REPORT ON THE PALEONTOLOGICAL FIELD-WORK FOR THE SEASON OF 1877.

By C. A. White, M. D.

The outfitting camp being located on Owl Creek, twelve miles south of Cheyenne, field examinations were begun in that neighborhood. This district is one of considerable importance from the fact that the southern boundary of the large region occupied by the deposits known as the White River Tertiary Group, probably of Miocene age, passes through it in an easterly and westerly direction. This formation is seen to rest directly upon the lignite-bearing strata of the Laramie Group; and although the strata of both formations are so nearly level here as to betray no unconformity of deposition, the two are known to be unconformable by sequence. In other words, certain Tertiary formations in the great Green River Basin west of the Rocky Mountains, are now known to belong in the geological series between the White River and Laramie Groups, although they are seen in contact in the region under discussion. No special examination of the White River Tertiary beds was made upon this occasion, except so far as to ascertain their general characteristics for immediate comparison with the Laramie Group, to which it was proposed to give especial attention. The White River formation is known to extend from the base of the mountains far out upon the great plains, and also far to the northward; and wherever these beds exist in the broad reigon thus indicated they cover those of the Laramie Group, and are believed to rest in all cases directly, although unconformably, upon them. In all the great plateau region west of the Rocky Mountain Range proper, the extensively eroded and deeply carved strata of the Mesozoic and Cenozoic formations are so perfectly denuded of the débris resulting from their erosion that scarcely any impediment exists to their complete and rapid study. Their investigation is still further facilitated by the sparsness of vegetation and the multitude of elevated points for observation left as a result of deep erosion before referred to. In the plains east of the mountains, however, even the same formations, retaining the same lithological characteristics as those western ones just mentioned, while they may have suffered much erosion in the aggregate, have been eroded less deeply. Therefore the débris resulting from their erosion is abundant upon the surface, and the free exposures of the undisturbed strata are compatively few, except where they are upturned against the immediate flank of the mountains. In that portion of the plains, however, which I examined in 1877, the exposures were sufficiently numerous, aided by the extreme simplicity of the stratigraphic structure of the region, to enable me to trace out the formations and to determine their characteristics, without difficulty.

The first exposures of the Laramie Group which I examined were at and in the vicinity of some abandoned coal-mines about two miles west of Maynard's Ranch, a few miles east of the foot-hills of the Rocky Mountains, and about twenty-five miles south of Cheyenne. The strata here are nearly level, or have only a slight dip to the eastward, and the

openings in the coal-bed have been made in a broad depression of the surface, or shallow valley, along a line a couple of miles in length and having a northerly and southerly trend. The rocks here, and in this vicinity, both of the Laramie and Fox Hills Groups, consist of soft sandstones and sandy shales, the latter apparently predominating, and among the strata of the Laramie Group there are occasional layers that contain a considerable amount of carbonaceous matter, besides the bed of coal before referred to.

In this neighborhood the only fossils obtained were from the Laramie Group, and with the exception of a single imperfect example of a *Corbula* probably *C. perundata* Meek and Hayden, they belong to one species each of *Ostrea* and *Anomia*. The latter is the *Anomia mieronema* of Meek which is common but not abundant. The *Ostrea* was found to be quite abundant, especially in some places. They were found to occupy at least two layers of considerable constancy and extent and only a few feet apart. The principal oyster layer is between 50 and 100 feet above the bed of coal already mentioned. The position of the coal and the fossiliferous layers in relation to either the base or summit of the Laramie Group as it exists in this region could not be ascertained, but observations made both here and in the valley of Crow Creek, where the same layers were clearly recognized, seem to indicate that their position is nearer to the base than to the summit of the group as it is developed east of the Rocky Mountains. It may be remarked here in passing that the aggregate thickness of the Laramie Group is much less east of the mountains in Colorado than it is west of them in the great basin of Green River.

The shells of *Ostrea* found at the locality near Maynard's Ranch, like those of all the known species of that genus proper, are very variable, so much so that it would be impossible to represent the species (for I regard them as belonging to one species only) by the most careful selection of only a few examples. After a careful study of a large collection of these shells, made not only at this locality, but also in numerous other localities of the Laramie strata of this region east of the mountains, most of which are from substantially one and the same limited horizon, I am convinced that they constitute only one species, notwithstanding their great variation. A large proportion of the lighter, thinner, and more elongate shells, are plainly identical with those forms that were originally described by Meek and Hayden as *Ostrea glabra*, their examples having been obtained from the Judith River beds of the Upper Missouri River region. Others, among the larger and more massive shells, are undistinguishable from *O. wyomingensis* Meek, as found at the typical locality at Point of Rocks Station, Union Pacific Railroad, in the valley of Bitter Creek, Wyoming. There are still others, small examples, that may reasonably be referred to those forms which Meek, in vol. ix of the United States Geological Survey of the Territories referred, and perhaps correctly, to *O. subtrigonalis* Evans & Shumard. Among the large collections of these shells that I have made in the region adjacent to the eastern base of the Rocky Mountains in Colorado, it is easy to select forms that will connect together all three of those that have just been mentioned, and which have been described as distinct species. Such selections and arrangement leave the differences between any of the varietal forms so employed far within the most rigid limits of recognized specific variation among the *Ostreidæ*. If this conclusion is correct, as it is believed to be, it not only shows an identity of three forms, hitherto supposed to be specifically distinct, but it also shows a very wide geographical distribution of the species, and a geological equivalency of

the strata in which they occur. But this subject will be discussed farther on in this report, in connection with facts of a similar nature in relation to other species also.

Going westwardly from the fossil and coal locality, in the neighborhood of Maynard's ranch, I passed the base of the foot-hills and went a few miles up "Box Elder Cañon," examining the strata of the different Mesozoic formations as they successively rise from beneath the Laramie Group and each other, and are upturned there against the flanks of the mountains.

Owing to the friable condition of all the Laramie strata, they have been mostly removed by erosion wherever they were formerly upturned. The formations that successively rise beneath these are, in the descending order, the Fox Hills, Colorado, and Dakota Groups, of Cretaceous age, and the "Red Beds," of supposed Triassic age, the latter resting directly upon the granite. In this vicinity I failed to find any fossils in any of the strata of these formations beneath the Laramie Group, but from the well-known lithological characteristics of each group respectively, they were readily identified. The strata of the Fox Hills and Colorado Groups, at least the upper portion of the latter, being like those of the Laramie Group, comparatively soft and easily eroded, the surface of the plains is continuous toward the mountains over these formations, the foot-hills of the mountains being composed mainly of the harder strata of the Dakota Group and the Red Beds. The lower portion of the Colorado Group is composed in this region of light-colored, firm, siliceous shales, which in some places are rocky enough to form hog-backs of considerable elevation. At no locality east of the mountains did I find the strata of the Colorado Group composed of the soft, blue, clayey shales that so generally characterize that group west of the mountains. In the last-named region, however, the lower portion of the Colorado Group is almost everywhere characterized by a greater or less thickness of bluish or dark fissile shales, which is perhaps only a modification of the more rocky portion, holding a similar position in the group east of the mountains.

From Box Elder Cañon I traversed the space between that point and Cache à la Poudre River, a tributary of the South Platte, which I reached opposite the town of Greeley, going by the way of Higley's coal-mine. I recognized the existence of the Laramie Group beneath the surface *debris* all the way, but collected no fossils on that portion of my route. From the valley of the Cache à la Poudre I proceeded eastward to the valley of Crow Creek, another tributary of the South Platte, having its confluence with that river a few miles below that of the Cache à la Poudre. Upon the elevated ground, constituting the watershed between these two tributaries, some five or six miles northeastward from Greeley, I found some slight exposures of strata, among which I recognized the fossiliferous horizon of the neighborhood of Maynard's ranch. Here I obtained not only the *Ostrea* and *Anomia* which I collected there, but also *Corbula subundata* Meek and Hayden, and *Corbicula cleburni* White. Going directly to Crow Creek to camp, I commenced an examination of the valley. I found no exposures of strata between that point and the mouth of the creek, a distance of about five miles, but along the eastern summit of the valley side, where I hoped to have found exposures, the surface was found to be largely occupied by sand dunes. Proceeding up the valley I found no exposures of strata for five miles more, nor until I reached a point about ten miles from the mouth of the creek. From this point to five or six miles farther up the valley I found numerous limited exposures of strata containing many fossils, mainly on the

east side of the valley. In this valley, as in all the plains region round about, the exposures of strata are not only few, but none of them are extensive. The most southerly exposure is about ten miles from the mouth of the creek, and here I again recognized the oyster horizon which has been mentioned twice before. The species mentioned before were found abundantly here, and many other molluscan species besides, in associated layers. I traced this fossiliferous horizon northward for a distance of five or six miles above the point where I first discovered it, and found it to occupy nearly a uniform height above the level of the creek. The exposures are in the face of the low sloping hills that border the east side of the valley, and are distant from the creek only from a few hundred feet to half a mile.

The full section of the strata constituting the valley side here was quite clearly ascertained, although the *débris* which prevails upon the plains has so obscured them in most places, even on the slope, that they were not all observable at any one point. The following is a record of the section as ascertained by measurements at several different points within the few miles that they were found exposed, as before stated:

Crow Creek section.

	Feet.
1. Sandy soil or *debris* of the plains	10
2. Grayish siliceous marl	5
3. Sandy and calcareous layers; with *Corbicula*, &c	3
4. Soft, sandy, and argillaceous material; with *Ostrea* and *Anomia*	5
5. Arenaceous rock, somewhat concretionary; with numerous fresh-water forms.	2
6. Arenaceous marly strata	20
7. Carbonaceous shale	6
8. Gray siliceous marl	6
9. Carbonaceous shale	3
10. Gray siliceous marl	25
11. Unexposed to the surface of the creek	5

No. 1 is the prevailing *debris* of the plains, which at top constitutes the sandy soil.

No fossils were found in No. 2, but it is evidently a part of a continuous deposit with those beneath.

No. 3 is remarkably prolific in fossils, especially the genus *Corbicula*, of which there are no less than six or seven distinct species. In this member of the section I also found the majority of the examples of *Melania wyomingensis* Meek, although all its associates are regarded as brackish-water forms. This member of the section is variable, being in some places soft, sandy, and argillaceous, while in others it is mainly composed of harder sandy or argillaceous rock.

No. 4 constitutes one of the most if not the most persistent fossil-horizons in this neighborhood. It is especially characterized by an abundance of the *Ostrea* and *Anomia* which has been before mentioned as characterizing a definite limited horizon in the neighborhood of Maynard's ranch and elsewhere.

No. 5 is a local development of irregular and somewhat concretionary layers, the rock being siliceous, and also somewhat argillaceous and calcareous. The masses in this layer, that are referred to as concretionary, are comparatively large, and are abundantly charged with fossils, while the intervening portions of the layer are less fossiliferous. This member of the section was recognized at only one point, and that at the southern end of the series of exposures in the valley of Crow Creek, now under discussion. Unlike the other fossiliferous layers which compose this section, all of which contain brackish-water forms, No. 5 contains only those which are properly regarded as of purely fresh-water origin,

if we except *Volsella* (*Brachydontes*) *regularis* White, a couple of imperfect examples of which were found among those forms.

No. 6 ought, perhaps, to be properly subdivided, but, being composed of soft material, it was found nowhere freely exposed. Some of the layers seem to have been of purely fresh-water origin, because fragments of a species of *Unio* and one of *Campeloma* were found there; while other layers were as evidently of brackish-water origin, because the *Ostrea* before mentioned was frequently found in them, though it is not so abundant there as in No. 4. Although these fragments of *Unio* were too imperfect for specific identification, they were sufficient for unmistakable generic recognition, and their discovery has especial interest as being the first recognition of that genus that has hitherto been made in the strata of the Laramie Group east of the Rocky Mountains in Colorado, although many species have been discovered in strata of that period west of the mountains and in the Upper Missouri River region.

Nos. 7, 8, 9, and 10 were found exposed only at one locality, in a gully that led down to the creek. Their characteristics are doubtless represented with approximate correctness in the foregoing record of the section, but they were not without some evidence of having been partially disturbed by the valley erosion. Either No. 7 or No. 9, or both, probably represents the bed of coal that is worked at Higley's Mine and elsewhere, and is reported to have been worked in this neighborhood also, but I did not find it. The following is a list of the fossils obtained from the different members of this section:

LIST OF FOSSILS FROM THE VALLEY OF CROW CREEK, COLORADO.

1. *Anomia micronema* Meek.
2. *Anomia gryphorhynchus* Meek.
3. *Ostrea glabra* Meek & Hayden.
4. *Volsella* (*Brachydontes*) *regularis* White.
5. *Anodonta parallela* White.
6. *Unio* ——— ?
7. *Corbicula cleburni* White.
8. *Corbicula obesa* White.
9. *Corbicula cardiniæformis* White.
10. *Corbicula* (*Leptesthes*) *subelliptica* Meek & Hayden.
11. *Corbicula* (*Leptesthes*) *fracta* Meek.
12. *Corbicula* (*Leptesthes*) *macropistha* White.
13. *Corbicula* (*Leptesthes*) *planumbona* Meek.
14. *Corbula subtrigonalis* Meek & Hayden.
15. *Bulinus disjunctus* White.
16. *Bulinus subelongatus* Meek & Hayden.
17. *Physa felix* White.
18. *Goniobasis gracilienta* Meek & Hayden.
19. *Goniobasis nebrascensis* Meek & Hayden.
20. *Melania wyomingensis* Meek.
21. *Viriparus prudentia* White.
22. *Tulotoma thompsoni* White.
23. *Campeloma multistriata* Meek & Hayden.
24. *Corydalites fecundum* Scudder.

NOTES ON THE LARAMIE FOSSILS OBTAINED IN THE VALLEY OF CROW CREEK, COLORADO.

No. 1. *Anomia micronema* Meek.

This species was originally described by Meek in the Bulletin of the United States Geological and Geographical Survey of the Territories,

No. 1, second series, p. 43, "from a shaft sunk on the Kansas Pacific Railroad, 200 miles east of Denver, Colo., 45 feet below the surface, from beds of the age of the Wyoming Bitter Creek coal series." Besides my own collections of this species already recorded, I found it also abundant in the valley of Crow Creek, where it seemed to be confined to No. 4 of the section there. Upper valves only were discovered, almost all of which plainly show the characteristic radiating striæ upon the surface, but upon a few they are obsolete. In view of the apparent identity of the muscular markings and other generic characteristics of *Anomia* possessed by these shells, it seems imperative that we should regard them as bivalves, and yet it is difficult to understand why no trace of an under valve, among the thousands of upper valves that have been collected, has yet been discovered. These remarks apply with equal force to *Anomia gryphorhynchus*, also of the Laramie Group, and so far as I am aware, to all the species of that genus in the American Mesozoic strata. It is worthy of remark that upon some of the shells of the *Ostrea* found in the neighborhood of Maynard's ranch, already mentioned on previous pages, shells of *Anomia micronema* were found adhering after the manner of *Patella* or *Crepidula*. In some cases they were found adhering to both sides of the oyster-shell, always conforming to the inequalities of the surface of the latter, and in all cases with the interior surface of the *Anomia* against the oyster-shell; never the reverse. Furthermore, a careful removal of the adhering shell revealed no trace of an opposite or fellow valve beneath it. These circumstances, together with the fact of the non-discovery of the under valve, as before stated, seem to suggest at least the possibility that only one valve pertained to this mollusk. The existence of the characteristic muscular impressions of *Anomia* in these shells, implying the necessity for both proximal and distal insertion of the muscles into shelly substance, seems, however, to be decidedly against such a supposition.

While the bulk of the shell substance of this species, like that of other species of *Anomia*, is pearly, and often brilliantly so, that portion which is occupied by the nearly centrally located broad muscular scar has a subprismatic structure similar to that of the interlamellar layers upon the outer surface of *Ostrea* or the subepidermal layers of *Unio*, but it is usually less distinctly prismatic than are the portions of the other shells referred to.

The direction of these shell-fibers in the case of the *Anomia* being, as in all other cases, perpendicular to the plane of the valve, and yielding to destructive disintegration more readily than the remainder of the shell, it not unfrequently happens that a hole is thus made through the valve, suggesting that it may be the byssal aperture of an under valve. But in all these cases the muscular markings and other interior characteristics show them to be upper valves, and of course without a byssal aperture.

Anomia micronema, as will be seen from records of species and localities on following pages, is one of the most common species of the Laramie Group on both sides of the Rocky Mountains, having also a great vertical range in that group.

No. 2. *Anomia gryphorhynchus* Meek.

This species was first described by Meek in the Annual Report of the United States Geological Survey of the Territories for 1872, p. 509. His type-specimens were very numerous, and came from a stratum in the Bitter Creek series two miles west of Point of Rocks Station on the Union Pacific Railroad, Wyoming, which stratum holds a position sev-

eral hundred feet beneath the fossiliferous layers at that station, and their equivalents near Black Buttes Station, some twelve miles distant. It has also been found at the higher horizon just mentioned, west of the Rocky Mountains, and a couple of examples were found in the Laramie strata of Crow Creek that seem unmistakably to belong to this species. Besides this, an example, apparently of this species, has been recognized among some fossils collected by Prof. J. W. Powell in the Cañon of Desolation of Green River, Utah. It seems to be a comparatively rare species except at the locality where it was originally discovered.

No. 3. *Ostrea glabra* Meek & Hayden.

The same variations exist among the examples of this species from the valley of Crow Creek, where it is quite abundant, that have been noticed on a previous page as prevailing at the locality in the neighborhood of Maynard's ranch; and the same variations also exist among the examples found here that suggested the reasons before mentioned for regarding *O. wyomingensis* Meek, and perhaps *O. subtrigonalis* Evans & Shumard also, as specifically identical with *O. glabra*. The differences are believed to be mainly the result of difference in age, but they were doubtless due, in part, to environment also.

This species especially characterizes No. 4 of the Crow Creek section, but it is also found sparingly in other members, both above and beneath that one. It is also found in strata both above and beneath the one (No. 5) that appears to have been a purely fresh-water deposit.

A curious habit of this species (not altogether unknown in the case of the living *O. virginica* Gmelin, and first noticed among fossil oysters by Meek, in his description of *O. soleniscus*) is that three specimens not unfrequently attached themselves together by the whole length of their under or deeper valves. Instances of these shells being otherwise attached together are not common, and the great majority of them are entirely free, and show little or no indication of having been attached to anything, at least since they were very small.

The interlamellar layers of prismatic shell structure, commonly observable upon the exterior surface of the shells of living species of edible oysters, have been detected upon all varieties of this fossil species which have been obtained from the Laramie Group. As a rule, however, I have found it more plainly shown upon specimens obtained from localities west of the mountains than east of them; and in the case of all collections I have found it more distinctly shown upon the upper than upon the under valve. The latter peculiarity seems also to prevail in the case of the recent *O. virginica* Gmelin; but in other respects the difference seems to be due to difference in the conditions of their preservation, or rather to the different degrees of their destructive disintegration and not to mere geographical location. It may be mentioned here that I have never been able to detect this prismatic structure upon the shells of any species of the subgenus *Alectryonia*, nor upon any of either *Gryphæa* or *Exogyra*. This does not prove, however, that such a structuer does not exist in those members of the *Ostreidæ*, especially so since I have hitherto failed to find it upon any species of *Ostrea* proper which I have found associated with those forms.

These fossil oysters of the Laramie Group were subject to a pest that produced an effect upon the shells somewhat similar to that which is produced by the burrowing sponge *Cliona* upon the shells of living oysters. This pest to the Laramie *Ostrea* seems not to have been a burrowing sponge, but more probably a burrowing worm. The burrows are very numerous, of uniform size, not larger than a horse-hair, straight or curved,

often branching, the branches being uniform in size with the main burrows. Although these burrows completely "riddle" those portions of the shell where they are most numerous, they are not quite so destructive in their effects as the burrows of *Cliona* are.

A Polyzoan, probably belonging to the genus *Membranipora*, was found encrusting portions of a few shells of this species at Point of Rocks Station, but it has not been observed upon shells from other localities of Laramie strata, except those of Bear River Valley. This Polyzoan will be noticed under the head of collections from both these localities. While the presence of the *Ostrea* and *Anomia* in those strata seems sufficient to prove the saline condition of the water in which they lived, the character of these parasitic or commensal species seems to afford additional proof

No. 4. *Volsella* (*Brachydontes*) *regularis* White.

The specimens regarded as types of this species, which is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 707, were discovered in beds Nos. 3 and 5 of the Crow Creek section. The species, however, has been recognized at several localities of the Laramie Group west of the Rocky Mountains, as will be noticed on following pages. It was the only presumably brackish-water species that was found in bed No. 5, in which all the other discovered species are regarded as of fresh-water habitat.

No. 5. *Anodonta parallela* While.

This species was discovered in No. 5 of the Crow Creek section, and has not since been recognized elsewhere. It has a peculiar elongate form, resembling *Solemya* in that respect, but its generic characteristics are those of *Anodonta*, and its associated species are all fresh-water forms, except the *Volsella* noticed in the preceding paragraph. It is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 709. With the exception of *A. propatoris* White, discovered by Prof. E. D. Cope in the Judith River beds of the Upper Missouri River, this, so far as I am aware, is the only species of fossil *Anodonta* that has been discovered in any North American strata. The family, however, to which it belongs is well known to be abundantly represented by numerous species of *Unio* in the western portion of the national domain, from the Jurassic beds to the Bridger Tertiary inclusive. The great differentiation of type among even the more ancient of these *Uniones*, and their similarity to living forms, makes it probable that the genus *Anodonta* coexisted with them all. The probable reason why, with the two exceptions named, they have escaped detection, is the well-known fact that their congenial habitat is in still waters and on a soft bottom, and seldom in direct association with any species of *Unio*.

No. 6. *Unio* ——— *?*

Only a few fragments of this species were discovered, and these only in No. 6 of the Crow Creek section. They were too imperfect for specific determination, and are interesting only from the fact that they furnish the only evidence yet discovered of the existence of the genus *Unio* during the Laramie period east of the Rocky Mountains in what is now Colorado. The probabilities are, however, that they did exist then and there in considerable numbers.

No. 7. *Corbicula Cleburni* White.

Some five years ago Mr. W. Cleburn discovered this species in the valley of Crow Creek, either at or near the same place where I obtained additional specimens in 1877. This species has hitherto been found only

at that locality, and was obtained only from No. 3 of the section. It is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 711.

No. 8. *Corbicula obesa* White.

This species has been discovered both in Crow Creek and Bijou Creek valleys, but not elsewhere. It comes from No. 3 of the Crow Creek section. It is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 712.

No. 9. *Corbicula cardiniæformis* White.

This is a rare but well-marked species. It was found only in bed No. 3 of the Crow Creek section, and is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 711.

No. 10. *Corbicula* (*Leptesthes*) *subelliptica* Meek & Hayden.

Dr. Hayden originally discovered this species in the valley of Cherry Creek, Dakota, in beds that both he and Meek referred either to the Fort Union or Judith River series, but were unable to decide which. While at the original localities these two groups seem to be sufficiently distinct, subsequent discoveries (most of which are presented in this report) of the fossils of each group associated in the same layers elsewhere make it doubtful whether they will ever be recognized as distinct groups elsewhere than at the original localities. *C.* (*L.*) *subelliptica* is described and figured in vol. ix of the United States Geological Survey; and Mr. Meek there refers to this species as having been found in the valley of Bijou Creek (where I also found it), as well as in the Upper Missouri River region. It comes from bed No. 3 of the Crow Creek section, where it is associated with several other species of that genus.

No. 11. *Corbicula* (*Leptesthes*) *fracta* Meek.

Several imperfect examples and fragments of a species, which is without doubt identical with the one named above, were found in bed No. 3 of the Crow Creek section. The species, which is the type of the subgenus *Leptesthes*, was originally discovered in the upper part of the Bitter Creek series, near Black Buttes Station, Wyoming. It has been found there quite abundantly where it is quite variable in form, and where it also reaches a larger size than the average at the other localities at which it has been discovered. It is known at other localities west of the Rocky Mountains, and was also obtained by Dr. Hayden from the same shaft with Nos. 1 and 13, two hundred miles east of Denver, Colo.

No. 12. *Corbicula* (*Leptesthes*) *macropistha* White.

The type-specimens of this species came from No. 3 of the Crow Creek section, but it was also obtained in the valley of Bijou Creek, and at these two localities only. It is the smallest known species of this subgenus, in which respect it contrasts strongly with the type-species of *Leptesthes*, noticed in the last paragraph. It is described in the Bulletin of the Geological and Geographical Survey of the Territories, vol. iv, p. 713.

No. 13. *Corbicula* (*Leptesthes*) *planumbona* Meek.

This species was obtained in considerable numbers from bed No. 3 of the Crow Creek section, and also, but less plentifully, in the valley of Bijou Creek. It was originally discovered "two hundred miles east of Denver City, on the Kansas Pacific Railroad, where they were found in a shaft at a depth of 40 feet below the surface." By reference to

remarks under the head of No. 1, *Anomia micronema*, it will be seen that that species also was discovered in the same shaft, but at a depth of 45 feet; that is, in a layer beneath the one in which the *Corbicula* here discussed was found. The layers which are respectively characterized by these two species hold the same relative position at both the Crow Creek and Bijou Creek localities. This fact is without important significance, so far as the vertical range of the different species alone is concerned, at least that of the *Anomia*, the vertical range of which is known to embrace almost the entire thickness of the Laramie Group west of the mountains; but it has much significance as indicating great uniformity of the conditions that affected deposition of sediment during the Laramie period in the region which now constitutes a portion of the great plains adjacent to the east base of the Rocky Mountains in Colorado. This subject, however, will be further discussed upon following pages.

No. 14. *Corbula subtrigonalis* Meek & Hayden.

Dr. Hayden obtained the type-specimens of this species from the Judith River Group of the Upper Missouri River region. It is described and figured in vol. ix of the United States Geological Survey of the Territories. Like all species of this genus, it is very variable in surface-markings and outline, but there seems to be no reason to doubt the identity of the specimens found at the Crow Creek locality with the species above named, which is regarded as identical with *C. perundata* of the same authors, and which is associated in the same strata in the Upper Missouri River region. Neither have I any serious doubt of the identity of this species with both *C. tropidophora* Meek and *C. crassitelliformis* Meek, both originally described by him from specimens obtained from the Laramie strata in the valley of Bitter Creek, Wyoming. The latter, according to Meek, was also found associated with No. 11 in the same shaft, 200 miles east of Denver, Colo. The differences between these forms that have received different specific names are believed to be not greater than the range of properly recognized interspecific variation under different conditions of environment. Several of the examples discovered, not only in the valley of Crow Creek, but also in localities west of the Rocky Mountains, are much larger than either of the Upper Missouri River forms, or than any known examples of *C. tropidophora*, but this is believed to be only a variation due to conditions of environment, probably in this case a difference of saltness of the waters.

No. 15. *Bulinus disjunctus* White.*

This species was obtained from No. 5 of the Crow Creek section, and specimens were also obtained from the coal-bearing series of the upper part of the Laramie Group at the Almy coal-mines, near Evanston, Wyo., that appear to belong to this species, but they have the spire somewhat shorter.

No. 16. *Bulinus subelongatus* Meek & Hayden.

This species was originally discovered by Dr. Hayden in the strata of the Judith River Group of the Upper Missouri River, and it was also recognized among some collections made in that region by Professor

* This species has not hitherto been described. It closely resembles *B. elongatus* Meek & Hayden, but the spire is more elevated, and consequently the body-volution is proportionally smaller. Besides this, the anterior half of the callus which forms the inner lip is not appressed against and adherent to the body, whereas the posterior half is, and as the whole of it is in other species of *Bulinus*, but it is deflected or disjoined so as to leave a kind of umbilical space between it and the body of the shell. This peculiarity is not accidental, as was at first supposed, but it was observed in all the specimens, young and old, of both the localities at which it was obtained.

Cope in 1876. It is described and figured in vol. ix of the United States Geological Survey of the Territories. Only a few fragments, which I refer to this species, were found at the Crow Creek locality, and only in No. 5 of that section. More perfect examples were found in the coal-bearing series constituting the upper part of the Laramie Group, near Evanston, Wyo., which I refer to this species.

No. 17. *Physa felix* White.

Only two imperfect examples of this species were anywhere discovered, and these only in bed No. 5 of the Crow Creek section. It seems to be a true *Physa*, yet the remarkable inflation of the body volution and a peculiarity of its surface ornamentation suggest probably subgeneric differences. See Bull. U. S. Geol. & Geog. Surv. Terr., Vol. IV, p. 714.

No. 18. *Goniobasis gracilienta* Meek & Hayden.

Dr. Hayden also discovered this species in the Judith River beds; and it is figured and described in vol. ix of the United States Geological Survey of the Territories. A goodly number of examples were found in bed No. 5 of the Crow Creek section, which seem in all respects to possess the typical characteristics of the species. Black Buttes Station, Wyo., is the only other locality at which the species has been recognized, where it is found in strata of the upper portion of the Laramie Group, but all the examples found there are more slender than the types.

No. 19. *Goniobasis nebrascensis* Meek & Hayden.

This species was among the large collections made many years ago by Dr. Hayden, from the Fort Union Group of the Upper Missouri River region. It is described and figured in vol. ix of the United States Geological Survey of the Territories. Both this species and *G. tenuicarinata* of the same author, associated together as they are where they were originally discovered, were obtained by one of the parties under Lieutenant Wheeler's direction at Wales, Utah, and are described and figured in White's Report, vol. ix, Part I, Exploration and Survey West of the One Hundredth Meridian. *G. nebrascensis* was also recognized among some fossils collected by Prof. J. W. Powell from strata exposed in the Cañon of Desolation, of Green River, in Utah; and the same species only was found at the Crow Creek locality, and only in No. 5 of that section. It is possible that *G. tenuicarinata* is only a variety of *G. nebrascensis*, as has been suggested by Mr. Meek; but if so it is an interesting fact that the variation should be so precisely the same at the two very distant localities where the two forms are so intimately associated, while the characteristics that distinguish the last-named form are constant at all the localities where it has been found.

No. 20. *Melania wyomingensis* Meek.

Mr. Meek first discovered some imperfect examples of this fine shell in the strata of the upper part of the Laramie Group, near Black Buttes Station, Wyo., from which he described the species in the Annual Report of the United States Geological Survey of the Territories, for 1872, p. 516. In Professor Powell's Report of the Geology of the Uinta Mountains, published in 1876, on page 131, I unwittingly described the same species under the name of *M. laruada*, from some large and beautifully preserved specimens that were obtained by Mr. W. Cleburn from the valley of Crow Creek some three years previously. Upon my own examination of that region in 1877, I collected a number of specimens of the same species from the same locality. I got fragments of it also from the valley of Bijou Creek; besides which Mr. George L. Taylor, of

Denver, gave me a fine specimen that he informed me came from Horse Tail Creek, a tributary of South Platte River, some seventy-five miles eastward from Greeley, Colo. Besides these specimens from strata east of the mountains, I collected others from the original locality in the Bitter Creek series at Black Buttes Station; at two or three localities in Yampa River Valley; and at one locality in White River Valley. A careful comparison of all these specimens, collected at the localities just named, on both sides of the Rocky Mountains, shows *M. wyomingensis* Meek and *M. larunda* White to be one and the same species. It must therefore take the name originally given it by Meek, which is here adopted.

At the Crow Creek locality it was found in bed No. 5 associated with purely fresh-water forms, but more plentifully in bed No. 3, where it was found associated with *Corbula*, *Corbicula*, &c., but no species were found in that bed that are regarded as purely fresh-water forms. It was found at all the localities named west of the mountains, with similar associates, by which I infer that this species was capable of living in waters that were at least in some degree saline.

No. 21. *Viviparus prudentia* White.

This species has been found only at the Crow Creek locality, and only in bed No. 5 of that section. It is an unusually short species, and in general aspect it recalls the living species, *V. intertexta* Say. It is described in the bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 716.

No. 22. *Tulotoma thompsoni* White.

No other species of this genus has yet been discovered in American strata, and only one living North American species is known. Its claims to be regarded as a distinct genus from *Viviparus* will be discussed elsewhere. *T. thompsoni* was first discovered by me in the upper strata of the Bitter Creek series of the Laramie Group, at Black Buttes Station, Wyoming, and described in Powell's Report on the Geology of the Uinta Mountains, p. 134. It was then found to occupy a thin layer immediately above one that at the same locality is crowded with *Corbicula*, but the *Tulotoma* apparently had no other than purely fresh-water associates. At the Crow Creek locality it was found only in No. 5 of the section there, its associates being purely fresh-water forms, except *Volsella* (*Brachydontes*) *regularis*, which occurs in that bed as already mentioned, but perhaps accidentally.

It has hitherto been discovered at only these two localities, one on each side of the Rocky Mountains, but this fact shows that it was a widely distributed species, and it is found in large numbers at both localities. The identity of the species at these two distant localities is unmistakable, but there appears to be a greater variation among the examples from the Crow Creek locality than among those obtained at Black Buttes Station, but the latter are mostly very imperfect. One of the variations observable among the examples obtained in the valley of Crow Creek is a tendency of the nodes to become obsolete, even upon the last volution. The aspect of those examples in which the obsolescence of the nodes is greatest is closely like that of the typical forms of *Viviparus trochiformis* Meek & Hayden, thus suggesting the possible passage of a molluscan species from one recognized generic form to another without any clearly definable change of specific characters.*

* Dr. M. Neumayr, of Vienna, has shown a similar gradation to exist between certain Miocene Tertiary forms from Sclavonia which American conchologists would not hesitate to refer respectively to *Viviparus* and *Tulotoma*, but all of which he refers to the former genus. The paleontologist is of course confined to the study of the shell

No. 23. *Campeloma multistriata* Meek & Hayden.

This somewhat variable species was originally discovered by Dr. Hayden in the strata of the Fort Union Group at Fort Clark, Dakota, and is described and figured in vol. ix of the United States Geological Survey of the Territories. It was found in great numbers also by Mr. J. A. Allen over a large area of the Upper Missouri River region, or, more properly speaking, in the region drained by the Yellowstone. Most of his specimens are larger than either the type-specimens or any of those that were found at the Crow Creek locality. They were also distinguished by a greater prominence and angularity of the shoulder at the distal side of the volutions, which, to a greater or less extent, characterizes the species, but no doubt is entertained of their specific identity. The examples found at the Crow Creek locality are closely like the typical examples, and were obtained only from No. 5 of the section there, its associates being fresh-water forms. No unmistakable examples of this species have been discovered at any locality west of the Rocky Mountains, but some imperfect examples of a closely related, if not identical, species were found in strata of the upper portion of the Bitter Creek series at Point of Rocks and Black Buttes stations, in Wyoming. The fragment of *Campeloma* found in bed No. 6 of the Crow Creek section perhaps belongs to this species, but it was too imperfect for specific determination.

No. 24. *Corydalites fecundum* Scudder.

The above name was given by Mr. Scudder, in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 537, to an insect that laid some remarkable egg-masses, which I discovered associated with a part of the foregoing mollusks in bed No. 5 of the Crow Creek section. No trace of them was found in any other member of the section, nor at any other locality. These egg-masses were found promiscuously intermixed with the shells of branchiferous and pulmonate mollusks, and had evidently been drifted more or less from the place of their original oviposition, as had at least a part of the shells with which they were associated.

Conclusions that in their application pertain alike to all the localities from the strata of which I have made collections of fossils will be reserved for the discussions closing this report, but those observations that were found to be more or less peculiar to separate localities may properly be briefly discussed in more immediate connection with their statement. I may thus especially note here the local and apparently limited development of that member of the Crow Creek section of strata which contains a purely fresh-water fauna. It is true the full extent of that bed is not even approximately actually known, but the locality where it was discovered and examined is apparently its northern border, and no trace of it was discovered at any other locality east of the Rocky Mountains in Colorado. The evidence that its northern border exists at thel ocality mentioned consists in the fact that the bed No. 5 is exposed at only one point, although the whole series of strata which are exposed in

alone, but it is proper to state that Haldeman's genus *Tulotoma* was founded upon the shell only, the soft parts, so far as I am aware, having never been described. The only known living American species of *Tulotoma*, *T. magnifica*, Haldeman's type, is a very variable shell, especially as regards its nodes and carinæ, and it may well be questioned whether any conchologist would have ventured to separate the smoother forms from *Viviparus* if they alone had been known. It is proper to state, however, that the shell of *T. magnifica* is more massive than that of any known living species of *Viviparus*; but, on the other hand, the shell of the fossil species, *T. Thompsoni*, is not thicker than that of *Viviparus* generally is, except where it is thickened by the nodes.

the valley for a distance of five or six miles, and which constitute the Crow Creek section, is frequently cut from top to base by gullies leading directly across the exposures into the creek, and bed No. 5 is nowhere else recognized, although the beds which immediately underlie and overlie it respectively are at those other points clearly distinguishable and in contact. The prevalence of one and the same species of *Ostrea*, both above and beneath the fresh-water bed, also suggests the limited extent of that fresh-water deposit and the unbroken continuity of sedimentary deposition in at least partially saline waters at no great distance away from the limited area in which the fresh-water deposit was made. Although the border of this bed is thus recognized at the Crow Creek locality, it does not seem to possess the characteristics of a true littoral deposit, such as water-worn pebbles, marks of wave action, &c. The presence in it of the insect egg-masses, palustral shells, and fragments of wood and deciduous leaves, however, seem to indicate that a shore-line was not far distant.

A marked peculiarity of the fauna of the Crow Creek locality is the great prevalence of *Corbicula*, including both the typical forms of the genus and those of the subgenus *Leptesthes*. The recognized species are six in all, and some of them appear to be intermediate in character between the typical forms and those of the subgenus *Leptesthes*, and one of them approaches the form to which Mr. Meek has given the subgeneric designation of *Veloritina*.

Other important observations were made in relation to the Laramie Group and its fossils in the valley of Bijou Creek, and elsewhere east of the Rocky Mountains, but the plan adopted for my report is to make the record of my observations in the order of my line of travel. Therefore the Cretaceous rocks of the valley of the Cache à la Poudre and other localities will now be discussed, and the consideration of the Laramie Group and its fossils will be resumed on following pages.

Returning from the valley of Crow Creek to the Cache à la Poudre, I passed up the south side of its valley, by way of Greeley, to a point about five miles westward from the town. Here, and also at intervals within a distance of six or seven miles farther westward, I found the upper series of Cretaceous strata exposed. From these exposures I collected quite a number of species of invertebrate fossils, some of which respectively characterize the different divisions of the Cretaceous series that have been recognized in the Upper Missouri River region, from and including the Fort Pierre Group upward. Those obtained in the valley of the Cache à la Poudre within the limits just named were collected mainly at, and in the vicinity of, the farms of Frank Marcks and Aaron Eaton, respectively.

The dip of the strata in this region is gently to the eastward, but as it is a little greater than the coincident slope of the stream, one comes upon lower and lower strata as he passes westward up the valley. The broad lower lands of the valley are covered with alluvium, and the higher surfaces with the usual prevailing *débris* of the plains, so that the exposures of strata, even in the valley side, are very few, and the thickness exposed at any one locality is very small. Much the most important exposure, as regards extent and thickness of strata, that I observed in this valley, was found at and in the vicinity of Mr. Eaton's farm, where it forms a precipitous bluff near the river, and shows a thickness of strata amounting to about 100 feet. The fossiliferous layers of this exposure are few and limited, but traces, at least, of fossils occur throughout the whole thickness. No continuous measurements of the strata exposed in the valley side within the distance named could be

made, and consequently the aggregate thickness of them is not known. This thickness, however, is estimated to be about 250 feet between Marck's farm and a point about four miles above Eaton's farm.

