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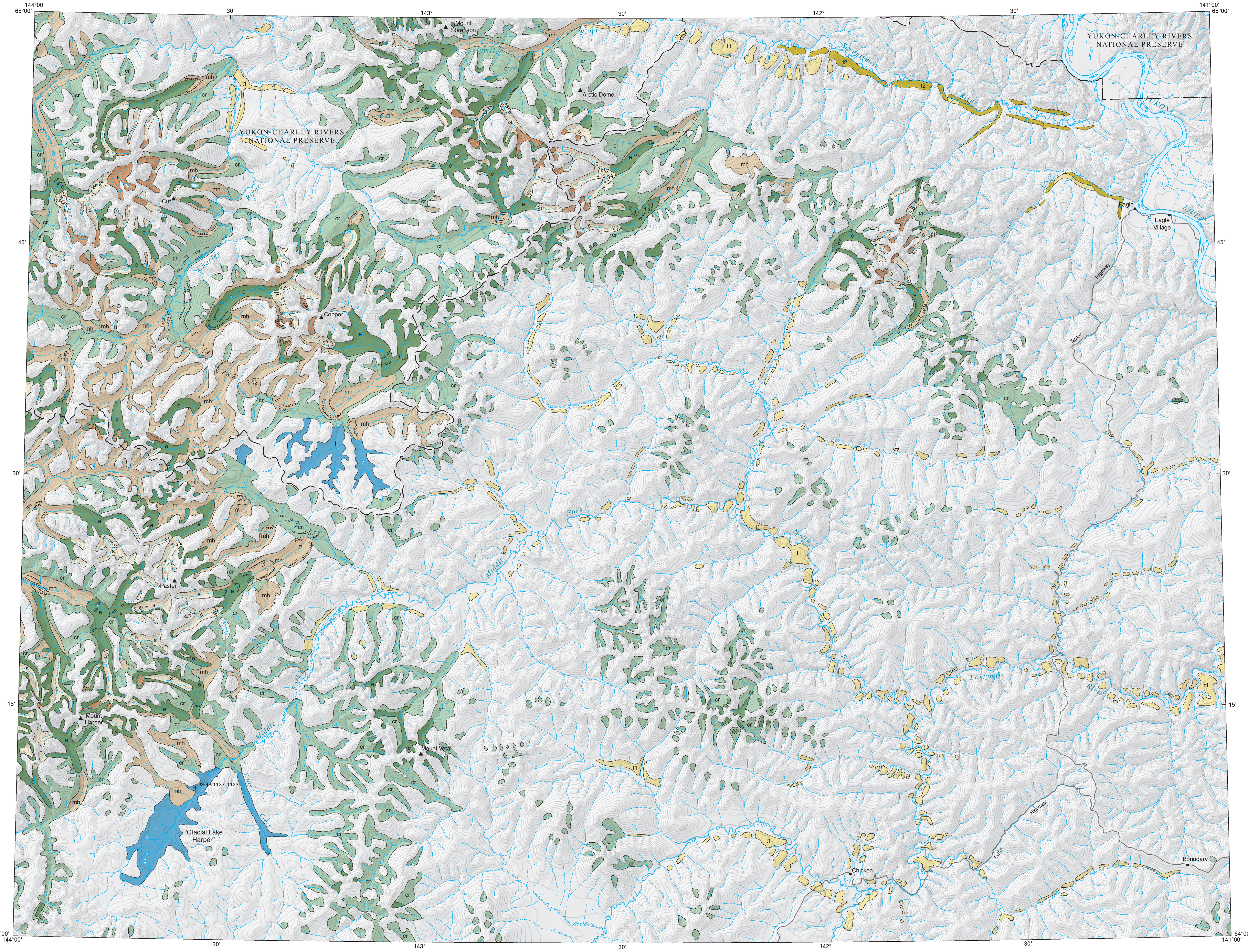

Base from U.S. Geological Survey, 1:250,000-scale Eagle, 1957 (minor revisions 1982)

Topographic contours generated from U.S. Geological Survey National Elevation Dataset (NED) 41.6-meter Digital Elevation Model (DEM)

Universal Transverse Mercator projection; Zone 7N

1927 North American Datum

22°
TRUE NORTH
MAGNETIC NORTH
APPROXIMATE MEAN DECLINATION, 2012

SCALE 1:250 000

5 0 5 10 15 20 25 MILES

5 0 5 10 15 20 25 KILOMETERS

CONTOUR INTERVAL 200 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped by F.R. Weber

