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THE FLAXVILLE GRAVEL AND ITS RELATION TO OTHER TERRACE GRAVELS OF THE NORTHERN GREAT PLAINS

BY

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THE FLAXVILLE GRAVEL AND ITS RELATION TO OTHER TERRACE GRAVELS OF THE NORTHERN GREAT PLAINS.

By ARTHUR J. COLLIER and W. T. THOM, Jr.

INTRODUCTION.[1]

In Nebraska and South Dakota there are widespread deposits of gravel and other material, largely surficial and generally unindurated, known as the White River, Arikaree, Ogalalla, and other formations,[2] which range in age from Oligocene to Pleistocene. West of these deposits, on the flanks of the Rocky Mountains, are several high plateaus covered with gravel, whose age, though not known, is generally regarded as Pleistocene. At some places the position of this gravel indicates its continuity with the Tertiary formations farther east, but their equivalency has not been proved. It is the purpose of this paper to outline the evidence obtained by the writers in 1915 and 1916 regarding the age of the gravel found on two high terraces in the northern part of the Great Plains and to show its relation to a still higher gravel, known to be of White River age, discovered by Canadian geologists some years ago. Messrs. R. F. Baker, E. T. Conant, and H. R. Bennett were enthusiastic coworkers in collecting this evidence, and to them much of the credit is due.

The area described, as shown in Plate LXII, extends along the south side of the international boundary from Redstone, about 30 miles west of the Montana-North Dakota line, westward to the west side of Boundary Plateau,[3] a distance of 175 miles. It continues northwestward from the plateau far enough to take in the whole of the Cypress Hills, where Canadian geologists have discovered deposits of White River (Oligocene) age.

[1] An abstract of this paper has been published by the Washington Academy of Science.

[2] Osborn, H. F., Cenozoic mammal horizons of western North America: U. S. Geol. Survey Bull. 361, p. 65, fig. 10, 1909.

[3] The name Boundary Plateau was used by McConnell to designate the northern extension of what is called Cherry Ridge on the American side. It is retained in this paper for convenience.

FLAXVILLE GRAVEL.

The Flaxville gravel, named from the town of Flaxville, on the Scobey branch of the Great Northern Railway, was deposited in Miocene or early Pliocene time. The history of its discovery is as follows:

During the field seasons of 1915 and 1916, in the course of an investigation of the lignite resources of northeastern Montana, the writers found some extensive plateaus that are so deeply buried beneath a cap of gravel and kindred materials as to make the location of lignite outcrops impossible. This gravel has been described by several writers under the names "glacial overwash," "quartzite gravel," etc. Bauer[4] had recognized the possible significance of this terrane and had provisionally referred it to the Oligocene of the Cypress Hills.[5]

On the third day in the field the senior writer inquired of Atle Taerum, the proprietor of the store at Avondale, whether in digging his well he had seen any signs of lignite. Being answered in the negative, the writer made a personal examination of the well and found on the dump some fragments of bone said to have been found in sand at a depth of 30 or 40 feet. From this beginning as close an inspection as the circumstances would permit was made of wells and other natural and artificial exposures of the gravel by members of the Geological Survey party. In many places fragments of fossil bones had been found but not preserved, as their significance was not appreciated. D. H. Linton, Hagen Hayenga (postmaster at West Fork), L. T. Greenup, Martin Presnell, Warren Redfield,

[4] Bauer, C. M., Lignite in the vicinity of Plentywood and Scobey, Sheridan County, Mont.: U. S. Geol. Survey Bull. 541, p. 301, 1912.

[5] Cope, E. D., Species from the Oligocene or lower Miocene beds of the Cypress Hills: Canada Geol. Survey Contr. Canadian Paleontology, 1891.

J. A. Stewart, Herman Forbregd, and Prof. L. O. Swenson contributed specimens.

As a result of the search, fragments of fossil bones have been collected from 25 widely distributed localities. These fragments were submitted to Dr. J. W. Gidley, of the United States National Museum, who identified them as representing various forms of the three-toed horse (protohippid, *Protohippus*, *Neohipparion*, and *Merychippus*), horned gopher (mylagaulid), rabbit (*Lepus*), rhinoceros (*Teleoceras*), oreodont (*Merycodus*), camel (*Procamelus*, camelid, and *Camelops*), saber-tooth tiger (machaerodont), doglike animal (amphicyonid), and fish. His full report follows:

F. 1. SE. ¼ sec. 26, T. 34 N., R. 42 E., Atle Taerum's well at Avondale:
Protohippid (astragalus).

F. 2. Near north side of SW. ¼ sec. 27, T. 34 N., R. 42 E., excavation on land of D. H. Linton, Avondale:
Protohippid (distal end of radius).
?Mylagaulid (proximal half of humerus).
Lagomorph cf. ?*Lepus* (fragment of maxillary and toe bone).

F. 4. 300 feet southwest of northwest corner sec. 5, T. 35 N., R. 45 E.
Protohippid (astragalus).
?*Procamelus* sp. (phalanx).

F. 5. SW. ¼ NW. ¼ sec. 24, T. 34 N., R. 44 E., Hagen Hayenga's well:
Neohipparion sp. (part of upper cheek tooth).
Procamelus sp. (distal end of metapodial).

