ART. III.—*Post-Laramie Deposits of Colorado*; by WHITMAN CROSS.

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Introductory.

AMONG questions in American geology which have given rise to prolonged discussion and controversy, few if any have been more prominent than that as to the age of the great Laramie Formation or Group of the Rocky Mountain region. This observation, made by Mr. Clarence King in the final report of the Fortieth Parallel survey, in 1878, is still more true to-day than it was at that time. When it is considered, however, that a very large part of the earlier publications were based upon mere geological reconnaissance, and that the area involved extends across the United States in its most inaccessible and least known portion, from Mexico to British America, it must be plain that controversies and misunderstandings were unavoidable, and indeed quite natural.

A few years ago it seemed to many geologists that the Laramie question was practically settled, or in a fair way to settlement. But, as certain areas of the West have been more carefully explored, the question has been in a measure reopened, but with a change in its phase, so that it is not now so much "To what age does the Laramie belong?" as it is "What belongs to the Laramie?" For the newer researches, whatever their direction, all tend to show that the Laramie has been a great omnibus division into which has been cast everything ascertained to lie between the marine Cretaceous and the lowest recognized Eocene deposits, together with a number of other formations whose positions were not determined. It is the aim of this paper to show that there exists at least one important group of formations which have been considered as belonging to the Laramie, but which are very markedly distinct from the formation to which that name properly belongs.

As far as the writer is aware the first definite proof that a given section assigned to the typical Laramie contained members separated by important unconformities and of widely different lithological character, was afforded by the work done in the vicinity of Denver, by the Colorado Division of the U. S. Geological Survey, in charge of Mr. S. F. Emmons. A preliminary account of these researches was presented to the Colorado Scientific Society, July 2, 1888, in articles by G. H.

Eldridge and the writer.* In this Journal for April, 1889, the second of these articles "The Denver Tertiary Formation," was published in revised form. During the last three years further discoveries bearing upon this question have been made in various fields by several observers, and it is desired to present here a connected statement of these new facts, together with a discussion of their significance.

Description of the Deposits.

Denver and Arapahoe Formations.—In the detailed examination of the Denver region above mentioned, it was found that the continuous so-called "Laramie" section exposed near Golden consisted of three divisions: 1°, a lower member, 700–800 feet thick, conformable with the Fox Hills, containing productive coal measures and a flora and fauna characteristic of the Laramie as commonly known; 2°, a middle member, 800 feet thick, unconformable with the lower member, characterized by a conglomerate which carries pebbles recognized as coming from the Laramie, Fox Hills, Niobrara, Benton, and Dakota, Cretaceous, the Jura, the Trias, and the Carboniferous; 3°, an upper member, 1400 feet thick, unconformable with the middle member, and characterized lithologically as composed very largely of debris of andesitic lavas, none of which appeared in the preceding deposits. To the middle member of this series Mr. Eldridge gave the name "The Arapahoe Beds;" to the upper member was assigned the name "The Denver Beds." It was found that the celebrated fossil-leaf horizon of Table Mountain, at Golden, belonged to the Denver beds and consequently that the "Laramie" flora of Golden, described by Lesquereux and Ward, belonged to two distinguishable horizons, and chiefly to the upper one. The Arapahoe and Denver beds were found to contain a vertebrate fauna not known in the coal measures below, and to this point reference will be made in a later section of this article.

The stratigraphical and lithological evidence above summarized indicated clearly that the Arapahoe and Denver beds were separated from the Laramie below by a long period of very important orographic disturbances, as attested by the pebbles in the Arapahoe conglomerate. As the fossil flora and fauna of the formations did not seem to be necessarily opposed, the two formations in question were referred in the publications cited to the early Eocene, and probably to a horizon

* On some stratigraphical and structural features of the country about Denver, Colorado; by George H. Eldridge. The Denver Tertiary Formation; by Whitman Cross. Proc. Col. Sci. Soc., vol. iii, part I, pp. 86–133.

below any other recognized member of that division. Having thus briefly restated the stratigraphical evidence of the formations near Denver the developments of the last three years in other districts will be reviewed.

Huerfano Series.—In the Huerfano basin in southern Colorado Mr. R. C. Hills has discovered and described * a series of strata 7,100 feet in thickness which he refers to the Eocene, because their lower member is decidedly unconformable with the underlying well-known coal-bearing Laramie of southern Colorado, and because the upper division contains mammalian remains of the Bridger Eocene. For the whole series Mr. Hills submits the following scheme of division :

Huerfano Series (Eocene)	{ Huerfano beds, 3,300 feet=Bridger Group.	
	{ Cuchara beds, 300 feet	
	{ Poison Cañon beds, 3,500 feet { Lower Eocene.	

Great angular unconformity exists between the Laramie and the Poison Cañon beds, but none has been detected between the designated members of the new series. The Poison Cañon and Cuchara beds are at present separated from each other and from the Huerfano beds on lithological grounds only, the former consisting of "soft sandstones and fine conglomerates of a yellowish tint, with occasional bands of yellow clay or marl," while the latter is a well defined horizon of "pink and white massive sandstones." The Huerfano beds consist of "marls, clays, soft shales and sands, of red, gray, yellow, green and purple colors, red predominating." In these have been found remains of *Tillotherium*, *Hyrachyus*, *Glyptosaurus*, *Palæosyops*, and other forms which seem to correlate the strata containing them with the Bridger Eocene. This discovery of Eocene deposits, containing a well-marked mammalian fauna, on the eastern slope of the Rocky Mountains is certainly significant. And it is highly probable, as pointed out by Mr. Hills, that the Cuchara and Poison Cañon beds are contemporary with some of the other post-Laramie formations to be mentioned.

Gunnison County.—A fund of new observations bearing upon the present question is to be found in the address of Mr. R. C. Hills as retiring President of the Colorado Scientific Society, delivered December 15, 1890, but only very recently published.† In that portion of this address treating of the

* The recently discovered Tertiary beds of the Huerfano river basin, Colorado (with map): Proc. Col. Scientific Society, vol. iii. part I. pp. 148-164, 1888.

Additional notes on the Huerfano beds; *ibid.*, vol. iii. part II. pp. 217-223. 1889.

Remarks on the classification of the Huerfano Eocene. Read before the Col. Sci. Soc., Feb. 2, 1891. Not yet published in full.

† Orographic and structural features of Rocky Mountain geology, Proc. Col. Sci. Soc. vol. iii, part III. pp. 359-458. 1891.

period between the marine Cretaceous and the Wasatch Eocene, Mr. Hills gives much important original information concerning the Laramie and various post-Laramie formations.

