Map Unit Properties Table: Denali National Park and Preserve (Large Scale [1:63,360] Map Units)

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
QUATERNARY	Peat (**Qp**) Artificial Fill and Excavation Sites (**Qh**) Undifferentiated Stream Alluvium (**Qa**) Stream Gravel (**Qsg**) Alluvial Fan Deposits (**Qaf**) Outwash Gravel (**Qo**) Floodplain Alluvium (**Qfp**)	**Qp** contains dense, dark organic material, often found in boggy areas. **Qh** is composed of pebbles, cobbles, gravels, sand, and silt beneath roads and former gravel pits. Unit is well- to poorly sorted. **Qa** includes stream gravel, pebbles, cobbles, sand, and silt, with some boulders in well-stratified and moderately sorted channels, floodplains, and low terraces. Stream gravel (**Qsg**) is present in active streambeds. **Qaf** contains fan-shaped, heterogeneous strata of gravels, sands, silts, and boulders. Some debris flow deposits present locally. **Qo** contains gravel in layers fluvially deposited and well sorted. **Qfp** consists of elongate deposits of fluvial sand, gravel, and silt with scattered boulders. Unit is well- to moderately sorted, well-stratified, often mantled by thin silt-clay layers. Some terrace deposits locally.	Low to very low.	Hummocky topography and scarps make **Qfp** unstable if water saturated.	Units are prone to rapid erosion during flood events, slope failure if undercut, and slope creep, especially when water saturated.	Modern remains possible; pollen, plant macrofossils, insects.	May contain campsites, settlements, and other artifacts. Historic mining?	Gravel, sand, silt, and clay. Placer deposits? Congeliturbate deposited along Alaska Railroad between Lagoon and Carlo.	None.	**Qa** supports extensive willow-alder thickets and other riparian habitats. **Qfp** supports bog environments and riparian zones.	Units are suitable for most recreation. Avoid development of use-areas on riparian zones and undercut floodplain areas.	Units record most recent geologic activity in the area.
	Undifferentiated Colluvium (**Qc**) Landslide Deposits (**Qcl**) Talus and Rubble Deposits (**Qct**) Rock Glacier Deposits (**Qrg**)	Units contain irregular masses, aprons, tongues, and fans of angular rock fragments, sand, and gravel. May include drift and outwash. Surface expression often mirrors underlying rock structure. Medium to thickly bedded layers of lobed and terraced deposits. Rubble includes blocks up to 15 m in diameter. **Qct** contains mostly large blocks, with little- to no matrix material such as silt and sand. **Qrg** includes mixtures of blocks, ice, gravel, sand, and silt in tongue- and fan-shaped masses with very irregular surfaces.	Low.	Units are often found at the base of unstable slopes. Surfaces are usually steep and irregular with large spaces between blocks; unsuitable for most forms of infrastructure.	Units are associated with mass movement processes, including sliding, rolling frost creep, gelifluction, and flowing. Open work rubble surfaces are dangerous. Extensive ground cracks present locally.	Modern remains possible; pollen, plant macrofossils, insects.	None documented.	Sand, gravel, and boulders.	None.	Lichen communities help determine relative ages of deposits. Units may support large trees if old enough.	Avoid for recreational use; dangerous surfaces associated with units.	Units record recent slope processes in the area; vegetation patterns can date slide activity.
	Swamp Deposits (**Qs**) Outwash Alluvium (**Qao**) Colluvial-Alluvial Valley Fill, Fan, and Apron Deposits (**Qcf**) Terrace Gravel (**Qtg**) Abandoned Channel Deposits (**Qac**) Terrace Alluvium (**Qat**)	**Qs** includes water/ice-saturated layered peat, and organic silt and sand of variable thickness. **Qao** and **Qcf** contain elongate, apron, tongue- and fan-shaped heterogeneous mixtures of boulder, pebbles, and cobbles with matrices composed of sand and silt in thick beds. Terrace and channel gravels (**Qtg**, **Qac**, **Qat**) are typically more rounded than angular cobbles, and are well sorted with local crossbeds and smooth surfaces.	Low.	Slopes and scarps associated with **Qao** and **Qtg** may be too unstable for heavy infrastructure. High permeability of these units are probably not suitable for waste-water treatment facilities.	**Qcf** is associated with debris flow mechanisms, and may include avalanche deposits.	Peat, plant fragments.	May contain campsites, settlements and other artifacts. Historic mining?	Sand, silt, and gravel. Placer deposits?	None.	Units contain bogs, wetlands, and riparian environments.	Fine for most light recreation. Avoid development of use-areas on riparian zones and undercut floodplain areas.	Units record Quaternary fluvial activity in the area.

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Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
QUATERNARY	Till of Latest Holocene Age (**Qt2**) Till of Early to Middle Holocene Age (**Qt1**) Alluvium (**Qca**) Outwash Gravel (**Qco**) Sand (**Qcls**) End Moraine of the Carlo Readvance (**Qcm**)	Units contain heterogeneous mixtures of pebbles, cobbles, sand, silt, and clay with scant boulders. Some ice may exist locally. Surfaces of till units are often hummocky with morainal topography. **Qcls** is deposited in a dammed lake behind the end of the Carlo Readvance.	Low to very low for sand-rich units	Heterogeneous nature of these unconsolidated units renders them unstable on slopes and too permeable for waste treatment.	Units are associated with slumping and mass movements; hummocky topography is difficult to traverse.	Modern remains possible; pollen, plant macrofossils, insects.	May contain campsites, settlements, and other artifacts.	Sand, silt, and gravel. Placer deposits?	None.	**Qt1** supports some soil development with lichens, mosses, and tundra herbs.	Units are fine for most light recreation. Avoid areas of very large rubble.	Unit records latest glacial activity in the area.
	Alluvium and Pediment Gravel (**Qra**) Younger Alluvium and Pediment Gravel (**Qra2**) Older Alluvium and Pediment Gravel (**Qra1**) Varved Clay (**Qrlc**) Outwash Gravel (**Qro**) Rubble of Jumbo Dome (**Qrr**) Glacial Moraine Deposits (**Qrm**)	Units contain mixed pebbles, gravels, and sands in smooth surfaced lobes and pediments. **Qrlc** was deposited in glacial lakes prior to the Carlo Readvance. **Qrr** is composed of inactive (non-flowing) rock glaciers and solifluction sheets cored with ice. **Qrm** contains till with extremely heterogeneous mixtures of boulders, pebbles, and clay with some outwash deposits interlayered.	Low.	Heterogeneous nature of these unconsolidated units renders them unstable, especially if water-saturated and/or present on undercut slopes.	Units are susceptible to frost creep, erosion, and mass wasting. Open work rubble surfaces are dangerous. Extensive ground cracks present locally.	Modern remains possible; pollen, plant macrofossils, insects.	May contain campsites, settlements, and other artifacts.	Gravel and sand; igneous stone rubble.	None.	Unit supports valley floor vegetation, some riparian zones.	Units are fine for most light recreation. Avoid areas of very large rubble.	Varved clays record seasonal cycles of deposition associated with glacial lakes.
	Varved Clay and Silt (**Qhlc**) Alluvium and Pediment Gravel (**Qha**) Outwash Gravel (**Qho**) Rubble of Jumbo Dome (**Qhr**) Morainal Deposits (**Qhm**) Glacial Erratics (**Qhe**) Lacustrine Silt and Clay (**Qhl**)	Units contain layered clays, gravels, pebbles, and sands, as well as large boulders floated on ice rafts across glacial lakes (including Glacial Lake Moody). Morainal deposits include cobbles and boulders with a gravel-sand-silt matrix.	Low to very low for clay-rich units.	Heterogeneous nature of these unconsolidated units renders them unstable, especially if water-saturated and/or present on undercut slopes.	Boulders and other large rocks may weather out of finer-grained matrix and pose rockfall hazard; units are susceptible to erosion and gullying.	Plant fragments.	None documented.	Clay, gravel, sand, and boulders.	None.	None documented.	Avoid areas of very large rubble for recreational opportunity development.	Units record glacial activity. Varved clays record seasonal cycles of deposition associated with glacial lakes.