At the exposures here referred to the following list of fossils was collected, all belonging to the extreme upper portion of the Cretaceous series beneath the Laramie Group. A part of them also characterize the highest known Cretaceous strata beneath the Judith River Group in the Upper Missouri River region, as shown by Meek and Hayden, but the relations of those fossils in this respect will be discussed in connection with those collected at Fossil Creek, Little Thompson Creek, the mouth of the Saint Vrains, &c., because the strata exposed at these localities all belong to one natural group.

LIST OF THE FOSSILS COLLECTED FROM CRETACEOUS STRATA IN THE VALLEY OF THE CACHE À LA POUDRE, FROM FIVE TO TWELVE MILES WEST OF GREELEY, COLORADO.

1. *Fragments of fossil wood.*
2. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard.
3. *Nucula cancellata* Meek & Hayden.
4. *Nucula planimarginata* Meek & Hayden.
5. *Tancredia americana* Meek & Hayden.
6. *Veniella humilis* Meek & Hayden.
7. *Cardium speciosum* Meek & Hayden.
8. *Tellina scitula* Meek & Hayden.
9. *Mactra* (*Cymbophora*) *formosa* Meek & Hayden.
10. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.
11. *Dentalium gracile* Hall & Meek.
12. *Cylichna scitula* Meek & Hayden.
13. *Lunatia moreauensis* Meek & Hayden.
14. *Anchura*, ———?
15. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden.
16. *Placenticeras lenticulare* Owen sp.

Leaving the valley of the Cache à la Poudre at a point about four miles west of Aaron Eaton's farm, I went more directly westward toward the mountains. Search was made in this region for the line of junction, or plane of demarkation between these Upper Cretaceous strata and the base of the Laramie Group. In consequence of the great prevalence of the *débris* of the plains, which has already been referred to, I was not successful in this search, although it is quite evident that the lower strata of the Laramie Group occupy the upper part of the slope of the valley side, as well as the higher lands of the region on both sides of the valley. Higley's coal-mine, which has been already mentioned, is opened in Laramie strata in the upper part of the long, low, sloping, opposite valley-side, and its position is thus shown to be not far above these Cretaceous strata, and consequently near the base of the Laramie Group. But this subject will be taken up again on a subsequent page.

Proceeding westward after leaving the valley of the Cache à la Poudre, I found no exposures of rock until I reached Fossil Creek, about two miles east of the base of the foot-hills of the Rocky Mountains. Along a ridge having the local name of "Fossil Ridge," which runs southward from this creek three or four miles parallel with the foot-hills, there are considerable exposures of coarse sandstones containing fossils that characterize the upper series of Cretaceous strata, known in the Upper Missouri River region as the Fox Hills and Fort Pierre Groups. From

Fossil Ridge I passed up to Spring Cañon, and thence through a portion of it among the foot-hills. Some minor hills that lie immediately adjacent to the foot-hills proper are formed of the hardened shales and calcareous layers of the lower portion of the Colorado Group; but the principal foot-hills are mostly in the form of hogbacks that were produced by the upturning of the strata of the Dakota Group and the Red Beds.

I prosecuted a labored but unsuccessful search for fossils in the strata of these hogbacks, as I did, also, in those of Box Elder Cañon, which is a similar gorge, through these same strata, similarly upturned. From their stratigraphical characteristics and relative position the Red Beds were easily recognized as those that have been generally regarded as of Triassic age, and the strata of the Dakota Group were just as readily identified, although no fossils were discovered. There is also a series of strata between these two groups, which, being softer than the others, has yielded more to disintegration. These were recognized and described by the late Mr. Marvine, in his report, as Jurassic strata. In this he was probably correct, but so far as I am aware no invertebrate fossils* of any kind have been found in these strata or in their equivalents east of the Rocky Mountains in Colorado, except a shell found by Mr. Lakes and noticed in connection with fossils found in the vicinity of Golden City, on a following page.

Returning to Fossil Ridge I made considerable collections of fossils there, a part of the species being very abundant. They were obtained mainly from "cannon-ball" concretions, some of which are very large and which were weathered out of softer layers of sandstone. It has already been mentioned that a part of these fossils are of the same species that characterize the Fort Pierre Group of the Upper Missouri River region. It is a well-known fact that several species of fossils are common alike to both the Fort Pierre and Fox Hills Groups, even in the region just mentioned, and this is so especially the case in Colorado that no attempt is made to separate them, and I have in my report of last year ranged the equivalents of both groups under the single name of Fox Hills Group, and shall do so in this report. It is nevertheless true that a greater proportion of the species found in the lower part of the Fox Hills Group, as thus recognized in Colorado, are identical with those of the Fort Pierre Group than with those of the Fox Hills Group, as those two groups are recognized in the Upper Missouri River region. This fact is apparent in the strata exposed in Fossil Ridge, as is shown in the following list of fossils:

Not only this fact, but also the known dip to the eastward, which brings up lower and lower strata toward the foot-hills, indicates that those at Fossil Ridge belong to a lower horizon than those which I examined in the valley of the Cache à la Poudre.

LIST OF CRETACEOUS FOSSILS COLLECTED AT FOSSIL RIDGE, THREE MILES SOUTHEASTWARD FROM SPRING CAÑON, AND ABOUT SIX MILES SOUTH OF FORT COLLINS, COLORADO.

1. *Ostrea patina* Meek & Hayden ?
2. *Pinna lakesi* White.
3. *Pteria linguiformis* Evans & Shumard.

* Some remarkable Dinosaurian remains have been obtained from the upper strata of this group at the town of Morrison, on Bear Creek, Colorado. See address of Prof. O. C. Marsh, Proc. Am. Assoc. Adv. Sci. vol. xxvi, pp. 22 *et seq.* See also further remarks on a following page.

4. *Inoceramus oblongus* Meek.
5. *Inoceramus vanuxemi* Meek & Hayden.
6. *Cardium speciosum* Meek & Hayden.
7. *Callista deweyi* Meek & Hayden.
8. *Mactra (Cymbophora) warrenana* Meek & Hayden.
9. *Glycimeris berthoudi* White.
10. *Anchura haydeni* White.
11. *Baculites ovatus* Say.
12. *Scaphites nodosus* Owen.
13. *Placenticeras placenta* var. De Kay sp.

The different species composing this list will be discussed on following pages, in connection with those of other lists obtained from other localities in this district.

The junction between the Fox Hills strata at or in the vicinity of Fossil Ridge, and the Colorado Group beneath them, was found to be everywhere covered by the *débris* of the plains, but it is probably not more than one or two hundred feet beneath the lowest strata exposed at that locality, as all the strata begin almost immediately to rise rapidly to the foot-hills. I desired very much to know the aggregate thickness of the Fox Hills Group of this region from that junction to the highest strata of the series, at Marcks's farm, but on account of the obscuration of a large part of the series, and the varying dip, I found myself unable to estimate it with any good degree of satisfaction.

Proceeding southward from Fossil Creek to the valley of Thompson River, I examined its valley, without adding materially to the facts already enumerated. I then crossed southeastwardly to the Little Thompson Creek, in the south valley side of which I found some exposures of Cretaceous strata, the aggregate exposed thickness of which is apparently not above 40 or 50 feet. Here I made the collections of the following list, which, it will be seen, corresponds more nearly with those obtained in the valley of the Cache à la Poudre than with the Fossil Ridge collection, a list of which has just been given. It differs somewhat, however, from the collection obtained from the upper layers as they are found both at Marcks's farm, on the Cache à la Poudre, and at the mouth of the Saint Vrains, which latter locality will presently be noticed. I therefore regard these strata in the valley of Little Thompson Creek as holding a position intermediate between the strata of Fossil Ridge and those of the summit of the group as developed in this district.

LIST OF FOSSILS COLLECTED IN THE VALLEY OF LITTLE THOMPSON CREEK.

1. *Crenella elegantula* Meek & Hayden.
2. *Sphæriola? obliqua* Meek.
3. *Sphæriola? endotrachys* Meek.
4. *Veniella humilis* Meek & Hayden.
5. *Cardium speciosum* Meek & Hayden.
6. *Protocardia rara* Evans & Shumard sp.
7. *Protocardia subquadrata* Evans & Shumard sp.
8. *Callista deweyi* Meek & Hayden.
9. *Tellina scitula* Meek & Hayden.
10. *Thracia gracilis* Meek & Hayden.
11. *Teredo?* borings in fossil wood.
12. *Lunatia* ———?
13. *Anchura americana* Evans & Shumard sp.
14. *Pseudobuccinum nebrascense* Meek & Hayden.

15. *Placenticeras lenticulare* Owen sp.
16. Fish vertebræ.

From the valley of Little Thompson Creek I continued southeastwardly to the valley of the Saint Vrains, meeting with no other exposures of strata until I reached that valley. Proceeding down the valley upon its northern side I observed a few slight exposures of friable sandstones in the valley side, and although I obtained no fossils from them I regard them as belonging to the Fox Hills Group.

Reaching the confluence of the Saint Vrains with the South Platte River, I found considerable exposures of the uppermost strata of the Fox Hills Group. For the distance of a mile or more, these strata, having a visible thickness of about 60 feet, are exposed in the form of a more or less precipitous bluff with a talus of *débris* at its base. These strata are composed of soft, sandy, and partially argillaceous, bluish, and grayish material below, capped with sandstones above, the layers of which vary in condition from hard and somewhat massive to soft and laminated. The principal or only layer containing invertebrate fossils was found near the top of the section, and only two or three feet in thickness. Some eight or ten feet above this, in softer sandstone layers, that peculiar fucoid, *Halymenites*, was found in abundance. Above this is a few feet of still softer sandy material that merges above into the *débris* of the plains.

As will be seen by the following lists of fossils collected here, these strata are without doubt exactly equivalent with the uppermost layers found in the valley of the Cache à la Poudre, and are doubtless the highest Fox Hills strata that exist in this region; they are also without doubt the highest marine Cretaceous strata that are yet known in North America.* Between the top of the section at the mouth of the Saint Vrains and the higher adjacent land surface there is sufficient thickness of material to make it evident that the lower strata of the Laramie Group exist there, but they were not recognized with certainty. However, for reasons that I shall state farther on, I think it not improbable that the bed containing the *Halymenites* belongs to the Laramie Group. If so, there is no perceptible plane of demarkation between the Fox Hills and Laramie Groups, at least at this point.

LIST OF FOSSILS COLLECTED AT THE MOUTH OF THE SAINT VRAINS RIVER, COLORADO.

1. *Halymenites major* Lesquereux.
2. *Pteria Haydeni* Hall & Meek.
3. *Nucula planimarginata* Meek & Hayden.
4. *Tancredia americana* Meek & Hayden.
5. *Cardium speciosum* Meek & Hayden.
6. *Protocardia subquadrata* Meek & Hayden.
7. *Tellina scitula* Meek & Hayden.
8. *Tellina equilateralis* Meek & Hayden.
9. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.
10. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.
11. *Pholadomya?*
12. *Pachymya herseyi* White.
13. *Dentalium gracile* Hall & Meek.
14. *Cylichna scitula* Meek & Hayden.
15. *Actæon woosteri* White.

*Whether the Laramie Group is of Cretaceous age or not will be briefly discussed on following pages.

16. *Actæonina prosocheila* White.
17. *Lunatia* ——— ?
18. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden.
19. *Ammonites* ——— ?
20. *Placenticeras lenticulare* Owen sp.
21. *Lamna* ——— ?
22. *Bones and scales of teliost fishes.*

The district which I have thus traversed, and which is embraced between the South Platte River on the east and the base of the Rocky Mountains on the west, and the Cache à la Poudre on the north and the Saint Vrains on the south, probably presents the best exemplification of the Cretaceous groups, more especially of the Fox Hills Group and its fauna, that is to be found east of the Rocky Mountains in Colorado. The strata with which I am now more immediately concerned are those to which I have in my report for last year applied the single name of Fox Hills Group,* and which are here, without doubt, both the stratigraphical and paleontological equivalent of all those in the Upper Missouri River region, to which both the names Fort Pierre Group and Fox Hills Group, Upper and Lower, have been applied. Those northern divisions are no doubt sufficiently characteristic there, but their recognition as indicating seperate epochs of geological time is impracticable here. Therefore, in the following discussion of the species I shall consider as belonging to only one category all that have been separately enumerated as coming from the valley of the Cache à la Poudre, Fossil Ridge, the valley of Little Thompson Creek, and the mouth of the Saint Vrains River; but I shall discuss the subordinate horizons that are indicated by certain of the species, in connection with their separate consideration, in the following notes:

NOTES ON THE FOSSILS OF THE FOX HILLS GROUP AS DEVELOPED IN COLORADO, EAST OF THE ROCKY MOUNTAINS.†

1. *Halymenites major* Lesquereux.

The only localities east of the Rocky Mountains at which I obtained this fucoid is at the mouth of the Saint Vrains, and in the valley of Platte River some eighteen miles east of Greeley, but Dr. Hayden and others report it at several localities in that region, and as holding a similar stratigraphical position. Although I am much inclined to regard this as a Laramie fossil, I discuss it in connection with the Cretaceous fossils of this region as a matter of convenience. Its upward range west of the Rocky Mountains is to the very summit of the Laramie Group, where I have found it near Black Buttes Station, in the valley of Bitter Creek, Wyoming. Even here, however, it was in or beneath strata that contain brackish-water invertebrate fossils. So far as I am aware, it has never been found in stata containing only fresh-water mollusks, but it

*Mr. Clarence King, in his map of the Green River Basin, applied the name Colorado Group to the equivalents of not only the Fort Benton and Niobrara Groups, but he included with them the equivalent of the Fort Pierre Group also, leaving the Fox Hills Group to stand alone, as Hayden and Meek did originally. There are excellent paleontological objections to such a division between the equivalents of Fort Pierre and Fox Hills Groups, but not between those of the Fort Pierre and Niobrara Groups.

†All the invertebrate fossils of this list, unless otherwise stated, are figured in vol. ix of the United States Geological Survey of the Territories. This applies not only to the species originally described by Meek and Hayden, but to those of other authors also.

has been reported from the marine Cretaceous strata of the Fox Hills Group at several points west of the Rocky Mountains. Regarding it provisionally as a Laramie fossil of course implies the reference of the stratum containing it east of the mountains to the Laramie Group, which Dr. Hayden has usually regarded as the lower stratum of the Lignitic series; but as the sedimentation was evidently continuous from the lower to the upper of these groups, he is understood to have selected that stratum as approximately upon the plane of demarcation between them. This fucoid is quite abundant at the Saint Vrains locality.

2. *Fossil wood.*

Fragments of fossilized exogenous wood are somewhat commonly met with in these Cretaceous strata, both in the form of comminuted carbonized material, and that of pieces of wood which, although mineralized, still retain much of the original texture and aspect. In the latter condition it is not unfrequently found to have been bored by a species of *Teredo.*

3. *Ostrea patina* Meek & Hayden?

A few scattered shells of an *Ostrea* were found among the other fossils at Fossil Ridge, which probably belong to this species, which was originally described from the Fort Pierre Group of the Upper Missouri River region. The species of this genus are too variable, and the specimens in question too few to allow of positive specific identification, besides which *O. patina* is an unusually variable species.

4. *Pteria haydeni* Hall & Meek.

Dr. Hayden originally discovered this species in the vicinity of Fort Pierre, on the Upper Missouri River, near the base of the Fort Pierre Group, and with the present exception, so far as I am aware, it has not been found elsewhere. A single valve only was found at the mouth of the Saint Vrains, but it seems to be identical with the species here named. The original description and figure given by Hall and Meek are copied in vol. ix of the United States Geological Survey.

5. *Pteria linguiformis* Evans & Shumard.

This is nowhere a very abundant species, but it is one of the most widely distributed of those which characterize the Cretaceous strata of the West. It occurs on both sides of the Rocky Mountains, but I obtained it myself only at Fossil Ridge, in the district under discussion. It is also known to range through both the Fort Pierre and Fox Hills Groups of the Upper Missouri River region, where it was first discovered. This species is *very* like the *Avicula nitida* of Forbes, from the Cretaceous rocks of Southern India; but it is not my purpose in this connection to discuss questions of identity of these species, except so far as relates to the equivalency of the strata in which I found them with other Cretaceous strata of North America.

6. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard.

This is also a widely-distributed and often abundant species, being found in both the Fort Pierre and Fox Hills Groups of the Upper Missouri River region, and also having been discovered far up in British America. It was found abundantly, but not very well preserved, in a thin, soft, sandy, and clayey layer near Frank Marck's farm, five miles west of Greeley.

7. *Pinna lakesi* White.*

This species has been found only at Fossil Ridge, and being new, it has little value for comparison in this discussion.

8. *Inoceramus oblongus* Meek.

This is one of the largest and most robust species of the *Catillus* section of the genus *Inoceramus* that is yet known in American strata. Meek's original specimens were obtained from the vicinity of Fossil Ridge, and, so far as I am aware, it has not been certainly identified in any other district, except the vicinity of Morrison, Colo., where Mr. A. Lakes obtained some imperfect specimens apparently belonging to this species. It is very abundant and generally very large at Fossil Ridge, some of the shells being nearly a foot in length and fully four inches in transverse diameter. The shell substance is comparatively thin, although the shells are so large. Most of the specimens were found with both shells in juxtaposition, as were also those of most of the other associated bivalves, probably indicating that the waters in which they lived and died were comparatively still. It is probable, however, that these *Inocerami* died in the sand into which they had burrowed, and which now forms their stony sepulchre. The original description of this species is in the form of a brief foot-note to page 297 of the Annual Report of the United States Geological Survey of the Territories for 1870. It is also described and figured in another part of this report.

9. *Inoceramus vanuxemi* Meek & Hayden.

Dr. Hayden originally discovered this species at the Great Bend of the Upper Missouri River, and it seems not to be a common species. I found it only at Fossil Ridge, the specimens being apparently identical with authentic examples of the species from the Upper Missouri River region. This species is not improbably the same as *I. sagensis* Owen, but I defer the discussion of that question until a future occasion.

10. *Crenella elegantula* Meek & Hayden.

The original specimens of this species, also, were collected by Dr. Hayden. He obtained them from the valleys of both the North Platte and Yellowstone Rivers, and, so far as I am aware, the species has not been elsewhere found until I obtained it in the valley of Little Thompson Creek, where alone I have found it. Its position there is near the top of the Fox Hills Group as developed east of the Rocky Mountains in Colorado, but in the original localities it was found in both the Fort Pierre and Fox Hills Groups as they are recognized in the Upper Missouri River region.

11. *Nucula cancellata* Meek & Hayden.

This is a widely distributed species, having been collected at various localities in Dakota, Wyoming, Montana, and Idaho Territories. I found some imperfect examples of it in the valley of the Cache à la Poudre, and Capt. E. L. Berthoud has sent examples to the office of the Survey from near Golden City, Colo. At both the latter localities it was found in the upper strata of the Fox Hills Group, but Dr. Hayden found it in the valley of the Yellowstone to range as low as the upper part of the Fort Pierre Group.

* This species is named in honor of Mr. Arthur Lakes, of Golden, Colo., and has not hitherto been described. It is sometimes near a foot long, slender, sides not angular along the middle nor very convex; dorsal border longer than the base; posterior border convex, and sloping from about the middle far forward and meeting the base without an angle. Surface marked with slender, slightly-raised, radiating ribs, extending from front to rear and covering both valves above and in part below the median line. The ribs are nearly of uniform size throughout, except near the beak, but are wider apart behind than in front.

12. *Nucula planimarginata* Meek & Hayden.

The localities east of the Rocky Mountains in Colorado at which this species has been found are the valley of the Cache à la Poudre, the mouth of the Saint Vrains, and near Golden City, at all of which places it seems to hold a position near the top of the Fox Hills Group. I am not aware that it has anywhere been found at a lower horizon, it having been found only in the Fox Hills Group of the Upper Missouri River region.

13. *Sphæriola? obliqua* Meek.

The original description of this species is in the Bulletin of the United States Geological and Geographical Survey of the Territories, 2d series, No. 1, p. 46, but it has never yet been figured. I found it only in the valley of the Little Thompson. These and the type specimens are the only representatives of the species yet discovered. The latter were found some eighteen or twenty miles southwestward from the locality of the former.

14. *Sphæriola? endotrachys* Meek.

The type-specimens of this species were obtained from "ninety miles below Fort Benton on the Missouri, from Cretaceous beds holding a position in the very upper part of the Fox Hills Group." I found it in a similar position, associated with the foregoing species, in the valley of Little Thompson Creek. It has never been reported as occurring elsewhere. One of my examples especially shows a still greater degree of roughness of the inner surface than is represented by Meek's figures.

15. *Tancredia americana* Meek & Hayden.

The first known specimens of this species were obtained "from a Cretaceous bed holding a position in the very upper beds of the Fox Hills Group at the mouth of Judith River on the Upper Missouri." I obtained it in the valley of the Cache à la Poudre, and at the mouth of the Saint Vrains, where it holds a similar position. I am not aware that it has ever been found at a lower horizon, and it may therefore be regarded as one of the species which characterize the very highest strata of undisputed Cretaceous age in North America.

18. *Tancredia? cœlionotus* White.

One of the types of this species, which is described and figured in another part of this report, was recognized in a collection sent to the Survey by Mr. J. C. Hersey from "the Cache à la Poudre, ten miles west of Greeley, Colo." Only two examples of it have been discovered, the exact locality of the other not being accurately known.

17. *Veniella humilis* Meek & Hayden.

Dr. Hayden first discovered this species in the Fox Hills Group, on a branch of Cheyenne River, near the Black Hills. I obtained a goodly number of specimens of it, well preserved, in the valleys of the Cache à la Poudre and Little Thompson Creek. At both these localities it seems to hold a position above the middle of the Fox Hills Group, as it is developed east of the Rocky Mountains in Colorado. So far as I am aware, it has never been found west of the Rocky Mountains.

18. *Cardium speciosum* Meek & Hayden.

This seems to be a widely distributed species, and to characterize the uppermost layers of the undisputed Cretaceous rocks of the West, where alone it has been found in the Upper Missouri River region. The lowest horizon at which it is known to have been found is that of the strata at

Fossil Ridge, where I discovered it; which strata, although not separable from the Fox Hills Group in Colorado, are no doubt equivalent with those of the Fort Pierre Group in the Upper Missouri River region. I obtained it in considerable numbers from the higher strata of the Fox Hills Group at the mouth of the Saint Vrains and in the valleys of the Cache à la Poudre and Little Thompson Creek. Some well preserved pieces of the test of this species obtained at Fossil Ridge show that what appear to be nodes between the ribs in certain specimens are in the unchanged shell really holes through its substance. The pieces referred to were found to break along the line of these holes, just as postage-stamps separate along the lines of holes made for that purpose. In other examples from the valley of the Cache à la Poudre I found the appearance of nodes in the place of the holes, just as described by Mr. Meek; but careful examination showed that the supposed nodes consist of the stony filling of the holes in the test, which, being harder, had withstood subsequent weathering better than the test itself. It is possible, however, that the outer end of these holes was covered with a shelly layer; but it must have been only a film at most, for I could discover nothing of the kind in the narrow grooves between the ribs of the specimens referred to, which seemed to be perfectly preserved.

19. *Protocardia subquadrata* Evans & Shumard sp.

Dr. Evans first discovered this species in the Fox Hills Group of the Upper Missouri River region. I obtained it in the valley of the Little Thompson; and I have also recognized it in some collections made by Mr. W. H. Holmes at the mouth of the Saint Vrains. It seems never to have been discovered in the Fort Pierre Group of the Upper Missouri.

20. *Protocardia rara* Evans & Shumard.

Associated with the foregoing in the valley of the Little Thompson, I found some small shells that seem to belong to this species, but their identification was not quite satisfactory.

21. *Callista deweyi* Meek & Hayden.

A few imperfect examples, found both at Fossil Ridge and in the valley of Little Thompson Creek, evidently belong to the *Dosinopsis* section of this genus. They are too imperfect for certain specific determination, but the character of the internal cast and what remains of the shell indicates a proper reference to *C. deweyi*.

22. *Tellina scitula* Meek & Hayden.

This is a very common and widely distributed Cretaceous species, being found on both sides of the Rocky Mountains. It seems, however, to be confined everywhere to the strata of the Fox Hills Group. In this district I obtained it only from the upper strata of that group, and only at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre.

23. *Tellina equilateralis* Meek & Hayden.

A single valve of a species, apparently the *T. equilateralis* of Meek and Hayden, was found at the mouth of the Saint Vrains. The original examples were found in the uppermost of the Fox Hills layers at the mouth of Judith River on the Upper Missouri. Meek referred the species to *Tellina* from external characters only, and there are reasons for believing that it does not properly belong to that genus.

24. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.

This species was found in the upper strata of the Fox Hills Group, both at the mouth of the Saint Vrains and near Aaron Eaton's farm in the valley of the Cache à la Poudre; also, at Fossil Ridge, the strata of which are near the base of the group. The examples from both the latter and the first-named localities are referred to this species without hesitation, but those of the second-named locality appear to agree more nearly with the description of *M.* (*C.*) *formosa* Meek & Hayden. However, I regard the difference between these two forms as varietal only. The range of the species is through the whole of the Fox Hills Group as developed in Colorado east of the Rocky Mountains, but it seems never to have been found in the Fort Pierre division in the Upper Missouri River region.

25. *Pholadomya?*

A single fragment, evidently belonging to this genus, was found at the mouth of the Saint Vrains. It is plainly different from *P. subventricosa* Meek & Hayden, which has been found only in strata holding a similar stratigraphical position at the mouth of Judith River. It is probably new, but the specimen is too imperfect for characterization.

26. *Glycimeris berthoudi* White.

This fine species has been found only at Fossil Ridge, in strata near the base of the Fox Hills Group. It is figured and described in another part of this volume.

27. *Pachymya? herseyi* White.

This species is figured and described in another part of this volume. It was found by myself only in the upper part of the Fox Hills Group as developed in this district, and only at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre; but Mr. A. Lakes has obtained it from a similarly high horizon in the valley of Bear Creek, near Morrison, Colo. It is figured and described in another part of this volume.

28. *Teredo?*

In a fragment of fossil wood obtained among the other fossils at Little Thompson Creek I detected borings, evidently of *Teredo*, or an allied form, but they were too imperfect for specific determination.

29. *Dentalium gracile* Hall & Meek.

Our examples were found in considerable numbers in the uppermost strata of the Fox Hills Group at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre. They were found only in the form of casts, which, not showing the surface characters very clearly, leave a little doubt whether they may not really belong to another species, but they seem to be identical with *D. gracile*. The type specimens were obtained from the upper beds of the Fort Pierre Group in the Upper Missouri River region.

30. *Cylichna scitula* Meek & Hayden.

The type-specimens of this species were obtained from the Fox Hills Group on the Moreau River, a tributary of the Upper Missouri. It seems not to be a common species, as it has not been reported from any other locality until it was found in the district here discussed. I found it only in the uppermost strata of the Fox Hills Group, and only at the mouth of the Saint Vrains and in the valley of the Cache à la Poudre.

31. *Actæon woosteri* White.

In the district here discussed this species was found only at the mouth of the Saint Vrains. A couple of examples found by Mr. W. H. Holmes on the Rio San Juan, in Southern Colorado, seem to be specifically identical with the Saint Vrains specimens. It is figured and described in another part of this volume.

32. *Actæonina prosocheila* White.

This species has been recognized nowhere except at the mouth of the Saint Vrains, where the type specimens were discovered. It is figured and described in another part of this volume.

33. *Lunatia suberassa* Meek & Hayden.

In the uppermost strata of the Fox Hills Group, on the Cache à la Poudre, I found a number of specimens which evidently belonged to this species, the type specimens of which were obtained by Dr. Hayden from a similarly high position in the upper Fox Hills strata at the mouth of Judith River. Imperfect examples of a species of *Lunatia* were also found at the Little Thompson Creek and Saint Vrains localities, but they appear to belong to *L. concinna* Hall & Meek.

34. *Anchura haydeni* White.

This remarkably large and fine species has been found only at Fossil Ridge, and in strata that belong near the base of the Fox Hills Group, as it is developed and recognized east of the Rocky Mountains in Colorado. It is figured and described in another part of this volume. A calcareous substance was found almost entirely encrusting the spire of the typical example, which is apparently that of a *Nullipora*. At first I supposed it to be an encrusting callus formed by the mollusk itself, such as that of *Calyptraphorus* Conrad and *Lispodesthes* White; but careful examination shows it to be parasitic, or at least not connected with the shell.

35. *Anchura americana* Evans & Shumard.

The types of this species were obtained from beds in the Upper Missouri River region, in which were found a mixture of the characteristic fossils of the Fox Hills and Fort Pierre Groups respectively. In the region here discussed I found the species only at the Little Thompson Creek locality. Some fragments, apparently belonging to this species, were found in the valley of the Cache à la Poudre, but they were too imperfect for satisfactory determination.

36. *Pseudobuccinum nebrascense* Meek & Hayden.

This species, originally discovered in the strata of the Fox Hills Group of the Upper Missouri River region, was found holding a similar position in the valley of Little Thompson Creek. It seems to be a rare species.

37. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden.

Imperfect specimens of a species of this genus were found at the mouth of the Saint Vrains, and also in the valley of the Cache à la Poudre. I have referred them to *F.* (*P.*) *culbertsoni*, but their specific identification is not quite satisfactory, partly inconsequence of the imperfection of the specimens and partly owing to the difficulty I have encountered in recognizing, in the specimens I have examined, the specific differences relied upon by the authors quoted in separating their published species.

38. *Baculites ovatus* Say.

This widely distributed species was found at Fossil Ridge, but it has not been discovered in the upper strata of the Fox Hills Group in the

region under discussion, nor has it been found in the upper Fox Hills strata of the Upper Missouri River region. Its first appearance in the Cretaceous rocks of the West seems to be at the base of the Fort Pierre Group, in the last-named region, and it apparently became extinct there before the close of the Fox Hills period. In the uppermost strata of the Fox Hills Group of that region it seems to be replaced by *B. asper* Morton, or an allied species, but, as will be seen on a subsequent page, I found it associated with *Cardium speciosum* and *Mactra alta* in the upper strata of the Fox Hills Group in the valley of White River, west of the Rocky Mountains.

39. *Scaphites nodosus* Owen.

Some good examples of this species were obtained at Fossil Ridge, but it was found at no other locality in this district. In the Upper Missouri River region it seems to be confined to the Fort Pierre Group, and it also seems to hold a similarly low position here.

40. *Ammonites* ———.

A fragment of an *Ammonites* was found at the Little Thompson Creek locality, which appears to differ from any described species, but it is too imperfect to base a satisfactory description upon.

41. *Placenticeras lenticulare* Owen.

This species was found in at least a recognizable condition at Fossil Ridge, at the mouth of the Saint Vrains, and in the valleys of the Cache à la Poudre and Little Thompson Creek. It seems to range through the whole Fox Hills Group, including the Fort Pierre division.

42. *Fish remains.*

The only vertebrate remains discovered in the Cretaceous strata of this district were those of fishes, and which are very rare. At the mouth of the Saint Vrains I found a single imperfect tooth; and in the same strata a few vertebræ and fragments of other bone and a few scales of teliost fishes were discovered. Two or three similar vertebræ were also found in the valley of Little Thompson Creek.

The object of the foregoing lists of fossils and accompanying notes is the presentation of ready means for the comparison of the fauna of those Cretaceous strata of Eastern Colorado which I especially examined in the season of 1877, with that of the equivalent strata of the Upper Missouri River region, the grouping of which by Hayden and Meek has become typical in the paleontological history of the West. In the course of my field investigations east of the Rocky Mountains in Colorado I also examined the Cretaceous strata of the Colorado and Dakota Groups; but as I only obtained a few fossils from them, and these being all quite different from any of those of the Fox Hills Group already enumerated in the foregoing lists, I defer a consideration of them to a subsequent page. Besides those Fox Hills fossils already enumerated, I also obtained others from near the towns of Golden and Morrison, Colo., but as they present no additional facts of general application in the following discussion, I shall consider them separately on a subsequent page, in relation to other facts of important but more restricted application.

For the purpose of avoiding confusion in the minds of those who shall read this report, it may be well to repeat the statement already made in a foot-note, that the original grouping of the Cretaceous strata adopted by Hayden and Meek for the Upper Missouri River region, which is still regarded as entirely appropriate there, has been so modified for Colorado and the Territories adjacent as to include the equivalent strata of both

the Fort Benton Group (Cretaceous No. 2) and the Niobrara Group (Cretaceous No. 3) in a single group, under the name of Colorado Group. Also the consolidation of the Fort Pierre Group (Cretaceous No. 4) and the Fox Hills Group (Cretaceous No. 5) under the single name of Fox Hills Group. It is in this sense that the latter name will be used in all references to the Cretaceous strata of Colorado and adjacent Territories; but for the Upper Missouri River region it will continue to be used in the restricted sense applied to it by its authors. This consolidation will reduce the Cretaceous groups as recognized in Colorado and Territories adjacent to three, the names of which are, in the ascending order, Dakota, Colorado, and Fox Hills Groups.

The Dakota Group (Cretaceous No. 1) is so constant in its lithological and paleontological characteristics over the great Western region as to separate it distinctly from all the others. No species of any kind, so far as I am aware, has been found to pass up from it into the Fort Benton Group or equivalent strata. In Colorado and Territories adjacent, neither the lithological nor paleontological characteristics of the equivalents of the Fort Pierre and Fox Hills Groups, respectively, are such as to afford any satisfactory ground for a separation, such as has been made in the Upper Missouri River region; and even in that region a blending of the fossils of each has been frequently found. Precisely similar remarks may be made concerning the equivalents of the Niobrara and Fort Benton Groups. Between the equivalents of these two groups on the one hand and those of the Fort Pierre and Fox Hills Groups on the other there is, however, a well-marked paleontological difference; in some places with a corresponding lithological change, but in other places with no change of the latter character to separate the two consolidated groups. It is to this fact that are largely due the discrepancies between the surface limits assigned by different geologists to the Fox Hills and Colorado Groups respectively in Colorado and Territories adjacent, some of whom appear to have given little attention to the paleontological characteristics of the strata they examined or ignored their importance in the grouping of strata. With this statement and definition of terms, I return to the consideration of the fossils of the foregoing lists.

Of the forty-two species or entries embraced in the foregoing notes, fifteen are either at present unknown in Upper Missouri strata, or they are otherwise irrelevant in the comparison here proposed, between the fossils obtained from the consolidated Fox Hills Group east of the Rocky Mountains in Colorado, and those of the Fort Pierre and Fox Hills Groups together, of the Upper Missouri River region. Twenty-six species of that list were first described from either one or the other or both of those groups in that region. In that northern region eight of these species are common to both the Fox Hills and Fort Pierre Groups; five are confined, so far as known, to the Fort Pierre Group, eight to the Fox Hills Group, and five of them, not including any of the others, are there known only in the uppermost strata of the Fox Hills Group, a series which Mr. Meek was at one time disposed to separate as a subdivision of the Fox Hills Group proper, if not to make it a group coördinate with the others.

The strata of Fossil Ridge are among the lowest of the series in question that found in Colorado east of the mountains, and they are no doubt equivalent with the Fort Pierre Group of the Upper Missouri, and yet they are plainly not separable from the Fox Hills Group in Colorado. The following is a statement of the relations of its list of thirteen species of fossils, as given on a previous page, with those of the

Fox Hills and Fort Pierre Groups in the Upper Missouri River region. Four species are new and therefore irrelevant; five are common to both the Fort Pierre and Fox Hills Groups; one (*Cardium speciosum*) is known only in the uppermost strata of the Fox Hills Group in that region, and, so far as known, only three are there confined to the Fort Pierre Group alone.

Of those thirteen species found at Fossil Ridge, only four were discovered by myself in any of the higher Fox Hills strata of that district. This fact shows a very considerable difference between the fauna of the lower and that of the upper portions of the Fox Hills Group as it is developed in Eastern Colorado; but the other facts cited show that the difference is not sufficient to warrant its separation into two distinct groups, as has been done in the Upper Missouri River region. Furthermore, while certain species seem to be confined to the uppermost strata, both in Colorado and the Upper Missouri River region, these strata are so intimately connected with those beneath them, by other fossils, that range from one to the other, as to make any proper separation of them from the Fox Hills Group proper impracticable. In short while the limitation of the vertical range of certain species serves as an approximate indication of recognizable horizons within the vertical limits of the Fox Hills Group as developed in Eastern Colorado, the range of other species is such as to connect the whole together into one natural group only.

Leaving the district between the South Platte and the base of the Rocky Mountains, which I found occupied by the strata of the Fox Hills Group, I crossed that river at Evans and passed down the south side of its valley to the mouth of Bijou Creek, one of its tributaries from the southward. At a point about eighteen miles east of Greeley I found the uppermost strata of the Fox Hills Group in the south valley side of South Platte River, and from that point to about six miles farther eastward I continued to see small exposures of the same, most of which were obscure. I however recognized about 20 feet in thickness of strata, and the fossils, which were few and imperfect, were quite sufficient to indicate an exact equivalency of the strata containing them with those of the upper part of the section at the mouth of the Saint Vrains. Besides these few characteristic invertebrate fossils, I also found fragments of the fucoid *Halymenites major* in one of the upper layers. The known general dip of the strata of all that region makes it practically certain that the Cretaceous strata pass beneath the level of the streams along a northward and southward line, which may be drawn a couple of miles west of Greeley; that they receive a greater or less thickness of Laramie strata upon them beneath the *débris* of the plains. Then a gentle rise brings them up again to view in the valley of South Platte River, from eighteen to twenty-five miles east of Greeley, as already mentioned. They seem then to pass again by a gentle easterly dip beneath the surface of the river, but I did not trace them farther, as my journey led up the valley of Bijou Creek. It is probable, however, that the exposures of these uppermost of the Fox Hills strata continue at the surface farther down the South Platte, in its immediate valley. Between Greeley and the point where these Cretaceous strata are exposed, the space is no doubt occupied by at least a small portion of the strata of the Laramie Group, which are covered with the *débris* of the plains, but I found no exposures of Laramie strata until I reached the valley of Bijou Creek, about twelve miles above its mouth. In the higher portions of the valley side of South Platte River, where I hoped in passing to have discovered exposures of Laramie strata, I found many sand dunes or accumulations of apparently wind-drifted sand, such as those that have been already mentioned as

existing upon the east valley side of Crow Creek, four or five miles above its mouth. I discovered similar dunes only in the neighborhood of South Platte River.

The valley of Bijou Creek is merely a broad, shallow depression in the surface of the plains, bordered by ill-defined valley sides from two to five miles apart, the elevation of which is, perhaps, 50 feet above the level of the creek. The lower ten or twelve miles of the valley is apparently without any exposures of strata, but the district which it traverses is, doubtless, underlaid by a greater or less thickness of the Laramie Group, beneath the abundant *débris* of the plains. This opinion is based upon the known easterly general dip of all the strata of the region, the known existence of the uppermost layers of the Fox Hills Group in the valley of the South Platte, ten or twelve miles west of the mouth of the creek, and the existence of Laramie strata, presently to be described, in the west valley-side of the creek. These exposures of Laramie strata first appear opposite, and about four miles west of, the junction of Muddy Creek with the Bijou, and continue southward, at intervals, some three or four miles up the creek. The exposures are small and inconspicuous, but I made out satisfactorily the following section in the slope of the low hill or valley-side:

Bijou Creek section.