GIS database and digital cartography by F.H. Wilson, K.A. Labay, and N.B. Shew

Edited by J.L. Zigler

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Map Showing Extent of Glaciation in the Eagle Quadrangle, East-central Alaska

By

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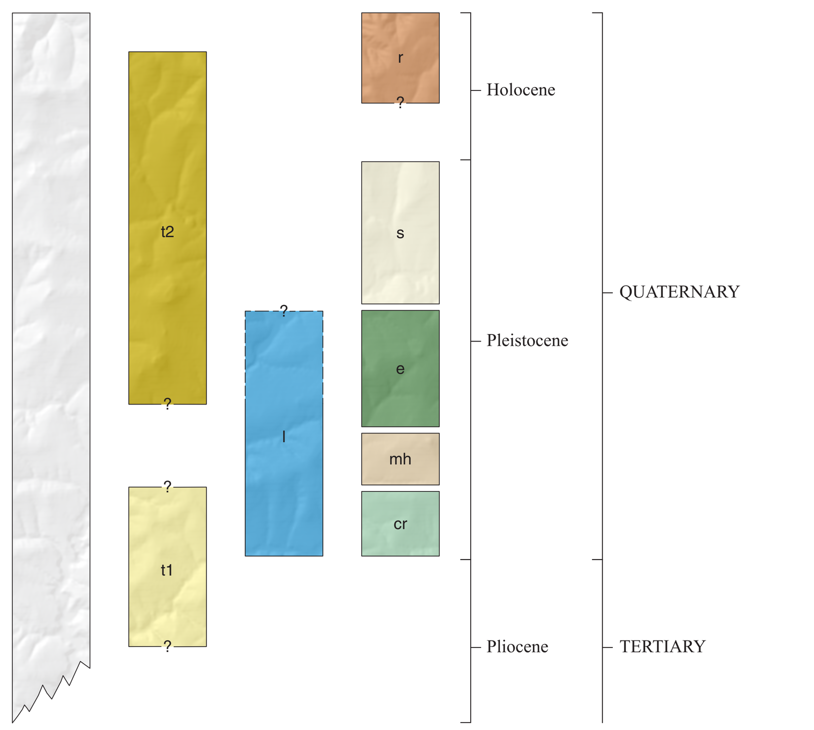
2012

CORRELATION OF MAP UNITS

[See Description of Map Units for precise unit ages; dashed where age range uncertain]



DESCRIPTION OF MAP UNITS

Bedrock and unconsolidated deposits, undivided (Quaternary to Paleozoic)—Areas of bedrock or other unconsolidated deposits not otherwise described on this map. Bedrock as mapped and described by Foster (1976). Unconsolidated deposits are dominantly of Quaternary age and include stream gravels on valley floors, talus and solifluction debris on upland slopes, and windblown silt (loess) adjoining source areas such as ancient lake beds

UNCONSOLIDATED DEPOSITS

t2 **Younger terrace deposits (late Quaternary)**—Silt, sand, and primarily gravel form low-level terrace deposits along the Seventymile River and Mission Creek. Windblown silt and sand (loess) locally mantle terrace deposits (Foster, 1976)

t1 **Older terrace deposits (early Quaternary and Tertiary, Pliocene?)**—Silt, sand, and primarily gravel form high-level terrace deposits along the Fortymile River and its tributaries and the Seventymile River, locally as much as 215 m above present streams (Foster, 1976). Terraces are commonly composed of uplifted outwash of Charley River age. Windblown silt and sand (loess) locally mantle terrace deposits (Foster, 1976)

l **Glacial lake deposits (Pleistocene)**—Silt, sand, and gravel commonly in alternating layers. Gravel, a minor component is found primarily in outwash fans deposited in the lakes. Glacial lakes formed where streams were blocked by moraines or ice during several of the glacial advances. Informally named glacial Lake Harper (Weber and Ager, 1984; Weber, 1986) occupied the valley of the Middle Fork Fortymile River southeast of Mount Harper. Deposits of this lake (Weber and Ager, 1984) consist of as much as 9 to 10 m of alternating thin layers of sand and silt. "The sand is coarse and gravelly, but, in contrast to the lower part of the section, gravel is made up of angular bits of schist or quartzite and contains no igneous rocks. The metamorphic-rock clasts are mostly about 2.5 cm in diameter; the largest schist clast observed was 20 cm in diameter, although such large flat angular fragments are very rare. Much fine dark organic material is mixed in the silty layers, particularly near the base (Weber and Ager, 1984, p. 68)." Glacial Lake Hake Harper may have formed twice, as the result of ice advances during both Charley River and Mount Harper glacial advances. Weber and Ager (1984) reported a radiocarbon age determination of 21,410±190 radiocarbon years (USGS 1123) on wood debris associated with a volcanic ash overlying the uppermost lake deposits. A second radiocarbon age, underlying the lake deposits but overlying an outwash fan, attributed to the Charley River advance was greater than 50,300 radiocarbon years (USGS 1122). A small lake was also formed on a tributary of the Middle Fork Fortymile River at the time of the Eagle advance; Weber (1986, fig. 9) suggested this lake formed behind the moraine of a retreating glacier; these photographed lake deposits are not shown on the map because Wilson was uncertain of their location