Map Unit Properties Table: Denali National Park and Preserve (Large Scale [1:63,360] Map Units)

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
QUATERNARY	Delta Gravel (**Qhd**) Drift of Late Wisconsin Age (**Qd**) Outwash Gravel (**Qdo**) Rubble of Jumbo Dome (**Qdr**) Morainal Deposits (**Qdm**) Lacustrine Silt and Clay (**Qdl**)	**Qhd** is gravel contained in tongue- to lobe-shaped layered deposits. **Qd** is composed of blanket deposits of heterogeneous pebble, gravel, cobble, sand, silt, and clay interlayers. Some large (2-m) boulders present locally. Sorting and bedding depends on degree of reworking by fluvial processes. Eskers present locally. Loess silt often blankets these units up to 1 m thick. Other units (**Qdo**, **Qdr**, **Qdm**, **Qdl**) range from scattered rubble, to layered heterogeneous lobes, to well-bedded silts and clays from lake deposits.	Low.	Eskers and diamictons may form steep slopes that would be unstable for infrastructure.	Scarps and slopes associated with these units are prone to mass movement and slope failures.	Modern remains possible; pollen, plant macrofossils, insects.	May contain campsites, settlements, and other artifacts.	Gravel, sand, and silt.	None.	Units support vegetation that prefers strong drainage.	Avoid areas of very large rubble for recreational opportunity development.	Clay-rich diamictons and eskers showcase glacial landforms.
QUATERNARY	Glacial Erratics (**Qde**) Alluvium and Pediment Gravel (**Qba**) Outwash Gravel (**Qbo**) Glacial Erratics (**Qbe**) Colluvium (**Qpc**) Terrace and Pediment Gravel (**Qtp**) Dune Sand (**Qsd**) Rubble, Possibly Rock Glacier Origin (**Qrb**)	Units contain large, scant boulders dropped from drifting glacial ice, as well as angular slope deposits in lobe- to fan shapes. Gravels and sands are better sorted than heterogeneous rubble and boulders, possibly associated with an ice-cored rock glacier.	Low.	Colluvial units are often found at the base of unstable slopes. Surfaces are usually steep and irregular with large spaces between blocks.	Units are susceptible to frost creep, erosion, and mass wasting. Open work rubble surfaces are dangerous.	Modern remains possible; pollen, plant macrofossils, insects.	None documented.	Gravel, sand, and boulders.	None.	None documented.	Avoid areas of very large rubble for recreational opportunity development.	Glacial erratics are an interesting interpretive topic, and contain clues to glacial provenance.
QUATERNARY - TERTIARY	Hornblende Dacite of Jumbo Dome (**QThj**)	Unit contains hornblende-rich basaltic igneous intrusives.	High.	Suitable for most forms of infrastructure unless highly fractured and/or altered.	Unit associated with sheet-like exfoliation, which may lead to rockfall hazards.	None.	None documented.	Hornblende phenocrysts.	None.	Unit may alter to form calcium-, aluminum-, and magnesium-rich soils.	Unit is fine for most forms of recreation; may attract climbers.	Isotopically-determined date on this unit of 2.72 ± 0.25 million years.
TERTIARY AND OLDER	Thinly Covered Bedrock (**Ttcb**)	Undifferentiated bedrock of various ages overlain by thin layers of unspecified surficial deposits.	Variable, depending on properties of underlying bedrock and surficial deposits.			Unknown. Resources from bedrock units may be present.				Variable, depending on properties of underlying bedrock and surficial deposits.		Indicates where bedrock is located near the surface.

Map Unit Properties Table: Denali National Park and Preserve (Large Scale [1:63,360] Map Units)

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
TERTIARY	Nenana Gravel (**Tn**) Coal Bearing Group, Undivided (**Tcu**) Lignite Creek Formation (**Tlc**) Gravel and Sand (**Ts**) Grubstake and Lignite Creek Formations, Undivided (**Tgl**)	**Tn** contains poorly consolidated layers of buff to reddish-brown pebble and boulder conglomerate with coarse sandstone, mudflow, and claystone interbeds. Some lignite present locally. **Tlc** contains crossbedded arkosic sandstone with pebble conglomeratic lenses and clay interbeds. Unit is mostly buff colored. **Ts** contains orangish- to buff colored sandy pebble, cobble, and gravel conglomeratic beds. Unit is typically well sorted and massively bedded with horizontal layering and crossbeds. Sands occur as broad lenses with total thickness ranges from 6 to 45 m. **Tgl** contains greenish-gray siltstone and claystone with some interbedded pebbly arkosic sandstone and silt and clay layers.	Moderately low.	**Ts** is exposed as cliffs in stream-incised areas, and may prove unstable on slopes. Units are permeable, but may be utilizable for waste water treatment. Avoid poorly consolidated areas for infrastructure.	**Ts** is prone to gullying and cliff formation, which may pose rockfall and mass movement hazards.	Pollen.	Chert pebbles may have provided tool material.	Lignite, sand, gravel, clay, and subbituminous coal.	None.	Units support wide range of habitats.	Units are fine for most recreation unless highly weathered, rendering them unstable for trail base.	Chert, argillite, graywacke, volcanic rocks, Felsic to intermediate intrusive rocks, and Cantwell conglomeratic clasts indicate source area.
	Suntrana Formation (**Tsn**) Sanctuary Formation (**Tsc**) Healy Creek Formation (**Thc**) Coal Bearing Sandstone (**Tcs**)	**Tsn** contains crossbedded pebbly sandstone, poorly consolidated and interbedded with silty claystone and some coal lenses. Appears white on weathered surfaces. **Tsc** is poorly consolidated and weathers brown- to gray with abundant banded (varved?) shale. **Thc** contains clay-rich quartz and micaceous sandstone, some quartz-chert conglomerate, claystone, and coal interbeds. Unit is poorly consolidated. **Tcs** is pebbly sandstone and conglomerate with lignite, silty claystone, and carbonaceous claystone interbeds.	Moderately low to low where consoli-dation is poor.	Most units are poorly consolidated, which may render them unsuitable for heavy infrastructure.	**Tsc** is extremely susceptible to landslides and slope creep.	Potential plant fossils associated with coal beds.	Chert pebbles may have provided tool material.	Subbituminous coal lenses, conglomerate, sand, gravel, clay, and silt. Lignite 3 to 6 m thick are correlative with nearby Dunkle coal mine deposits.	Not enough carbonate present.	Units support wide range of habitats.	Poor consolidation of units may render them too unstable for heavy recreational use.	Contains Oligocene coal units.
	Rhyolite (**Tr**) Latite (**Tl**) Andesite Plugs, Hypabyssal Intrusions, Plug-Domes and Associated Flows and Breccia (**Ti**) Vent Breccia (**Tvb**) Biotite Granite (**Tg**) Basaltic Composition Dikes (**Tb**) Diabase Sills (**Tdb**)	**Tr** contains assorted felsic volcanic extrusive layers in widespread deposits. Units contain intermediate composition (Si content) igneous intrusive, as well as basaltic composition flows and intrusive dikes. Volcanic breccia indicating forceful eruptions present locally. **Tg** is fine-grained in dikes to coarser-grained irregular intrusions with alkali feldspar, biotite, ilmenite, and quartz. Unit is commonly intruded by basaltic or lamprophyric dikes. **Tb** are narrow (0.3- to 2-m) basaltic dikes cutting older granites with abundant phenocrysts. **Tdb** are intrusive into the Cantwell Formation (**Tc**)	Moderately high to high.	Units may contain radon emitting materials. Avoid for basements and foundations.	Blockfall and exfoliation of large sheets of rock associated with several units.	None.	Phenocrysts may have provided trade material.	Geodes; **Tb** contains clinopyroxene phenocrysts. Tourmaline, zinnwaldite, topaz, zircon, apatite, and fluorite.	None.	Unit may weather to enriched soils.	Phenocrysts and other sharp fragments associated with unweathered portions of these units may prove undesirable for trail base.	**Tg** is dated by argon isotopes at 46 to 55 million years (composition indicates felsic magma source). **Tb** is dated by argon isotopes at 52 million years, with magnetic signature indicating early Tertiary paleolatitude?
