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Glaciation in Montana

Alvin H. Lense

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GLACIATION IN MONTANA

by

Alvin H. Lense

A thesis

submitted to the Department of Geology in partial fulfillment of
requirements for the Degree of Bachelor of Science in Geological
Engineering

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Montana School of Mines
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INTRODUCTION

Glacial deposits are increasingly entering into consideration in engineering projects, soil surveys, ground-water supply, sources for industrial materials, and other economic enterprises. In the field of engineering, glacial deposits if present must be considered in connection with reservoir sites, dam or bridge abutments, road building, and other types of construction work. Hence a knowledge of the occurrence and character of glacial deposits is of definite economic significance as well as of scientific interest. The writer has chosen a study of the glacial deposits in Montana for a thesis to be submitted to the Department of Geology at Montana School of Mines.

Essentially this work has been one restricted to a compilation of all available information concerning glaciation in Montana, the information being derived chiefly from books in the library of the Montana School of Mines. In this compilation the author has attempted an over-all summary of Montana's glaciation, and for more specific detail, has chosen three different areas which he considers typically representative. Since no

personal investigation was made of areas described, the author had no recourse but to accept almost wholly any statement made in recognized works of glaciation. Only when several authors described identical areas was some means of evaluation offered.

Important acknowledgement must be made to Dr. Eugene S. Perry and Dr. E. William Heinrich of the Department of Geology of Montana School of Mines, the former for acting as both contributor and director of this work, and the latter for his help and sound advice. The author also wishes to express his appreciation for the aid rendered in compilation by Mrs. C. L. Peck, librarian of the Montana School of Mines.

CLASSIFICATION

Glaciers may be divided into two classes, ice streams and ice caps, in accordance with the mechanics of the movement within the ice, and the cause of this movement. An ice stream, typically a valley glacier, is a mass of glacial ice having a rock floor of sufficiently high gradient so as to cause flow of ice under the pull of gravity, and whose usually elongated form comes as a result of secondary topographic controls. The ice cap, a broad blanket of ice, covers land areas of moderate relief, and has as its characteristic of flow a "piling up" effect, which produces lateral pressure comparable to hydrostatic pressure resulting in extrusive or lateral motion. Representing somewhat the midway niche of classification, the relatively thin ice mass of the small plateau glacier reflects in some measure the configuration of the land beneath it and may move by virtue either of gravitational or lateral flow. Likewise the coalescence of valley glaciers on a piedmont plain has aspects of an ice cap.

It has been stated that plastic flow may be the distinctive characteristic of ice motion in glaciers which sets them apart from all stationary bodies of accumulated snow. (Meinzer, 1945) However, it has become increasingly clear that plastic flow does not alone account for all of the different phases of glacier motion. Rigid shearing must also be considered, and it too must not be

treated as a single entity; both types of motion occur in association with each other. It is upon this newly gained insight into the mobility, and the reaction to obstruction of glacier ice, that the above classification of ice stream and ice cap is based.

In summation, it may be stated that the classification as listed here does not include all the subordinate types and varieties of glaciers; only the major classes have been outlined. The purpose of such generalization is simply to outline the modern views as may be found necessary for the interpretation of Montana glaciation.

DIFFERENTIATION

One of the most important single results of glacial-stratigraphic study is the recognition of repeated glaciation in Montana. Any subdivision of the glacial activity in the state must then depend on certain well-recognized criteria so that correlation with other areas is standardized. The presently accepted basis of standard subdivision is fourfold and consists, in order of decreasing importance, of these elements: (1) degree of decomposition of the drift; (2) presence of nonglacial sediments between drift sheets; (3) degree of erosion of the drift; (4) recognition of the sources of stones in the drift. (Flint, 1947)

Repeated glaciation is recorded best by fresh till overlying decomposed till, and the degree of decomposition gives some indication of the relative lengths of time that elapsed between successive glaciations. However, such variable factors as climate, topography, permeability of the drift, and chemical composition of the unaltered drift, confuse the record so that time intervals can not be determined accurately. (Alden, 1909) For instance, a till consisting chiefly of limestone grains of silt size, in a hilly region and under a moist climate like that of the midwestern United States, would decompose more rapidly than a till consisting essentially of clay in a plains region with a semiarid climate like that of Montana.