The first one of these later deposits to be mentioned occurs in western Colorado on the western slope of the Elk Mountains. Its southern limit, as now known, is about Irwin, a few miles to the westward of Crested Butte in Gunnison County. It rests upon the normal Laramie carrying anthracite coal beds on the northern slopes of the Anthracite range, occupies a considerable area at the head of Anthracite creek, and thence extends northward for 80 miles to Grand river. The development on Anthracite creek comes within a district which has been examined in detail by the Colorado division of the U. S. Geological Survey. In the course of this work the provisional name of the "Ruby beds" was assigned to these strata on account of their prominent development in Ruby Peak, near Irwin, where their thickness exceeds 2,000 feet, and this name is used by Mr. Hills in his address in referring to them.

In the Irwin region the Laramie strata have a thickness of about 1500 feet. They are succeeded by 2000 feet of conglomerates, sands and shales, composed almost entirely of the debris of volcanic rocks of andesitic character, here much hardened and metamorphosed by later eruptive rocks which pierce them in numerous dikes. The basal member of the series is a conglomerate of small pebbles, which is usually uncomformable on a small scale with the Laramie, and also exhibits a great variability in constitution. In some places it consists entirely of andesitic pebbles, in others, of a mixture of such material with white, black or reddish chert pebbles, some of which show cavities representing crinoid stems. Again, the lower part of the conglomerate may be free from andesitic pebbles.

To the northward of the Irwin region Mr. Hills has traced out the Ruby beds, with a decreasing thickness reaching a minimum of 300 feet near the northern limit on Grand river. Concerning their development at this point Mr. Hills says: "South of the Great Hogback at Coal ridge, there is an abrupt change in the composition of the sediments previously regarded as Laramie. The firm gray sandstones of the coal measures are there succeeded by about 200 feet of soft white sandstones and yellow clays, followed by about 300 feet of tufaceous strata, more or less conglomeritic and usually loosely aggregated, but resting on a hard, coarse basal conglomerate about 40 feet thick made up wholly of eruptive debris. The tufaceous beds are in turn succeeded by 600 feet or more of shales and soft brownish sandstones which may be in part of Wasatch age." *

* Op. cit., p. 390.

On Ohio creek, but a few miles beyond the southern limit of the Ruby beds, there are two small isolated patches of loose friable sandstones, grits, and fine conglomerates, resting on the coal-measures of the Laramie, and seemingly in small basins of erosion. Owing to the disturbances caused by adjacent laccolites it is impossible to see the relationship of the formations clearly. The chert pebbles of these beds contain crinoid stems and other apparently Carboniferous fossils, and are identical in character with those already mentioned as frequently found in the basal conglomerate of the Ruby beds near Irwin. These facts suggest that the chert pebbles of the Ruby conglomerate may be the residuum from the destruction of Ohio creek beds formerly existing to the north of the Anthracite range. Mr. Hills does not mention such pebbles in the section near Coal ridge above described, but he does suggest a possible correlation between the Ohio creek beds and the soft yellowish sandstones found at the north between the "firm gray sandstones of the coal-measures" and the Ruby conglomerate. He also thinks that the Carboniferous chert pebbles of the Ohio creek beds indicate a post-Laramie erosion of the entire Cretaceous section, exposing Carboniferous strata. Whether this hypothesis be established or not it is true that such materials are not seen in the Cretaceous beds above the Dakota conglomerate, and it is not known to the writer that they have been found at that horizon in this region, though not uncommon along the Front range and in Middle Park.

Mr. Hills has found that on Grand river the Ruby beds lie between the Wasatch and the Laramie. The lithological and stratigraphical evidence given there distinctly suggests that the Ruby beds may be the equivalent of the Denver formation, and less decidedly that the Ohio creek beds may possibly represent the Arapahoe formation. No fossils excepting carbonized plant stems have been found in the two new formations. The writer does not place much weight on the mere coincidence in eruptive character of the materials in the Ruby and Denver beds, beyond the marked fact which seems to be developing from experience that a number of formations of apparently the same stratigraphical position are thus characterized. It may finally come to be a criterion of considerable value.

Yampa River.—In northwestern Colorado on the Yampa river Mr. Hills finds reason to believe that there is a distinct formation between the Laramie proper and the Wasatch, but is at present able to give no positive evidence for this view except that the normal series of the Laramie has above it a formation "of soft sandy strata with some shales and clays" containing impure lignitic beds, and of general different

physical appearance from the beds of the Laramie. Above these are unquestioned Wasatch beds.*

South Park.—Near Como in South Park, Colorado, Mr. Hills has found a very remarkable formation which will be best described in his own language: "While recently engaged in the examination of the small Laramie area in the South Park basin, I there observed unquestionable evidence of a former grand eruption, of a character not previously noted in that part of Colorado. The evidence consists in the occurrence of thick sheets of eruptive conglomerate, intruded partly into the marine Cretaceous and partly into the Laramie, to some extent above the workable coal. These sheets are continuous from Mine No. 5 near Como to the southern limit of the Laramie beds, a distance of fully fifteen miles, beyond which I did not trace the exposures. About three miles south of Mine No. 5, the intrusions above and below the coal beds coalesce and form a body of conglomerate several hundred feet thick completely cutting out the workable measures for nearly a mile. The material consists of rounded pebbles and bowlders of andesite embedded in a matrix of finer material of similar composition." . . . "The material itself may be regarded as the product of intense dynamic movement, probably brought to the surface as a hot conglomeritic mud, or in a condition to produce an explosive eruption, whenever, owing to diminished pressure, the contained water flashed into steam." . . . "The material then thrown out and scattered over the surface would be in a condition to be transported in large quantities to the nearest area of sedimentation—the Denver basin—and presumably at the very time when the Denver beds were laid down." †

It seems to the writer that the character ascribed to the South Park eruption is so novel and its extent so far a matter of speculation that it can at present hardly enter as an important factor into the question as to the origin of the eruptive materials of the Denver beds. The facts concerning the constitution of the Denver beds given in the original article do not allow of the adoption of Mr. Hills' suggestion. They demand a source near at hand and one whose location shall explain why eruptive material practically excludes Archæan material in fine, slowly deposited sediments, close to an Archæan shore-line.

Cañon City.—In his address Mr. Hills refers to remnants of a formation near Cañon City which seems related to the Denver formation. Through his kindness in personally communicating the news of his discovery, my colleague, Mr. G. H. Eldridge, was enabled in the season of 1890 to hurriedly

* Op. cit., p. 389.