F. 6. Near West Fork post office, T. 34 N., R. 44 E.:
?*Neohipparion* sp. (upper cheek tooth of left side).

F. 7. NW. ¼ SW. ¼ sec. 25, T. 34 N., R. 44 E.:
Protohippid (fragments).

F. 11. NE. ¼ sec. 31, T. 36 N., R. 45 E., "from gravel and sand resting on top of Fort Union bluff."
Protohippid cf. *Neohipparion* sp. (astragalus, portion of upper molar, and fragments).
Camelid cf. *Procamelus* sp. (astragalus, piece of toe bone, and fragments).

F. 13. SW. ¼ sec. 13, T. 34 N., R. 45 E., slope of Taylor-Green prospect:
Camelid cf. *Procamelus* sp. (distal end of phalanx).

F. 14. Near east quarter corner of sec. 6, T. 34 N., R. 47 E., from well at depth of 28 feet:
?Camelid (lumbar vertebral centrum).

F. 15. NE. ¼ sec. 33, T. 35 N., R. 47 E.:
Mylagaulid (lower molar).

F. 19. Sec. 20, T. 36 N., R. 45 E.:
Protohippid (fragment of upper molar).
?*Procamelus* sp. (phalanx and astragalus).

F. 20. Sec. 15, T. 37 N., R. 44 E.:
Protohippid (genus and species not determined).

F. 21. SW. ¼ sec. 7, T. 36 N., R. 44 E.:
Merycodus sp. (fragment of a left lower jaw containing four deciduous premolars).

F. 22. Near center of T. 35 N., R. 41 E.:
Neohipparion sp.

F. 23. Sec. 12, T. 35 N., R. 41 E., J. A. Stewart's well:
Protohippid.

F. 26. Sec. 32, T. 36 N., R. 49 E.:
Protohippid (end of metapodial, fragment of lower molar).

F. 27. Cut of Great Northern Railway a mile west of Flaxville station:
?*Teleoceras* sp. or ?*Aphelops* (toe bone and fragments).
?*Procamelus* sp. (tooth and toe-bone fragments).
Protohippid, probably *Neohipparion* sp. (fragment of lower jaw containing teeth, three parts of teeth, astragalus, and fragments).

F. 28. Just south of quarter corner between secs. 28 and 29, T. 35 N., R. 50 E.:
Protohippus sp. (fragments of teeth).
Carnivore (?amphicyonid) (fragment of left maxillary containing fangs and alveoli).

F. 29. T. 35 N., R. 50 E., first cut of Great Northern Railway west of Flaxville.
Neohipparion ?*affine* or n. sp. (upper molar and lower molar possibly belonging to same species).
Neohipparion sp. (lower molar).
Procamelus sp. (fragmentary foot bones and teeth).
?*Camelops* sp. (large tooth, last right lower molar, wrapped in mud ball). Apparently Pleistocene species.
Machaerodont, genus and species not determined (metapodial).
Fish, not determined (lower jaw).

F. 31. Sec. 33, T. 36 N., R. 50 E., 2 miles north of Flaxville:
Camelid cf. *Procamelus* sp. (portion of posterior molar or left lower jaw).

F. 33. In railroad cut a mile west of Flaxville:
Protohippid (fragments of jaw, toe, and limb bones).
Artiodactyl, probably *Merycodus* (single phalanx).

