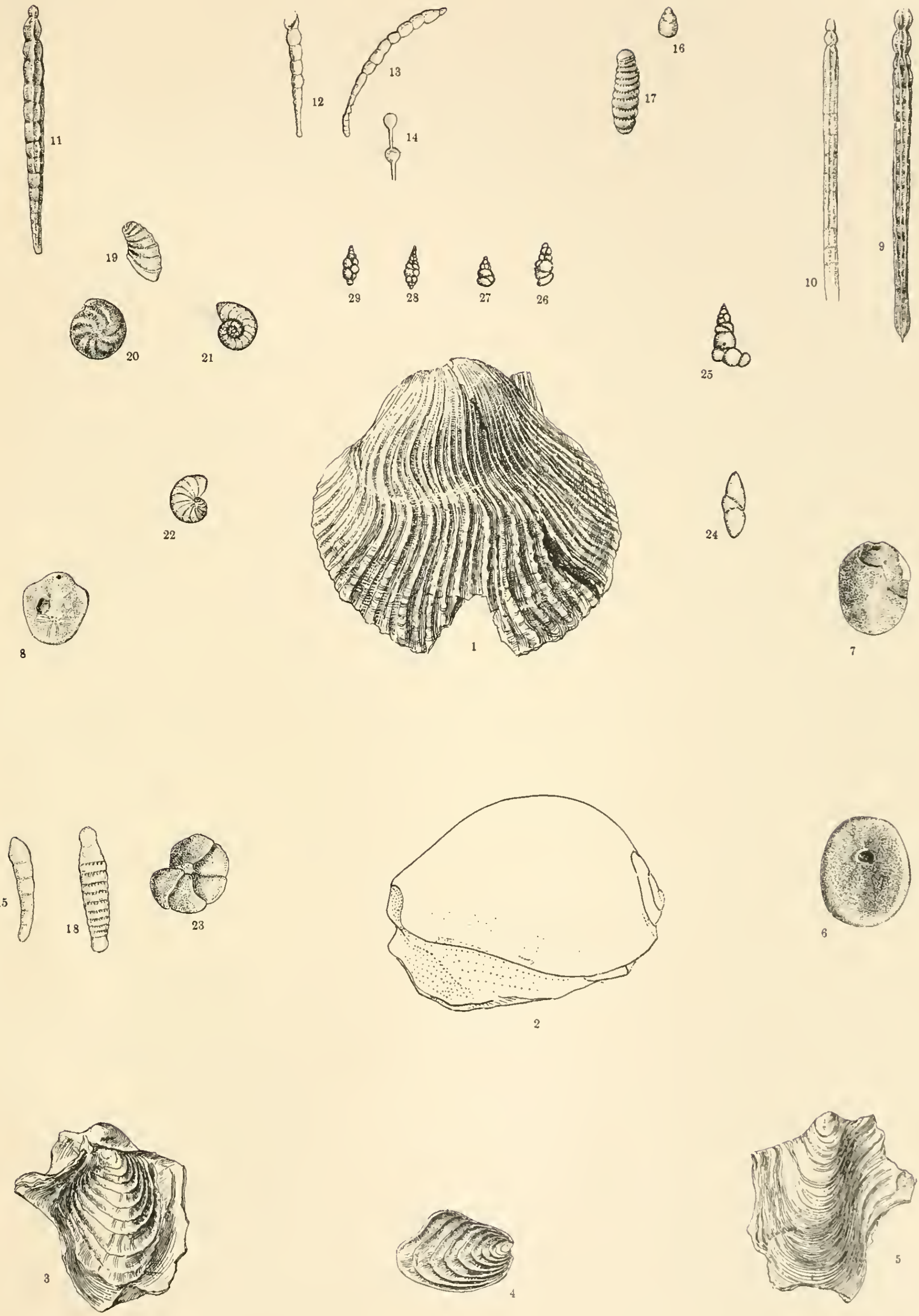
	Page
Nodosaria Figs. 9–15.	193
Lagena (?) Fig. 16.	193
Sagrina Figs. 17–18.	193
Vaginulina Fig. 19.	193
Cyclammina Figs. 20–22.	193
Pulvulina Fig. 23.	193
Polymorphina (?) Figs. 24–29.	193

Echinodermata.

Cassidulus californicus n. sp. Figs. 6–7.	194
Sculella sp. A. n. sp. Fig. 8.	193

Mollusca.

Spondylus carlosensis n. sp. Fig. 1.	194
Ostrea aviculiformis n. sp. Figs. 3–5.	194
Cypraea fresnoënsis n. sp. Fig. 2.	198

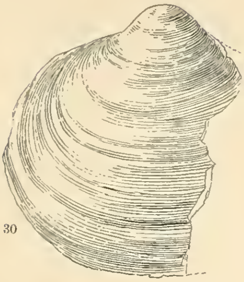


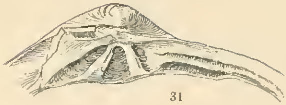
MARY WELLMAN, DEL

PHOTO LITH BRITTON & REY

EXPLANATION OF PLATE XIV.

