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CALIFORNIA ACADEMY OF SCIENCES

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GEOLOGY VOL. II, NO. 1

CRETACEOUS DEPOSITS

OF THE

PACIFIC COAST

BY

FRANK M. ANDERSON

WITH TWELVE PLATES

Issued December 24, 1902

SAN FRANCISCO

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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.

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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 conformable 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 basin 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			*					
Baculites 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 ellipticus, 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.	Phoenix.	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			*					
Helcyun 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					*	*
Stomatia suciænsis White			*					
Straparollus lens Gabb				*				
Straparollus paucivolvus Gabb				*				
Tritonium sp						*		*
Trochus gemiferus White			*					
Trophon condoni White		S						
Turritella chicoënsis Gabb	*	*						
Turritella 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.
Baculites chicoënsis
Dentalium stramineum
Cylichna costata
Pectunculus veatchi
Meekia sella
Cinulia obliqua
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.

Acanthoceras turneri WHITE
Anchura californica GABB
Baculites chicoënsis TRASK
Chione varians GABB
Cucullæa truncata GABB
Dentalium cooperi GABB
Dentalium stramineum GABB
Eriphyla umbonata GABB
Lutraria alveata GABB
Lytoceras batesi TRASK
Mactra tenuissima GABB
Meretrix nitida GABB
Nautilus sp.
Pachydiscus suciaënsis MEEK
Pecten operculiformis GABB
Pinna breweri GABB
Schlutheria diabloënsis, sp. nov.
Scobinella dilleri WHITE
Trigonia æquicostata GABB
Trigonia evansana MEEK

SOUTHWEST OF MARTINEZ.

Chione varians GABB
Cinulia obliqua GABB
Corbula cultriformis GABB
Cylindrites brevis GABB
Dentalium cooperi GABB
Gyrodes expansa GABB
Gyrodes conradiana GABB
? Helicoceras vermiculare GABB
Meekia sella GABB
Meekia navis GABB
Meretrix arata GABB
Mytilus pauperculus GABB
Nucula truncata GABB
Pachydiscus sp.
Pecten martinezensis GABB
Perissolax brevirostris GABB
Pectunculus veatchi GABB
Pugnellus hamulus GABB
Solarium inornatum GABB
Tellina æqualis (?) GABB
Tellina hoffmanni GABB

LIST OF FOSSIL SPECIES FROM TODOS SANTOS BAY, LOWER CALIFORNIA.

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

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[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-clegans* 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.

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[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*.

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[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.

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[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 *Helicancylus 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.

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[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, finger-like 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 subelliptical, 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. 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 originally 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.

Sehlœnbachia 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. 1, 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.

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INDEX OF SPECIES

CRETACEOUS DEPOSITS OF THE PACIFIC COAST.

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

EXPLANATION OF PLATE I.

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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

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Schlœnbachia siskiyouensis, sp. nov. 119

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Schlœnbachia chicoënsis TRASK. 116