r **Deposits of Ramshorn advance (late Holocene)**—Fresh deposits of till that contain angular clasts and significantly more fine-grained matrix than older moraines in the highest, mostly north-facing cirques (Weber, 1986). "In most places, these deposits consist of essentially shapeless masses of till concentrated at the uppermost limits of the mountain valleys. However, a few glaciers of the older Ramshorn I age left distinctive terminal moraines." Typically, glaciers were small and confined to highest upland areas; however, a few glaciers were as long as 6.5 km. However, deposits of the younger Ramshorn II advance consist of large angular blocks lacking classic morainal forms and containing little or no fine-grained matrix and occur only in few north-facing cirques (Weber, 1986)

s **Deposits of Salcha advance (Pleistocene; late Wisconsin)**—Confined to higher mountain valleys, these end moraines form arcuate ridges across relatively narrow valleys or at mouths of small tributaries to larger valleys (Weber, 1986). Moraines have a variable height above their respective valley floors, ranging from 13.5 to 30 m and have ridge crests ranging from 1.5 to 9 m wide, averaging 6 m. "Unmodified knob and kettle topography extends upvalley from the largest moraines. Because it is situated well above tree line, most drift is barren of vegetation or at the most is 40 percent covered with tundra plants. Only a few moraines extend below tree line, and these have partial forest cover. *** Erratic boulders as large as 3 m in diameter are present on the crests of some moraines. Clasts are typically subangular but range from rounded to angular, depending on lithology. Clasts of metamorphic rock types are significantly more angular than those of granitic rock types on moraines of the same age." Outwash deposits associated with this episode are confined to narrow valleys below the moraines and are relatively small compared to those of older advances. Most Salcha age glaciers originated at altitudes of 1,580 m or more and flowed down to altitudes as low as 1,200 m. A few of the most extensive glaciers, up to 9.6-m-long, reached as low as 900 m (Weber, 1986)

e **Deposits of Eagle advance (Pleistocene; early? Wisconsin)**—Prominent end moraines have well-defined ridge crests about 30 m high and 4.5 to 6 m wide and subdued knob and kettle topography is commonly upvalley of end moraines; small ponds are still present in many kettles (Weber, 1986). Clasts in till are less rounded than clasts of earlier episodes and compositionally reflect the local source areas of the individual glaciers. Metamorphic rock clasts, such as gneiss or quartzite, are less rounded than granitic rock clasts in moraines of this age. Clasts in these deposits are less weathered, less etched, and tend to be significantly smaller than clasts in older deposits (Weber, 1986). Glaciers of this episode formed on mountains 1,460 m or higher; the longest of these glaciers was 19 km long and reached altitudes as low as 900 m, though they typically terminated in upper mountain valleys; end moraine deposits mostly occur above present-day treeline (Weber, 1986)

mh **Deposits of Mount Harper advance (middle? Pleistocene)**—Type locality is found on Ramshorn creek, where the terminal moraine is fairly sharp-crested having slope angles of 25° and 17° on the inner and outer faces, respectively. More commonly, terminal moraines are broad or flat having crests as much as 100 m wide. "The surfaces of the largest moraines are so deflated and eroded as to have virtually no relief. They commonly consist of low ridges of lag boulders at the edges of a broad plain. Most of the terminal moraines of Mount Harper age are found in lower valleys and are half or fully covered with vegetation, either woodland or tundra. In many valleys the original tundra forms are partly covered or obscured by solifluction lobes or talus deposits." Clasts in the Mount Harper deposits typically usually subrounded to well-rounded granitic rocks in a bimodal size distribution of boulders and cobbles in a grus to sand matrix. Boulders are as much as 1.2 m in diameter; weathering has etched boulders as much as 10 cm; in porphyritic rocks, feldspars stand in relief. Less resistant rocks have broken down to grus. Outwash deposits associated with this advance commonly form broad gravel fans originating at the otherwise inconspicuous end moraines. Source areas for Mount Harper advance essentially same as the source area of the Charley River advance; however, typically only mountains more than 1,200-m-high supported glaciers or limited ice caps during Mount Harper time. Mount Harper glaciers extended to altitudes as low as 600 m and attained lengths of as much as 29 km

