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GEOLOGIC MAPS AND REPORTS RELEASED FOR PUBLIC INSPECTION

The Geological Survey is releasing in open files the following maps and reports on the geology of various parts of the United States and Alaska. Copies are available for consultation at the Geological Survey, Room 1033 (Library), General Services Administration Building, Washington, D. C., and at other places as listed. Copies are not available for distribution unless so indicated.

1. Brief review of Pleistocene events and climatic changes in Alaska, by T. L. Pewe, 14 P.

   On file at the following Public Inquiries Offices of the Geological Survey: Room 468, New Customhouse, Denver, Colo.; Room 504, Federal Bldg., Salt Lake City, Utah; and Room 529, Post Office and Court House, Los Angeles, Calif.; and Geological Survey Offices in the Federal Bldg., Anchorage, Alaska; the Lavery Bldg., Fairbanks, Alaska; and the Subport Bldg., Juneau, Alaska.

2. Geologic map of the Golconda tungsten deposit, Humboldt County, Nev., by Paul C. Bateman, no text.

   On file at the Geological Survey Public Inquiries Office, 504 Federal Bldg., Salt Lake City, Utah; and the Nevada Bureau of Mines, University of Nevada, Reno, Nev.

3. Geologic map of parts of Glastonbury and Middle Haddam quadrangle, Conn., by Frederick Stugard, Jr., no text.

   On file at the Director's Office, Connecticut Geological and Natural History Survey, Trinity College, Hartford, Conn.; and at the Geological Survey Bldg., Agricultural Research Center, Beltsville, Md.

4. Geologic map of the Spruce Pine district, N. C., by J. L. Kulp and D. A. Brobst, 11 sheets, 1 explanation.

   On file at the Geological Survey Office, Room 13, Post Office Bldg., Knoxville, Tenn.; and the Division of Mineral Resources, Department of Conservation and Development, State Office Bldg., Raleigh, N. C.

5. Geologic setting of the clay deposits of Latah County, Idaho, by V. E. Scheid, 15 p., 1 pl.

   On file at the Geological Survey Office, South 157 Howard Street, Spokane, Wash.; and the Idaho Bureau of Mines and Geology, University of Idaho, Moscow, Idaho.

The following reports, items 6 and 7, were released September 16, 1953, in open files at various places. They are now available for public inspection at the Geological Survey Public Inquiries Office, Room 529, Post Office and Court House, Los Angeles, Calif., in addition to the originally listed depositories.

6. The Alberhill and other clay deposits of Temescal Canyon, Riverside County, Calif., by S. N. Daviess and M. N. Bramlette, 10 p., 1 pl.

7. Clay deposits of the Tierra Colorado district, southern Orange County, Calif., by S. N. Daviess and M. N. Bramlette, 11 p. 1 pl.

The following 11 maps (no texts) are on file at the places listed after item 18.

8. Photogeologic map, Tidwell-5 quadrangle, Emery County, Utah, by P. P. Orkild.

9. Photogeologic map, Tidwell-15 quadrangle, Emery County, Utah, by V. M. Hosley.

10. Photogeologic map, Orange Cliffs-8 quadrangle, Wayne and San Juan Counties, Utah, by W. R. Hemphill.

11. Photogeologic map, Stinking Spring Creek-9 quadrangle, Emery County, Utah, by W. R. Hemphill.

12. Photogeologic map, Desert Lake-14 quadrangle, Emery County, Utah, by B. H. Kent.

13. Photogeologic map. Woodside-13 quadrangle, Emery County, Utah, by P. P. Orkild.

14. Photogeologic map, Desert Lake-11 quadrangle, Emery County, Utah, by B. H. Kent.

15. Photogeologic map, Notom-15 quadrangle, Garfield County, Utah, by R. H. Hackman and G. E. Tolbert.

16. Photogeologic map, Orange Cliffs-1 quadrangle, Wayne and San Juan Counties, Utah, by P. P. Orkild.

17. Photogeologic map, Orange Cliffs-4 quadrangle, Wayne County, Utah, by W. H. Condon.

18. Photogeologic map, Tidwell-9 quadrangle, Emery and Grand Counties, Utah, by C. E. Bates and V. M. Hosley.

Maps listed under items 8 through 18 are on file at the Geological Survey Public Inquiries Office, Room 468, New Customhouse, Denver, Colo.; Geological Survey Public Inquiries Office, Room 504, Federal Bldg., Salt Lake City, Utah; and Geological Survey Office, Grand Junction, Colo.