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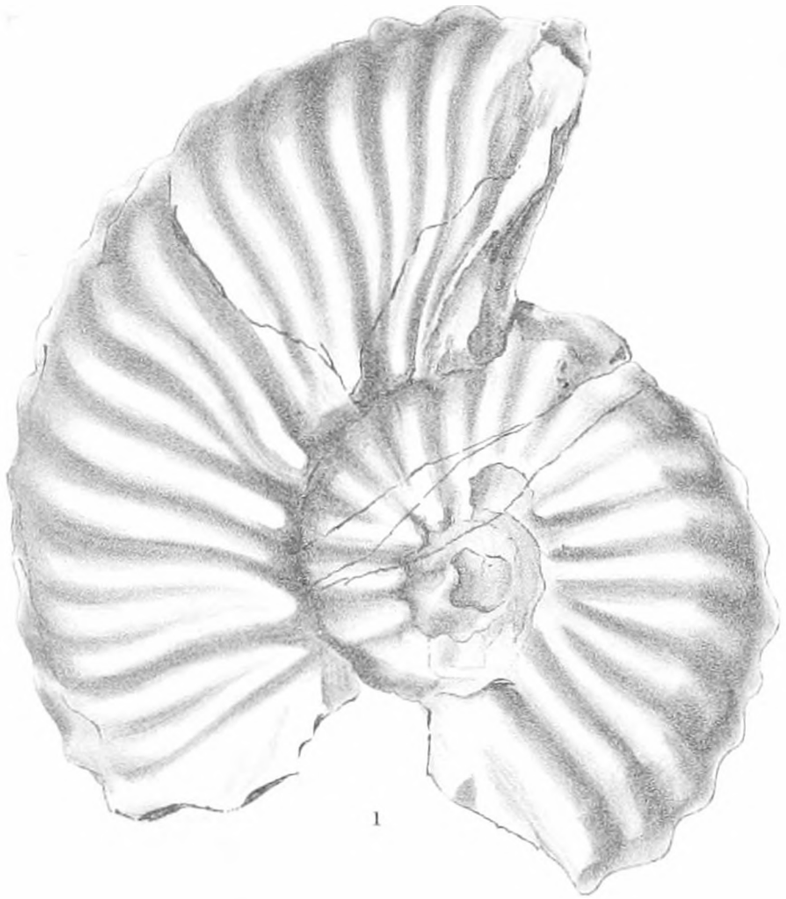
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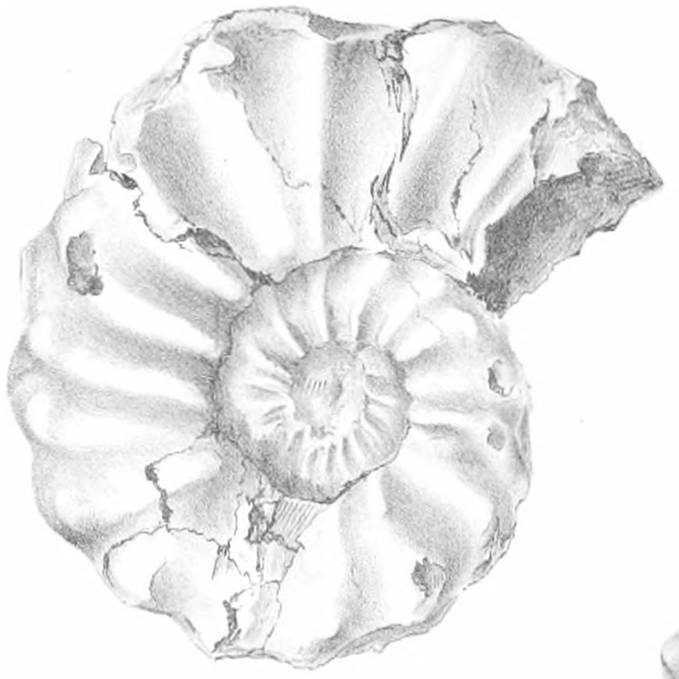
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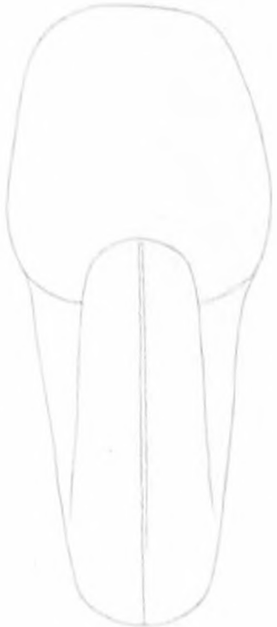

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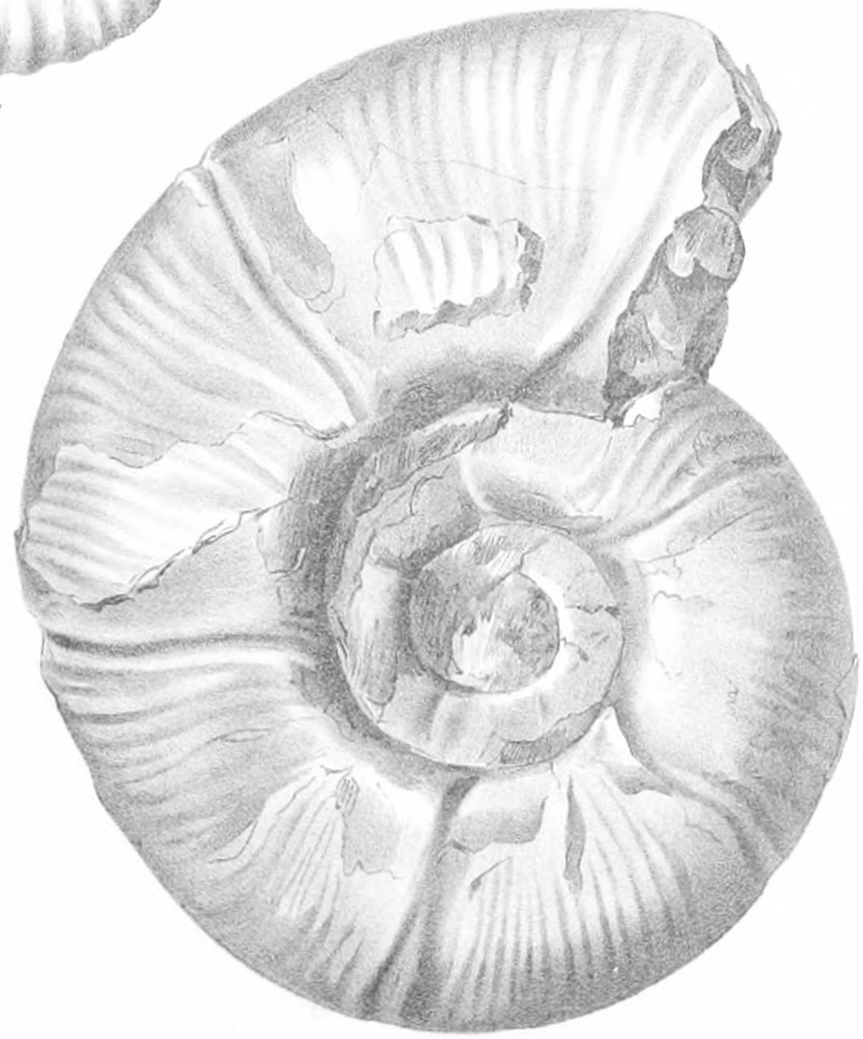

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Desmoceras hoffmanni GABB. 97

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Figs. 122–123. Younger shells.