	Cantwell Formation (**Tc**) Cantwell Formation, Tuff Bed (**Tct**)	Unit contains buff- to light gray sandstone and pebble conglomerate with some darker layers, siltstone, and shale interbedded. Several volcanic tuff layers are present locally (**Tct**). Unit is moderately- to well consolidated and provides bedrock source material for colluvial deposits.	Moderate.	Units are fine for most infrastructure unless highly heterogeneous and/or fractured	Unit is associated with slope processes, including landslides.	None documented in large scale source maps. See **Kcs** on small scale data table, below.	Abundant chert pebbles may have provided tool material.	Building stone.	Not enough carbonate present.	Units support slope preferring vegetation.	Units are fine for most recreation.	Source rocks well documented from volcanic rocks to the south.

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Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
MESOZOIC	Granite (**MZgr**)	Undifferentiated granite found in irregular bodies with no clear crosscutting relationships to place in an age bracket. Granite contains quartz, feldspar, biotite, and hornblende with various accessory minerals.	High.	Unit may alter into materials known to cause radon problems.	Sheet-like exfoliation of unit may pose blockfall hazard.	None.	Phenocrysts may have been used for trade materials.	Accessory minerals and phenocrysts. Building material.	None.	None documented.	Fine for most recreation unless highly fractured and/or altered.	Unit is widespread.
CRETACEOUS	Hornblende Biotite Granite (**Kg**) Intermediate Composition Plutonic Rocks (**Km**) Rhyolite Intrusive into the Cantwell Formation (**Kr**) Diabase Intrusive into the Cantwell Formation and Basalt Intrusive into the Birch Creek Schist (**Kdb**) Andesite Intrusive into the Cantwell Formation (**Ka**)	**Kg** is present in narrow dikes and small stocks with granitic porphyry textures of monzogranite to syenogranite compositions. Grain size ranges from less than 2 mm to 2 cm. Unit grades into **Km**, which contains northeast/southwest-oriented stocks and dikes with textures ranging from fine-grained porphyritic to medium grained. Unit is generally quartz poor with monzodiorite, monzonite, and diorite compositions, and alters to chlorite, carbonate, sericite, albite, epidote, and pyrite. Intrusions into **Tc** indicate a younger age for the unit than previously thought, additional investigation is needed to resolve. Compositions range from felsic to intermediate to mafic (basaltic), and most are present as narrow dikes.	Moderately high to high depending on degree of weathering.	Units may contain radon producing materials. Avoid for basements; avoid heavily fractured areas.	Units are susceptible to rockfall hazards on slopes.	None.	Pyrite may have been used for starting fires.	Hornblende phenocrysts, zircon, apatite, ilmenite, muscovite, and rutile. Hydrothermal alteration minerals include chlorite, calcite, and white mica.	None.	Units may give rise to fertile soils.	Suitable for most recreation; may be attractive to climbers.	**Kg** has minimum age of 61.4 to 71 million years (determined by argon isotopes) origin is likely volcanic island arc-related. **Km** is dated at 67 to 71 million years. Associated with gold-related Kuskokwim Mountains magmatic belt event.
CRETACEOUS - DEVONIAN	Undifferentiated Sedimentary Rocks of Devonian to Cretaceous Age (**KDu**)	Heterogeneous mix of sedimentary rocks, including sandstone, claystone, shale, limestone, conglomerate, and tuff (volcanic ash fall).	Moderate; variable among units.	Units are fine for most infrastructure unless highly heterogeneous and/or fractured.	Heterogeneous layers of these units may be prone to mass wasting; shrink-and-swell clays may be present in volcanic ash units.	Various fossils, none specified.	None documented.	Building stone.	Possible in limestone-rich units.	Units support wide range of habitats.	Units are fine for most recreation.	Records eras of sedimentary deposition settings.
CRETACEOUS - JURASSIC	Calcareous Sandstone and Argillite, with Coquinoid Limestone (**KJs**) Argillite and Sandstone (**KJas**) Sandstone and Argillite (**KJsa**) Conglomerate (**KJc**)	Units are rich in gray, poorly sorted sub-angular to sub-rounded lithic sandstones mixed with argillite layers and coquinoids locally. Some of the sandstone is calcareous (e.g., **KJs**). In outcrop, units weather to an orangish-brown color. Bedding is predominantly thin, parallel, and sheet-like. Some isoclinal folding is present, leaving cleavage in the argillaceous lithologies. **KJas** contains dark gray and black argillite and sandstone. Unit weathers orangish-brown with prominent cleavage parallel to bedding. Some white quartz veining is present locally. Argillite accounts for a smaller percentage in the lower units (e.g., **KJsa**), with massive sandstone beds becoming more prominent. Lowermost unit (**KJc**) is conglomerate with sandstone matrix. Clasts are mostly quartz, chert, and argillite.	Moderate to moderately high, depending on degree of weathering.	Prominent cleavage, thin bedding, heterogeneous composition, and minor dissolution in these units may render them weak on slopes for heavy infrastructure.	Slaty layers are prone to slides, and conglomeratic blocks may pose rockfall hazard if underlain by weaker claystone units.	Coquinoid beds with *Buchia sublaevis* shells in 2-m-thick layer (Lower Cretaceous age).	Chert nodules may have provided tool material; pyrite may have been used to start fires.	**KJas** contains white quartz veins, sulfides, crystal filled vugs, and fractures; **KJsa** contains rare tripolitic chert and white mica. Building stones.	Minor carbonate dissolution is possible in coquinoid layers.	Units support wide range of habitats.	Units are fine for most recreation.	Unit records orogenic provenance of sediments in a shallow (<125 m) shelf environment.

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JURASSIC	Argillite, Cherty Argillite, and Minor Cherty Tuff and Basaltic Tuff (**Jac**) Calcareous Sandstone, Sandy Limestone, and Argillite (**Js**)	**Jac** is mostly deformed and slightly metamorphosed argillite with some minor chert-rich layers and tuff layers. Chert is light gray to black. Sheared areas are phyllitic. **Js** is thin to medium bedded, calcareous sandstone, with minor interbeds of limestone and argillite.	Moderate.	Suitable for most infrastructure unless highly altered and/or fractured. Avoid phosphatic areas.	Altered tuff layers may contain shrink-and-swell clays.	Radiolaria, ammonites, other Jurassic fossils.	Chert nodules may have provided tool material.	Phyllite. Phosphates in **Js**.	Not enough carbonate present.	Unit may produce soils rich in phosphorus.	Unit is fine for most light recreation. Avoid finely bedded areas for stability.	Radiolarians restrict **Jac** to Late Jurassic age. Ammonites in **Js** are Early Jurassic age (Sinemurian).
TRIASSIC	Redbed Sandstone and Conglomerate (**TRrb**) Brown Sandstone and Argillite (**TRs**) Limestone (**TRul**)	**TRrb** contains calcareous sandstone, siltstone, and conglomerate layers that weather to reddish-maroon colors. Hematite lends color to this unit; clasts are mostly well-rounded quartz, basalt, and volcaniclastics. **TRs** contains thick-bedded yellowish-brown sandstone, argillite, and minor calcareous sandstone and limestone. **TRul** contains thick-bedded limestone, with shale, siltstone, and mudstone interbeds. Lithologies include 300 m of mudstone, wackestone, packstone, and rudstone.	Moderate to moderately high.	Units may contain shrink-and-swell clays; heterogeneous layering may be unstable on slopes. Fine for most infrastructure unless highly fractured.	If massive layers are underlain by weaker layers locally, rockfall hazard may result.	**TRs** contains *Heterastridium* (4-cm diameter), snails, and bivalves. **TRul** contains scleractinian thicket reefs, brachiopods, corals, bivalves, and gastropods.	Caves possible in this unit; may have been settlement areas.	Building stones.	Karst features such as dissolution holes and caves are possible for lower unit.	Units weather to calcium- and iron-rich soils locally.	Fine for most recreation; if caves are present, may attract speleologists.	Fossils record Late Triassic age; near-shore environment grading offshore in lower units.
