U.S. DEPARTMENT OF THE INTERIOR
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SURFICIAL GEOLOGIC MAP OF THE TANACROSS B-4 QUADRANGLE, EAST-CENTRAL ALASKA

By Paul E. Carrara
2006

SCIENTIFIC INVESTIGATIONS MAP 2935
Version 1.0

Base from U.S. Geological Survey, 1949;
minor revision 1994
Universal Transverse Mercator projection
10,000-foot grid based on Alaska coodinate system, zone 2
1,000-meter Universal Transverse Mercator
grid ticks, zone 7
1927 North American Datum

Geology mapped by P.E. Carrara in 2001–2004;
assisted in field by J.P. Beann, J.S. Honke, and F.R. Weber
Digital database prepared by Kenzie J. Turner
Editing and digital cartography by
Gayle M. Dumonceaux,
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INTRODUCTION

The Tanacross B-4 quadrangle, encompassing an area of about 720 km^2 in east-central Alaska, is about 330 km southeast of Fairbanks and about 160 km west of the border of the Yukon Territory of Canada. The quadrangle contains parts of two physiographic provinces, the Yukon-Tanana Upland and the Northway-Tanana Lowland (Wahrhaftig, 1965). The gently rolling hills of the Yukon-Tanana Upland, in the northern and eastern map area, generally rise to between about 850 and 1,000 m asl (above sea level) (see topographic map for equivalent elevations in feet). The highest peak in the area, an unnamed summit near the eastern map border, rises to 1,068 m. The Northway-Tanana Lowland contains the west-flowing Tanana River and the broad Tok alluvial fan of the north-flowing Tok River. Altitudes along the valley floor generally range between 475 and 520 m asl.

The dominant surficial feature within the map area is the Tok fan (composed of map units Qtfo, Qtfy, and Qfto), which occupies the southwestern map area and much of the adjacent Tanacross B-5 quadrangle to the west (Carrara, 2004a). This large (about 450 km^2), nearly featureless fan is composed of a high percentage of volcanic clasts derived from outside the present-day drainage basin of the Tok River. Relative to the size of this fan, the present Tok River is an underfit stream. During the various Pleistocene glaciations, a series of glaciers filled the Copper River basin to the south of the map area and ice lobes spilled northward over Mentasta Pass (75 km south of the map area), near the northern end of the Mentasta Mountains into the Tok River drainage. For instance, during the late Wisconsin (Donnelly) glaciation, an ice lobe extended about 16 km north of Mentasta Pass into the Mineral Lake area (Richter, 1976) about 55 km south of the map area. This ice lobe undoubtedly carried clasts of volcanic rocks from the Copper River basin, and upon deglaciation these clasts were deposited as outwash throughout the Tok River valley and onto the Tok fan. Hence, the Tok fan was built by outwash from a succession of glacial lobes, which spilled over Mentasta Pass during the various glaciations of the Pleistocene. Further information is given in the unit description of this fan.

Permafrost (permanently frozen ground) is common throughout the map area, especially in the highly organic deposits (Qor) within the Tanana Valley and in the fine-grained colluvium and alluvium (Qca) of the Yukon-Tanana Upland. In these areas a thick mat of vegetation covers the ground, and permafrost is common below a depth of 50 cm. At many localities the presence of permafrost is indicated by stunted black spruce (Picea mariana). Man-made structures can be disrupted and damaged by the melting of underlying permafrost. Hence, care should be taken when building in permafrost areas.

The two White River Ash layers are widespread over eastern Alaska and the southern Yukon region (Lerbekmo and Campbell, 1969; Clague and others, 1995). The ash layers, erupted from a vent in the St. Elias Range of eastern Alaska about 230 km south-southeast of the map area, were deposited by two separate eruptions. The younger ash layer, which is limited to the southern Yukon Territory, was deposited about 1,200 14C yrs ago (Clague and others, 1995). The older ash layer, which is widespread in eastern Alaska including the map area, was deposited between 1,500 and 1,900 14C yrs ago (Fernald, 1962; Clague and others, 1995). This layer (about 2–10 cm thick) consists of a white (10YR 8/1), light-gray (10YR 7/2), or very pale brown (10YR 7/3) fine sand or silty fine sand, composed of volcanic glass fragments, is commonly found within the upper 20 cm of the modern soil. Based on stratigraphic position, the majority of volcanic ash sites shown on the map are probably the older of the White River Ash layers.