Lytoceras (Tetragonites) jacksonense, sp. nov 82

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Hamites armatum, sp. nov. 89

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Fig. 131. Ventral surface, showing spines.

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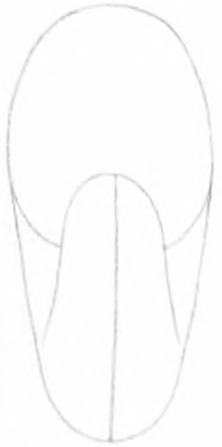

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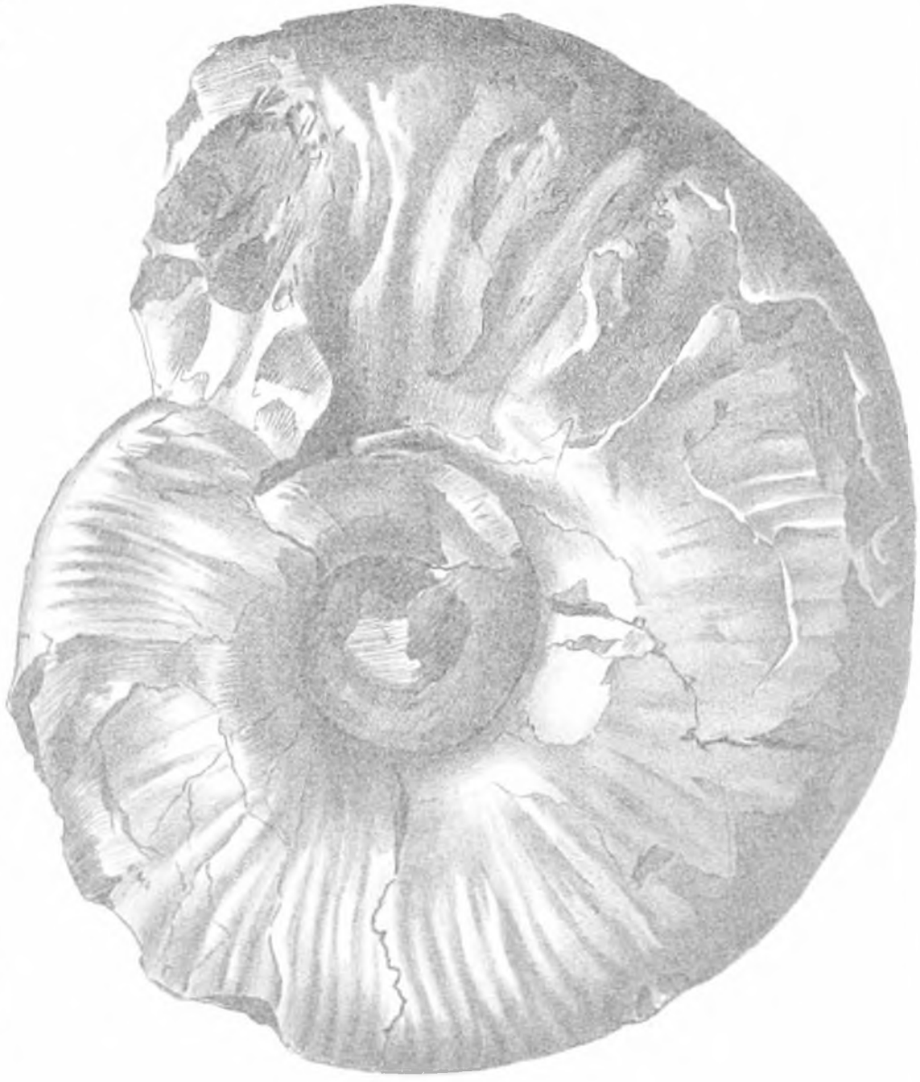