	Page
Cyrena (*Corbicula*) *dumblei* n. sp. Figs. 30–32.	195
Astrodapsis merriami n. sp. Figs. 33–34.	193
Venus (*Chione*) *conradiana* n. sp. Fig. 35.	195
Venus (*Chione*) *temblorensis* n. sp. Figs. 36–38.	196

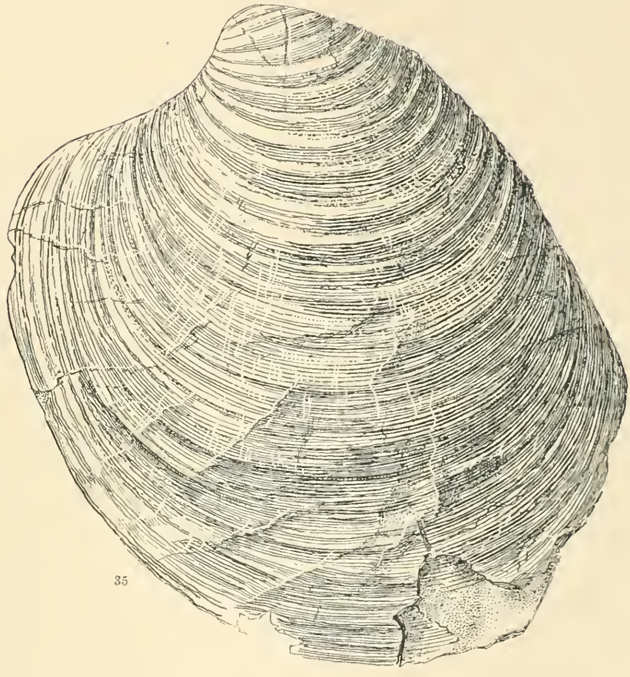

30

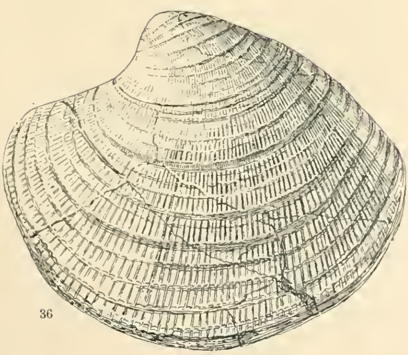

31


32

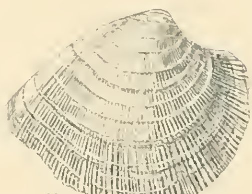

33


34


35


36


37


38

MARY [illegible] DEL. PHOTO LITH BRITTON & REY [illegible]

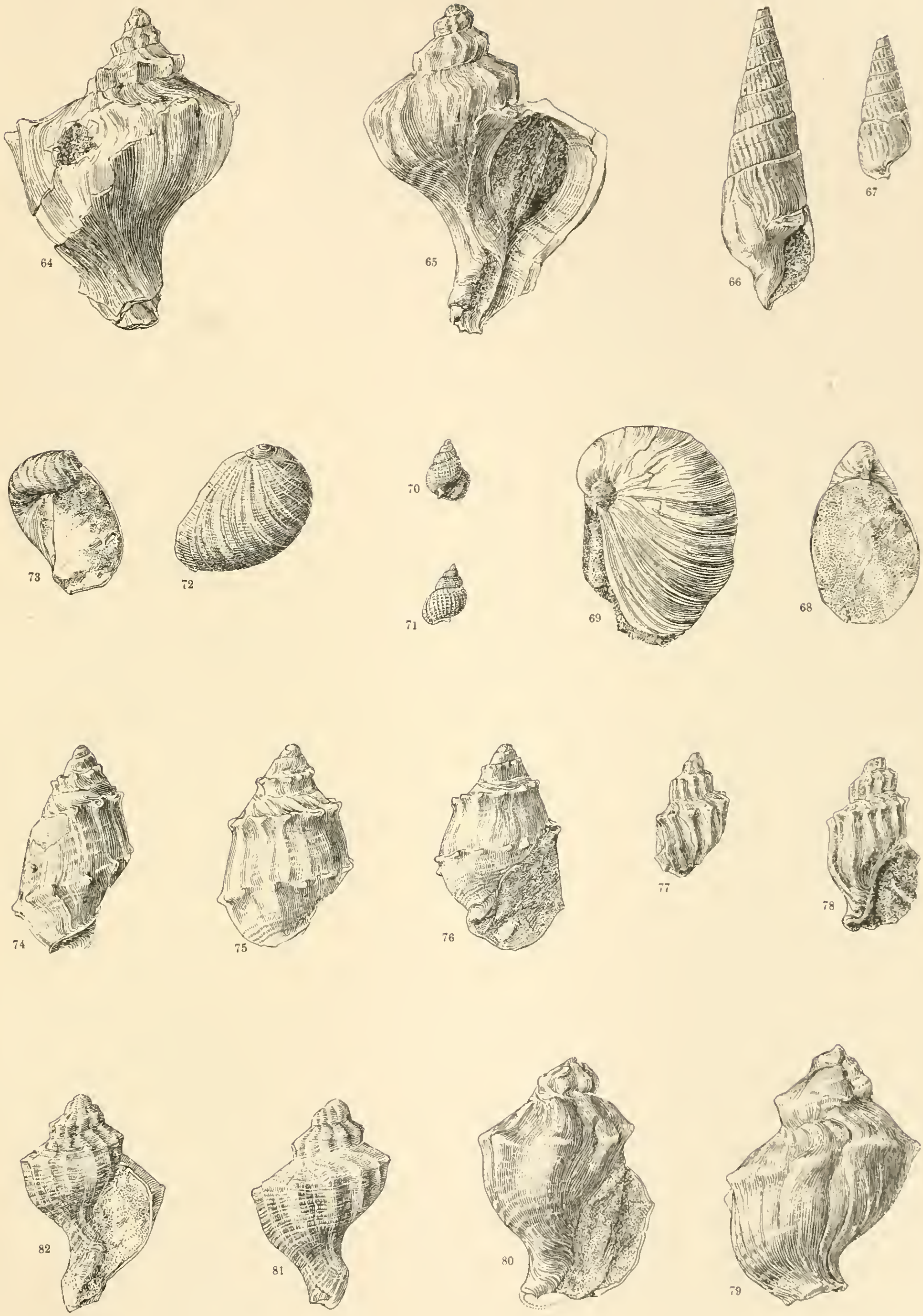
EXPLANATION OF PLATE XV.

