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EARLY PLEISTOCENE GLACIATION IN THE ROCKY MOUNTAINS OF GLACIER NATIONAL PARK, MONTANA.¹

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With a map

Glacier National Park comprises that part of the front range of the Rocky mountains in Montana lying between the line of the Great Northern railway and the International boundary. Immediately adjacent to it on the east is the Blackfeet Indian Reservation and to the north is Alberta. Investigations by the writer and Mr. J. E. THOMAS in connection with the survey of Glacier Park by the United States Geological Survey in 1911, and by the writer and Mr. EUGENE STEBINGER in connection with a geological survey of the Blackfeet Indian Reservation in 1912, showed that the so-called "quartzite gravels" which cap remnants of the Tertiary peneplain, to which Mr. BAILEY WILLIS has given the name Blackfoot peneplain, are in reality glacial drift that was deposited by an extension of the Rocky Mountain glaciers on to the plains in early Pleistocene time and prior to the dissection of this peneplain. The relations of these deposits and their modification by weathering indicate that this extension of the mountain ice occurred as early as the Kansan if not the pre-Kansan extension of the Continental ice-sheets into the northern Mississippi valley.

The relations of these high-level tracts to the mountains and to the present drainage lines are shown on the accompanying map (Pl. I) and also on the Chief Mountain, Browning, and Blackfoot sheets of the topographic map published by the U. S. Geological Survey, the contour interval being 100 feet.² The remnants of the early mountain drift are on either side of Belly river, on Kennedy ridge east of Chief mountain, on Swift Current and Boulder ridges to the north and south of Swift Current creek, on Hudson Bay divide and St. Mary ridge east of St. Mary river and lake, on Milk River ridge and other ridges bordering Milk river, on the ridge south of Outbank creek and on the ridge north of Lower Two Medicine lake. The flat tops of these high-level deposits stand at elevations of 5,300 to 6,300 feet above sea-level and at heights above the present drainage lines ranging from a few hundred to 1,600 feet.

The high mountain range on the west is shown on this map by the broken-

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² The contour interval on the Blackfoot sheet is 20 feet.

drift-capped remnants of the Blackfoot peneplain. This shows the whole 40 miles of the mountain front of Glacier National Park, from Chief mountain on the right or north to Marias pass on the south, rising above the dissected Blackfoot peneplain. The valley of Middle Fork of Milk river in the middle ground is cut 500 feet deep in the upturned and beveled shales and sandstones that underlie this plain, although the stream does not head in the mountains and receives no drainage therefrom. In the middle background may be seen the crest of St. Mary ridge lying athwart the mountain gorge in which lies Upper St. Mary lake.

Fig. 2 is a view looking northeastward from a point on the flat top of

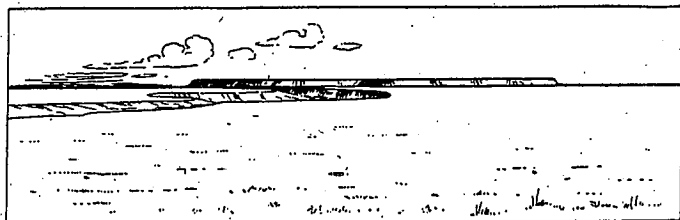


FIG. 2.—View northeastward from Browning-Babb stage-road on the crest of Milk River ridge showing the relations of the second peneplain, in foreground, to a remnant of the first, or Blackfoot peneplain, in background. (From photograph, partly diagrammatic in foreground.)

the main part of Milk River ridge, on a second, lower, drift-capped plain to a drift-capped remnant of the highest plain, 20 miles from the mountain front.

At the time when this early drift was deposited the ice heading in St. Mary and adjacent valleys evidently extended directly northeastward on to the Blackfoot peneplain (Pl. I). By the time of the last great extension of the ice, so deep and broad a trough had been developed west of St. Mary ridge and the Hudson Bay divide that St. Mary glacier, instead of extending eastward on to the high-level plain, was diverted northward down St. Mary valley into southern Alberta. The St. Mary lakes now lie 1,600 feet below the crest of St. Mary ridge. The ice completely filled the valley and laid a lateral moraine upon the early drift which in places forms the upper 200-300 feet of the ridge. In the vicinity of Duck lake, where the crest is lower, the ice extended a short distance on to the upland, leaving its well-marked moraine encircling the lake basin. The ice did not, however, override the crest of Hudson Bay divide beyond a point north of Duck lake. At this point, which is 1,300 feet above St. Mary river, the moraine begins to descend the eroded north slope of the ridge. At the place shown in Fig. 3, the moraine of the later drift is 200 feet below the flat top of the divide and a few miles farther northeast it is 400 feet below the crest of the ridge. This Hudson Bay divide is capped with the so-called quartzite gravel. At some places it has the composition of glacial till; and as far eastward as traversed by the writer, where the gravels had not been removed by erosion—a distance

of nearly 15 miles from the point where the later moraine crossed—striated, glacial pebbles were found in the deposit.