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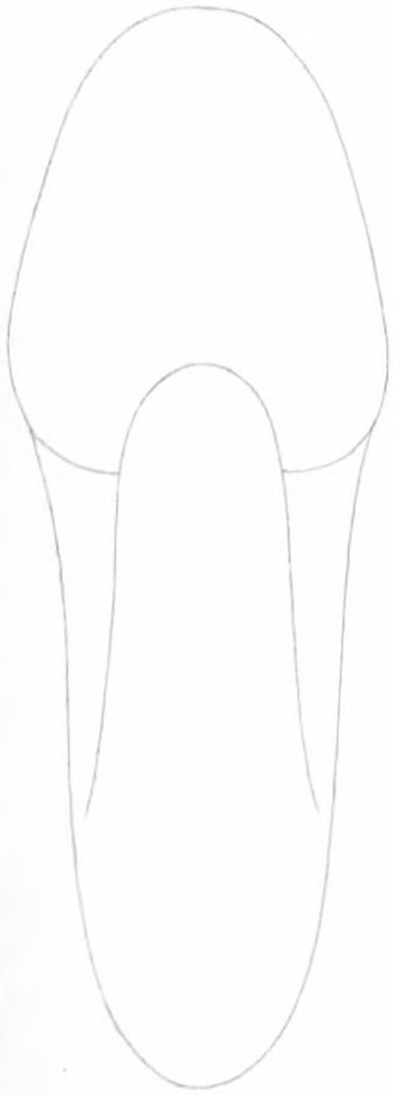

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Pachydiscus sacramenticus, sp. nov. 105

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Figs. 137–138. Younger coils.

Lytoceras (*Gabbioceras*) *angulatum* (GABB's var.), sp. nov. 87

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Schlœnbachia oregonensis, sp. nov. 122

Fig. 144. Cross-section of whorls; 22.25 mm. diameter. After J. P. SMITH.

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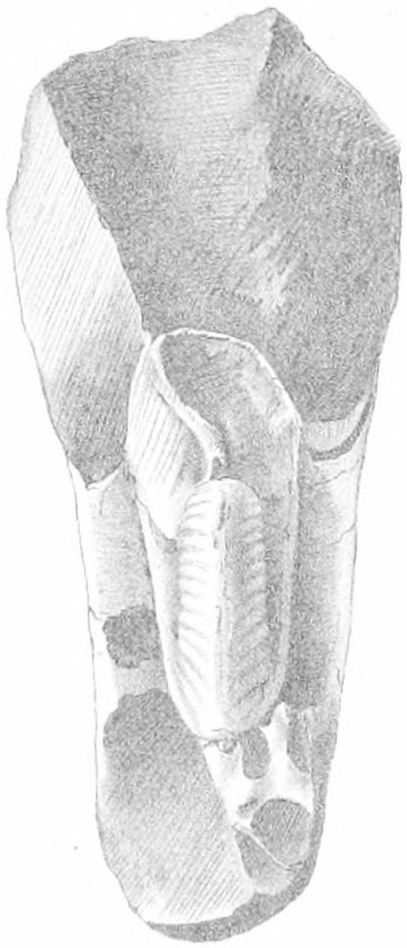

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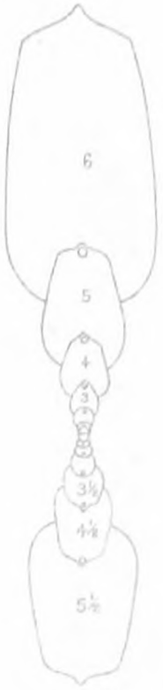

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Schlœnbachia oregonensis, sp. nov. 122

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

After J. P. SMITH.

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

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Rhynchonella whiteana, sp. nov. 72

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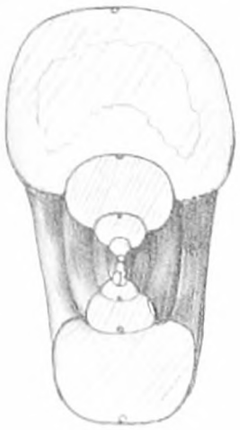

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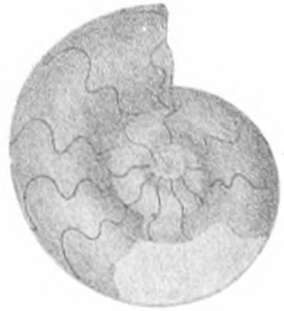

