

PLEISTOCENE DRAINAGE CHANGES IN WESTERN NORTH DAKOTA¹

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INTRODUCTION

The continental ice-sheet produced important drainage changes in western North Dakota. Its effects are particularly well shown in the case of the Missouri, the Yellowstone, and the Little Missouri rivers, since all these streams were forced to seek new channels. The region was three times invaded by the ice-sheet—the later Wisconsin, earlier Wisconsin, and an earlier invasion, which was probably Kansan or possibly sub-Aftonian—but it was the earlier, or pre-Wisconsin, invasion which caused most of the changes. The southerly course of the Missouri River below old Fort Stevenson has been attributed to the latest or later Wisconsin ice-sheet, but evidence is here presented that the valley, at least in North Dakota, is preglacial, using the term preglacial to mean older than the oldest ice-invasion of this region—it may mean either pre-Kansan or pre-sub-Aftonian.

AGE OF THE MISSOURI RIVER VALLEY

As long ago as 1868 Gen. G. K. Warren made the statement that the present course of the Missouri River was determined by the edge of the

¹ Manuscript received by the Secretary of the Society December 20, 1915.

ice-sheet: "There, then, on that limit a river must have been formed to carry away the melting water from the glacier, and this limit was the Missouri River, and that was the river formed thereby."²

Todd, in 1884, stated his belief that the Missouri River formerly flowed east or northeast, either to the present James or to the Mouse River.³ In a later paper he elaborates this view and gives reasons for his theory that the river flowed northeast to the Mouse Valley.⁴ Todd believes that there is evidence that the Heart and Cannon Ball rivers once flowed on east to the James River, and that the valley of Snake Creek is the preglacial valley of the Missouri River. The valley of Snake Creek is no larger than the valleys of other tributaries entering the Missouri above this point, and the notch in the east front of the divide north of Fort Stevenson, which is shown on some maps, does not exist in reality, and there is no evidence of any preglacial valley here. The valley of Long Lake Creek could hardly have been the eastward extension of the Cannon Ball River Valley, since its lower course is not opposite the mouth of the latter stream, but joins the Missouri four miles to the north. There is no reason for believing that the Knife River ever joined the Missouri near Fort Stevenson, and the lower valley of this stream has every appearance of great age, having a broad flood-plain and gentle slopes. It is clearly a preglacial valley. The Heart River is thus the only important tributary of the Missouri which might have continued eastward to the James River if the valley of Apple Creek, which has its mouth just opposite the Heart, is an indication of this. But Apple Creek is readily accounted for as a preglacial tributary of the Missouri and one of the chief outlets for the glacial waters when the ice-margin occupied the position marked by the Altamont moraine. Its valley is largely filled with glacial outwash from the moraine.

There is abundant evidence that the Missouri Valley below the mouth of Snake Creek is preglacial, and that the river was not forced by the ice-sheet to take its present southerly course through North Dakota. This evidence is based on the presence of glacial boulders on the valley bottom and at many points on a terrace representing a former flood-plain of the Missouri. Boulders have been encountered in two wells in Bismarck at a depth of 125 feet below the surface or 80 feet below river level. These wells are near the edge of the terrace bordering the Missouri Valley at Bismarck, and since the boulders rest on the bedrock they indicate that the valley was excavated to this depth prior to the Glacial period. In

² Annual Report, Chief of Engineers, U. S. Army, for 1868, pp. 307-314.

³ Proc. Am. Assoc. Adv. Sci., vol. 33, 1884, pp. 381-392.