† Op. cit., pp. 393, 394.

examine the region, in connection with other field work, and kindly allows me to state the results. At Windy Gap, a few miles east of south from Cañon City, Mr. Eldridge found the normal section of the Laramie sandstones very steeply upturned, resting on Montana shales, while above them came a heavy conglomerate composed mainly of Archæan debris, but containing in addition pebbles recognized as belonging to various older sedimentary horizons, such as the Niobrara and Dakota Cretaceous, and the Jura. These conglomerates are also upturned, but, probably because they come directly in the fold, they are less steeply inclined than the Laramie. Angular unconformity with the Laramie was not determined. Separated from the conglomerate by a gap of 500 feet, in which there are no outcrops, are horizontal beds of conglomerate consisting of andesitic pebbles. As the fold is plainly abrupt, this position is not evidence of angular unconformity.

Mr. Eldridge did not have time to trace out either of these formations, which, though apparently remnants at the place observed, are probably represented elsewhere in the immediate vicinity. The fact was established, however, that two formations corresponding in stratigraphical position and lithological character to the Arapahoe and Denver beds exist near Cañon City.

Animas River.—Through the courtesy of Dr. C. A. White and his assistant, Mr. T. W. Stanton, I am enabled to state that the latter has recently found the formation crossing the Animas River about five miles south of Durango, Colorado, which is represented as Laramie upon the Hayden map; to consist of conglomerates, sandstones and shales, whose material is of andesitic rocks, as far as shown by the specimens collected. By referring to the Hayden atlas of Colorado, sheet 15, it will be seen that the coal-measures of this region were there referred to the Fox Hills, though their identity with the normal Laramie measures elsewhere in Colorado is at present probably unquestioned by any one.

On the western bank of the Animas River Mr. Stanton found a bed of conglomerate about 200 feet thick resting upon the coal-measures with apparent conformity. The specimens of this conglomerate collected by him are purplish or yellowish brown in color, the pebbles are of hornblende- or pyroxene-andesite, and the matrix is a gravel of the same character. Above the conglomerate are brown sandstones, very similar to the Denver sandstones of Table Mountain, and in one stratum some fossil leaves were found. The only identifiable species collected has been determined by Mr. F. H. Knowlton as *Magnolia tenuinervis* Lx. The specimen first described by Lesquereux came from the Denver beds of Table Mountain.

Since then the species has been repeatedly collected from the same beds and has also been detected at Black Butte, Wyoming.

That portion of the Hayden map representing the area to the westward from the Animas River is based upon the work of Mr. W. H. Holmes. In describing the series called the Laramie, to which the strata observed by Mr. Stanton evidently belong, Mr. Holmes usually refers to them as composed of brown sandstones, shales, and dark colored clays. In the section on the La Plata River* he assigns a thickness of 800 feet to the "Puerco marls" of Piñon mesa which overlie them, and 1120 feet to the coal-measure rocks below, which are called Fox Hills. Through the kindness of Mr. Holmes I have been allowed to examine his original field-notes in this area, and find that the general resemblance of these "Laramie" strata to those at Table Mountain near Golden was recorded. There is, however, no definite evidence in these notes to confirm the generalization suggested by Mr. Stanton's observations that the strata between the "Puerco marls" and the coal-measures, west of the Animas River, are equivalents of the Denver beds, although the strata noted by him certainly occur in that part of the section.

In an article entitled: "The relations of the Puerco and Laramie deposits"† Professor E. D. Cope states that according to the observations of Mr. David Baldwin "the Laramie beds succeed [the Puerco] downward, conformably it is thought by Mr. Baldwin; and have a thickness of 2,000 feet at Animas City, New Mexico. [?] They rest on Fox Hills marine Cretaceous of less thickness. A few fossils sent from time to time by Mr. Baldwin identify the Laramie. This is especially done by the teeth of the dinosaurian genus *Dysganus* Cope, which is restricted to the Laramie formation everywhere. Also by the presence of the genera *Laelaps* and *Diclonius*, which in like manner do not extend upward into the Puerco beds. The *Laelaps* is principally represented by teeth, which resemble those of the *L. incrassatus* Cope, more than those of any other species . . ." "The *Dysganus* agrees with the *D. encaustus* Cope, which, with the *Laelaps incrassatus*, was described from specimens from the Upper Missouri."

In recent "Notes on the Dinosauria of the Laramie"‡ Professor Cope describes a new Dinosaur, *Pteropelyx* "found near Cow Island, Montana, on the Upper Missouri, in 1876." "The genus *Pteropelyx* displays characters between the

* Ninth Ann. Rep. U. S. G. & G. S. 1875, p. 248.

† American Naturalist, vol. xix. p. 985, 1885.

‡ American Naturalist, vol. xxiii, p. 904, 1889.

Hadrosauridæ and Agathaumidæ" (= Ceratopsidæ, Marsh). He then remarks that it is to be compared with *Dysganus*. Now the original descriptions of the genera *Dysganus* and *Diclonius* and of the species *Laelaps incrassatus* are in an article entitled: "Descriptions of some vertebrate remains from the Fort Union beds of Montana,"* without any further statement in the text as to the geographical or geological position of the occurrence. The new dinosaurian genus *Monoclonius* was also described in this article. *Monoclonius* is now regarded as belonging to the horned Dinosaurs, and four species have been named by Professor Cope,† from Montana. One of these, *M. sphenocerus*, came from near Cow Island, on the Missouri, while another, *M. recurvicornis*, came from the "Judith River beds" on the north side of the Missouri River nearly opposite the mouth of Dog Creek. This last information is found in Professor Cope's report of the expedition during which all of these Dinosaurs appear to have been collected.‡

From the casual statements of localities and horizons above recapitulated it appears that somewhere in the 2000 feet of strata assigned by Professor Cope to the Laramie on the Animas River several species of Dinosaurs have been found, and that they most resemble a fauna collected in "Fort Union" beds near Cow Island, on the Upper Missouri River, in Montana, a locality which has furnished at least one species of the Ceratopsidæ. It is worthy of note that the so-called "Laramie" section below the Puerco on the Animas River contains strata resembling the Denver beds, and also Dinosaurian remains of types resembling, or associated in Montana with, the Ceratopsidæ. Whether the Dinosaurs occur in the Denver-like beds remains to be proven. It is certainly of importance to discover the character of the vertebrate fauna in beds thought to occur conformably below the Puerco.