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BRIEF REVIEW OF PLEISTOCENE EVENTS AND CLIMATIC CHANGES IN ALASKA

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Preliminary review prepared for presentation at the Biogeography Symposium, Fourth Alaska Science Conference, Juneau, Alaska, September 29, 1953. Talk given with the permission of the Director, U. S. Geological Survey. This manuscript has not been reviewed for conformity to U. S. Geological Survey standards and terminology.

BRIEF REVIEW OF PLEISTOCENE EVENTS AND CLIMATIC CHANGES IN ALASKA

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INTRODUCTION

Events and climatic changes in Alaska during Pleistocene time record the advance and retreat of glaciers, changes of position of sea level, deposition of loess, and alternating formation and disappearance of permafrost. Also recorded are the alluviation and erosion of lowlands, building of mountains, volcanism, changes in distribution of plants and animals, and the coming of man.

This brief review of some Pleistocene geologic events is based largely on studies in progress. Final reports will enlarge and clarify many details and may introduce new major concepts. Many broad areas are not yet studied, and this review of necessity must be expressed in generalities.

In addition to data available from existing literature, information has been contributed on studies in progress by the following U. S. Geological Survey personnel: R. L. Detterman, north flank of the Brooks Range between Okpikruak and West Fork Shaviovik Rivers; A. T. Fernald and D. R. Nichols, Kobuk Valley; A. T. Fernald, Upper Kuskokwim region; D. M. Hopkins and R. S. Sigafoos, Seward Peninsula; T. N. V. Karlstrom, upper Cook Inlet region; D. B. Krinsley, southwest Kenai Peninsula, E. H. Muller, Bristol Bay region; T. L. Péwé, Fairbanks and Galena areas and Delta River region; C. L. Sainsbury, Juneau area; Clyde Wahrhaftig, Nenana River valley and vicinity; J. R. Williams, Chandalar area of the south flank of the Brooks Range, Yukon Flats, and the southwest Copper River basin; and H. E. Wright, Jr., Mentasta Mountains.

As in many studies of the Pleistocene epoch, the most abundant and clearest information is available for the more recent part of the record. In this brief review the Wisconsin age, the last 80,000 years or so (Hough, 1953), is treated as a unit and all pre-Wisconsin events are grouped together.

PRE-WISCONSIN EVENTS

Recognized pre-Wisconsin glacial advances in Alaska were considerably more extensive than Wisconsin advances, and therefore the so-called maximum Pleistocene glaciation is a feature of pre-Wisconsin events. Also, the warmest interglacial interval recorded in Alaska is pre-Wisconsin in age. The pre-Wisconsin part of the Pleistocene epoch was a period of mountain building, deposition of placer gold, and changes in sea level. Even though the fossil record of authenticated pre-Wisconsin fauna is very scant, many animals now extinct must have been present in central Alaska.

In the light of existing data, perhaps the best way to view the record is to consider briefly main events in each of the areas of study. In southeastern Alaska very few data are available on pre-Wisconsin events. Undoubtedly the glaciers pushed into the sea and covered all but the highest peaks.

South-central Alaska

In this report, south-central Alaska embraces the Alaska Range and the area to the south, including the Kilbuck Mountains and northern Aleutian Range. Most of the present studies of Pleistocene deposits and the most detailed glacial record are from this part of Alaska.

At least the central part of the Alaska Range was gradually uplifted during pre-Wisconsin time (Wahrhaftig, 1953). One or more glacial advances are recorded; and on the north side of the range, glaciers probably extended to the Yukon-Tanana upland in the area from the Canadian border on the east to Richardson (Péwé, 1953) on the west. In the Nenana River valley, glaciers extended as far north as Browne (Wahrhaftig, 1953). South of the range, ice filled the broad Copper River basin and was interconnected through the Susitna and Matanuska Valleys with ice that filled Cook Inlet to altitudes of 4,000 feet (Karlstrom, 1952). This ice was coextensive through low cols with the piedmont ice sheets from the Aleutian Range and Kilbuck Mountains, which covered the Nushagak and Alaska Peninsula lowlands, and with Kodiak Island ice (Karlstrom, 1953). Prince William Sound was undoubtedly covered by glacier ice that extended as marine-shelf ice at least as far as Middleton Island.