	Feet.
1. Sandy soil and *débris* of the plains	20
2. Ordinary light-brown sandstone	5
3. Sandy shales	5
4. Shale, sandy and argillaceous, containing *Corbicula*, &c	4
5. Similar to No. 4, containing *Ostrea* and *Anomia*	3
6. Unexposed to the general low surface of the valley, about	15

Although in full detail the recognized members of this section differ, as we should expect them to do, from those of the Crow Creek section, some 35 miles distant, yet no hesitation is felt in recognizing the precise general equivalency of the two sections. This recognition is all the more satisfactory because two or three of the members of each section, respectively, are unmistakably identical, as will be seen from the following comparison:

No. 1 of the Bijou Creek section doubtless corresponds with Nos. 1 and 2 of the Crow Creek section; No. 4 of the former with No. 3 of the latter; and No. 5 of the former with No. 4 of the latter. Nos. 2 and 3 of the Bijou Creek section are not definitely recognized in that of Crow Creek, but this is of no consequence in view of the precise agreement of the fossiliferous members of the section, which are of far more importance than the others. The material composing No. 1 of the Bijou Creek section is too uniform in all this region to need comparison or special description. The sandstone of No. 2 differs in no respect from the ordinary sandstones of the Laramie Group that are found elsewhere. No fossils were found in it. No. 3 is not separable lithologically from No. 4, beneath it, and they are treated as separate members only because I found no fossils in No. 3, while No. 4 is quite fossiliferous, containing at least six species that are identical with those of No. 3 of the Crow Creek section. No. 5 contains *Ostrea glabra* Meek & Hayden and *Anomia micronema* Meek in abundance, and in all respects like those of the Crow Creek section; and, so far as I could discover, no other species were associated with them. No trace of an equivalent of No. 5 of the Crow Creek section, was found at the Bijou Creek locality. It is a fresh-water deposit, and its local character in the valley of Crow Creek has already been remarked upon.

No strata were seen *in situ* in No. 6 of the Bijou Creek section, but at

numerous points on the slope of the valley-side, and not more than four or five feet beneath the base of No. 5, the prairie dogs had, in their burrowing, brought to the surface fragments of coal and carbonaceous shale. This indicates the existence of a bed of coal there, which, if identical with that of the Crow Creek locality, implies an absence in the valley of Bijou Creek of an equivalent of a considerable part of the Crow Creek section beneath its No. 5. But it is more probable that the coal of Bijou Creek is a local development of another bed, which is not represented in Crow Creek Valley where the section was measured, and also that the upper and more fossiliferous part only of the Crow Creek section is represented in that of Bijou Creek.

LIST OF FOSSILS FROM THE VALLEY OF BIJOU CREEK, COLORADO.

1. *Anomia micronema* Meek.
2. *Ostrea glabra* Meek & Hayden.
3. *Corbicula obesa* White.
4. *Corbicula* (*Leptesthes*) *subelliptica* Meek & Hayden.
5. *Corbicula* (*Leptesthes*) *macropistha* White.
6. *Corbicula* (*Leptesthes*) *planumbona* Meek.
7. *Corbula subtrigonalis* Meek & Hayden.
8. *Melania wyomingensis* Meek.

NOTES ON THE LARAMIE FOSSILS COLLECTED IN THE VALLEY OF BIJOU CREEK, COLORADO.

All the species of this list were also found in Crow Creek Valley, and they are separately discussed in notes on the fossils of that locality, on preceding pages. Therefore the notes on this list of fossils will be very brief, and the reader is referred to the notes on the same species of the Crow Creek list.

The examples of *Anomia micronema* and *Ostrea glabra* were found quite abundantly at the Bijou Creek locality, but only in bed No. 5; and no other species were found immediately associated with them. This association of the two species and exclusion of others, in a single stratum, has also been recognized at other localities east of the mountains.

The four species of *Corbicula* named in the list were found associated in bed No. 4 of the Bijou Creek section and in none of the others. Fragments of *Corbula subtrigonalis* and *Melania wyomingensis* were also found associated with them, and all six of these species were found similarly associated in bed No. 3 of the Crow Creek section. The condition of the fossils at the two localities respectively is practically the same, but I observed that the beaks and umbonal portions of some of the specimens of *Corbicula obesa* were eroded, having apparently been done during the life of the mollusk, as the material of the imbedding matrix filled the eroded cavities. This condition was observed in the case of no other species, nor was it observed upon the same species at the Crow Creek locality, the only other place at which the species is known to occur.

The whole valley of Bijou Creek, from its mouth to the crossing of the Kansas Pacific Railroad, was searched for other exposures, but no others were discovered except a few at and in the neighborhood of Bijou Station, where that railroad crosses the creek. These consisted of soft ferruginous sandstone with bluish and variegated shaly and clayey alternating layers. They appear to belong in the series just above the section further down the creek that has already been recorded, or they are perhaps in part identical with No. 2 of that section.

From the valley of Bijou Creek my investigation led me southwestward to Cherry Creek Plateau, during which I passed over the higher strata of the Laramie Group, which come in the series between those that I found exposed near Bijou Station and the sandstones of the Monument Creek Group, that constitute the plateau. I found no fossils of any kind in these higher Laramie strata except silicified wood, which in some places was quite plentiful. It is possible that certain layers in this portion of the Laramie Group contain invertebrate fossils, but the whole series in this region above the horizon of the fossiliferous layers of the Crow Creek and Bijou Creek sections is apparently destitute of invertebrate remains.

The whole thickness of Laramie strata which I thus passed over, from the uppermost layers of the Fox Hills Group in the valley of South Platte River to the base of the Monument Creek Group on Cherry Creek Plateau, is estimated at about 1,800 feet. So far as I could discover, only about the lower 200 or 250 feet of this series is known to contain invertebrate fossils; and the lower 700 or 800 feet appears also to contain all the coal of the Laramie Group in this region.

Exhibiting to some ranchmen whom I met in the valley of Bijou Creek the fossils I had collected there, they informed me that they had found similar ones some twenty-five or thirty miles directly to the eastward; and, as already stated, *Melania wyomingensis* is similarly reported to occur on Horse Tail Creek, upon the south side of the South Platte, and about seventy-five miles eastward from Greeley. These reports are not offered as conclusive evidence of the existence of Laramie strata at those two localities, but taken in connection with other known facts, we are at least warranted in accepting them as provisional evidence. The other facts referred to are the known easterly dip of all the strata near the mountains and their almost level extension out upon the plains; and the known presence of characteristic Laramie strata on the line of the Kansas Pacific Railroad, two hundred miles east of Denver, as already recorded on previous pages. In short there seems to be no reason to doubt that immediately beneath the *debris* of the plains, the strata of the Laramie Group occupy, besides other considerable areas to the northward and southward, the whole broad space between the South Platte and Arkansas Rivers (except narrow spaces immediately adjacent to the two rivers respectively, where the strata of the Fox Hills Group appear to come up to the surface), extending eastward from the base of the Rocky Mountains quite within the limits of Western Kansas.

Sedimentation seems where I crossed the place of division to have been continued without interruption from the Laramie Group, which is mainly a brackish-water, but in part a fresh-water deposit, to the Monument Creek Group, which is probably a purely fresh-water deposit, although no invertebrate fossils have been found in it. This last-named deposit is probably equivalent with the White River Tertiary, a formation that has already been mentioned as occupying a large area of the plains north of the South Platte, but from my present limited personal knowledge I regard it as possibly equivalent with either the Wasatch, Green River, or Bridger Group, which have their full development west of the mountains. It is possible that the upper 800 feet of what I have referred to the Laramie Group ought also to be included with the Monument Creek sandstones, but as I discovered no plane of demarkation between the groups where I examined them I prefer to leave it with the Laramie Group.

Following these statements it is proper that I should make some reference to the reported discovery of marine Tertiary fossils by Professor Powell in the valley of Bijou Creek, as reported upon by myself in

his Report on the Geology of the Uinta Mountains, and also noticed in the American Journal of Science, vol. xi, 3d series, p. 161.

The Bijou Creek locality, the strata and fossils of which have been described on previous pages, is the same one at which the marine fossils just referred to were reported to have been obtained by Professor Powell, and I visited it with specific information furnished by him.* That collection of Professor Powell's was composed entirely of marine species, among which was a coral, and they were referred by me to the age of the Eocene Tertiary strata at Vicksburg, Miss. The fossils which I found at the Bijou Creek locality were not only all of different species, but they were all of either brackish- or fresh-water origin, and identical with species especially characteristic of the Laramie Group. The serial continuity of the strata seems so perfect, from the uppermost strata of the Fox Hills Group as seen in the valley of the South Platte and its branches, to those of the Monument Creek Group upon Cherry Creek Plateau, that it is in the highest degree improbable that a marine deposit could have been made in this region between the close of the Fox Hills epoch and the beginning or even the close of the Monument Creek epoch. If such a deposit were made there at the close of the latter epoch we ought to find it, if found at all, resting on the uppermost strata of the last-named epoch, but none has been reported to exist there. If made at the beginning of the Monument Creek epoch the conformity of its strata upon those of the Laramie Group could not be either real or apparent as it is now. From the explanation that has already been given of the character and condition of the strata between the South Platte and Arkansas Rivers it is evident that if a marine deposit later than the Cretaceous really exists there it must rest unconformably upon the eroded surface of Laramie strata. The great erosion that has left the strata of that region in their present condition took place after the close of the Monument Creek epoch, and that would bring the date of such an assumed marine deposit later than that which is indicated by the character of the fossils of Professor Powell's collection. From these facts and considerations I am forced to the conclusion that the marine Tertiary fossils referred to were collected in some more eastern region and that they were inadvertently substituted in the collections furnished me by Professor Powell for investigation for fossils that he did collect in the valley of Bijou Creek.

Scarcely any subject connected with the geological history of North America could be of more absorbing interest than that of the exact chronological relation of the marine Tertiary deposits of the sea-border regions with the fresh- and brackish-water deposits of the western interior of the continent. It is to be hoped that this subject may yet receive elucidation from discoveries similar to that which was supposed to have been made in the valley of Bijou Creek; but it now seems evident that we need not look for them east of the Rocky Mountains in any district west of Western Kansas. This subject is further referred to in discussions upon later pages of this report.

From the Cherry Creek Plateau I went to the neighborhood of Golden City by way of Denver without adding any material geological or paleontological facts to those already recorded. In my investigation of this district I was accompanied by Mr. Arthur Lakes, of Golden City, and our first examinations were made at the village of Morrison, seven miles to the south of Golden. The strata here are exposed on a grand scale,

*In Professor Powell's report on the geology of the Uinta Mountains the name of the locality is given as "Bijou Basin," which was intended to mean the valley of the Bijou Creek, and not a locality near the head of the creek to which that name is given on some maps.

both in the form of the hogbacks that skirt the base of the Rocky Mountains and form its foot-hills, and as natural sections in the valley sides of Bear Creek which cuts transversely through them on its way from the mountains to the plains. These rocks are very clearly illustrated in a section facing page 32 of Dr. Hayden's Annual Report for 1874.

At the time of my visit, Mr. Lakes and Professor Mudge were engaged in exhuming some enormous Dinosaurian remains from the western or escarpment face of the principal hogback, a couple of miles north of Morrison. These strata form the member of the section referred to, which is there designated as "variegated shales," and which immediately underlies the layers of massive sandstone that form the crest of the principal hogback. These sandstone layers are referred without hesitation to the Dakota Group or Cretaceous No. 1, in which reference all other geologists who have mentioned them are understood to agree.

Upon the discovery of the Dinosaurian remains above referred to, Professor Marsh referred the strata containing them to the age of the Wealden of Europe;* but in the final publication of his address before the Am. Asso. Adv. Sci. for 1877, he referred them to the Jurassic. In his later conclusion I am much inclined to agree, not that invertebrate paleontology furnishes any direct evidence, but because of the evidence that exists of unbroken continuity of deposition from those strata that are regarded as certainly of Jurassic age with those containing the Dinosaurian remains, called "Atlantosaurian beds," by Professor Marsh.†

Only a few fossils were collected in this vicinity at the time of my visit; but Mr. Lakes subsequently sent to the office of the Survey a box of fossils which he collected here, containing many species, a list of which is given in an appendix to this report, and they are also included in a list of the fossils of this district, presently to be given, together with notes upon them.

The fossils of this locality were collected mostly from the strata of the Fox Hills Group; but three species, namely, *Inoceramus deformis*, *I. problematicus*, and *Ostrea congesta*, are from those of the Colorado Group. These three species were in fact found in some layers of limestone or calcareous rock at the upper part of the Colorado Group, which no doubt in part represent the Niobrara division of the Cretaceous section of the Upper Missouri River region.

Search for fossils was prosecuted in the strata of the Table Mountains of this district, which are mainly composed of strata of the Laramie Group, and are capped by a trap outflow. In this search I was not successful, although the strata are no doubt equivalent with those that were found so fossiliferous in the valleys of Crow and Bijou Creeks. Continuing my examination of the Cretaceous strata northward, I visited the valley of Ralston‡ Creek, about four miles northward from Golden City. At a locality in the valley of this creek, near the foot-hills and about four miles northward from Golden City, a shaft was sunk several years ago in a search for coal. A bed of lignite was found there which, although not proving profitable for working, is reported to possess about

* See Introduction and Succession of Vertebrate Life in America, page 17; advance copy of Professor Marsh's Address before Am. Assoc. Adv. Sci. 1877.

† Dr. Hayden referred the exact equivalent of these beds on the Saint Vrains and Big Thompson Creeks to the Jurassic in his annual report for 1873. (See sections facing page 20 of this report.)

‡ There seems to be some confusion as to the name of this creek. In the various reports referring to fossils there it is called "Ralston Creek;" but on the maps of the atlas of Colorado it is called "Van Bibber Creek." It is the first creek north of the North Table Mountain, while on the map the name Ralston Creek is applied to the second one north of that mountain.

the same general characteristics as that which is mined in the face of Table Mountain, near Golden City, three or four miles away.

Mr. W. H. Holmes, artist and geologist of the Survey, visited the place about that time and collected a few specimens of a shell that Mr. Meek afterward described as *Cyrena? holmesi* in the Bull. U. S. Geol. Surv. Terr. 2d ser. No. 1, p. 45.

The shells were found in the uppermost of the layers that were dug through in sinking the shaft, and, so far as I can learn, no other fossils were found in any of the other layers. I was not able to learn at what depth the coal was found beneath these fossiliferous layers, but it was probably not more than fifty feet. The strata, as I saw them by looking down the shaft, were alternating layers of soft and harder sandstone with sandy shales, and the series of layers appeared, and are reported to have been found without any material change from top to the coal below. The *débris* and soil so completely cover the valley sides and its neighborhood as to obscure all strata adjacent to those that were seen in the shaft, and the surface presents no direct indication that the strata beneath have ever been violently disturbed. Mr. Holmes, therefore, not being in possession of the paleontological facts which I have since ascertained, supposed the natural position of the fossils referred to, to be above the bed of coal which is mined in Table Mountain, near Golden City, as it was found now to be above the coal in the shaft.*

A year or two after Mr. Holmes's examination of this district Mr. Arthur Lakes also examined the strata of the then abandoned shaft, and besides specimens of *Cyrena? holmesi* he found associated in the same layer an unmistakable fragment of a *Scaphites*. According to our present knowledge of the geological range of this genus, this discovery is assumed to show conclusively the Cretaceous age of the strata in question. This specimen is too imperfect for full specific identification, but it seems to belong to *S. mandanensis* Morton, which indicates the epoch of the Fox Hills Group. As there seemed to be no stratigraphical break between the layers containing the fossils and those in contact with the coal, the latter has been inferred to be of Cretaceous age also; but the following difficulties are in the way of such a conclusion:

Nothwithstanding the fact that west of the Rocky Mountains coal has been found in both the Fox Hills and Colorado groups, so far as I am aware no indication whatever of coal has yet been found in the strata of either of those groups, nor in any strata older than those of the Laramie Group, east of the Rocky Mountains in Colorado. All the Mesozoic strata known in this region are well exposed in this immediate neighborhood, and they have been carefully explored for coal without success. Again, some small masses of compact calcareous rock were obtained from Mr. Geo. L. Taylor of Denver, Colo., labeled, "From near Colorado Springs, Col." These were filled with shells almost certainly identical with the *Cyrena? holmesi* of Meek, and imbedded among them I found a fragment of a gasteropod having the characteristics of *Lunatia* so far as they could be ascertained. This is the history of the perplexing discovery at Ralston Creek at the time of my visit there in 1877.

Being in possession of the foregoing paleontological facts I could not accept the reference to Laramie or later age of the strata containing *Cyrena? holmesi*, and I made as careful an examination as possible of that neighborhood with a view to a proper understanding of the true condition of the strata there, and with the following result:

* So far as I am aware, Mr. Holmes never published his observations in this district, and the view he then held is inferred from the statement made by Mr. Meek in connection with his description of *Cyrena? holmesi* (*loc. cit.*).

As is shown in the numerous sections which accompany Dr. Hayden's reports upon this region, all the Mesozoic strata are upturned against the flanks of the Rocky Mountains; the whole series, including the Laramie Group, thence extending out almost horizontally upon the plains.

The Laramie strata were originally flexed with the others, but being softer they have mostly, but not in all cases, been removed by denudation from the immediate line of flexure, so that we oftener than otherwise see these strata in a nearly level position, while the others close by are flexed. But they are plainly seen to rest upon the strata of the Fox Hills Group, and no distinct stratigraphical plane of demarkation has yet been detected between them.

The outflow of the trap which now caps the two Table Mountains in the immediate vicinity of Golden City, the northern side of the northern one of which is near to the locality under discussion, took place at a comparatively late date, and its outburst must have necessarily ruptured and, at least locally, disturbed the strata at and around the place of exit. The little group of hills immediately upon the north side of Ralston Creek, and at the southern base of one of which is the coal-shaft with its fossiliferous layer of sandy shale, here considered, are composed entirely of trap similar to that which caps the adjacent Table Mountain.

A careful examination of these hills convinces me that they occupy the site of the rent through which a large part if not all the melted trap came, which doubtless once covered a large portion of this district adjacent to the foot-hills, but of which only comparatively small portions have escaped destructive erosion. These small portions now cap the two Table Mountains and form the small group of hills here referred to. This outburst took place directly in line of the upturned edges of the Cretaceous strata against the flanks of the Rocky Mountains, the position and extent of which have already been explained. This dynamic movement, however, did not materially affect the strata of either the Red Beds or the Dakota Group, as is shown by the present direct continuity of the crests of their hogbacks. The strata of the Colorado Group are too soft to produce a hogback, and they are so covered by *débris* that we cannot know to what extent they may have been disturbed by the outburst. The hogback of the Fox Hills Group has been disturbed and interrupted. A portion of it standing conspicuously in the valley at a point not far to the southwestward from the coal-shaft in question has its strata nearly vertical, instead of standing at the much less angle of elevation shown by the other hogbacks, when, if undisturbed, since the mountain uplift they should be the steeper, because they are nearer to the foot-hills. The trend of this short hogback of Fox Hills strata is also so deflected that if a line representing its axis were continued in the curve it indicates in a northward and northeastward direction it would lie approximately tangent to the southeastern base of the group of trap hills here referred to, near the point where the coal-shaft has been sunk.

I offer the following explanation of these phenomena: The trap rent was a very large one, not in the form of a dike, but circumscribed, irregular, and several hundred yards across. It came in the line of flexure of the Cretaceous strata where they are upturned against the flank of the mountains, probably breaking through those of the Colorado Group, but evidently lifting, displacing, and *overturning* at least a portion of the Fox Hills strata, together with a portion of the then and there superimposed Laramie strata. This is believed to be the exact condition of those adjacent to the trap hills, through which the coal-shaft has been

sunk. That is, the strata at that particular point have been entirely reversed by the uplifting force of the outflowing trap; so that the shaft was begun in strata of the Fox Hills Group and continued downward until those of the Laramie, including the coal, were reached in reversed order.

This bed of coal is believed to be the same that is now worked in the Laramie strata of Table Mountain near Golden City, its change of thickness and quality within that distance not being unusual with the coal-beds of the Laramie Group.

This explanation makes it evident that *Cyrena? holmesi* Meek is a Cretaceous instead of, as Meek supposed, a Tertiary fossil, even without the conclusive testimony of the associated *Scaphite*.

Besides this, by carefully cutting away the embedding shale from an authentic specimen of that species, which I obtained from the same layer that furnished the type specimens, I discovered that it has not the hinge characteristics of *Cyrena*, but has those of *Mactra*, or at least of a section of that genus; thus confirming the marine character of the stratum containing it, which was indicated by the associated *Scaphite*. These facts alone would seem to be sufficiently conclusive, but within the last few months Mr. Lakes has sent to the office of the Survey some specimens of the *Cyrena? holmesi* of Meek, collected by him from the Fox Hills strata on Bear Creek, near Morrison, about twelve miles southward from the place where that species was originally discovered. The shells sent by Mr. Lakes were imbedded in a small mass of stone, and imbedded in the same mass I also found a fragment of a *Scaphite*, evidently of the same species as that which was found in the layer that furnished the type specimens of *Cyrena? holmesi*, on Ralston Creek. It also contained a fragment of a *Baculite*. These facts are conclusive as to the Cretaceous age of Mr. Lakes's fossils, even without the field-label, which was "Bear Creek, 750 feet below the coal-bed." The coal-bed referred to is that of the Laramie Group and which is not far from its base.

The questions of interest involved in the discussion of the phenomena observed in connection with the fossils of the coal-shaft on Ralston Creek are in part purely geological and in part paleontological, and some of them are so important that the subject has here received more attention than would otherwise have been given to it.

The location of the great trap vent upon the line of flexure of the strata, which are upturned against the flank of the Rocky Mountains, would seem to indicate that the outburst came there because of the weakening of the strata by having been flexed, thus lessening the resistance to upward pressure. But while the strata are continuously flexed along the base of the mountains, the vent is circumscribed, and is not in the form of a dike, nor a lengthened sheet along the line of flexure. Besides this, the dike at Valmont, fifteen miles to the northward, is not upon, but several miles eastward of, the line of flexure, and at right angles to it. It is doubtless true that the inclined posture of the strata, when the trap burst through, facilitated the overturning of those that were upon the outer side of the vent; those between the vent and the granite mass of the mountains offering greater resistance to the pressure were comparatively undisturbed.

It is also desirable to elucidate every question which bears upon the order of succession of the brackish- and fresh-water deposits upon those of marine origin, and the consequent order of succession of invertebrate types. Coal-making conditions are known to have existed at times in both the Colorado and Fox Hills Cretaceous epochs, in what are now the regions west of the Rocky Mountains, but they are believed not to

have existed during either of those epochs within what are now the limits of Colorado, east of those mountains. The foregoing explanation of the phenomena observed on Ralston Creek removes the doubt upon this point that was at one time felt in consequence of finding Cretaceous fossils above a bed of coal there. At all the localities which I have visited in Eastern Colorado the strata of the Colorado, Fox Hills, and Laramie Groups all indicate great uniformity of condition of deposition throughout each epoch respectively, to which rule the formerly-supposed presence of a bed of coal in the Fox Hills strata at Ralston Creek would, if true, have been an exception. A comparison of these indications of former physical conditions in regions that are now respectively east and west of the Rocky Mountains, will be made on subsequent pages, but it should be always borne in mind that this great physical continental feature did not then exist.

The following list of fossils obtained from Cretaceous strata near the base of the Rocky Mountains, between Bear and Ralston Creeks, a distance of about twelve miles and including the vicinity of Golden City, has been collected in part by Mr. A. Lakes and Capt. E. L. Berthoud, but I also visited all the localities in person. The strata of the Red Beds, the Jurassic and Dakota Groups of this district have been long and carefully searched for invertebrate fossils by both these gentlemen, but without success, except the discovery of a single shell which is reported by Mr. Lakes, presently to be mentioned.

LIST OF CRETACEOUS FOSSILS FROM THE VICINITY OF GOLDEN CITY AND MORRISON, COLO.

Fox Hills Group.

1. *Pteria linguiformis* Evans & Shumard. Bear Creek, near Morrison.
2. *Pteria* (*Pseudoptera*) *fibrosa* Meek & Hayden. Bear Creek, near Morrison.
3. *Inoceramus oblongus* Meek. Bear Creek, near Morrison.
4. *Nucula planimarginata* Meek & Hayden. Near Golden City.
5. *Nucula cancellata* Meek & Hayden. Near Golden City.
6. *Cardium speciosum* Meek & Hayden. Bear Creek, near Morrison.
7. *Tellina scitula* Meek & Hayden. Bear Creek, near Morrison.
8. *Mactra holmesi* Meek sp. Bear and Ralston Creeks.
9. *Pachymya? herseyi* White. Bear Creek, near Morrison.
10. *Dentalium gracile* Hall & Meek. Bear Creek, near Morrison.
11. *Lunatia suberassa* Meek & Hayden. Bear Creek, near Morrison.
12. *Baculites ovatus* Say. Bear Creek, near Morrison.
13. *Scaphites nodosus* Owen. Bear Creek, near Morrison.
14. *Scaphites mandanensis* Morton sp.? Bear and Ralston Creeks.
15. *Placenticeras placenta* var. Bear Creek, near Morrison.

Colorado Group.

16. *Ostrea congesta* Conrad. Bear Creek, near Morrison.
17. *Inoceramus deformis* Meek. Bear Creek, near Morrison.
18. *Inoceramus problematicus* Schlotheim. Bear Creek, near Morrison.

NOTES ON THE FOSSILS FROM THE VICINITY OF GOLDEN CITY AND MORRISON.

The fossils obtained from the strata of the Fox Hills Group at Bear Creek were found at two horizons or in two layers; one about two hun-

dred feet below the bed of coal there, and the other about seven hundred and fifty feet below it. The coal is embraced within the strata of the Laramie Group, and is apparently not much more than one hundred feet above its base, but no plane of demarkation between the two groups has yet been satisfactorily recognized. Nos. 6, 7, 9, and 10 of the foregoing list were obtained from the upper fossiliferous horizon on Bear Creek, and they are also all characteristic of the uppermost strata of the Fox Hills Group as seen in the valley of the Cache à la Poudre and at the mouth of the Saint Vrains, and the upper Bear Creek horizon is therefore no doubt equivalent with those strata. The species represented by the four foregoing numbers are discussed in the notes following the lists of fossils collected in the district of the Cache à la Poudre and Saint Vrains. The two species of *Nucula* represented by Nos. 4 and 5 of the list were obtained from near Golden City by Captain Berthoud. They also exist in the uppermost fossiliferous strata of the Fox Hills Group in the valley of the Cache à la Poudre, but in the Upper Missouri River region No. 5 at least ranges as low as the upper part of the Fort Pierre Group. All the remaining species of the list that were found in the Fox Hills strata of Bear Creek are from 750 feet below the coal. The existence and association of the *Cyrena? holmesi* of Meek (=*Mactra holmesi* White) and *Scaphites mandanensis?* at both the Ralston Creek and Bear Creek localities has already been stated and commented on.

The three species obtained from the Colorado Group at Bear Creek are from the upper portion, doubtless representing in part the Niobrara Group or Cretaceous No. 3 of the Upper Missouri section. The specimens of *Ostrea congesta* were found adhering to the shells of *Inoceramus deformis*. The former is an abundant and widely-distributed species, but the latter has never, to my knowledge, been found in the Upper Missouri River region, although it is common in the latitude of Colorado and southward. *Inoceramus problematicus*, No. 18 of the list, does not appear to range above the horizon at which it is found in the valley of Bear Creek, east of the Rocky Mountains in Colorado, but in Southwestern Wyoming forms that are undistinguishable from this species are found in strata of the Fox Hills Group.

The discovery by Mr. Lakes of a fossil shell in the strata of the Dakota Group has been already referred to. The following is his account of it in a personal letter to me under date of June 21, 1878: "To-day in exploring some rocks of the Dakota Group, I found in some finely laminated drab shales about 100 feet below the usual ridge of sandstone which so characteristically caps the Dakota hogback, the shell which I forward to you by to-day's mail. The shell was found in undoubted Dakota rocks, a little north of the river Saint Vrains." This is quite an unexpected discovery, and the specimen is the first *Inoceramus* that has, so far as I am aware, been found in strata of the Dakota Group. From the above remarks of Mr. Lakes, and a pencil-sketch which accompanied them, it seems probable that the shell in question really came from the upper layers of the Atlantosaurian beds of Professor Marsh. It has been much compressed, and is too imperfect for specific identification, and is perhaps identical with *I. umbonatus* Meek & Hayden, a Fort Benton Group species, but it has in its compressed condition much the aspect of *I. vanuxemi* Meek & Hayden, from the Fort Pierre Group. It is of a decidedly Cretaceous, and not Jurassic type, which fact has an interesting relation to the age of the Atlantosaurian beds of Professor Marsh, if the specimen really came from them.

The deposition of sediment which formed these beds seems to have been continued without interruption or material change of character to

the formation of those layers in which Mr. Lakes found the *Inoceramus* here referred to; and the Atlantosaurian beds seem also to be a part of a continuous deposition of sediment from those of undisputed Jurassic age beneath. This subject will be again referred to on subsequent pages, but our present knowledge is hardly sufficient to warrant any conclusive generalizations upon it.

From Ralston Creek I proceeded northward along the base of the foot-hills, by way of Marshall's coal mines to the valley of the South Boulder. Going thence eastwardly, I found in the slope of the hills some two or three miles eastward from Marshall's mines at about 50 feet above the horizon of the coal some imperfect specimens of oyster-shells. They were, however, perfect enough to allow their identification with *O. glabra* which I had found so abundant at several localities of Laramie strata, as already recorded.

Continuing eastward to the village of Erie, on Coal Creek, I found, just south of the village and of the coal mines which are worked there, some considerable exposures of Fox Hills strata that have evidently been brought up by a fault. I could not ascertain the extent of this fault because of the presence of the abundant *débris* of the plains, but it seems to be a short one and to have its northern end at the south side of the village, and to extend southward only between one and two miles. The throw of the fault is a slight one compared with many of those which we find west of the mountains, as the fossils indicate a horizon near the upper part of the Fox Hills Group, and the layers containing them are on a level with the coal, which is not far from the base of the Laramie Group. The fault is thus seen to involve the upper strata of the Fox Hills Group and the lower strata of the Laramie, and the throw probably does not exceed 500 feet. The fossils referred to are in the form of casts in sandstone, and consist almost wholly of *Veniella humilis* Meek & Hayden.

I traversed in different directions a large part of the district between South Platte and Boulder Rivers, hoping to find other exposures of the fossiliferous horizons of Laramie strata, but without success. These examinations ended my paleontological field-work east of the mountains for this season, and I returned to the foot-hills at Boulder City to prepare for crossing the Rocky Mountains by way of Boulder Pass. Many interesting and important paleontological questions pertaining to this eastern region still remain unsettled, the investigation of which I hope to resume at another time. I have also passed over many important features of structural geology without comment because they have already been so fully reported upon by Dr. Hayden and the late Mr. Marvine.

The following brief summary of the observations made east of the mountains is presented here for the purpose of facilitating the discussion that on subsequent pages will follow the record of the field-work for the whole season.

Every practicable opportunity was improved to note the character of the strata at the junction of the well-recognized groups respectively, and also to seek for the precise point or plane where the characteristic fossils of the one cease, and those of the other begin, to appear. Also, as far as possible, the vertical range of each species collected was observed and compared with the vertical range of the same and associated species elsewhere, especially with those from the typical localities of the Upper Missouri River region.

As to the limits of the formations or groups which I have examined, although each one as a whole is sufficiently distinct and characteristic lithologically, and also paleontologically when fossils occur in them, the

precise boundaries of all of them, from the base of the Red Beds to the top of the Monument Creek Group, were found to be obscure, even where they could be best observed. It is true that the opportunities for such observation are limited by prevailing *débris*, but in no place where opportunity has offered have I been able to select any stratum or any line or plane of demarkation between any two strata, and say with confidence that it constitutes the precise boundary between any two of these groups or formations. Besides this, the horizons which are indicated by the presence, or known vertical limits of range, of certain species of fossils are all parallel with the assumed planes of demarkation between the groups, and consequently with each other. Thus, for example, a well-characterized fossiliferous horizon occurs near the top of the Fox Hills Group and another near the base of the Laramie Group, both being constant throughout a large part of this region. They are comparatively near together, no distinct plane of demarkation existing between the two, as before stated, and yet no two fossiliferous horizons in any series more plainly belong to different groups. In the present state of our knowledge edge it is perhaps too much to say positively that sedimentation was continuous and uninterrupted over the area that now constitutes the region I have examined, from the beginning of the epoch of the Red Beds to the close of the Laramie period, and, perhaps, also, to the close of the Monument Creek epoch, but such now seems to have been the case. That oscillations of land-level took place within that time, which shifted the eastern, and doubtless other shore-lines of then existing seas, is certain, as will be hereafter shown, but such oscillations do not seem to have interrupted or materially affected the continuity of sedimentation in the area that now constitutes the portion of Colorado which lies east of the Rocky Mountains. Important physical changes of course took place elsewhere, which had their effect in producing the changes of the faunæ of the passing epochs which are represented by the groups in question, and in defining those epochs themselves, but that subject will be briefly discussed on following pages. The observations which I made there indicate that all the movements which resulted in the elevation of the Rocky Mountain range certainly took place after the close of the Laramie period, and at least in large part after the close of the epoch of the Monument Creek Group.* The faults and trap outflows, however, that have just been noticed, took place at a much later epoch, probably as late as the Pliocene Tertiary, and were probably contemporaneous with a large part of those that are found on the west side of the Rocky Mountains.

Before taking leave of the east side it is proper to refer to certain drift phenomena which I observed along the eastern base of the mountains, because I shall also have occasion to refer to this subject briefly when treating of regions farther westward.

Near the base of the mountains, and sometimes reaching several miles out upon the plains, are beds of drift, composed of gravel, usually coarse, and small bowlders. Almost without exception, this material is com-

*As to whether the Monument Creek Group is really conformable upon the Laramie, I can only say that it appeared to be so where I examined it. It is probably a considerably later deposit than the Laramie.

There is, as reported by the late Mr. Marvine, a limited unconformity of the Laramie strata upon those of the Fox Hills Group in Middle Park; but that is believed to have been caused by comparatively slight movements that took place previous to those of the Rocky Mountain uplift proper. Very extensive displacements, however, are known to have taken place at or near the close of the Laramie period in the region that now constitutes the western portion of Green River Basin, as will be shown on following pages; but even those movements are believed not to have interrupted continuous sedimentation in comparatively large areas.

posed of fragments of granitic and metamorphic rocks like those composing the immediately adjacent mountains. These beds have been much removed by later erosion, the approximately level portion, not eroded, being from 200 to 300 feet above the neighboring streams. Sometimes they break off by terrace slopes that are apparently not caused by erosion. The higher surfaces of the deposit have a slight uniform slope toward the plains. It is difficult to estimate the thickness of the deposit even approximately, and it is also difficult to ascertain whether the stratified rocks upon which it was deposited were first leveled off to receive the deposit, or whether the leveling was only of its own upper surface. Its appearance suggests that it may have been deposited by a formerly existing ice-sheet moving off from the immediately adjacent mountains, but there are some facts connected with it that are difficult to explain in connection with that suggestion. High hogbacks of Mesozoic rocks stand between those nearly level reaches of drift and the granite rocks that furnished the material of which it is composed. If the surface of the drift was really leveled off by an outwardly moving ice-sheet, it is difficult to understand why the hogbacks were not also reduced to the same plane. But they stand there, immediately adjacent, several hundred feet above the surface of the drift, and also above many of the adjacent granite foot-hills, and, so far as I could discover, they show no signs of former glacial action upon them.

Again, the source of the material of which the drift is composed is only from two to ten miles away, and yet its gravel and bowlders are as perfect and smoothly rounded as the water-worn pebbles of a sea-shore. They evidently have a history beyond that of mere detachment from their original ledges and a few miles of glacial transportation. But this subject will be again referred to on subsequent pages, though perhaps not elucidated.

Passing through the foot-hills near Boulder City, consisting mainly of the great hogbacks of the Red Beds and Dakota Group, we left all the sedimentary rocks of the east side and traveled upon the great granite nucleus of the Rocky Mountains until we had crossed the Front, or principal range. Crossing this by way of Boulder Pass, we reached the large, elevated intra-mountain region known as Middle Park. Our journey led us into the park by way of the headwaters of Frazier River, where we came upon the first stratified rocks after leaving the east side, which were the "Lake Beds" of Dr. Hayden's reports.

The geological structure of the park having been so ably reported upon by the late Mr. Marvine, my attention was more especially directed to the characteristics of the Laramie strata and the Lake Beds, with the hope of learning something of their paleontological history. The latter deposit is very extensively developed in the park and occupies a large part of its surface. It rests unconformably upon all the other rocks, from the granite to the Laramie strata inclusive.

The strata (for it is distinctly stratified) generally presents a nearly level aspect, but the original upper surface of the deposit has been everywhere removed by erosion; so that of an original thickness of a thousand feet or more, scarcely more than one-third of that thickness is now found at any one point. While the strata of this deposit have nowhere been so much displaced as all the other stratified rocks of the park have been, they have, however, been in many places tilted at angles varying from one to fifteen degrees. This deposit was carefully searched for fossils at all the points which I visited, but without success except at one point on Ranch Creek, a tributary of Frazier River. Here I found two imperfect specimens of a species apparently belonging to the genus

Helix; and imbedded in the same mass a small metacarpal or metatarsal bone, about one centimeter long, and apparently belonging to a small rodent. These give no indication of the age of the deposit, because they belong to common living types, and because fossil forms of living invertebrate types are abundant in strata as old as those of the Laramie Group. We must, therefore, rely upon other phenomena to indicate the age of this deposit. The following is a summary of the conditions and indicated circumstances bearing upon this point:

The Lake Beds are known to be considerably more recent than the Laramie Group, because the former rests conformably upon the flexed and much-eroded strata of the latter. The deposit is a circumscribed one, evidently of fresh-water origin, occupies only the lower surfaces of the park, and has plainly derived its material from the immediately adjacent and surrounding hills, but doubtless before either the deposit or the hills were elevated to their present height above the level of the sea. On the other hand it is known to be quite ancient as compared with the present time, because it has suffered extensive erosion, evidently amounting to more than half its original bulk. It bears the evidence of drift-leveling similar to that which has been already noticed as occurring at the eastern base of the mountains, and is consequently older than the epoch of that drift; and its strata have been considerably flexed in some places, showing that mountain elevation was continued after its deposition. This deposit is regarded as of the same or about the same age as the one found west of the mountains which has been called the Brown's Park Group by Professor Powell, and Uinta Group by Mr. King. A comparison of the two was made in my report of last year, and reference to the subject will necessarily be made on following pages.