⁴ Science, vol. 39, 1914, pp. 265-274.

several borings made for the Northern Pacific Railroad previous to the building of its bridge across the river at Bismarck, from 70 to 80 feet of silt and gravel were passed through before reaching the bedrock, and in

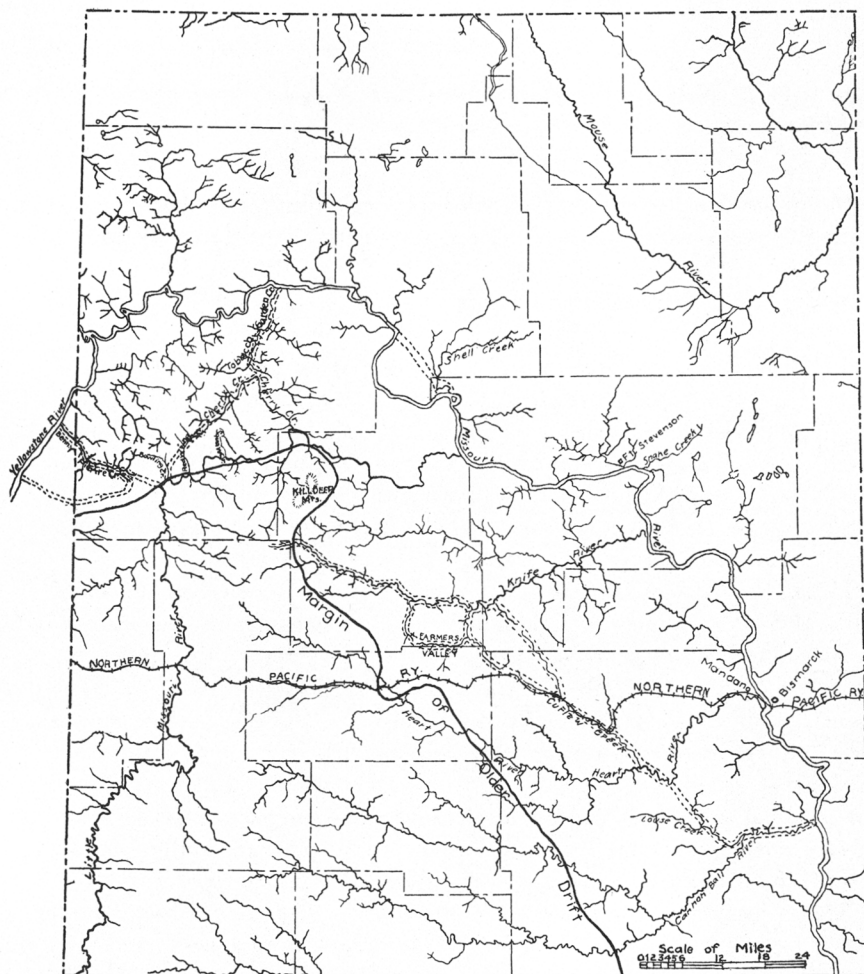


FIGURE 1.—Map showing old Pleistocene Valleys of western North Dakota

one boring a boulder was struck at a depth of about 50 feet below the river bed.

On the west side of the Missouri Valley, between Mandan and the mouth of the Knife River, there is a well developed terrace which in places is a mile and more wide. This terrace has an elevation of 55 to 60

above the river and the upper portion of it is in many places composed of glacial gravel and good-sized boulders. A railroad cut in this terrace a mile northeast of Mandan, near the cemetery, shows the following section:

	Feet	Inches
Soil	2-3
Boulders and gravel.....	5-9
Sand, finely laminated, with several thin layers of gravel.....	2-5
Boulders and pebbles.....		6-12
Lance beds, exposed above railroad track.....	15

In another cut less than one-quarter of a mile south a bed of boulders, many of them several feet in diameter, mixed with gravel and resting on the Lance beds, extends a distance of at least 100 yards along the railroad.

Several miles south of Price the upper part of the terrace is composed of boulders and coarse gravel, the deposit having a thickness of 5 to 6 feet. Between Sawyer and Price the terrace is finely developed and is covered in some places by a layer of gravel and boulders; in other places by unstratified glacial drift or boulder-clay. In the vicinity of Hensler the Missouri Valley is several miles wide, and here, as well as in other places, numbers of low, rounded drift hills, covered with numerous boulders, rest on the valley floor. Some of the railroad cuts show the boulder-clay to be 30 to 40 feet thick.

Before the time of the earlier ice-invasion, when the ice-sheet advanced 40 to 50 miles beyond the Missouri River, that stream must have flowed in its present broad, terraced valley, and on the floor of this valley the glacier deposited the boulders, gravel, and till so well exposed at many points. These deposits, shown in the railroad cuts of the terrace, lie about 40 feet above the ordinary stage of the river and vary considerably in thickness.