From the Bristol Bay, Cook Inlet, and central Alaska Range areas we have evidence that there were at least two distinct major glacial advances with an intervening interglacial interval.

Central Alaska

The term "central Alaska" is applied to the region between the Alaska and Brooks Ranges and includes much of the drainage of the Yukon, Tanana, Koyukuk, and Kuskokwim Rivers. This area was unglaciated in pre-Wisconsin time except for small glacial centers in the Beaver, Ray, and White Mountains, and other small groups of peaks (Capps, 1932). However, the major rivers in central Alaska alluviated their valleys as a result of receiving glacial sediment from the heavily glaciated surrounding mountain ranges. Near Fairbanks, evidence is available that suggests three periods of alluviation and downcutting in the Tanana River Valley during pre-Wisconsin time. The interior of Alaska also was a favorable site for disposition of great amounts of windblown silt derived from the braided streams draining the glacial areas.

Seward Peninsula

At least two pre-Wisconsin glaciations are recorded from Seward Peninsula, and they were the most extensive of the Pleistocene ice advances (Hopkins, 1953a). Glacier ice was centered in the Kigluaik, Bendeleben, and Darby Mountains with smaller accumulations in the York Mountains and other highlands. Ice extended south from the

Kigluaik Mountains into the sea in the vicinity of Nome. At maximum glaciation only 20 percent of the peninsula (mainly in the southern part) was covered with glacier ice, leaving much ice-free terrain connected with the ice-free central Alaska (Hopkins, personal communication).

Organic deposits between sediments identified with the two pre-Wisconsin glaciations indicate an interglacial interval during which forests on Seward Peninsula contained trees which now grow no farther north than southeastern Alaska (Hopkins and Benninghoff, 1953).

If the sea level were lowered 200 to 300 feet during glacial maxima, as is commonly accepted, a land bridge could have existed from the ice-free areas of Alaska to the ice-free areas of Siberia; however, Hopkins (personal communication) states that during at least part of pre-Wisconsin time the sea lapped at the foot of the glacier and no land bridge was present. Evidently Seward Peninsula stood relatively low at this time and was uplifted during Wisconsin time along with the Bering shelf.

Brooks Range

Glaciers coalesced to form piedmont lobes along major rivers on the north side of the Brooks Range. The glaciers extended almost to the Colville River north of the central part of the range (Schrader, 1904; Detterman, 1953) and perhaps to the sea farther to the east (Leffingwell, 1919). At least two pre-Wisconsin glacial advances are recorded on the north side of the Brooks Range. On the south side, in the Chandalar drainage, glaciers may have extended to the edge of the Yukon Flats, radiating large outwash fans into the flats (Williams, personal communication).

PRE-WISCONSIN TO WISCONSIN INTERVAL

Between the deposition of pre-Wisconsin sediments and the deposition of sediments grouped as Wisconsin, there occurred a considerable time break. This is suggested by the extreme modification and dissection of the older glacial deposits as compared with the Wisconsin deposits, and by the poor preservation and position of the deposits far out from the mountains or at high altitudes, well above the limits of glacial deposits of Wisconsin age.

Evidence from the Fairbanks area in central Alaska indicates that the climate was warmer than now and permafrost was absent.

WISCONSIN EVENTS

The events of Wisconsin time are the clearest in our record and perhaps the most important in understanding the present distribution of plants and animals and the distribution and activity of early man. In most of the glaciated areas studied, there has been recognized a prominent twofold division of the Wisconsin deposits: two well-developed glacial or cold periods separated by a glacial retreat or warm period. Moraines of the last major glaciations are fresh, little dissected, and have well-preserved knob and kettle topography; moraines of the earlier Wisconsin glaciation are more subdued and generally partly buried by late Wisconsin outwash. In the lowlands, drainage through the late Wisconsin morainal belts is better integrated and is controlled less closely by morainal ridges. Although deposits of late Wisconsin glaciations are distinctly more modified than those of the last major glaciation, they are much better preserved than the fragmentary remnants of the pre-Wisconsin glaciations.