The drift phenomena observed in Middle Park consist of scattered gravel and bowlders upon quite extensive, nearly level, or gently sloping surfaces of different heights, which often assume the character of terraces. The gravel and bowlders are sometimes scantily and sometimes profusely spread, and the material of which they are composed has evidently been derived from the immediately adjacent mountains and hills. The pebbles and small bowlders have been as smoothly rounded, evidently water worn, as those which have already been referred to as existing at the eastern base of the mountains. The leveling of the surfaces upon which this material rests may have been produced by the same forces which scattered it, but the evidence on this point is not conclusive. The various aspects in which one may view these surfaces in different portions of the park suggest the idea that they may represent different base-planes of erosion which were successively reached during the process of erosive excavation of the deposits which formerly more completely than now filled the park. This terracing of the deposits of the park is known to be of comparatively recent date, because they occur upon the older and later deposits alike, and even the higher or older terraces or levels are, in many cases, upon the Lake Beds, which are much the latest of the formations.

In Egeria Park, which lies west of Middle Park and of the Park Range of mountains, these drift terraces or levels are very extensive, and constitute even more conspicuous features of that district than they do in Middle Park, but they are there mainly or wholly carved out of the Cretaceous deposits, there being no later deposits within its limits.

The strata of the Laramie Group are abundantly developed in Middle Park, so far as aggregate thickness is concerned, which is fully double that of the strata of the same period in the region which I examined

adjacent to the eastern base of the mountains. They occupy a large area in the mountain region between the Front and Park Ranges, extending from near the southern portion of Middle Park to the southern portion of North Park, and including the hill region between both. It has been searched for fossils by every geological party that has visited it, but, so far as Middle Park is concerned, without success except as to fossil plants.

Among the collections of the survey are some fossils obtained by the late Mr. Marvine, from strata that have been referred to the Laramie Group, in North Park, accompanied by the following label: "North Park, SW. corner, 8 miles from Muddy divide." "Muddy divide" is doubtless the locality which is designated as "Muddy Pass" on the maps of the Atlas of Colorado, lately published by the survey. The fossils referred to consist of two, or perhaps three, species of gasteropods, which are in a partially crushed and imperfect condition of preservation, being in the form of casts in soft sandstone. One is a *Viviparus*, the specimens of which are remarkably like some of those of *V. wyomingensis* Meek, which I have collected from the Bridger Group, in a similar state of preservation; but there is nothing in the observable characters of these specimens that would forbid a reference of them to *V. Reynoldsianus* Meek & Hayden, from the Fort Union Group of the Upper Missouri River region. The correctness of the latter reference, rather than the former, is suggested by the fact of the known identity of the Fort Union beds with the Laramie Group; and also the further fact that *V. Wyomingensis* has not been recognized in any other strata than those of the Bridger Group, not even those of either the Green River or Wasatch Group.

Of the other species, one is referred to *Campeloma*, and is probably identical with *C. multistriata* Meek & Hayden, from the Fort Union beds, and also found by myself in the Laramie strata of Crow Creek Valley.

The other form is somewhat more elongate than the last, and has a slight angularity at the outer side of its body volution. It perhaps belongs to the genus *Goniobasis*, but neither its generic or specific characteristics could be clearly distinguished. These are all the invertebrate fossils that are known to have been collected from any of the strata of this large intramountain area that have been referred to the Laramie period. Of themselves they are not sufficient to determine the age of the strata containing them, or their equivalency or otherwise with those of the Laramie Group. The strata of all the other areas which in this report are referred to the Laramie period are, as I shall show, so referred because of the specific identity of a greater or less number of species of invertebrate fossils found in the strata of the different areas or regions respectively. This paleontological evidence is in all cases corroborated by the stratigraphical relations of the Laramie strata with those of the Fox Hills Group beneath, and also, in some cases, with other groups above. In the case of the strata of Middle Park of assumed Laramie age, we are reduced to the latter kind of evidence alone, if we except that which may be derived from the fossil plants and the few fossil shells before mentioned.

While we seem warranted in assuming that the strata in question, of the Middle Park region, are really equivalent with the Laramie Group of the Upper Missouri, the great Green River Basin, and of the plains at the eastern base of the Rocky Mountains, the following comparisons are of interest.

The strata in question have an aggregate thickness in Middle Park

fully double that of those in the plains at the eastern base of the Front Range, but not greater than that at the western base of the Park Range. The Middle Park strata contain no fossils that are certainly identical in species with any of the numerous forms found on each side of that region at the eastern and western bases, respectively, of the Rocky Mountains; and they contain, so far as known, only those imperfectly known species before referred to that are possibly identical with forms in the Fort Union beds of the Upper Missouri.

So far as I am aware, no coal has been found in the Laramie beds of Middle Park, while it is more or less abundant in all the other known regions of that group.

In connection with this latter fact it may be mentioned that Mr. Marvine found a bed of coal in the Fox Hills strata of Middle Park, and it is well known to exist in strata of that age west of the mountains, but none has ever been found in strata of the same age east of the mountains in Colorado, so far as I am aware.

Leaving Middle Park I crossed the Park Range to the headwaters of Yampa River, by way of Egeria Park.

Owing to want of time, comparatively little was done in the examination of the Cretaceous Groups of Middle Park, except to identify them as unmistakably equivalent with the groups of that period as recognized elsewhere in Colorado, both east and west of the Rocky Mountains. In my generalizations, I shall therefore make use of the observations that have been made by Hayden, Powell, and Marvine in this district. I found limited exposures of these groups in connection with the Laramie Group in the vicinity of Hot Sulphur Springs in the middle portion of the park, and also farther westward. Passing down the valley of Grand River, only the Lake Beds were observed within immediate view from my line of travel, until we reached the valley of Muddy River, a northern tributary of the Grand, that has its course along the western portion of the park. Here the strata of the three Cretaceous Groups are exposed along the valley of the Muddy and also flanking the neighboring eastern base of the granite nucleus of the Park Range, the Red Beds only intervening. Crossing their outcrops, I passed over the Park Range into Egeria Park, where I found, at the western base of the range, as at its eastern base, the Red Beds resting upon the granite, and these in turn overlaid by the Dakota and Colorado Groups.

The strata of the latter groups occupy nearly the whole of Egeria Park as well as an adjacent part of the valley of the Yampa, but they are here and there capped with basalt, consisting of shreds of the great sheet that once doubtless covered the whole region of the headwaters of the Yampa and White Rivers. The strata of the Colorado Group in the park and adjacent neighborhood consist largely of light-colored sandstones, often only slightly compacted. In some parts, however, the group here consists of the characteristic bluish sandy shales.

After passing a few miles down the valley of the Yampa, we crossed over in a northwesterly direction, to Terrible and Sage Creeks. In the valley of the last-named creek, near the crossing of the wagon road, I found an exposure of Cretaceous strata. Judging from their lithological aspect I was at first disposed to regard them as belonging to the Colorado Group, but the position of the outcrop, not more than 200 feet beneath the base of the Laramie Group, the strata of which are seen in the adjacent hills, forbade such a reference. The exposure consists of about thirty feet in thickness of light-bluish, grayish, and dark carbonaceous shales, with occasional compact concretions of calcareous and argillaceous rock. In these concretions I obtained the fossils of the following list, most of which are of well-known species.

LIST OF CRETACEOUS FOSSILS COLLECTED ON SAGE CREEK, AN UPPER TRIBUTARY OF YAMPA RIVER, COLORADO.

1. *Caryophyllia egeria* White.
2. *Lingula nitida* Meek & Hayden.
3. *Pteria linguiformis* Evans & Shumard.
4. *Inoceramus barabini* Morton.
5. *Inoceramus pertenuis* Meek & Hayden?
6. *Nucula planimarginata* Meek & Hayden.
7. *Thetis? circularis* Meek & Hayden.
8. *Teredo* ——— ? (borings in fossil wood).
9. *Anisomyon centrale* Meek.
10. *Baculites ovatus* Say.
11. *Scaphites nodosus* Owen.

NOTES ON THE CRETACEOUS FOSSILS OF SAGE CREEK.

The fossils of this list, unless otherwise stated, are described and figured in vol. ix, United States Geological Survey of the Territories.

1. *Caryophyllia egeria* White.

This species was newly discovered with the fossils of the foregoing list, and is described and figured in another part of this volume, together with the only other known species of this genus that has yet been discovered in American Cretaceous strata. The latter was discovered by Professor St. John, in strata of the Fox Hills Group, at Cimarron, N. Mex., and in similar argillaceous strata. This circumstance seems to be worthy of note, in view of the fact that the usual habitat of living corals is in the purest waters; and the comparatively pure calcareous strata that inclose most fossil corals indicate that similar conditions have always been essential to their abundant growth. Coming, as this species does, from near the top of the series of Fox Hills strata, it adds to other evidence that true marine conditions were continued up to the close of that epoch.

2. *Lingula nitida* Meek & Hayden.

A single example only of this species was found. Only one other species of the genus has been recognized in the Cretaceous rocks of the West, both having been first discovered in the Upper Missouri River region, and both are rare, but widely distributed.

3. *Pteria linguiformis* Evans & Shumard.

On a previous page of this report, this species has been noticed at some length. It is widely distributed, and ranges through both the Fort Pierre and Fox Hills Groups, in the Upper Missouri River region.

4. *Inoceramus barabini* Morton.

Scarcely any Cretaceous species has a wider range in Western North America than this. Its vertical range is also through the Fort Pierre and Fox Hills Groups of the Upper Missouri River region, and Mr. Meek has described a variety of it from the uppermost strata of the Fox Hills Group, at the mouth of Judith River.

5. *Inoceramus pertenuis* Meek & Hayden.

A couple of imperfect examples of *Inoceramus* were found among the other fossils that seem to belong to this species, although it is possible they may belong to the *I. vanuxemi* of Meek & Hayden. The last-named species has been found only in the Fort Pierre Group of the Upper Mis-

souri River region, and it also ranges low in the strata of the Fox Hills Group of Eastern Colorado. In view of the high position of these fossils, it seems probable that the examples in question belong rather to *I. pertenuis* than to *I. vanuxemi*.

6. *Nucula planimarginata* Meek & Hayden.

Several examples of this species were found here, all imperfect, but all showing characteristic features. It is always found to range high in the Fox Hills strata of Colorado.

7. *Thetis? circularis* Meek & Hayden.

Two or three imperfect examples were found, which seem, from their external characteristics, to belong to this species, although they are all smaller than the type specimens. The latter also have been found only in the Fort Pierre Group of the Upper Missouri River region, while those in question hold a much higher position.

8. *Teredo* ———?

These examples consist only of some borings in pieces of fossil wood which have become filled with stony material; but they seem without doubt to have been made by a species of *Teredo* or an allied mollusk.

9. *Anisomyon centrale* Meek.

A single example only of *Anisomyon* was found with the other fossils of this collection. It doubtless belongs to this species, although it shows a greater than the usual number of the irregular radiating grooves which characterize most of these forms. Figures of Meek's types of this species are given in another part of this volume.

10. *Baculites ovatus* Say.

In the notes upon this species on a previous page it was stated that its vertical range was not known to extend, either in the upper Missouri River region or in Eastern Colorado, to the uppermost strata of the Fox Hills Group. At the locality in question, however, as well as at another locality also west of the mountains, in the valley of White River, presently to be mentioned, it ranges not only into the uppermost strata of the Fox Hills Group, but it is there associated with species that especially characterize the uppermost strata of that group elsewhere.

11. *Scaphites nodosus* Owen.

Four or five examples of this species were obtained at the locality here discussed, one of which possesses all the characteristics of the variety to which Mr. Meek gave the name of *plenus*. The others are by natural growth so much compressed laterally that they might be readily mistaken for a separate species. They appear, however, to possess the essential characteristics of the form to which Mr. Meek gave the varietal name of *quadrangularis*, except that they want the flattened periphery, bordered by numerous small nodes, which characterizes his type of that variety.

While discussing the fossils of the Fox Hills Group, which were collected east of the mountains in Colorado, it was shown that certain of the species characterize certain horizons in the great group. For example, certain species that are found only in the Fort Pierre Group of the Upper Missouri River region, are found only at a correspondingly low horizon in the consolidated Fox Hills Group as it is developed in Eastern Colorado. Also, that the species which characterize the uppermost Fox Hills strata in one of those regions are, as a rule, equally characteristic of corresponding strata in the other. While these facts

are very valuable for general application, the known great vertical range of some of the species makes it impracticable to place implicit reliance upon any single species as indicating a definite limited horizon within the group. The following comparisons and references will show how far the paleontological indications agree with the known stratigraphical position of the fossils in question. According to our present knowledge of the range of the species of the Fox Hills Group, the presence of *Scaphites nodosus* among these fossils indicates for them a low horizon in the Fox Hills Group, as does also *Thetis? circularis*, if that species has been correctly identified.

On the other hand, all the others may be regarded as ranging through the whole upper half of the Fox Hills Group in Colorado, and some of them below it, including *Baculites oratus*, which, as before stated, ranges higher upon the west side of the Rocky Mountains than it is known to do upon the east side. Besides this, *Inoceramus pertenuis*, which is doubtfully identified here, is a species hitherto known only in the uppermost strata of the Fox Hills Group in the Upper Missouri River region; and a variety of *I. barabini* also exists in the same strata. Summing up the whole paleontological evidence then, it is seen that while it is suggestive of a lower horizon, there is nothing to prove that the strata containing these fossils may not really belong, as they appear to do, to the uppermost portion of the Fox Hills Group. Therefore we need not assume that the strata of the last named group were in any degree removed by erosion in this neighborhood before the deposition of the Laramie strata. Careful examination at the junction of the two groups in the neighboring hillsides also failed to discover any plane of demarkation between them. This fact has the same general application in this region west of the mountains that it was found to have at their eastern base.

No other fossiliferous horizons were found in this neighborhood, either in the Fox Hills or Laramie Groups. My journey led me down the valley of the Yampa, during which I passed much of the way over Laramie strata, as determined by their stratigraphical position and characteristics, as far down as opposite the confluence of Williams River before I found any fossils to confirm those previous conclusions. From this point to one about seven miles below, in the north valley side of the Yampa, I found somewhat frequent exposures of fossiliferous layers, the principal of which was found in Cañon Park, a portion of Yampa Valley. The fossils collected here will be treated as from one locality, because they are practically upon one horizon and essentially the same species of fossils occur at each locality, except two or three limited ones, where no others besides the *Ostrea* were found.

LIST OF LARAMIE FOSSILS COLLECTED IN YAMPA VALLEY, NEAR CAÑON PARK, NORTHWESTERN COLORADO.

1. *Ostrea glabra* Meek & Hayden.
2. *Anomia micronema* Meek.
3. *Anomia gryphorhynchus* Meek.
4. *Volsella* (*Brachydontes*) *regularis* White.
5. *Corbicula occidentalis* Meek & Hayden.
6. *Corbicula* (*Leptesthes*) *fracta* Meek.
7. *Corbula subtrigonalis* Meek & Hayden.
8. *Neritina volvilineata* White.
9. *Melania wyomingensis* Meek.
10. *Viviparus plicapressus* White.
11. *Campeloma multistriata* Meek & Hayden.

NOTES ON THE LARAMIE FOSSILS OF YAMPA VALLEY.

The fossils of this list occupy a distinct horizon of limited vertical extent and probably not more than four or five hundred feet below the top of the Laramie Group. The *Ostrea*, however, appears to have a greater vertical range than the other fossils of the list do, as I found a few examples of it in different places, from one to two hundred feet below the horizon of the other species. All the species appear to be intimately associated together, except that the gasteropods appear to be mainly or wholly confined to a single layer, but that layer has other layers containing the other fossils, both above and below it.

1. *Ostrea glabra* Meek & Hayden.

Most of the specimens of this species which were obtained in Yampa Valley are comparatively large, massive shells, being fully adult. They are in all respects like those which have been obtained from the same horizon at Point of Rocks, something more than 100 miles to the northwestward, and which were described by Meek as *O. wyomingensis*. It has been shown on a previous page that in the Laramie strata of Eastern Colorado intermediate forms are found associated with typical forms of *O. glabra* and *O. wyomingensis* that connect these two types unmistakably. I therefore retain the name *O. glabra* as having priority of date, although it is seldom that any specimens are found in the Laramie strata west of the Rocky Mountains that closely resemble the types of *O. glabra* which were selected for illustration by Meek and Hayden. This species is extremely variable, even for one of the genus *Ostrea*, and there is much reason to believe that not only *O. glabra* Meek & Hayden, *O. subtrigonalis* Evans & Shumard, *O. wyomingensis* Meek, as already suggested, but *O. arcuatilis* Meek and *O. insecura* White also belong to one and the same species. But this subject will be further referred to in connection with a discussion of the collections made in the valley of Bitter Creek.

2. *Anomia micronema* Meek.

The specimens of this species which were obtained in Yampa Valley have a smaller average size than those which were obtained from the Laramie strata east of the Rocky Mountains, and smaller also than those found at Rock Springs in the valley of Bitter Creek, which occur there at a somewhat lower horizon in the Laramie series; but they are doubtless specifically identical at all these localities. See further remarks under the head of notes on the Laramie fossils of Crow Creek on a previous page.

3. *Anomia gryphorhynchus* Meek.

Two or three examples only of this species were found in the Yampa Valley. It is a rare species at all places except the original locality in Bitter Creek Valley. See further remarks under the head of notes on the Laramie fossils of Crow Creek and Bitter Creek Valleys.

4. *Volsella* (*Brachydontes*) *regularis* White.

A couple of fragments only of this species were obtained in Yampa Valley, where they were found mingled with the shells of *Ostrea* and *Corbicula*. The type specimens were found in the valley of Crow Creek, under which head the species is more fully noticed; but it has been recognized at several places west of the Rocky Mountains in Colorado and Wyoming.

5. *Corbicula occidentalis* Meek & Hayden.

This species was originally described by Meek & Hayden from the Judith River Group in the Upper Missouri River region, and it is also

described and illustrated in vol. ix of the United States Geological Survey of the Territories. It is quite abundant at some places in the valleys of the Yampa and Bitter Creek, in the upper portion of the Laramie Group; but although the genus is so well represented east of the mountains in Colorado, this species is not known there. I have at present no doubt of the identity of these Northwestern Colorado and Southern Wyoming forms with the typical forms of the species. There is a possibility that this species is also identical with *C. eytheriformis* Meek & Hayden, originally obtained from the same group and region; but as the differences between the two forms there, as represented by Meek, are repeated in the valley of Bitter Creek, as will be shown on a subsequent page, I prefer at present to regard them as separate species. *C. occidentalis* is a somewhat variable species, and the shell described by Mr. Meek in the An. Rep. U. S. Geol. and Geog. Surv. Terr. for 1872, p. 513, as *C. Bannisteri*, is no doubt specifically identical with it. This view is confirmed by finding forms that are not distinguishable from the type specimen of the latter form among those that are not distinguishable from *C. occidentalis*, and also with associated forms that connect the two. This subject will be further discussed under the head of notes on the Laramie fossils of the Bitter Creek Valley.

6. *Corbicula* (*Leptesthes*) *fracta* Meek.

A few imperfect but unmistakable examples of this species were found at the locality in question. The species has been discussed under the head of notes on the Laramie fossils of Crow Creek Valley, and it will be further noticed in connection with the Laramie fossils of Bitter Creek Valley.

7. *Corbula subtrigonalis* Meek & Hayden.

This is one of the most widely distributed species of the Laramie Group, and it has also a considerable vertical range. It was found associated with the two foregoing species in Yampa Valley. Under the head of notes on the Laramie fossils of Crow Creek Valley, its characteristics, distribution, and synonymy are briefly discussed. It is known to occur at two separate horizons in the valley of Bitter Creek, and will be further discussed in connection with the fossils of that district.

8. *Neritina volvilineata* White.

This species has hitherto been found only west of the Rocky Mountains, the only other locality being near Black Buttes station in the valley of Bitter Creek, where the species was originally discovered. The horizon at both localities is practically the same and near the top of the Laramie Group. Most of the specimens found in Yampa Valley are considerably larger than the types, but they are without doubt specifically identical. The species was first described in Powell's Report on the Geology of the Uinta Mountains, p. 131.

9. *Melania wyomingensis* Meek.

A few imperfect examples only of this species were obtained in Yampa Valley. Its horizon here is practically the same as at Black Buttes Station in Bitter Creek Valley, where it was first discovered, namely, near the top of the group. Its great geographical distribution and vertical range have already been referred to, and will be still further discussed on subsequent pages.

10. *Viviparus plicapressus* White.

This species, like its associate, *Neritina volvilineata*, has yet been found only at Black Buttes Station in Bitter Creek Valley, and in the valley

of the Yampa, the horizon being practically the same at both localities. It was first described in Powell's Report on the Geology of the Uinta Mountains, p. 133.

11. *Campeloma vetula* Meek & Hayden.

A couple of imperfect specimens only of this species were discovered in the valley of the Yampa, but they are doubtless identical with those at Black Buttes Station, which I have identified with this species. It was originally discovered in the Judith River beds of the Upper Missouri River region, and is described and figured in vol. ix of the United States Geological Survey of the Territories.

As has before been stated, with the exception of the greater range of the *Ostrea*, the Laramie fossils found in the valley of the Yampa have there a very limited vertical range, probably not exceeding ten or fifteen feet. It was also stated that this horizon is within four or five hundred feet of the top of the Laramie Group. As shown by its fossils and position it is plainly equivalent with the principal fossiliferous horizon at Black Buttes, Hallville, and Point of Rocks Stations in the valley of Bitter Creek, about 100 miles to the northwestward of the Yampa Valley locality; which horizon is also known to be comparatively near the top of the Laramie Group in that region.

With a view to learning all that can be known concerning the junction of this group with the Wasatch Group above it, I spent two days in the vicinity of the north side of Yampa Valley, searching for a plane of demarkation between the two groups, but wholly without success. As a rule, one is usually able to recognize their respective identity without difficulty, by general lithological characteristics; and the fossils of each, when found, leave no doubt as to which of the two groups the strata containing them belong. The differences of lithological character, however, are so little anywhere within a limited vertical range as to offer no suggestion of a boundary plane between formations where I examined them in this region; and, so far as I could discover, all the strata between those which contain characteristic Laramie fossils and those that contain characteristic Wasatch fossils are strictly conformable. It is in view of these facts that I reached the conclusion that whatever of catastrohpal or secular changes may have taken place elsewhere to interrupt sedimentation and mark a boundary between the strata of the Laramie and those of the Wasatch Group or their equivalents (and such are known to have taken place), in this region at least, sedimentation was continuous from the one epoch to the other. This fact, if it be such, has a most important bearing upon the geological history of the North American continent, and which will be discussed on following pages.

The region of the valleys of the Yampa and White Rivers is an important one as regards the development of the Laramie and Fox Hills Groups west of the Rocky Mountains, and for an account of its geological structure I refer to my report for 1876, together with maps published by this survey, and to King's geological map of the Green River Basin, published in advance of his report.

Proceeding down the valley of Yampa River to the vicinity of Yampa Mountain, I made some examinations of the Fox Hills strata, and observations concerning their connection with the Laramie Group. The only invertebrate fossils I found in the neighborhood of that mountain were some fragments of *Inoceramus barabini* Morton, *I. vanuxemi* Meek & Hayden, and *Baculites ovatus* Say. They were found in the neighborhood of the south end of the mountain in upturned strata of the Fox

Hills Group, estimated to be about twelve hundred feet above its base. In the overlying strata of the Laramie Group near by I found an abundance of fragments of plants, but they were too imperfect for specific identification.

Crossing the axial flexure southeastwardly, in the direction of White River Indian Agency, I next examined the Laramie strata among the Danforth Hills. As shown in my report for last year, the strata of the Laramie Group have in this region an aggregate thickness of 3,500 feet; and I am now inclined to regard its thickness as above rather than below that estimate. This is somewhat remarkable when we remember the limited thickness of the group east of the Rocky Mountains, but the thickness of the western Laramie strata is nowhere known to be greater than that of those which are referred to the Laramie Group in Middle Park. I obtained invertebrate fossils from two separate horizons of the Laramie Group in the Danforth Hills, one of which is near the top, and exactly equivalent with the fossiliferous horizon in the valley of the Yampa, some twenty miles to the northward; and the other is 200 to 400 feet above its base; the two horizons being about 3,000 feet apart. The upper horizon I found exposed in the gentle synclinal at the eastern end of the Danforth Hills, about twelve miles due north from the White River Indian Agency, and the lower one about four miles farther westward. The only species found at the upper horizon in the Danforth Hills is *Ostrea glabra*, the species which is so abundant at the same horizon in Yampa Valley and elsewhere; but those of the lower horizon are more numerous and very instructive, as the following list will show:

LIST OF THE LARAMIE FOSSILS FOUND IN THE DANFORTH HILLS, NORTHWESTERN COLORADO.

1. *Anomia micronema* Meek.
2. *Volsella* (*Brachydontes*) *regularis* White.
3. *Volsella* (*Brachydontes*) *laticostata* White.
4. *Nuculana inclara* White.
5. *Corbicula cytheriformis* Meek & Hayden.
6. *Corbicula* ——?
7. *Corbicula* (*Leptesthes*) *fracta* Meek.
8. *Corbula undifera* Meek.
9. *Melania wyomingensis* Meek.
10. *Odontobasis? formosa* White.
11. *Cytherina?*
12. *Teliost fish-scales.*

NOTES ON THE LARAMIE FOSSILS OF DANFORTH HILLS.

1. *Anomia micronema* Meek.

The examples of this species are small, as they are in the valley of the Yampa. They are preserved in the form of casts in the compact reddish shale that contains all the fossils of this locality, and show the numerous radiating lines which characterize the species very distinctly. The distinctness and arrangement of these lines in some of the examples strongly recall the appearance of *Orthis* or *Hemipronites* when preserved under similar conditions in paleozoic rocks. The occurrence of this species here, as well as at the other localities already mentioned, shows that its vertical range is practically through the whole great thickness of the Laramie Group.

2. *Volsella* (*Brachydontes*) *regularis* White.

Only fragments of this species were found at this locality, but they seem certainly to be specifically identical with the type specimens from the valley of Crow Creek, east of the Rocky Mountains, and also with those that have been identified with them elsewhere west of the mountains. It is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 707.

3. *Volsella* (*Brachydontes*) *laticostata* White.

This species has been recognized at no other locality. It is described in the same article with the preceding species.

4. *Nuculana inclara* White.

Peculiar interest is attached to this species, not only because it is the first one of the genus and family to which it belongs that has been discovered in the strata of the Laramie Group, but because the whole family is regarded as a purely marine one; while all the other species yet discovered in this group, with perhaps the exception of *Odontobasis*, are regarded as of either brackish or fresh water origin. Only two examples were found, but the condition of their preservation is such that their generic identity is not doubted. It is described in the Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iv, p. 708, and it has been discovered at no other locality. Its own characters, and being also associated with No. 10 of this list (which is probably another marine form) near the base of the Laramie Group, seem to suggest that marine saltness of the waters was preserved in some places for some time after the peculiar conditions of the Laramie period were introduced. This suggestion is somewhat strengthened by the fact that *Odontobasis buccinoides* White holds in the valley of Bitter Creek a position considerably below the principal fossiliferous horizon there, in which both fresh and brackish water forms are found, but none whose living congeners are exclusively marine. It is a singular fact, however, that in both these layers containing marine types specimens of *Melania* were found; but this subject will be discussed at some length on subsequent pages.

5. *Corbicula cytheriformis* Meek & Hayden.

The specimens which I have referred to this species are imperfect, and in the form of casts in the compact reddish shales which contain all the fossils of this locality. A couple of the examples found here indicate a larger size than any of those which have been identified with this species from Bitter Creek Valley, but not larger than the types of Meek & Hayden. These were discovered by Dr. Hayden in the Judith River beds of the Upper Missouri River region, and are figured and described in vol. ix of the United States Geological Survey of the Territories.

6. *Corbicula* ———?

These shales contain casts of another species of *Corbicula* which seems to be different from any described form, but because those examples are yet known only in the form of casts, and are probably not fully adult, they are not specifically named. They resemble young examples of *C. planumbona* Meek.

7. *Corbicula (Leptesthes) fracta* Meek.

Casts of this species were also found here, which are interesting as showing that it began its existence early in the Laramie period. Heretofore it has been found only in the upper portion of the Laramie Group,

west of the Rocky Mountains; but its position east of the mountains is apparently near the base of the group.

8. *Corbula undifera* Meek.

This species was described by Meek in the Annual Report of the United States Geological and Geographical Survey of the Territories for 1872, p. 513, from the Laramie strata at Rock Springs in the valley of Bitter Creek. In Powell's Report on the Geology of the Uinta Mountains, p. 129, I described another form under the name of *C. subundifera* from a higher horizon of the Laramie strata of the same valley, which I now regard as only a variety of Mr. Meek's species. The original variety has been found only at Rock Springs and at the Danforth Hills locality. The variety *subundifera* was originally found at Point of Rocks in Bitter Creek Valley, and I have also recognized it among some fossils brought from Upper Kanab, Southern Utah, by Professor Powell. The two varieties thus seem to be quite constant.

9. *Melania wyomingensis* Meek.

The wide geographical distribution of this species, as well as its characteristics, has already been commented on under the head of notes on the Laramie fossils of Crow Creek Valley. Its occurrence here not only adds to our knowledge of its distribution, but also to that of its vertical range in the Laramie Group. Its position at the original locality in Bitter Creek Valley, and also at that of Yampa Valley, is near the top of the group. At the Danforth Hills locality its position is near the base of the group, showing the known vertical range of the species to be about 3,000 feet. It is a noticeable fact that all the associates of this species at the Danforth Hills locality are brackish-water, or perhaps in part marine species, none being purely or exclusively of fresh-water habitat. It is also a singular fact that while other fresh-water forms are sometimes associated with it, some of its associates at all the localities where it has been discovered are brackish-water forms, or those that may have inhabited both fresh and brackish waters. The characteristics of the shell are such as to scarcely admit of a doubt that it is either a true *Melania* or a very closely allied form.

10. *Odontobasis? formosa.*

Only a single example of this species was discovered. It is imperfect, and perhaps does not belong to that genus, to which it is referred provisionally. It is published in the Bulletin of the United States Geological Survey, vol. iv, p. 718, and also in this volume, with a figure.

11. *Cytherina?*

In the fine-grained indurated reddish shales of this locality are numerous casts of an Ostracoid crustacean which I refer provisionally to *Cytherina*. These are the first examples of that order of crustaceans, so far as I am aware, that have been discovered in strata of the Laramie Group.

12. *Fish remains.*

A few cycloid scales were also found in these shales, which, except a few similar examples found in Bear River Valley, are the only fish remains discovered by myself in Laramie strata; but there seems to be no reason why fishes may not have existed abundantly during that period. The absence of the *Ostrea* here is noticeable, and is probably due to the uncongeniality of habitat that was produced by the fine sediment which now constitutes the shales. *O. glabra* was found further down the valley of White River in strata fully as near the base of the group as

these shales are, and that species is therefore known to have as great a vertical range as any of the other species of the group.

The Laramie Group of this district is made up of sandstones and sandy shales, with occasional layers of clayey shales, which toward the base are reddish in color, indurated, fine-grained, and fissile. There are also several beds of coal or lignite in the group as developed in this region, one being near the horizon of the fossils of the foregoing list and another near that of the fossils collected from the upper strata of the group in Yampa Valley. Besides this, comminuted fragments of plants are very common in almost all the strata from base to top of the group, and in some of the layers they are very abundant.

In the Danforth Hills, and also extending far down White River Valley, and over to Yampa Valley, the strata of nearly the whole group have a decided reddish aspect, which often appears as if produced by heat. The fossils of the foregoing list were all collected from the reddish fissile shales before mentioned, about fifteen miles northwestward from White River Indian Agency, mostly about 400 feet above the base of the group, and I found fragments of a part of the same species three miles to the southward of that locality, some 300 feet lower in the series, or within 100 feet of the base. About 200 feet beneath these lowest Laramie fossils I obtained some characteristic fossils of the Fox Hills Group, which will be discussed on following pages. The plane of division between these two groups is of course between these two fossiliferous layers, which are only 200 feet apart. No unconformity of any of these strata could be detected, nor is there any abrupt change from the lower to the higher group; yet viewing the strata as they are abundantly exposed in the hillsides of the district, one has little difficulty in tracing a sufficiently distinct line of division by the aspect of the strata. This difference of aspect is due mainly to the greater thinness of the layers that compose the strata which are referred to the Laramie Group, and also to a perceptible difference of color.

The remaining investigations of the Laramie Group for this season, (except those of the peculiarly developed portion of the group at the western part of Green River Basin) were made near its close in the valley of Bitter Creek, in Southern Wyoming, from 100 to 125 miles northwestwardly from the Yampa and White River localities. As the faunæ of the two districts are intimately related, I shall depart from the course of my journey to discuss, in immediate connection with the foregoing, the Laramie Group and its fossils as developed in the valley of Bitter Creek, and then return to the Fox Hills Group, in the valley of White River, and follow the line of my journey to its close.

In the valley of Bitter Creek, a tributary of Green River, the whole series of Laramie strata is twice exposed, once on each side of a broad anticlinal flexure, called by Professor Powell the Aspen Mountain Uplift. Fossils were obtained from them on both sides of the fold, but they all come apparently from the upper half of the series, although they occur at several distinct fossiliferous horizons. My examinations began in the valley of Bitter Creek, just west of the village of Rock Springs, where the uppermost strata of the group occur, the dip being to the westward. I made careful examination here, as well as formerly in Yampa Valley, for a plane of demarkation between the Laramie and Wasatch Groups, but without success. I rode back and forth, on the western side of the valley, over the upturned edges of the strata between two fossiliferous horizons containing characteristic fossils of each group respectively, and I could nowhere find a plane of demarkation or any particular layers suggestive of a plane of separation between the two groups.

The uppermost fossiliferous layer of the Laramie Group, doubtless equivalent with the fossiliferous horizon both at Point of Rocks Station and in Yampa Valley, was found in the hill just west of the village of Rock Springs, where I obtained only one species, *Ostrea glabra* Meek & Hayden. The fossils of the following list were obtained at other and lower horizons in the group just east of the village:

LIST OF LARAMIE FOSSILS COLLECTED AT ROCK SPRINGS, WYOMING.

1. *Ostrea glabra* Meek & Hayden.
2. *Anomia micronema* Meek.
3. *Volsella (Brachydontes) regularis* White.
4. *Corbula undifera* Meek.
5. *Melania insculpta* Meek.

No other fossils were obtained from the Laramie strata on the west side of the Aspen Mountain Uplift, but important collections were made from them at three localities upon the east side. The first of these localities is about two miles below or west of Point of Rocks Station, where the following fossils were obtained:

LIST OF LARAMIE FOSSILS FROM BITTER CREEK VALLEY, TWO MILES WEST OF POINT OF ROCKS STATION, WYOMING.

1. *Ostrea glabra* Meek & Hayden?
2. *Anomia gryphorhynchus* Meek.
3. *Corbicula cytheriformis* Meek & Hayden.
4. *Corbula subtrigonalis* Meek & Hayden (=*C. tropidophora* Meek).
5. *Melania insculpta* Meek.
6. *Odontobasis buccinoides* White.

The exposure here is only a very limited one of a single stratum of fossiliferous rock, being the same as that from which Mr. Meek collected his type specimens of *Anomia gryphorhynchus*. The position of this fossiliferous horizon in the Laramie series is probably about the same as that just east of the village of Rock Springs, although most of the fossils are of different species.

The fossiliferous horizon at Point of Rocks station, two miles farther up the creek, holds a position several hundred feet above the one in question. Just how much higher in the series it belongs could not be accurately known, because there is an unconformity of the strata between the two horizons. This unconformity is evidently of limited extent in this district and has probably not greatly affected the aggregate thickness of the whole group. I could find no trace of it in the Laramie strata of the valleys of Yampa and White Rivers, but Professor Powell has reported it to exist elsewhere, and upon it he made the division between his Point of Rocks and Bitter Creek groups. I adopted his views in this respect in my report upon his collections, in the third chapter of his Report on the Geology of the Uinta Mountains; and also in my Paleontological Papers Nos. 2, 3, and 5 in the Bulletin of the United States Geological and Geographical Survey of the Territories. Subsequent investigations, however, show that the paleontological characteristics of the strata above and below this unconformity are too nearly identical to admit of their separation as belonging to separate epochs, even if that unconformity were general instead of local.

The fossiliferous horizon at Point of Rocks station is the uppermost one of the group that is yet known, and is essentially the same as that

at Black Buttes station, twelve miles farther up the creek, and also the same as that in the valley of the Yampa. At Point of Rocks it comprises two layers containing the fossils, separated by 50 feet of strata in which none were found. Only *Corbula subundifera* White and *Campeloma vetula* Meek & Hayden were found in the lower layer, and the remainder of the following list were obtained from the upper layer.

LIST OF LARAMIE FOSSILS COLLECTED AT POINT OF ROCKS STATION, WYOMING.

1. *Membranipora?*
2. *Ostrea glabra* Meek & Hayden.
3. *Corbicula occidentalis* Meek & Hayden.
4. *Corbula subundifera* White.
5. *Campeloma vetula* Meek & Hayden.

The layers that have furnished the important collections of plant remains at Point of Rocks station, which have been described by Mr. Lesquereux, were found to be lower in the Laramie series than those which furnished the fossils of the foregoing list, and they are also below the unconformity that has been referred to. Proceeding up the valley of Bitter Creek the horizon of the invertebrate fossils was once or twice detected by some scattered fragments of oyster-shells, but no important collections were made until I reached Black Buttes station, some twelve miles to the southeastward. I stopped on the way at the Hallville mines where Mr. Meek had formerly obtained some Laramie fossils, but as the mines had been abandoned I was unable to make any collections. The strata of the Black Buttes locality were found to contain fossils for a considerable distance both above and below the railroad station and upon both sides of the creek, the principal locality being about a mile south of the station.

LIST OF THE LARAMIE FOSSILS COLLECTED AT BLACK BUTTES STATION, WYOMING.

1. *Anomia micronema* Meek.
2. *Anomia gryphorhynchus* Meek.
3. *Ostrea glabra* Meek & Hayden.
4. *Unio couesi* White.
5. *Unio propheticus* White.
6. *Unio aldrichi* White.
7. *Unio proavitus* White.
8. *Unio holmesianus* White.
9. *Unio endlichi* White.
10. *Unio cryptorhynchus* White.
11. *Unio brachyopisthus* White.
12. *Unio goniambonatus* White.
13. *Unio dancæ* Meek & Hayden.
14. *Corbicula occidentalis* Meek & Hayden.
15. *Corbicula (Leptesthes) fracta* Meek.
16. *Corbula subtrigonalis* Meek & Hayden.
17. *Neritina volvilineata* White.
18. *Neritina (Velatella) baptista* White.
19. *Goniobasis gracilienta* Meek & Hayden.
20. *Cassiopella turricula* White.
21. *Melania wyomingensis* Meek.
22. *Viviparus plicapressus* White.

23. *Tulotoma thompsoni* White.
24. *Campeloma vetula* Meek & Hayden.
25. *Campeloma multilineata* Meek & Hayden?

NOTES ON THE LARAMIE FOSSILS OF BITTER CREEK VALLEY.

As the fossils of the different localities in Bitter Creek Valley are so closely related they will all be discussed in zoological order in the following notes instead of treating those of each locality separately.

1. *Membranipora?*

Upon many of the shells of *Ostrea glabra* Meek & Hayden (=*O. wyomingensis* Meek), which were obtained at Point of Rocks, there are small patches of an incrusting Polyzoan. None of them are quite perfectly preserved, but they are evidently the calcareous cell-bases of a species of *Membranipora* or of a closely allied genus. I have detected similar objects at no other locality of Laramie fossils except in the valley of Bear River, but there seems to be no good reason why they may not have existed with any of the many brackish-water species of that period. They are interesting as indicating the continuance of a considerable degree of saltness of the waters until near or quite the close of the Laramie period.