C. M. Bauer believes that during late Tertiary time the Missouri River flowed northeast from Poplar, Montana, and that its waters finally reached Hudson Bay.⁵ Also that the Yellowstone flowed northward from Williston by way of the valley of Muddy Creek. But it has been shown that the present Missouri Valley in North Dakota is preglacial, and it is doubtful whether the river in late Tertiary time had a course differing from its present one. Additional evidence that the present valley is preglacial, and that the trench of the river was excavated to its present depth at the time of the earlier ice-invasion, is shown by the boulder bed less than half a mile below the mouth of Tobacco Garden Creek. This bed of

⁵ C. M. Bauer: "A sketch of the late Tertiary history of the Upper Missouri River." *Jour. Geol.*, vol. xxiii (1915), pp. 52-58.

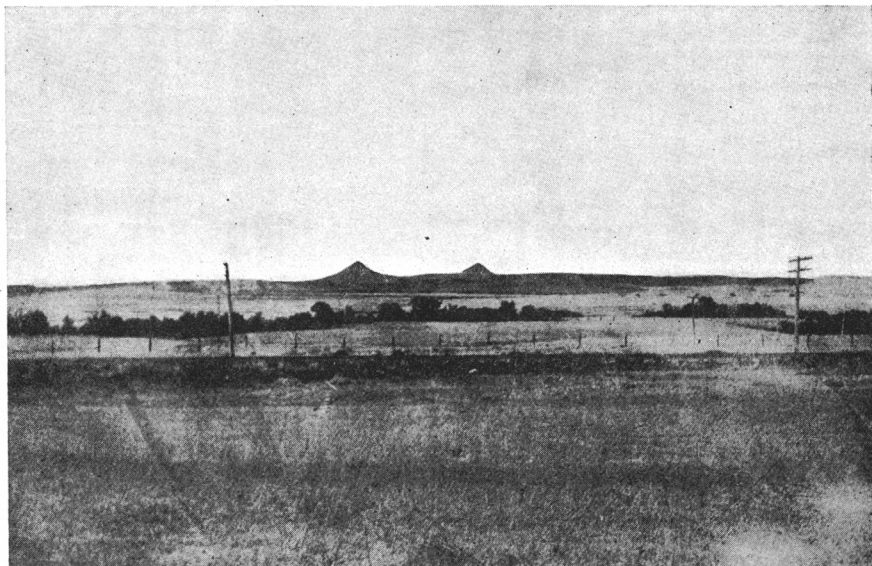


FIGURE 1.—LOOKING ACROSS THE OLD PLEISTOCENE VALLEY OF THE MISSOURI AND YELLOWSTONE RIVERS NEAR GLEN ULLIN, NORTHWESTERN MORTON COUNTY, NORTH DAKOTA.