Middle Park.—The Hayden atlas of Colorado represents a large continuous area of Laramie beds in Middle and North Parks, a representation based very largely upon the work of the late A. R. Marvine, during the seasons of 1873 and 1874. In the annual report for the former year Marvine describes in considerable detail the region of Middle Park, but this able and lamented geologist died before the notes of the next season's work could be put in shape for publication, and the data he then collected are practically lost to science. No publication of importance concerning the supposed Laramie beds of Middle Park has appeared since Marvine's report.

* Proc. Acad. Nat. Sci. Phil., vol. xxviii, p. 248, 1876.

† "The Horned Dinosauria of the Laramie," Am. Naturalist, vol. xxiii, p. 715.

‡ Bulletin, U. S. G. & G. S., vol. iii, p. 565, 1877.

In his report on Middle Park Marvin describes very clearly the excellent section of the Cretaceous formations exposed in a synclinal basin cut across by the Grand River for eight miles above Hot Sulphur Springs. He also gives detailed maps, and sketches from the master hand of W. H. Holmes. He well understood the importance of the locality from the standpoint afforded by his interpretation of the stratigraphy, and since 1873 the "Laramie" of Middle Park has been cited as probably the only decided instance of great unconformity between this formation and the lower Cretaceous horizons.

To summarize Marvin's description of the Grand River section, he found the Cretaceous, from the Dakota to the Fox Hills, inclusive, exposed on both sides of the syncline mentioned. Then comes a formation occupying the center of the shallow syncline, which is described as follows: * "Above the Cretaceous No. 5, the next youngest rock is a local occurrence of volcanic doleritic material, consisting partially of subaqueous-arranged material—dolerite, tuff, and breccia—and partially as accompanying lava-flows; in all, reaching a maximum thickness of 800 or 900 feet." This formation is thereafter usually designated as "Doleritic breccia." "Resting upon the latter [the breccia] when it occurs, but elsewhere upon Cretaceous No. 5, and apparently conformable with the latter, except at one point where there is a decided unconformability, is a series of beds which reach a thickness of about 5500 feet." . . . "They are composed in part of sandy shales, in places more or less argillaceous and quite soft, spaced rather regularly with more prominent and characteristic horizons of coarse sandstones, which are often inclined to grits and fine conglomerates. The texture of the latter is usually open and not firmly compacted, while the material of which they are composed is characteristically the debris of the Archæan rocks of the mountains, granitic debris prevailing." . . . "Impressions of deciduous leaves are quite numerous at favorable localities and small isolated patches, and one or two thin seams of carbonaceous material were also observed. No other fossils were observed in these beds. It has been strongly affected by the last great folding accompanying the formation of the Rocky Mountains, portions of it being abruptly upturned, together with the underlying sedimentary rocks. In position and character, therefore, this group of beds appears to be the equivalent of the lignitic group east of the mountains."

To the westward of this syncline, in which the formations are apparently conformable, Marvin found that the "lignitic beds" above the "breccia" in fact overlap the latter and rest successively on the inclined strata of the entire Cretaceous

* Seventh Ann. Rep. U. S. G. and G. S., pp. 156, 157. 1874.

section, the Jura, and the Archæan. This was clear in the horizontal position of the "lignitic" strata of Mt. Cross which rest upon upturned Dakota and Ft. Benton strata, and of the ridge south of Hot Sulphur Springs. The relationships are expressed in the Hayden atlas and in the large scale maps accompanying Marvine's report, to which the reader must be referred for details. The "thin seams of carbonaceous material" mentioned by Marvine became coal beds in subsequent writings of other geologists, and the fossil plants said to have been collected here were identified by the paleobotanists as "Laramie," excepting a few which are described by Lesquereux without explanatory comment as coming from the Green River Eocene. The plainly provisional correlation of these beds with the coal-measure horizon east of the mountains by Marvine has not been questioned until recently.

It is evident to any one intimately acquainted with the Laramie proper that the description and statements of Marvine do not establish a satisfactory correlation between the Middle Park "lignitic" beds and the Laramie. In the light of the investigations of the Denver region the unconformity noted by Marvine and the thick beds of eruptive material at the base of the series suggested a different correlation. In the summer of 1889 Mr. George L. Cannon, Jr., of Denver, a geologist well acquainted with the local formations, was sent into Middle Park by Mr. Emmons to examine the so-called "lignitic formation" of Marvine. On the basis of Mr. Cannon's work it has already been stated by Mr. Emmons that the Middle Park series does not correspond with the true Laramie.* In October, 1891, the writer visited Middle Park, extending the observations of Mr. Cannon and determining still further the relationships of the formation in question. A paper giving the results of these examinations is in process of preparation, but the main features may be here summarized.

The statements of Marvine as to the unconformity existing between the "lignitic" beds and the Cretaceous section are very clearly correct. There are faults not noticed by him which complicate the local geology very much but they cannot explain the transgression of the newer beds across the entire Cretaceous section and to the Archæan. The unconformity is also shown by an examination of the Cretaceous horizon upon which the "doleritic breccia" rests in the section of the "breccia spoon," the syncline above mentioned. It is evident that no strata corresponding to the Laramie proper now exist in this section. Marvine refers the strata below the "breccia" to the Fox Hills, but gives no special reason for the assign-

* Orographic Movements in the Rocky Mountains. Bull. G. S. A., vol. i, p. 281, 1890.

ment aside from the general stratigraphical position. Mr. Cannon, however, collected a number of fossil shells from the shales below the breccia about one mile east of Hot Sulphur Springs, and on the south side of Grand river, that is, on the western flank of the "breccia spoon." These shells were submitted to Dr. C. A. White for determination. The following species were found at 15 feet below the "breccia:" *Pteria parkensis* White, *Scaphites nodosus* Owen, sp., *Ostrea translucida* M. & H., *Leda* (*Yoldia*) *scitula* M. & H., *Inoceramus convexus* M. & H., *I. sagensis* Owen, *Baculites ovatus* Say, *B. compressus* Say?, *Placenticeras placenta*, De Kay, sp., and Dr. White is of the opinion that they indicate the lower or Ft. Pierre division of the Montana rather than the Fox Hills.

Marvine's description of the mechanical constitution of the "lignitic" series is generally applicable to the part above the "doleritic breccia," but as regards the character of the materials composing both parts of the series some important corrections are to be made. In the first place the "doleritic breccia" was unfortunately named, for the rocks composing the complex are andesites as far as examined, and the entire mass seems to be a water-arranged deposit containing finely preserved leaves in some of the most massive parts. The beds are very irregular in thickness, and are decidedly thicker on the eastern border of the area than on the western.