2. *Anomia micronema* Meek.

This species has already been discussed upon previous pages as to its geographical distribution and vertical range in the Laramie Group. A few small examples of it were found at the Black Buttes locality, and it was also found quite abundantly at the Rock Springs locality, but nowhere else in Bitter Creek Valley. At both those localities it was found in a separate layer associated only with *Ostrea glabra*. At the Rock Springs locality the examples are of good size, and many of them have a greater than the average convexity of form.

At none of the numerous localities where this species has been found, from the one reported by Dr. Hayden, two hundred miles east of Denver, to those of Bitter Creek Valley, none but upper valves have been discovered. It is very difficult to even suggest an explanation of this remarkable fact, which has before been referred to.

3. *Anomia gryphorhynchus* Meek.

The locality two miles below Point of Rocks is the only one that has furnished many examples of this species, although it has been clearly recognized at the Crow Creek locality east of the Rocky Mountains, and also at the Black Buttes and Yampa Valley localities. This shows a wide geographical distribution and a considerable vertical range of the species. As in the case of *A. micronema*, none but upper valves of this species have been found.

4. *Ostrea glabra* Meek & Hayden.

This species has already been discussed at length on former pages, and reasons given for referring these western forms to *O. glabra* Meek & Hayden rather than to regard them as a separate species under the name of *O. wyomingensis* Meek, the types of which were found at Point of Rocks. If it were not for the lately obtained proof that the Judith River, Fort Union, Colorado Lignite and Bitter Creek series all belong to one and the same period, and the discovery of intermediate forms connecting these two formerly recognized species of *Ostrea*, it is not probable that I should have ever suspected them to be distinct. The lack of intermediate

forms west of the mountains like those which were found in Eastern Colorado is suggestive that there may after all be really two species, especially so since only thin, small examples are found at the locality two miles west of Point of Rocks. In Professor Powell's Report on the Geology of the Uinta Mountains I gave the name of *O. insecuris* to these last-mentioned examples, but comparison of my types directly with those of *O. glabra* shows too little difference to be satisfactorily regarded as specific. Comparison of large collections made at the typical localities, Point of Rocks and Black Buttes Station, with the types themselves, leaves no doubt in my mind that *O. wyomingensis* Meek and *O. arcuatilis* Meek are specifically identical. It will of course be understood that I regard such forms as the types of *O. glabra* Meek & Hayden, *O. subtrigonalis* Evans & Shumard, and *O. insecuris* White as young examples of the species, and *O. wyomingensis* Meek as adult forms of the same. By these and other remarks on previous pages it will be seen that at present I recognize only one species of *Ostrea* in all the Laramie Group, unless the obscure one that is found in Bear River Valley, yet to be noticed, shall prove to be distinct from *O. glabra*.

5. *Volsella* (*Brachydontes*) *regularis* White.

A few large but imperfect examples of this species were found just east of Rock Springs, which is the only locality in Bitter Creek Valley, at which it was discovered. See further remarks under the head of notes on the Laramie fossils of Crow Creek Valley.

6. *Unio couesi* White.

This is one of nine or ten species of *Unio* that have been found associated in one and the same layer at Black Buttes Station, and also associated with *Corbicula* (*Leptesthes*) *fracta*, *Neritina volvilineata*, *Neritina* (*Velatella*) *baptista* and *Melania wyomingensis*. None of these species of *Unio* have been discovered at any other locality west of the Rocky Mountains, but two of them, *U. cryptorhynchus* White and *U. danæ* Meek & Hayden, have been somewhat satisfactorily identified with the typical forms from the Upper Missouri River region. This is the largest species of the genus that has yet been found fossil in any strata of the West. It was originally described by me under the name of *U. petrinus* in Powell's Report on the Geology of the Uinta Mountains, p. 125, together with Nos. 7 and 8 following. That name being preoccupied, it was changed to *U. coucsi*, in Bull U. S. Geol. and Geog. Sur. Terr., vol. iii, p. 605.

7. *Unio propheticus* White.
8. *Unio brachiopisthus* White.
9. *Unio proavitus* White.

} See remarks under No. 6.

This species, together with Nos. 10 and 11 following, are described in Bull. U. S. Geol. Sur. Terr. vol. iii, pp. 603 and 604.

10. *Unio holmesianus* White.
11. *Unio endlichi* White.
12. *Unio aldrichi* White.

} See remarks under No. 6.

This species, together with No. 13 following, are described in Bull. U. S. Geol. Sur. Ter. vol. iv, pp. 709 and 710.

13. *Unio goniambonatus* White.

See remarks under No. 6.

14. *Unio cryptorhynchus* White.

Some imperfect examples found associated with the foregoing species appear to be specifically identical with the types of *U. cryptorhynchus*

which were collected by Prof. E. D. Cope from the Judith River beds of the Upper Missouri River region. It is described in Bull. U. S. Geol. and Geog. Sur. Terr. vol. iii, p. 600.

15. *Unio danæ* Meek & Hayden?

Several well-preserved examples were obtained with the other species of *Unio* at Black Buttes Station that have much the form of the living species *U. rectus*. They appear, however, to be too nearly related to, if not specifically identical with, *U. danæ* Meek and Hayden to warrant any other reference at present.

16. *Corbicula occidentalis* Meek & Hayden.

The possible identity of this species with the following has already been referred to, but the two forms although closely related are (when studied by numerous specimens of each form from Bitter Creek Valley) quite readily distinguishable. The two forms are also from two separate horizons, *C. occidentalis* being found only in that of Point of Rocks and Black Buttes Stations, and *C. cytheriformis* only in that of the locality two miles below Point of Rocks. *C. bannisteri* Meek, as has already been stated, is regarded as only a variety of *C. occidentalis*. This species is quite abundant in the principal oyster layer at Point of Rocks, and is similarly associated at the Yampa Valley locality. Among some collections brought by Professor Powell from Upper Kanab, Utah, are some examples that appear to belong to this species. It has not been recognized east of the Rocky Mountains in Colorado.

17. *Corbicula cytheriformis* Meek & Hayden.

Many well-preserved examples of this species were obtained at the locality two miles below Point of Rocks. They are of smaller average size than the types of the species, but they seem to be specifically identical. This species was not recognized east of the Rocky Mountains in Colorado, and only doubtfully so in the Danforth Hills, which is the only other locality at which it has been recognized west of the Rocky Mountains.

18. *Corbicula* (*Leptesthes*) *fracta* Meek.

A single layer at Black Buttes Station contains this species in great abundance, and it was here and at Hallvile, four miles distant, that Mr. Meek obtained the types of this species and of the subgenus *Leptesthes*. Its geographical distribution is about the same as that of *Melania wyomingensis*, and its vertical range apparently through the whole thickness of the Laramie Group. For further remarks on this subject see notes on the Laramie fossils of Crow Creek Valley.

19. *Corbula undifera* Meek.

The typical forms of this species have hitherto been found only at Rock Springs and in the Danforth Hills. The type collection of *C. subundifera* White was obtained at Point of Rocks station from a layer about fifty feet below the oyster horizon there, and the form was described in Professor Powell's Report on the Geology of the Uinta Mountains, p. 129. The only other known examples were brought by Professor Powell from Upper Kanab, Southern Utah, as mentioned on a previous page. The differences between these two forms are so slight that I am now disposed to regard them as only varieties of one species; but still the variation seems to be constant as found in widely separated localities, which is suggestive of a permanency that may prove to be specific.

20. *Corbula subtrigonalis* Meek & Hayden.

It has been stated on a previous page that good reasons appear to exist for regarding *C. subtrigonalis* Meek & Hayden, *C. perundata* Meek & Hayden, *C. crassatelliformis* Meek, and *C. tropidophora* Meek, as belonging to one and the same species, the difference being only varietal and probably due to local environment. Mr. Meek's types of the two last-named forms were obtained from the Bitter Creek series of Laramie strata, the former at Hallville and Black Buttes stations, and the latter at the locality two miles below Point of Rocks. The difference between these two latter forms is significant as being similar to that between *C. undifera* and *C. subundifera*, and also similar to that between other forms from different strata of the Bitter Creek series presently to be noticed.

21. *Neritina volvilineata* White.

The type specimens of this species were found at Black Buttes Station associated with *Melania wyomingensis*, *Corbicula* (*Leptesthes*) *fracta*, and seven or eight species of *Uniones*. Yampa Valley is the only other locality at which this species has been discovered. See remarks under that head on a previous page.

22. *Neritina* (*Velatella*) *baptista* White.

In Ann. Rep. U. S. Geol. and Geog. Sur. Terr. for 1872, pp. 497–499, Mr. Meek described three species of *Neritidæ* from the Cretaceous rocks at Coalville, Utah, for which he proposed the subgeneric name of *Velatella*. In their distinguishing charactistics they approach *Velates* Montfort, but the differences pointed out by Mr. Meek are doubtless of at least subgeneric value. Two of the species described by him were found in the brackish-water layers at Carleton's coal mine, which are both underlaid and overlaid there by marine strata of the Fox Hills Group; and the other was from marine Cretaceous strata of the same series a couple of miles away from the first-named locality. *N.* (*V.*) *baptista* is described in Bull. U. S. Geol. and Geog. Sur. Terr. vol. iv, p. 715, and was found in the Laramie strata at Black Buttes Station associated with the preceeding species and its brackish- and fresh-water associates there. This peculiar type has been found at no other than the Coalville and Black Buttes localities, the one in the Fox Hills Group and the other in the Laramie.

23. *Goniobasis gracilienta* Meek & Hayden.

A goodly number of examples were found at the Black Buttes locality which appear to be specifically identical with *G. gracilienta* Meek & Hayden, although they are smaller and rather more slender than the types of that species are, and also more slender than those examples are that were found in Crow Creek Valley east of the Rocky Mountains. For remarks on that species see notes on the fossils of the last-named locality.

24. *Cassiopella turricula* White.

This is the type and only species of the genus *Cassiopella* that has yet been discovered. It has been found only at the Black Buttes locality, where it is associated with *Unio*, *Corbula*, *Goniobasis*, *Campeloma*, &c. Although it is a very interesting form, being unique, it is of little value in the present discussion, which is mainly one of comparison. It is described in Powell's Report on the Geology of the Uinta Mountains, page 133, under the name of *Leioplax? turricula*, but it was made the type of *Cassiopella* in Bull. Geol. and Geog. Sur. Terr. vol. iii, p. 606.

25. *Melania wyomingensis* Meek.

This is one of the finest and most interesting species yet discovered in

the Laramie Group. Mr. Meek obtained his type specimens at the Black Buttes locality, and it has since been obtained in considerable numbers both east and west of the Rocky Mountains, in Colorado and Wyoming, but it has not yet been discovered in the Upper Missouri River region. Its wide geographical distribution; its great vertical range in the Laramie Group; its apparently true *Melanian* type and its relation to the following species from a lower horizon in the group in Bitter Creek Valley, all make it a species of unusual interest. For further remarks on it see notes on Laramie fossils from Crow Creek Valley and the Danforth Hills localities.

26. *Melania insculpta* Meek.

Mr. Meek described this species in the Ann. Report of the U. S. Geol. and Geog. Sur. Terr. for 1872, p. 515, along with *M. wyomingensis*, his types of the former having been obtained at Rock Springs, and those of the latter at Black Buttes Station. No examples of *M. insculpta* have been found elsewhere than at Rock Springs, except two or three imperfect ones at the locality two miles below Point of Rocks. It is much more nearly related to *M. wyomingensis* than would appear at first glance, because the principal difference consists in the row of prominent nodes or short spines that adorn the larger volutions of the latter; while the upper turns of the spine of each seem to be undistinguishable. This is another case of very closely related species or well-marked varieties existing the one above and the other below the line of unconformity that has been shown to exist in the Laramie strata of Bitter Creek Valley.

27. *Viviparus plicapressus* White.

The only localities at which this species has yet been discovered are those of Black Buttes Station and Yampa Valley. At the latter locality it was found associated with *Melania wyomingensis* and *Neritina volvilineata;* and at the former with *Unio*, *Corbula*, *Goniobasis*, *Cassiopella*, *Campeloma*, &c. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 133. It is not yet known east of the Rocky Mountains.

28. *Tulotoma thompsoni* White.

Black Buttes Station is the first locality at which this species was discovered, and the valley of Crow Creek, east of the mountains, is the only other one at which it has been found. It occurs in considerable numbers at each of these localities, and its identity at each is beyond question. Its associates at Crow Creek are all fresh-water forms; and at Black Buttes it seems to occupy a thin layer by itself between those which contain both brackish- and fresh-water forms. See further remarks under the head of "Notes on the Laramie fossils of Crow Creek Valley."

29. *Campeloma vetula* Meek & Hayden.

Dr. Hayden first discovered this species in the Judith River beds of the Upper Missouri River region, and it is described and figured in volume IX of the United States Geological Survey of the Territories. A goodly number of examples were obtained at Black Buttes Station, where they were found associated with *Unio*, *Corbula*, *Goniobasis*, *Cassiopella*, &c. Their specific identity with *Campeloma vetula* seems to be unmistakable.

30. *Campeloma multistriata* Meek & Hayden.

Some examples found associated with the foregoing species at Black Buttes Station possess distinct revolving lines like those of *C. multistriata*, but they lack the shouldering of the distal side of the body-volution so common in that species. As they do not appear to differ materially in

general shape from *C. vetula*, they may perhaps be only a variety of that species. This is rendered probable by the fact that the revolving lines are often obsolete on *C. multistriata*, as well as other striated species.

31. *Odontobasis buccinoides* White.

This species is described in Powell's Report on the Geology of the Uinta Mountains, p. 124. With the exception of a single species found in the Danforth Hills, and doubtfully referred to this genus, only two other species of the genus are known. These are both of Cretaceous age, and are associated only with marine forms. The living affinities of the genus are also with those only of marine habitat, and it is probable that this species actually lived only with those that could endure a considerable degree of saltness of the water. It has been found only at the locality two miles west of Point of Rocks, where its associates are *Ostrea*, *Anomia*, *Corbicula*, *Corbula*, and *Melania* (*insculpta*). The specimens of the last-named species may have been drifted to their present association from a more natural habitat, but it is possible they all lived together, especially so since *M. wyomingensis* has been found at various localities associated with brackish-water forms.

Bitter Creek Valley is one of the most important districts yet known for the study of the Laramie Group; and on account of the large number of species of its fossils found there the Black Buttes locality is one of especial importance and interest. The following is a section of the strata as they appear about a mile south of the station, the point where the greater part of the fossils were obtained:

Section of Laramie Strata at Black Buttes Station.

	Feet.
1. Thin bedded sandstones and sandy, ferruginous shales to the top of the Laramie Group	500?
2. Sandstone, containing *Unio coucsi*, *Campeloma vetula*, and *Anomia gryphorhynchus*	3
3. Sandy shales, somewhat carbonaceous	4
4. Shales, containing *Cassiopella turricula*, *Viviparus plicapressus*, *Goniobasis gracilienta*, *Campeloma vetula*, *Unio dancæ?*, *Corbula subtrigonalis*, &c	1
5. Bluish, clayey shale, containing fragments of *Ostrea* and *Anomia*	5
6. Calcareous fragmentary layer, containing an abundance of *Tutoloma thompsoni*, mostly decomposed	1
7. Calcareous and sandy fragmentary material, very fossiliferous, containing all the species of *Unio* of the foregoing list, *Corbicula* (*Leptesthes*) *fracta*, *Melania*, *wyomingensis*, *Neritina volvilineata*, *N.* (*Velatella*) *baptista*, &c	4
8. Sandy shales, with alternating calcareous fragmentary layers	30
9. Dark carbonaceous shales, with *Ostrea* and *Anomia*	6
10. Common sandstones	100
11. Sandy, grayish shales and soft sandstones	300

In the neighborhood of Black Buttes Station there are, within the limits of this section, three or four coal or carbonaceous horizons, two of which have been worked for coal. One of these appears to be represented by No. 3, and another by No. 9 of the section; but all the beds of the series exposed in this neighborhood are so extremely variable that sections taken at points not more than a quarter of a mile distant from each other would hardly be recognized as intended for the same locality, especially in its thinner members.

The beds of coal are not continuous here, as they usually are in the Carboniferous Coal-Measures; but from a good workable thickness at one point a bed will disappear entirely within half a mile. The layers containing the fossils are equally inconstant as regards their fossil contents, and a measured section half a mile away from the point where the foregoing one was measured, comprising the exact equivalents of those beds,

might be examined in vain for fossils of any kind. Yet there is no evidence that any of these layers are of truly estuary origin, or that they were formed in any other than lacustrine or interior sea waters. In other words, the variation referred to seems to have been the result of shifting conditions of limited extent in a large body of water, rather than that of the meeting of fluviatile and lacustrine or sea waters. This inconstancy of the layers composing a large part of the Laramie Group is common almost everywhere, and indicates a general prevalence of shallow water during the Laramie period. The frequent mixture in a single layer of fresh-water, brackish-water, and marine types in these and other Laramie strata is very perplexing, and will be further discussed on following pages.

The dip of all the strata at Black Buttes Station is gently to the eastward, and going in that direction a few miles one finds himself upon the strata of the Wasatch Group. I crossed and recrossed this space at different places in the neighborhood, and failed, as I had done before at other localities, to find any plane of demarkation, or any indication of a division between the Laramie and Wasatch Groups. The thickness therefore that is assigned to No. 1 of the foregoing section is only an approximate estimate. I do not doubt that there are places, even within the Green River Basin, where there is a true unconformity of strata at or about the junction of the two groups, but I have not had the good fortune to examine any such localities personally. In this statement reference is not made to the great unconformity of the Wasatch upon the Laramie at the extreme western portion of that geographical basin, or rather upon the eastern borders of the Salt Lake Basin, which will be discussed on following pages.

Within 100 feet above the base of No. 1 of the foregoing section I found fragments of bones, probably those of *Agathaumas sylvestris* Cope, which is probably the identical locality at which Professor Cope obtained his type specimens. I found no invertebrate fossils of any kind above No. 2 of the section; and it will thus be seen that vertebrate remains of Cretaceous type are found above all the invertebrate fossils of the Black Buttes locality, and that the former were obtained from the uppermost portion of the Laramie Group. Some reference to the discussions that have taken place as to the geological age of these strata will be made on a following page.

Before taking leave of the Bitter Creek series there is an interesting matter to be considered in relation to it. The existence of an unconformity of the strata of the upper part of the Laramie series upon those of the lower part, especially observable in the neighborhood of Point of Rocks, has already been noticed. As already hinted, there are some interesting differences among the fossils that respectively characterize the strata above and below the unconformity. For example, in Bitter Creek Valley the typical forms of *Corbula undifera* are not found above the unconformity, and those of *C. subundifera*, which I now regard as only a variety of the first, are not found below it. The variety of *Corbula subtrigonalis* to which Mr. Meek gave the name of *C. tropidophora* is found only below the unconformity, while that which he called *C. crassatelliformis* is found only above it. *Melania insculpta*, which seems to differ from *M. wyomingensis* only in the absence of the nodes or short spines which characterize the latter, is found only below the unconformity, while the last-named species is found only above it. Also *Corbicula cytheriformis* is found only below the unconformity, while the closely related form *C. occidentalis* is found only above it. It would be too much to assume that all the upper forms here named are the lineal

descendants of their lower representatives respectively, but the local facts are at least suggestive of some such connection. At any rate, there seems to be no reason for doubt that the change of condition consequent upon the movement that caused the unconformity brought about a corresponding change in the aqueous fauna.

Leaving the Bitter Creek district, with much that is interesting there, to be noticed in the closing discussion, I now return to the Danforth Hills, near White River, and resume my observations, in the order of my journey, where I left them to consider the Bitter Creek series.

My journey upon leaving the Danforth Hills was by way of a cañon that opens into Agency Park at a point about six miles directly south of the locality where I obtained the collection of Laramie fossils, and near the western end of the park.

In the sides of this cañon appears the junction between the Laramie and Fox Hills Groups, the character of which has already been described. Following down the drainage of the cañon into the park, we come upon the Colorado Group, and upon the banks of White River we find the strata of the Dakota Group also. No fossils were found in the latter, but fragments of *Inoceramus deformis* with *Ostra congesta* were found in the former. About a mile up from the mouth of the cañon I obtained, from a layer of the Fox Hills Group, within 100 feet of its top, the fossils of the following list. Near by, in the same cañon-side, 200 feet above the layer just mentioned (100 feet above the base of the Laramie Group), I collected fragments of some of the same species of fossils, both vegetable and invertebrate, that were found to characterize the Laramie strata in the hills five miles to the northward, which have already been discussed. The fact has already been stated, that although the plane of division between the Laramie and Fox Hills Groups in this neighborhood is quite plainly recognizable, it is marked by no unconformity, nor by any such abrupt change in the character of the deposits as would prove a break to have taken place in the continuity of sedimentation. Thus we find a purely marine condition indicated for the origin of the stratum affording the fossils of the following list, and a brackish-water condition for that of all the strata which are more than 100 or 200 feet above it, which condition continued unchanged through a deposition of strata nearly or quite 4,000 feet in thickness:

LIST OF CRETACEOUS FOSSILS FROM A CAÑON SIX MILES NORTHWEST FROM WHITE RIVER INDIAN AGENCY, NORTHWESTERN COLORADO.

1. *Inoceramus barabini* Morton.
2. *Cardium speciosum* Meek & Hayden.
3. *Mactra (Cymbophora) alta* Meek & Hayden.
4. *Anisomyon centrale* Meek.
5. *Actæon woosteri* White?
6. *Baculites ovatus* Say.

NOTES ON THE CRETACEOUS FOSSILS FROM NEAR WHITE RIVER INDIAN AGENCY.

1. *Inoceramus barabini* Morton.

Examples of this species were found to be quite abundant at some places in the fossiliferous stratum in which they were found. They seem to agree well with the typical forms of the species.

2. *Cardium speciosum* Meek & Hayden.

This species has not been found so common west of the Rocky Mountains as east of them. Besides this locality, I also found it at that of Dodds's Ranch, presently to be noticed. In these western localities it appears to possess all the characteristics of the typical examples. Its presence here, associated as it is with the next following species, indicates that the strata containing it are the uppermost of the series.

3. *Mactra* (*Cymbophora*) *alta* Meek & Hayden.

So far as I am aware, no example of this species has ever been found in any other than the uppermost strata of the Fox Hills Group. It is, therefore, valuable here as indicating the highest horizon of the group; which is also indicated by the position of the strata in relation to those of the Laramie Group. For remarks on this and the two preceding species, see foregoing pages; and for figures and descriptions, see vol. ix, U. S. Geol. Sur. Terr.

4. *Anisomyon centrale* Meek.

The examples found here seem to be referable to this species, but they might with equal propriety be referred to some one of those which Mr. Meek has described from the Upper Missouri River region, all of which are difficult of separation. *Anisomyon* appears to range higher in the Fox Hills Group west of the Rocky Mountains than east of them. I have never before found it associated with either of the two foregoing species.

5. *Actæon woosteri* White.

A single fragment was found, associated with the fossils of the foregoing list, that seems to belong to this species, which has been hitherto found only in Southern and Eastern Colorado.

6. *Baculites ovatus* Say.

It has already been shown that this species is not known to range to the top of the Fox Hills Group in the Upper Missouri River region, nor in Eastern Colorado. Here, however, it is not only found in the uppermost strata of that group, but it is associated with species that are regarded as especially characterizing its highest fossiliferous horizon.

These Danforth Hills localities are especially interesting, because they contain, in one and the same exposure of strata, fossiliferous horizons that are respectively characteristic of the Fox Hills and Laramie Groups within comparatively a few feet of each other, and with no unconformity of strata between them. It seems, therefore, conclusive that the change from a marine to a brackish condition of the waters, and the consequent total change of aqueous fauna, took place in consequence of movements that occurred elsewhere, but which were not sufficient here to break the continuousness of sedimentation.

The structural geology of this region having been reported on by me for the year 1876, all relating to it, except matters of a paleontological character, will be omitted from this report. Proceeding down the valley of White River a few comparatively unimportant collections were made on the way. The first of these was made from Wasatch strata from point to point between Piñon Ridge and Raven Park, where the upper strata of that group were found exposed in the valley of White River. The fossils collected were not abundant, and consisted of only five species, most or all of which are known to pass up into the Green River Group at other localities.

LIST OF FOSSILS OF THE WASATCH GROUP COLLECTED IN WHITE RIVER VALLEY, COLORADO.

1. *Unio shoshonensis* White.
2. *Unio washakiensis* Meek.
3. *Physa pleromatis* White.
4. *Goniobasis tenera* Hall.
5. *Viviparus paludinæformis* Hall.

NOTES ON THE WASATCH FOSSILS OF WHITE RIVER VALLEY.

1. *Unio shoshonensis* White.

This species is described in Powell's Report on the Geology of the Uinta Mountains, p. 126, the types having been collected from different portions of the Green River Group in Southern Wyoming. Not only this, but also all the other species of the foregoing list, except *Physa pleromatis*, are known to range from the Wasatch Group into, and part of them entirely through, the Green River Group.

2. *Unio washakiensis* Meek.

Mr. Meek described this species in the Ann. Rep. U. S. Geol. Sur. Terr. for 1870, p. 314. It is quite a common species in both the Wasatch and Green River Groups, but it is seldom, if ever, found well preserved. Among typical examples of this species were found some that are at least one-third larger than Mr. Meek's types. Being only in the condition of casts, their specific determination was not satisfactory, and it is possible they represent a new species.

3. *Physa pleromatis* White.

This species is described and figured in vol. iv, Expl. and Sur. West of the 100th Meridian, the types having been collected at Last Bluff, Utah. It is not an uncommon species in the Wasatch Group in Utah, Wyoming, and Colorado. An example found in White River Valley is remarkably large, fully double the size of the type, and the largest example of the genus known to me.

4. *Goniobasis tenera* Hall sp.

In Fremont's Report on Oregon and North California, 1845, Professor Hall described and figured *Cerithium tenerum* and *C. nodulosum*, both of which, without doubt, belong to the genus *Goniobasis*, and both are doubtless of the same species. *G. tenera* being the first in order of description in that report, that name is used as the proper name of the species. In Proc. Acad. Nat. Sci. Philad. 1860, Meek described a form from Wyoming under the name of *Melania simpsoni;* and in the Am. Jour. Conch. 1868, Conrad described another, from Wyoming, under the name of *G. carteri*, both of which are other synonyms of *G. tenera*. In the An. Rep. U. S. Geol. Sur. Terr. for 1870, Meek changed *G. nodulosum* Hall sp. to *G. nodulifera*, because the former name was preoccupied by Lea for a recent species. This was unnecessary, because both are other synonyms of *G. tenera*. Several distinct species of *Goniobasis* are known to exist in the Laramie Group, but so far as I am able to discern, only one species of that genus has yet been collected from either of the three great fresh water deposits of the west, namely, the Washakie, Green River, and Bridger Groups. This species is subject to great inter-specific variation, and is known to range through the greater part of the Wasatch Group; through the Green River Group; and is believed to range well up into the Bridger Group also. It has even a greater variation than is indicated by the fact that it has already received three specific names, because a variety which I collected at Tabor Mountain in Southern Wyo-

ming is more spinous and otherwise more strongly marked than any of those other forms which have received separate specific names. The examples of this species found in the valley of White River are large, some of them being more than two inches in length, and correspond with Hall's figure and description of the variety *nodulosum* more nearly than the other varieties do.

5. *Viviparus paludinæformis* Hall sp.

This species was described in the same report together with the preceding species under the name of *Turbo paludinæformis*. It is a constant associate of *Goniobasis tenera*, and at none of the very many localities where I have collected these two species I have never found either of them unaccompanied by the other. This species varies comparatively little, even in the different groups in which it has been found. Only one other species of the genus has yet been found in either the Wasatch, Green River, or Bridger Group. This is *V. wyomingensis* Meek, which has been found only in the Bridger Group. *V. paludinæformis* apparently ranges up into the lower portion of the Bridger Group.

The fossiliferous horizon that furnished the fossils of the foregoing list was also found among the upturned strata of Raven Ridge, west of Raven Park. The ridge has its southeastern end at the western side of Raven Park and its northwestern end near Section Ridge, a spur of Yampa plateau. In the upper portion of the Wasatch Group, near the northwestern end of Raven Ridge, I obtained an abundance of specimens of *Goniobasis tenera* and a few of *Viviparus paludinæformis*. Near the southeastern end of the ridge and at the same horizon I obtained a few examples of both those species together with some of *Unio washakiensis* and *U. shoshonensis*. The Green River Group is abundantly shown in this region, in all the peculiarities which characterize the group at its typical localities, and yet no distinct plane of demarkation or place of separation between it and the Wasatch Group could be anywhere recognized.

While passing down the valley of White River from Agency Park to Raven Ridge the strata of the Laramie Group came frequently under observation. They were there found to possess all their usual lithological characteristics, and also to contain the great abundance of plant remains that was observed in the Danforth Hills. The only invertebrate fossils, however, that were found in its strata in that region were occasional examples of *Ostrea glabra*, which was found to range nearly to the base of the group. Directly north of Raven Park and about midway between White River and Midland Ridge I found numerous examples of *Halysites major* Lesquereux in layers that belong either to the base of the Laramie or to the top of the Fox Hills Group. The horizon is doubtless precisely the same as that at which this fucoid occurs at the mouth of the Saint Vrain's and elsewhere in Eastern Colorado.

From a point on White River about twenty miles below Raven Park I crossed to Section Ridge over the broad bad-land district that lies to the northward. The dip of the Green River strata which border the lower portion of White River Valley is gently to the northward where I traversed them. About eight or ten miles north of White River I found them to pass beneath characteristic strata of the Bridger Group, containing fragments of mammalian and chelonian remains. These Bridger strata occupy only a very small area of surface in the immediate valley of Red Bluff Wash, and are overlaid by the strata of the Uinta Group, which occupy the greater part of the surface of this bad-land district bordering Green River Valley. They rest unconformably upon strata

of all ages in this region from those of the Colorado to the Bridger Group, inclusive. As to its unconformity upon the Bridger strata, however, my observations south of the Uinta Mountains alone would not prove, but I found such unconformity a few years ago in the valley of Snake River, north of Junction Mountain.

Leaving the region of the White and Yampa Rivers I crossed Green River by a ford a few miles below Split Mountain and continued my journey westward after making some observations from that mountain to add to my report for the year 1876. After crossing Green River I spent some time in examining the geology of the district on the west side adjacent to the southern base of the Uinta Mountains, especially in the valleys of Brush Creek and Ashley's Fork. In this district, as well as in that which lies immediately upon the other side of Green River, I made some observations that have a most important bearing upon the proper correlation of the different groups of strata which geologists have recognized, but more especially those of Cretaceous age. In a large part of Colorado, Wyoming, and Utah the two Cretaceous groups, which in the classification modified from that which was originally adopted by Hayden and Meek for the Upper Missouri River region are designated as the Colorado and Fox Hills Groups, have been found so constant in their general lithological characteristics that field geologists have usually made these the basis of their classification of the strata, often ignoring the paleontological features entirely. My own investigations have led me to the conclusion that the paleontological characteristics of these groups are far more constant and reliable than the lithological, and this fact is especially exemplified in the district in question. Generally the plane upon which the Colorado and Fox Hills Groups are separated is marked by a more or less sudden change from a shaly or uncompacted sandy material below to ordinary stratified sandstone above. A large part of the Colorado Group, especially toward its base, is also usually made up of bluish clayey and sandy shales, with usually a horizon of bluish fissile shales at or very near the base of the group. Often, however, the lithological change from the Colorado to the Fox Hills Group is very obscure, the sandy shales of the lower group extending far up into the upper one.

In the district adjacent to Green River, at the southern base of the Uinta Mountains, more than half the thickness of the Fox Hills Group is inseparable from the Colorado Group by lithological characters, and their separation is thus practicable only by means of their respectively characteristic fossils. It is true that the relative thickness of these two groups varies very considerably in different districts, and this fact is never more plainly or truthfully shown by lithological than by paleontological features. In short there is, as a rule, in all the great western region, a distinctly recognizable paleontological horizon separating the two groups in question, irrespective of lithological variation, above and below which certain species respectively do not pass. For example, on both sides of the Rocky Mountains I have found *Inoceramus deformis* Meek, *I. problematicus* Schlotheim, and *Ostrea congesta* Conrad quite common if not abundant in the Colorado Group, while none of the Cretaceous species of any of the foregoing lists in this report have been found in that group, but all belong above it.*

* In my report upon the invertebrate fossils of Professor Powell's collections, in chapter III of his Geology of the Uinta Mountains, a considerable number of the Cretaceous species there discussed are referred to the Colorado Group (= Sulphur Creek Group of Powell), which I have now no doubt properly belong to the Fox Hills Group (= Salt Wells Group of Powell). The error made by the collectors, of referring the fossils to wrong groups, no doubt occurred in consequence of the lithological changes that have taken place in their strata, which has just been explained.

In the valley of Brush Creek I observed several more or less massive layers of sandstone distributed in the softer layers of the Colorado Group, the like of which I have not seen elsewhere in that group. Just north of Dodds's Ranch, in the valley of Ashley's Fork, a high hogback of sandstone rises up toward the flank of the mountains from the valley-plain of that stream. As one approaches it by going up the valley it has the appearance of the usual hogback of the Dakota Group, which appears almost everywhere at the flanks of the mountains, especially as the plain is known to be in part, and so far as the lithological characters of the strata can be observed beneath the surface *débris* it appears to be wholly, occupied by the strata of the Colorado Group. In fact, however, as proved by the fossils, a large part of the valley-plain is occupied by strata of the Fox Hills Group which are as soft and easily eroded as those of the Colorado Group are; and the hogback referred to constitutes the lower portion of the former group. From the strata of this hogback I collected the following fossils:

LIST OF CRETACEOUS FOSSILS AT DODDS'S RANCH ON ASHLEY'S FORK, UTAH.

1. *Inoceramus howelli* White.
2. *Cardium speciosum* Meek & Hayden?
3. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.
4. *Anchura* ——— ?

NOTES ON THE CRETACEOUS FOSSILS FROM ASHLEY'S FORK.

1. *Inoceramus howelli* White.

This species was originally discovered by Mr. E. E. Howell in Southern Utah, and was described by me in Powell's Report on the Geology of the Uinta Mountains, p. 114, where it was referred to a much lower horizon than it is now believed to occupy. It is redescribed and illustrated in another part of this volume.

2. *Cardium speciosum* Meek & Hayden.

Some casts of a *Cardium* in soft sandstone were found among the other specimens that seemed to belong to this species, but they are too imperfect to allow of satisfactory determination. If they really belong to this species it has here as low a range in the Fox Hills Group as it was found to have in Eastern Colorado, which, however, is not improbable.

3. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden.

Although the examples found here are in the form of casts, their identity with this species seems hardly questionable. For further remarks on this and the next preceding species, see notes on the fossils of the Fox Hills Group in Colorado, east of the Rocky Mountains.

4. *Anchura* ——— *?*

Some casts only of this species were found, and they are too imperfect for specific determination. They probably belong to *A. fusiformis* Meek.

These fossils, although imperfect, are too clearly characteristic of the Fox Hills Group to admit of doubt as to the age of the strata containing them. To the north of the hogback, composed of these strata, those of the Colorado and Dakota Groups are seen to rise successively, and to rest in order upon the Jura-Trias. Both the Colorado and Dakota Groups, especially the former, are here of much less than their usual thickness,

but they are unmistakable in their lithological characteristics, and yet the latter does not here form a hogback as it usually does elsewhere.

Proceeding westward from Ashley's Fork my journey, after the first three or four miles, was over the Uinta Group until we reached Lake Fork. This group is much more extensively developed in this region than I have anywhere seen it before. It is many hundred feet in thickness, and it is quite as regularly stratified as any of the other fresh water Tertiary deposits of the West. In some places, as for example, in the vicinity of Green River, south of the Uinta Mountains, it is largely composed of soft, bad-land sandstones, having a general reddish color. But further westward it assumes a somewhat darker hue and character of quite regularly bedded sandstones, some of which are soft, but many of the strata are firm and even massive. At Wonsitz Ridge, four miles west of Dodds's Ranch, it rests unconformably upon the Laramie Group, and at Lake Fork on the Uinta and Salt Lake trail, some forty miles further west, it is found to rest upon the Bridger Group, as it was shown to do near White River, in my report for 1876.

No fossils of any kind were found by myself in the Unita Group this year, but in 1875, I obtained a *Physa* from it in the valley of Snake River, a few miles above Junction Mountain. The Uinta Group, as already shown, is regarded as equivalent with the Brown's Park Group of Powell; and it is probably also equivalent with the Lake Beds of Middle Park.

Three or four hundred feet in thickness of the strata of the Bridger Group are exposed in the valley side of Lake Fork, which have there all the peculiar lithological characteristics which they possess at the typical localities north of the Uinta Mountains, even including the various tints of coloration and the style of weathering of the bad-land sandstones of which the formation is largely composed. From these strata I made a very good collection of vertebrate fossils, consisting of Ganoid, Chelonian and Mammalian remains, but the only invertebrate form I discovered was the well known *Planorbis Utahensis* Meek (= *P. spectabilis* Meek.)

Following the trail, the course of which lies south of the wagon-road, to the east fork of the Duchesne, I found near the crossing some limited exposures of Bridger strata in its valley side, with those of the Uinta Group resting upon them, but I obtained no fossils there. Still following the obscure trail before mentioned, our journey from the east fork of the Duchesne to the main stream was over sandy barrens with here and there an exposure of sandstone. Upon reaching the latter stream I found it to run in a cañon or deep monoclinal valley excavated out of the Green River Group. The dip of these strata at the valley where I examined it is three or four degrees to the northward or northeastward, but as they are seen in the high hills south of the valley the dip seems to be considerably more there. This dip seems to be part of a broad accessory fold, subordinate to the Uinta Mountain uplift, by which these Green River strata have risen from beneath those of the Bridger Group that were seen on Lake Fork and the east fork of the Duchesne. No fossils were found in these Green River strata although diligent search was made, but the lithological characteristics are the same as they are at the typical localities north of the Uinta Mountains, the upper and lower divisions of the group being plainly recognizable. The thickness of the group as seen in this region is estimated at about 1,000 feet, but as the base was not visible where the upper division was observed, the entire thickness of the group here is probably equal to that which it attains at the typical localities. The cañon of the Duchesne, where I observed it, has high precipitous sides, and is in all respects like that

of the lower portion of White River, which is cut through the same formation.

Continuing my journey I proceeded up the north valley side of the Duchesne to the first creek that comes into it from the northward, and then up the valley of that creek to the wagon-road. None but Green River strata were seen on the way until we reached a point two or three miles south of the wagon-road, where strata that appear to be the top of the Wasatch Group were seen. At and in the vicinity of the point where the wagon-road crosses the creek the Uinta Group is seen to rest unconformably upon the Green River Group, the latter having been somewhat tilted and in some places much eroded before the deposition of the latter.