	Page
Cancellaria dalliana n. sp.	199
Figs. 39–42.	
Cancellaria pacifica n. sp.	199
Figs. 43–45.	
Cancellaria joaquinensis n. sp.	199
Figs. 46–48.	
Cancellaria condoni n. sp.	200
Figs. 49–50.	
Cancellaria simplex n. sp.	200
Figs. 51–52.	
Oliva futheyana n. sp.	201
Fig. 53.	
Oliva californica n. sp.	201
Figs. 54–55.	
Scaphander jugularis Conrad	201
Figs. 56–57.	
Conus oweniana n. sp.	201
Figs. 58–59.	
Pleuroloma (*Clathurella*) *dumblei* n. sp.	204
Figs. 60–61.	
Purpura lima Martyn.	202
Figs. 62–63.	

MARY WELLMAN, DEL.

PHOTO-LITH BRITTON & REY, S.F.

EXPLANATION OF PLATE XVI.

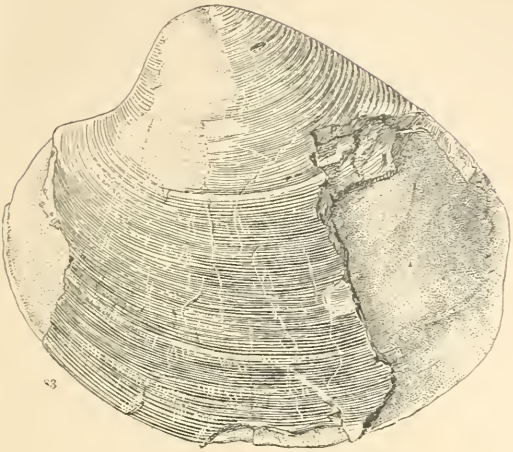


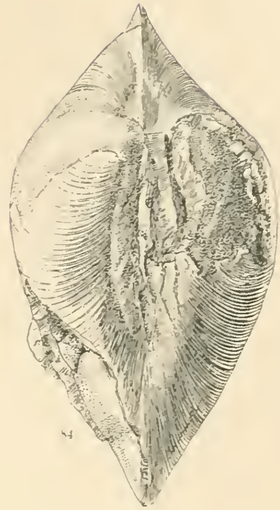
MARY WELLMAN, DEL

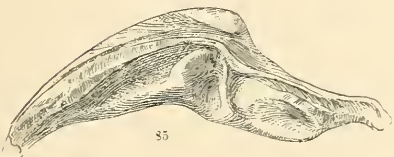
PHOTO. LITH BRITTON & REY S.F.

EXPLANATION OF PLATE XVII.

	Page
Cytherea (*Callista*) *diabloënsis* n. sp.	196
Figs. 83–85.	
Pectunculus septentrionalis Middendorf.	197
Figs. 86–87.	
Diplodonta harfordi n. sp.	197
Figs. 88–89.	
Chorus carisaënsis n. sp.	206
Figs. 90–91.	