Examples are widely present in the Rocky Mountains of Montana indicating multiple glaciation as evidenced by the extent of erosion of bedrock that occurred between the times of deposition of two tills. (Alden, 1932) The intervening erosion of bedrock amounts in depth to many hundreds of feet, predicating a very long time interval, but providing no basis for satisfactory estimate of the actual amount of time involved.

With such variables and vagaries modifying the picture, and with information so scanty, it is no wonder that hardly more than a beginning at correlation can yet be made. Montana's glacial record still remains obscured.

AGE CORRELATION

So far as can be shown from the evidence gathered by the few glaciologists and glacial geologists who have written about Montana glaciation, the Wisconsin stage of the Pleistocene epoch was the time of most extensive glaciation in the state. Yet, beyond the edge of the Wisconsin continental sheet, which covered the Great Plains area east of the Rocky Mountains, is a record of glaciation somewhat older, though the data obtained are not sufficient to determine its age.

(Calhoun, USGS PP 50)

Presenting an even greater age obscurity are the early ice streams of the mountainous regions; Calhoun states that they retreated only a short period of time before the maximum development of the Wisconsin ice sheet. Clear summarization is difficult because in most of the mountain districts the evidence of successive glaciations has not yet been thoroughly studied, and because rapid erosion in this region of steep slopes has removed a far greater proportion of the evidence of earlier glaciations than has been removed from the lower lands farther east. (Flint, 1947) Furthermore, deposits of recent glaciers tend to cover older deposits.

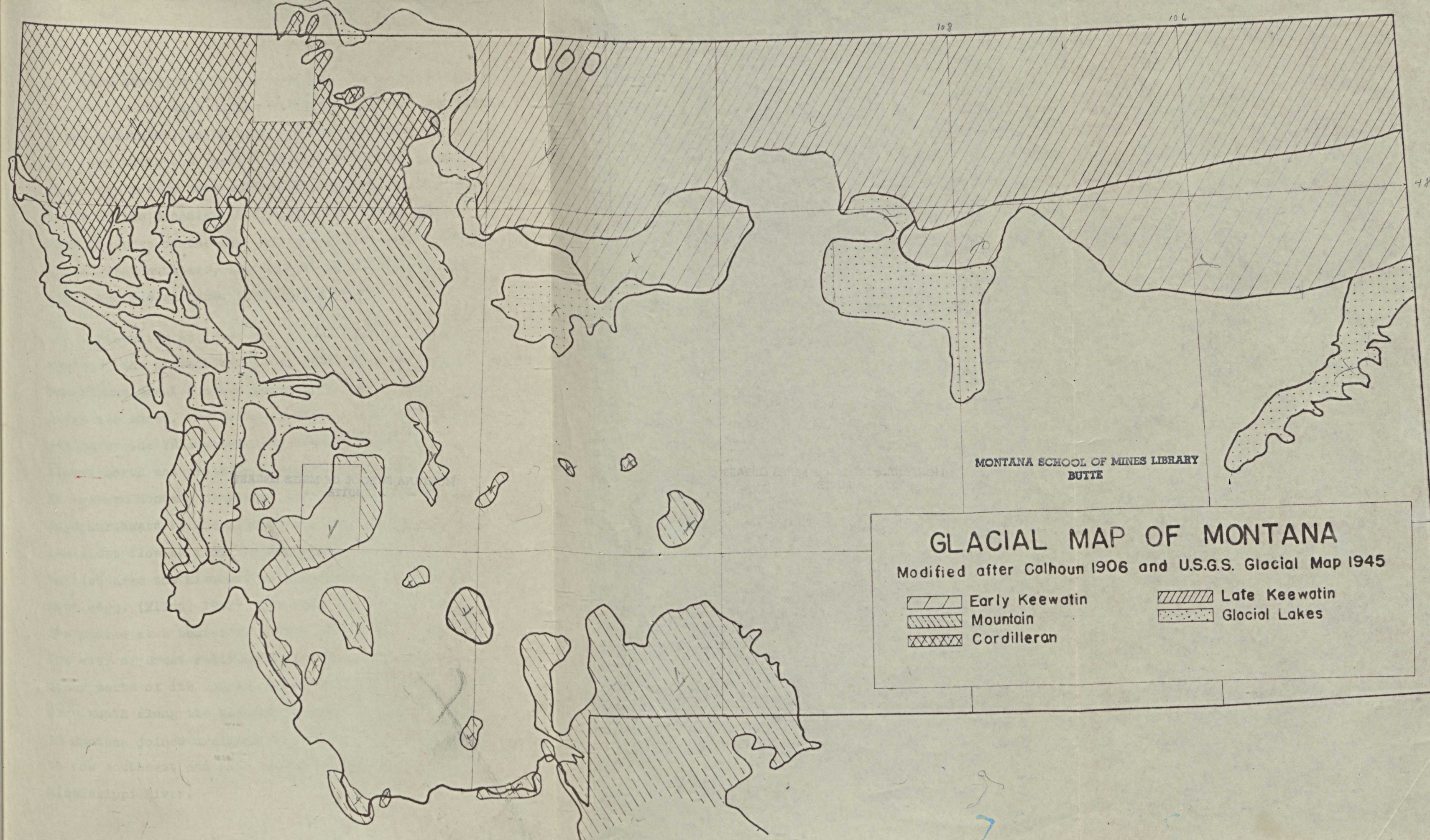
Much the same difficulty is encountered when one attempts any accurate age identification of the