After leaving the valley of the Duchesne only a few important observations were made concerning the structural geology of the region traversed between there and Salt Lake, and no fossils were obtained from any of the strata over which we passed. All along the southern flank of the Uinta Mountains drift phenomena were observed, similar to those already noticed as observable along the eastern flank of the Rocky Mountains and in Middle Park; and also similar to those at the western base of the Rocky Mountains, which are discussed at some length in my report for 1876. The bowlders and pebbles composing the drift found along the southern flank of the Uinta Mountains is composed entirely of the rocks that make up the bulk of those mountains. There being no granite in that range, of course none is found in the drift along its flanks, wherein it differs materially from that which is distributed along both the eastern and western flanks of the Rocky Mountains, which are largely composed of granite. The drift is found almost everywhere distributed upon the surface, upon the uplands and valleys alike. In some places it is abundant, and in others almost wanting. The terraces are all more or less strewn with it, especially their abrupt sides. The beds of the streams are often so thickly covered with its bowlders as to make crossing by our animals both difficult and dangerous.

Some of the terraces along the flanks of the Uinta Mountains are quite conspicuous objects, their upper surfaces having a very gentle slope away from the foothills. The upper, flat, gently sloping surface is apparently due to erosion and not to aqueous deposition, because the deposit of gravel and bowlders upon it is generally, if not always, thin, while similar surfaces are produced indiscriminately upon the strata of the Colorado to the Uinta Groups inclusive. Moreover the surfaces of these terraces have a general correspondence with each other, while the strata out of which they are carved are tilted at various angles.

Leaving our camp at the wagon-road crossing of the creek before referred to, our way westward was along the line of strike of the Uinta Group, the dip being gently to the southward. Not far to the southward a line of hills was seen, parallel with our course, which are doubtless mainly composed of strata of the Green River Group; but I lost sight of that formation after crossing Red Creek. After crossing this creek we came upon strata that are doubtless of Cretaceous age, but these were soon passed, and none but Uinta strata were seen on our way until we reached the head of Strawberry Valley. From this valley our way was again over strata of the Uinta Group to Provo Valley, by way of Daniel's Cañon. This cañon is a long, deep gorge between high hills, which are, according to King, composed of Uinta strata. They, however, differ considerably in lithological character from any of those of that formation which I have hitherto observed. The rock is of a slightly

yellowish-gray color, and although its stratification is regular, it seems to have undergone some degree of metamorphism.

From Provo Valley our journey was by the wagon-road to Salt Lake City. At the museum in the city Mr. Barfoot showed me some fossils that had been collected at different places in the Territory, among which I recognized some of the species, specimens of which were brought from Upper Kanab, Southern Utah, by Professor Powell, whence these also are reported to have come. After renewing my outfit at Salt Lake City I turned eastward, going by way of Parley's Park, to Coalville, on Weber River, where a large series of fossiliferous Cretaceous strata is exposed.

In the An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 439, Mr. Meek gives, as the result of his investigations in Weber Valley, a detailed section of the strata exposed there, from the vicinity of Coalville to Echo Cañon. This section was found to represent, with sufficient accuracy, the Cretaceous strata of that vicinity, except that there seems to be in it, near the southeastern end, some duplication of strata, doubtless caused by the presence of a fault there. This, however, does not seriously impair the usefulness of the section. About 3,000 feet in thickness of these strata are fossiliferous, many of them profusely so. The following list comprises only those that have been found within the compass of this section, in the neighborhood of Coalville.

The greater part of the species of the following list were published by the late Mr. Meek in the Am. Rep. U. S. Geol. Sur. Terr. for 1872, and vol. iv U. S. Geol. Sur. 40th Parallel. Other publications of a part of them were made by myself in vol. iv U. S. Sur. & Expl. West of 100th Meridian, Powell's Report on Geol. Uinta Mts., and in another part of the present volume.

LIST OF FOSSILS FROM THE CRETACEOUS SERIES AT COALVILLE, UTAH.

1. *Ostrea solenicus* Meek.
2. *Ostrea coalvillensis* Meek.*
3. *Ostrea congesta* Conrad?
4. *Ostrea* (*Alectryonia*) *sannionis* White.†
5. *Gryphæa* ———?
6. *Anomia* ———?
7. *Pteria* (*Pseudoptera*) *rhytophora* Meek.†
8. *Pteria* (*Pseudoptera*) *propleura* Meek.
9. *Pteria gastrodes* Meek.†
10. *Inoceramus problematicus* Schlotheim.‡
11. *Inoceramus erectus* Meek.*
12. *Inoceramus* ———?
13. *Pinna* ———?
14. *Volsella* (*Brachydontes*) *multilinigera* Meek.
15. *Barbatia coalvillensis* White.†
16. *Macrodon* ———?
17. *Unio* ———?
18. *Lucina* ———?
19. *Cardium curtum* Meek & Hayden.*
20. *Cardium subcurtum* Meek.*
21. *Cyrena carletoni* Meek.
22. *Cyprimeria? subalata* Meek.*

*Figured in vol. iv U. S. Geol. Sur. 40th Parallel. (King.)

†Figured in another part of this volume.

‡Figured in vol. iv Expl. & Sur. West of 40th Meredian (Wheeler). The other species not yet figured, but they are all described or noticed in An. Rep. U. S. Geol. Sur. Terr. for 1872.

23. *Tellina? isonema* Meek.*
24. *Tellina? modesta* Meek.*
25. *Tellina* (*Arcopagia*) *utahensis* Meek.*
26. *Corbula nematophora* Meek.†‡
27. *Corbula dubiosa* White.*
28. *Martesia* ——— ?
29. *Melampus antiquus* Meek.
30. *Physa carletoni* Meek.†
31. *Physa* ——— ?†
32. *Neritina bannisteri* Meek.
33. *Neritina pisum* Meek.†
34. *Neritina pisiformis* Meek.
35. *Neritina* (*Velatella*) *bellatula* Meek.
36. *Neritina* (*Velatella*) *carditoides* Meek.
37. *Neritina* (*Velatella*) *patelliformis* Meek.†
38. *Neritina* (*Velatella*) *patelliformis* var. *weberensis* White.†
39. *Euspira coalvillensis* White.†
40. *Gyrodes depressa* Meek.*
41. *Anchura fusiformis* Meek.*
42. *Turritella coalvillensis* Meek.†
43. *Turritella spironema* Meek.
44. *Turritella* (*Aclis?*) *micronema* Meek.†
45. *Turbonilla* (*Chemnitzia?*) *coalvillensis* Meek.†
46. *Eulimella? inconspicua* Meek.
47. *Eulimella? chrysalis* Meek.
48. *Eulimella? funicula* Meek.†
49. *Valvata nana* Meek.
50. *Fusus* (*Neptunea?*) *gabbi* Meek.†
51. *Fusus* (*Neptunea?*) *utahensis* Meek.
52. *Admetopsis rhomboides* Meek.†
53. *Admetopsis gregaria* Meek.‡
54. *Admetopsis subfusiformis* Meek.†
55. *Baculites ovatus* Say?*‡

NOTES ON THE CRETACEOUS FOSSILS OF COALVILLE, UTAH.

1. *Ostrea soleniscus* Meek.

This remarkable oyster ranges through something more than the upper half of the fossiliferous series that is exposed in the vicinity of Coalville. So far as I am aware it has been found only in the region bordering the eastern flank of the Wasatch Mountains.

2. *Ostrea coalvillensis* Meek.

This species is very much like the forms of *O. glabra* which are found at Point of Rocks Station and elsewhere in the Laramie Group, to which Mr. Meek gave the name of *O. wyomingensis*. It is assumed to be of a different species because of its known difference of geological position, but comparatively little is known concerning it, as only a few examples have been found.

3. *Ostrea congesta* Conrad?

Numerous examples of a small oyster were found attached to the large

*Figured in vol. iv U. S. Geol. Sur. 40th Parallel. (King.)
†Figured in another part of this volume.
‡Figured in vol. iv Expl. & Sur. West of 100th Meridian (Wheeler). The other species not yet figured, but they are all described or noticed in An. Rep. U. S. Geol. Sur. Terr. for 1872.

examples of *Inoceramus erectus* Meek, which were obtained from No. 24 of Mr. Meek's section, at the upper part of the fossiliferous series. It is difficult if not impossible to say how it differs from *O. congesta* Conrad; and its identity with that species is still further suggested by the similarity if not identity of *I. erectus* with *I. deformis* Meek of the Colorado Group, which is usually found to have lived commensally with *O. congesta*, as the *Ostrea* in question is seen to have done with *I. erectus*. It was for these reasons and for the want of access to types or illustrations that I referred this *Ostrea* and its commensal *Inoceramus* to *O. congesta* and *I. deformis* respectively, in Powell's Report on the Geology of the Uinta Mountains, p. 99.

4. *Ostrea* (*Alectryonia*) *sannionis* White.

This well-characterized species has been found only at Coalville, and only in the strata representing the space between Nos. 18 and 19 of Mr. Meek's section.

5. *Gryphæa* ——— ?

Only a couple of imperfect examples of this species were found, but it seems to be properly a *Gryphea*. If so, it is interesting as occurring at a higher horizon than usual in the Cretaceous series of the West. It occurs in No. 11 of Mr. Meek's section, with many other species.

6. *Anomia* ——— ?

Some fragments of an *Anomia* were found associated with the last-named species, and Mr. Meek also mentions the occurrence of one in No. 17 of his section, where it is associated with brackish- and fresh-water forms, intermixed with some marine forms.

7, 8, and 9.

These three species of *Pteria* are from the second ridge represented in Mr. Meek's section; and, so far as I am aware, neither of them have been found elsewhere.

10. *Inoceramus problematicus* Schlotheim.

Meek reports this species from No. 7 of his section, near the village. I found the same at Old Bear River City, thirty-five miles to the northeastward, associated with species that occur in the second ridge at Coalville, the strata of which are considerably higher in the series than those from which Mr. Meek obtained his specimens. The former horizon is certainly within the limits of the Fox Hills Group, while the latter possibly falls within those of the Colorado Group.

11. *Inoceramus erectus* Meek.

It is this species that has already been referred to under the head of No. 3, as differing but little from *I. deformis*. In the classification adopted in Powell's Report on the Geology of the Uinta Mountains, I referred the strata containing this species to the base of the Laramie Group (=Point of Rocks Group of Professor Powell). At that time it was not uncommon for different geologists to include some of the uppermost marine Cretaceous strata in the Laramie Group. Now, however, I never intentionally include any truly marine strata in that group.

12. *Inoceramus* ——— ?

See remarks under No. 29.

13. *Pinna* ——— ?

Known only by fragments discovered by Mr. Meek.

14. *Volsella* (*Brachydontes*) *multilinigera* Meek.

This species was found in the sandstones of the first ridge at Coalville. I have also found examples, probably of the same species, in apparently equivalent strata, in the valley of Bear River, some thirty-five miles to the northeastward of Coalville.

15. *Barbatia coalvillensis*, White.

A considerable number of examples of this species were also found in the sandstones of the first ridge shown in Mr. Meek's section. It seems never to have been discovered elsewhere.

16. *Macrodon* ——— *?*

The examples referred by Mr. Meek to *Macrodon* have never been seen by me. An imperfect example found by me, and apparently referable to this genus, indicates a rather large elongate species.

17. *Unio* ——— *?*

See remarks under head of No. 29.

18. *Lucina* ——— *?*

The few examples found were obtained from No. 3 of Meek's section. They seem to indicate a species closely allied to, if not identical with, *L. subundata* Hall & Meek.

19. *Cardium curtum* Meek & Hayden.

The proper horizon of the types of this species, which were obtained by Dr. Hayden on the Gros Ventres River, Wyoming, seems not to have been ascertained. It is therefore of no present value for the purpose of correlating those strata with those which contain this species at Coalville.

20. *Cardium subcurtum* Meek.

Besides the specimens obtained from No. 3, of Meek's section, I obtained others from some of the sandstones of the third ridge, which is much higher in that series. I also obtained some examples of it near Old Bear River City, which were associated with forms which indicate that the strata there belong to the Fox Hills Group.

21. *Cyrena carletoni* Meek.

The differences between the recognized genera *Cyrena* and *Corbicula* are so slight as to be of doubtful generic importance as regards fossil shells. I am not acquainted with any species from the Cretaceous strata of the West, except the one in question, that is referable to either of these generic forms, the examples of which have the hinge so perfectly preserved as to show the crenulations of the lateral teeth if they had ever existed. I have, therefore, referred all such to *Cyrena*, although in outward form they closely resemble some of those Laramie shells that I refer to *Corbicula*. This species, however, seems to have been entirely without crenulations of the lateral teeth, and Mr. Meek has no doubt correctly referred it to *Cyrena*. As to its associates, see remarks under No. 29.

22. *Cyprimeria? subalata* Meek.

The examples of this and the three following species collected by me afford no further information concerning their characteristics than is recorded by Mr. Meek in vol. iv., U. S. Geol. Sur. 40th Parallel.

23. *Tellina? isonema* Meek.

See remarks under No. 22.

24. *Tellina? modesta* Meek.

See remarks under No. 22.

25. *Tellina* (*Areopagia*) *utahensis* Meek.

See remarks under No. 22.

26. *Corbula nematophora* Meek.

Meek reports the type specimens of this species from Southern Utah. I figured an example from that region in vol. iv, U. S. Expl. and Sur. West of the 100th Meridian, which is probably of this species. The examples that I have referred to at Coalville were found associated with true marine, and not brackish-water, forms; as is also the following species. A figure of Mr. Meek's type is also given in another part of this volume.

27. *Corbula dubiosa* White.

Found also in the valleys of Bear River and Sulphur Creek. See notes on Cretaceous fossils of Bear River Valley.

28. *Martesia* ——— ?

Too imperfect for specific determination.

29. *Melampus antiquus* Meek.

In No. 16 of Mr. Meek's section, which he found exposed in Carleton's coal-mine about two miles southwestward from Coalville, he discovered a very interesting group of fossils, being Nos. 12, 17, 21, 29, 30, 32, 35, 36, 46, 47, and 49 of the foregoing list. Soon after his visit there the mine was abandoned and the fallen *débris* has so obscured the strata that no further collections from them have ever been made. Neither has any discovery of this deposit ever been made in the neighborhood or elsewhere, although one or two of the species have been doubtfully identified from Cretaceous strata elsewhere in Utah. Two of these eleven species of mollusks, Nos. 29 and 30, are palustral or littoral pulmonates; two, Nos. 17 and 49, are fresh-water branchifers; four, Nos. 21, 32, 35, and 36 are brackish-water forms, and the remaining three species, Nos. 12, 46, and 47, may be regarded as marine forms. To the latter may be added a *Cardium*, mentioned by Mr. Meek, but not enumerated in the foregoing list; and to either the brackish or marine forms may be added the *Anomia*, also mentioned by Mr. Meek as occurring with the others. This last-named species may be identical with the one found by myself in the sandstones of the second ridge and mentioned under the head of No. 6; but it is probably not the same.

This mixture of palustral, fresh- and brackish-water and marine mollusks may be taken to indicate an estuary origin of the strata containing them, although a somewhat similar admixture is found in a large part of the Laramie Group, extending over an area so wide as to make it certain that these deposits at least were made in a large, brackish-water sea. However, the evidently limited extent of this Coalville deposit, and the presence in it of so large a proportion of marine forms, may be regarded as almost certainly indicating its true estuary origin. This view is also supported by the evidence that a western shore-line to the Cretaceous sea existed not far distant from this locality. The *Physa*, No. 31 of the list, was found among the marine forms of the sandstones of the second ridge of Mr. Meek's section. This also indicates a then neighboring shore-line, but not necessarily an estuary; but the presence of brackish- and fresh-water branchiferous mollusks, as in No. 16 of that section, seems to plainly indicate an estuary origin of the strata containing them. These last-named mollusks, as well as their pulmonate associates, are

remarkably modern in type, and, seen separately, and without any knowledge to the contrary, no paleontologist would be warranted in referring them to an earlier period than the Tertiary.

The evidence of their Cretaceous age, however, is unquestionable, there being more than 1,000 feet in thickness of marine Cretaceous strata resting upon them; and more than an equal thickness of Cretaceous strata lies beneath them.

30. *Physa carletoni* Meek.

The figure of this species in another part of this volume shows plainly its modern type. For further remarks concerning it and its associates, see No. 29.

31. *Physa* ——— ?

This is possibly identical with *P. carletoni*. See a figure of it in another part of this volume; and also remarks under No. 29.

32. *Neritina bannisteri* Meek.

This is apparently a typical *Neritina*. See under No. 29 for general remarks upon its associates.

33. *Neritina pisum* Meek.

This is very like the next following species, but it is probably distinct. It is from a calcareous sandstone layer in the first ridge of Mr. Meek's section, associated with Nos. 34, 37, 38, and other species. Although it is of the same type as No. 32, its associates are all marine forms.

34. *Neritina pisiformis* Meek.

See remarks under No. 33.

35. *Neritina* (*Velatella*) *bellatula* Meek.

Mr. Meek discovered this species together with No. 36 in stratum No. 16 of his section at Coalville, associated with other brackish- and fresh-water forms. See remarks under No. 29. Together with Nos. 36, 37, and 38, it belongs to a section of the genus *Neritina*, to which Mr. Meek gave the subgeneric name of *Velatella*. Some of the associates of Nos. 35 and 36 are both brackish- and fresh-water forms, but those of Nos. 37 and 38 are all marine forms. The only other known species of this subgenus is *N.* (*V.*) *baptista* White, from the Laramie strata at Black Buttes Station, where its associates are both fresh- and brackish-water forms. In vol. iv, Expl. & Sur. West of the 100th Merid., I described and figured a form from Cretaceous rocks of Utah, which I referred to *N.* (*V.*) *carditoides* Meek, but which possibly belongs to another, but closely allied, species. Its associates there are understood to be marine forms only.

36. *Neritina* (*Velatella*) *carditoides* Meek.

See remarks under Nos. 29 and 35.

37. *Neritina* (*Velatella*) *patelliformis* Meek.

See remarks under Nos. 33 and 35.

38. *Neritina* (*Velatella*) *patelliformis* var. *weberensis* White.

See figures and description in another part of this volume.

39. *Euspira coalvillensis* White.

Found only at Coalville and in the first ridge of Mr. Meek's section.

40. *Gyrodes depressa* Meek.

This well-marked species has been found only in the form of casts, and, so far as I am aware, only from the sandstones of the second ridge of Mr. Meek's section.

41. *Anchura fusiformis* Meek.

This species was found associated with No. 39, at Coalville; and also in the Cretaceous sandstones at Old Bear River City, some thirty-five miles to the northeastward, where it is associated with *Inoceramus problematicus* &c.

42. *Turritella coalvillensis* Meek.

This, together with Nos. 33, 34, 36, 43, 44, 45, 48, and other species, was found in a calcareous sandstone layer in the first ridge of Mr. Meek's section at Coalville. It has also been found in Southern Utah.

43. *Turritella spironema* Meek.

See remarks under No. 42.

44. *Turritella* (*Aclis?*) *micronema* Meek.

See remarks under No. 42.

45. *Turbonilla* (*Chemnitzia?*) *coalvillensis* Meek.

This form is much like those in the Laramie beds of Bear River Valley which Mr. Meek and myself have referred to *Goniobasis*. None of the Coalville specimens are entirely perfect, but, so far as I can see, their marine associates only, suggest the impropriety of classifying them generically with the Laramie fossils just mentioned.

46. *Eulimella? inconspicua* Meek.

This, together with No. 35 and other species, was found by Mr. Meek in stratum No. 16 of his section at Coalville, associated with brackish and fresh water forms. See remarks under No. 29.

47. *Eulimella? chrysalis* Meek.

See remarks under Nos. 29 and 45.

48. *Eulimella? funicula* Meek.

This species, unlike the two next preceding ones, which have been referred to the same genus, has marine associates only, having been found at Coalville only in a layer of calcareous sandstone in the first ridge of Mr. Meek's section. I described and figured a form from the North Fork of Virgin River, Utah, in vol. iv Expl. & Sur. West of the 100th Merid., and referred it to this species, with which it is probably identical. It was there associated with a form which I referred to *Admetopsis gregaria* Meek, and the two species are also found associated together at Coalville.

49. *Valvata nana* Meek.

This little shell was discovered by Mr. Meek in stratum No. 16 of his Coalville section. See remarks under No. 29.

50. *Fusus* (*Neptunea?*) *gabbi* Meek.

This and the following species were found in the sandstones of the second ridge of Mr. Meek's section, and, so far as I am aware, they have never been recognized at any other locality.

51. *Fusus* (*Neptunea*) *utahensis* Meek.

See remarks under No. 49.

52. *Admetopsis rhomboides* Meek.

This form and No. 53 are associated together at Coalville, and I believe them to be specifically identical.

53. *Admetopsis gregaria* Meek.

See remarks under Nos. 48 and 52.

54. *Admetopsis subfusiformis* Meek.

This form is figured in another part of this volume from a drawing by Mr. Meek. I have some doubts as to its generic relation with Nos. 52 and 53.

55. *Baculites ovatus* Say?

The only example of any Cephalopod that has been discovered in the whole Cretaceous series at Coalville is a fragment of a small *Baculites* that seems to belong to *B. ovatus* Say. It was found in thin-bedded sandstone immediately overlying the strata from which Mr. Meek obtained the estuary forms that are mentioned under No. 29.

The series of strata exposed at and in the neighborhood of Coalville, as represented by its invertebrate fauna, is a remarkable one in several respects. There can be no doubt of the Cretaceous age of that whole series, of strata, together with its fauna, as shown in the foregoing list of fossils; but yet, out of the fifty-five species there enumerated, only seven, namely, Nos. 5, 10, 11, 12, 40, 41, and 55, indicate the Cretaceous age of the strata, or that they belong to an earlier period than the Tertiary. Out of these fifty-five species also only four of them, namely, Nos. 3, 10, 19, and 55, have been found outside of the region adjacent to the east flank of the Wasatch Mountains and extending southward to Northern Arizona, and the identity of Nos. 3 and 54 is somewhat doubtful. Furthermore, about half of these species have hitherto been found only at and in the immediate neighborhood of Coalville, although they perhaps exist in the equivalent strata of the region that has just been referred to.

The absence from this series of Cretaceous strata at Coalville of such species as characterize the respective Cretaceous groups which have been established makes it impracticable to refer them to any one or more of those groups with certainty. Moreover, although the aggregate thickness of the strata there is greater than we should expect to find any one of those groups to possess the series seems to be a perfectly unbroken one, both stratigraphically and paleontologically. I think there is no reason for doubt that the greater part of the series at least is referable to the Fox Hills Group as it is developed and understood in Colorado and adjacent parts of Utah and Wyoming. The possibility that the lower portion of the series may be referable to the upper portion of the Colorado Group is suggested only by the greater thickness of the series than the Fox Hills Group usually attains, and the presence in those lowest strata of the Coalville section of *Inoceramus problematicus*. On the other hand this species has been found at Old Bear River City associated with forms that occur in the top of the second ridge at Coalville, the strata of which evidently belong to the Fox Hills Group. The real relations of these Coalville strata and their equivalents will doubtless be ascertained by tracing and studying the Cretaceous strata northwardly to the Missouri and Yellowstone Rivers.

These Coalville deposits were probably made in comparatively shallow waters; yet the lithological evidence of it is no greater than that presented by those widespread Cretaceous strata which contain the more common and well-known marine forms. At least, the character of their invertebrate fauna seems to have been greatly modified by the proximity of a then existing western shore to the Cretaceous sea. This view is supported by the presence of palustral, littoral, and estuary forms in some of the strata of the series, but the modification referred to, while doubtless due remotely to the same cause, is separate from such local conditions as gave those estuary mollusks their congenial habitats with-

out modifying their types, and affected all or nearly all the marine species also.

A marked contrast between the invertebrate fauna of the Coalville series and that of the whole Upper Missouri River series is shown in the almost entire absence of Cephalopods from the former, while the profusion and great variety of such forms constitutes a marked faunal feature of the latter. It is hardly to be expected that the equivalents of those Coalville strata, even in that immediate region, will be found to be quite so deficient as the present collections indicate, but a comparative paucity of them there is doubtless the rule. There is also a considerable contrast between the Cretaceous invertebrate fauna of Texas, and the territories adjacent, and that of the Upper Missouri River region, but with which that of the Coalville region has no greater affinity than with the former.

The contrast between the invertebrate Cretaceous fauna of the Coalville region and that of the Upper Missouri River region, together with its representatives in Colorado and Wyoming, has a parallel in the difference between the invertebrate fauna of the Laramie Group as represented in the valley of Bear River and that of the same group in those other regions which have been already discussed in this report; and the contrast in both cases is probably due to similar causes.

From the valley of the Weber I proceeded northward to that of Bear River, for the purpose of examining the Laramie strata there. The strata of this group have been much displaced in the region bordering the western side of Green River Basin, and the areas of surface upon which they are exposed are few and small compared with those more eastern regions of the Laramie Group which have already been noticed. This displacement of the Laramie strata has caused them to be unconformable with the Wasatch beds that rest upon them, the degree of unconformity being great in some places and only slight in others. This condition of the strata will be considered on a subsequent page, in connection with the apparently uninterrupted deposition of both the Laramie and Wasatch Groups farther eastward. The only localities of Laramie strata which I visited in this region are in two neighborhoods a few miles apart, in the valley of Bear River. The principal of these localities are in the neighborhood of the crossing of the Union Pacific Railroad, near Mellis Station on that railroad, and also near the mouth of Sulphur Creek and some eight or ten miles southeastward from Evanston, Wyo. The Laramie strata exposed in this neighborhood are those which are represented by Mr. Meek in No. 28 of his section of the rocks of that vicinity, as shown on page 451, An. Rep. U. S. Geol. Sur. Terr. for 1872, and which have become so generally known as the "Bear River Estuary Beds." They are there about 500 feet in thickness, and conformably with them, in upward order, about 200 feet in thickness of dark gray shales occur, which contain teliost fish-scales; but no other fossils were obtained from them. My examination of this neighborhood added little to a knowledge of these strata beyond that which had already been published by Mr. Meek and Mr. King, except that I found them quite fully exposed on the west side of the river, which fact is not shown on Mr. King's map, nor mentioned by Mr. Meek. My collections, however, embrace some species not before known.

The Laramie strata of the other neighborhood comprise the exact equivalents of those near Mellis Station, and contain an abundance of the same fossils, together with the Evanston coal series, the best development of which appears at the little hamlet of Almy, three miles northward from Evanston. From that point to about four miles farther north-

ward these Laramie strata are found exposed in the east valley-side of Bear River. This coal-bearing series contains an entirely different fauna from that of the beds beneath; but because of its apparent stratigraphical conformity with them, and the fact that some of its fossils have been identified with Laramie fossils elsewhere, I refer the whole to the Laramie Group. The equivalent strata in this neighborhood of the dark gray shales in the other, which contain the teliost fish-scales, are a little greater in aggregate thickness, and a portion of them are composed of thicker layers, but their identity is easily recognized. For convenience of reference in the following remarks I shall designate these, together with the coal-bearing series, as the "upper beds"; and those beneath them, containing the brackish-water fossils, I shall, for the same purpose of local reference and present discussion, use the term "lower beds." Of invertebrate fossils only fresh-water and land shells have been found in the upper beds, and these only at the Almy or Evanston-coal mines; but those of the lower strata embrace both brackish and fresh water molluscan forms, the latter including a few palustral pulmonates. Among those brackish and fresh water forms are two or three types which have never been recognized except in these lower beds or their immediate equivalents, and nearly their whole fauna is in marked contrast with that of any other portion of the Laramie Group. The following list is intended to embrace all the invertebrate fossils that have hitherto been found in the Laramie strata of Bear River Valley within the limits of Southwestern Wyoming:

LIST OF LARAMIE FOSSILS FROM BEAR RIVER VALLEY, WYOMING.

1. *Membranipora*?
2. *Ostrea* ——— ?
3. *Volsella* ——— ?
4. *Unio vetustus* Meek.
5. *Unio belliplicatus* Meek.
6. *Pisidium saginatum* White.
7. *Sphærium* ——— ?
8. *Corbicula* (*Veloritina*) *durkeei* Meek.
9. *Corbula pyriformis* Meek.
10. *Corbula Englemanni* Meek.
11. *Rhytophorus priscus* Meek.
12. *Rhytophorus meeki* White.
13. *Limnæa* (*Limnophysa*) *nitidula* Meek.
14. *Acella haldemani* White.
15. *Planorbis* ——— ?
16. *Bulinus longiusculus* Meek & Hayden.
17. *Bulinus subelongatus* Meek & Hayden.
18. *Bulinus disjunctus* White.
19. *Macrocyclis spatiosa* Meek & Hayden?
20. *Helix evanstonensis* White.
21. *Columna teres* Meek & Hayden.
22. *Neritina naticiformis* White.
23. *Goniobasis arcta* Meek.
24. *Goniobasis cleburni* White.
25. *Goniobasis chrysallis* Meek.
26. *Goniobasis chrysaloidea* White.
27. *Goniobasis endlichi* White.
28. *Pyrgulifera humerosa* Meek.
29. *Hydrobia recta* White.

30. *Viviparus couesi* White.
31. *Campeloma macrospira* Meek.
32. *Spirorbis ?*
33. *Cypris* ———?
34. *Cycloid fish-scales.*
35. *Nutlets of Chara.*

NOTES ON THE LARAMIE FOSSILS OF BEAR RIVER VALLEY, WYOMING.

1. *Membranipora ?*

Some fragments of a Polyzoan were found incrusting the surface of *Corbula pyriformis* and other shells of the lower beds, which are apparently of the same species as those found on the oyster-shells at Point of Rocks, mentioned on a former page. They are too imperfect for satisfactory classification, but are of some value as additional evidence of at least some degree of saltness of the water in which the associated mollusks lived.

2. *Ostrea* ———?

A few separate valves of an undetermined species of *Ostrea* were found here and there in the lower beds; and in some places a thin layer was found mainly composed of them. They are all comparatively small shells, and all seem to have been somewhat waterworn before being finally imbedded.

3. *Volsella* ———?

A couple of fragments only of a small undetermined species of this genus were found near Mellis Station.

4. *Unio vetustus* Meek.

Shells of this species are quite abundant in the lower beds, a large proportion of which have both valves unseparated. It is figured and described in vol. iv, U. S. Geol. Sur. 40th Parallel, and also in U. S. Expl. Great Basin of Utah (Simpson).

5. *Unio belliplicatus* Meek.

This species is found associated with No. 4 and in similar condition; but it is not quite so abundant. It is figured and described in vol. iv, U. S. Geol. Sur. 40th Parallel. This species is an interesting one because of the fact that its style of surface ornamentation is different from that of any other known North American species, either fossil or recent.

6. *Pisidium saginatum* White.

Only three or four examples of this species were discovered, and these only at the Evanston coal-mines, in the upper Laramie beds there.

7. *Sphærium* ———?

A few casts only of a small species of this genus were found associated with numerous other small fresh-water shells in a gray clayey layer, about 40 feet above the principal bed of coal at the Evanston mines.

8. *Corbicula* (*Veloritina*) *durkeei* Meek.

A large number of examples of this species exist in the lower beds wherever they have been exposed. It is the type of Meek's subgenus *Veloritina*, and is described and figured by him in vol. iv, U. S. Geol. Sur. 40th Parallel. Among the collections made by Lieutenant Wheeler's parties in the valley of Virgen River, Southern Utah, I identified this species, and figured and described it in vol. iv, U. S. Expl. and Sur. West of the 100th Merid.

9. *Corbula pyriformis* Meek.

This is also an abundant species in the lower beds, and, like many of its associated bivalves, a large proportion of the examples have both valves unseparated. It is figured and described in vol. iv, U. S. Geol. Sur. 40th Parallel and also in U. S. Expl. Great Basin of Utah (Simpson).

10. *Corbula englemanni* Meek.

Probably only a variety of No. 9 (*loc. cit.*).

11. *Rhytophorus priscus* Meek.

This is evidently a littoral pulmonate, closely related to *Melampus*, and it doubtless had a similar saline habitat. It is the type of the genus, and is described and figured by Meek in vol. iv, U. S. Geol. Sur. 40th Parallel, and also in U. S. Expl. Great Basin of Utah (Simpson).

12. *Rhytophorus meekii* White.

This is possibly only a variety of No. 11, but the observable differences seem to be of specific value. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 118.

13. *Limnæa nitidula* Meek.

Mr. Meek figured and described this species in vol. iv, U. S. Geol. Sur. 40th Parallel. It is quite abundant in some of the layers near Mellis Station, where it is associated with numerous fresh- and brackish-water forms.

14. *Acella haldemani* White.

Among the siliceous *debris* remaining after an acid solution of some pieces of calcareous shaly rock found among the fossiliferous layers near Mellis Station, several examples of this species were discovered. It has never been discovered elsewhere, and so far as I am aware no other species of this genus has ever been found fossil. It is important as adding another indication of the great degree of differentiation which the pulmonate mollusca had attained at that early epoch. It is described in Bull. U. S. Geol. Sur. Terr. vol. iv, p. 714.

15. *Planorbis* ——*?*

Among the *debris* associated with Nos. 14 and 15, numerous examples of a minute *Planorbis* were found. They are all of nearly uniform size, which suggests the possibility that they are adult; but they are probably young examples of a larger species. No other examples of *Planorbis* were found in the lower beds, but in the upper ones at the Evanston coal-mines some fragments of another but undetermined species were found.

16. *Bulinus longiusculus* Meek & Hayden.

Among a considerable number of examples found in the upper beds at the Evanston coal-mines, referable to *Bulinus*, are some that I refer with some confidence to *B. longiusculus* and *B. subelongatus* respectively. The former was originally discovered in the Fort Union, and the latter in the Judith River beds, both in the Upper Missouri River region; and both are figured and described in vol. ix U. S. Geol. Sur. Terr.

17. *Bulinus subelongatus* Meek & Hayden.

A single specimen found associated with Nos. 13, 14, 15, and others in the lower beds near Mellis Station, appears to belong to this species. See, also, remarks under No. 16.

18. *Bulinus disjunctus* White.

This species is described in a foot-note on page 170 of this report. It has been found in the Laramie beds of the valley of Crow Creek, Eastern Colorado, and in the upper beds at the coal-mines near Evanston, Wyo., there is a form which is probably specifically identical with it.

19. *Macrocyclis spatiosa* Meek & Hayden?

A species evidently referable to this genus, and, so far as the somewhat imperfect examples will admit of comparison, seems to be identical with *M. spatiosa*, was found in the upper beds at the Evanston coal-mines. This species is described and figured by Mr. Meek in vol. ix, U. S. Geol. Sur. Terr., and is there referred to the Wind River Group. Overlooking this fact, but following a general label found accompanying a tray of Upper Missouri fossils, among which were the types of both this species and *Columna teres* Meek & Hayden, I referred them both to the Judith River Group in the table on page 722, Bull. U. S. Geol. and Geog. Sur. Terr. vol. iv. Concerning the *Columna*, the error, if it be one, amounts to but little, as it is now well known that several species of fossils which respectively characterize the Judith River and Fort Union beds, are associated together in the same strata of the Laramie Group elsewhere. As to the *Macrocyclis* I can at present only say that the examples which I obtained from the Upper Laramie beds at the Evanston coal-mines in Bear River Valley answer well to the description and figures of *M. spatiosa* given by Mr. Meek. It is true my examples are not perfect, and it may be that when better ones are found they will show specific differences from the types of *M. spatiosa*.

20. *Helix evanstonensis* White.

This species was found in the upper beds at the Evanston coal-mines, and is described in Bull. U. S. Geol. and Geog. Sur. Terr. vol. iv, p. 714, where the mention of its locality was inadvertently omitted.

21. *Columna teres* Meek & Hayden.

So far as the specimens will admit of comparison this species appears to be identical with *C. teres* from the Fort Union beds of the Upper Missouri River region, the type of which is figured in vol. ix U. S. Geol. Sur. Terr. (See remarks under No. 19.)

22. *Neritina naticiformis* White.

This small shell was found quite plentifully in certain of the clayey layers of the lower beds near Mellis Station, but it has not been discovered elsewhere. It is described in Bull. U. S. Geol. and Geog. Sur. Ter., vol. iv, p. 715.

23. *Goniobasis arcta* Meek.

Associated with Nos. 13 and 22 and other species in the lower beds near Mellis Station numerous examples have been found which answer to the figure and description of *G. arcta* as given by Meek in U. S. Expl. Great Basin of Utah (Simpson). The locality is there given as "Ham's Fork," but this reference is probably an error, as was that of its associate (No. 13 *Limnæa* (*Limnophysa*) *nitidula*), as shown by Mr. Meek in U. S. Geol. Sur. 40th Parallel, vol. iv, p. 182.

24. *Goniobasis cleburni* White.

This, together with the two following species, which have been found only in the lower beds of the Bear River Group in Bear River Valley, forms a natural group, which might properly be regarded as a section

under *Goniobasis*. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 122.

25. *Goniobasis chrysallis* Meek.

Described in An. Rep. U. S. Geol. Sur. Terr. for 1870, p. 316. (See remarks under No. 24.)

26. *Goniobasis chrysaloidea* White.

Described in Powell's Report on the Geology of the Uinta Mountains, p. 123. The figure given by Professor Hall in Fremont's Exploration of Oregon and Northern California of his *Cerithium Fremonti* so much resembles this species as to suggest the possibility that it may be identical. (See remarks under No. 24.)

27. *Goniobasis endlichi* White.

This is rather a rare species, having been found only in the lower beds seven miles northward from Evanston, where it is associated with the common species of those beds. It posesses the raised revolving lines of the three foregoing species, but is without their longitudinal varices or ridges. It is described in the Bull. U. S. Geol. and Geog. Sur. Terr., vol. iv, p. 716. In the Evanston coal-mines some fragments of a species have been obtained which indicate that it resembles this in its surface markings, but that it is a smaller and more slender species.

28. *Pyrgulifera humerosa* Meek.

This is one of the most abundant and characteristic species of the lower beds of the Laramie Group in Bear River Valley. Mr. Meek made it the type of his genus *Pyrgulifera*, and described and figured it in the U. S. Geol. Sur. 40th Parallel; and also in U. S. Expl. Great Basin of Utah (Simpson). It is probably a widely-distributed species in the equivalents of the Bear River Laramie. Among some fossils brought by Professor Powell from Upper Kanab, Southern Utah, I have recognized this species, together with some which characterize the Laramie Group farther eastward, but I do not know whether they were there associated together in the same layers.

29. *Hydrobia recta* White.

This species has been found only in the upper beds at the coal-mines, three miles from Evanston. It is associated with fresh-water and land shells only, and is probably not a true *Hydrobia*, but the condition of the specimens does not warrant a conclusive reference to any other genus. It is described in Powell's Report on the Geology of the Uinta Mountains, p. 132.

30. *Viviparus couesi* White.

This is the largest species of *Viviparus* known to me. It has has been found only in the lower Laramie beds of the Bear River Valley, but examples of it have been obtained wherever those strata have been examined by me. It is described in the Bulletin U. S. Geol. Sur. Terr. vol. iv, p. 717. Mr. Meek gave two figures of an imperfect example of it in U. S. Geol. Sur. 40th Parallel, vol. iv, pl. 17, fig. 15 and 15*a*, under the generic name of *Campeloma*, but without a specific name. It has the straight outer lip and other characteristics of *Viviparus*, and not the sinuate outer lip of *Campeloma*.

31. *Campeloma macrospira* Meek.

This species is associated with No. 30, and has been found in considerable numbers wherever the lower beds are exposed in Bear River Valley.

Mr. Meek describes it and figures an imperfect example in the United States Geological Survey 40th Parallel.