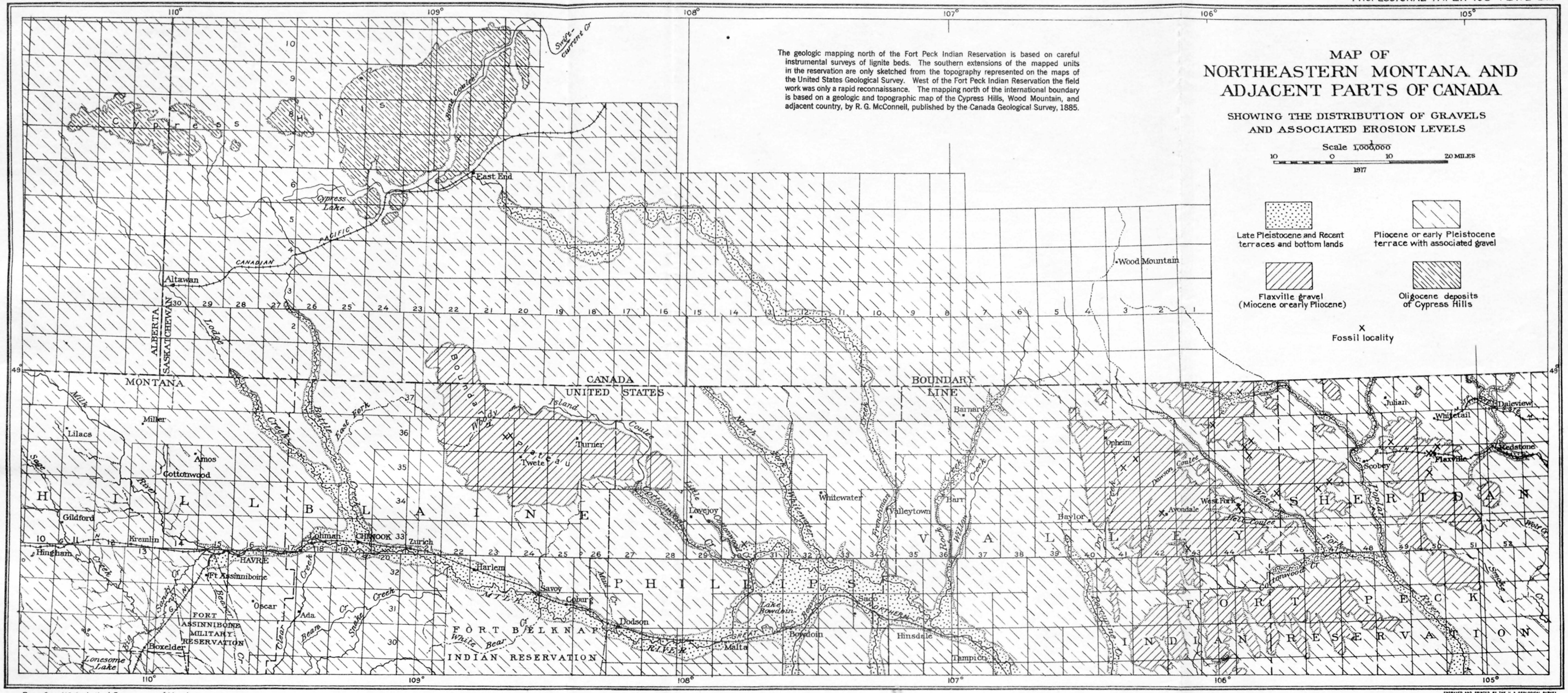
F. 34. Cut of Great Northern Railway a mile west of Flaxville:
Mylagaulid cf. *Ceratagaulus* sp. (large cheek tooth).
Protohippid cf. *Neohipparion niobrarensis* (right upper molar).
Protohippid ?*Neohipparion* sp. (fragments of three upper teeth).

F. 35. Railroad cut a mile west of Flaxville:
?*Procamelus* sp. (part of ulna, much broken).

F. 36. Southeastern part of T. 33 N., R. 43 E., collected by W. C. Alden:
Merychippus sp. (toe bone and fragment of jaw). Certainly one of the Miocene three-toed horses; probably upper Miocene.

F. 37. Sec. 23, T. 36 N., R. 23 E., Prof. Swenson's well:
?*Protohippus*, fragments of fossil mammals, one piece recognizable as fragment of upper molar of one of the Miocene horses.

F. 38. Sec. 24, T. 36 N., R. 23 E., Louis Hoff's well:
?*Protohippus*, fragments of mammalian remains; among them portion of an upper molar of one of the Miocene horses.



Base from U.S. Geological Survey map of Montana and geologic and topographic map of the Cypress Hills, Wood Mountain, and adjacent country by R.G. McConnell, published by the Canada Geological Survey, 1885.

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Mr. Gidley further remarks:

None of the material is sufficiently good or complete to make positive specific determinations, and it is therefore of no value as indicating horizon, except in a broad way. With the exception of the specimen reported as Pleistocene all the material appears to belong to the upper Miocene. It can be stated positively, I think, that with the exception noted, the beds from which these fragments were collected can not be older than Miocene or younger than lower Pliocene.

The formation from which these fossils were collected caps a series of even-topped plateaus ranging in altitude from about 2,600 feet at its east end, a few miles south of Redstone, to 3,200 feet in the west front of the Boundary Plateau in the Cherry Creek quadrangle. It is from a few feet to 100 feet thick and rests upon the eroded surfaces of the Fort Union, Lance, and Bearpaw formations. A characteristic view of the plateau surface is given in Plate LXIII, *A*. In the opinion of the writers this plateau represents an erosional level developed during a period subsequent to the Oligocene as represented in the Cypress Hills, and the fossil-bearing formation must have been deposited in Miocene or early Pliocene time. It seems hardly possible that these fossils could have been eroded and redeposited over so wide an area in the Pleistocene epoch, especially as no source from which they could have come has been recognized. Moreover, there seems to be no intermingling of Pleistocene fossils with the Miocene.

The distribution of the Flaxville gravel is shown on the accompanying map (Pl. LXII). It is generally composed of yellowish to ash-gray gravel, clay, and sand, but in some places it contains beds of white marl and volcanic ash. The gravel consists of well-rounded pebbles from less than an inch to a foot or more in diameter, of quartzite and argillite derived from the Rocky Mountains. Limestone pebbles from the same source may have been dissolved and the lime redeposited as cementing material and beds of marl. The materials composing the Flaxville gravel are mostly noncoherent and are excavated easily by well diggers, though beds of hard sandstone and conglomerate cemented with calcite from 1 foot to several feet thick are encountered in most of the wells. In places the formation is very thoroughly cemented with calcite and forms prominently outcropping ledges of sandstone and conglomerate, as shown in Plate LXIII, *B* and *C*. Many such outcrops present a great deal of cross-bedding and are not continuous over large areas.