However one ash layer, at a site along the north side of the Tanana River about 0.8 km west of the mouth of Porcupine Creek, was found in a deep gully in a thick loess deposit. Major element analyses of the glass fraction of this ash layer (E. Wan and A. Sarna-Wojcicki, written commun., 2005) indicate it is the Old Crow tephra, which was deposited about 140 ka (Westgate and others, 1990).

The climate of the map area is typical of that of the Alaskan interior. Winters are long and cold, summers are short and generally mild, and precipitation is light. Climate records for the town of Tok, along the Alaska Highway near the western map border, indicate a mean January temperature of –26.4°C, and a mean July temperature of 14.5°C. Mean annual precipitation at Tok is 23.5 cm with almost 60 percent occurring during the summer months (June, July, and August) (Western Regional Climate Center, unpublished data accessed Dec. 1, 2003, on the World Wide Web at URL http://www.wrcc.dri.edu/index.html).

Boreal forest and muskeg, which in many areas reflect the underlying geology, colonize much of the map area. The boreal forest consists primarily of black spruce, white spruce (Picea glauca), balsam poplar (Populus balsamifera), and quaking aspen (Populus tremuloides). Black spruce, characteristic of cold, poorly drained, nutrient-poor sites, commonly grows as small, stunted trees 3–5 m high (Johnson and others, 1995). Well-drained sites are commonly inhabited by white spruce, 10–20 m in height, and by balsam poplar, quaking aspen, and some black spruce, which can reach a height of about 10 m in these more favorable locations. Muskegs, which commonly contain Sphagnum mosses and heath shrubs, are characterized by areas of poor drainage and high water table, and may contain permafrost at shallow depths. Black spruce may also be present in the muskegs and will commonly form open-canopied stands of low, stunted trees (Johnson and others, 1995).

The Alaska Highway (originally called the “Alcan” Highway) generally crosses east to west through the Tanacross B-4 quadrangle for about 28 km. The highway stretches for 2,290 km from Dawson Creek, British Columbia, to Delta Junction, Alaska, and traverses rugged mountains, wild rivers, and large expanses of forest and muskeg. The U.S. Army Corps of Engineers built the original highway in just eight months and 12 days in 1942 (Cohen, 2001) as an overland route to relieve Alaska from the wartime hazards of shipping; the highway was later turned over to civilian contractors for improvements (widening, graveling, and rerouting in many areas). Paving was completed in about 1984. Today, the Alaska Highway is one of the primary transportation corridors in Alaska, carrying both freight and passengers. Other roads in the map area include the Glenn Highway at the western edge of the map, connecting Anchorage to Tok, and the Taylor Highway near the eastern edge of the map, connecting the Alaska Highway to Dawson in the Yukon Territory.

The town of Tok (population about 1,400) is located near the western edge of the map at the intersection of the Alaska and Glenn Highways. Tok had its beginning as a construction camp on the Alcan Highway and was named after the mascot, a Husky pup, of the U.S. Army 97th Engineers Corps when they arrived at the present-day site of Tok on

August 15, 1942 (data accessed June 30, 2006, on the World Wide Web at URL www.alaska-wintercabin.com/about_tok.htm). The town is the major overland point of entry to Alaska and is primarily a trade and service center for all types of transportation, especially for summer travelers along the Alaska Highway.

Mapping of the surficial deposits in the Tanacross B-4 quadrangle was accomplished by a variety of methods, including (1) compilation from existing geologic maps—mainly Holmes (1965), Foster (1970), and Carter and Galloway (1978); (2) stereoscopic analysis of aerial photographs (1:46,000-scale 1954 black and white and 1:63,000-scale 1978 color-infrared); and (3) fieldwork, including limited helicopter use. Where localities could be examined in the field, detailed information was obtained on the surficial deposits. Data from these easily accessible areas were then extrapolated to the less accessible areas. Map unit boundaries were plotted on a stable mylar topographic base with the use of a photogrammetric stereo plotting instrument (Kern PG2). The contacts were then digitized on screen from the scanned mylar.