Cordilleran ice system, which invaded the northwestern part of Montana. Except within a few well-studied areas any attempt to separate the drifts would be more misleading than helpful. Therefore, both Wisconsin and pre-Wisconsin are usually considered together.

MONTANA GLACIATION

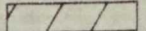
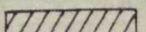
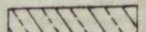
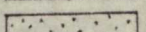
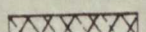
Areas of Pleistocene glaciation in Montana may be grouped into three general categories: (1) continental glaciation which spread southward from a center near Winnipeg onto the Great Plains (Keewatin ice sheet); (2) continental glaciation, of mountain origin, which spread southward from a center in British Columbia across and in places over the mountainous terrane of northwest Montana (Cordilleran ice sheet); and (3) more or less isolated areas of local mountain glaciation wherein ice accumulated on scattered mountain ranges or plateaus, and flowed away from relatively small centers through deep-cut valleys to adjacent lowlands. These three general phases of Montana glaciation are discussed separately.

(1) Keewatin Glaciation: The glacial stratigraphy of the Great Plains region, including all the plains of Montana east of the Rockies and north of the Missouri River, indicates that at least two great drift sheets were present. (Alden, 1932) These great ice sheets derived from the Keewatin center in Canada developed during the period and in the locale of Montana's greatest ice invasion. At the early or middle Wisconsin stage of glaciation they had covered most of the area north of the present channel of the Missouri River and extended southwestward nearly to Great Falls. Their



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GLACIAL MAP OF MONTANA
Modified after Calhoun 1906 and U.S.G.S. Glacial Map 1945

 Early Keewatin	 Late Keewatin
 Mountain	 Glacial Lakes
 Cordilleran	

southern edges were lobate in form, the lobation being due to the presence of the Highwood, Bearpaw, and Little Rocky mountains, which retarded the forward progress of the ice, while the great open plains between them allowed the ice to move more readily to the south. Just south of the Canadian line, and about 30 miles back from the edge of the ice, the Sweetgrass Hills stood as three great nunataks, the highest reaching 2000 feet above the ice surface. (Calhoun, 1906)

Antedating at least one of the last minor ice invasions, the present course of Missouri River represents one of the great changes wrought by the invasion of the large ice sheet. Prior to glaciation the Missouri, joined by the Yellowstone and the Little Missouri, flowed north and probably discharged into Hudson Bay. In eastern Montana abandoned and partly buried valleys lead northward to the Milk River, and suggest that the ice sheet flowing from the northeast blocked all drainage and detoured the Missouri to closely border its southernmost edge. (Flint, 1947) The river was turned from its course at a number of places causing the falls near the city of Great Falls, and the rapids and narrows in other parts of its course. (Calhoun, 1906) Forced to flow south along the glacier margin, the upper Missouri in Montana joined drainage with the lower Missouri far to the southeast and thus became a tributary of the Mississippi River.