In the railway cuts west of Flaxville (see Pl. LXV, *A*), where the best collection of fossils was made, about half the material exposed is gravel and the remainder clay and sand; about 1 foot of marl or concretionary calcite is also present. The bedding is very irregular, as might be expected of deposits on the flood plain of a river. North of Flaxville the road to Whitetail crosses a considerable thickness of gravel. Ten miles southeast of Flaxville, in the escarpment at the edge of a plateau, the formation consists of about 35 feet of cemented sand and gravel overlain by uncemented sand. Northeast of Scobey about 55 feet of more or less cemented sand and gravel is overlain by 25 feet of uncemented gravel and soil. Plate LXIV, *A*, shows a bed of gravel interstratified with sand. The following section of a well southwest of Scobey was given by Martin Presnell, the owner:

Section of a well southwest of Scobey, Mont., in sec. 33, T. 35 N., R. 47 E.

	Ft.	in.
Gravel	6	0
Clay	52	0
Lignite slack		6
Clay	2	0
Lignite slack	1	0
Gravel and bones; water.		
	61	6

In a well 2 miles southwest of the Presnell well 28 feet of coarse gravel, carrying bones, was found. About 20 miles west of Scobey there are several good exposures of the lower 20 feet of the formation, together with the underlying Fort Union. The gravel is uncemented and interstratified with cemented sand, and the surface is strewn with loose gravel containing bone fragments. A very striking exposure of the formation occurs 5 miles west of West Fork post office, south of Hell Coulee, in sec. 30, T. 34 N., R. 44 E., where about 30 feet of hard sandstone showing very marked cross-bedding caps the edge of the plateau. This feature is shown in Plate LXIV, *B*. The sandstone probably rests on gravel, for an exposure of uncemented gravel was found near the bottom of the coulee. In secs. 19, 20, and 29, T. 35 N., R. 43 E., 8 miles northeast of Avondale, south

of Dawson Coulee, a slightly different phase is presented, as shown by the following generalized section:

Generalized section of Flaxville gravel in secs. 19, 20, and 29, T. 35 N., R. 43 E.

[Thicknesses approximate.]

	Feet.
Marl, containing a few scattered quartzite pebbles	15
Sandstone cemented with calcite	30
Volcanic ash, white to yellow, very pure but mixed with the underlying gravel at the base	15
Gravel, more or less cemented	20
Fort Union formation.	
	80

The marl (an impure soft white limestone) was either deposited by water flowing over the surface into a shallow pond or gathered from the underlying beds and brought to its present position by percolating waters. Similar occurrences are indicated by fragments of marl in the soil of the townships to the west and north. This is the only locality where pure volcanic ash has been recognized, though similar material mixed with sand has been noted about 12 miles to the northeast. The gravel is very coarse, and well-rounded pebbles at least a foot in diameter, which must have been derived from it, were noted on the surface a short distance away in Dawson Coulee.

On Boundary Plateau in the vicinity of Cherry Ridge 74 feet of sandy gravel overlies 8 feet of cemented sandstone in a well in sec. 10, T. 36 N., R. 23 E., south of which two other wells of somewhat less depth have yielded fragments of fossil bone. The eastern edge of the formation is exposed in Tps. 35 and 36 N., R. 27 E., where it is dissected by Woody Island Coulee; the western edge of the formation along the west escarpment of the Boundary Plateau has been mapped by Stebinger in Tps. 35, 36, and 37 N., R. 21 E., where it consists of cemented sand, gravel, and marl.

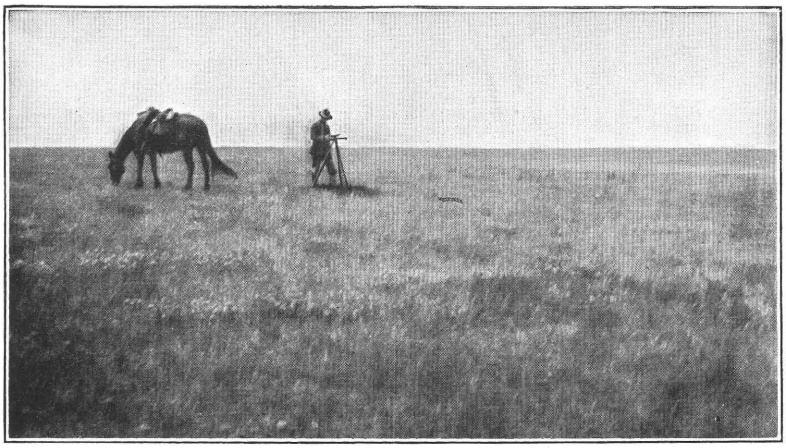
LATE PLIOCENE OR EARLY PLEISTOCENE GRAVEL.

Below the Flaxville level there are extensive areas varying in altitude from 2,500 to 2,800 feet on which the bedrock is exposed or can be found in wells at no very great depth. The relative altitudes of this bedrock surface are indicated on the maps prepared but not yet published by the International Boundary Commission. In the vicinity of Redstone it is a well-marked plateau or bench ranging in altitude from 2,400 to 2,500 feet. This feature extends westward near the international boundary to Scobey (altitude 2,450 feet), at the forks of Poplar River.