Surficial deposits in the Tanacross B-4 quadrangle consist of artificial fill, alluvial, colluvial, eolian, lacustrine, and organic deposits. Deposits shown on this map are generally greater than 1 m thick; thinner discontinuous colluvial and eolian deposits, residual material on bedrock, and some artificial fill were not mapped and are incorporated with the underlying mapped unit. For example, many areas are mantled by a light-yellowish-brown (10YR 6/2) loess, usually less than 25 cm thick, but because it is thin and discontinuous and lacks geomorphic expression, it could not be accurately mapped. In addition, many contacts between map units are approximately located because of the lack of exposures or the gradational nature of the surficial deposits (for example, the contact between colluvium and alluvium (Qca) and bedrock (Br) on steep slopes in the Yukon-Tanana Upland).

The durations of the various time divisions of the Quaternary Period are modified from Hansen (1991) and Richmond and Fullerton (1986) and are as follows: (1) Holocene, 0–10,000 yrs ago; (2) late Pleistocene, 10,000–127,000 yrs ago; (3) middle Pleistocene, 127,000–778,000 yrs ago; and (4) early Pleistocene, 778,000–1,806,000 yrs ago. Age assignments for the surficial deposits in the quadrangle are based chiefly on stratigraphic and depositional relations, the degree of erosional modification of the original-surface morphology, several radiocarbon ages, and stratigraphic position relative to the White River Ash layer. Grain-size terminology of the surficial deposits is based on visual identification and follows the modified Wentworth grain scale (American Geological Institute, 1982). In descriptions of surficial deposits, the term “clast” refers to a particle greater than 2 mm in diameter, whereas the term “matrix” refers to particles less than 2 mm in size. The dry matrix colors of the surficial deposits in the map area were determined by comparison with a Munsell Soil Color Chart (Munsell Color, 1973).

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Artificial fill deposits

Artificial fill (latest Holocene)—Compacted and uncompacted fill composed mostly of silt, sand, gravel, and rock fragments beneath the Alaska, Glenn, and Taylor Highways. Beneath the Glenn Highway and Alaska Highway west of the Tanana River, the fill consists of subrounded and rounded, pebble- and cobble-size clasts derived mainly from local gravel pits on the Tok fan (Qtfo and Qtfy) and angular (crushed), pebble-size basaltic rock fragments, also derived from Tok fan deposits, all in a pale-brown (10YR 6/3) to light-yellowish-brown (10YR 6/4) silty sand to sand matrix. Beneath the Taylor Highway and the Alaska Highway east of the Tanana River, the fill commonly consists of angular (crushed) pebble-size granitic fragments derived from the local bedrock. Matrix is mostly pale-brown (10YR 6/3), coarse sand. In places, where unit overlies areas with a high water table, such as along the floodplain of the Tanana River, unit may be susceptible to failure by liquefaction and slumping of underlying material during seismic events. Such liquefaction and slumping caused severe damage along the Glenn Highway between Slana and Mentasta Pass (about 75 km south of map area) during the magnitude 7.9 earthquake of November 3, 2002 along the nearby Denali fault (Harp and others, 2003). Thickness of unit ranges from about 1–1.5 m on the Tok fan to as much as 5 m in areas of permafrost and muskeg

Alluvial deposits

Floodplain alluvium of Tok River (Holocene)—Floodplain deposits of Tok River, including those in recently abandoned channels and low terraces. Upper 1 m of unit, commonly an overbank deposit, consists of light-brownish-gray (10YR 6/2), well-sorted, massive, micaeous, silty fine to medium quartz sand which locally contains minor amounts of pebbles. The sand contrasts markedly with that of the Tanana River floodplain (Qfpt) and Tok fan (Qtfo and Qfty) in that it is much lighter in color and contains more quartz and mica derived from the Alaska Range to the south. Poorly exposed lower part of unit consists of light-brownish-gray (10YR 6/2), unstratified to stratified, well-sorted, fine to medium sand, pebbly sand, and sandy pebble gravel. Clasts are chiefly subrounded to rounded cobbles and pebbles and include various quartz-rich gneisses and schists, and quartzites from the Alaska Range as well as basalt and andesite probably reworked from the older parts of the Tok fan and originally derived from the Wrangell Mountains to the south. Unit locally includes organic deposits (Qor). Areas underlain by this unit are subject to periodic flooding during times of high discharge and, because of the high water table, it may also be prone to liquefaction during seismic events. Exposed thickness about 2 m; estimated maximum thickness 10 m

