ART. XXIV.—*On the Relative Ages of certain Pleistocene Deposits*; by OLIVER P. HAY.

The writer accepts the conclusions of those glaciologists who hold that there occurred during the Pleistocene epoch four or five glacial stages, each of which was followed by a stage of mild climate. As a result of great extremes of climate and of alternate reduction and expansion of the habitable areas one might expect that, as the glacial epoch passed on, obvious changes in the faunas would show themselves through both extinctions and modifications. As to the development of new species during the part of the Pleistocene known to us, this might be hard to prove. As a matter of fact, it would now be hazardous to assert that any particular existing species had not been present, either here or in Asia, early in the Pleistocene. As to extinctions, these stand out clearly. I have a list of over 600 species of vertebrates which have been reported from our Pleistocene deposits; and of these about 60 per cent are extinct.

As is shown in and near the glacial region, many species, mostly conspicuous because of their size, as elephants, the American mastodon, the giant beaver, the existing beaver, and *Megalonix jeffersonii*, lived on from the first interglacial stage to the post-Wisconsin. A considerable number of other species, as the long-horned bisons, at least one species of horse, the tapirs, saber-tooth tigers, and mylodon, no longer appear after the Wisconsin stage, but did exist during the interval between the Illinoian and the Wisconsin. Other mammals, again, as *Elephas imperator*, the camels, and many species of horses, are not found after the second glacial epoch, the Kansan. Hence, in the glaciated region, we may for the present recognize three Pleistocene faunas, an early, a middle, and a late. Did these faunas have the same history in the nonglaciated region as in the glaciated; or did the early fauna continue on in the southern States virtually unchanged up to the end of the Pleistocene? There are those who take the view last mentioned. Some of these base their opinions on the geological structure of the Pleistocene part of the coastal plain; others on the fact that in certain localities the animal remains are associated with relics of man. It must be granted that

either those who believe that the low-lying deposits along the Atlantic coast of the southern States belong to the late Pleistocene must surrender their position or it must be acknowledged that the animals found fossil in them existed up to near the end of the Pleistocene or later.

It seems improbable that the early Pleistocene vertebrate fauna remained practically unchanged up to the end of the epoch. Time itself is a powerful factor in bringing about extinctions among living beings. All species are continually under stress; and it is to be expected that normally first one and then another will succumb; so that in the course of a long period there will result a more or less gradual change in the fauna, even though there are no great changes in the environment. During the course of the Pleistocene there were, especially in the north, several alternations of climate from one extreme to another; and it is hardly probable that these changes did not affect the vertebrates of the southern States. Furthermore, the northern species were at each glacial stage forced southward, so that these regions tended to become overpopulated. Also, if there is anything of importance in the idea that northern animals are more hardy, these would have had an advantage over those not accustomed to the colder climate. It is the species of the southern States which especially might be expected to have gradually died out during the progress of the Pleistocene. There are those¹ who assert that the fauna in question belongs to the late Pleistocene or even to the Recent. If such an assemblage of vertebrates as is found in the low-lying formations of Florida, Georgia, and South Carolina, existed there after the end of the last glacial epoch and then suffered the extinction of more than two-thirds of the species, some adequate cause ought to be sought for such a disaster. That the Indians with their feeble weapons effected the destruction is not to be believed. They were making no impression on the game animals of the country when the whites arrived. Nobody has found the bones of elephants, horses, or ground-sloths in the shell heaps of Florida.²

If such animals as *Elephas imperator*, the camels, the tapirs, horses, the great cats, the saber-tooth tigers, the mylodons, and *Bison latifrons*, had lived around the Gulf

¹ MacCurdy, Jour. Geol., vol. 25, p. 62; R. T. Chamberlin, vol. cit. p. 662.