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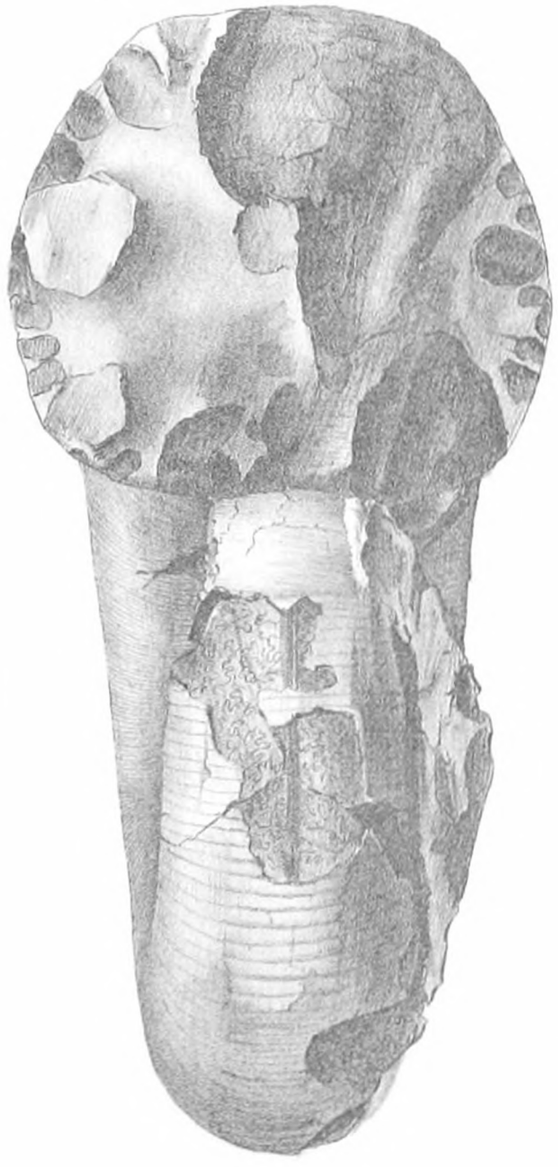

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EXPLANATION OF PLATE VIII.

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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.

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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.

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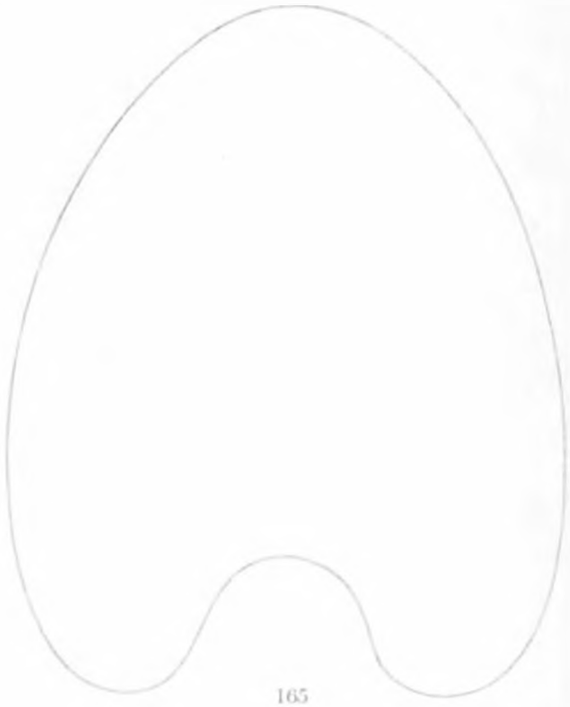

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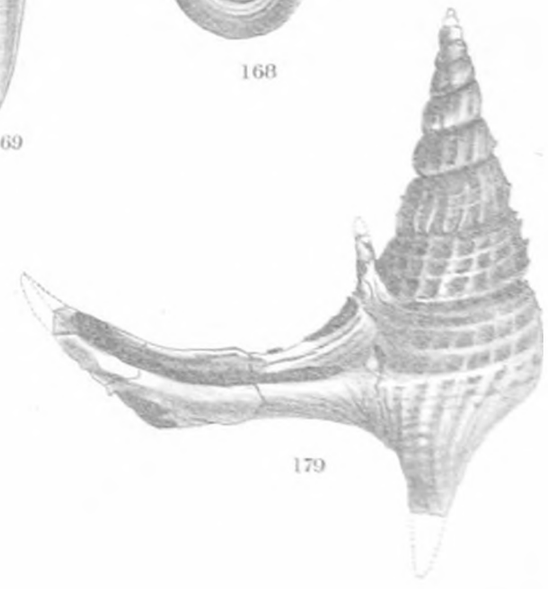

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EXPLANATION OF PLATE IX.

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Placenticeras pacificum SMITH. 79

(After J. P. Smith, Proc. Cal. Acad. Sci., 3d Ser., Geol., Vol. I, Plate XXVI; figure redrawn.)

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Inoceramus klamathensis, sp. nov. 73

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Fig. 186. Left valve with hinge; natural size.

Acanthoceras compressum, sp. nov. 107

Fig. 187. Shell; natural size.