Floodplain alluvium of Tanana River (Holocene)—Floodplain deposits of Tanana River, including those in recently abandoned channels and low terraces. Upper 1 m of unit, commonly an overbank deposit, consists of dark-olive-gray (5Y 3/2), massive, well-sorted, fine to medium sand, which locally contains minor amounts of pebbles. Poorly exposed lower part of unit consists of unstratified to stratified, well-sorted sand, pebbly sand, and sandy-cobbly pebble gravel. Clasts are chiefly subrounded to rounded and include a high percentage of basaltic and andesitic cobbles and pebbles derived from the Wrangell Mountains to the south, as well as various quartz-rich gneisses and schists, and quartzites from the Alaska Range. Unit locally includes organic (Qor) deposits and alluvium underlying low terraces that are marked by meanders and channel scars (Holmes, 1965) along river. A backhoe pit, in the east-central map area just east of the Tanana River, exposed 30 cm of dark-brown (7.5YR 3/2) peat overlying 90 cm of dark-brown (10YR 3/3) silt. Below the silt is a black (10YR 2/1) peaty unit containing numerous wood fragments. An accelerator mass spectrometer (AMS) radiocarbon age of 1,610±40 yr B.P. (WW-5158) was obtained from a Salix fragment at a depth of 120 cm in lower peat unit, which was also at permafrost depth. Areas underlain by this unit are subject to periodic flooding during times of high discharge and, because of unit's high water table, are also prone to liquefaction during seismic events. Harp and others (2003) observed that in the Tok area nearly every bar along the Tanana River showed extensive liquefaction effects from the November 3, 2002 earthquake. Exposed thickness about 2 m; estimated maximum thickness 20 m

Younger Tok fan deposit (Holocene and late Pleistocene)—Large, low-gradient, poorly drained, younger part of Tok fan deposited by Tok River. Unit occupies large part of southwestern map area. Unit consists mainly of well-stratified, well-sorted, unconsolidated pebble, cobbly pebble, and pebbly cobble gravel. Matrix is light-brownish-gray (10YR 6/2), well-sorted, micaeous, silty fine to medium quartz sand, similar to that of Tok River, and dark-olive-gray (5Y 3/2) medium sand, similar to that of Tanana River. Also contains lenses and layers of sand and pebbly sand, usually less than 25 cm thick. Clasts are chiefly subrounded to rounded and include abundant basaltic and andesitic cobbles and pebbles derived from Copper River drainage to south, as well as various quartz-rich gneisses and schists, and quartzites from the Alaska Range. Unit assigned a Donnelly age by Foster (1970). Unit locally overlain by 10–20 cm of loess consisting of light-yellowish-brown (10YR 6/4) silt and fine sandy silt. Exposed thickness about 3–5 m; estimated maximum thickness 20 m

Terrace alluvium of Tanana River (late Pleistocene)—Poorly exposed, dark-grayish-brown (2.5Y 4/2), well-sorted, massive medium sand, deposited by Tanana River. Approximately 30 cm below top of unit, a thin (2 cm) layer of light-brownish-gray silt contains small gastropod shells. An AMS radiocarbon age of 11,715±40 yr B.P. (WW-5139) was obtained from these shells indicating a late Pleistocene age for the terrace. Unit is commonly overlain by 50 cm of loess consisting of massive, yellowish-brown (10YR 5/4) fine sandy silt. Unit underlies a terrace remnant about 5–6 m above Tanana River floodplain in east-central map area. Thickness 5–6 m