Between Opheim and the Boundary Plateau the same period of erosion is represented by a great expanse of highly dissected country including level-topped areas, sloping grass-covered hills, and badlands on which the Bear-paw shale is exposed, ranging in altitude from 2,500 feet near Milk River to 3,000 feet at the international boundary near the crossing of Frenchman Creek. Small bodies of stratified gravel and silt have been noted in sec. 3, T. 36 N., R. 52 E., east of Daleview; in several wells in the neighborhood of Julian; west of Opheim, in sec. 13, T. 37 N., R. 39 E., and west of Baylor, in sec. 25, T. 35 N., R. 38 E. The best exposures seen are in sec. 23, T. 33 N., R. 30 E., north of Malta, a few miles from Milk River, where about 25 feet of interstratified gravel and yellowish silt caps the edge of the bench at an altitude of about 2,500 feet above the sea, or 300 feet above Milk River. The gravel is cemented, presumably with calcite, forming a conglomerate that crops out in the form of a small cliff. Fragments of bone and a single tooth were obtained from the face of the cliff. Dr. Gidley identified the tooth as that of a horse resembling the living species and states that it can not be so old as the Flaxville fauna. The formation here rests upon the Judith River formation, but about 5 miles east of this locality it rests upon the Claggett shale and consists of about 25 feet of yellowish silt containing two beds of gravel, one at its base and another 15 feet higher. The gravel is comparatively fine, the pebbles being less than an inch in diameter. In the light of the evidence now at hand this formation is regarded as of late Pliocene or early Pleistocene age. The erosion of the very extensive areas below the Flaxville level must have been accomplished during middle Pliocene time.

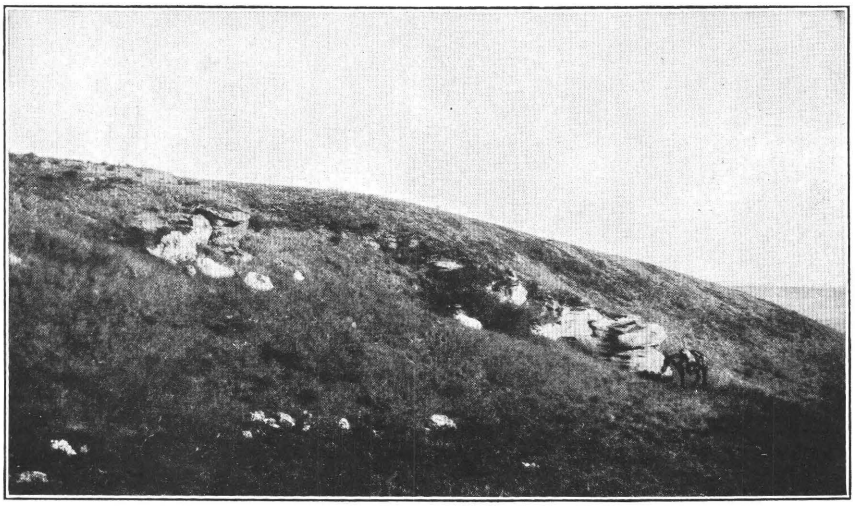
LATE PLEISTOCENE AND RECENT EROSION AND DEPOSITION.

The streams of the region have eroded their valleys from 100 to 500 feet below the level assigned to the late Pliocene or early Pleistocene. Milk River now occupies a valley 1 to 5 miles wide eroded by Missouri River before the last great invasion of ice in the glacial