² Nelson, Science, vol. 46, p. 394.

and along the south Atlantic coast after the passing away of the last glacial stage, there appears to be no good reason for supposing that they would not have moved northward and reoccupied their ancestral hunting grounds. All of these had once lived in the regions of Iowa, Nebraska, Kansas, and most of them as far east as New Jersey. Many species, large, medium-sized and minute, did return to the newly opened fields. *Equus complicatus* had more than once been driven from the glaciated region; but each time it returned; and its remains have been found in deposits overlying Illinoian drift. Is there any reason to be suggested why, after the Wisconsin glacial stage, this horse and *Bison latifrons* preferred to remain and perish on the sandy plains of Florida when they might have reoccupied their old ranges, which furnished as fine grazing lands as have existed? It cannot be said that the climate in the northern States was unfavorable, for we cannot doubt that, as the glacier began to withdraw, the climate grew milder; and there are evidences in both the animal and the vegetable kingdoms that the climate was for some time warmer than it is to-day. The writer has elsewhere noted the former existence of peccaries along the south shore of Lake Ontario and in Michigan; also the presence of *Megalonyx* as far north as Minneapolis. In 1915 Dr. H. L. Shimer³ printed a list of mollusks which had been found in post-glacial deposits at Boston. Of about 60 species, approximately one-half no longer live north of Cape Cod, or only rarely in sheltered areas. He says that the record is of primary interest because of the evidence it furnishes as to a warmer period after the retirement of the glacier.

In the same volume of this Journal, on pages 17, 18, Barrell quotes a letter written by Fernald regarding certain plants which had been found on Prince Edward Island, the Magdalen Islands, and in Newfoundland, but whose relationships are with plants found in the pine-barrens of New Jersey. "Thirty-five per cent of the plants of Newfoundland are southwestern types, and 7.7 per cent of these are plants characteristic of the coastal plain of New Jersey and the South" (Barrell, p. 16). The reader may consult with regard to this matter also J. W. Dawson's Canadian Ice Age, pages 140 to 144.

³ This Journal (4), vol. 40, pp. 437-442.

That the Pleistocene camels, horses, and bisons were better adapted to the sort of climate that was furnished during interglacial stages in the northern States than they were to that of Florida is shown by the fact that it is in the north where the greatest number of species of each is found. Four or five species of camels appear to have inhabited Nebraska and Iowa, whereas rare traces are found of one in the Pleistocene of Florida. About nine species of horses are credited to the northern States, to three in Florida. Some seven species of bisons have been described as inhabiting the northern States during the Pleistocene, while only *B. latifrons* is known to have occurred in Florida; although one, possibly more, smaller species probably existed there.

It must be taken into account also that the camels, horses, bisons, tapirs, saber-tooth tigers, and edentates, if they existed during the Wisconsin glacial epoch, were certainly not all crowded down into Florida. There was, east of the Mississippi, a wide stretch of territory between Florida and the glacier which the hardier species might with safety and comfort have occupied. Finally, there were the great plains of Texas down to the Gulf where the mammals which existed during the Wisconsin might have betaken themselves and whence they might have made their way over the northern lands after the passing of that epoch. Two species of bison, *Bison occidentalis* and *B. alleni*, were apparently abundant west of Mississippi river during the early Pleistocene, but are not known after the Wisconsin stage. Both of these species ranged into Alaska and Yukon. Why then, if they existed during any part of the Wisconsin stage, should they have perished between the Wisconsin moraine and the Gulf of Mexico?

For all those who hold that the animals referred to existed in Florida during and until after the Wisconsin stage, it may be recalled that at Charleston, S. C., a Pleistocene fauna of at least 40 species has been collected, of which 70 per cent are extinct. Among these are such warm climate forms as two species of capybaras, two species of tapirs, a megathere, an alligator, and a huge land-tortoise. If these were living there during the last glacial stage they had as companions the North Atlantic walrus and a moose identical with, or closely related to, the existing species.

Of those who insist that the great roll of extinct species which perished in Florida met their doom during the prevalence of the Wisconsin ice sheet and not at its end, it may be asked why this epoch was more fatal than the three or four preceding glacial stages, during some of which the ice reached still farther south. I think that there are no evidences to show that during this stage the climate was more rigorous than during earlier glacial stages; and it is probable too, that it was a stage of shorter duration.