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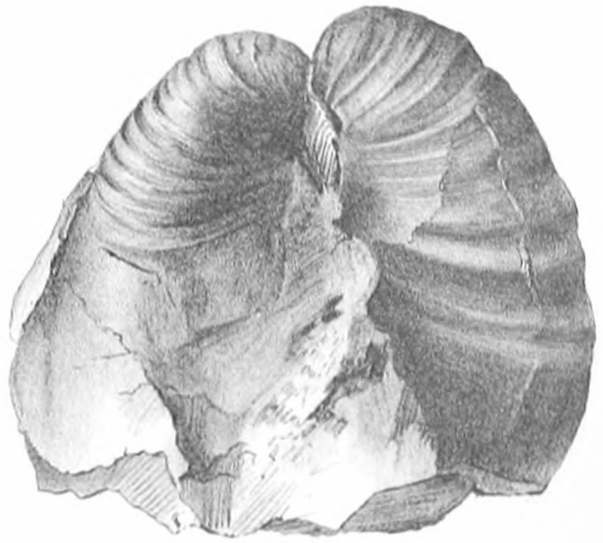

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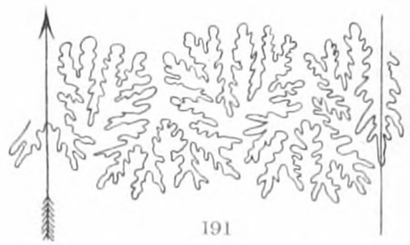

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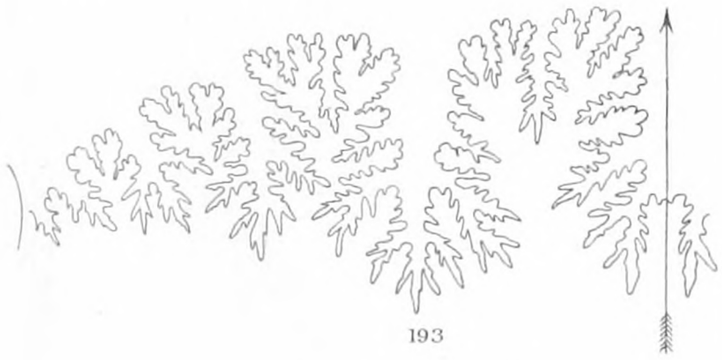

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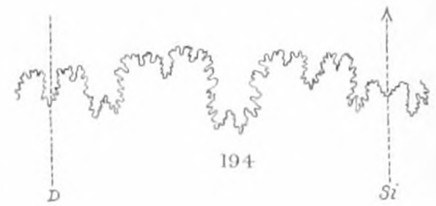

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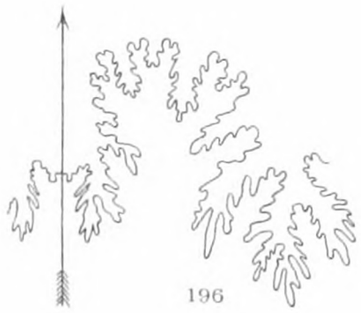

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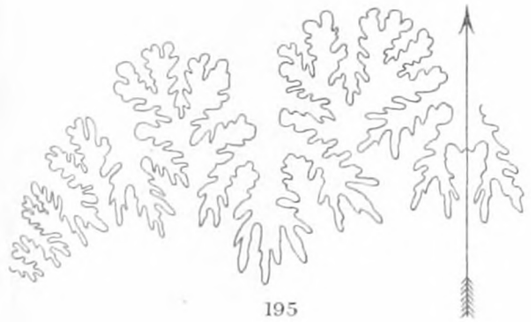

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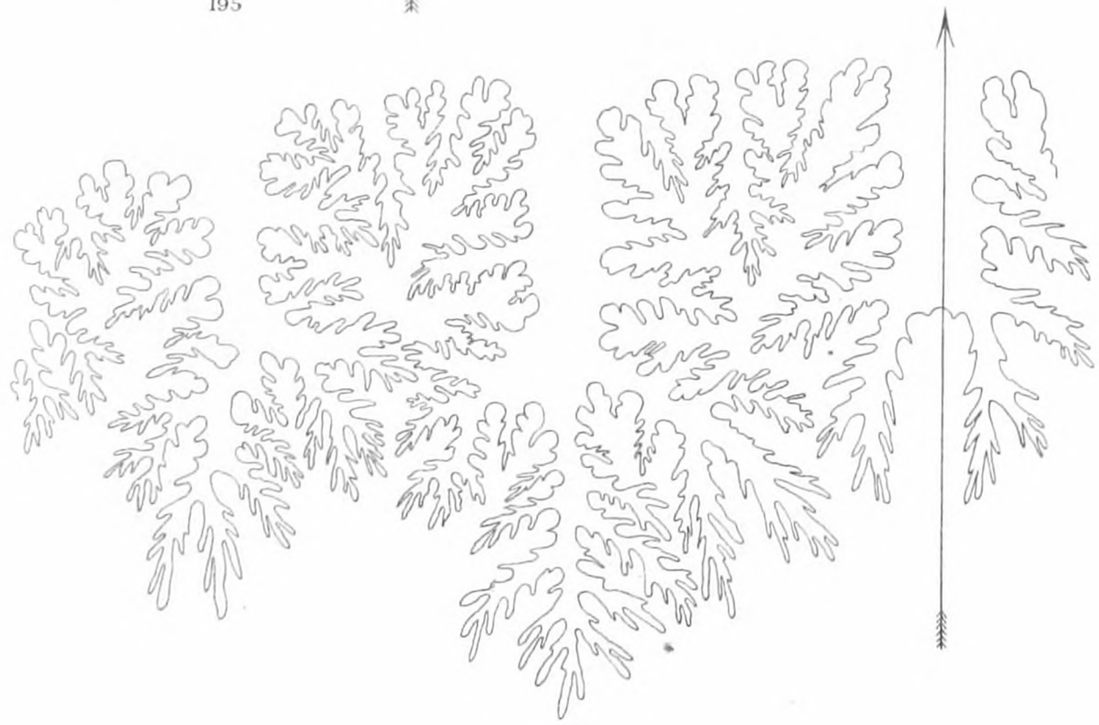