Older Tok fan deposit (middle Pleistocene)—Large, low-gradient, well-drained, nearly featureless fan deposited by Tok River, which occupies southwestern map area and large part of adjacent Tanacross B-5 quadrangle to west (Holmes, 1965; Foster, 1970; Carrara, 2004a). Surface is generally 5–10 m higher than younger Tok fan deposit (Qtfy). Unit consists mainly of well-stratified, well-sorted, unconsolidated pebble, cobbly pebble, and pebbly cobble gravel with a matrix of dark-olive-gray (5Y 3/2) medium sand. Also contains lenses and layers of sand and pebbly sand, usually less than 25 cm thick. In places, upper meter or more of the unit is iron stained (Holmes, 1965; Foster, 1970), and in some areas clasts have a thin (< 2 mm) coating of calcium carbonate. Clasts are chiefly subrounded to rounded and include high percentage (commonly 60–70 percent) of basaltic and andesitic (Holmes, 1965) cobbles and pebbles derived from Copper River drainage to south, as well as various quartz-rich gneisses and schists, and quartzites from Alaska Range. Unit locally overlain by 10–20 cm of loess consisting of a light-yellowish-brown (10YR 6/4) silt and fine sandy silt. Unit assigned a Delta age by Foster (1970); subsequent work indicates that Delta-age deposits are equivalent in age to marine oxygen isotope stage 6 (Begét and Keskinen, 2003), thought to have occurred between about 130 and 188 ky ago (Martinson and others, 1987).
Unit is an aquifer and supplies water to homes and public structures on it. At head of Tok fan, near southern map boundary, water table is at a depth of 40–50 m; in vicinity of town of Tok, water table is about 15–20 m deep; at Tanacross (about 20 km west of Tok) near distal margin of Tok fan, water table is at a depth of 2–4 m (T. Holohan, Holohan Drilling Co., oral commun., 2001; G. Burnham, Burnham Construction Inc., oral commun., 2003). Exposed thickness about 15 m; estimated maximum thickness 50–100 m

Alluvial and colluvial deposits

Colluvium and alluvium (Holocene and late Pleistocene)—Poorly exposed; appears to consist mainly of poorly sorted, poorly stratified, locally organic-rich, silt, silty sand, sand, and pebbly sand deposited by both colluvial and alluvial (including sheetwash) processes. Foster (1970) referred to these deposits as “alluvium and colluvium in small stream valleys” of Holocene age and described unit as consisting of “primarily silt and sand.” Unit occupies valleys and adjacent slopes primarily in the northern map area where it forms broad, gently sloping areas. Permafrost common at depths below 50 cm. Maximum estimated thickness of unit 10 m

Fan deposits (Holocene and late Pleistocene)—Fans deposited mainly by flowing water and debris flows. Poorly exposed; fans on the adjacent Tanacross B-5 quadrangle consist of unstratified to poorly stratified, poorly sorted gravel with pale-brown (10YR 6/3) silty sand matrix (Carrara, 2004a). Clasts are angular to subangular cobbles and boulders mainly of fine-grained biotite and biotite-hornblende granodiorite, although a small fan along western map border north of Tanana River is composed of dark-gray basalt clasts. Unit’s surface may contain bouldery debris flow levees about 1 m high. Locally, may include colluvium and sheetwash alluvium. Unit is subject to both flood and debris-flow hazards from adjacent uplands. Estimated maximum thickness 20 m

Colluvial deposits

Landslide deposits (Holocene and late Pleistocene)—Two landslide deposits were identified within map area. Variations in size and lithology of clasts and matrix depend on various bedrock and surficial deposits involved in the landslide. One of the deposits, near confluence of Tanana River and Porcupine Creek, was inspected in August 2003. Trunks of many large white spruces on this small landslide were tilted and split by recent movement, and ground contained “pull-apart” trenches 1–2 m deep and 3–5 m across. This deposit may have been induced by magnitude 7.9 earthquake of November 3, 2002, which triggered thousands of landslides in nearby Alaska Range and surrounding areas (Harp and others, 2003). Maximum thickness of unit estimated to be about 10 m

Eolian deposits

Loess (Holocene)—Mainly light-grayish-brown (10YR 6/2) and light-yellowish-brown (10YR 6/4) to brown (10YR 5/3), massive silt and fine sandy silt deposited by wind. Mapped at only two localities in map area, immediately east of Tanana River and north of Alaska Highway and in area west of mouth of Porcupine Creek. Loess was noted at many locations in map area, but was not mapped in most cases as it is generally less than 25 cm thick and has no geomorphic expression. Unit locally contains a White River Ash layer, usually 3–5 cm thick, in its upper 20 cm indicating a late Holocene age. At several locations unit overlies eolian sand (Qes). Maximum thickness 3–5 m