To the writer it appears, therefore, that the assignment of the formation which contains the extinct fauna referred to and which constitutes the lowest plain in Florida, Georgia, and South Carolina, to the last glacial epoch is made impossible by the character of the fossils contained in it.

Some of our geological friends argue that the lowest formation in the southern States, which they synchronize with the Talbot, is young because it shows little erosion and dissection. Time, however, is not the only factor in the production of erosion and dissection. One would not expect much diversification of the surface of Dismal Swamp to occur in a million years. In his description of the Sardis plain, in southern Mississippi, belonging to the Citronelle (Pliocene) formation, Matson⁴ says that there are some interstream plains from five to more than ten miles in width which have inadequate drainage. W. M. Davis,⁵ in speaking of an area which has reached the stage of a peneplain, says that "if no accident enters to disturb the relation of mass and base-level, the area will remain indefinitely with insignificant change, maintaining, like the Sybil, an immortal old age." Contrariwise, the formation which, in the southern States, has been regarded as equivalent to the Cape May and Talbot might continue to maintain an immortal infancy.

In North Carolina the Pleistocene formations have been studied and mapped by Dr. L. W. Stevenson.⁶ Five terrace plains are recognized, as follows, beginning with the oldest and most elevated: Coharie, Sunderland, Wicomico, Chowan, and Pamlico. The last two together are regarded as being equivalent to the Talbot of Mary-

⁴ U. S. Geol. Surv., Prof. paper, 98 L, p. 182.

⁵ Jour. Geol., vol. 2, p. 546.

⁶ N. C. Geol. Surv., vol. 2, pp. 266-290, pl. XIII, 1912.

land. It may here be noted that from Charleston, S. C., to New York City, the Pleistocene deposits do not furnish a great number of species of vertebrates. In North Carolina mastodons, in twelve localities, have been found, and these within the areas of all of Stevenson's formations, except the Coharie. *Elephas columbi* and *E. primigenius* have been discovered within the Pamlico; but, as these elephants and the mastodons lived from the first interglacial stage to near the Recent, their presence furnishes no certain basis for determining the age of any of the terraces. However, horse remains have been secured at four localities, Elizabethtown, apparently in Sunderland or Wicomico; at Greenville, in the Wicomico area; at New Bern, in the Pamlico area; and at Plymouth, near which are found Chowan and Pamlico. At New Bern it is pretty certain that the fossil-bearing stratum does not belong to the Pamlico, but to the underlying Chowan, or something still older. Stevenson (op. cit. p. 288) grants the possibility of this. The present writer believes that the horse remains are as old as those found at Vero and Charleston.

Writers who are interested in maintaining the geological youthfulness of the lowest plain, or terrace, along the coast, and who do not feel required to hold that the animals lived late in the Pleistocene, may insist that the remains of the latter are really buried in older deposits which are overlain by the Chowan and Pamlico and their equivalents. Now, at Brunswick, Georgia, eleven species of mammals have been collected, all of which are extinct. There are present *Elephas columbi*, the common mastodon, a tapir, three species of horses, mylodon, and the great megatherium. Lyell observed that the skeleton of the last-named animal was so near the surface that it was penetrated by the roots of a pine. The fossil vertebrates found at Vero and at Charleston occupy equally superficial beds; and this fact makes it impossible to refer the animals to an earlier deposit which is overlain by a later one.

In Virginia the same terrace plains are recognized by Clark and Miller as in Maryland. No equivalent of the Pamlico is mentioned by them. Few vertebrate fossils are known from the coastal plain of this State, especially no horses.