TRIASSIC	Basalt, Basaltic Tuff, and Limestone (**TRlb**) Basaltic Dikes and Sills (**TRb**) Intrusive Greenstone (**TRgn**) Red Colored Tuff, Andesite, Basalt, Graywacke, Conglomerate (**TRvs**) Limestone (**TRll**)	**TRlb** is a massive stack of basalt and basaltic tuff layers, 50 to 100 m thick, with fine-grained gray limestone interbeds. Basalt is tholeiitic and strongly magnetic. Alteration minerals include chlorite, albite, carbonate, and hematite. Unit is commonly intruded by fine-grained equigranular to porphyritic basaltic dikes and sills (**TRb**). **TRgn** is an intrusive greenstone unit. **TRvs** contains a red-weathered stack of volcanic and volcaniclastics, including lithic tuff, conglomerate, graywacke, tuffaceous siltstone, and mudstone with some basalt and dacite flows. Calcareous cements and clasts are present. Lithic fragments include quartz, felsic volcanics, and plutonic and metamorphic rocks. Unit was exposed to contact metamorphism near Cretaceous plutons. **TRll** is thin-bedded, light gray to brown on weathered surfaces composed of carbonaceous mudstone and packstone present in fault-bounded slivers.	Moderate.	Calcareous layers and cements may dissolve, rendering unit unstable in some areas; units may contain shrink-and-swell clays. Avoid for heavy infrastructure.	If carbonate layers and cements are dissolved, rockfall hazards exist; heavily altered layers may fail when water saturated on slopes.	Limestone layers include colonial scleractinian corals, megalodontid bivalves, and brachiopod *Spondylospira lewesensis*; **TRll** contains at least 13 species of ammonites.	None documented.	Chlorite, albite, clinopyroxene, and hornblende. Tin-type mineralization; gold, silver, beryllium, uranium, rubidium, boron, cobalt, and nickel resources.	Dissolution possible for limestone interbeds.	Units weather to produce iron-, magnesium-, and aluminum-rich soils.	Fine for most recreation unless heavily altered and/or dissolved locally; may interfere with compass readings (**TRb** is strongly magnetic).	Basalts contain magnetite recording paleolatitudes of 5 degrees, possibly of hotspot origin correlative with Nikolai Greenstone flood basalts? **TRb** has argon isotope date of 179 million years. **TRvs** correlates with Tangle subterrane. **TRll** contains fossils found in northern Washington.
PERMIAN	Limestone (**Pl**)	Unit is approximately 100 m thick with a succession of limestone. Lower beds are medium- to thick-bedded limestone (packstone to grainstone). Upper unit contains light gray silicified mudstone, packstone, and grainstone. Unit weathers to orange-yellow-brown color.	Moderate.	Unit may be friable and too permeable for wastewater treatment infrastructure.	Dissolution may pose sinkhole hazard; susceptible to rockfall if highly dissolved on slopes.	Horridonid brachiopods, bryozoans, pelmatozoan debris, solitary rugose corals, ostracodes, and trilobites.	Caves possible in this unit; may have been settlement areas.	None documented.	Karst features such as dissolution holes and caves are possible.	Unit weathers to basic calcium- and magnesium-rich soils.	Avoid heavily dissolved areas for recreation; any caves may attract speleologists.	Unit contains megafauna of "Arctic Permian" type.

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Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
PERMIAN - PENNSYLVANIAN	Permian Mudstone and Graywacke (**PPNs**)	Unit is at least 200 m thick with thinly bedded mudstone and graywacke. Lower beds are gray-green graywacke turbidites that weather to yellow-brown, composed of lithic sandstones with thin intervals of mudstones. Thin-bedded, medium to dark gray and yellow-brown mudstone and siltstone comprise upper beds.	Moderate.	Unit is relatively weak and unstable for most heavy infrastructure, especially if exposed on slope.	Unit is prone to mass wasting hazards, including slumping, slope creep, and possibly debris flows if unvegetated slopes are water saturated.	Trace fossils of ichnogenera *Chondrites* and *Scalarituba*; some brachiopods, bivalves, and bryozoans.	None documented.	None documented.	Not enough carbonate present.	None documented.	Unstable on slopes. Avoid for most use.	Unit records transition from Pennsylvanian to Permian in the area with conformable contacts.
PALEOZOIC	Tuff (**PZt**) Argillite and Tuff (**PZst**) Chert, Argillite, and Graywacke (**PZs**) Rhyolite Schist (**PZr**) Greenstone and Metamorphosed Basic to Intermediate Agglomerate (**PZga**) Marble (**PZm**) Schist of Sedimentary Origin (**PZss**)	**PZt** contains a mélange of dark gray-green andesitic to rhyodacitic composition ash and crystal tuff, subordinate argillite, and cherty argillite, siltstone, and graywacke, and minor volcanic flows. Bedding ranges from fine and flinty to more massive and crystalline. **PZst** contains similar assemblages with more siltstone and chert. **PZs** contains bedded chert, carbonaceous, fissile black argillite with yellow- and orange-weathering salts, basalt, cherty tuff, green volcaniclastic rock, siltstone, greywacke, and white quartz–pebble and black argillite conglomerate. **PZr** is metamorphosed silica-rich volcanic deposits. Units become less volcanic to more sedimentary, including metamorphosed limestone (marble) (**PZm**) and other mixed, slightly metamorphosed schists (**PZss**).	Moderately high.	Heterogeneous nature of units may render them unstable on slopes. Some units may contain radon-emitting materials and shrink-and-swell clays if altered.	Unit is susceptible to slope processes, including blockfall, landslides, slumping, and slope creep for finer grained units.	Radiolaria.	Massive chert deposits may have provided tool material.	Volcanic breccia, red argillite, and marble. Building material.	Some dissolution possible in limestone interbeds.	None documented.	Units fine for most recreation unless heavily altered.	Records basinwide volcanism and coincident sedimentary deposition as part of "West Fork terrane."
MISSISSIPPIAN	Moose Creek Member (**Mtmg**)	Unit is composed of slightly metamorphosed basaltic to intermediate composition volcanic rocks. Green metavolcanic schists dominate this unit.	Moderately high.	Unit is fine for most infrastructure unless heavily altered and/or fractured.	Rockfall hazard when unit is exposed on slope.	None.	None documented.	Chlorite, epidote, and green micas.	None.	Unit weathers to iron- and magnesium-rich soils.	Units fine for most recreation unless heavily altered.	Unit records Mississippian-age volcanism.
DEVONIAN	Andesitic Tuff and Flows (**Dv**) Red and Brown Chert (**Dc**) Limestone (**Dl**)	**Dv** contains green-weathering, pyroxene andesite tuff and flows, with compositions ranging from island-arc tholeiitic basalt (locally pillowed) to dacitic tuff. The lower contact is interlayered with massive red and brown ferruginous and manganiferous radiolarian chert (**Dc**). Slight greenschist metamorphism is prevalent with alteration minerals, including chlorite, albite, carbonate, and epidote. **Dl** contains medium- to thick-bedded, medium to dark gray lime mudstone to wackestone that is locally fossiliferous.	Moderately high depending on degree of weathering.	Unit may contain radon-emitting materials and shrink-and-swell clays if altered.	Shrink-and-swell clays may buckle trail bases and may be slippery when water saturated; rockfall hazard associated with resistant units underlain by weaker units.	Radiolaria; **Dl** contains rugose and tabulate corals, brachiopods, conodonts, and assorted megafossils.	Massive chert deposits may have provided tool material.	Manganese- and iron-rich cherts.	Karst features such as dissolution holes and caves are possibly found in **Dl**.	Unit weathers to iron- and magnesium-rich soils.	Units fine for most recreation unless heavily altered.	**Dv** correlates with **Dc** and **UNKsp** as part of an island arc complex; units record Devonian island arc and basin depositional setting.