The old drift is exposed in the marginal scarp of the flat top of Swift Current ridge 1,100 to 1,200 feet above the present stream; in Kennedy ridge (Pl. II), the narrow remnant of the high divide five miles east of Chief mountain and 900 feet above the creek on the south; and in scarps at the top of the slope east of Belly river, 1,300 to 1,600 feet above this stream.

That a very long time intervened between the deposition of the earlier and later drift is evident from the topographic relations described. It is

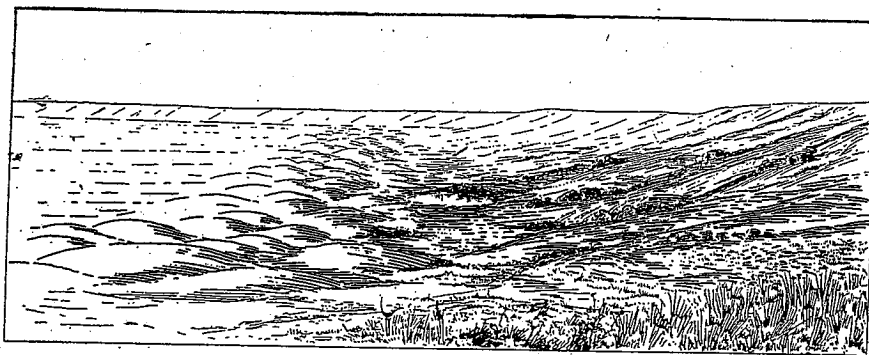


FIG. 3.—View looking eastward from a point about 4 miles north of Duck lake, showing relations of the terminal moraine of St. Mary glacier, of Wisconsin stage of glaciation, to the north slope of the Hudson Bay divide on whose top lies pre-Wisconsin glacial drift.

also clear from the degree of modification of the older drift by weathering. On Two Medicine ridge, as already stated, where there is a thickness of 150 feet of till, and on St. Mary ridge, where there is, in places, nearly 300 feet of early drift, the limestone pebbles and boulders have been for the most part removed by solution from the upper 15 to 20 feet of the deposit, and the drift below has been cemented by deposition of calcium carbonate to a hard tillite conglomerate. The same is true in other places where the deposit is thick. Where it is thin no limestones are found, they having been entirely removed by solution. The diorite pebbles are in a state of disintegration and the glacial striæ have been removed by etching from almost all the pebbles, excepting only the densest fine-grained siliceous rocks, the greenish so-called argillite. Some of the latter were found 20 miles out from the mountain-front on the isolated remnant shown in Fig. 2. These are typical glaciated pebbles, some of the striæ being as sharp and fine as could be cut by an engraver's tool.

The gravel capping the isolated Horsethief and Landslide buttes, 30 to 40 miles from the mountain-front, is of the same character as that nearer the mountains, but we did not find any striated pebbles at these places.

It is evident that a very large amount of erosion of the plains has been accomplished since the deposition of this early drift. Not only has there been