For many of our geologists Maryland and the District

of Columbia furnish a standard for the number and names of terraces, Sunderland, Wicomico, and Talbot. Here, as in North Carolina, *Elephas columbi* and *E. primigenius* and mastodon occur, but they do not help us in deciding the age of the formations. In Charles county, near Patuxent river, Cope found two extinct vertebrates, *Grison macrodon* and supposed *Tagassu lenis*. The latter occurs at Vero, Florida, and Charleston, South Carolina; also in Wythe county, Virginia, with many extinct species; but possibly also in post-Wisconsin at Galena, Illinois. At Marshall Hall, 15 miles below Washington, *Equus leidy* was discovered many years ago, in supposed Talbot deposits. Long ago horse remains were found near Georgetown, now a part of Washington, during the construction of the Chesapeake and Potomac canal. Near Mitchellville, Prince George's county, teeth of an extinct horse have been discovered in Tertiary materials evidently reworked during the Pleistocene. A horse, probably *Equus leidy*, has been met with at Chesapeake beach. In the eastern peninsula some vertebrates not characteristic of any special formation have been discovered at Oxford Neck, and in Queen Anne's county, both localities not far from Chesapeake bay. No Pleistocene vertebrates are known to have been met with in the eastern half of this peninsula or in the State of Delaware.

In New Jersey three formations are recognized alike by the State Survey and by the Maryland geologists; but the local deposits are often differently identified by the two schools. If a line be drawn from Salem, Salem county, near Delaware river, to Long Branch, on the Atlantic, it will mark pretty accurately the outcrop of the Cretaceous. Nearly all of New Jersey southeast of this line, comprising nearly one-half of the State, is occupied by the Cohansey sands, overlain to a considerable extent by deposits belonging to the Cape May formation. Now it is a fact, the significance of which is not understood, that nowhere in this area of Cohansey sands have any Pleistocene vertebrate fossils been found, while close along the line indicated and north of it they are not uncommon. At nine or ten different localities along the Cretaceous outcrop mastodons have been met with. These do not help us much on the question of the age of the deposits containing them, and there are few other

species which give us help. Horse remains, however, were found long ago in the Navesink Hills and again at Swedesboro; but too little is known about the condition under which they were discovered. Fortunately the conditions are better understood at Fish House, just above Camden. The clays at this place had long been regarded as belonging to the Cretaceous; but in 1869⁷ Cope announced that he had found at the bottom of the clays a skull of a horse, and he referred the deposit to the Pliocene. In 1897⁸ Woolman described other horse remains, teeth, from the same clays; and he referred the beds to the Pensauken formation. Salisbury and Knapp⁹ recorded their final opinion that these beds belong to the Pensauken. On page 78 of the volume just cited these geologists suggest that this formation was, in part at least, older than the Kansan drift.

Immediately below the horse-bearing layer are found many shells which have been referred to the genera *Unio* and *Anodonta*. Twelve species were described during the time that the beds were regarded as Cretaceous; but a close relationship with existing species was recognized. They are quite certainly to be identified with species now existing in rivers of North America; but at present only one-half or fewer of them live in that region. The others are now found in the St. Lawrence drainage system or still further away. One is confined to the Ohio, Cumberland, and Tennessee rivers. Another occupies the Mississippi and Gulf drainage regions; while one of the species of *Anodonta* is found only in the upper Missouri river region. We have then these reasons for believing that the clays at Fish House are of early Pleistocene age:

(1) Competent geologists have referred them to Pensauken. (2) They contain remains of *Equus*, no native species of which is known to have lived during or after the Wisconsin glacial stage. (3) The clays enclose many species of Unionidae, the majority of which now live only in far distant regions.

There are those who believe that the Fish House clays belong to the Cape May formation, which was laid down, as Salisbury and Knapp inform us, during Wisconsin times. These people ought to explain what has caused

⁷ Trans. Amer. Phil. Soc., vol. 14, p. 249, fig. 55.

⁸ N. J. Surv. Rep. for 1896, p. 201.

⁹ Geol. Surv. N. J., vol. 8, p. 104, 1912.

the wide dispersion of the Unionidæ since that relatively late time. Furthermore, if those horses, belonging apparently to *Equus leidyi* and *E. complicatus*, lived at Fish House during the prevalence of the last ice sheet, both of these species must have occupied a widely extended region west and south of the Wisconsin moraine. To this same late time would naturally be referred the horses found at Navesink and Swedesboro, N. J., those found along the Potomac at Washington; and those found at the various localities in the Carolinas. In such case what need is there to suppose that Florida furnished them and their contemporaries a last asylum? Why, too, after the close of the Wisconsin stage should these horses have migrated to Florida and not to the grazing lands which stretched from Hudson river to the Great Plains?