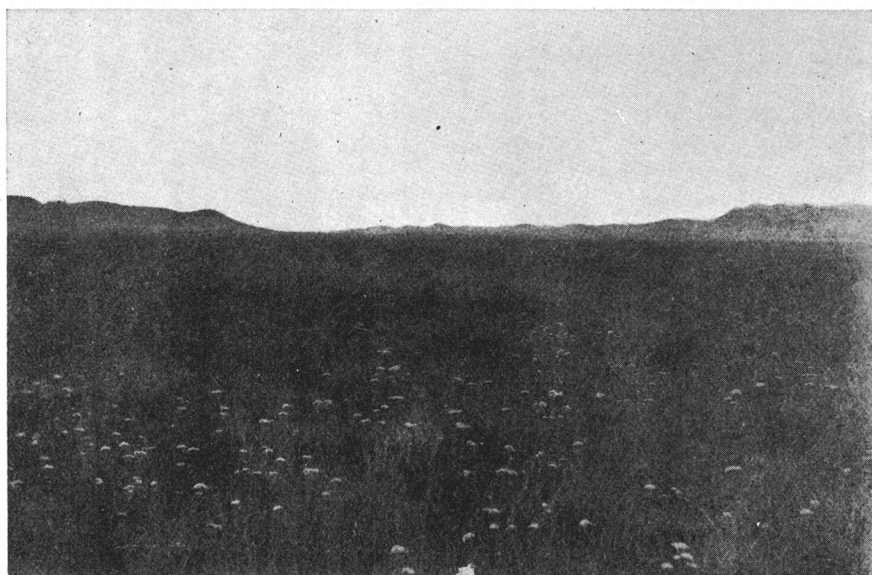


FIGURE 2.—BROAD PLEISTOCENE VALLEY OF THE YELLOWSTONE RIVER, LOOKING EAST THROUGH THE VALLEY TOWARD THE LITTLE MISSOURI RIVER, WESTERN MCKENZIE COUNTY, NORTH DAKOTA.

OLD PLEISTOCENE VALLEYS IN WESTERN NORTH DAKOTA

boulders, which lies just above river level, is at least 12 to 14 feet thick and extends along the water's edge for a distance of 100 yards, while scattered boulders and ferruginous gravel occur at intervals for another 200 yards. Overlying the boulders are 15 feet of gravel. While some of the boulders of this deposit may have been brought here by floating ice, it is probable that most of the deposit was left here by the pre-Wisconsin ice-sheet when it advanced south of the river. The finer materials of the drift, if they were ever present, have been carried away, leaving the gravel and boulders.

PLEISTOCENE VALLEY OF MISSOURI AND YELLOWSTONE RIVERS

But while the Missouri River probably occupied its present valley for a considerable time prior to the Glacial period, the ice-sheet, when it invaded the region, blocked the valleys of both the Missouri and Yellowstone rivers and also the preglacial valley of the Little Missouri, forcing these streams to seek new channels. Lakes were formed in the valleys of the Yellowstone and Little Missouri rivers, the water rising until it overflowed the divide between the latter and the Knife River south of the Killdeer Mountains. The combined waters of the three rivers flowed east across Dunn County and southeast across Morton to the mouth of the Cannon Ball River. The valley thus formed crosses the divide between the Knife and Heart rivers and also that between the Heart and Cannon Ball. The length of this Pleistocene valley of the Yellowstone and Missouri rivers from the head of the Knife to the mouth of the Cannon Ball is 155 miles. It is followed for 30 miles by the Northern Pacific Railroad between Almont and Hebron, this portion of the valley being today occupied by Curlew Creek (figure 1, plate 14). The Heart River follows the valley for 6 to 8 miles below the mouth of Curlew Creek, and the broad depression continues its southeasterly course through the divide to the Cannon Ball, being followed for many miles by Louse Creek, a tributary of the Cannon Ball.

Two broad valleys connect the Knife River Valley with that of Curlew Creek. One enters the latter valley between 3 and 4 miles below Glen Ullin and is followed by the northward flowing Elm Creek throughout a portion of its extent. Between the latter and the tributary of Curlew Creek the valley bottom is occupied in part by a hay marsh. The other valley, which joins that of Curlew Creek just below Hebron, is known as Farmers Valley and extends to the head of Deep Creek, a tributary of Knife River.

It will be noted that the Knife, Heart, and Cannon Ball rivers, together with several of their tributaries, now occupy parts of this old Pleistocene valley of the Missouri and Yellowstone rivers. The valley is clearly much too large to have been formed by several of the streams which today flow through it, such as Curlew, Elm, or Louse creeks, and some portions now have no stream. Throughout much of its course the old valley has a broad, flat bottom one-half to one mile and more wide, with gently sloping sides.

PLEISTOCENE VALLEYS OF THE YELLOWSTONE RIVER

The lower 50 miles of the Yellowstone Valley was blocked with ice during the Glacial period and the river was forced to seek a new channel. Its waters flowed east to the valley of the Little Missouri and formed at least two broad, flat-bottomed valleys connecting these streams. The most northerly of these old valleys, which is 28 miles long, is now occupied by the northwestward flowing Benny Pierre Creek, a tributary of the Yellowstone, and by the eastward flowing Hay Draw Creek, a tributary of the Little Missouri (figure 2, plate 14).