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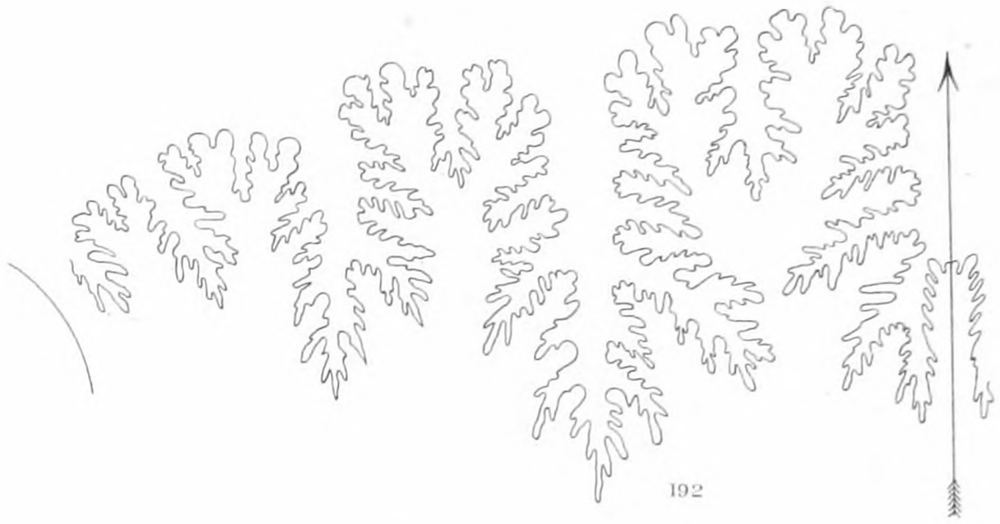

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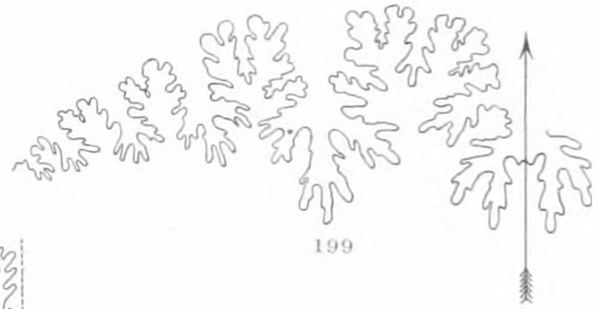

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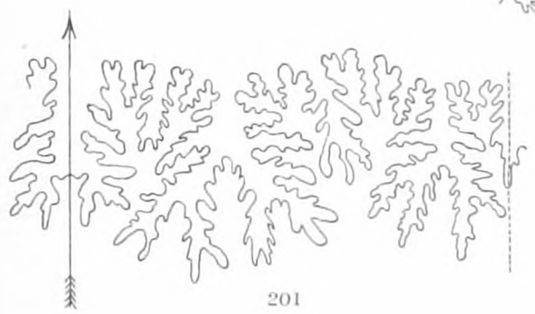

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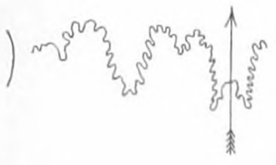

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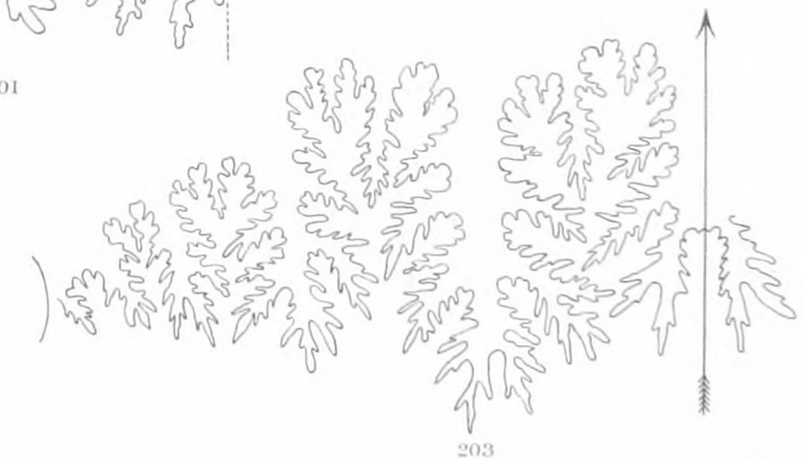

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EXPLANATION OF PLATE XI.