If the numerous species found at Vero, at Charleston, and Brunswick, and the horses found farther north are to be assigned to the latest stages of the Pleistocene there appears to the writer no good reason why the same disposition should not be made of the numerous species of mammals, the great majority of which are extinct, which have been gathered in the Port Kennedy cave, above Philadelphia. It seems to the writer that this assembly of species is satisfactorily connected up with those of South Carolina and Florida; and according to the writer's views, they all belong to about the time of the first interglacial stage.

This conclusion means, of course, that the formations known as the Sunderland, the Wicomico, and much that goes under the name of Talbot, and their geologic equivalents of whatever names, were laid down during the time of the first interglacial and perhaps of the Kansan stages.

Salisbury and Knapp refer the Cape May to the Wisconsin epoch, and the writer knows of no reason for questioning this conclusion; also, as they say, the southern part of the State may at the time of its deposition have been submerged to the extent of from 30 to 50 feet. At very shallow depths at Long Branch and Manasquan inlet, have been found remains of mastodons; but these could hardly have lived there during the submergence. Fairchild¹⁰ is probably correct in representing this part of the coast of New Jersey as being submerged while the glacial front was occupying northern New Jersey and

¹⁰ Bull. Geol. Soc. Amer., vol. 28, pl. XI.

southern New York and New England. Not until the region north of Manasquan river had slowly emerged from the sea could mastodons have lived there; and this was probably not before the glacial sheet had retreated some considerable distance up the Hudson. That is, these mastodons belong probably to the Champlain stage of the Pleistocene.

In the peninsula lying east of Chesapeake bay is found typical Talbot. None of the few vertebrate fossils found along the eastern shore of Chesapeake bay in supposed Talbot give us any clue as to the part of the Pleistocene to which it appertains. It probably corresponds to the Cape May. The central part of the peninsula is occupied by an older formation. Sanford¹¹ states that in Virginia the Talbot is 30 miles wide at the south. If Stevenson's map of the superficial formations of North Carolina be consulted it will be found that this corresponds almost exactly with the width of the Pamlico formation at the line between the two states. That seems to mean that the Talbot merges into the Pamlico alone. On the latitude of Cape Lookout this formation narrows abruptly and continues on down the coast as an inconsiderable strip. The writer knows no reason why it may not be referred to the Wisconsin stage of the Pleistocene. In Carteret county, a little north of Beaufort, there was dredged up a tooth of *Elephas primigenius*, the most southern point known for this cold climate species. It seems to be most natural to refer it to the last glacial stage.

According to this view, the Cape May of New Jersey, as recognized by Salisbury and Knapp, the Talbot of Maryland (or at least most of it), and the Pamlico of North Carolina are of late Pleistocene time. All of those deposits, which furnish remains of horses, the Navesink Hills, Fish House, Swedesboro, Chesapeake Beach, Marshall Hall, Washington, Plymouth, New Bern, Charleston, and Vero, belong to a much older Pleistocene time, approximately the first interglacial.

Prominent geologists, especially those of the Maryland Geological Survey and of some of the States farther south, have recognized the various formations and terraces above-mentioned as the product of as many periods of submergence in the sea. At the foot of each terrace

¹¹ Virginia Geol. Surv., vol. 5, p. 25, 1913.

these geologists find, or believe they find, remains of old sea-beaches. The writer's views regarding the existence of the three faunas referred to above do not require him to contest the actuality, only the ages, of the supposed marine terraces. He must, however, call attention to the fact that the two oldest terraces, the Sunderland and the Wicomico, are confessedly devoid of all remains of marine animals, of mollusks as well as of bony creatures. On the other hand, there are found in them, all along the coastal plain, bones and teeth of such land animals as elephants, mastodons, and horses. At some localities, close to the seashore and near the surface, collections have been made of considerable numbers of species of land vertebrates. That is, in these formations the very things that the theory of submergence requires are wanting, and the very things that would not be expected are present. It is vain to insist that in all that stretch of coast, from the mouth of Mississippi river to Staten island, in such abundant deposits of clays, sands, and gravels, the conditions have been so uniformly unfavorable that no beds of oysters or of other mollusks could be formed and preserved. The conditions have not precluded the preservation of the bones of numerous land animals.