The second valley has a northeasterly course, is about 32 miles long, and joins the first about 10 miles above its junction with the Little Missouri. That portion of the Benny Pierre-Hay Draw Valley floor which forms the low, flat, almost imperceptible divide between the Yellowstone and Little Missouri drainage systems has an elevation of 185 feet above the latter river, or about 2,209 feet above sealevel. The valley is bordered on either side by high, steep bluffs and the level plain forming its broad bottom is nearly a mile wide. This great trench was clearly occupied at one time by a stream many times larger than those now having possession of it.

PREGLACIAL VALLEY OF THE LITTLE MISSOURI RIVER

The Little Missouri, as well as the Yellowstone and Missouri rivers, was forced out of its preglacial valley by the ice-sheet. The lower 55 miles of this valley was filled with ice, so that a lake was formed back of the glacial barrier, the water rising and overflowing to the east by way of the old valley previously described as occupied by the Missouri and Yellowstone rivers during the Pleistocene period.

The abandoned valley of the preglacial Little Missouri was first men-

tioned by Wilder,⁶ who saw one end of it in 1903, but its course was not explored.

During the summer of 1914 this old valley was mapped in detail by the writer and a line of levels was run from the south edge of the Ray quadrangle to the Little Missouri River. The valley extends from the mouth of Bowling Creek north and east to the Missouri River at the mouth of Tobacco Garden Creek, a distance measured along the axis of the valley of 55 miles. Its bottom varies in width from half a mile to one and three-quarters miles and throughout much of its course it is a mile or more wide.

Two very low and inconspicuous divides are present in this valley, one between Tobacco Garden and Cherry creeks and another between Cherry and Redwing creeks. The former is between 3 and 4 miles north of Schafer, where the divide is less than 20 feet above Cherry Creek. Even more flat is the divide separating the headwaters of Cherry from those of Redwing Creek, which is located about two miles south of Elsworth. For a distance of 3 to 4 miles along the valley floor the elevation does not vary more than 4 or 5 feet, and so flat is this interstream area in the old valley that the water does not run off after a rain, but stands on the surface until it sinks into the ground or evaporates.

The present divide between Redwing and Bowling creeks constitutes the highest point in the old river valley. Its elevation is 2,191 feet above sealevel, or 177 feet above the Little Missouri at the mouth of Bowling Creek. In that portion now occupied by Cherry Creek the average slope of the valley floor is 7.4 feet per mile for a distance of 20 miles, while in that portion occupied by Tobacco Garden Creek the slope averages 5.5 feet per mile.

ABNORMAL DRAINAGE FEATURES OF LITTLE MISSOURI TRIBUTARIES

The upper valleys of both Squaw and Redwing creeks open out into this preglacial valley of the Little Missouri, so that the floors of these valleys tributary to the Little Missouri are continuous with the broad flats of Cherry Creek. The explanation of this peculiarity, in the case of Redwing Creek, is found in the fact that this youthful and vigorous stream, with a fall of 23 feet per mile, has worked its way back by headward erosion and taken possession of a portion of the flats forming the

⁶ The lignite of North Dakota and its relation to irrigation. Water Supply and Irrigation Paper No. 117, U. S. Geol. Surv., p. 43; also Third Biennial Report, North Dakota Geol. Surv., map, p. 16.

old valley floor, so that now the tributaries of Redwing Creek meander over the flats in shallow trenches cut in the valley plain.

That portion of Squaw Creek above the sharp bend was formerly a tributary of the Little Missouri when it occupied the old valley. But in postglacial time the young and vigorous Squaw Creek, which is now tributary to the Little Missouri of today, with a fall of about 22 feet per mile, worked its way back until it captured the northward flowing tributary of the preglacial river and diverted the waters to the south, thus forming the sharp bend in the present course of Squaw Creek.