In unglaciated areas in the Alaska Range fluctuations in climate during the Wisconsin stage have also been recorded by fluctuations in intensity of frost action and solifluction sheets (Wahrhaftig, 1949).

In unglaciated regions of central Alaska two prominent loess deposits are separated by a thick muck deposit (Péwé, 1952b). Throughout unglaciated Alaska, Wisconsin silt deposits have yielded great quantities of vertebrate remains (Frick, 1930; Geist, 1953).

Southeastern Alaska

During the latest major glaciation, ice covered the land up to an altitude of about 3,000 feet near Juneau but descended to an altitude of about 2,000 feet on Admiralty Island, and perhaps to 1,500 feet on Prince of Wales Island. Such an ice distribution would leave many nuntaks of considerable size. Above these altitudes are evidences of earlier glaciations, which may or may not be of Wisconsin age (Sainsbury, personal communication).

South-Central Alaska

In early Wisconsin time the glaciers of the Alaska Range reached the Yukon-Tanana upland and were in general more extensive than those of later Wisconsin time. The Delta River valley glacier extended northward to the Tanana River and was connected with ice on the south side of the range. Ice pushed down the Nenana River valley to the vicinity of Healy (Wahrhaftig, 1953); and in the upper Kuskokwim region glaciers from the Alaska Range, along the South, Middle, and West Forks of the Kuskokwim River, spread terminal bulbs on the piedmont lowlands adjacent to the range (Fernald, 1953). The glaciers were larger and longer on the south side of the range than on the north, and probably filled the Copper River basin. This ice in the basin was coextensive with the ice in Cook Inlet and the Susitna Valley. This early Wisconsin glacial advance was followed by glacial recession during which the ice probably was no more extensive than present day glaciers.

In later Wisconsin time there occurred the latest major glaciation represented in the Alaska Range (Péwé, 1953). In the east, ice from the Wrangell Mountains pushed northward into the Mentasta Mountains (Wright, 1953), and ice from the Johnson and Robertson Rivers pushed northward to the Yukon-Tanana upland. To the west, distinct glacial ice lobes spread northward onto the plain from Delta River, Delta Creek, and Little Delta River valleys and did not coalesce. Ice in the Delta River pass was connected with ice on the south side of the range and advanced northward to the vicinity of Donnelly Dome (Péwé, 1952a). In the Nenana River valley ice advanced as far north as the Mount McKinley National Park station (Wahrhaftig, 1953). In the upper Kuskokwim region near Farewell, glaciers from the Alaska Range spread distinct lobes of ice on the piedmont, falling short by several miles of the point reached by piedmont lobes of early Wisconsin age (Fernald, 1953).

Glaciers on the south side of the range were again larger than those on the north and extended into the Copper River basin and upper Susitna Valley. It is thought that the Copper River basin was not completely filled with ice during this glaciation; however, more work is needed before this concept is completely verified. Ice in the Delta River area of the Alaska Range probably extended south as far as Meier, and ice from the Chugach Mountains may have extended as far north as Lake Louise (Williams, personal communication). The ice in the southwestern part of the basin was coextensive with ice in the Matanuska valley and Knik Arm of Cook Inlet. Lowland areas not glaciated in the Copper River basin at this time perhaps were buried under glaciofluvial sediment. When the glaciers retreated they left a collection of confused and disrupted drainages evident today.

In the Cook Inlet area the extent of Wisconsin glaciations is fairly well known (Karlstrom, 1952, 1953; Krinsley, 1952, 1953). In early Wisconsin time ice tongues flowed down the Susitna, Matanuska, and Turnagain Valleys and partly or completely coalesced near the axis of the trough with ice from the Alaska Range and Kenai Mountains. This was followed by climatic warming and extensive deglaciation with subsequent accumulation in local basins of several feet of peat over the glacial deposits. This peat is more than 18,000 years old by radiocarbon dating (Karlstrom, 1953).

During the latest major glaciation in this area, glaciers extended into the Cook Inlet trough from the surrounding mountain ranges and spread out as tongues or bulbs on the lowlands. One such large tongue terminated near the mouth of the Matanuska Valley; others were prominent in the areas now occupied by Skilak and Tustumena Lakes and Kachemak Bay. The latter lobe may have coalesced with ice from the Alaska and Aleutian Ranges to form a shallow lake in upper Cook Inlet trough (Krinsley, 1953). Many highland areas, exclusive of the mountains, were unglaciated. Radiocarbon dating indicates that this later major glaciation is older than 8,000 years and younger than 14,000 years (Karlstrom, 1953).