If Maryland, during the Wisconsin stage, was depressed as much as 45 feet, the maximum thickness of the Talbot, one might suppose that the depression was connected in some way with that within the glaciated region. Fairchild has determined, however, that the submergence diminished from about 800 feet in northern New York to nothing near the mouth of Manasquan river, New Jersey.

While not denying that there may have occurred change of level along the coast and occasional limited submergence, especially in the case of the latest formation, the writer believes that the terraces have been laid down mostly by some kind of river action. Salisbury¹² has shown how the terraces of New Jersey might in some such way have been produced.

The low-lying formations around the Gulf coast of Texas, the Lissie, and the Beaumont of Deussen's report (Water-supply paper No. 335), have been supposed

¹² Geol. Surv. N. J., vol. 8, pp. 2-10, figs. 1-6.

See also Chamberlin and Salisbury's Geology, vol. 3, page 452.

likewise to have been laid down rather late in the Pleistocene and in the sea; but here, as along the Atlantic coast, there is a lack of marine fossils and an abundance of land animals. All along that coast, down to salt-water or close to it, are found remains of mastodons, *Elephas columbi*, *E. imperator*, *Equus complicatus*, and a camel. To say that these animals lived here at a later period than they did in Kansas and Nebraska is pure assumption. Unless the further assumption is indulged in that these and numerous other species and genera perished in Texas during the prevalence of the Wisconsin glacial conditions, there appears to be no reason why they should not have migrated northward as these glacial conditions relaxed; especially since it is hardly to be conceived that all these animals were confined to a narrow strip immediately along the Gulf.

As will be noted, the writer assigns the Sunderland and Wicomico and their equivalents to the early part of the Pleistocene, but not to the earliest. What was going on in our country during the probably long first glacial epoch is not known. At some time, either in the late Pliocene or early Pleistocene, the whole continent appears to have had a much greater elevation than it has at present. During that time the courses of the great streams appear to have been excavated to enormous depths and sometimes to great widths, so that our country became furrowed by vast canyons. It is well known that many of our great rivers are flowing at levels far above former channels. It appears possible that at some later period of diminishing altitude, during perhaps the first interglacial stage, these old channels and canyons became filled up completely, or nearly so. While they were being filled, the bones and the teeth of animals of the time might have been buried in the deposits. Still later, these old deposits, soils, sands, gravel and stones, might have been partially removed by quickened currents, but partly retained as terraces. It seems possible to account thus for the presence of the same kinds of extinct animals in the upper and the lower terraces and in the present banks of some Texas rivers. In the upper and the lower terraces are found well-preserved remains of camels. In apparently the higher lands at Fort Worth and at Waco have been collected fine teeth of mastodons of the genus *Gomphotherium*, not long ago supposed to have lived only

in the Miocene and the Pliocene; and Dr. Mark Francis finds that Brazos river is now washing out from its flood-plain or from deposits underlying it, jaws and teeth of mastodons of the same genus.

At the same time that such channels were being re-excavated the materials might have been dumped at the lower and flatter reaches and have built up a terrace-like plain.