32. *Spirorbis?*

Near Mellis Station some examples of a minute coiled shell resembling a *Spirorbis* were found attached to *Unio vetustus* and other associated shells. It is possible that they are the first coils or young examples of the *Planorbis*, No. 15, but they seem to have been of a parasite or commensal habit. Water that was salt enough for *Corbula*, *Membranipora*, &c., would no doubt have been congenial for *Spirorbis*.

33. *Cypris ——— ?*

Multitudes of casts of a species of Cypris were found in the gray clayey shale, 40 feet above the principal bed of coal at the Evanston coal mines, belonging to the upper Laramie beds.

In this soft, clayey shale were also found, besides the *Sphærium* and *Cypris* already mentioned the casts of numerous other small shells, mostly those of *Physa* or *Bulinus;* and in addition to these, a few cycloid fish-scales; also associated with Nos. 37 and 38 numerous minutes nutlets of a species of *Chara* were found.

Besides the species enumerated or referred to in the foregoing list, there are among the collections, especially those from the upper beds, fragments that indicate the existence of several yet undetermined species of invertebrate fossils.

In all the other collections of Laramie fossils that have been discussed in this report some species are represented which connect the strata of the different localities from which they respectively came, as unmistakably belonging to the great Laramie Group; but a comparison of the collections from the lower beds of Bear River Valley with all the other collections of Laramie fossils is one entirely of contrast, so far as specific identity is concerned, unless the *Bulinus* mentioned under No. 17 be an exception. Moreover, as has already been mentioned, these lower beds of the Bear River Laramie contain two or three molluscan types of generic or subgeneric value, that have never been found elsewhere, besides some other modifications of type perhaps of less value than the others, but still sufficiently characteristic.

Inquiring into the inhabitancy of the whole fauna of these lower beds we do not find an indication that its condition, so far as saltness of the water is concerned, was materially different from that of the brackish-water fauna of the Laramie Group in general, there being always, and in the case of both faunæ, a mixture of both brackish and fresh water forms, with some palustral pulmonates and an occasional land shell. The marked difference, then, between the invertebrate fauna of the lower beds of Bear River Laramie and that of the group in general is not such as is produced by a change in the saltness or by a complete freshening of the inhabited waters; but it is evidently due to other causes. My own investigations of these strata have been far too limited to warrant any present discussion of the causes that have produced these faunal differences, but there seems to be little room for doubt that it was due in large part to conditions consequent upon the proximity and character of the western shore of the Laramie sea. It will also be remembered that the Cretaceous fauna of the Coalville series, which occupies a similar relative geological position, shows almost if not equally as great a contrast with that of its assumed equivalent strata which occupy the same regions farther eastward with the various Laramie strata herein discussed. But after all the inquiry naturally arises, are these Bear River beds properly referable to the Laramie Group, and, if so, are they true equivalents of those Lara-

mie strata that have already been discussed in this report? Too much yet remains to be done in the investigation of these beds and their fauna to admit of definite replies to these questions, but the following already ascertained facts have an important bearing upon them. In the section published by Mr. Meek in the An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 451, these brackish-water Laramie beds are seen to come in the series above the Fox Hill Cretaceous strata. In the neighborhood extending from three to seven miles north from Evanston the coal series is seen to rest upon the brackish-water beds, and in turn to be overlaid by the Wasatch Group. This warrants their general reference to the Laramie Group, but whether they may not be older than any of the other Laramie strata that have been discussed in this report remains for further investigation to decide. The fact that some of the invertebrate types of these brackish-water beds are apparently extinct, while none of those of the other Laramie beds are now known to be so, suggests their greater antiquity, but does not necessarily prove it; especially so as those types are not known in older strata. On the other hand some of the species in the upper beds at the Almy coal mines, some 400 or 500 feet above the range of the brackish-water species, are regarded as identical with forms that have been found both in the Fort Union and the Lignitic beds of the Laramie Group east of the Rocky Mountains in Colorado. It should furthermore be remarked that the conditions of the strata at the junction of the Fox Hills Group with the brackish-water Laramie beds in this region are not accurately known; and also that I am not sure of the exact conformity of the coal-bearing upper beds upon the latter; while the unconformity of the Wasatch, upon the Laramie *in this region*, is well known to be general. It therefore seems not improbable that the displacements which took place in this region were not confined to the immediate close of the Laramie period, but that other lesser movements took place at different times between the close of the Fox Hills epoch and the earlier part of that of the Wasatch.

The displacements that took place at or near the close of the Laramie period, in what is now the vicinity of Bear River Valley, were very great, and they are doubtless of considerable extent in this region, although not at all apparent in a large part of the Green River Basin. They involved not only the Laramie strata, but the older groups also; at least those of the Fox Hills and Colorado Groups, which are seen to be so involved in this immediate neighborhood, if the latter have been correctly identified. This is shown in Mr. Meek's section of the strata in the valley of Sulphur Creek at its confluence with Bear River, which has already been referred to. That section shows not only abrupt and deep foldings of those strata, but certain slips or faults also. The portion of it which is numbered 28 consists of the brackish-water Laramie beds as they are seen at Mellis Station on the east side of Bear River, and which there appear to occupy the east side of an abrupt synclinal fold. No strata above those of the Laramie Group appear to be involved in this sharp fold, against the upturned strata of which those of the Wasatch Group appear to abut unconformably. The whole group is probably thus involved, but the upper beds, as seen at the Evanston coal-mines, have not been discovered there, the waters and scattered shingle of Bear River covering the surface they would otherwise occupy if present. The Laramie strata that occupy the western side of the fold appear upon the western side of Bear River, a couple of miles southwestwardly from Mellis Station, those of both sides of the fold being nearly perpendicular.

Flanking these upturned Laramie strata upon their west side, and in

contact with them, I found a small exposure of Fox Hills strata, which are composed of soft sandstones and, like the Laramie strata there, they are nearly vertical. From one of these Fox Hill's layers I obtained a small collection of fossil shells, all of which are imperfect, and some of the species which they indicate are not recognizable. The identification of those of the following list is probably correct, and shows an intimate relation of these strata with those of the Coalville series.

LIST OF CRETACEOUS FOSSILS FROM THE VALLEY OF BEAR RIVER, WYOMING.

1. *Ostrea———?*
2. *Volsella (Brachydontes) multilinigera* Meek.
3. *Nucula———?*
4. *Barbatia coalvillensis* White.
5. *Cardium trite* White?
6. *Cyrena securis* Meek.
7. *Tellina? modesta* Meek.
8. *Tellina (Arcopagia?) utahensis* Meek.
9. *Corbula dubiosa* White.*

NOTES ON THE CRETACEOUS FOSSILS OF BEAR RIVER VALLEY.

1. *Ostrea———?*

The examples of this oyster are numerous and many of them well preserved, but they are all small, and so wanting in specific characters that they cannot be satisfactorily identified with any published species or described as new. They are possibly identical with *O. coalvillensis* Meek.

2. *Volsella (Brachydontes) multilinigera* Meek.

This species was originally discovered by Meek at Coalville. It also occurs near Hilliard Station, four miles east of this locality.

3. *Nucula———?*

The examples are too imperfect for specific determination. They indicate a species much like *N. planimarginata* Meek & Hayden.

4. *Barbatia coalvillensis* White.

Hitherto discovered only at Coalville. (See remarks under head of Cretaceous fossils of that locality.)

5. *Cardium trite* White.

The examples found here are only imperfect casts, but the surface markings are more nearly like those of *C. trite* than those of either *C. curtum* or *C. subcurtum*, the only two other species of *Cardium* that are likely to be found in these strata. *C. trite* was discovered at the head of Waterpocket Cañon, Utah, by Mr. Gilbert, and is described and figured in another part of this volume.

6. *Cyrena securis* Meek.

This species has been discovered at Coalville and also at Hilliard Station, four miles east of this locality. It is described and figured in another part of this volume.

7. *Tellina? modesta* Meek.

A Coalville species. (See remarks under that head.)

8. *Tellina (Arcopagia?) utahensis* Meek.

See remarks under notes on Coalville fossils.

* See following remarks under No. 9.

9. *Corbula dubiosa* White.

This species has never been described. It is the one that has been referred to at different times by myself and Mr. Meek when discussing the fossils of Coalville, and is figured by Mr. Meek in U. S. Geol. Sur. 40th Parallel, vol. iv, pl. 14, f. 2. It appears so often among the Cretaceous fossils of this region, although the examples are usually imperfect, that the foregoing name is given to it, provisionally, as a matter of convenience.

Crossing Bear River we proceeded eastward up the valley of Sulphur Creek, along the line of Mr. Meek's section, as given in An. Rep. U. S. Geol. Sur. Terr. for 1872, p. 451, and which has already been referred to in relation to the Laramie strata of Bear River Valley. From No. 12 of that section, immediately overlying the bed of coal* there, I collected numerous examples of *Inoceramus problematicus* Schlotheim, and a few imperfect examples of *Anchura fusiformis* Meek? These strata belong without doubt within the limits of the consolidated Fox Hills Group, notwithstanding the presence there of *Inoceramus problematicus*.

Continuing up the valley to Hilliard Station I obtained the fossils of the following list from Fox Hills strata there which are not represented in Mr. Meek's section, but which are equivalent with some of those within that section about three miles further westward.

LIST OF CRETACEOUS FOSSILS COLLECTED AT HILLIARD STATION, WYOMING.

1. *Ostrea soleniscus* Meek.
2. *Placunopsis hilliardensis* White.
3. *Volsella* (*Brachydontes*) *multilinégera* Meek.
4. *Cardium curtum* Meek & Hayden.
5. *Cardium subcurtum* Meek.
6. *Cyrena securis* Meek.
7. *Corbula dubiosa* White.
8. *Neritina incompta* White.
9. *Turbonilla* (*Chemnitzia?*) *coalvillensis* Meek.

NOTES ON THE CRETACEOUS FOSSILS OF HILLIARD STATION.

1. *Ostrea soleniscus* Meek.

This species is common in the vicinity of Coalville, and, so far as I am aware, it has never been found except in this region, bordering the western side of the Green River Basin. It seems also to have a great vertical range within the Fox Hills Group.

2. *Placunopsis hilliardensis* White.

Discovered only at this locality. It is described and figured in another part of this volume.

3. *Volsella* (*Brachydontes*) *multilinigera* Meek.

See remarks under head of notes on Cretaceous fossils of Coalville, and also on those of Bear River Valley.

4. *Cardium curtum* Meek & Hayden.

See remarks under head of notes on Cretaceous fossils of Coalville.

* The mining of this coal was abandoned with the abandonment of Old Bear River City, upon the site of which it was formerly worked. It has been thought that this bed of coal is equivalent with the lower one at Coalville, but it is more probably equivalent with that of Carleton's mine, at the same place.

5. *Cardium subcurtum* Meek.

See remarks under head of notes on Cretaceous fossils of Coalville.

6. *Cyrena securis* Meek.

See remarks under head of notes on Cretaceous fossils of Bear River Valley, and also on those of Coalville.

7. *Corbula dubiosa* White.

See notes on Cretaceous fossils of Bear River Valley.

8. *Neritina incompta* White.

Discovered only at this locality. It is described and figured in another part of this volume.

9. *Turbonilla* (*Chemnitzia?*) *coalvillensis* Meek.

See remarks under head of notes on Cretaceous fossils of Coalville. It is described and figured in another part of this volume.

A glance at these collections from Bear River Valley and near Hilliard Station, in the valley of Sulphur Creek, the two localities being only about four miles apart, shows that the Cretaceous invertebrate fauna here, although much less fully represented, is essentially the same, and quite as peculiar as that of Coalville. In discussing the Coalville fossils it was shown that we may expect to find a similar Cretaceous fauna south of the Uinta, and east of the Wasatch Mountains; and it now appears equally certain that we shall find that peculiar fauna to extend further northward than the valley of Bear River.

In connection with the strata which are exposed along the valley of Sulphur Creek, a part only of which are represented in Mr. Meek's section, there are some near Hilliard Station that appear to possess the peculiar characteristics of the Colorado Group, but which inclement weather prevented me from investigating. If this supposition be correct, the strata coming in the series between them and those of the Laramie Group of course belong to the consolidated Fox Hills Group. As these strata here have an aggregate thickness of not less than 3,000 feet, it is probable that the whole fossiliferous series of Cretaceous rocks at Coalville are referable to the same group; especially so as, almost without exception, the fossils of the Bear River and Sulphur Creek strata have been recognized in the Coalville series.

While making the foregoing observations in the valleys of Bear River and Sulphur Creek, a fall of snow gave admonition of the approaching close of the season, and I therefore then went eastward to Green River, crossing it at Green River City. From there I passed up Bitter Creek, a tributary of Green River, and the weather being then favorable, I made the observations upon the Laramie strata there, which have been recorded on preceding pages of this report.

From Black Buttes Station eastward to Bitter Creek Station our route was over the strata of the Wasatch Group, the dip being gently to the eastward, but becoming very slight or hardly perceptible in the neighborhood of the last-named station. From this station our route was near to and parallel with the Union Pacific Railroad until we left the field at Rawlins' Springs. As far east as Red Desert Station our course seemed to be directly upon the line of strike, and near or upon the division between the Wasatch and Green River Groups. In this region as well as at other places where I have examined these two groups near their junction, it is impossible to say where one ends and the other begins. This is rendered still more difficult by the fact that the best known of the molluscan species of both groups range from the Wasatch up into the Green

River Group; and also by the fact that several similar fossiliferous horizons occur near to and both above and below the plane where, for stratigraphical reasons, we find it desirable to make the division between the two groups.

Among some of the better known molluscan species just referred to, I found in these debatable strata, about three miles east of Table Rock Station, a small undescribed *Planorbis*, which I have called *P. cirrus*.*

The last field-work that was done for the season was an examination of the Laramie strata between the continental watershed and the line of outcrop of the Fox Hills Group, between Separation Station and Rawlins Springs. These strata have there all their usual lithological characteristics, and their aggregate thickness is estimated at not much if any less than 4,000 feet. The only fossils found there were a few fragments of *Unio* and a single imperfect specimen of *Viviparus*, apparently *V. trochiformis* Meek & Hayden. These were obtained near the railroad about a mile eastward from Separation Station.

GENERAL DISCUSSION.

The desirability of extending an established classification of strata over the whole of a great region or portion of a continent is two manifest to need comment. Within limited areas the lithological characteristics of strata are, as a rule, alone sufficiently constant for the ready recognition of natural groups; and in the Western Territories there is so unusual a degree of constancy in this respect that certain of the established groups of strata can thus be satisfactorily recognized over very large areas. But even in the most favorable cases of this kind the fossil contents of the groups are the most trustworthy guides to their identity; while for their recognition over large or separate regions, their fossils are almost the only guides worthy of confidence. It is in view of these facts that the present plan for paleontological field-work has been established, the present report being that for the first season's labors of this kind.

The value of fossil collections for the purposes just indicated depends upon two circumstances, namely, the geographical distribution of the species and types, and their geological or vertical range; and for the purpose of giving a synoptical view of the species collected during this season's labors, together with their geographical distribution, the two following general tables have been prepared, the one of Cretaceous, and the other of Laramie fossils. Similar and equally instructive tables of any and all other groups might be prepared, but the present object is to embrace only the results of my field observations for the year 1877.

While there are, as has already been shown on preceding pages, some important exceptions to the rule of constancy of paleontological characteristics of both the Laramie and Fox Hills Groups, the results of this season's labors give great reason to hope that a perfectly harmonious classification may be established for the strata of both these and other epochs over the greater part of the national domain. These investigations have been quite sufficient to show that the grouping of the Cretaceous strata which was proposed several years ago by Hayden and

* This species has not been hitherto described, but may be characterized thus: Shell small, discoid; volutions six or seven, very slender, coiled closely and almost exactly in a plane so that the upper side is known only by the greater backward obliquity of the striæ of growth; their transverse diameter a little greater than the vertical; surface smooth or marked only by the ordinary striæ of growth. Diameter of the coil of the largest example discovered, 8 millimeters; transverse diameter of the last volution, 1½ millimeters.

Meek for the Upper Missouri River region constitutes a natural and reliable basis for the classification of the Cretaceous rocks of much the greater part if not all of the region embracing the Western States and Territories. The modification of that grouping which is followed in this report consists, as already explained on previous pages, only in omitting certain of the subdivisions which were recognized in the Upper Missouri River region, while the leading features are retained without change.

These labors have also demonstrated the unity of all the principal brackish-water deposits hitherto known in the Western Territories, and justified their recognition as a comprehensive group of strata under the name of the Laramie Group, which represents a great period in geological time, and especially such in the geological history of North America.

The known extent of the vertical range of each species named in the following table, within its own group of strata, has been indicated on previous pages in the notes that follow each list of the fossils which were collected at the localities visited during the season. Their geographical distribution is indicated by columns in the table which represent certain arbitrarily designated regions embracing the whole extent of my season's travels, to which is added for comparison a column representing the Upper Missouri River region.

Table showing the geographical distribution of the Cretaceous species collected during the season of 1877.

FOX HILLS GROUP.

	Upper Missouri River region.	Eastern Colorado.	Northwestern Colorado.	Coalville, Utah.	Bear River Valley.
1. *Caryophyllia egeria* White	-----	-----	×	-----	-----
2. *Lingula nitida* Meek & Hayden	×	-----	×	-----	-----
3. *Ostrea patina* Meek & Hayden	×	× ?	-----	-----	-----
4. *Ostrea soleniscus* Meek	-----	-----	-----	×	×
5. *Ostrea coalvillensis* Meek	-----	-----	-----	×	× ?
6. *Ostrea congesta* Conrad	-----	-----	-----	× ?	-----
7. *Ostrea (Alectryonia) sannionis* White	-----	-----	-----	×	-----
8 *Placunopsis hilliardensis* White	-----	-----	-----	-----	×
9. *Pteria haydeni* Hall & Meek	-----	×	-----	-----	-----
10. *Pteria linguiformis* Evans & Shumard	×	×	×	-----	-----
11. *Pteria gastrodes* Meek	-----	-----	-----	×	-----
12. *Pteria (Pseudoptera) fibrosa* Meek & Hayden	×	×	-----	-----	-----
13. *Pteria (Pseudoptera) rhytophora* Meek	-----	-----	-----	×	-----
14. *Pteria (Pseudoptera) propleura* Meek	-----	-----	-----	×	-----
15. *Pteria (Oxytoma) nebrascana* Evans & Shumard	-----	×	-----	-----	-----
16. *Pinna lakesi* White	-----	×	-----	-----	-----
17. *Inoceramus barabini* Morton	×	-----	×	-----	-----
18. *Inoceramus howelli* White	-----	-----	×	-----	-----
19. *Inoceramus erectus* Meek	-----	-----	-----	×	-----
20. *Inoceramus oblongus* Meek	-----	×	-----	-----	-----
21. *Inoceramus vanuxemi* Meek & Hayden	×	×	×	-----	-----
22. *Inoceramus pertenuis* Meek & Hayden	-----	-----	× ?	-----	-----
23. *Inoceramus problematicus* Schlotheim	-----	-----	-----	×	×
24. *Volsella (Brachydontes) multilinigera* Meek	----	-----	-----	×	×
25. *Crenella elegantula* Meek & Hayden	×	×	-----	-----	-----
26. *Nucula planimarginata* Meek & Hayden	×	×	×	-----	-----
27. *Nucula cancellata* Meek & Hayden	×	×	-----	-----	-----
28. *Barbatia coalvillensis* White	-----	----	-----	×	×
29. *Sphæriola? obliqua* Meek	-----	×	-----	-----	-----
30. *Sphæriola? endotrachys* Meek	×	×	-----	-----	-----
31. *Tancredia americana* Meek & Hayden	×	×	-----	-----	-----
32. *Tancredia? cœlionotus* White	-----	×	-----	-----	-----
33. *Veniella humilis* Meek & Hayden	×	×	-----	-----	-----
34. *Cardium speciosum* Meek & Hayden	×	×	×	-----	-----
35. *Cardium curtum* Meek & Hayden	-----	-----	-----	×	×
36. *Cardium subcurtum* Meek	-----	-----	-----	×	×
37. *Cardium trite* White	-----	-----	-----	-----	× ?
38. *Protocardia rara* Evans & Shumard	×	×	-----	-----	-----

Table showing the geographical distribution of the cretaceous species collected, &c.—Cont'd.

FOX HILLS GROUP—Continued.

	Upper Missouri River region.	Eastern Colorado.	Northwestern Colorado.	Coalville, Utah.	Bear River Valley.
39. *Protocardia subquadrata* Evans & Shumard	×	×			
40. *Cyrena carletoni* Meek				×	
41. *Cyrena securis* Meek				×	×
42. *Callista deweyi* Meek & Hayden	×	×			
43. *Thetis? circularis* Meek & Hayden	×		× ?		
44. *Tellina scitula* Meek & Hayden	×	×			
45. *Tellina equilateralis* Meek & Hayden	×	× ?			
46. *Tellina? isonema* Meek				×	
47. *Tellina? modesta* Meek				×	×
48. *Tellina (Arcopagia) utahensis* Meek				×	
49. *Cyprimeria? subalata* Meek				×	
50. *Corbula nematophora* Meek				×	
51. *Corbula dubiosa* White				×	×
52. *Mactra holmesii* Meek		×			
53. *Mactra (Cymbophora) alta* Meek & Hayden	×	×	×		
54. *Mactra (Cymbophora) warrenana* Meek & Haydend	×	×	×		
55. *Glycimeris berthoudi* White		×			
56. *Pachymya? herscyi* White		×			
57. *Dentalium gracile* Hall & Meek	×	×			
58. *Cylichna scitula* Meek & Hayden	×	×			
59. *Actæon woosteri* White		×	× ?		
60. *Actæonina prosocheila* White		×			
61. *Anisomyon centrale* Meek		×			
62. *Mclampus antiquus* Meek				×	
63. *Physa carletoni* Meek				×	
64. *Neritina bannisteri* Meek				×	
65. *Neritina incompta* White					×
66. *Neritina pisum* Meek				×	
67. *Neritina pisiformis* Meek				×	
68. *Neritina (Velatella) bellatula* Meek				×	
69. *Neritina (Velatella) carditoides* Meek				×	
70. *Neritina (Velatella) patelliformis* Meek				×	
71. *Lunatia suberassa* Meek & Hayden	×	×			
72. *Euspira coalvillensis* White				×	
73. *Gyrodes depressa* Meek				×	
74. *Anchura haydeni* White		×			
75. *Anchura fusiformis* Meek				×	×
76. *Anchura americana* Evans & Shumard	×	×			
77. *Turritella coalvillensis* Meek				×	
78. *Turritella spirouema* Meek				×	
79. *Turritella (Aclis?) mieronema* Meek				×	
80. *Turbonilla (Chemnitzia?) coalvillensis* Meek				×	×
81. *Eulimella? inconspicua* Meek				×	
82. *Eulimella? chrysallis* Meek				×	
83. *Eulimella? funicula* Meek				×	
84. *Pseudobuccinum nebrascense* Meek & Hayden	×	×			
85. *Fasciolaria (Piestocheilus) culbertsoni* Meek & Hayden	×	×			
86. *Valvata nana* Meek				×	
87. *Fusus (Neptunea?) gabbi* Meek				×	
88. *Fusus (Neptunea?) utahensis* Meek				×	
89. *Admetopsis rhomboidea* Meek				×	
90. *Admetopsis gregaria* Meek				×	
91. *Admetopsis subfusiformis* Meek				×	
92. *Baculites ovatus* Say	×	×	×	× ?	
93. *Scaphites nodosus* Owen	×	×	×		
94. *Scaphites nandanensis* Morton	×	×			
95. *Placenticeras lenticulare* Owen	×	×			
96. *Placenticeras placenta* Dekay	×	×			

COLORADO GROUP.

1. *Ostrea congesta* Conrad	×	×			
2. *Inoceramus problematicus* Schlotheim	×	×			
3. *Inoceramus deformis* Meek		×	×		

NOTE.—The species that, on account of the imperfection of the specimens, have not been satisfactorily recognized, are not included in this list, as they are in the local lists.

The column representing the Upper Missouri River region is added for purposes of comparison, in recognition of the classification which has been established by Hayden and Meek for the Cretaceous strata there, as a standard for all the Cretaceous strata of the Western Territories. The existence of the species there which are named in the list is given on the authority of those authors, as I have never yet visited that region in person. The column assigned to Eastern Colorado includes, for the present purpose, only that portion of it, east of the Rocky Mountains, which I visited during the season; and the same may be said of the column assigned to Northwestern Colorado. The column assigned to Coalville is intended to include the whole valley of Weber River in that neighborhood; and the one assigned to Bear River Valley includes also the adjacent portion of the Valley of Sulphur Creek up to Hilliard Station.

In the table of the Laramie fossils next following, one of the vertical lines separating the columns which represent localities or regions is made double, to indicate the fact that those upon one side of it are east, and those upon the other side of it west, of the Rocky Mountains. Such a modification might be made in this one, but it is hardly necessary, because few facts are more patent than that the elevation of the Rocky Mountains began long after the deposition of the latest strata represented in the table.

It will, of course, be understood that this table embraces only the collections made either by myself or others at the localities which I visited during the season of 1877. It not only does not represent the full geographical distribution of those species, but it is probable that many other species will yet be found in some of the localities which have been thus visited. There is a notable paucity of the species of the Colorado Group represented in the table. This is in large part due to the fact that its strata in the region I traversed are less fossiliferous than those of the Fox Hills Group are; partly to the fact that, being softer, they are less freely exposed, and partly, that they came less in the way of my season's investigations.

The construction of the following table of the Laramie fossils which have been collected from the various regions visited by myself during the season of 1877 is similar to that of the preceding table of the Cretaceous fossils. The species are not only thus tabulated for a synoptical view, but the table shows the present known extent of their geographical distribution, and demonstrates the fact that all the principal brackish-water beds yet known in the Western Territories are members of one comprehensive group of strata representing a great period in the geological history of North America. The two columns representing the Judith River and Fort Union beds, respectively, are introduced for purposes of comparison, and to show their geological equivalency with the strata of the other localities. The species indicated in those two columns are given on the published authority of Hayden and Meek, as I have not yet visited the Upper Missouri River region in person. The two columns designated respectively as Eastern and Northwestern Colorado are of course intended to include only the species that have been collected at the localities which I have visited in person, and which have been discussed on preceding pages of this report. The column assigned to Bitter Creek includes the whole series of Laramie strata there: the differences in the fauna at different horizons of the series having already been shown are not repeated here. The column assigned to Bear River Valley includes the species of both brackish and fresh water beds that are found in the district extending from the mouth of Sulphur Creek to seven miles northward from Evanston, Wyo.

Table showing the geographical distribution of the fossils of the Laramie Group, collected during the season of 1877.

	Judith River beds.	Fort Union beds.	Eastern Colorado.	Northwestern Colorado.	Bitter Creek Valley.	Bear River Valley.
1. *Membranipora?*	.....	.....	.....	.....	×	×
2. *Ostrea glabra* Meek & Hayden	×	.....	×	×	×	.....
3. *Anomia micronema* Meek	.....	.....	×	×	×	.....
4. *Anomia gryphorhynchus* Meek	.....	.....	×	×	×	.....
5. *Volsella (Brachydontes) regularis* White	.....	.....	×	×	×	.....
6. *Volsella (Brachydontes) latieostata* White	.....	.....	.....	×	.....	.....
7. *Nuculana inclara* White	.....	.....	.....	×	.....	.....
8. *Anodonta parallela* White	.....	.....	×	.....	.....	.....
9. *Unio vetustus* Meek	.....	.....	.....	.....	.....	×
10. *Unio belliplicata* Meek	.....	.....	.....	.....	.....	×
11. *Unio couesi* White	.....	.....	.....	.....	×	.....
12. *Unio propheticus* White	.....	.....	.....	.....	×	.....
13. *Unio aldrichi* White	.....	.....	.....	.....	×	.....
14. *Unio proavitus* White	.....	.....	.....	.....	×	.....
15. *Unio holmesianus* White	.....	.....	.....	.....	×	.....
16. *Unio endlichi* White	.....	.....	.....	.....	×	.....
17. *Unio cryptorhynchus* White	×	.....	.....	.....	×	.....
18. *Unio brachyopisthus* White	.....	.....	.....	.....	×	.....
19. *Unio goniambonatus* White	.....	.....	.....	.....	×	.....
20. *Unio dancæ* Meek & Hayden	×	.....	.....	.....	×?	.....
21. *Pisidium saginatum*	.....	.....	.....	.....	.....	×
22. *Corbicula occidentalis* Meek & Hayden	×	.....	.....	×	×	.....
23. *Corbicula cytheriformis* Meek & Hayden	×	.....	.....	.....	×	.....
24. *Corbicula cleburni* White	.....	.....	×	.....	.....	.....
25. *Corbicula obesa* White	.....	.....	×	.....	.....	.....
26. *Corbicula cardiniæformis* White	.....	.....	×	.....	.....	.....
27. *Corbicula (Leptesthes) fracta* Meek	.....	.....	×	×	×	.....
28. *Corbicula (Leptesthes) planumbona* Meek	.....	.....	×	.....	.....	.....
29. *Corbicula (Leptesthes) macropistha* White	.....	.....	×	.....	.....	.....
30. *Corbicula (Leptesthes) subelliptica* Meek & Hayden	×	.....	×	.....	.....	.....
31. *Corbicula (Veloritina) durkeei* Meek	.....	.....	.....	.....	.....	×
32. *Corbula subtrigonalis* Meek & Hayden	×	.....	×	×	×	.....
33. *Corbula pyriformis* Meek	.....	.....	.....	.....	.....	×
34. *Corbula undifera* Meek	.....	.....	.....	×	×	.....
35. *Rhytophorus priscus* Meek	.....	.....	.....	.....	.....	×
36. *Rhytophorus meeki* White	.....	.....	.....	.....	.....	×
37. *Limnæa (Limnophysa) nitidula* Meek	.....	.....	.....	.....	.....	×
38. *Acella haldemani* White	.....	.....	.....	.....	.....	×
39. *Bulinus disjunctus* White	.....	.....	×	.....	.....	×
40. *Bulinus subelongatus*, Meek & Hayden	×	.....	×	.....	.....	×
41. *Bulinus longiusculus* Meek & Hayden	.....	×	.....	.....	.....	×
42. *Physa felix* White	.....	.....	×	.....	.....	.....
43. **Macrocyclis spatiosa* Meek & Hayden	.....	.....	.....	.....	.....	×?
44. *Helix evanstonensis* White	.....	.....	.....	.....	.....	×
45. *Columna teres* Meek & Hayden	.....	×	.....	.....	.....	×
46. *Neritinia naticiformis* White	.....	.....	.....	.....	.....	×
47. *Neritinia volvilineata* White	.....	.....	.....	×	×	.....
48. *Neritina (Velatella) baptista* White	.....	.....	.....	.....	×	.....
49. *Goniobasis arcta* Meek	.....	.....	.....	.....	.....	×
50. *Goniobasis cleburni* White	.....	.....	.....	.....	.....	×
51. *Goniobasis endlichi* White	.....	.....	.....	.....	.....	×
52. *Goniobasis chrysallis* Meek	.....	.....	.....	.....	.....	×
53. *Goniobasis chrysalloidea* White	.....	.....	.....	.....	.....	×
54. *Goniobasis gracilicnta* Meek & Hayden	×	.....	×	.....	×	.....
55. *Goniobasis nebrascensis* Meek & Hayden	.....	×	×	.....	.....	.....
56. *Cassiopella turricula* White	.....	.....	.....	.....	×	.....
57. *Melania wyomingensis* Meek	.....	.....	×	×	×	.....
58. *Melania insculpta* Meek	.....	.....	.....	.....	×	.....
59. *Pyrgulifera humerosa* Meek	.....	.....	.....	.....	.....	×
60. *Hydrobia recta* White	.....	.....	.....	.....	.....	×
61. *Viviparus couesi* White	.....	.....	.....	.....	.....	×
62. *Viviparus prudentia* White	.....	.....	×	.....	.....	.....
63. *Viviparus plicapressus* White	.....	.....	.....	×	×	.....
64. *Tulotoma thompsoni* White	.....	.....	×	.....	×	.....
65. *Campeloma vetula* Meek & Hayden	×	.....	.....	×	×	.....
66. *Campeloma multistriata* Meek & Hayden	.....	×	×	.....	.....	.....
67. *Campeloma multilineata* Meek & Hayden	.....	×	.....	.....	×?	.....
68. *Campeloma macrospira* Meek	.....	.....	.....	.....	.....	×
69. *Odontobasis buccinoides* White	.....	.....	.....	.....	×	.....
70. *Odontobasis? formosa* White	.....	.....	.....	×	.....	.....
71. *Corydalites fœcundum* Scudder	.....	.....	×	.....	.....	.....

*See remarks under No. 19 on p. 244.

NOTE.—As a rule, those species which, on account of imperfection of the specimens, have not been satisfactorily recognized are not included in this list, as they were in the local lists. An ? following a name, of course indicates a doubt as to its accuracy. Placed in one of the columns with an asterisk, indicates a doubt as to whether the species found at the locality indicated is really the one named in the list.

The double vertical line in the foregoing table may be taken to represent the Rocky Mountains, or the great range that extends northward through Colorado, Wyoming and Montana; the localities or districts represented on its left being east, and those on its right west, of those mountains. An examination of the table will show that this mountain range has no paleontological significance as a geographical boundary between those eastern and western localities of Laramie strata, because the species range across it almost as freely as they do across the space which separates any two or more of the others. Indeed, the great contrast that is presented between the fauna of the brackish-water beds of the Laramie Group in Bear River Valley and that of the great body of the group elsewhere, as now known, is not marked by any now existing physical feature, and what the real cause of that contrast was, yet remains to be discovered. It is evident that the present hypsometric condition of the North American continent has no direct relation to the distribution of species in the strata of the Laramie Group, or in any of the Cretaceous groups.

It is a fact worthy of especial notice that not a single species of all those that have been found in the brackish-water beds of Bear River Valley, with perhaps the exception of a *Physa*, is identical with any that have yet been found in any other Laramie strata; those indicated in the table as thus identified having been obtained from the upper Laramie beds at the Evanston coal-mines, which are of fresh-water origin. Another significant fact is that those species which are thus identified are pulmonate mollusks; the species which differ most widely from other Laramie forms being branchiferous mollusks. The natural inference from this fact is that the modifying conditions which then existed in this part of the continent produced their effect upon that portion of the invertebrate fauna which inhabited the principal waters, leaving the land and palustral fauna comparatively unchanged.

Taking a general view of the species as represented in the foregoing table it will be seen that the palustral pulmonates occur in all the districts indicated, and that land-shells also are not uncommon. These facts, together with the identity of species and types of those mollusks in the various districts, indicate great uniformity throughout the whole Laramie period of such physical conditions as would affect those mollusks. In considering the distribution of the other types represented in the table, namely, those of the branchiferous mollusks, for reasons already given, those of the brackish-water beds of Bear River Valley must be, at least in part, excluded. We find, however, that the *Unionidæ*, *Ceriphasiidæ*, and *Viviparidæ*, among fresh-water types, and the *Ostreidæ*, *Anomiidæ*, *Cyrenidæ*, and *Corbulidæ*, among brackish-water types, are common to all the districts represented, the *Cyrenidæ* being especially numerous in species in Eastern Colorado. Besides these, there are other types belonging to both categories which, so far as is now known, are less widely distributed, but those families just mentioned are sufficient to serve as a basis for some general remarks which are to follow. So far as may be seen from the foregoing table, or from any similar tabular exhibition of species, they may have occurred promiscuously associated in the same layers at any and all of the localities indicated. On the contrary, certain of these types are, as a rule, confined locally to certain layers, which respectively represent the ground of their former habitats; but there is not unfrequently found such an admixture of types in one and the same layer as to show plainly that some of them must have been drifted to the places of their present entombment and association.

It is easy to understand how the light shells of land and palustral gasteropods might, after having been emptied of their decomposed bodies, have been drifted to almost any distance unharmed, and finally have found entombment with the shells of mollusks that lived and died in the very sediments that now inclose them all. But there are cases of equally heterogeneous association which cannot be accounted for in that way. These cases consist of the presence in the same layers of the shells of branchiferous mollusks, both conchifers and gasteropods, belonging to types that are respectively recognized as of brackish and fresh water habitat. It is well known that the shells of fresh-water mollusks are often carried down by the current of rivers and deposited in the sediments of the brackish waters of estuaries along with those of such mollusks as find a congenial habitat there. Where such is the case the drifted shells suffer attrition, the effects of which are readily recognized; the opercula of gasteropods are separated from the shells, and the valves of conchifers are separated from each other. Besides this the sedimentary accumulations of an estuary contain inherent evidence of their character as such aside from that which is afforded by the types of its mollusca; such as accumulation of river silt with its current-worn fresh-water shells, and the peculiar stratification produced by floods and changing currents. Although it has been not uncommon for geologists to speak of the different brackish-water strata of the Laramie Group as "estuary beds," or to refer to them as of estuary origin, I do not know of a single deposit or part of one in any district, or in any of the divisions of the great Laramie Group, to which the foregoing test of its estuary origin can be applied.

Although rivers of greater or less magnitude must necessarily have flowed into the Laramie sea, in no part of the group at any of the numerous localities where I have studied it have I found the character or condition of its strata in any way indicating that they were either influenced or modified by fluvatile influx. On the contrary, its sandstones, and most of its other lithological features, are everywhere of the same general character as those of the Fox Hills Group of Cretaceous strata, which are plainly of marine origin. But notwithstanding this evident uniformity of deposition, a large proportion of the fossiliferous Laramie strata contain a commingling of brackish and fresh-water forms, the condition and association of which show that those of neither category could have been drifted to their present position from a different habitat. For example, in the brackish-water beds of Bear River Valley great numbers of the shells of *Corbicula*, *Corbula*, and *Unio* (two species of the latter genus) are found associated together in the same layers, the majority of the examples of all of which have both their valves together in their natural position. Besides this, none of the numerous associated shells of gasteropods show any evidence of attrition such as they would have received if they had been drifted. These facts indicate that all the mollusks referred to lived contemporaneously in the same waters, and that the sediment upon which they lived is the same as that which now incloses them. It is a well-known fact that some species of *Corbicula* and *Neritina* may live in waters that are nearly or quite fresh, but the presence among those shells of the Bear River strata of *Corbula*, *Membranipora*, and a few scattered oyster-shells seems to make it certain that the waters containing all of them were, at least in some degree, saline. It also seems certain that there was some alternation of the degree of saltness of those waters, because there has been found at least one thin layer there which is composed almost wholly of a small *Ostrea*, with no other associated shells.

Again, at Black Buttes Station there is also evidence of alternation of

saltness in the waters. In one layer *Unio* and *Corbicula* in abundance, the former represented by half a dozen species, are associated together, a very large proportion of all of them having their valves together in natural position, showing that none of them had been drifted; and with these, in the same layer, are associated *Neritina* and *Melania*, which also show no evidence of having been drifted. At the same locality there are certain layers, alternating with other fossiliferous layers, which contain *Ostrea* and *Anomia* alone, and which probably represent the maximum saltness of the waters that prevailed there. There are also other alternating layers, which contain fresh-water types alone, which probably represent the minimum saltness, or perhaps entire freshness of the water that prevailed at that particular place at certain times, and the layers containing a mixture of types probably represent intermediate grades of saltness of those waters. It is remarkable that, with all this variation of their fossil contents, none of the strata present any evidence of littoral or estuary deposition.