83

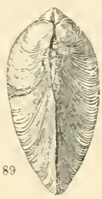

84


85


86


87

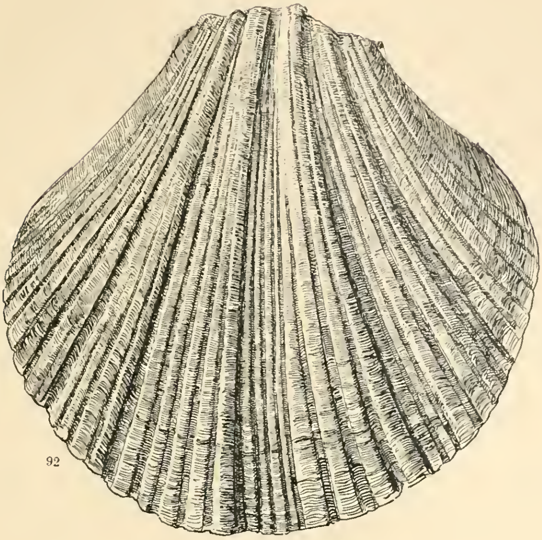

88


89

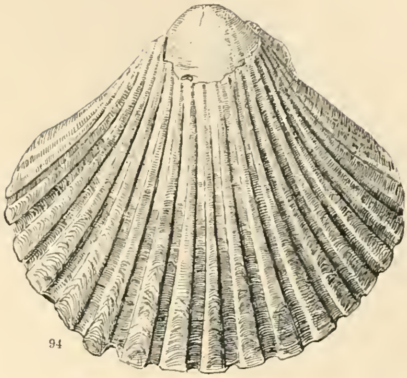

90


91

EXPLANATION OF PLATE XVIII.

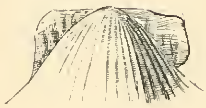


92



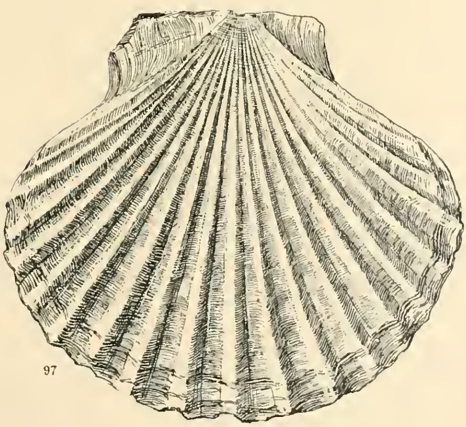
94

93

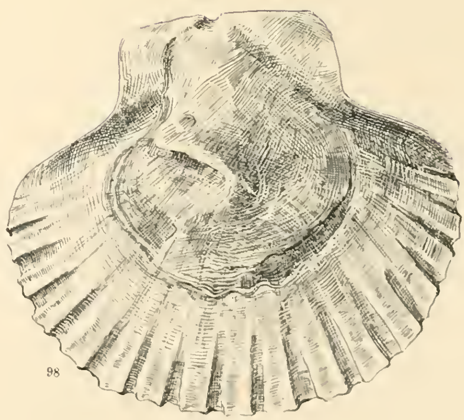


96

95



97



98

MARY WELLMAN, DEL.

PHOTO-LITH BRITTON & REY S.F.

EXPLANATION OF PLATE XIX.

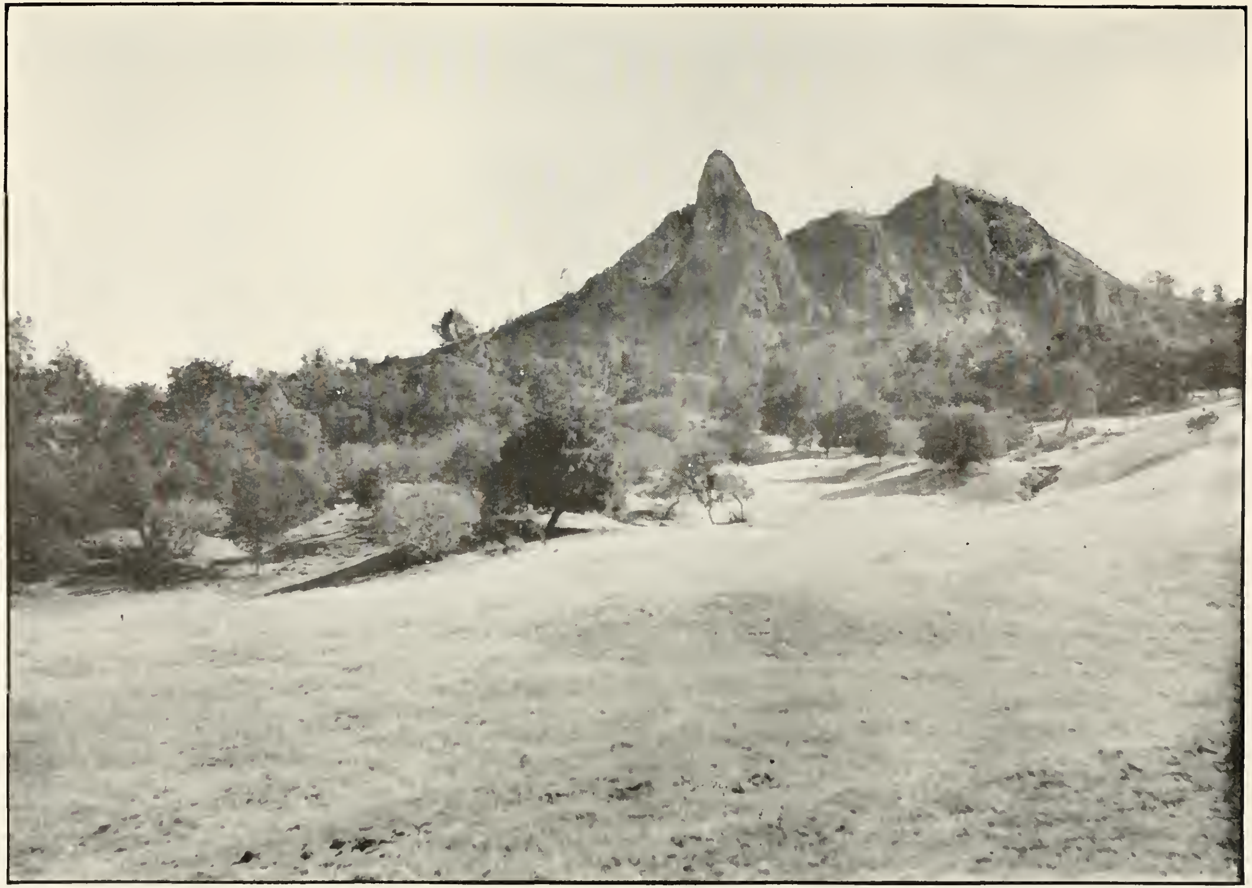
View near Stone Canyon, showing Franciscan rocks and topography; radiolarian jaspers in the foreground.