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. $\frac{10}{1}$.

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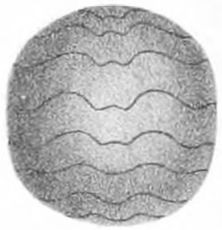

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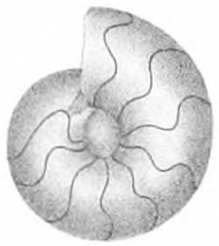

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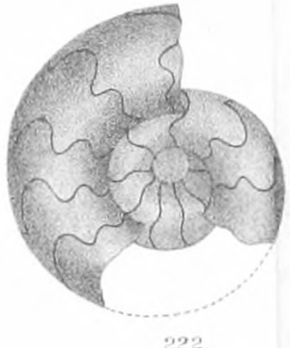

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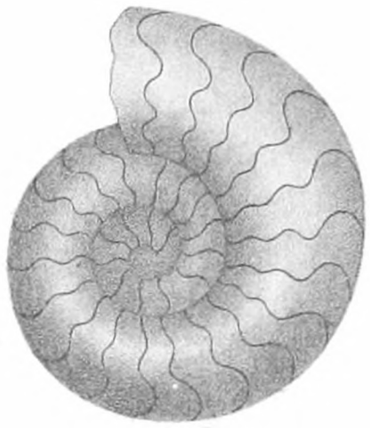

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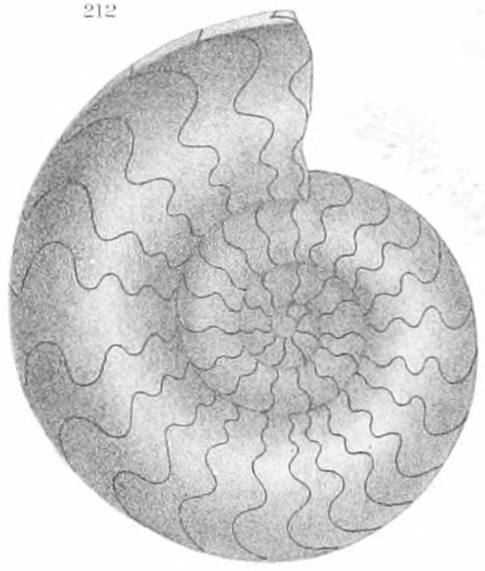

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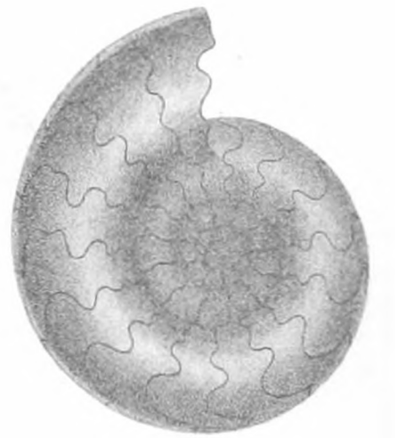

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P.R. SMITH, DEL.

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.

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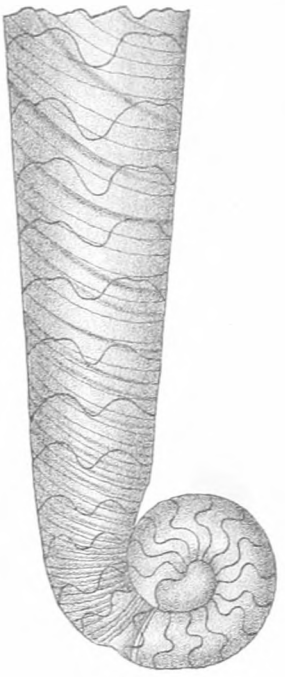
[1] These drawings are copied from a paper by J. P. Smith, "The Larval Coil of Baculites," *American Naturalist*, Vol. XXXV, p. 39, Jan., 1901. The numbers on this plate do not correspond to the originals of Smith's plates, since not all his figures are reproduced here.



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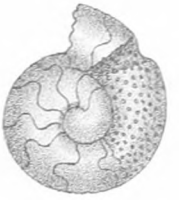

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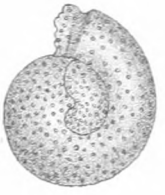

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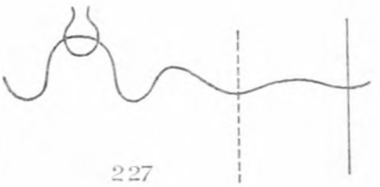

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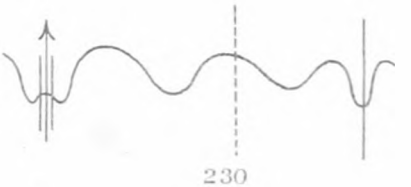

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