Map Unit Properties Table: Denali National Park and Preserve (Large Scale [1:63,360] Map Units)

Age	Unit Name (Symbol)	Features and Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
PRECAMBRIAN OR PALEOZOIC	Keevy Peak Formation (**PZPCkp**) Birch Creek Black Carbonaceous Schist (**PZPCbcb**) Schist and Slate (**PZPCss**) Gneiss and Schist (**PZPCgs**) Schist, Quartzite, and Marble (**PZPCsqm**) Stretched Conglomerate (**PZPCscg**) Schist (**PZPCsch**) Birch Creek Schist (**PZPCbc**)	**PZPCkp** contains a heterogeneous mixture of quartz-sericite schist, quartzite, and purple and green schist interlayered with slate arkosic gritlike schist, marble, and scant limy schist. **PZPCcb** contains a similar assemblage with local layers of green chloritic and epidotic schist and impure marble. **PZPCss** contains fine-grained yellow, pale-green, and maroon schist and slate with some quartz-sericite schist and meta-chert. **PZPCgs** contains microcline and quartz gneiss with interlayered lenses of black carbonaceous schist. Lower units contain brown to gray cataclastic and crystalloblastic textures of interlayered quartz-sericite schist (**PZPCsqm**, **PZPCbc**, **PZPCsch**), chloritic to epidotic schist with some calcite (**PZPCbc**), stretched conglomerate (**PZPCscg**), quartzite, and marble present locally.	Moderately high.	Altered schist layers, as well as brittlely deformed layers, render these units locally unstable for heavy infrastructure.	Unit is susceptible to slope processes, including blockfall, landslides, slumping, and slope creep for altered, deformed, and fine-grained units.	None documented; deformation and metamorphism likely obscures any preexisting fossil remains.	Pyrite may have been used for fire starting.	Disseminated pyrite, marble, chlorite, and epidote.	Not enough carbonate or marble present.	Quartzite may form spires attractive to goats and birds.	Altered and deformed areas of units should be avoided for most forms of recreation.	**PZPCss** and **PCPZgs** may correlate with Nilkoka Group or Totatlanika Schist; units record deformation and metamorphic conditions of terrane formation.
UNKNOWN	Serpentine Gabbro and Silica-Carbonate Rocks (**UNKsp**) Aeromagnetic High, Probably Serpentine and Gabbro (**UNKsp***)	Units are heterogeneous stacks of serpentinized, chromite-bearing dunite to altered, layered gabbro. Gabbro ranges from fine- to coarse-grained leucocratic to melanocratic altered clinopyroxene–plagioclase-bearing. Unit is altered locally to silica-carbonate magnetic rock.	Moderately high.	Avoid areas of heavy alteration and pervasive fracturing for infrastructure.	Highly altered nature of unit renders it weak on slope; rockfall hazards.	None.	None documented.	Clinozoisite, albite, sericite, chlorite, and epidote; magnetite(?).	None.	Unit contains abundant iron and magnesium for basic soil compositions.	Strong magnetic signature may interfere with compass readings.	Possibly part of feeder dike complex for **Dv** island arc complex.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
QUATERNARY	Surficial Deposits, Undifferentiated (**Qs**)	Unit includes unconsolidated and interlayered silt, sand, and fluvial gravel, as well as glacial deposits—including moraines, till, and outwash. Unit also includes slope colluvium in fan-shaped lobes at the bases of slopes. Some terrace deposits and floodplain deposits present along rivers.	Very low.	High permeability of these units likely not suitable for wastewater treatment facilities.	Units are associated with heavy erosion and mass wasting, including frost creep along moderate slopes.	Modern remains possible; pollen, plant macrofossils, insects.	May contain campsites, settlements and other artifacts, and historic mining areas.	Gravel, sand, silt, placer gold deposits, and other heavy metal sediments.	None.	Units support riparian zones and valley floor vegetation and forests.	Units are fine for most light recreation. Avoid riparian areas and large rubble zones.	Units record surficial landscape evolution throughout the area.
TERTIARY	Kenai Group, Undivided (**Tk**) Sterling Formation (**Tsf**) Hornblende Dacite (**Thd**) Nenana Gravel (**Tn**) Sedimentary Rocks, Undivided (**Tsu**) Tsadaka, West Foreland, and Wishbone Formations, Undivided (**Ttw**)	**Tk** contains pebble and cobble conglomerate interlayered with medium-grained sandstone, some clay layers, and coal seams. **Tsf** contains massively bedded, coarse conglomerate that appears orange-tan to light gray in outcrop. **Thd** contains intrusive igneous hornblende dacite (intermediate silica content) of Jumbo Dome. **Tn** is more than 1,300 m thick containing conglomerate and sandstone with mudstone, claystone, and lignite interbeds. Unit is well sorted, but poorly consolidated, and appears yellowish to brownish in outcrop. **Tsu** and **Ttw** contain mixtures of dark gray shales, yellowish sandstones, multi-colored siltstone, pebble conglomerate, and some claystone and lignite beds locally. **Ttw** contains cobble to boulder conglomerate with other sedimentary lenses and some tuffaceous beds.	**Tn** and other sedimentary units are moderately low to moderate; igneous unit is high.	Heterogeneous nature of units renders them less stable on slopes. Avoid highly fractured areas for infrastructure.	Unit is prone to rockfall, especially in boulder conglomerates underlain by poorly consolidated units.	None documented.	None documented.	Plutonic conglomerate clasts in **Ttw**. Coal seams up to 5 m thick in **Tk**, lignite.	Not enough carbonate present.	Units support wide range of habitats.	Units are fine for most recreation. Avoid slope toes and highly fractured zones.	**Thd** has an isotopically-determined age of 2.79 ± 0.25 million years. **Tk** records estuarine and fluvial depositional environments during the Pliocene to Oligocene.