EXPLANATION OF PLATE XX.

View showing hard siliceous Franciscan rocks in an area of serpentine; Mount Carlos.

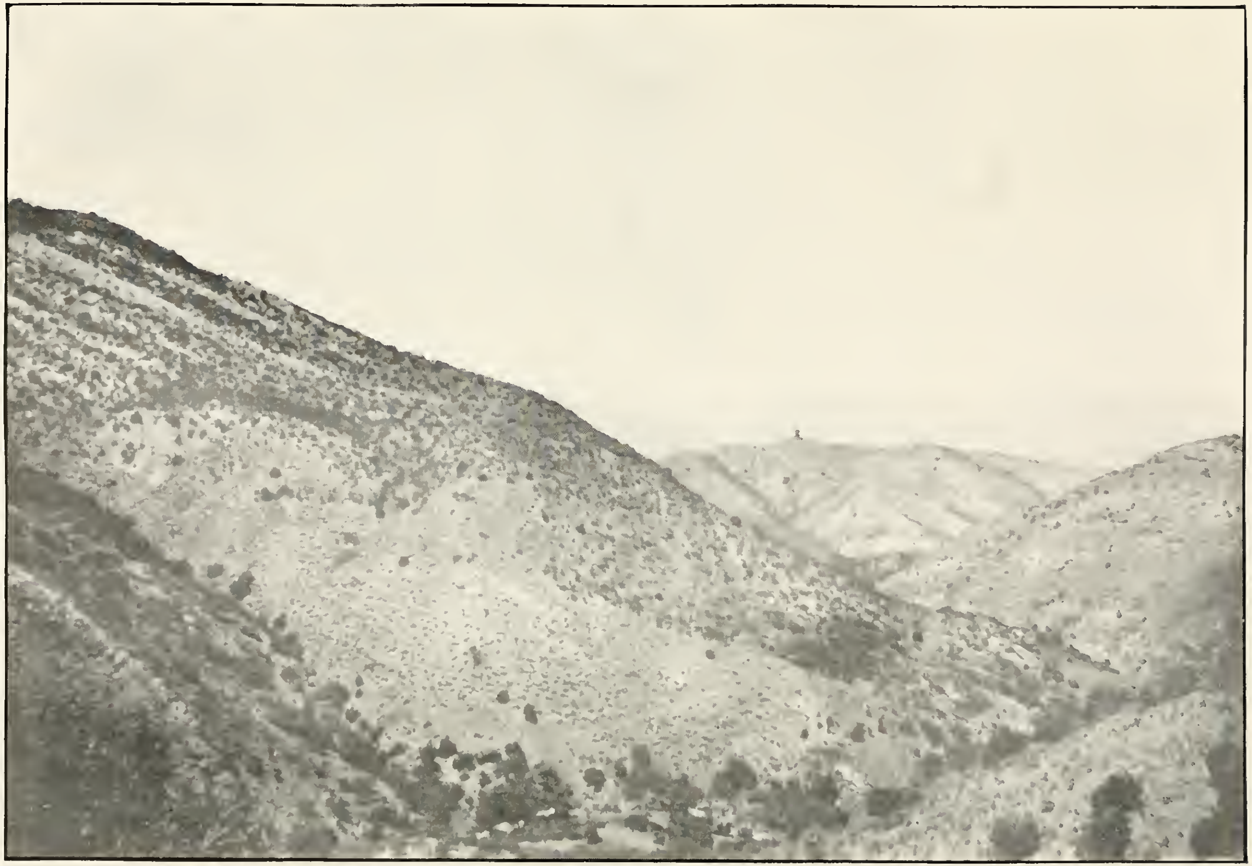
EXPLANATION OF PLATE XXI.