During retreat of the latest major glaciation, here as elsewhere in Alaska, a major readvance or stillstand is recorded by a prominent moraine. Work in progress indicates that a more detailed subdivision of the Wisconsin glaciations may be possible.

In the northern Alaska Peninsula during early Wisconsin time, ice extended westward from the mountains onto the Bristol Bay lowlands but did not coalesce with eastward-flowing ice from the

Kilbuck Mountains (Muller, 1952, 1953). This perhaps left a corridor open to the unglaciated middle Kuskokwim Valley, although not enough work has been done to verify this possibility.

Following a glacial recession of considerable magnitude, ice from the north Aleutian Range in late Wisconsin time filled the mountain valleys and advanced westward onto the lowlands forming broad lobes outlining the present Iliamna, Nanwhyenuk, Naknek, Brooks, and Becharof Lakes and other lake basins. Eastward-moving ice from the Kilbuck Mountains reached only to the mountain front and remained as distinct valley lobes, moraines of which now dam the finger lakes of the eastern Kilbuck Mountains (Muller, 1953).

Central Alaska

The most detailed record of the Wisconsin events in central Alaska comes from the frozen silts exposed in mining excavations near Fairbanks (Péwé, 1952b). Here is recorded a complex history of deposition, erosion, freezing, and thawing during Wisconsin time. An extensive blanket of loess was deposited in early Wisconsin time, more than 30,000 years ago by radiocarbon dating (Péwé, 1950). This loess probably coincides in time with the early Wisconsin glaciations recorded throughout the Territory.

Much of this loess was carried to creek bottoms, burying vertebrate remains. With abatement of loess deposition, creeks cut headward, incising the loess valley fill.

The cold period represented by this loess deposition and by the formation of permafrost and ice wedges was followed by a warm interval thought (1) to be at least 18,000 years in duration and (2) to have had a climate warmer than now. During this period, the valleys cut in loess were sporadically filled with muck, organic silt, that contains buried trees, bones of extinct mammoth, mastodon, horse, bison, and other animals, and a few partial carcasses of extinct animals. Radiocarbon dating of wood from this muck indicates that the upper part is at least 12,000 years old and the lower part more than 30,000 years old (Kulp et al., 1952). Plant fossils recovered from both the muck and the underlying loess reveal no species different from those in central Alaska today. Perhaps this intraglacial interval was warmer and longer than the interval since the last major glaciation and was a favorable time for existence of man in Alaska

Evidence from central Alaska reveals that extinct Quaternary mammals not only lived until fairly recently, but apparently lived in abundance during both glacial and interglacial intervals. This is an opposite view from the well-known statement by Johnston (1933, p. 34) that, ".... large Quaternary mammals did not live in Alaska in late-glacial and post-glacial time; that they were present in large numbers in interglacial time and were killed off by severe climatic conditions during the last glaciation which affected the mountainous parts of Alaska and Yukon". One might question why climatic conditions of earlier and more extensive glaciations did not "kill off" the mammals. Reintroduced horses and bison now live wild in central Alaska where winter temperatures are at least -70°F.

Some carcasses buried in the muck were long preserved in the cold, damp organic silt before being perennially frozen. Before the muck of this warm interval became frozen, water percolated through it into the underlying loess of earlier Wisconsin age, and reduced ferric to ferrous compounds that colored the loess green. With the freezing of this muck and underlying loess, huge ice wedges formed in the muck.

This period of deep freezing, which formed the permafrost and ice wedges present today, is thought to have occurred less than 12,000 or 13,000 years ago (radiocarbon dating) and probably represents the period of late Wisconsin glacial advances throughout Alaska. During this cold period more loess was deposited.