	Volcanic Rocks, Undivided (**Tvu**) Tyonek Formation (**Tty**) Coal-Bearing Rocks (**Tcb**) Hypabyssal Felsic and Intermediate Intrusive Rocks (**Thf**) Hypabyssal Mafic Intrusive Rocks (**Thm**) Andesite and Basalt (**Tvb**) Granitic and Volcanic Rocks, Undivided (**Tiv**) Granodiorite to Tonalite (**Toem**)	**Tvu** consists of interlayered volcanic flows of compositions ranging from basalt to rhyolite, some pyroclastic rocks, and intrusive rocks present locally. **Tty** is a mixture of sandstone, siltstone, shale, and claystone with various carbonaceous cements. Locally divided into sandstone member and conglomerate member. **Tcb** contains cyclic sequences of siltstone, claystone, mudstone, shale, sandstone, subbituminous coal and lignite, quartz, and pebble conglomerates. **Thf** comprises small stocks, sills, and dikes of rhyolitic to dacitic intrusive rocks. **Thm** is widely exposed, containing small stocks and irregularly shaped bodies of diorite porphyry, diabase, basalt, and lamprophyre. **Tvb** contains andesitic breccia and tuff layers with some local basalts and pyroclastic layers. **Tiv** contains portions of a granitic batholith and erosional remnants of rhyolitic flows. **Toem** contains biotite, biotite-hornblende, and hornblende granodiorite, quartz diorite, and quartz monzodiorite.	Moderate to high for intrusive igneous bodies; lower for poorly consolidated tuffs and breccias, hetero-geneous units, and sedimentary units.	Units are very heterogeneous and may be slightly unstable on slopes; may also contain radon-emitting materials. Avoid for basements and foundations. Shrink-and-swell clays may be present, which could undermine roads and foundations.	Unit is prone to rockfall, particularly in areas where resistant igneous intrusive rocks are underlain by friable, weathered sedimentary rocks.	Scant shell fragments, bioturbation, plant fragments(?).	Chert pebbles in **Tcb** may have provided tool material.	Geodes; vesicles in **Tvb** may contain secondary minerals. Subbituminous coal and lignite.	Dissolution of carbonate cements may lead to unit instability.	Units support wide range of habitats and may weather to nutrient-rich soils.	Units are fine for most forms of recreation.	Records deposition environment in Tertiary basins.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
TERTIARY	Fluviatile Sedimentary Rocks and Subordinate Volcanic Rocks (**Tfv**) Arkose Ridge Formation (**Tar**) Granite and Granodiorite (**Tegr**) Chickaloon Formation (**Tch**) Basalt (**Tb**) Volcanic Rocks of the Cantwell Formation (**Tcv**) Granitic Rocks (**Tpgr**) Granodiorite and Other Intermediate Plutonic Rocks (**Thgd**)	**Tfv** contains interlayered sequences of conglomerate, sandstone, siltstone, and mudstone with a few basalt-andesite flows. **Tar** is as much as 700 m thick of fluvially deposited feldspathic and biotitic sandstone, conglomerate, siltstone, and shale layers in coarsening upward sequences. **Tegr** contains biotite-hornblende granite and granodiorite present in irregular bodies. Some altered biotite and hornblende tonalite present locally. **Tch** contains a heterogeneous mixture more than 1,500 m thick of carbonaceous mudstone, siltstone, conglomeratic sandstone, and conglomerate with interbedded bituminous coal beds. **Tb** contains vesicular olivine basalt that appears brownish-black in outcrop. **Tcv** contains deformed sequences of andesite, altered basalt, rhyolite and interlayered dacite flows, felsic pyroclastic rocks, and minor sandstone and mudstone. Some calcareous rocks present locally. **Tpgr** is widespread unit of biotite-muscovite granite and quartz monzonite present generally in plutonic bodies. **Thgd** is biotite and biotite-hornblende granodiorite, with some smaller quartz diorite, monzonite, and monzodiorite plutons present locally.	Moderate to moderately high for sedimentary rocks; high for intrusive igneous rocks.	Heterogeneous nature of sedimentary layers may be unstable on slopes. Units may contain radon-emitting materials. Avoid for basements and foundations; fine for most infrastructure unless highly fractured.	Heterogeneous layers of these units may be prone to mass wasting and landslides on steep slopes; shrink-and-swell clays may be present in volcanic ash units.	Carbonized plant fragments (may correlate with Cantwell Formation).	Crystallized vesicles may have provided trade material.	Geodes; vesicles may contain secondary mineral crystallization, pillow lavas, and muscovite. Bituminous coal; may contain copper-bearing mineral ores.	Minor dissolution of carbonate cements.	Units may degrade into relatively magnesium-, iron-, and calcium-rich soils.	Units are fine for most recreation unless unaltered crystalline or glassy areas persist in basalt flows, rendering them unsafe for foot traffic.	**Tar** records deposition on alluvial fans overlain by braided stream deposits throughout the Tertiary and Cretaceous transition. **Tegr** dated at 45, 44, 48, and 52.8 million years. **Tcv** dated at 49 million years using potassium-argon isotopes of tuffs. **Tpgr** has dates between 52 and 65 million years. **Thgd** dated at 58 to 66 million years.
CRETACEOUS–TERTIARY	Rhyolite and Related Rocks (**TKvr**) Andesite and Related Rocks (**TKvi**) Intrusive Rocks (**TKi**) Granitic Rocks (**TKg**) Granodiorite, Tonalite, and Monzonite Dikes, and Stocks (**TKgd**) Gabbro and Leucogabbro (**TKgb**) Gneissose Granitic Rocks (**TKgg**)	**TKvr** consists of light gray to pink rhyolitic volcanic rocks with minor dacite, including flows, tuff, welded(?) tuff, and volcanic breccias. **TKvi** is predominantly andesitic, but has some minor dacite and basalt flows, tuffs, and breccias present locally. **TKi** contains intrusive rocks ranging from granite to diorite in composition, mostly intermediate silica contents. **TKg** is a widespread unit containing biotite and biotite-hornblende granite and lesser amounts of Granodiorite, quartz monzonite, and alkali granite locally. **TKgd** contains monzonite bodies and other intermediate silica composition dikes, stocks, and irregular intrusions. **TKgb** is present in small plutons of hypidiomorphic granular textured gabbro and leucogabbro. **TKgg** contains gneissose granodiorite, quartz diorite, and local granite in small plutonic bodies, structural grain strikes northeast-southwest and dips vertically to 80° northwest.	Moderately high to high.	Units may contain radon-emitting materials. Avoid for basements and foundations; fine for most infrastructure unless highly fractured.	Units are associated with blockfall and landslides if present on an undercut slope. Bulbous plutons may be subject to exfoliation (sloughing) of large blocks of rock.	None.	None documented.	Migmatite and mylonite layers. Building material.	None.	Portions of these units follow valley floors and support low forests.	Units are suitable for most recreation unless highly fractured and/or altered, rendering them unstable for trails and other uses.	**TKvr** age ranges from 70 to 50 million years. **TKgd** has dates from 59 to 75 million years from potassium-argon isotopes. **TKgg** has dates from uranium-lead isotopes in zircon and sphene, as well as dates from potassium-argon isotopes in mica, from 70 to 29 million years; youngest ages may relate to unroofing of Denali fault system.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
PALEOCENE(?) - CRETACEOUS	Cantwell Formation, Sedimentary Rocks Subunit (**Kcs**) Matanuska Formation (**Km**) Wilber Creek Flysch (**Kwcf**) Nelchina Limestone (**Knl**)	**Kcs** contains a 4,000-m-thick interlayered sequence of polymictic conglomerate, sandstone, arkosic sandstone, siltstone, argillite, and shale, and a few thin coal beds. **Km** contains shallow marine shales with calcareous concretions. Unit appears well-indurated, dark gray, and thinly bedded. Some volcanic-lithic siltstone, sandstone, graywacke, and subordinate conglomerate present locally. **Kwcf** is a mixture of massively bedded siltstone, shale, sandstone, and conglomerate of clasts derived from quartzite, limestone, mafic and felsic igneous rocks, greenstone, diorite, sandstone, siltstone, phyllite, chert, rare grit, shale rip-ups, and very rare carbonatite. Units appear dark gray to greenish in outcrop and are well-sorted. **Knl** is shallow-water calcareous sandstone, siltstone, claystone, and thick-bedded to massive clastic limestone. Some conglomerate beds present locally.	Moderate.	Units are fine for most infrastructure unless highly heterogeneous and/or fractured; units may contain radon-emitting materials and/or shrink-and-swell clays from altered volcanic ash.	Unit is associated with slope processes, including landslides.	Paleocene(?) plant fossils; *Paragastroplites flexicostatus* of Albian age. Regionally, concretions in **Km** can be highly fossiliferous. **Kcs** contains dinosaur foot prints and other plants and traces.	None documented.	Calcareous concretions; carbonatite. Thin coal beds.	**Knl** may contain karst features such as dissolution holes and caves; some areas may be too clastic for extensive dissolution.	Unit may weather into calcium-, iron-, magnesium-, and aluminum-rich soils.	Units are suitable for most recreation unless highly fractured and/or altered	**Kcs** contains tuffs with potassium-argon isotope dates from Cretaceous. **Km** records shallow marine deposition environment during the Cretaceous between volcanic arcs.
CRETACEOUS	Mélanges of the Alaska Ridge (**Kmar**) Volcanic Rocks (**Kvl**) Granitic Rocks (**Kg**) Mafic and Ultramafic Rocks (**Kmum**)	**Kmar** contains four major suites: (1) cherty tuff, chert, argillite, and volcaniclastic sandstone; (2) dark gray to black argillite, slate, shale, graywacke, and subordinate chert, chert-pebble conglomerate, and polymict conglomerate; (3) limestone; and (4) mixed ultramafic rocks. **Kvl** includes dacite, andesite, basalt and assorted flows, tuffs, and dikes and sills locally; alteration of most units is widespread. **Kg** contains granitic to dioritic dikes, sills, and plutons. **Kmum** contains mixtures of gabbro, diorite, serpentinite, and mafic volcaniclastics. Most layers are altered and deformed to varying degrees present in lenses and dikes.	Moderate to high for granitic rocks.	Units may contain radon-emitting materials and/or shrink-and-swell clays from altered volcanics; heterogeneous layering may be unstable for foundations.	Heavy alteration associated with units render them likely to fail on slopes and if water saturated.	*Buchia* bivalves of Late Cretaceous to Jurassic age; Radiolaria and conodonts fragments.	Chert may have provided early tool material.	Tourmaline in **Kg**. Abrasives and building materials.	**Kmar** suite 3 is subject to karst dissolution.	None documented.	Highly altered units are unstable base.	**Kmar** records a nearshore environment caught up in a narrow belt during orogenesis. **Kg** has dates from 120 to 65 million years.