View showing eruptive rocks (basalt ?) within an area of Franciscan; Lewis Creek, Monterey County.



EXPLANATION OF PLATE XXII.

View showing stratigraphic series near New Idria; Cretaceous strata on left and right, Eocene in middle distance, Neocene in the distance.



EXPLANATION OF PLATE XXIII.

View on Warthan Creek; Franciscan rocks in the foreground, Cretaceous in the distance, Monterey Shales on the left.

EXPLANATION OF PLATE XXIV.

View on Los Gatos Creek, showing upturned Cretaceous strata.

EXPLANATION OF PLATE XXV.

View five miles north of Temblor, showing massive Eocene rocks in foreground, overlain unconformably by Temblor Beds.

EXPLANATION OF PLATE XXVI.

View four miles north of Temblor, showing unconformity between Temblor Beds and the underlying Eocene, dipping in opposite directions.

EXPLANATION OF PLATE XXVII.

View on north side of Antelope Valley, showing weathering of Eocene sandstone.

EXPLANATION OF PLATE XXVIII.

View south of Warthan Creek, at summit of range, showing Temblor Beds dipping northerly; Franciscan rocks on extreme left.

EXPLANATION OF PLATE XXIX.

View on summit of range south of Warthan Creek, showing Temblor Beds dipping south, overlain by Monterey Shales, seen on the left.

EXPLANATION OF PLATE XXX.

View on south side of Warthan Creek, showing Monterey Shales dipping northerly; Franciscan rocks in the foreground and to the left.

EXPLANATION OF PLATE XXXI.

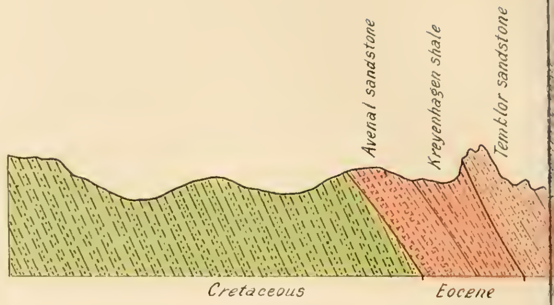
View eight miles north of Coalinga, showing Monterey Shales, Coalinga Beds, and Etchegoin Beds successively, from right to left.

EXPLANATION OF PLATE XXXII.

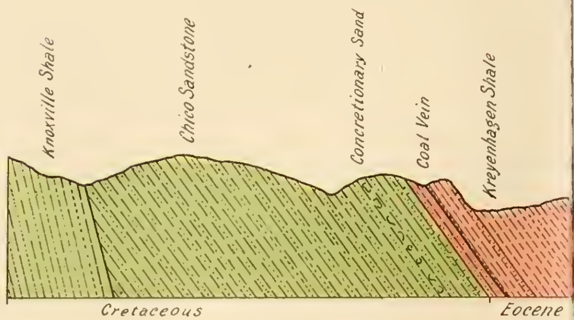
View eight miles north of Coalinga, showing Etchegoin Beds dipping southerly.

EXPLANATION OF PLATE XXXIII.

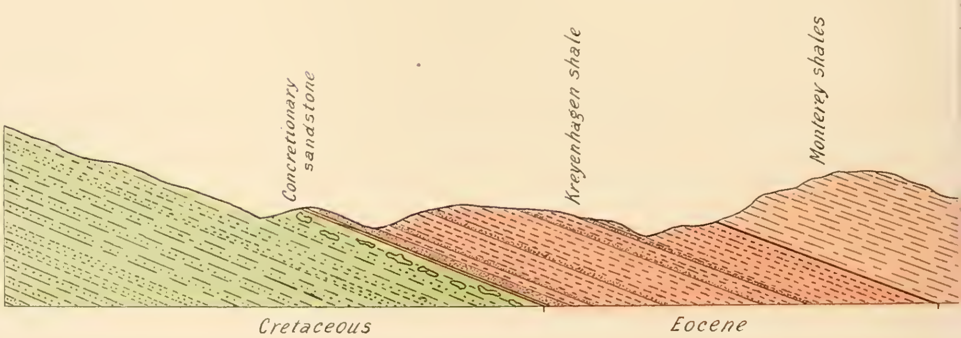
View eight miles north of Coalinga, showing disturbance of Coalinga Beds overlying Monterey Shales; Reef Bed seen at center, extreme right, and extreme left, above.