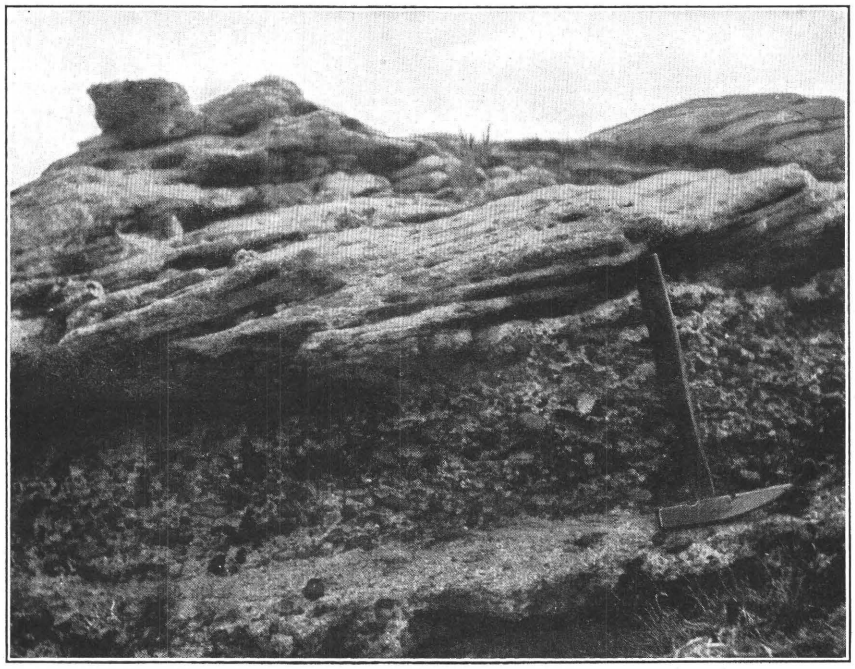


A. SURFACE OF THE FLAXVILLE PLATEAU, NORTHEASTERN MONTANA.

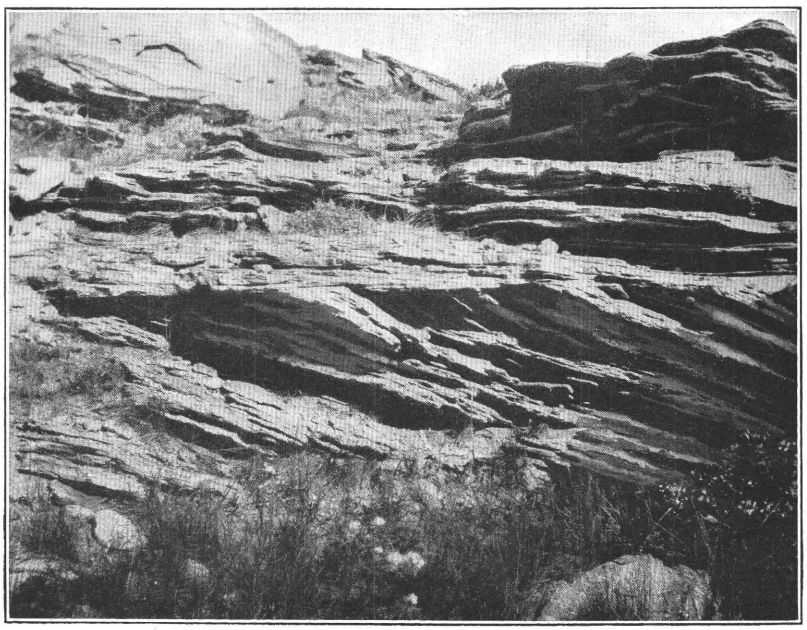
B. OUTCROP OF CEMENTED FLAXVILLE GRAVEL IN ESCARPMENT OF PLATEAU NORTHWEST OF OPHEIM, MONT.



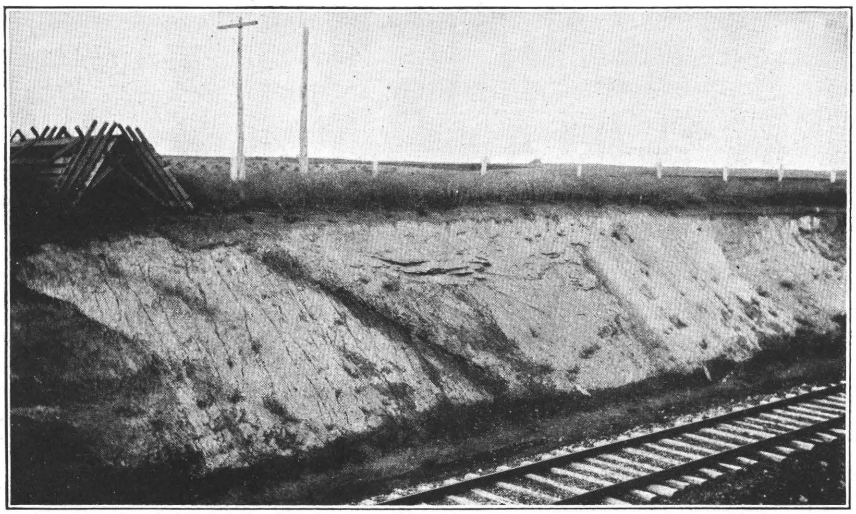
C. ESCARPMENT OF THE FLAXVILLE PLATEAU, NORTHEASTERN MONTANA, SHOWING OUTCROPS OF CEMENTED SAND AND THE THICKNESS OF THE FLAXVILLE GRAVEL.



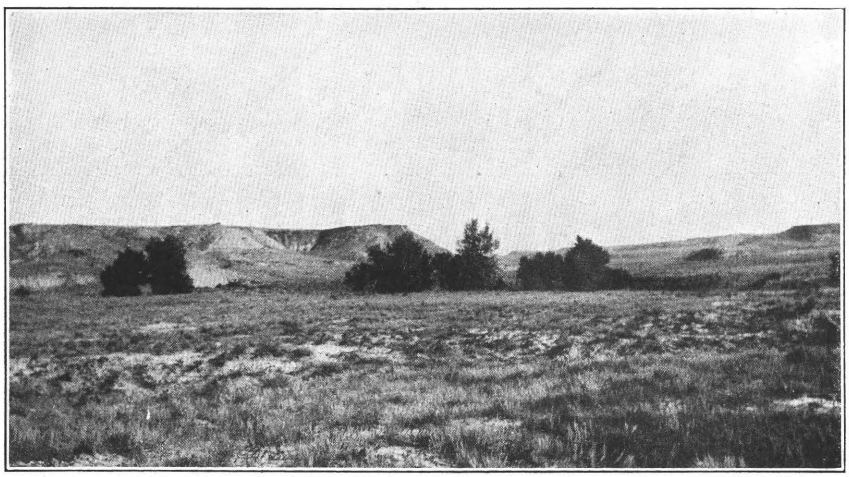
A. CEMENTED GRAVEL INTERSTRATIFIED WITH CEMENTED SAND 9 MILES NORTHEAST OF SCOBEY, MONT.