Seward Peninsula

Wisconsin glaciation on the Seward Peninsula was much less extensive than pre-Wisconsin ice advances (Hopkins, 1953a). Two separate glaciations are recorded: the early Wisconsin glaciers, which extended short distances from mountain valleys, and the late Wisconsin ice which was restricted to the upper parts of the mountain valleys. All during the Wisconsin stage glacial ice covered very little of the Seward Peninsula, thereby permitting free migrations of plants and animals including man. Hopkins states (personal communication) that a land bridge with Siberia surely existed in Wisconsin time.

Abundant remains of extinct mammals occur throughout the Seward Peninsula in silt deposits, which probably are of Wisconsin age.

In Wisconsin time, as well as in pre-Wisconsin time, extensive lava flows were extruded in the Imuruk Lake area; a study of the weathering of these flows and their subsequent soil formation indicates a chronology for this unglaciated region correlative with glacial chronology of the peninsula (Hopkins, 1953b).

Brooks Range

Two Wisconsin glacial advances are recorded in the eastern Brooks Range. The glaciers extended about 60 to 100 miles from the crest on the south side but only about 40 to 50 miles on the north. From a study of aerial photographs it is thought that in early Wisconsin time, ice advanced southward down the forks of the Chandalar to a point near Caro and in later Wisconsin time terminated several miles up the valleys (Williams, personal communication). As in the Brooks Range, and in Alaska in general, large lakes are held behind moraines of the latest major glaciation.

Glaciers on the north side of the Brooks Range did not extend onto the piedmont during the two distinct Wisconsin glacial advances as they did during the pre-Wisconsin advances (Detterman, 1953).

Preliminary study of the western part of the range by Fernald and Nichols indicates that the middle Kobuk River valley did not contain a glacier in late Wisconsin time. Glaciers at this time were confined to the north-south valleys, and end moraines of these glaciers aid in holding in Lake Selby and Walker Lake (Fernald, personal communication).

It is not definitely known if ice from the late Wisconsin glaciers filled such prominent migration-route passes through the Brooks Range as the Anaktuvuk, Howard, and others, although extrapolation from other areas in the range suggests that the passes probably were filled with glacial ice.

POST-WISCONSIN EVENTS

World-wide climatic variations in the last 10,000 years have been reflected in Alaska by fluctuation of glaciers, thawing and refreezing of sediments, formation of muck, disturbance of sediments by solifluction, and variation in the position of tree line.

The broadest climatic variations recorded are: (1) the warm and perhaps drier period of 3,500 to 4,000 years ago, which was followed by (2) a colder and perhaps wetter period that climaxed 200 to 400 years ago. During this warm period, (climatic optimum) permafrost was thawed to a depth of a few feet in central Alaska (Fairbanks) and muck was deposited. No remains of extinct mammals have been found in this muck. The dating of this muck, as well as the muck of this period in Seward Peninsula, is verified by radiocarbon tests (Hopkins and Giddings, 1953). On the Peninsula trees buried in muck indicate that forests were more extensive 3,500 years ago than they are today. Throughout Alaska glaciers receded to points beyond their present position; and, especially in southeastern Alaska, forests flourished in areas now covered or only recently uncovered by ice (Gilbert, 1910, p. 103; Cooper, 1937, 1942; Heusser, 1952).

After this warm period the climate appears to have become slightly cooler, as indicated by the refreezing of the thawed silts in the interior of Alaska and by the recession of tree line, especially on Seward Peninsula. Also, glaciers throughout Alaska underwent their greatest expansion since the last major glaciation in the so-called Little Ice Age of Matthes (1942) and culminated about 200 to 300 years ago. This is demonstrated by field work at Black Rapids (Péwé, 1951; Péwé and Taylor, 1953), Canwell, and Castner glaciers in the Alaska Range and at the Mendenhall and many other glaciers in southeastern Alaska (Gilbert, 1910; Tarr and Martin, 1914; Cooper, 1937; Lawrence, 1950). In addition to these localities, study of aerial photographs indicates that hundreds of glaciers representing many areas in Alaska appear to have had a major climax within the last few centuries (Péwé, 1953). Such a cold cycle is also represented by increased activity of rock glaciers (Wahrhaftig, 1953). Most of the recent massive ice wedges of the coastal plain in northern Alaska which overlie older truncated wedges, are less than 3,500 years old (Black 1952) and are thought to have formed in the period that followed the climatic optimum.

Since this climax of 200 to 300 years ago, most of the glaciers in Alaska have been receding, as have glaciers throughout the world (Matthes, 1942; Ahlmann, 1953).