(2) Cordilleran Glaciation: Glacial activity in northwestern Montana is intimately associated with the development of the Cordilleran Glacier Complex, the network of former glaciers that occupied the mountains of western North America. Essentially, this system consisted of a continuous and interconnecting mass of valley glaciers, piedmont glaciers, and an ice sheet; a mass that centered in British Columbia and stretched southward into Montana, Idaho, and Washington. The glaciers formed chiefly in the Coast Ranges and Cascade Mountains and to a lesser extent in the Rocky Mountains farther east. (Flint, 1947)

Though as yet not definitely determined in Montana, the Cordilleran glaciers on the eastern slopes of the northern Rockies met and coalesced with the continental ice sheets. However, in the interior, between the Rockies and the Coast Ranges, the ice finding no escape piled up, and for a time constituted an ice sheet of considerable thickness. Glacial drift exposed on many of the high ridges is evidence that ice coverage was complete even to many of the highest peaks. (Perry) The southernmost advance of this ice sheet is obscure; the author has encountered no detailed description of its southern limit. However, Clark's Fork River and Blackfoot River may mark its termination.

In addition to this vast confluent mass, the Cordilleran Glacier Complex included separate disconnected

glacier groups and systems, each centering on a mountain range or other highland mass. (Flint, 1947) Cordilleran ice, in northern Montana, extended 20 to 30 miles east of the main mountain front. (See Glacier Park section) Usually, however, since these ice masses lay past the strong rain shadow of the Coast Ranges and the Rockies, their lack of sufficient nourishment is evidenced in their limited eastward areal extent.

(3) Mountain Glaciation: Many of the higher-level peaks and ranges of the mountains which lie in the western part of Montana have been the sites of relatively local Pleistocene glaciers. The greater majority of the ice streams which originated near the peaks of Montana's mountains had limited extensions seldom reaching far beyond their respective valleys. Occasionally, though, ice from several glacial valleys united to form larger piedmont glaciers which extended miles from the foot of the mountains. Yet, generally speaking, glaciation in the mountainous regions of Montana is of a localized character.

In addition to such ice streams, there were, and still are, many fields of snow, neve, and ice which lacked sufficient feed and magnitude to give rise to actual glaciers. These small fields, totally lacking perceptible motion, persist to this day in regions not quite cold enough nor moist enough to nourish full-sized

mountain glaciers. This is true even of the highest ranges of the Rocky Mountains.

Present-day Montana glaciation is minor and its glaciers are almost negligible. They are so small that they are confined almost entirely to cirques opening to the north and east. Such small ice masses occur in the Lewis Range in the Glacier Park district. (Flint, 1947)

Some of the specific localities affected by this type of glaciation are: Big Horn area, Mount Tory area, Red Mountain south of Butte, the Tobacco Root Range, and the Madison Range. The Philipsburg quadrangle and the Beartooth plateau south and southeast of Livingston are typical as areas of mountain glaciation.