While it seems evident that at different times in certain places these Laramie waters alternated from a decidedly salt to a nearly or wholly fresh condition, it seems equally evident that certain species belonging to different types, the representatives of which are now found only in fresh waters, were then capable of living and thriving in waters that contained a considerable degree of saltness. The species referred to belong to the *Unionidæ*, *Cariphasiidæ*, and *Melaniidæ*, the fact of the association of certain species belonging to the first and second of these families with brackish-water forms at Bear River Valley having been already stated; and on previous pages the association of *Melania wyomingensis* and *M. insculpta* with *Ostrea* and *Anomia* has already been noted.

It is a remarkable fact that the species belonging to the three families named, which are found with the brackish-water associates, almost without exception present a greater degree of differentiation than those do which are found in later but purely fresh-water deposits; and also in some cases greater than that which is shown by recent congeneric forms. This fact led me in a former publication* to suggest that the peculiar differentiation that has been attained by our North American *Unionidæ* began under the influence of a certain degree of saltness of the waters in which they lived.

There are many well-known instances of living species of mollusks, belonging to families that are regarded as of distinctively marine habitat, which are found far up from the mouths of certain rivers, inhabiting waters that are wholly and always fresh, to which habitats they seem to have made their way against opposing and, at first, uncongenial conditions. On the other hand it is not to be denied that instances of living mollusks of fresh-water types encroaching upon marine waters are rare; †

* See Bull. U. S. Geol. and Geog. Sur. Terr., vol. iii, p. 623 *et seq.*

† The Baltic, Black, and other *tideless* seas appear to afford the majority of the known instances of the commingling of living fresh-water with brackish or marine forms, and these occur in estuaries whither the fresh-water forms had been carried from their fluviatile habitats by floods or the ever-present pressure of the river-flow. Fresh-water mollusks in saline waters are not, however, always there by compulsion, because upon the shores of Great Salt Lake, as noted by Mr. Gilbert and myself, a species of *Physa* and one of *Limnæa*, both of which are common in the fresh waters of that region, have been found inhabiting pools of water that was found to be much too salt to drink; and at the Hot Sulphur Springs in Middle Park, Colorado, I found the same species in water strongly charged with sulphur. In both these cases, however, the adult size of the individuals was considerably less than that of those found in fresh waters. The presence of tides, even in waters that are always fresh, seems to be quite uncongenial to most if not all species of fresh-water mollusks, and it is probably this condition that aids in preventing the commingling of fresh and brackish water forms.

and in all such cases their changed habitat seems to have been, at least in some degree, forced upon them by environing conditions; and the individual condition of those mollusks, when compared with that of the same species in fresh waters, shows evidence of the uncongeniality of their changed habitat. It seems impossible, however, to account for the commingling of types which we find in the Laramie strata in any way except by assuming that they lived together in the same waters; and their individual condition in all cases suggests that they all thrived equally. Furthermore, it seems to be unquestionable that the waters in which the greater part of this commingling of types took place possessed a considerable degree of saltness, and that the great Laramie sea was essentially one of brackish waters.

While very much remains to be known concerning the geological structure of the North American continent, the great array of facts that have been already accumulated enables us to draw from them many legitimate conclusions concerning the former physical conditions of certain portions of it, and to begin with some confidence to arrange them as materials toward its physical history. The following remarks upon this subject are presented as supplementary to the foregoing report, but they are based largely upon facts that have been previously accumulated and published by various authors. They relate almost wholly to the Mesozoic and Cenozoic Groups, and to the corresponding epochs in the geological history of the continent. They are necessarily general in their character, and are intended to apply especially to that portion of the national domain which may in a general way be designated as lying north of north latitude 37° and between west longitude 95° and 113°.

East of longitude 95°, North America is mainly occupied by Paleozoic and Archæan rocks, as is also a large area which extends northward and southward through Western North America; the eastern border of the latter area being adjacent to the region here discussed, and not far from the one hundred and thirteenth meridian of west longitude. These two great areas are taken to represent approximately the outline and extent of the principal portions of the present North American continent that were above the level of the sea at the close of paleozoic time. A broad expanse of Mesozoic sea then stretched between these two continental factors, which were finally united by a general continental elevation and the consequent recedence of the sea. This elevation was not, properly speaking, catastrophal, but gradual and oscillatory. That intercontinental Mesozoic sea was narrower during the Jura-Trias period than it was afterward, but it was always shallow as is shown by the lithological character of the strata of all the Mesozoic formations; and as these aggregate a great thickness there was, of course, for a long time, and over a very large part of the space which it occupied, a gradual subsidence of the bottom which allowed the successive deposition of shallow-water formations. The following facts prove the occurrence of oscillations of land surface and sea-bottom by which from time to time the eastern border of the Mesozoic sea was shifted and the whole finally displaced.

In Western Iowa, Eastern Nebraska, and Eastern Kansas the Cretaceous strata are known to rest directly upon Carboniferous strata, the Jura-Trias being absent. These last-named strata, however, are in full force where the Mesozoic rocks are turned up against the eastern flanks of the Rocky Mountains and Black Hills, as well as farther westward. Their eastern border is certainly somewhere in the great plains beneath later Mesozoic strata and the prevailing surface *débris*, but its location is not even approximately known. Cretaceous strata, continuous with those of the West, are known to have been deposited as far eastward as

within fifty or sixty miles of the Mississippi River in Northern Iowa and Southern Minnesota, southward from which region their eastern border gradually recedes to the westward nearly as far as Central Kansas. In the northeastern region just named it is the attenuated strata of the Fort Benton and Niobrara Groups that are found, and these rest directly upon the Paleozoic rocks, the Dakota Group being absent there. In Western Iowa and Eastern Nebraska the strata of the Dakota Group are found to rest upon the Paleozoic rocks, the former extending farther eastward then than any other Cretaceous strata; but the eastern border of the Fort Benton and Niobrara Groups are there not very far to the westward. The eastern border of the Fort Pierre and Fox Hills Groups or the later Cretaceous is still farther westward, but its position is hidden by the later formations and the prevailing *débris* of the plains.

From the foregoing facts the following inferences may be legitimately drawn. During the period represented by those Western rocks which have received the designation of Jura-Trias (and apparently during a portion of the Permian period also), the western shore-line of the eastern or principal continental factor extended so far westward that the eastern border of the deposits of the period referred to reached no farther eastward than along some line now far out on the great plains but the location of which is not known. It is now covered from possible discovery by superimposed Mesozoic strata and the prevailing surface *débris*. At the close of the Jurassic period a subsidence took place which carried the deposits of the Dakota Group nearly as far eastward as Central Iowa. Still later, continued subsidence, but of more limited extent, to the southeastward caused the deposition of Fort Benton and Niobrara strata still farther eastward, in Northern Iowa and Southern Minnesota. At or before the close of the Niobrara epoch, the elevation of the western portion of the eastern or principal continental factor was resumed, and apparently continued without further interruption by any other subsidence sufficient to carry any of the recovered or added land surface again beneath the level of the sea; although portions of the area which the inter-continental Mesozoic sea had covered were afterward occupied by great bodies of brackish and fresh waters. The eastern border of the later Cretaceous deposits was thus carried westward where its place is now covered like that of the earlier border of the Jura-Trias deposits, but not so deeply.

The eastern border of the Laramie Group is hidden in the same manner, but there is yet no evidence that it is anywhere overlapped by any subsequent *marine* deposit, although it is known to have received upon it in several places different groups of fresh-water strata. Perhaps no fact in the physical history of North America is better established than that the elevation of the Rocky Mountains, as such, is of later date than that of the Laramie Group, but the foregoing facts show that both oscillatory movements and general continental elevation took place before the beginning of those movements which resulted in the elevation of those mountains. Besides the oscillations of surface which have already been mentioned, there are indications that other similar movements occurred elsewhere within the same limits of time; such, for example, as the unconformity of the Laramie strata upon those of the Fox Hills Group in Middle Park, reported by Mr. Marvine; the unconformity in some places of the Jura-Trias upon rocks older than the Carboniferous, &c.

But leaving now the subject of the elevation and subsidence of land surface to be resumed further on, the prevailing physical conditions of what is now Western North America may now be considered. No fresh-water deposits of any kind have yet been discovered in any of the Paleo-

zoic rocks of North America, unless the coal of the Carboniferous age may be regarded as such; but even in that case the elevation of the land upon which it was formed could have been only barely above the sea-level, because the conformity of the coal-beds with the strata above and below them is never broken, and the latter strata contain marine fossils. Therefore, for our present purpose, all the Paleozoic strata may be regarded as of marine origin. As a rule, also, all the Mesozoic strata, from the Jura-Trias to the Fox Hills Group inclusive, are, by the character of their fossils, known to be of marine origin, although at a few localities in some of the strata of each period fresh-water mollusca have been discovered. These exceptions, no doubt, indicate the proximity of then existing shores rather than the prevalence of any such bodies of either brackish or fresh water as afterward covered wide areas in the same region.

Resting directly upon the strata of the Fox Hills Group are those of the Laramie Group, the latter, as already shown, having been at least in part deposited continuously with the former. The geographical boundaries of the great Laramie formation are not known, but its area embraces many thousand square miles, for it is known to extend from Southern Colorado and Utah northward beyond the northern boundary of the United States; and from the Wasatch Mountains, eastward far out on to the great plains. It reaches a maximum thickness of about 4,000 feet, and its general lithological characteristics are similar to those of the Fox Hills Group, a known marine formation. Its fauna, however, has been shown to be largely of brackish and partly of fresh water origin, and not marine. Furthermore, the brackish-water species are distributed throughout its entire thickness and its whole geographical extent. These facts, together with the absence from all the strata yet examined of any true estuary characters, show that the Laramie Group was deposited in a great brackish-water sea. This being the case, it must have received its peculiar character, as well as its boundaries, by having been separated from the great open sea by an encircling elevation of land; the continuity of shore-line having been completed by elevations connecting the two great continental factors at the northern and southern portions of the inter-continental Mesozoic sea. Whether the brackish saltness of the Laramie sea was sustained throughout the period by limited communication of its waters with those of the great open sea, or whether such communication was entirely cut off, and the supply of salt above that which was originally retained of its marine saltness came by adjacent continental drainage in amount sufficient to balance the waste by overflow, can probably never be known, but the latter seems probable.* If the former condition existed, one of the places of communication was no doubt at the southeastern border of the Laramie sea, and some fortunate exposure of strata in the region between Western Kansas and the Gulf of Mexico may yet reveal the true relations of the Laramie Group with the Cretaceous and Eocene deposits of the Gulf border. If tide-level communication between the Laramie sea and the great open sea was entirely cut off, as there is much reason to believe it was, the question of such relationship or contemporaneousness of deposition must ever remain an open one.

It is evident that the movements which caused the inclosure of the

* The frequent presence of fresh-water forms in the strata of this group, from its base to top, such as *Unio, Melania, Viviparus, Campeloma, Goniobasis*, &c., are suggestive of the non-existence of tides in its waters, such as would have existed if they had communicated freely with the open sea, for the living representatives of these mollusks do not find a congenial habitat in tide-water, even if it be fresh.

Laramie sea did not materially interrupt the continuity of sedimentation within at least a very large part of its area, although the effects of those physical changes were such as to cause a total change in at least the molluscan fauna. The wide geographical distribution and great vertical range of many of the molluscan species of the Laramie Group, and the great uniformity of its lithological characters, show that the period was one of comparative quiet within the region which was occupied by its waters. There were, however, some comparatively slight oscillations of surface or sea-bottom which caused local unconformity of strata, but these cases are so limited in extent, so far as they are known, that at no great distance away from each the strata, which evidently correspond with the displaced ones, show no evidence of disturbance. An example of such an oscillation is illustrated by the unconformity among Laramie strata in Bitter Creek Valley, which has already been discussed.

While there is evidence that this general quiet was preserved, not only through the Laramie period, but that it was continued into the Tertiary epochs which immediately followed, it is true that at or near the close of the Laramie period in the region which now embraces a part of Bear River Valley, and there covered in part by the western border of the Laramie sea, there was an extensive displacement of the Laramie and older strata, which brought the subsequently-formed Tertiary deposits unconformably upon them. These facts have been briefly discussed on preceding pages, but that region, with its important geological and paleontological features, I have yet only slightly investigated. It has been shown on preceding pages that notwithstanding these and doubtless other disturbances which occurred elsewhere at several localities, in the great Green River Basin and in the valleys of White and Yampa Rivers the strata show satisfactory evidence that there was continuous sedimentation from the close of the Laramie period to the beginning of, and during the Wasatch epoch. Besides this, the continuity of sedimentation from the epoch of the Wasatch to that of the Bridger Group inclusive is a fact that, so far as I am aware, is disputed by no one. Admitting these facts, together with the conclusions that have been drawn on preceding pages, we have in these Western strata an unbroken geological record, extending, at least, from earlier Mesozoic far into Tertiary time; the apparent paleontological breaks in that record being really only faunal displacements, which were caused by radical changes of environment, notably the removal or variation of the saltness of the waters that were consequent upon the different physical changes which took place in the progress of the evolution of the continent.

The already accumulated geological facts show that the general continental elevation was continued after the Laramie period much in the same manner that it progressed up to that time (for the Rocky Mountains were not yet elevated), still inclosing large bodies of water, but which were no longer salt. The elevation of the Laramie sea was doubtless, at most, only slightly above that of the great open sea, but the elevation of its former bed was no doubt considerably increased during its successive occupancy in part by the Wasatch, Green River, and Bridger lakes. There must, however, have been a gradual subsidence of the bottom of each of these great bodies of fresh water, which permitted the accumulation of the immense thickness of their strata which now remain, besides that which has been removed by erosion. Free drainage of overflow into the open sea must also have been maintained during these later epochs, which kept their waters fresh, but which evidently did not exist during the Laramie period; but it is not my purpose to discuss these questions in this report. It is proper, however, to present very

briefly some of the facts that bear upon the physical conditions which prevailed during the Laramie period within the region that was occupied by its waters.

After the facts presented and the remarks made upon preceding pages of this report it is almost superfluous to say that the great Laramie Group is regarded as having been deposited in a brackish-water sea, which, for extent and character, has no existing parallel. There are, however, certain characteristics of fossil fauna and strata that indicate some very peculiar conditions of that sea then existing which deserve much investigation, but which, for obvious reasons, can receive only brief consideration here. First, it is evident that at all times its waters had comparatively little depth, and that in many places it was repeatedly very shallow; and, furthermore, that the great thickness of the group, amounting to a maximum of 4,000 feet, was accumulated by a gradual subsidence of the bottom. As a rule, its molluscan fauna was composed of brackish-water types, but often, and in many places, the waters were so far freshened as to give congenial habitat to fresh-water forms. Judging from the characteristics of existing land-locked seas, it is difficult to understand clearly how fresh and brackish waters could have existed in one and the same sea in the absence of or at a distance from the mouths of tributary rivers. But the character of the deposits of the Laramie sea, as well as its molluscan fauna, warrants the suggestion that very large portions of its area were at different times and in different places in the condition of marshes, which were only slightly raised above the general water level, upon which fresh waters from rains accumulated and gave congenial habitat to such members of the molluscan fauna of the period as would preferably avoid the brackish waters. This view is supported by the occasional presence of land-shells among those of branchiferous mollusks, the more common occurrence of palustral shells, the occurrence of deciduous leaves and other fragments of vegetation, all in the same or associated strata; and also the presence of numerous beds of lignite throughout the group. It is also supported by the fact that the fossil mollusca are found not uniformly distributed throughout the group either vertically or geographically, but to occupy very small, distantly-separated areas, which are not only locally restricted, but within which areas the vertical range of the different species is limited. Admitting that such conditions prevailed, it is easy to understand how it may have happened that certain layers, containing the remains of mollusca, which could have flourished only in salt or brackish waters, are found to alternate in close succession with those containing fresh-water species. The conditions thus indicated would also have brought the brackish and fresh water habitats of those mollusca into such juxtaposition that they must have frequently encroached upon each other. This frequent encroachment, or mingling of habitats, and no doubt the frequent impracticability of retreat, would have had a tendency to inure at least a portion of the mollusks of each to an existence in the other. It is evident that many of the species were capable of such interchange of habitat without disadvantage; and that some of the species whose living representatives are regarded as strictly fresh-water forms may have then lived in part in brackish waters, such as *Melania*, *Unio*, &c., has already been suggested.

In the foregoing report I have purposely avoided an expression of opinion as to the true geological age of the Laramie Group, because, notwithstanding the positive opinions that have been expressed by others upon that subject, I regard it as still an open question. All paleontologists agree that the Cretaceous period extended at least to the close of the Fox Hills epoch, and that the Tertiary period began at least as early

as the beginning of the Wasatch epoch; and the question is whether the Cretaceous period closed with the close of the Fox Hills epoch or with that of the Laramie period. The question might be extended so as to embrace the inquiry whether the true chronological division between Cretaceous and Tertiary did not really occur within the Laramie period; but this, while not unreasonable, would perhaps be inconvenient and unprofitable. The claim that Cretaceous types of vertebrates are found in even the higher strata of the Laramie Group is freely conceded, and I have no occasion to question the reference that has been made of its fossil plants, even those of the lowest strata, to Tertiary types. The invertebrate fossils of the group itself, as I have elsewhere shown, are silent upon this subject, because the types are either unique, are known to exist in both Mesozoic and Tertiary strata, or pertain to living as well as fossil forms. Every species found in the Laramie Group is no doubt extinct, but the types have collectively an aspect so modern that one almost instinctively regards them as Tertiary; and yet some of these types are now known to have existed in the Cretaceous and even in the Jurassic period.

In view of the conflicting and silent character respectively of these paleontological oracles the following suggestions are offered: It is a well-known fact that we have in North America no strata which are, according to European standards, equivalent with the Lower Cretaceous of Europe, but that all North American strata of the Cretaceous period are equivalent with those of the Upper Cretaceous of that part of the world. That the Fox Hills Group is of Upper Cretaceous age no one disputes, the only question being as to its place in the series. A comparison of its fossil invertebrate types with those of the European Cretaceous indicates that it is at least as late as, if not later than, the latest known Cretaceous strata in Europe. If, therefore, that parallelism is correctly drawn, and the Laramie Group is of Cretaceous age, we have represented in America a great and important period of that age which is yet unknown in any other part of the world. Besides this, we may reasonably conclude that the Fox Hills Group of the west is equivalent with the Upper Cretaceous strata of the Atlantic and Gulf coasts, between which and the Eocene Tertiary of those regions there is no known equivalent of the Laramie Group.

If paleontologists should finally agree upon regarding the Laramie Group as of Cretaceous age, it must be because of the continuance of certain vertebrate Cretaceous types to the close of that period, and the presence of mammalian Tertiary types in the strata immediately following; but the following facts, in addition to those which have been already stated, should be carefully considered before any such agreement is made.

With rare and obscure exceptions no mammalian remains are known in North American strata of earlier date than that of those which were deposited immediately after the close of the Laramie period and upon its strata. Immediately from and after the close of the Laramie period their abundant remains in the fresh-water Tertiaries of the West show that highly organized mammals existed in great variety and abundance; all of which may be properly regarded as constituents of a Tertiary fauna, and many of which are, by accepted standards, of distinctively Tertiary types. If the presence of these forms in the strata referred to, and their absence from the Laramie strata immediately beneath them, together with the presence of Dinosaurians there, be held to prove the Tertiary age of the former strata, then was the Tertiary period ushered in with most unnatural suddenness. Sedimentation was, at least in part, unbroken between the Laramie Group and the strata which contain the mammalian remains referred to, so that the local conditions of the ori-

gin of all of them were substantially the same, and yet, so far as any accumulated evidence shows, those mammalia were not preceded in the Laramie period by any related forms. Such suddenness of introduction makes it almost certain that it was caused by the removal of some physical barrier, so that ground which was before potentially Tertiary became so by actual faunal occupancy. In other words, it seems certain that those Tertiary mammalian types were evolved in some other region before the close of the Laramie period, where they existed contemporaneously with at least the later Laramie Dinosaurians of Cretaceous types, and that the barrier which separated the faunæ was removed by some one of the various movements connected with the evolution of the continent. The climate and other physical conditions which were essential to the existence of the Dinosaurians of the Laramie period having evidently been continued into the Tertiary epochs that are represented by the Wasatch, Green River, and Bridger Groups, they might doubtless have continued their existence through those epochs as well as through the Laramie period, but for the irruption of the mammalian horde, to which they probably soon succumbed in an unequal struggle for existence.

CATALOGUES OF FOSSILS.

The following lists of fossils are those of collections which have from time to time been sent to the office of the survey from different places in the western part of the national domain by persons who are not, or were not then, officially connected with the survey. They are introduced here partly to show the association of the species, a part of which were originally described in publications of the survey, and partly to show the geographical distribution of species and types, especially those of Cretaceous age, in the strata of North America.

LIST OF CRETACEOUS FOSSILS SENT BY MR. ARTHUR LAKES FROM BEAR CREEK VALLEY, NEAR MORRISON, COLORADO.

Fox Hills Group.

1. *Pteria linguiformis* Evans & Shumard; 750 feet below the coal.*
2. *Pteria* (*Pseudoptera*) *fibrosa* Meek & Hayden; 750 feet below the coal.
3. *Inoceramus oblongus* Meek; 750 feet below the coal.
4. *Cardium speciosum* Meek & Hayden; 200 feet below the coal.
5. *Tellina scitula* Meek & Hayden; 200 feet below the coal.
6. *Mactra holmesi* Meek, sp.; 750 feet below the coal. This is the species which was originally described as *Cyrena?* and supposed to have belonged in Laramie strata.
7. *Pachymya herseyi* White; 200 feet below the coal.
8. *Dentalium gracile* Hall & Meek; 200 feet below the coal.
9. *Lunatia occidentalis* Meek & Hayden; 750 feet below the coal.
10. *Baculites ovatus* Say; 750 feet below the coal.
11. *Scaphites nodosus* Owen; 750 feet below the coal.
12. *Scaphites mandanensis* Morton?; 750 feet below the coal. This is recognized as belonging to the same species as the fragment which was found associated with *Mactra holmesi* at the original locality on Ralston Creek. (See remarks under No. 6 of this list.)
13. *Placenticeras placenta* Dekay (var.); 750 feet below the coal.

* The coal referred to is within and near the base of the Laramie Group, but all the fossils of the list are found in unmistakable Cretaceous strata.

Colorado Group.

14. *Ostrea congesta* Conrad. From limestone layers near the top of the group.
15. *Inoceramus deformis* Meek. From limestone layers near the top of the group.
16. *Inoceramus problematicus* Schlot. From limestone layers near the top of the group.

LIST OF FOSSILS SENT BY MR L. C. WOOSTER FROM THE VICINITY OF GREELEY, COLORADO.

Fox Hills Group.

1. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard. Valley of the Cache à la Poudre.
2. *Pachymya? herseyi* White. Mouth of the St. Vrains. It is described and figured in another part of this volume.
3. *Nucula planimarginata* Meek & Hayden. Valley of the Cache à la Poudre.
4. *Tancredia americana* Meek & Hayden. Valley of the Cache à la Poudre.
5. *Cardinum speciosum* Meek & Hayden. Valley of the Cache à la Poudre.
6. *Tellina scitula* Meek & Hayden. Valley of the Cache à la Poudre.
7. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden. Valley of the Cache à la Poudre.
8. *Dentalium gracile* Hall & Meek. Valley of the Cache à la Poudre.
9. *Actæon woosteri* White. Valley of the Cache à la Poudre.
10. *Lunatia moreauensis* Meek & Hayden? Valley of the Cache à la Poudre.
11. *Fasciolaria* (*Piestocheilus*) *culbertsoni* Meek & Hayden. Valley of the Cache à la Poudre.

Laramie Group.

12. *Corbula perundata* Meek & Hayden. Valley of Crow Creek.
13. *Corbicula* (*Leptesthes*) *fracta* Meek. Valley of Crow Creek.

LIST OF CRETACEOUS FOSSILS SENT BY MR. J. C. HERSEY FROM COLORADO.

Fox Hills Group.

1. *Pteria* (*Oxytoma*) *nebrascana* Evans & Shumard. Valley of the Cache à la Poudre.
2. *Inoceramus barabini* Morton. Monument Creek.
3. *Pachymya herseyi* White. Valley of the Cache à la Poudre. Described and figured in another part of this volume.
4. *Nucula cancellata* Meek & Hayden. Valley of the Cache à la Poudre.
5. *Veniella humilis* Meek & Hayden. Valley of the Cache à la Poudre.
6. *Tancredia americana* Meek & Hayden. Valley of the Cache à la Poudre.
7. *Tancredia? cœlionotus* White. Valley of the Cache à la Poudre. It is described and figured in another part of this volume.

8. *Cardium speciosum* Meek & Hayden. Valley of the Cache à la Poudre.
9. *Tellina scitula* Meek & Hayden. Valley of the Cache à la Poudre.
10. *Mactra* (*Cymbophora*) *warrenana* Meek & Hayden. Valley of the Cache à la Poudre.
11. *Dentalium gracile* Meek & Hayden. Valley of the Cache à la Poudre.
12. *Lunatia morcauensis* Meek & Hayden. Valley of the Cache à la Poudre.

Colorado Group.

13. *Gryphæa pitcheri* Morton? Valley of the Cache à la Poudre above Fort Collins. This seems to belong to this species, but it is, so far as I am aware, the most northerly point at which an example of it has been discovered.
14. *Inoceramus problematicus* Schlotheim. Spring Cañon, sixteen miles west of Greeley, Colo.
15. *Inoceramus deformis* Meek. Spring Cañon, sixteen miles west of Greeley, Colo.

LIST OF CRETACEOUS FOSSILS SENT BY CAPT. E. L. BERTHOND, FROM COLORADO.

Fox Hills Group.

1. *Inoceramus oblongus* Meek. Fossil Creek, 16 miles west of Greeley, Colo.
2. *Nucula plaminarginata* Meek & Hayden. Near Golden, Colo.
3. *Nucula cancellata* Meek & Hayden. Near Golden, Colo.
4. *Baculites ovatus* Say. Fossil Creek, 16 miles west of Greeley, Colo.

Colorado Group.

5. *Ostrea congesta* Conrad. Bear Creek Valley, near Morrison, Colo.
6. *Inoceramus deformis* Meek. Bear Creek Valley, near Morrison, Colo.

LIST OF CRETACEOUS FOSSILS SENT BY PROF. O. H. ST. JOHN, FROM NEAR CIMARRON, NEW MEXICO, FROM STRATA REFERRED TO THE FOX HILLS GROUP.

1. *Caryophyllia johannis* White. Described and figured in another part of this volume.
2. *Ostrea congesta* Conrad? This is a small oyster attached to some fragments of an *Inoceramus* resembling those of *I. deformis* or *I. erectus* Meek. It may not belong to this species, but like the one found attached to *I. erectus* in Fox Hills strata, at Coalville, Utah, it is difficult to say how it differs.
3. *Ostrea* ———. An undetermined species.
4. *Anomia* ———. An undetermined species.
5. *Camptonectes* ———. An undetermined species.
6. *Pteria linguiformis* Evans & Shumard.
7. *Inoceramus barabini* Morton.
8. *Inoceramus vanuxemi* Meek & Hayden.
9. *Inoceramus erectus* Meek? Mere fragments, with *Ostrea congesta?* attached. (See remarks under No. 2.)
10. *Crassatella* (*Pachythærus*) *cimarronensis* White. It is described and figured in another part of this volume.

11. *Trapizium.* Undetermined species.
12. *Idoncarca shumardi* Meek & Hayden? Examples all very small.
13. *Callista pellucida* Meek & Hayden.
14. *Teredo?* Separated tubes only.
15. *Anisomyon alvcolus* Meek & Hayden.
16. *Margarita* ———. Undetermined species. Perhaps new.
17. *Lunatia* ———. Undetermined species.
18. *Turritella* ———. Undetermined species.
19. *Aporrhais biangulata* Meek & Hayden.
20. *Spironema* ———. Undetermined species. Perhaps new.
21. *Pyramidella* ———. Undetermined species.
22. *Turbonilla* (*Chemnitzia?*) ———. Undetermined species.
23. *Fasciolaria* (*Piestocheilus*) ———. Undetermined species.
24. *Baculites ovatus* Say.
25. *Scaphites nodosus* Owen?
26. *Placeniticeras placenta* Dekay.
27. *Serpula* ———. Undetermined species.
28. Undetermined Crustacean. Probably a Brachyuran.

The specimens of this collection have had their specific and other characters much obscured by compression, and by calcareous encrustation.

LIST OF CRETACEOUS FOSSILS SENT BY PROF. B. F. MUDGE, FROM DENNISON, TEXAS.

1. *Ostrea quadriplicata* Shumard.
2. *Ostrea* (*Alectryonia*) *bellaplicata* Shumard.
3. *Gryphæa pitcheri* Morton.
4. *Neithea texana* Rœmer.
5. *Trigonia emoryi* Conrad.
6. *Turritella* ———. Undetermined species.
7. *Auchura* (*Drepanocheilus*) *mudgeanus* White. This species was found in the form of natural casts, together with those of several other undetermined species, in a mass of red hematite. The mass also contained partial casts of two or three of the species of this list, showing that the hematits came from the same formation. It is described and figured in another part of this volume.

LIST OF CRETACEOUS FOSSILS SENT BY MR. G. W. MARNOCH, FROM NEAR HELOTES, BEXAR COUNTY, TEXAS.

1. *Orbitulites texanus* Rœmer.*
2. *Astrocœnia sancta-sabæ* Rœmer.
3. *Toxaster texanus* Rœmer.
4. *Toxaster elegans* Shumard.
5. *Diadema texanum* Rœmer.
6. *Cyphosoma texana* Rœmer.
7. *Cidaris hemigranosus* Shumard.
8. *Hippurites texanus* Rœmer.
9. *Radiolites austinensis* Rœmer.
10. *Terebratula wacoensis* Rœmer.
11. *Ostrea subspatula* Lyell & Sowerby.
12. *Ostrea congesta* Conrad.
13. *Ostrea* (*Alectryonia*) *carinata* Lamarck?

*The nomenclature of the respective authors is here used without any attempt at rectification.

14. *Gryphæa pitcheri* Morton. Besides forms like those figured by Morton, Rœmer, and other authors, there are in this collection some large examples that are doubtless only a variety of *G. pitcheri*. The radiating prominence common to the larger valve of most of the typical examples is in this variety very prominent, angular, and roughened by occasional projecting or vaulted laminæ.
15. *Exogyra arietina* Rœmer.
16. *Exogyra texana* Rœmer.
17. *Exogyra ponderosa* Rœmer.
18. *Exogyra costata* Say.
19. *Neithea texana* Rœmer.
20. *Inoceramus* ———. Undetermined species.
21. *Lima leonensis* Conrad.
22. *Trigonia emoryi* Conrad.
23. *Protocardia texana* Conrad.
24. *Anatina* ———. Undetermined species.
25. *Liopistha* (*Cymella*) ———. Undetermined species.
26. *Cucullea terminalis* Conrad.
27. *Gyrodes* ———. Undetermined species.
28. *Pleurotomaria* ———. Undetermined species.
29. *Turritella marnochi*. White. Described and figured in another part of this volume.
30. *Turritella* ———. Undetermined species.
31. *Nerinæa* ———. Undetermined species.
32. *Turbonilla?* ———. Undetermined species.
33. *Ammonites peruvianus* Von Buch.
34. *Ammonites flaccidicosta* Rœmer.
35. *Ammonites woolgari* Mantell.?
36. *Turrilites brazosensis* Rœmer.

LIST OF CRETACEOUS FOSSILS SENT BY D. H. WALKER TO THE SMITHSONIAN INSTITUTION, FROM NEAR SALADO, BELL COUNTY, TEXAS.

1. *Astrocoenia sancta-sabæ* Rœmer.
2. *Toxaster texana* Rœmer.
3. *Toxaster elegans* Shumard.
4. *Diadema texanum* Rœmer.
5. *Cyphosoma texanum* Rœmer.
6. *Hippurites texanus* Rœmer.
7. *Radiolites austinensis* Rœmer.
8. *Terebratula waconsis* Rœmer.
9. *Ostrea congesta* Conrad.
10. *Ostrea* ———. A large undetermined species.
11. *Ostrea* (*Alectryonia*) *subovata* Shumard.? This appears to be identical with Dr. Shumard's species as figured and described in Marcy's Exploration of the Red River of Louisiana, but the description is brief and the figure poor.
12. *Ostrea* (*Alectryonia*) *carinata* Lamarck? This is the species which has been usually referred to *O. carinata* Lamk., and the same as No. 13 of the preceding list, but it is probably specifically distinct.
13. *Gryphæa pitcheri* Morton. The specimens, as usual, present considerable variety; this being the most variable species of the genus known.
14. *Exogyra valkeri* White. Described and figured in another part of this volume.
15. *Exogyra læviuscula* Rœmer.

16. *Exogyra ponderosa* Rœmer.
17. *Exogyra texana* Rœmer.
18. *Exogyra arietina* Rœmer.
19. *Spondylus?* ———. This is apparently a *Spondylus*. The few examples of it in the collection are attached at full length to other fossil shells. It is about two and a half centimeters long, and the surface marked by numerous fine radiating lines.
20. *Modiola sancta sabæ* Rœmer.*
21. *Neithea duplicata* Rœmer.
22. *Neithea texana* Rœmer.
23. *Pinna* ———. Undetermined species.
24. *Inoceramus deformis* Meek?
25. *Inoceramus* ———. A large broad species.
26. *Lima* ———. A robust spinulose species.
27. *Trigonia emoryi* Conrad.
28. *Tapes hilgardi* Shumard.
29. *Protocardia texana* Conrad.
30. *Arcopagia texana* Rœmer.
31. *Anatina?* ———. Undetermined species.
32. *Liopistha sancta-sabæ* Rœmer sp.
33. *Corymya* ———. This species resembles an elongate *Glycymeris*, but it has the internal rib radiating from the beak of each valve, which characterizes *Corymya*. The collection contains only one example, an internal cast. The species is undetermined.
34. *Pachymya austinensis* Shumard.
35. *Actæonella dolium* Rœmer.
36. *Spiractæon* ———. Undetermined species.
37. *Pleurotomaria?* ———. The examples are rather large, and being imperfect their generic characters cannot be clearly determined, but they appear to possess the general characteristics of *Pleurotomaria*.
38. *Lunatia collina* Conrad sp.
39. *Lunatia pedernalis* Rœmer sp.
40. *Nautilus elegans* Sowerby.
41. *Nautilus* ———. Undetermined species. A cast only.
42. *Ammonites flaccidicosta* Rœmer.
43. *Ammonites leonensis* Conrad.
44. *Ammonites peruvianus* Von Buch.
45. *Placenticeras placenta* DeKay.
46. *Turrilites brazosensis* Rœmer.
47. *Serpula intrica* White.
48. *Serpula* ———. A large undetermined species.

Taking a general view of the Cretaceous faunæ of the different regions of Western North America, we find that there is a marked difference between certain of the widely separated regions. For example, the fauna of the Texas region, including portions of the adjacent Territories; that of the Pacific coast, especially California, and that of the Upper Missouri River region, are each found to possess well-marked fanual peculiarities. Not only are almost all the species in each region different from those of any of the others, but several of the higher groups, as well as peculiar types, are found to be restricted to each. The differences of this character are as great, if not greater, between the Texas and Upper Missouri River regions as they are between either of these and that of

*As a rule I adopt the nomenclature of the various authors in this list without any attempt at rectification.

the Pacific coast; and yet, for reasons suggested in the following remarks, it is probable we shall be able to correlate the strata of the Upper Missouri River region with those of the Texas region more directly than with those of the Pacific coast. No doubt the Cretaceous sea connected the Texas and Upper Missouri River regions directly, without the interposition of land surface, great or small, and the strata of Cretaceous age may now be traced nearly or quite continuously from one region to the other; while it is certain that one or more continental factors were interposed between these, together with their intermediate region, and the waters which then covered what is now the Pacific coast region. It is in the intermediate region between that of Texas and the Upper Missouri River that my labors for 1877 were prosecuted, and a part of the collections made by others and recorded in the immediately preceding lists were obtained in the same intermediate region. Besides these, collections have been made by various parties of the United States surveys in the same and adjacent regions, all of which show a commingling of the forms which are among those that are respectively peculiar to each of the separated regions. It is expected that this subject will receive especial attention in future reports, but the following prominent facts may be noted here, the comparisons being mostly between portions of the Texas and Upper Missouri River regions, respectively.

Collections from the Cretaceous rocks of Texas show a remarkable profusion of the Ostreidæ, especially of the genera *Gryphæa* and *Exogyra*. So far as I am aware, no example of *Gryphæa* has been found in any Cretaceous strata of the West north of latitude 41°; nor any example of *Exogyra* north of latitude 38°; these parallels being used for convenience as approximate boundaries. While it is possible they do exist north of those boundaries respectively, it is very certain they are exceedingly rare there. These remarks apply only to Cretaceous rocks, for *Gryphæa* is well known to exist in Jurassic rocks much farther north. Southward from those boundaries respectively, the two genera named are well represented, but they apparently reach their greatest abundance in Texas, in the rocks of which region at least six species of *Exogyra* are found.

Again, the Hippuritidæ are common in the Cretaceous rocks of Texas, but I am not aware that an example of any species of the family has ever been found north of latitude 35°; and the same may be said of the genus *Nerinæa*, two or three species of which are found in Texas, but none farther northward. Echinoderms are very rare in the Cretaceous rocks of North America, except in those of Texas, where they are not uncommon, but hitherto none but the Echinoidea have been discovered, so far as I am aware. Northward from that region only one representative of the Crinoidea, one of the Asteroidea, and one of the Echinoidea have been found. Besides these differences, there are many genera and some families well represented in one region that are not known or only slightly represented in the other.

Aside from these faunal differences between different regions of North America, which seem not to have been due to separation by then existing land barriers, nor to mere local conditions, there are some regional differences that do seem to have been due to local conditions connected with proximity of extended coasts; such, for example, as those which appear in the fauna of the Coalville series of Cretaceous strata. Furthermore, the fauna of all these regions, taken collectively, compared with rocks of admitted equivalency of age in other parts of the world, present differences that cannot be accounted for by any of the causes suggested. These differences are no doubt due in part to the more or less remote effects of conditions which governed the distribution of species, but

doubtless in large part also to the condition of the bottom of the seas which covered the area that now constitutes the regions here discussed. It is sufficient in this connection to point out a single fact bearing upon this subject. The strata of the Cretaceous formations of the West are almost all and everywhere sandstones or sandy shales, and therefore the whole sea bottom in those regions must have been almost always and everywhere covered with sand. Our knowledge of the faunæ of existing seas tells us that the continued prevalence of this condition could not but have exerted a material effect upon the Cretaceous fauna of this portion of North America. Notwithstanding these faunal differences in the strata of the different regions, it is believed that they are all respectively synchronous or nearly so; and being so, it is expected that the classification adopted by Hayden and Meek for those of the Upper Missouri River region may be appropriately applied to the greater part if not all the Cretaceous strata of Western North America.

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OF

THE TERRITORIES,

EMBRACING

IDAHO AND WYOMING,

BEING A REPORT OF PROGRESS OF THE EXPLORATION FOR THE YEAR

1877.

By F. V. HAYDEN,

UNITED STATES GEOLOGIST.

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