As to the great series succeeding the dark massive beds, Marvine was in error in stating that they consist entirely of Archæan debris, for they contain andesitic material in very variable amount for more than 2000 feet above the dark breccia, and the whole series is evidently one. The character of the eruptive material changes somewhat upward in the series, lighter colored and more acid rocks prevailing. Many beds in the terraces north of Grand river are sandstones or grits consisting of quartz and feldspar to a strongly prominent degree but none are entirely free from andesitic fragments, and conglomerates composed very largely of eruptive material often succeed quartzose sandstones. The strata in the divide between Middle and North Parks belong to the same series, according to Marvine. These were not visited by the writer, but the beds shown in the high ridges some eight miles north of Grand river, east of Whiteface Mountain, still carry a large amount of pinkish andesitic material. The same eruptive constituents were found in the strata of Mt. Bross, and of the ridges south of Hot Sulphur Springs; in fact, no beds of this complex were found to be wholly free from materials of this character.

No animal remains are reported from the series by Marvine, nor were any found by either Mr. Cannon or the present

writer. Fossil plants are quite numerous in all parts of the series. Of those collected by the members of the Hayden survey a large majority came from Mt. Bross, and a few from distant localities on Willow and Troublesome Creeks, from strata referred to the same general horizon by Marvin. This material has been described by Lesquereux* but there has been such a serious confusion of localities in also assigning a number of other fossil plants to Middle Park, that little use can at present be made of these identifications. Collections of fossil plants made by Mr. Cannon and the writer in various horizons of this series have been provisionally identified by L. F. Ward and F. H. Knowlton. From these data it can be said that out of about 35 well defined species more than 20 are known in the Denver beds of Table Mountain, at Golden, a closer correspondence of floras than is shown with any other horizon. Until the investigation of the Laramie flora now in progress has been completed it is useless to enter into more definite comparisons.

The so-called Laramie beds of Middle Park seem from the foregoing facts to be the equivalent of the Denver beds. No strata corresponding to either the Arapahoe or Laramie proper are known in Middle Park, and the invertebrates collected by Mr. Cannon indicate that the upper part of the Montana is also wanting in the vicinity of Hot Sulphur Springs. Present information gives little ground for an estimate of the extent to which the missing formations were once developed in this region.

Age of the Lake-bed Deposits.

The facts of stratigraphy and lithology which have been recited show that in Colorado the great conformable series of Cretaceous formations ended with the coal-bearing Laramie strata. Deposition plainly ceased in this area because continental elevation, which had long been in progress, finally caused the retreat of the Laramie seas. The magnitude of this elevation, the time interval involved, and the question as to the identity of this particular movement with the great movement generally supposed to mark the ending of Mesozoic time in the Rocky Mountain area, are clearly problems of great importance. Confining discussion at present to the indisputable evidence of the deposits described, it is clear that when sedimentation began again in the region concerned it was in comparatively small seas or lakes. In the pebbles of the Arapahoe, Cañon City, and Ohio Creek beds, is found proof that adjacent landmasses consisted in part of upturned sedimentary rocks, and in the first named is the record of the

* Monographs of the Hayden Survey. vol. vi, Tertiary Flora.

slow erosion of 14,000 feet of strata, from the Laramie down to the "Red beds" of the Trias.*

Succeeding the first period of lake-beds came a time of great volcanic outbursts over a very large area. The length of geologic time occupied may not have been very great, but the extent of country in which eruptions occurred at this time, and the great variety of lavas found in the Denver and Middle Park beds, argue for the decided importance of the event as a dynamic manifestation. The position of the Middle Park beds on the edges of the Cretaceous section below the Ft. Pierre, proves a period of erosion there which was no doubt contemporary with the Arapahoe epoch though its record is not known in deposits. Marvin assigns a thickness of over 6000 feet to the Middle Park beds (including the "breccia"), characterized through the lower half at least by volcanic material,—striking testimony to the extent of the eruptions and the duration of the period of deposition, which must have been one of subsidence, approximately equalling the thickness of beds deposited.

The question as to the age of the formations under discussion is the question as to the length and importance of the periods in which the events clearly recorded in their sediments took place. From the standpoint of structural and physical geology an adequate chronology will distinguish or separate this period from that of the coal-bearing Laramie; but according to the principles of geology the measure of the geologic time involved is to be sought in the fossils,—in a comparison of the life of the two periods which are to be distinguished. But at the very outset of such an attempt it becomes evident that a very large number of fossils said to occur "in the Laramie" are not at present available for such a purpose. This difficulty arises chiefly from the fact that the stratigraphical position of the beds of many localities where "Laramie" fossils have been found has not been at all clearly determined.

In their recent discussions of orographic movements Messrs. Emmons and Hills have treated the post-Laramie disturbance as that closing Cretaceous time. The former says: "With the exception of the great unconformity between the Archæan

*The lithological evidence upon which the distinction of the local formations above mentioned has been largely made will probably make little impression upon some readers. It is a striking fact in many observations of the past and of the present in the western region, that the material constitution of coarse grained sandstones and conglomerates has been and is now practically ignored. But if a conglomerate in the apparently conformable Cretaceous section contains pebbles of Niobrara limestones, of the extremely characteristic Dakota conglomerate, of red Jurassic or Triassic sandstone, or of Carboniferous chert, a definite unconformity of great magnitude is made known which does not require proof in visible angular unconformity or in the fossils, though the latter undoubtedly will confirm it when they are known in sufficient detail.

and all overlying sediments, . . . no movement has left such definite evidence as that which followed the deposition of the coal-bearing rocks, to which the name Laramie has by universal consent been applied.”* And while Mr. Hills thinks that some of the effects hitherto ascribed to the post-Laramie movement belong to that following the Bridger Eocene, his conclusion in regard to the Arapahoe, Denver and equivalent beds, is as follows: “From all the evidence available it appears that stratigraphically these beds are not Laramie, since to refer them to the Cretaceous would bring us face to face with the necessity of conceding an earlier date than post-Cretaceous to the Rocky Mountain revolution. Nor are they, paleontologically, a part of the recognized Eocene. Whence we must conclude that they are not assignable to either of these terranes, but should be regarded as transition beds deposited subsequent to the beginning of the post-Cretaceous movement, or probably during its progress and hence of post-Laramie age.”†

The Denver beds contain a very large and well preserved fossil flora. So do the coal-measures of the Laramie in the same field, and more than 160 species have been described from this district by Lesquereux.‡ It has already been shown§ in describing the Denver beds that from the statements of this author only a very small percentage of the described species can be definitely assigned to one of the two plant-bearing horizons, nor is the desired information to be found on the labels or in the catalogue of the National Museum where the original specimens are now deposited. Examination has also shown a lamentable inaccuracy in designation of localities for the fossil plants of various other localities assigned to the Laramie. This is true especially of the plants from the Middle Park beds, as has been mentioned. The existing confusion is so great that no credible table can now be constructed from published data to show, excepting in a most general way, whether there is or is not a noteworthy difference between the known flora of the Denver and Middle Park beds and that of the Laramie proper. But on the basis of new and extensive collections from known horizons a thorough revision of this portion of the Laramie flora is now in progress in the paleobotanical department of the Geological Survey. Until the results of this revision can be made public a discussion of the

* Orographic movements in the Rocky Mountains, Bull. G. S. A., I, p. 285. 1890.