CRETACEOUS AND JURASSIC	Argillite, Chert, Sandstone, and Limestone (**KJs**) Kahlitna Flysch Sequence (**KJf**) Flysch Sequence 1 (**KJfk**) Flysch Sequence 2 (**KJfn**) Conglomerate, Sandstone, Siltstone, Shale, and Volcanic Rocks (**KJcg**)	**KJs** contains dark gray to greenish argillite interlayered with chert, sandstone, and thin shelly limestone layers. **KJf**, **KJfk**, and **KJfn** contain intensely deformed and metamorphosed turbidites. Units include dark gray to black argillite, graywacke, pebble conglomerate, black chert, and dark gray impure limestone beds. Units are tightly folded and faulted. **KJcg** is interbedded pebble and cobble conglomerate with sandstone, siltstone, shale, and volcanic flows and dikes (andesite to latite).	Moderate.	Units are fine for most infrastructure unless highly fractured, altered, and/or heterogeneous.	Intense deformation of unit renders it susceptible to fail if slope intersects predominant structural fabric.	Ammonites; bivalves *Inoceramus*, *Buchia sublaevis, B. keyserlingi* in coquina, *Inoceramus hobetsensis;* broadleaf plant fossils.	None documented.	Feldspar porphyry in **KJcg**.	Some dissolution of limestone in **KJs**.	None documented.	Units can be too friable for climbing.	Argon isotopes of hornblende clast dates at 94.6 ± 1.5 to 101.0 ± 0.7 million years.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
JURASSIC	Trondhjemite (**Jtr**) Naknek Formation (**Jn**) Chinitna Formation, Tuxedni Group, and Coeval Sedimentary Rocks (**Jct**) Mafic and Ultramafic Rocks (**Jmu**) Alaska-Aleutian and Chitina Valley Batholiths, Undifferentiated (**Ji**)	**Jtr** is foliated, altered, and deformed trondhjemite in northeast-trending plutons. **Jn** includes more than 1,400 m of thin- to thick-bedded gray siltstone, shale, sandstone, and conglomerate. **Jct** is a mixture of shallow marine clastic rocks ranging from conglomerate to siltstone to shale. All beds contain some volcanic elements, likely from nearby island arcs. **Jmu** contains dunite, harzburgitic dunite, wehrlite, websterite, alkali gabbro (monzogabbro), and clinopyroxenite in discontinuous belts, dikes, and sills. **Ji** contains widespread batholithic rocks of granite, granodiorite, quartz diorite, and tonalite as part of the Alaska-Aleutian Range batholith.	Moderate to high for granitic batholith units.	Heterogeneous nature of sedimentary layers may be unstable on slopes. Units may contain radon-emitting materials. Avoid for basements and foundations.	Sheet-like exfoliation weathering of plutonic units render them susceptible to large blockfall.	Megafossils; *Buchia* bivalves, ammonites.	None documented.	Olivine, phlogopite, and clinopyroxene. Abrasives and building materials.	Not enough carbonate present.	None documented.	Fine for most recreation unless highly fractured and/or altered.	**Jtr** potassium-argon isotope ages range from 129 to 149 million years. **Jn** constrains the age of uplift of the Alaska-Aleutian Range batholiths.
JURASSIC OR TRIASSIC?	Limestone and Marble (**JTRlm**) Talkeetna Formation (**JTRtk**)	**JTRlm** is fine- to medium-grained, gray metamorphosed limestone in discontinuous lenses as much as 30 m thick. Limestone is massive to poorly bedded. **JTRtk** contains greenstone and tuff layers. Greenstone is altered equivalent of basaltic lava, agglomerate, breccias, and tuff. Some interlayered sandstone and shale present locally.	Moderate.	Calcareous layers and cements may dissolve, rendering unit unstable in some areas. Tuff units may contain shrink-and-swell clays; avoid for heavy infrastructure.	If carbonate layers and cements are dissolved, rockfall hazards exist; heavily altered layers may fail when water saturated on slopes.	Shallow marine fossils.	Caves possible in this unit; may have been settlement areas.	Marble.	**JTRlm** is subject to karst dissolution.	Units may weather to produce calcium-, iron-, and magnesium-rich soils.	Fine for most recreation unless heavily altered and/or deformed.	**JTRtk** is extrusive product of an early Jurassic island arc setting.
JURASSIC - TRIASSIC	Red and Brown Sedimentary Rocks and Basalt (**JTRsu**) Crystal Tuff, Argillite, Chert, Graywacke, and Limestone (**JTRct**) Tatina River Volcanic and Equivalent Units (**JTRtv**)	**JTRsu** contains a redbed sequence of sandstone, siltstone, argillite, and conglomerates more than 2,000 m thick. Limestone and basalt interbeds present locally. **JTRct** is a deep marine sequence of tuff, minor chert, argillite, greywacke, and limestone that is heavily faulted and tightly folded. **JTRtv** consists of three distinct members: (1) upper green medium-grained, concretion-rich volcaniclastic sandstone, with gray, phosphatic shale, and minor tan chert-pebble conglomerate interbeds; (2) lower volcanic rocks, including greenish-gray pillow basalts interlayered with lenses of mudstone, shale, and siltstone gabbro bodies; and (3) brown silty shale and light gray, green, and black chert with some coarse volcanic sandstone and conglomerate.	Moderate.	Heterogeneous nature of units may render them unstable on slopes. Some units may contain shrink-and-swell clays from altered volcanics.	Unit is susceptible to slope processes, including blockfall, landslides, slumping, and slope creep for finer-grained units.	Radiolaria, other Late Triassic and Early Jurassic fossils, bivalve *Monotis subcircularis*, ammonites.	None documented.	Red chert pebbles. Phosphates and copper ore.	Dissolution is possible within limestone interbeds; may render units unstable.	None documented.	Fine for most recreation unless highly fractured; clay-rich layers may pose hazards to hikers if water saturated.	Records Jurassic – Triassic transition in marine and continental deposition settings.
JURASSIC? AND/OR PERMIAN	Ultramafic Rocks (**JPsu**)	Unit is a mixture of serpentinized (altered) peridotite, harzburgite, and dunite. Unit is highly folded and contains some low-grade metasedimentary rocks and chert layers locally.	Moderate due to high degree of alteration.	Avoid areas of heavy alteration and pervasive fracturing for infrastructure.	Highly altered nature of unit renders it weak on slope; rockfall hazards.	None.	Chert layers may have provided tool material.	Olivine, chlorite, and actinolite. Abrasives.	None.	Unit may weather to produce iron- and magnesium-rich soils.	Unit may interfere with compass readings.	Unit contains oceanic crust caught up during orogenesis.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
JURASSIC AND PENNSYLVANIAN	Uranatina Metaplutonic Complex (**JPNaur**)	The complex contains a greenschist facies (locally amphibolite facies) metamorphosed belt of schistose quartz diorite, quartz monzonite, granodiorite, hornblende diorite, amphibolite, and orthogneiss.	Moderately high.	Suitable for most infrastructure. Avoid schistose units and altered areas for heavy infrastructure.	Pervasive foliation and sheet-like exfoliation weathering of metaplutonic units render them susceptible to large blockfall.	None.	None documented.	Building materials.	None.	None documented.	Fine for most recreation unless heavily altered and/or deformed.	Jurassic potassium-argon isotope dates; uranium-lead isotope ages of 309 ± 11 to 153 ± 4 million years.