cr **Deposits of Charley River advance (early? Pleistocene)**—Subdued morainal landforms and erratic boulders along Charley River in vicinity of Ramshorn creek. Primary evidence is large erratic boulders at downvalley limit of U-shaped troughs that radiate from adjacent mountains. Boulders generally consist of the most resistant rock types, such as granitic rocks, gneiss, or quartzite. Locally, bench-like features along the sides of valleys and faint arcuate ridges crossing some of the larger drainages are thought to be moraines reflecting advance. Most ridges are heavily vegetated and covered by solifluction deposits. Outwash terrace remnants found locally above end moraines of younger advances beyond the vicinity of the higher peaks. Poorly developed cirques and U-shaped valleys are apparent on aerial photographs, although not readily apparent in the field. Several ephemeral lakes were formed behind moraines of advance. Glaciers of this advance thought to have formed on all mountains exceeding 900 m in elevation and flowed out from ice caps as much as 56 km; locally there is evidence that there were at least two major advances associated with this glacial episode

EXPLANATION OF MAP SYMBOLS

Contact—Solid where location is certain; dashed where approximate

Internal contact—Between glacial advances of the same age

Moraine—End, recessional, and lateral moraine limit

Roads

Preserve boundary

▲ **Peaks or benchmarks mentioned in text**

+ **^{14}C dates**—USGS radiocarbon laboratory number

• **Towns**

INTRODUCTION AND PREVIOUS WORK

This map covers the Eagle 1:250,000-scale quadrangle in the northeastern part of the Yukon-Tanana Upland in Alaska. It shows the extent of five major glacial advances, former glacial lakes, and present fragmented terrace deposits related to the advances. The Yukon-Tanana Upland is an area of about 116,550 km^2 between the Yukon and Tanana Rivers in east-central Alaska (Weber, 1986) that extends into the western part of the Yukon Territory of Canada. Traditionally, the Yukon-Tanana Upland was thought to be a part of unglaciated central Alaska; however, as demonstrated by Péwé (1975) and Weber (1986), a rather long history of localized alpine glaciation during Pleistocene and possibly Tertiary time can be shown. Deposits of five of the glacial episodes described by Weber (1986) can be found in the Eagle quadrangle.

This report is an outcome of studies conducted in conjunction with bedrock mapping intended for mineral resource assessment. "During the course of that project, it became apparent that more detailed mapping of the glacial deposits was necessary in order to make a better interpretation of the relation of glaciation to placer deposits, sand and gravel resources, and the general geomorphic history of the upland" (Weber, 1986). Wilson utilized an earlier unfinished version of this report, including the draft map and remaining notes, to prepare this report. As such, quoted passages from Weber (1986) are used extensively in this reconstruction; unless otherwise indicated, all quotes are from Weber (1986).

"Geological exploration in and around the Yukon-Tanana Upland began near the turn of the century (1900), and most of those studies were carried out by members of the U.S. Geological Survey. Prindle (1913) and Mertie (1937) both mention the conspicuous moraines at the confluence of Moraine Creek with Crescent Creek, a western tributary of the Charley River." The first reconnaissance field studies of glacial geology in the area were made by H.R. Schmoll in 1963. "Péwé and others (1967) published the first map depicting the deposits of multiple glaciation in the upland."