† Orographic and structural features of Rocky Mountain geology, Proc. Colo. Sci. Soc., vol. iii, Part III, p. 397.

‡ Monographs of the Hayden Survey: vol. vii. “The Tertiary Flora:” vol. viii, “The Cretaceous and Tertiary Floras;” also, Bull. Mus. Comp. Zool., Harvard College, vol. xvi, No. 3, 1888.

§ This Journal, vol. xxxvii, p. 272, 1889.

bearing of fossil plants in determining the age of the Denver and allied deposits is useless.

The few invertebrate fossils found in the Denver beds are, according to Dr. C. A. White,* of no special value in the present case. *Viviparus trochiformis* and *Goniobasis tenuicarinata* are the only specifically identifiable forms as yet known, while imperfect forms referable to *Corbicula*, *Physa*, and *Unio* accompany them.

The vertebrate fauna known from the Denver and Arapahoe beds is small, but its character is such as to raise some very broad questions for settlement before its value for purposes of detailed correlation can be determined. At the time the Denver and Arapahoe formations were described a considerable number of fossil bones had been found, and since that time additional material has been obtained by Mr. G. L. Cannon, Jr. All the material collected has been examined by Professor O. C. Marsh, who identifies fragments of turtles, crocodiles, and dinosaurs.† Only the latter are of especially recognized importance in this case. They belong for the most part to the remarkable new family, the Ceratopsidæ, of which so many wonderful forms have been described within the last three years, and it is necessary at this point to pass in review certain phases of the discoveries made by Professor Marsh, and the facts stated in the publications concerning them.

In a series of articles in the American Journal of Science beginning December, 1888, Prof. Marsh has described a wonderful new fauna said to occur in the Laramie of Montana, Wyoming and Colorado, the two most important elements of which are a group of horned Dinosaurs forming a new sub-order, the Ceratopsia, and a large number of small mammals. The new Dinosaurs are closely related to *Stegosaurus* in many features of the skeleton, but the skull and dermal armor have become strangely modified and possess marked characteristics "not before seen in the Dinosauria." With the exception of a few isolated bones and teeth mentioned by Cope the mammalian fauna associated with these Dinosaurs is the first to be discovered in the American Cretaceous, and is closely allied to that known in the Jura, and widely different from that characterizing the Wasatch Eocene.‡

* Cited in article describing the Denver Formation, this Journal, vol. xxxvii, p. 275.

† The fossil from the Denver beds originally described by Professor Marsh as *Bison alticornis* is now regarded by him as belonging to Ceratops (this Journal, xxxviii, 174, 1889).

‡ The writer wishes to acknowledge the courtesy and kindness of Professor Marsh in showing him a large number of the remarkable and important forms which have been found in the Ceratops beds, and in explaining the great problems they present to the evolutionist, together with their apparent bearing upon questions of historical geology.

In attempting to correlate the new formations of the Denver field by means of their vertebrate fossils it is necessary to know the horizon or horizons which have furnished the large new fauna recently described. A review of the papers published by Prof. Marsh shows, however, that except for fossils which came from the Denver region no detailed evidence is given as to the stratigraphical or geographical position of beds containing any of the fossils described. There are only the general statements that they "come from the typical Laramie of Wyoming" or "of Montana." All localities are correlated as belonging to one general horizon, "the Ceratops beds," and the assertion is made that: "This horizon is as strongly marked as that of the *Atlantosaurus* beds, and has now been traced for nearly eight hundred miles along the eastern base of the Rocky Mountains." And as to stratigraphical relation to lower beds, "Toward the north, it is underlaid by marine Cretaceous strata containing Fox Hill fossils, but farther south, various older formations are found immediately beneath it." * It certainly seems natural and it may almost be said probable that such a new and specialized group of animals should characterize a well marked geological horizon. But as far as the actual position of the Ceratops beds has been described, namely, in the Denver region, they are separated from the normal Laramie by a great unconformity, and it remains to be demonstrated that the new forms occur at all in the Laramie proper. It is believed to be a fact that in all the great Laramie formation of Colorado, where it has been studied more thoroughly and connectedly than anywhere else, no representatives of the Ceratopsidæ have been found; and that the same is true of the adjacent connected deposits in New Mexico and Utah. None of the species described by Prof. Marsh has been stated to come from the Laramie coal-measures of southern Wyoming, but it seems probable that the historic Dinosaur called *Agathaumas* by Cope, the discovery of which at Black Butte in 1872 played such an important part in deciding opinion as to the Cretaceous age of the Laramie, may prove to be of importance in the present discussion also. It is now thought by both Cope † and Marsh ‡ that this form is a horned Dinosaur. If this is true the Ceratopsidæ are represented to the west of the Front range in what have been called typical Laramie strata by some authors. But it happens that the Black Butte locality is one concerning which geologists have differed considerably in their observations and opinions. A

* This Journal, vol. xlii. p. 338, 1891.

† Amer. Naturalist. xxiii, p. 715, 1889.

‡ This Journal, xliii, p. 83, 1892.

succession of several thousand feet of strata in this region has been referred to the Laramie, but Major Powell claims to have found an important physical break below the horizon containing the *Agathaumas*, as he expressly states,* and if this is true this Dinosaur may actually occur here in strata contemporaneous in time with the Arapahoe beds. In any case it remains to be proven that the "Ceratops beds" of Marsh, from the "eastern base of the Rocky Mountains" are stratigraphical equivalents of the horizon at Black Butte in which the *Agathaumas* was found.