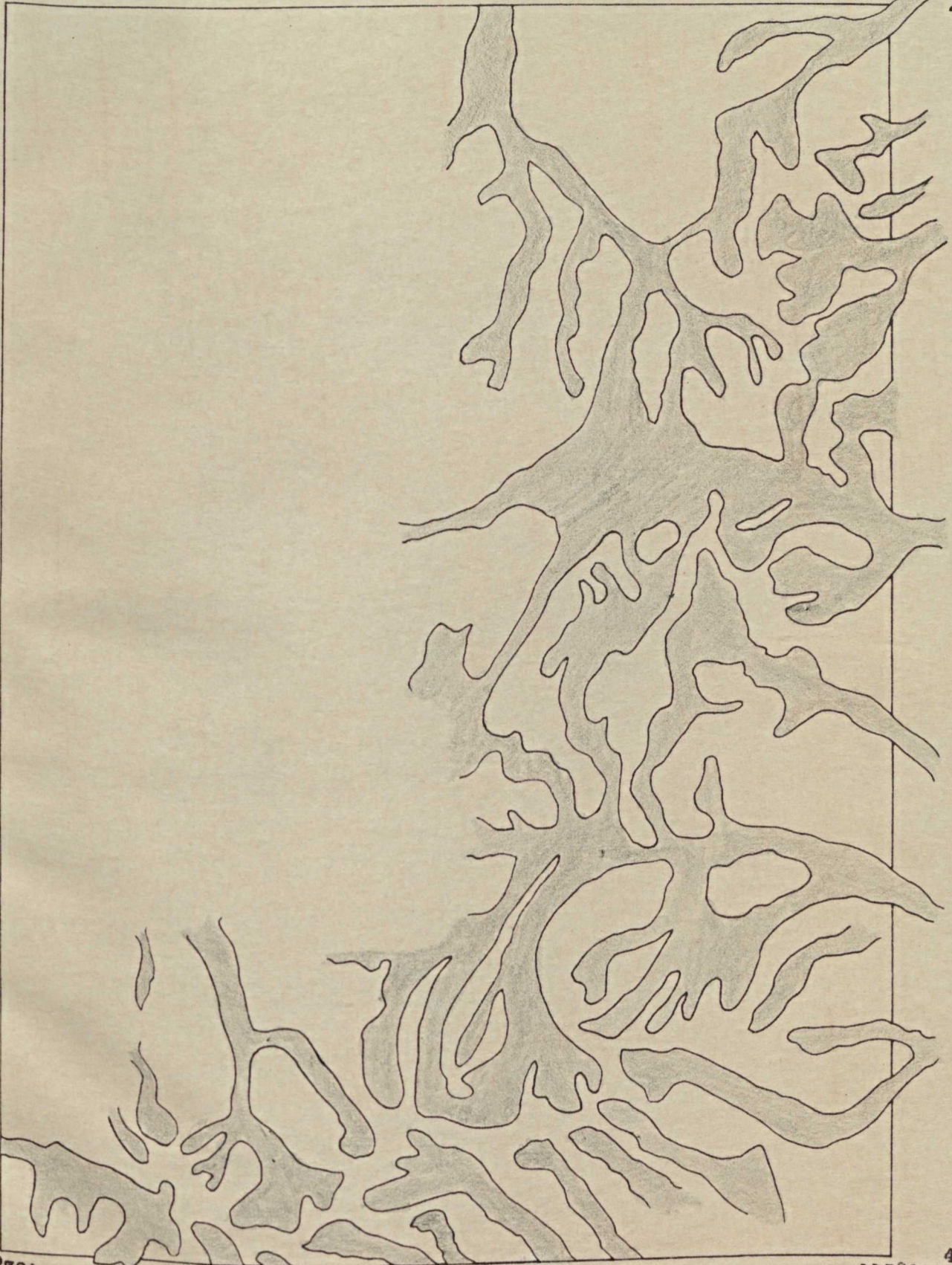
GLACIAL FEATURES IN THE PHILIPSBURG QUADRANGLE

This area, lying in southwestern Montana, presents most striking effects of glacial erosion in its well-defined cirques, and its steeply walled valleys. All of the characteristic sculpture of the glaciers is present so that one may, by interpretation of contour lines on a topographic map, trace mountain ice streams from gathering ground through glacial valley with not too much uncertainty. However, morainal relief is not apparent on present maps of the area. The sides of most of the peaks and ridges, up to 8000 feet elevation, are eroded most vigorously along their upper parts so that topographic contours are crowded close together and display good delineation of cirque and U-shaped valley borders.

Ample evidence is found of prolonged glaciation in the development of the broad, flat-floored cirques with steeply sloped sides. Such topography is shown with excellent clarity along most of the crests and ridges of the Anaconda Range, in the southern part of the quadrangle. Glaciated canyons can immediately be distinguished from the stream-carved types in the area. The flat floors and steep sides of Clear Creek, Mill Creek, and Barker Creek canyons make them typically representative.

Greater glacial erosion of the main canyon ice stream over that of its tributaries is responsible for the

46°30'



113°30'

113°00' 46°00'

DETAILS ON AREAS OF GLACIATION IN PHILIPSBURG SHEET.

As inferred from topography.

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characteristic "hanging" valleys found along Boulder Creek, and to a lesser extent along Flint Creek. Some lakes in the Anaconda Range occupy other typical hanging valleys. On the Philipsburg sheet 215 lakes are shown lying in the high mountains at the heads of valleys, and practically all are cirque lakes.