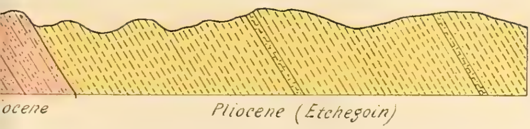
1. *Profile Section at Avenal*



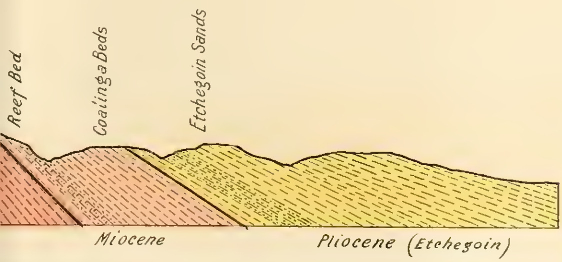
2. *Profile Section at Coal Mine wes*



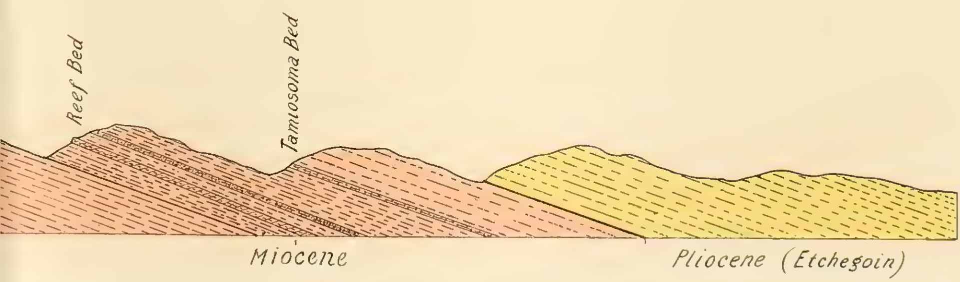
3. *Profile Section 9 Miles north of*



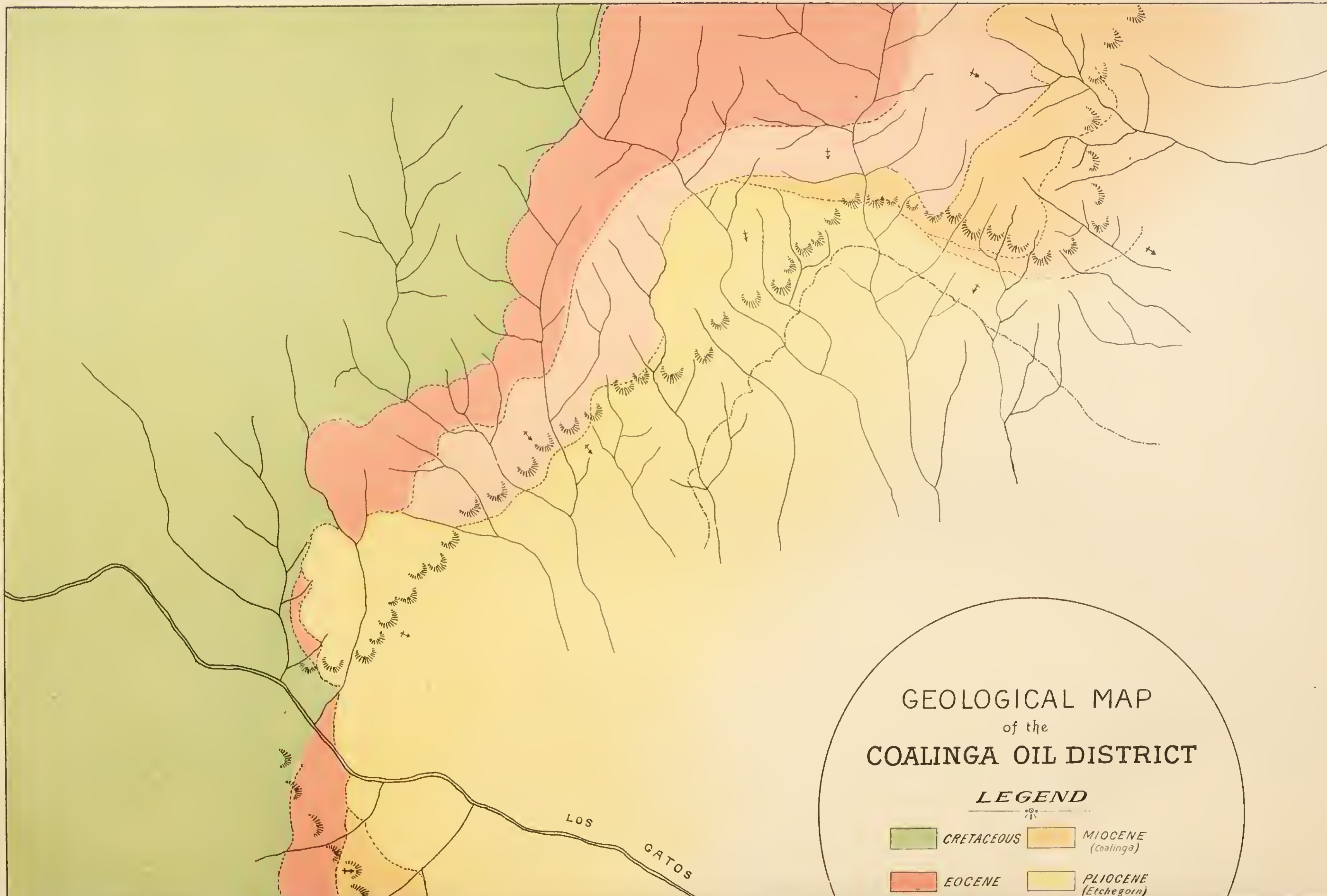
lls, Kings County, California.



of Coalinga, Fresno County, California.



oalinga, Fresno County, California.