Eolian sand (late Pleistocene)—Sand deposited by wind at several locations north and east of Tanana River. Unit consists of massive to poorly bedded, olive-gray (5Y 4/2), fine- to medium-grained sand in sand sheets and dunes. The largest dune field in map area, extending from Tetlin Junction north along Taylor Highway for a distance of about 10 km, forms a field of parabolic dunes with as much as 30 m of local relief. Sand within these dunes was found to consist of “about 2 percent magnetite and 35 percent dark-gray to black fine-grained rock fragments which give it the dark color. About 50 percent of the sand is quartz, feldspar, and small fragments of granitic and metamorphic rocks” (Foster and Keith, 1969, p. 6). Many sand grains are rounded and frosted by wind action (Foster and Keith, 1969). Orientation of dunes indicates they were formed by strong winds from the southwest. Although regional late Pleistocene winds were from north (Lea and Waythomas, 1990), this large dune field was probably deposited by katabatic winds that drained an ice field in the Copper River basin and funneled a high-velocity wind down the Tok River Valley. The wind scoured sand from the Tanana River floodplain and deposited it north and east of river forming this large dune field. Unit is well drained and presently stabilized by a forest of mainly quaking aspen and white spruce. Unit is locally overlain by 10–30 cm of loess, which locally contains White River ash. Stippled pattern indicates areas of dunes. Maximum thickness about 30 m

Lacustrine deposits

Lacustrine deposits (late Pleistocene)—Mainly dark-grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2), well-sorted, well-bedded, fine to medium sand eroded from nearby deposits of eolian sand (Qes) with which it is thought to be contemporaneous, and deposited in former lakes. Unit locally contains thin (< 1 cm) clay and silty layers, and a few pebbly sand layers less than 10 cm thick. Mapped at two localities, both along Porcupine Creek in east-central map area. At eastern location an exposure along Taylor Highway, first described by Foster and Keith (1969), consists of about 12 m of well-bedded, lacustrine sand overlain by 5 m of dark-grayish-brown (10YR 4/2), fine to medium eolian sand. An AMS radiocarbon age of 12,515±40 yr B.P. (WW-3861) was obtained from small freshwater bivalves near top of lake beds. Radiocarbon age provides a close minimum age for unit. Additional evidence of a late Pleistocene age for these lacustrine deposits was found at larger western deposit. In a stream cut along Porcupine Creek, lacustrine sand contains several thin (0.5–1 cm) peaty layers. Pollen analysis of these peaty layers indicates presence of shrub-herb tundra whereas present pollen spectra at this site is that of boreal forest. Shrub-herb tundra suggests harsh periglacial climate present during the late Pleistocene (T.A. Ager, U.S. Geological Survey, written commun., 2003). In addition, at this site lacustrine sand is underlain by a dark-green to dark-brown, poorly laminated, organic-rich clayey silt. Salix fragments near top of this clayey silt unit yielded an AMS radiocarbon age of 41,880±470 yr B.P. (Beta-171226), providing a maximum age for lacustrine sand. Maximum thickness about 15 m

Organic deposits

Organic-rich deposits (Holocene and late Pleistocene)—Mainly black (10YR 2/1) to brown (10YR 4/3) peat, woody peat, muck, and organic-rich sand, silt, and clay. Unit occurs mainly in low-lying areas mostly on floodplain of Tanana River. As limits of this unit were hard to identify in the field and on aerial photographs, in most cases unit boundaries were taken directly from those areas mapped as marsh on topographic base. Areas underlain by this unit have poor drainage and a high water table, are subject to periodic flooding, and may contain permafrost at shallow depths. Thickness 1–10 m

BEDROCK

Granitic, metamorphic, and volcanic rocks (Quaternary(?) to Paleozoic)— Mountain near western map border north of Tanana River is composed of dark-gray or dark-greenish-gray basalt believed to be Quaternary or Tertiary in age (Foster, 1970). In northeastern map area, Foster (1970) identified felsic volcanic rocks consisting of light-colored lava, tuff, tuff breccia, pumice breccia, volcanic conglomerate, and tuffaceous sediments of Tertiary age. Much of remaining bedrock in map area is primarily granitic rocks of Mesozoic age, consisting of mainly fine-grained biotite and biotite-hornblende granodiorite but ranging in composition from diorite to granite or biotite gneiss and schist of Paleozoic or Precambrian age (Foster, 1970)

Contact

Terrace scarp—Hachures on downside

Escarpment in sand dune field—Hachures on downside

Abandoned river meander

Pingo

Volcanic ash site

Radiocarbon age site

Gravel pit

Depositional wind direction, as indicated by dune form

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