Two separate glacial periods are implied by the presence of two systems of moraines; one deeply weathered, the other much better preserved. (USGS Folio) These moraines, terminal and lateral, are easily recognized by their constitution, form, and occurrence. They are of a heterogeneous character, indiscriminately mixed, containing fine sands and silts, loose gravel, and boulders of varying sizes. In this quadrangle they consist mainly of granite and other intrusive rocks with much quartzite and metamorphic hornstones. Surficially rough, they present knobs and isolated pits having no connection with the main valley channel.

The terminal moraines of the later glaciation are perhaps the most conspicuous, because their relief in spots amounts to 100 feet. Lateral moraines deposited at the same time lack any such distinctiveness for they are without any great degree of continuity, in many areas only represented by a few scattered boulders. (USGS Folio)

Fred Burr Creek, just south of Philipsburg, displays compositely all the characteristic features of later

morainal topography. (USGS Folio) At the mouth of the canyon of the creek is a terminal moraine, and in the north and south spurs of the canyon, ridges of the lateral delimit the path of the ice stream. The glaciers of Boulder Creek and Flint Creek combined into a main stream which deposited its material well beyond the limits of the quadrangle. Great quantities of morainal material occupy the middle part of Boulder Creek; huge boulders to which the stream owes its name. The glacier of the Middle Fork of Rocky Creek, about twenty miles in length, deposited large terminal moraines in whose hollows are contained the Potato Lakes. By far the largest ice sheet in the quadrangle was that of the Warm Spring glacier system which deposited an extensive complex of moraines just to the east of Georgetown Lake. Indications of the intermittency of glacial recession are shown in the rudely parallel moraine loops in the Anaconda Range along Seymour Creek and Big Gulch.

The well dispersed fragments of the earlier moraines are not readily distinguished, and in large part are covered by those of the latter ice streams. (USGS Folio) Beyond the eastern boundary of the quadrangle remnants of the earlier moraine may be found in the valleys of Mill Creek, Warm Spring Creek, and Lost Creek. At the mouth of Fred Burr Creek, soft decayed dioritic boulders apparently belonging to the earlier glaciation stand in sharp contrast to the slightly weathered boulders of the latter.

GLACIATION ON THE BEARTOOTH PLATEAU AND IN
YELLOWSTONE NATIONAL PARK

From the map it is apparent that the largest individual area of mountain glaciation in Montana lies just to the north of Yellowstone National Park on the Beartooth plateau. It represents the northern extension of glacier flow emanating from what Flint calls the Yellowstone-Teton-Wind River highlands. The Yellowstone plateau in the Park area was overwhelmed by coalescent piedmont ice which seems to have thickened and developed radial outflow in much the same manner as the ice cap of the Beartooth plateau lying to the northeast. (Flint, 1947) Their drift, combined with that of some fifteen glacial systems in the Beartooth Range, mark the area of the most extensive glaciation beyond continuous ice in Montana.

Evidence of pre-Wisconsin glaciation is restricted to weathered remains of large single erratics, some of which measure up to 20 feet in diameter lie outside the border of Wisconsin drift. (Weed, 1893) One such erratic, found just north of the northern branch of Barney Creek, is a weathered mass of Bighorn dolomite (Ordovician), and smaller fragments of Flathead quartzite (Cambrian) resting on crystalline rocks 8-10 miles away from the nearest exposures of these formations. Tentative age correlations place it as part of the earliest stage of Pleistocene glaciation.

From the northern part of the Absaroka Range and along the south flank of the Beartooth Range a great ice stream fed by numerous tributaries descended into Yellowstone Valley. (Weed, 1893) In total length it measured some 80 miles from its gathering ground to the site of its terminal moraine located just north of Pray, Montana. The topographic changes it wrought were much the same as any glacier; it produced U-shaped canyons, hanging tributaries, minor stream-bed deviation, hummocky moraines, and an extensive outwash plain. When compared to the drift deposited by following glaciations, the moraines of this earlier ice stream present a greater prominency despite the erosion which took place during the next interglacial period.