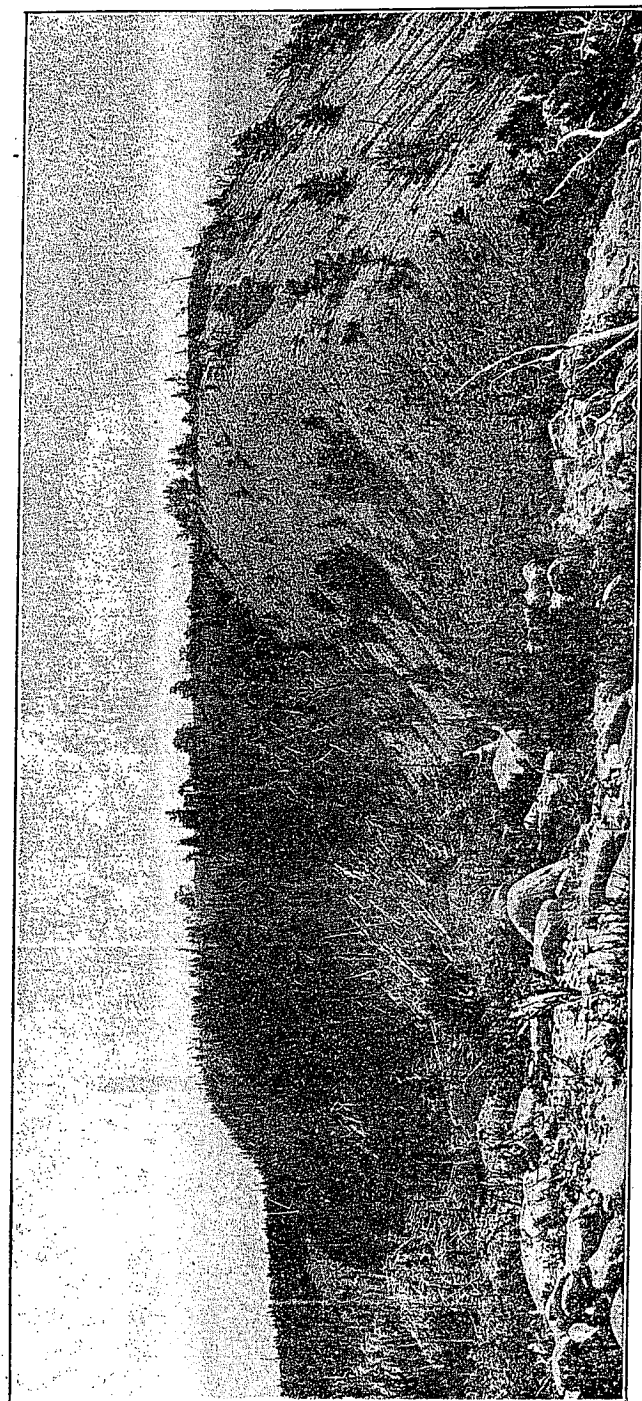


FIG. 4.—Mesa of "Kennedy gravel," probably pre-Wisconsin glacial drift, five miles east of Chief mountain.
(Photo by Bailey Willis.)

dissection of the highest plain, remnants of which are shown heavily shaded on the map (Pl. F), but there also was developed a second, lower, extensive flat plain, whose remnants, capped by similar early drift, are shown on the map by a lighter shade. In this were cut valleys several hundred feet deep with broad bottoms representing a third stage of peneplanation, and into these third plains Wisconsin and post-Wisconsin streams have cut sharp, inner valleys.

In this brief paper a full discussion of the phenomena and of the relations with the deposits in southern Alberta can not be presented. A more detailed discussion is presented in the Bulletin of the Geological Society of America, Vol. XXIV, 1913.

Where the streams headed in the mountains, almost all traces of the high-level plains have been removed. The mountain waters which would otherwise have been tributary to Milk river have been captured for the Hudson Bay system by St. Mary river, so that in the Milk River basin are the best preserved drift-capped remnants. Yet even here the amount of erosion has been great. North of the International boundary no such remnants are known to the writer, excepting in the vicinity of Belly river. On Oldman and Belly rivers deposits of pre-Wisconsin drift of the Keewatin ice-sheet have been found by DAWSON and McCONNELL and also seen by the writer in places in the valley bottoms. This early continental drift is not known to be as old as the high-level drift in Montana but from the fact that this drift is down in the valleys instead of on remnants of high-level plains, it may be inferred that in the region north of the boundary more erosion had already been accomplished than in Montana, before the early glaciation occurred. It is thus possible, if not probable, that the excavation of St. Mary valley below the level of the highest plain was begun before the early mountain ice extended eastward on to this plain. A comparison of the capacity of the catchment basin of Two Medicine glacier of the last stage of glacier extension with that of the catchment basin of the ice which deposited the older mountain drift farther north shows them to be approximately equal, and inspection of the topography also seems to indicate that the ridges and valleys overridden by Two Medicine glacier were such as to offer about the same amount of retardation to the ice movement as would have been offered by St. Mary ridge when St. Mary valley was 800 to 1,000 feet less deep than it is now. Hence I think it must be conceded that St. Mary valley has been deepened at least 800-1,000 feet, and that a correspondingly large amount of sculpturing of the mountain mass has been accomplished since the early Pleistocene glaciation.

There are some indications that the drift on the second set of high-level plain remnants was deposited at a distinct stage of mountain glaciation intermediate between the glaciation of the highest or Blackfoot plain and the extension of the glaciers down on to the third set of plains at the last, or Wisconsin, stage. The evidence in regard to this, however, is not regarded as conclusive.

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