On Seward Peninsula a slightly warm period also existed about 8,000 to 9,000 years ago (radiocarbon dating). During this time tree line advanced and muck was deposited (Hopkins and Giddings, 1953).

Recent shore-line emergences along the Pacific coast of Alaska (Twenhofel, 1952) are thought by the present author to be in great part a post-Wisconsin feature.

It is evident that, since the last major glaciation, Alaska has experienced marked climatic variations, which may be important in the present distribution of plants (Sigafoos, personal communication) and animals, including man. These fluctuations heretofore have been only locally studied or overlooked.

SUMMARY

In summary, we see that even a brief review reveals that Alaska had a complex history during the Pleistocene epoch. In addition to the advance and retreat of glaciers, permafrost in central Alaska formed, disappeared, and re-formed; streams alluviated and eroded their valleys, leaving terraces; windblown silts accumulated and a prodigious number of Pleistocene mammal remains have been preserved in the cold silts throughout the Territory, especially in the unglaciated part of Alaska. Fragmentary records indicate at least two prominent glacial advances in pre-Wisconsin time, and the major ranges all bore massive glaciers. Ice poured into the sea in southeastern and southern Alaska as well as from the Alaskan Peninsula. Ice from the Alaska Range abutted against the Yukon-Tanana upland on the north; ice from the Brooks Range pushed northward out of the valleys onto the piedmont. Seward Peninsula glaciers extended to the sea near Nome but covered only a small part of the peninsula. Despite extensive areas of glacier ice in Alaska, considerable ice-free terrain existed, especially in the central part of the Territory. The interglacial interval between the two pre-Wisconsin glaciations on Seward Peninsula was much warmer than anything recorded in Wisconsin or post-Wisconsin time.

Both the unglaciated and glaciated parts of the Territory record two prominent Wisconsin cold periods separated by a warm interval. This interval is thought to have been warmer and longer than the post-Wisconsin interval. Late Wisconsin glaciers were restricted to mountain valleys in northern ranges; however, in southern ranges glaciers extended beyond the mountains and spread terminal bulbs in the lowlands. In general, late Wisconsin glaciers advanced a shorter distance and were smaller than heretofore generally believed.

Pleistocene glaciation in Alaska cannot any longer be grouped under just "glaciation" or "maximum glaciation" or "the ice age" but has been shown to be composed of several distinct major ice advances and retreats. If distribution of plants and animals can be related to glaciation, care must be shown in relating this distribution to a particular glaciation. Also, climatic changes as well as the effect of these climatic changes upon the distribution of permafrost and unstable soils, since the latest major glaciation of 11,000 years ago have had considerable influence on distribution of plants and animals, a distribution heretofore casually related to "glaciation" or "maximum glaciation." Conversely, important floral and faunal changes and distributional patterns are pointing out to geologists information on climatic changes in Alaska during the Pleistocene epoch.

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TENTATIVE CORRELATION OF GLACIAL SEQUENCES IN ALASKA, 1952
(from Multiple glaciation in Alaska: a progress report, by T. L. Péwé, et al., 1953, U. S. Geol. Survey Circ. 289, 13 p.)

STANDARD	KENAI PENINSULA Karlstrom Krinsley	ALASKA PENINSULA Muller	UPPER KUSKOKWIM Fernald	NENANA RIVER Wahrhaftig	BIG DELTA Péwé	SEWARD PENINSULA Hopkins	BROOKS RANGE Detterman
Recent	Unnamed	Unnamed	Unnamed	Clear Creek	Black Rapids	Unnamed	Unnamed
Late Wisconsin	Nikolai Creek	Iliuk		Carlo	Summit Lake		
	Naptowne (older than 8,000 yrs. younger than 14,000 yrs.	Brooks	Farewell	Riley Creek	Donnelly	Mount Osbourne	Echooka
Early Wisconsin	Swan Lake (older than 18,000 yrs.)	Mak Hill	Selatna	Healy	Delta	Salmon Lake	Itkillik
Pre-Wisconsin	Caribou Hills	Johnston		Dry Creek	Darling Creek	Nome River	Sagavanirktok
	Mt. Susitna	Earliest		Browne		Iron Creek	Anaktuvuk