After a period of recession characterized by stream erosion, this ice stream again pushed forth in much the same manner as it had once before. Essentially, though, this movement was less extensive than the former; it deposited its terminal moraine along the Yellowstone River south of Pray, and its moraines were of subdued nature. It probably did not extend beyond the western edge of the present inner valley. The glacio-fluvial processes active during its recessional stage were responsible for the presence of widespread kame-like features, numerous outwash channels, and a well-developed frontal outwash plain and valley train. (Weed, 1893)

Glaciation in adjoining mountains: The Beartooth Mountains, just north and northeast of Yellowstone National Park, present evidence of multiple-type glaciation; an elaborate system of mountain ice streams is intimately associated with a broad, radiating ice-cap. (Bevan, 1927) Severe glaciation is implied for the mountains bear traces of intense glacial erosion in their numerous U-shaped canyons, scores of cirques, deeply scoured plateaus, and huge moraines. However, the forms, sizes, detailed extent, and general relations of the glaciers are still to be deciphered by extensive field studies.

In Pleistocene times, shortly after the uplift during late Tertiary and early Quaternary time, an ice cap developed on the plateau summit of the Beartooth Range. The ice cap radiated several tongue-like lobes in all directions, and a strong possibility exists that there was a continuous connection with the Rainbow ice cap on Lake Plateau to the north. Present surmises maintain that the ice moved eastward across the divide and amplified the supply of ice to the valley glaciers of Clark Fork, East Rosebud Creek, and Stillwater River. (Bevan, 1928)

Long broad valley glaciers originated along the south side of the divide which extends with only a single important gap from Stillwater canyon north of Cooke City toward the Yellowstone Valley north of Gardiner. On the

north and east slopes of the range larger glaciers developed, and were fed by numerous tributaries. At the time of maximum glacial activity extensive glacier systems were formed, many of which passed out upon the plains beyond the mountain front. In the North Snowy mountain section, forming the northwestern third of the Beartooth Range, all of the larger canyons were occupied by early Wisconsin ice streams whose depositional remains stand as prominent lateral ridges despite the effacement of subsequent stream erosion and late Wisconsin glaciation. (Weed, 1893) Correlative moraines have been developed along Mill Creek and Six Mile Creek in the South Snowy sector. (Horberg, 1940)

The moraines of later valley glaciers were more or less confined by the high lateral moraines of the early Wisconsin glaciers, although occasional breaching of the barrier permitted the younger terminal portions to spread out in front of the older deposits. Such was the situation along the margin of the North Snowy section. (Weed, 1893) Largely and generally, though, the dominance of the older ice invasion is clearly demonstrated; the younger was more pronouncedly controlled by pre-existing topography, and left deposits of relatively slight relief.

In the Gallatin Range west of Yellowstone River glaciation was present to a very minor degree. Only one terminal moraine has been found; it lies along Big Creek, one-quarter mile above the Gallatin National Forest.

However, it is probable that smaller fragments do exist in adjacent areas. (Weed, 1893) Though it appears that Tom Minor Creek was occupied by late Wisconsin ice, no moraine can be found; evidently its ice stream was tributary to the main glacier in Yellowstone Valley.

GLACIATION IN GLACIER NATIONAL PARK

Inaugurated in much the same manner as the glacial activities in other mountainous areas of Montana, such as a change in climate giving rise to heavy snowfall and the formation of vast fields of ice throughout the entire mountain region, the important glacial period of the national park occurred simultaneously with the development of the Cordilleran Glacial Complex. (Flint, 1947) However, detailed field work and study have tentatively determined three different times when the glaciers extended far down the valleys, and out onto the neighboring plains. (Alden, 1914) Their periods of extension and recession were probably contemporaneous with those of the great ice sheets covering the larger part of the North American continent.

The immense glaciers that originated in the Park descended from the mountain-top gathering grounds, and filled the valleys in places to a depth of 2000 to 3000 feet. (Alden, 1914) Some which attained great size extended some 20 to 30 miles out onto the eastern plains. The Two Medicine glacier, for instance, was a great piedmont glacier with a length of about 48 miles, and a breadth of 30 miles. As a whole, the Pleistocene glaciers occupied the entire valleys within the range, and spread eastward their aprons of Piedmont type. Their westward extension is noted a long distance down the valley of the Flathead River.