In this connection it may be allowed to discuss briefly the geological age of the Alachua clays in Florida and the Idaho formation in Idaho and Oregon. The Alachua clays have furnished a considerable vertebrate fauna, and have been assigned to the Pliocene apparently by nearly all who have written about them.¹³ This conclusion has doubtless been forced by the occurrence in those clays of rhinoceroses belonging to the genera *Teleoceras* and *Aphelops*, camels of the genus *Procamelus*, and species of *Hipparion*, all of which genera were represented in the Tertiary by numerous species; but which are not known, with the exception of *Hipparion*, in deposits acknowledged generally to belong to the Pleistocene. However, the Pleistocene fauna with which the Alachuan species have been compared is that which is found in the so-called *Equus* beds of the plains. This is itself to be regarded as equivalent to the fauna of the Aftonian beds, intercalated between the first and the second drifts. This stage was, therefore, preceded by another, the Nebraskan, about whose vertebrate animals we know nothing whatever. This stage probably occupied a long period of time. Indeed, Chamberlin and Salisbury¹⁴ suggest that it (the "sub-Aftonian") may have been as long as all the rest of the Pleistocene. Inasmuch as a considerable number of genera of mammals did continue on into the Aftonian Pleistocene from the Pliocene and even from the Miocene, it is not unreasonable to expect that still other Tertiary genera will be met with in deposits that were laid down during Nebraskan times, if such should be discovered. Now among the genera which continue on into undisputed Pliocene deposits are those found in the Alachua clays, *Teleoceras*,

¹³ Dall, U. S. Geol. Surv., Bull. 84, p. 127; Matson and Sanford, Water-supply paper 319, p. 142; Sellards, 8th Ann. Rep. Fla. Geol. Surv., p. 93; Merriam, J. C., Bull. Dept. Geol. Univ. Calif., vol. 10, p. 439.

¹⁴ Geology, vol. 3, pp. 383, 414, 420.

Aphelops, *Procamelus*, and *Hipparion*. *Hipparion* reaches also into the Aftonian stage; and remains of a camel found at Ocala, Florida, have been identified as those of *Procamelus*. It must certainly be admitted that the other genera might have attained the Nebraskan. Considering the strong, peculiarly Pleistocene element found in the Alachuan fauna, the writer is inclined to believe that the beds belong to the earliest Pleistocene rather than to the Pliocene. There do not appear to be in the collections made in them any considerable chances for admixture of fossils of different ages. Whether or not Sellard's Dunnellon belongs with the Alachua clays may be regarded as questionable.

In southwestern Idaho there is a deposit which has been called by Cope the Idaho beds. Merriam has discussed the age of these clays in his paper cited above (p. 431). They have been regarded as belonging to the Pliocene or even the Miocene. From these beds Cope described twenty-two species of fresh-water fishes. Merriam presents a list of the mammals that have been found in the same beds. Among them are species of *Equus*, a rhinoceros belonging either to *Aphelops* or to *Teleoceras*, and a species of *Procamelus*. That is, here is a fauna quite like that of the Alachua clays. Leidy's *Mastodon mirificus* (*Stegomastodon mirificus*) occurs there likewise. Merriam regards this as a Pliocene species, but it has been found in the Aftonian of Iowa; and Leidy's type quite certainly belonged to the Pleistocene.

Dr. W. D. Matthew (Bull. Amer. Mus. Nat. Hist., Vol. XVI, p. 321) has referred to a small collection of mammals which had been made somewhere in the Oregon desert. The deposits had been considered by Cope as belonging to the Pliocene, doubtless because it had contained *Hipparion*, *Teleoceras*, and camels of the genus *Camelops*, or possibly of *Procamelus*. It contained likewise bones of *Elephas* and *Equus*. In short, we have here the same unusual assemblage of genera that are met with in Florida and in Idaho. Merriam and Buwalda¹⁵ have discussed the Ringold formation, found along the Columbia river, in Franklin county, Washington. A vertebrate fauna, not determinable specifically, but consisting of about eight forms, was found. This included a species of

¹⁵ Bull. Dept. Geol. Univ. Calif., vol. 10, pp. 255-264.

Megalonyx, an equid (*Equus* or *Pliohippus*), one or two camelids (*Pliauchenia?*), a deer, a leporid, a *Testudo*, and fish remains. While these authors were inclined to place the Ringold in the Pleistocene, they had doubts on the subject. It has been supposed that at the Oregon, the Idaho, and the Florida localities, there has occurred a mingling of remains belonging, some to the Pleistocene, others to the Tertiary; but the occurrence of this combination through accidental admixture in so many different places is improbable. To the writer the most probable explanation is that the three deposits belong to the first stage, the Nebraskan, of the Pleistocene.

U. S. National Museum,
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