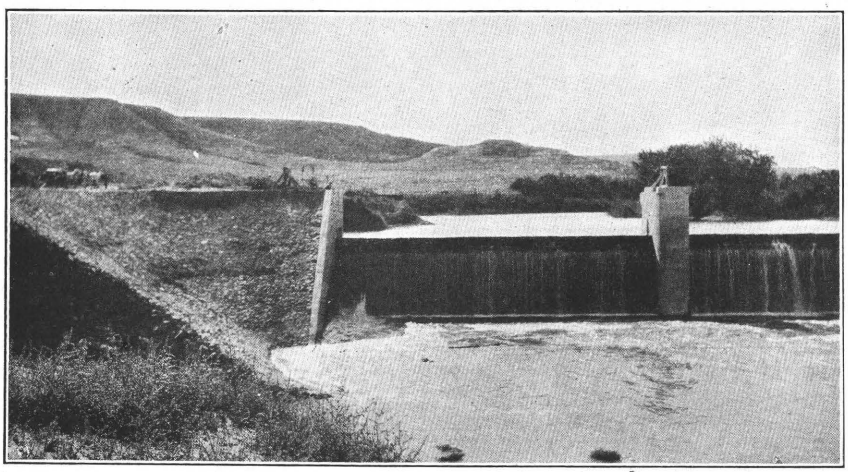
B. CROSS-BEDDING OF FLAXVILLE GRAVEL 5 MILES WEST OF WEST FORK POST OFFICE, MONT.



A. RAILWAY CUT WEST OF FLAXVILLE, MONT



B. ESCARPMENT SURROUNDING THE LATE PLIOCENE OR EARLY PLEISTOCENE BENCH IN MILK RIVER VALLEY, MONT.



C. VANDALIA DAM, MILK RIVER, MONT., SHOWING THE ESCARPMENT SURROUNDING THE LATE PLIOCENE OR EARLY PLEISTOCENE BENCH.

epoch.[1] This valley contains alluvium deposited by Missouri River, glacial drift, and the Recent alluvium of Milk River and is bounded on the north and south by steep escarpments rising 100 to 500 feet to the late Pliocene or early Pleistocene bench. Plate LXV, *B* and *C*, shows views of these escarpments taken from the flood plain of Milk River. Big Muddy Creek flows in a valley cut 200 feet in the same bench. Similar benches are found along Poplar River and its branches. The canyon of Rock Creek where it crosses the bench is so precipitous as to have been considered unsurveyable by the United States Land Office. Frenchman Creek and Woody Island Coulee occupy narrow valleys, and the latter was diverted from its old course westward into Whitewater Creek by the last glacial advance.

OLIGOCENE BEDS IN CYPRESS HILLS.

In 1883 and 1884 McConnell[2] and Weston, of the Canada Geological Survey, examined the Cypress Hills and made a very good collection of fossil vertebrates at Bone Coulee, in the east end of the hills. This collection was submitted to Cope,[3] who identified several species and pronounced them to be of Oligocene age and equivalent to the fauna of the White River formation of Nebraska. The locality was visited in 1904 by Lambe,[4] who made further collections of the fauna and reaffirmed the determination that the beds are of White River age.

The formation exposed in the Cypress Hills is shown on McConnell's map as capping a series of plateaus ranging from 3,700 feet in altitude at the east to 4,800 feet at the west. The gravel on the Swift Current Creek plateau, which lies northeast of the Cypress Hills, is regarded by McConnell[5] as an eastern extension of the Oligocene gravel, though only unidentifiable bone fragments were found in it. As its altitude is about 2,900 feet, or 200 feet below that of the nearest exposure of Flaxville gravel, it is suggested by the writers that a more thorough search might result in the discovery of the Flaxville fauna. The Oligocene beds exposed near Bone Coulee, Cypress Hills, are described by McConnell[6] as follows:

> The Miocene [Oligocene] beds are characterized by the great quantity of waterworn pebbles, derived from the quartzite formations of the Rocky Mountains, which are found in every part of the series. The pebbles are usually cemented together into massive beds of hard conglomerate but also occur distributed irregularly through or arranged in layers and lenticular beds in the sands and sandstones. The more massive conglomerate beds are found toward the western part of the area or around its outskirts. * * * [The beds] are all very irregular and seldom remain constant in composition for any distance along their strike.

SUMMARY.

The gravel that caps the Cypress Hills in Canada is of Oligocene (White River) age. It is made up of materials from the Rocky Mountains, to the west, and rests upon a series of plateaus cut on the Fort Union, Lance, and Bearpaw formations and ranging from 4,800 feet in altitude at its west end to 3,700 feet near its east end.