This brings us to the questions: On what ground does Prof. Marsh assign the Ceratops beds to the Laramie? and, What does the Laramie properly embrace? The assignment rests, as far as published evidence goes, on the presence of a new fauna of strong Mesozoic affinities, in beds more recent than the Fox Hills, and unknown, with the possible exception noted above, in strata known to occupy the stratigraphical position assigned to the Laramie in its original definition. The general statement of Prof. Marsh that the Ceratopsidae he has described "are found in the typical Laramie of Wyoming" is misleading in this sense, that, to any one acquainted with the literature of the subject, "the typical Laramie of Wyoming" must always be that formation in southwestern Wyoming to which Mr. Clarence King first applied the name, or its demonstrated equivalent. And it seems opportune to quote here the definition of the Laramie given by that author. After explaining, that on consultation with Hayden and without compromising differences of opinion as to the age of the beds in question, a common name had been adopted, he says: "Accordingly . . . it was amicably agreed between us [Hayden and King] that this series should receive the group name of Laramie, and that it should be held to include that series of beds which conformably overlies the Fox Hills."† Experience since this definition was set up has shown that over a very large area there is a great and important formation to which that definition strictly applies. And evidence continually accumulates to prove that this formation, which certainly must be called the Laramie, was the last of the series of conformable deposits belonging to the Cretaceous.

Returning to the question as to the evidence concerning the stratigraphical position of the "Ceratops beds," it is to be noted that in Montana and Wyoming they are said to occur on the eastern flank of the Rocky Mountains, in a district which

* *Geology of the Uinta Mountains*, p. 72.

† Final reports of the Fortieth Parallel Survey, vol. i, *Systematic Geology*, p. 331.

has not been carefully explored as yet except for vertebrate fossils. And marked angular unconformity at the base of these beds might not be distinguishable if the shore line was too far removed from the localities examined. But even the general statement of Prof. Marsh seems to indicate a great actual unconformity, for he says, in the sentence quoted above, that, in some places not specified, "various older formations are found immediately beneath it" (i. e. the Ceratops horizon, called "the typical Laramie"). As invertebrates and plants are stated to be associated with the vertebrate fauna it seems quite necessary that their testimony, as well as all available stratigraphical and lithological details, should be given, before the beds in question can be satisfactorily correlated.

The cited statement of Prof. Marsh that "the Ceratops beds have now been traced nearly eight hundred miles along the eastern flanks of the Rocky Mountains" implies the actual connection of the formations of the Denver field with that containing the new fauna in Wyoming. But the area of the Denver beds is known to be quite limited, and the Arapahoe beds on the plains east of Denver are thin and erosion has entirely removed them in many places, exposing the underlying Laramie. It is, however, possible that they thicken again farther out on the plains, or reappear to the northward beyond the Platte valley. If the investigations of Prof. Marsh have actually connected the Ceratops beds of Wyoming with the Arapahoe beds of Colorado, this fact is of great importance as fixing the stratigraphical position of the Ceratops horizon as post-Laramie. If, however, the Ceratops beds of Wyoming are contemporary with the true Laramie, then they do not belong to the same epoch as the Denver and Arapahoe beds.

The above considerations show that the vertebrate fossils of the Arapahoe and Denver beds cannot at present be used as an argument either for or against the proposed separation of these lake-beds and their equivalents from the Laramie, because the new fauna recently described has not been identified, in published statements at least, in strata satisfactorily identified with the true Laramie on other ground than that of the new fossils themselves. It is clearly suggested by the known evidence that the new family of Dinosaurs may be found to be specially characteristic of the epoch to which the lake-beds described belong, as distinctive from that of the Laramie proper; that their remarkable specialization may have taken place largely as a result of the changed conditions following the great orographic movement closing the Laramie. Until more is known about the distribution of the Ceratopsidae and their immediate ancestors in the Cretaceous series of forma-

tions, they certainly cannot be used as diagnostic fossils for any horizon.

The facts of stratigraphy and lithology demand that the interval between the Laramie and the lake-bed deposits should be recognized as a very important one. The known fossils do not aid us in determining the importance of that interval because their distribution with reference to it is so imperfectly established. Such seems to be the necessary verdict from the examination of the direct evidence available at present. Much collateral testimony might be introduced into this discussion, from observations in remote districts, but it seems undesirable and premature to consider such evidence at this time. Some of the reasons for this conclusion will appear in the more general discussion to follow.

Assuming that the lake-beds described in this article should be separated from the Laramie, the question as to whether they are Tertiary or Cretaceous is quite another problem. It was argued in the article on the Denver beds that the establishment of a profound orographic movement in the period succeeding the Laramie, followed by extensive and long-continued volcanic outbursts, indicated that the deposits of the Arapahoe and Denver epochs should be assigned to the Eocene. This was in harmony with the ideas to be found in all previous speculations as to what actually closed the Cretaceous period. At the time the article in question was written a few bones had been identified by Professor Marsh as belonging to Dinosaurs and other vertebrate forms of Mesozoic types, but the fact that these animals had survived a period of various dynamic disturbances of great magnitude seemed then to indicate that they were straggling survivors into earliest Eocene time rather than that the movement should be placed in the Cretaceous.

The facts presented in this paper make it plain that the discussion of this question involves now a discussion of the broader one as to the character and position of the line to be drawn between Mesozoic and Cenozoic deposits in the Rocky Mountain region, and as to the criteria to be used. And at present there is such a decided conflict between the results reached in applying different criteria that the necessity for more information on many points is clear. In illustration of this necessity a few of the recently expressed opinions upon this subject will be quoted.

Professor Marsh* in a recent publication on the Cretaceous mammalia and their associated vertebrate fossils, occurring in the Ceratops beds—"the Laramie of Wyoming"—says:

* This Journal, vol. xliii. p. 249, March, 1892.