GEOLOGICAL MAP
of the
COALINGA OIL DISTRICT
LEGEND
CRETACEOUS
MIOCENE (Coalinga)
EOCENE
PLIOCENE (Etchegoin)
LOS GATOS

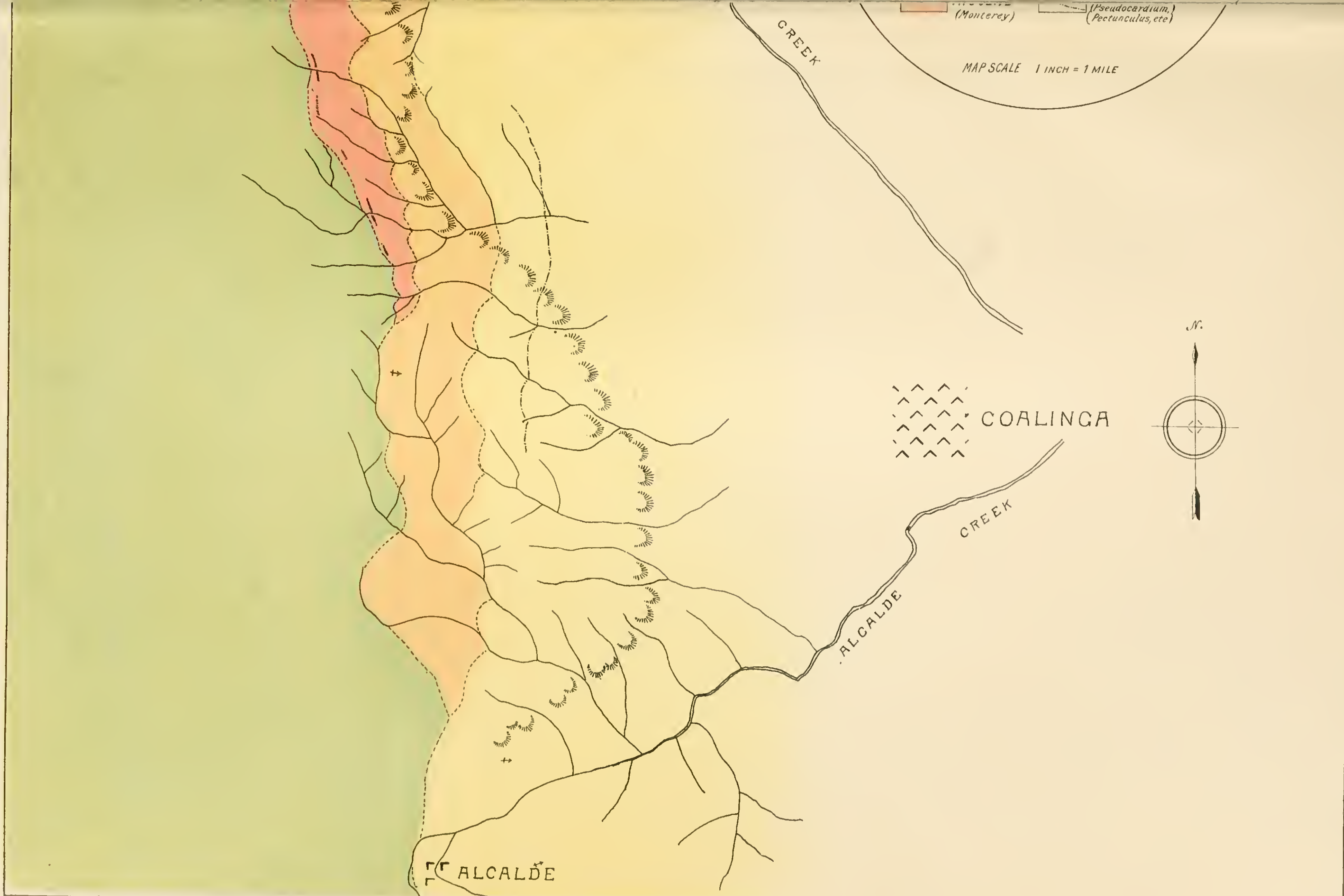


PHOTO LITH. BRITTON & REY, S.F.

PROCEEDINGS OF THE ACADEMY

(Octavo)

Third Series

GEOLOGY

Vol. I

Vol. II

INDEX TO VOLUME II, THIRD SERIES, GEOLOGY.

See page 130 for index to the Cretaceous Deposits of the Pacific Coast.

New names in **heavy-faced type**; Synonyms in *italics*.

Date Due

~~NOV 1970~~	
~~SEP 1973~~	
~~DEC 1 1966~~	