The Flaxville gravel in Montana is from a few feet to 100 feet thick and is composed of well-rounded quartzite and argillite pebbles from the Rocky Mountains, sand, clay, marl, and volcanic ash. It rests upon a series of plateaus cut on the Fort Union, Lance, and Bearpaw formations, and ranging in altitude from 2,600 feet at the east to 3,200 feet at the west. Fragmentary fossils collected at 25 well-distributed localities were not good enough for specific determination, but it can be stated positively that the formation can not be older than Miocene nor younger than early Pliocene.

Below the Flaxville level there are extensive areas, eroded since its deposition, on which the covering is thin or absent. Stratified gravels and silts have been noted at several localities. A single fossil tooth collected from one of these exposures of gravel was identified as that of a horse resembling the living species. It certainly is not so old as the fauna of the Flaxville gravel. The formation is known to be older than the advance of the Wisconsin glacier.

[1] Calhoun, F. H. H., The Montana lobe of the Keewatin ice sheet: U. S. Geol. Survey Prof. Paper 50, pp. 32–45, 1906.

[2] McConnell, R. G., On the Cypress Hills, Wood Mountain, and adjacent country: Canada Geol. Survey Ann. Rept., vol. 1, new ser., pp. 1c–78c, 1886.

[3] Cope, E. D., The Vertebrata of the Swift Current Creek region of the Cypress Hills: Idem, pp. 79c–85c; The species from the Oligocene or lower Miocene beds of the Cypress Hills: Canada Geol. Survey Contr. Canadian Paleontology, 1891.

[4] Lambe, L. M., A new species of *Hyracodon* (*H. priscidens*) from the Oligocene of the Cypress Hills, Assiniboia: Canada Roy. Soc. Proc. and Trans., 2d ser., vol. 11, sec. 4, pp. 37–42, 1906; Fossil horses of the Oligocene of the Cypress Hills; Idem, pp. 43–52; Vertebrata of the Oligocene of the Cypress Hills; Saskatchewan: Canada Geol. Survey Contr. Paleontology, vol. 3, pt. 4, 1908.

[5] McConnell, R. G., op. cit., p. 34c.

[6] Idem, p. 69c.

It must therefore be of late Pliocene or early Pleistocene age.

Present drainage has eroded valleys from 100 to 500 feet below the late Pliocene bench. Most of this cutting was accomplished before the advance of the Wisconsin glacier, whose drift deposits lie alike on uplands and bench lands and in the valleys.

The relative altitudes of these four erosion levels and the gravel assigned to them are shown diagrammatically in figure 27. The Oligocene of the Cypress Hills is the highest, the Miocene or early Pliocene Flaxville gravel bench represents a second stage of erosion and deposition, the late Pliocene or early Pleistocene bench a third stage, and the late Pleistocene and Recent level a fourth stage.

The correlation of these erosion levels with the Blackfoot peneplain and the second and third lower benches in the Glacier National Park region, described by Alden and Stebinger,[1] is suggested but must be regarded as not yet proved. These relations are at present under investigation.

Terrace gravel found by Bowen[2] in the neighborhood of Musselshell River, south of the Missouri, is probably either Oligocene or Miocene; that around the Bearpaw,[3] Little Rocky, Highwood, Judith, Big Snowy, Little Belt, Crazy, and other mountain groups is probably of Tertiary age and represents one or more of the erosion levels described. The relation of these erosion epochs to the physiographic history of the Rocky Mountains, as presented by Atwood[4] and Blackwelder,[5] is very problematic and can not be solved until all the factors are known.

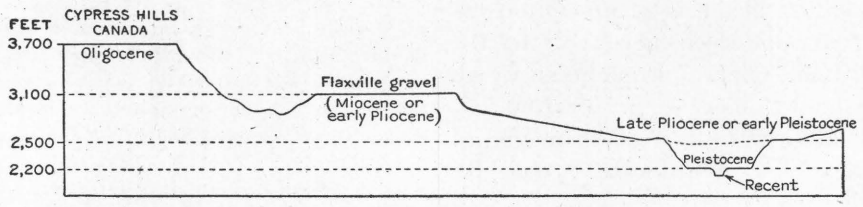


FIGURE 27.—Diagrammatic section showing the relative altitudes of the four erosion levels represented in northeastern Montana and the adjacent part of Canada.

[1] Alden, W. C., and Stebinger, Eugene, Pre-Wisconsin glacial drift in the region of Glacier National Park, Mont.: Geol. Soc. America Bull., vol. 24, p. 569, 1913.

[2] Bowen, C. F., The anticlines of the Musselshell Valley (in preparation).

[3] Bowen, C. F., The Cleveland coal field, Blaine County, Mont.: U. S. Geol. Survey Bull. 541, p. 348, 1912.

[4] Atwood, W. W., The physiographic conditions at Butte, Mont., and Bingham Canyon, Utah, when the copper ores in these districts were enriched: Econ. Geology, vol. 11, pp. 697–749, 1916.

[5] Blackwelder, Eliot, Post-Cretaceous history of the mountains of central western Wyoming: Jour. Geology, vol. 23, Nos. 2, 3, and 4, May-June, 1915.