"These remains are not transitional between Mesozoic and Tertiary forms, but their affinities are with the former beyond a doubt; thus indicating a great faunal break between the time in the Cretaceous when they lived and the earliest known Tertiary, or between the Ceratops horizon and the Coryphodon beds of the Eocene Wasatch. The lower division of the Coryphodon beds, or lower Wasatch (Puerco), is clearly Tertiary, and the great break is between this horizon and the Ceratops beds of the Laramie." Concerning the abundant faunas of the two horizons, "the more the two are compared the stronger becomes the contrast between them. Instead of placing them close together, as some geologists seem inclined to do, it will be more profitable in future to search for the great series of intervening strata containing the forms that lead from one to the other." "Bearing in mind all that is known to-day of the development and succession of vertebrate life in America, from the early Silurian on to the present time, it is safe to say that the faunal break as now known between the Laramie and the lower Wasatch is far more profound than would be the case if the entire Jurassic and the Cretaceous below the Laramie were wanting."*

Professor E. D. Cope† in his "Synopsis of the Vertebrate Fauna of the Puerco series" (1888) considers the Puerco fauna as widely distinct from that of the Wasatch, and points out that among 106 species of vertebrates known from the Puerco not one is found either in the Wasatch or in the Laramie; that some important Mesozoic types end in the Puerco; that "two orders universally present in the Eocenes, the Perisodactyla and the Rodentia, are wanting from the Puerco"; and that many Puerco forms are plainly the ancestors of Eocene types. Shortly before this publication Professor Cope‡ had assigned the Puerco and Laramie to the "Post-Cretaceous" as expressing their relationship better than to class one with the Eocene and the other with the Cretaceous. It is worthy of note that the Puerco was assigned to the Eocene by Professor Cope§ as recently as 1883.

Professor Marsh refers the Puerco to the lower Wasatch=

* Since the completion of this article Prof. Marsh has announced the presence of Ophidians and true Lacertilians with the gigantic dinosaurs of the Ceratops beds, "in the Laramie of Wyoming." No serpents have hitherto been found in America below the Eocene. (Notice of new reptiles from the Laramie Formation. This Journal, vol. xliii, p. 449, May, 1892.)

† Trans. Am. Phil. Soc., vol. xvi, pp. 298-361.

‡ The Relations of the Puerco and Laramie Deposits. Amer. Naturalist, vol. ix, p. 985, 1885. The Mesozoic and Cænozoic Realms of the Interior of North America. Ibid, vol. xxi, p. 445, 1887.

§ Monographs of the Hayden Survey. III, Tertiary Vertebrata, Book I, p. 4, 1883.

Lower Coryphodon beds, but Professor Cope says, in 1883: "Coryphodon is, so far, unknown," and in his last synopsis of the Puerco fauna (*loc. cit.*) he does not include that form.

Regarding the first mammalia described by Prof. Marsh "from the Laramie" Prof. Cope* has said: "These species are of identical character with the Puerco mammals, although there is no species identical with any in the Puerco, where there is not a single Cretaceous reptile. The mammals of the Laramie are, like the saurians, rather Cretaceous than Tertiary; but the character is not as pronounced."

The question as to the relations of the Laramie to the Eocene has recently been reviewed by Dr. C. A. White in the Correlation Essay on the Cretaceous prepared for the Fifth International Congress of Geologists,† and with the result that the Laramie "is held to represent both the close of the Cretaceous and the beginning of Tertiary time," with a probability that in certain known areas there has been continuous sedimentation from the coal-bearing Laramie through to the Wasatch Eocene or its equivalents. The molluscan fauna is said to favor such a conclusion.

Prof. J. S. Newberry‡ has recently expressed the decided opinion that the diverse views of geologists concerning the Laramie have in large part "arisen from the fact that many writers on the subject have combined two distinct formations in the Laramie and have called them one, when they have almost nothing common, belong to different geological systems, and should never have been united." He then assigns the Fort Union beds of Montana to the Eocene, and the remainder of what has been called Laramie to the Cretaceous, asserting that the floras of the two "are totally distinct."

In discussing this paper Prof. L. F. Ward claimed that the Ft. Union flora was not absolutely distinct from that of the Laramie though very different, and that it might well be considered as Cretaceous.

Prof. Marsh states§ that "the Ft. Union Eocene beds on the Upper Missouri" rest immediately upon the "Ceratops beds." It would be interesting to know the flora of the "Ceratops beds" and the vertebrate fauna of the "Ft. Union beds" in this region. Prof. Cope has published a "Description of some vertebrate remains from the Ft. Union beds of Montana,"||

* Bull. Geol. Soc. of Am., vol. i, p. 532 (Dec. 1890). In discussion of a paper by J. S. Newberry, The Laramie Group.

† Correlation Papers. The Cretaceous, Bull. 82, U. S. Geological Survey, 1891. Compare pp. 262.

‡ The Laramie Group. Bull. Geol. Soc. of Am., vol. i. p. 524.

§ This Journal. xlii, p. 336.

|| Proc. Acad. of Nat. Sci. of Phila., vol. xxviii, p. 248, 1876.

but without any statement of locality or stratigraphical data, so that his paper stands rather as an illustration of the common manner in which uncertainty and confusion have been introduced into the literature of the Laramie, rather than as evidence that Dinosaurs occur in beds containing the Ft. Union flora.

From these recent expressions of opinion concerning the Laramie in its comprehensive sense and of the period of time between the marine Cretaceous and the Puero or lower Eocene, it is clear that paleontologists have sought to correlate the formation and characterize the period from the evidence of the flora or of a particular fauna. In some cases at least the opinion has been rendered upon biological grounds alone, and has been announced with great confidence, often with but the slightest reference to the results reached upon other paleontological evidence or to contrary opinions from the same evidence, with little regard for known facts of stratigraphy, and still less for the very important fact of utter ignorance concerning the actual relationships of some of the places, horizons, and faunas or floras dogmatically correlated. This variance of opinion is a natural result of the methods used, yet no one will dissent from the proposition that a correct knowledge of the history of this interesting period cannot be reached until all classes of evidence are carefully compared on a basis of unbiased and accurate observations in all directions.

The facts brought together in this paper point to one important epoch in the period under discussion which has not been duly recognized, to say the least. Its broad intrinsic importance has yet to be determined, and the writer wishes to distinctly express his appreciation of the fact that that importance must ultimately be measured in great degree through the effect exercised by the conditions of that epoch upon the life of the time. But the great importance of the orographic movement which has been identified, in relation to the physical history of a very large district, must also be borne in mind.

In conclusion, the writer wishes to advocate the restriction of the term Laramie, in accordance with its original definition, to the series of conformable beds succeeding the marine Montana Cretaceous, and the grouping of the post-Laramie lakebeds described, with their demonstrated equivalents, in another series to which a comprehensive name shall eventually be given. This course has already been proposed by Mr. Hills in his conclusion which has been cited (p. 33). The question as to whether the series shall be referred to the Cretaceous or to the Eocene cannot be finally settled until the various conflicting elements of the evidence have been adjusted on a basis of

further and more exact information. But even if we assume that the lake-beds are Cretaceous, there remains a sufficient argument for restricting the scope of the term Laramie in the fact that to include the two or three series of deposits, with the long intervals between them, under one group name would make the latter unduly comprehensive and important in the scale of Cretaceous sub-divisions.*