49°00'



114°00'

48°30'
113°30'

DETAIL ON AREAS OF GLACIATION IN CHIEF MOUNTAIN SHEET.

As inferred from topography.

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Prior to the Wisconsin stage of glaciation, a long period of stream erosion was responsible for extensive sculpturing of the great mountain mass. This period of valley cutting produced a plain region to the east of the mountains considerably reduced and broken by many hills and valleys. Present topographic relations show that long ago, before the valleys which now separate existing ridges were eroded, and when remnant flat tops yet formed a continuous nearly flat plain, there was a stage of glaciation when the ice heading in St. Mary Valley and the tributary valleys was not diverted northward by St. Mary Ridge, and the great trough in which the St. Mary lakes and river now lie. However, it is not to be inferred that there was only a single emergence of this ice invader, for two deposits of pre-Wisconsin drift have been identified and differentiated. East of the mountains, in the Blackfeet Indian Reservation, there are remnants of three sets of plains above the levels of the present drainage lines. Two are deposits of pre-Wisconsin glacial drift, and the lower is of Wisconsin age. (Alden, 1914) Therefore, it is probable that there were two distinct earlier stages of glaciation in the mountains, accompanied by regional change of elevation, and each followed by long intervals of recession and stream erosion.

After a long period of stream erosion numerous valley glaciers again appeared, some of which coalesced

to form great piedmont glaciers. Of the latter, the Two Medicine glacier mentioned above represented the largest ice sheet of local origin in the area. Like the glaciers of St. Marys Valley and Belly River, it pushed beyond the boundary of the park to deposit its drift in an area later to be overlapped by drift of the Keewatin ice cap. (Alden, 1914) Just south of the forty-ninth parallel, between the meridians $113^{\circ}10'$ and $113^{\circ}15'$, the till of the Keewatin ice sheet and that of the mountain glaciers overlap. (Calhoun, 1906) The question as to whether any other areas south of the boundary line display signs of occupancy by ice from opposite directions has not yet been answered with any degree of precision. (Calhoun, 1906 and Flint, 1947)

The actual extent of glaciers to the west of the divide still lacks complete definition. It is believed that the great intermontane basin represented by West Flattop, Flattop, and Granite Park, was occupied by a great central mass of ice which discharged principally southwestward by the McDonald Creek Valley. (Alden, 1914) Evidently great mountain glaciers occupied the valleys of Kintla, Bowman, Quartz, Anaconda, Dutch, and Camas creeks, and those farther south, though it has been difficult to mark their limit of extension.

The Keewatin sheet reached its most advanced position after the valley glaciers from the west had

retreated, for its drift overlies that of the latter. (Calhoun, 1906) This is true in the St. Mary Valley as mentioned above, and also in the valleys of St. Mary River, Belly River, and Lee's Creek. The moraine formed by this Keewatin ice sheet has been traced from Fort Benton, through Choteau, to the international boundary at $112^{\circ}20'$ longitude; the Rocky Mountain area was too high so that the ice sheet did not invade far into western Montana.

The great glaciers of the past are gone; only a few score patches of ice still remain. There are no great ice streams or sheets in the Park, but Blackfeet, Grinnel, Sperry, Kintla, Agassiz, and a few other small glaciers still persist. Though constantly shrinking, they still maintain most of the attributes and characteristics of their larger ancestors, and consequently are still worthy of study. (Alden, 1914)

CONCLUSIONS

In the process of accumulation of data necessary for the preparation of this report it has become evident that much of Montana's glacial record is unwritten. In addition, no equalization of detailed field work has been attempted by various investigators; some areas have received abundant attention, while others have been sorely neglected. Above all, the total amount of field work completed seems inadequate to the problem.

Information relating to glacial activity west of the Rockies is sparse as is that of the Beartooth Mountain area. Some material is available in the form of abstracts and short articles, but most are restricted to areas of limited extent. As far as the writer can determine, no works of overall concept and sufficient detail are as yet available.

In conjunction with the writing of this report it was the author's intention to outline areas of glaciation in Montana by interpretation of contour-line relationships on topographic maps. However, in this enterprise he was unsuccessful for maps of many localities lacked sufficient accuracy and detail to permit such an undertaking. Glacial details of only a few areas were outlined in this manner.

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