PHYSIOGRAPHIC FRAMEWORK

The map area includes parts of three of the physiographic regions of Alaska as defined by Wahrhaftig (1965). The vast majority of the map area falls within the Yukon-Tanana Upland (Upland) physiographic division of Wahrhaftig (1965), which is characterized by rounded, fairly smooth ridges having gentle slopes; however, rugged peaks occur locally, and the Eagle quadrangle includes some of the highest and most rugged parts of the Upland. Ridges in this part of the Upland have no preferred direction, tend to be 900 to 1,500 m high and have 450 to 900 m relief relative to the adjacent valleys (Wahrhaftig, 1965). At present there are no glaciers in this region and the area is underlain by discontinuous permafrost (Wahrhaftig, 1965). "Periglacial mass-wasting is active at high altitudes, and ice wedges lace the frozen muck of valleys bottoms (Wahrhaftig, 1965)." The Tintina Valley physiographic division follows the trace of the Tintina Fault System, a major strike-slip fault separating bedrock terranes and having an estimated 400 to 900 km of offset (Wilson and Weber, 1998). This division is also generally underlain by permafrost. The northeasternmost part of the map area, northeast of the Yukon River, is part of the Ogilvie Mountains division, characterized by sharp crest lines, precipitous slopes, and deep narrow valleys (Wahrhaftig, 1965). Ridges are as much as 1,500 m high and relief is as much as 1,200 m. At present, there are no glaciers. Permafrost underlies most of this part of the map area and pingos are common (Wahrhaftig, 1965). The Yukon River flows within the Tintina Valley physiographic division, which is a narrow belt of low country having 300 to 450 m of relief and maximum elevations rarely exceeding 600 m (Wahrhaftig, 1965). Mount Harper, in the southwest corner of the quadrangle, at 1,994 m is the tallest peak in the Upland. It is at the southern end of a group of mountains that extend in an arc north to the headwaters of the Charley and Salcha Rivers and then east nearly to the Canadian border. "During the period of maximum glacial advance, ice caps formed on the higher mountains, and glaciers radiated down the surrounding valleys;" Mount Harper was the center of one of these ice caps.

GEOLOGIC FRAMEWORK

The bedrock of this map area is characterized by relatively high grade metamorphic rocks that have been subdivided into a variety of tectonostratigraphic terranes and intruded by many plutons of Mesozoic and early Cenozoic age (see Foster, 1976; Foster and others, 1994). Plutons of Triassic and Jurassic age are most common in the eastern and central parts of the Eagle quadrangle; Cretaceous and early Tertiary plutons are more common in the western part of the quadrangle. Allochthonous rocks of oceanic affinity are found at the highest elevations in the northern part of the quadrangle.

As mentioned previously, the Tintina Fault System cuts across the northwestern part of the map area. This fault system runs parallel to the similar Denali Fault System south of the map area. Both of these fault systems have demonstrated Quaternary offset; the Denali Fault System has had a recent significant offset event as demonstrated by the Denali Fault earthquake of 2002 (Eberhart-Phillips and others, 2003).

GLACIAL GEOLOGY

Alpine glaciation in the Yukon-Tanana Upland is restricted to higher altitude areas. These areas occur primarily in the western Eagle quadrangle where small icefields or icecaps developed. The most prominent of these centers were at Mount Harper in the southwestern part of the map area, southwest of Arctic Dome in the north central part of the map area, in the vicinity of benchmark "Copper," between Copper Creek and the Charley River in the northwest part of the map area, in the vicinity of benchmark Cut between the Charley River and Moraine Creek, and in the vicinity of benchmark "Paster," between the Goodpaster River and Eisenmenger Creek. Other ice caps were probably developed on Mount Sorenson and a smaller one possibly on Mount Veta. Other than the oldest deposits, called the Charley River episode, the type areas of the other four episodes are on informally named Ramshorn creek, a creek that drains into the Charley River west of benchmark Copper.

The oldest drift in the Yukon-Tanana Upland, known only from an exposure on the Goodpaster River (west of this map area), is inferred to be of Tertiary age. Its degree of induration is comparable to that of other late Tertiary tills described from nearby parts of the Alaska Range (Carter, 1980; Thorson, 1986). It differs lithologically from overlying till in that a change of provenance took place between deposition of the oldest drift and the onset of ice advances of Pleistocene (Charley River) age. The oldest drift includes both granitic and lesser metamorphic rocks of Cretaceous and Tertiary age and sedimentary and volcanic rocks of early Tertiary age; however, by Charley River time the softer Tertiary sedimentary rocks were largely or wholly removed by erosion. Resistant granitic plutons and silicic metamorphic rocks remained the major source of glacier detritus during Pleistocene time. The change in provenance suggests that a long span of time may have separated deposition of the two drift units.