The abnormal features of the Cherry Creek drainage are even more striking than those of Redwing Creek. The upper valley from Elsworth to the bend several miles north of Schafer is broad, the valley floor being in many places from one to one and one-half miles wide; the side slopes are for the most part gentle, and the rather numerous tributaries enter by broad, flat-bottomed valleys. In contrast to this the lower valley is comparatively narrow, from one-quarter to one-half mile wide, and the side walls are quite steep. In its upper course the creek has an average fall of 7.4 feet per mile, while below the bend the average fall is almost 10 feet per mile. The normal stream has its broad flats along its lower course, where the fall is also less than in the upper portions of its valley. The explanation for the abnormal features of Cherry Creek is clearly to be found in the fact that above the bend near Schafer it follows the old preglacial valley of the Little Missouri River, while below the bend it flows in a much younger postglacial valley. After the Little Missouri had been forced by the ice-sheet from its former valley and had cut its present trench, a tributary developed and extended itself by headward erosion, forming the present lower valley of Cherry Creek. This vigorous young stream worked back until it reached the preglacial valley of the Little Missouri and captured the upper portion of the creek flowing through it, diverting it to its present southeasterly course below the bend where the piracy took place. With such a development the Cherry Creek drainage would possess the abnormal features mentioned above.

EVIDENCE OF POSTGLACIAL AGE OF LOWER LITTLE MISSOURI VALLEY

* When the Little Missouri River was forced by the ice-sheet to seek a new channel, it probably flowed for a time through the Pleistocene valley of the Missouri and Yellowstone rivers, previously described. But later it took an easterly course and formed its present postglacial valley, which extends from the mouth of Bowling Creek to the Missouri River, a distance of 100 miles. There is abundant evidence that this lower valley of

the Little Missouri is much younger than the portion above the mouth of Bowling Creek, and that it has been formed since the ice-invasion of the Glacial period. The following are some of the reasons for believing it to be postglacial, or at least post-Kansan:

1. The great majority of the tributaries of the lower Little Missouri below Bowling Creek are short—much shorter than those above. Most of them are not over two or three miles in length, while the tributaries of the river for 60 miles above Bowling Creek are from four to eight times as long, since they have had a much longer time to lengthen by headward erosion.

2. Closely connected with the length of the tributaries is the width of the badlands, which are formed by the erosion of the Little Missouri River and the streams flowing into it. Below Bowling Creek the badlands in most places are not over five to seven miles wide, at some points extending back only two or three miles from the river on either side, while along the river above Bowling Creek the belt of badlands has a width of 15 to 25 miles.

3. One of the conspicuous features of the Little Missouri Valley in Billings County and for a few miles of its course in southern McKenzie County are the high, broad flats or terraces on one or both sides of the river. They have an elevation ranging from 240 feet at the south to nearly 300 feet above the river at the north and are one to two miles and over in width. They were undoubtedly formed prior to the Glacial period. These high terraces are wholly absent from the lower valley, which would seem to indicate that this portion is more recent and was formed since the region was elevated, so that the rejuvenated river cut its inner valley several hundred feet below the floor of its earlier one.

4. The fact that the Little Missouri River leaves its preglacial valley and turns east at a point which coincides closely with the southern boundary of the ice-sheet, and that for over 40 miles the new valley follows quite closely the former ice-sheet margin, suggests that the latter governed to some extent at least the location of the lower valley of that river. The old valley was blocked with ice as far south as the point where the Little Missouri abandons it, and the waters, when forced to seek a new channel, eventually made their way east not far from the edge of this ice-sheet, and the river thus cut its valley along this eastward course.

5. The Killdeer Mountains, in northwestern Dunn County, are flat-topped buttes or mesas, rising from 500 to 650 feet above the surrounding upland plain and nearly 1,200 feet above the Little Missouri River. They lie less than six miles south of the latter, and it does not appear

probable that they would have persisted and survived the rapid erosion to which they are subjected by the tributaries of the Little Missouri if they had long been in such close proximity to that stream. Had the latter occupied its lower valley longer than postglacial time, it is likely that the Killdeer Mountains would long since have been swept away by erosion. T. T. Quirke, in an unpublished paper, shows that the peculiar topographic features of the Killdeer Mountains are probably caused by the change in the course of the Little Missouri when it abandoned its preglacial valley.

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Notes