The typical deposits of the Charley River glacial episode consist of subdued morainal landforms and erratic boulders found along the Charley River in the vicinity of Ramshorn creek. Possible lateral moraines are preserved locally as bench-like features and terminal moraines as faint arcuate ridges across a few larger drainages. "Glaciers of this episode left the most extensive glacial record in the upland and established the basic pattern of modern drainages." Glaciers may have developed on all mountains above 900 m in elevation and flowed out from ice caps as far as 56 km. Sparse evidence suggests that this episode had at least two major advances. During this episode, glacial lakes formed in a number of valleys where streams were blocked by moraines. The informally named glacial Lake Harper developed in the valley of the Middle Fork of the Fortymile River about 16 km east of Mount Harper and had a surface area of about 30 km^2 (Weber and Ager, 1984). This episode is inferred to be of early(?) Pleistocene age because of (1) the long intervals of erosion and tectonic deformation that separated this ice advance both from older and younger glacial episodes; (2) the highly weathered state of the glacial deposits of Charley River age; and (3) correlations with glacier advances of early(?) Pleistocene age elsewhere in Alaska. Drift of Charley River age closely resembles that of the Anaktuvuk River glaciation of Detterman (1953) in the central Brooks Range (Hamilton, 1986) and both drifts have undergone similar post-glacial histories of tectonic deformation and regional downwasting. The Anaktuvuk River glaciation in turn is correlated with the Nome River Glaciation of Hopkins (1953) on the Seward Peninsula, which is older than 0.8 Ma on the basis of potassium-argon dates on an overlapping lava flow (Kaufman and Hopkins, 1986). Although no glacial episode of this age was named by Péwé in his work on the nearby Alaska Range (Péwé, 1975), substantial evidence for an ice advance of probable early Pleistocene age exists along the north front of the Alaska Range (Wahrhaftig, 1958; Thorson, 1986).

A very long interglacial period must have separated ice advances of Charley River and Mount Harper age. During the Charley River glacial episode, large quantities of glacial outwash filled the narrow valleys of the Yukon-Tanana Upland. The northern part of the Upland, particularly the northeastern part and adjoining Yukon Territory, was tilted to the south as a result of movement on the Tintina Fault. Subsequent vigorous downcutting left prominent terraces containing outwash of Charley River age as much as 150 to 180 m above the present streams, which are entrenched in deep V-shaped cuts.

The Mount Harper glacial episode is inferred to be of middle Pleistocene age and its type locality is on Ramshorn creek. Although on Ramshorn creek the terminal moraine of this advance is fairly sharp crested, in general the terminus is broad or flat, having crests as much as 100 m wide. Commonly, the largest moraines consist of low ridges of lag boulders at the edges of broad plains. The Mount Harper glacial episode appears to have consisted of at least two major advances because two end moraines are generally present and, locally, three may be found. Weber (1986) suggested that "Glacial Lake Harper," which originally formed in association with the Charley River advance, may have developed again as a result of a glacier associated with the Mount Harper advance blocking the channel; at the same time, another glacier associated with Mount Harper advance may have terminated in this lake.

The Eagle glacial episode is represented by prominent end moraines approximately 30 m high and having crests 4.5 to 6 m wide. Inferred to be of early Wisconsin age, the type locality for deposits of the Eagle episode is also on Ramshorn Creek. Subdued knob and kettle topography is preserved up-valley of end moraines; many small kettles retain ponds. In many localities, there is clear evidence of two advances; "* * * almost all terminal areas show two prominent end moraines and even two lateral moraines." Meltwater from the glaciers of this episode cut prominent channels through older glacial deposits and the outwash deposits of this episode form flat valley floors beyond the Eagle end moraines; present-day streams cross these deposits in anastomosing channels. A few small lakes were dammed behind moraines of this age, including one on a tributary of the Middle Fork Fortymile River (Weber, 1986).

The Salcha glacial episode is of presumed late Wisconsin age, equivalent to the last glacial maximum elsewhere; its deposits are found only in high mountain valleys. "The Salcha glacial episode was made up of three or four advances; remnants of four are typically present in most valleys. Moraines of the least extensive two readvances are the most weakly developed and in some valleys may be paired or even merge. In a few places, more than four moraines can be counted." Headwalls of preexisting cirques were steepened by renewed glacial erosion during Salcha time, giving them essentially their modern profiles. Other effects of alpine mass wastage on drift of Salcha age are varied. In contrast to older drifts, talus and solifluction debris have rarely encroached on the outer moraines of Salcha age. However, in upper reaches of mountain valleys where the walls are steep or bedrock highly fractured, talus cones or aprons cover some glacial deposits.

The Ramshorn glacial episode of late Holocene age is the youngest glacial event of the upland; its deposits are found in high- altitude north-facing cirques. Two minor advances are recognized, informally termed Ramshorn I and Ramshorn II phases by Weber (1986). Small cirque lakes are dammed by deposits of the older Ramshorn advance. Rock glaciers and rock slides merge with the younger advance deposits, making them difficult to distinguish.

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