JURASSIC - CAMBRIAN	Mystic and Dillinger Stratigraphic Sequences, Undivided (**JCmd**)	Unit is a folded, structurally complex assemblage of siliciclastic turbidites, cherty pelagite, pillow basalt, wildflysch, chert, shale, reefoid limestone, and conglomerate and sandstone representing a mixture of depositional environments.	Moderate.	Heterogeneous nature of units renders them less stable on slopes. Avoid highly fractured areas for infrastructure.	Unit is prone to rockfall, especially in massive beds underlain by deformed units.	Permian- to Silurian-age marine fossils, conodonts.	Chert may have been useful for early tool making.	Basalt alteration minerals and amygdules. Basalts may contain copper-bearing minerals.	Some dissolution is possible in limestone layers.	None documented.	Deformed nature of unit renders it unstable on slopes.	Unit records deposition in deep marine, slope and shelf, and nonmarine settings over millions of years.
TRIASSIC	Calcareous Sedimentary Rocks (**TRcs**) Conglomerate and Volcanic Sandstone (**TRcg**) Nikolai Greenstone and Related Rocks (**TRn**) Gabbro, Diabase, and Metagabbro (**TRgb**) Metavolcanic and Associated Metasedimentary Rocks (**TRnm**) Limestone and Basalt Sequence (**TRlb**) Red Beds (**TRr**)	**TRcs** contains thinly bedded, gray calcareous shale, argillite, sandstone, siltstone, and sandy to silty and argillaceous limestone. Unit is intensely deformed. Cherty limestone is present locally, as well as associated dikes, sills, and plugs of altered diabase and gabbro. **TRcg** is only present locally, and contains cobble to boulder conglomerate with clasts of green volcanic rocks and red radiolarian chert overlain by massive volcanic sandstone. **TRn** contains greenschist facies metamorphosed subaerial and submarine basalt flows with minor volcaniclastic layers. Unit appears dark gray-green to brown and is more than 2,000 m thick. **TRgb** is predominantly altered hornblende-clinopyroxene gabbros with quartz gabbro and quartz diorite present in lenses. **TRnm** contains metabasalt, slate, and other metamorphosed sedimentary and igneous rocks. **TRlb** is interlayered limestone and amygdaloidal basalt flows. The limestone is massive and gray with local marbleized areas. **TRr** contains redbeds of sandstone, argillite, siltstone, and conglomerate with clasts of gabbro, serpentinite, and limestone (fossils).	Moderate to moderately high for metamorphic rocks.	Units are highly heterogeneous which may render the rock column relatively unstable. Units may contain radon emitting materials as well as shrink-and-swell clays (altered volcanics). Avoid highly fractured and/or altered areas for infrastructure.	If present on slopes, rockfall, blockfall hazards exist for massive units, whereas slope creep, slumping, and debris flow potential exists for fine-grained, deformed, and/or altered units.	conodonts *Negondolella polynathiformis* and *Epigondolella primitia*, bivalve *Monotis subcircularis*, radiolaria, *Heterastridium* sp.	None documented.	Red radiolarian chert nodules and mineralized amygdules in basalt flows. Slate, building materials, and marble.	Some dissolution possible in limestone-marble layers.	Units weather into nutrient-rich soils. Dissolution in limestone layers may provide burrow habitat.	Units are suitable for most recreation unless heavily altered, deformed, and/or undercut on slopes.	**TRcs** records turbidite environment during mid-Triassic. **TRn** is a diagnostic unit of the Wrangellia terrane. **TRlb** suggests shallow water deposition in an ocean island shield volcano environment.
TRIASSIC - PENNSYLVANIAN	Flysch-like Sedimentary Rocks (**TRPNas**)	Unit is pervasively deformed and folded with dark massive to thin-bedded marine Flysch-like layers, including conglomerate, sandstone, siltstone, argillite, limestone, and chert. Unit is several hundred meters thick. Unit is fault-bounded.	Moderate.	Deformed nature of unit may weaken its ability to support heavy infrastructure.	Fractured rocks are susceptible to blockfall and landslides.	Triassic Radiolaria, conodonts, Pennsylvanian brachiopods.	Chert may have been useful for early tool making.	Building material.	Some dissolution is possible in limestone layers.	None documented.	Avoid heavily deformed areas for recreation development.	Fault-bounded unit records structural evolution of the area.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
TRIASSIC - DEVONIAN	Volcanic and Sedimentary Rocks (**TRDv**)	Unit contains interlayered greenish-gray to black chert, tuffs, volcanic conglomerate, with some maroon-colored volcanic mudstone, basaltic breccia, and graywacke-shale beds with lenses of limestone, and ammonite-bearing limestone present locally. Unit was metamorphosed to greenschist facies.	Moderate.	Unit may contain shrink-and-swell clays as well as radon-emitting material. Avoid for basements and foundations.	Mudstone-rich units are prone to failure on slopes, especially if water saturated.	Permian brachiopods, ammonites, conodonts. Devonian and Carboniferous fossils in the chert.	None documented.	Attractive maroon mudstone.	Some dissolution possible in limestone layers.	None documented.	Avoid particularly shaly areas for recreation development.	Unit is lower portion of Chulitna sequence.
SILURIAN - TRIASSIC	Limestone Blocks (**TRSl**)	Unit contains lenses and lozenge-shaped blocks of medium-bedded to massive gray limestone. Limestone is fine- to medium-grained and fossiliferous.	Moderately high.	Unit may be friable and too permeable for wastewater treatment infrastructure.	Dissolution may pose sinkhole hazard; susceptible to rockfall if highly dissolved on slopes.	Megafossils, conodonts.	Caves possible in this unit; may have been settlement areas.	None documented.	May contain karst features such as dissolution holes and caves.	If caves are present, unit may provide bat and other cave dweller habitat.	Any caves will attract caving interest.	Unit records marine basin conditions during a longstanding depositional setting.
MESOZOIC	Phyllite, Pelitic Schist, Calc-Schist, and Amphibolite of the MacLaren Metamorphic Belt (**MZpca**) Schist and Amphibolite (**MZsa**)	**MZpca** is a metamorphosed (amphibolite facies, then retrograde greenschist facies) belt of mainly phyllite, quartz-mica schist, calc-schist, amphibolite, and subordinate marble and meta-andesite, derived from mixed deposits of siltstone, graywacke, marl, andesite, and gabbro. Unit was folded extensively at least twice during orogenesis. **MZsa** contains fine- to medium-grained schist and hornblende amphibolites, with some irregular bodies of calc-silicate schist and quartzite and local gneissose granitic to gabbroic metaigneous rocks.	High; may be lower with increased degree of weathering.	Altered schist layers, as well as brittlely-ductilely deformed layers, render these units locally unstable for heavy infrastructure.	Unit is susceptible to slope processes, including blockfall, landslides, slumping, and slope creep for altered, deformed, and fine-grained units.	None documented; deformation and metamorphism likely obscures any preexisting fossil remains.	Garnets may have been used for early trade.	Garnets; abrasives.	Not enough carbonate present.	None documented.	Avoid schistose layers for recreation development.	**MZpca** has potassium-argon isotope dates from mica 48.0 to 30.6 million years and amphibole ages of 69.6 million years. Unit contains Meteor Peak fault. **MZsa** has potassium-argon isotope dates ranging from 65.9 to 31.9 million years with biotite ages youngest.
MESOZOIC OR PALEOZOIC	Intrusive and Volcanic Rocks, Undivided (**MZPZi**)	Units composition ranges spatially from granodiorite of Rainbow Mountain, diorite, and gabbro and quartz diorite, with dark gray to greenish dikes of basalt and granodiorite and some volcanics interlayered locally.	High; lower for less consolidated volcanic units.	Altered volcanics may contain shrink-and-swell clays, which could undermine road and building foundations. Avoid fractured areas.	Sheet-like exfoliation of plutonic areas poses blockfall hazard.	None.	None documented.	Building material.	None.	Unit may weather to produce calcium- and aluminum-rich soils.	Suitable for most recreation; may attract climbers. Avoid fractured areas.	Units are widespread and provide unique dating opportunity through isotope dating and cross cutting relationships.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
MESOZOIC?, PALEOZOIC?, AND (OR) LATE PROTEROZOIC?	Ultramafic and Mafic Rocks, Undivided (**MZZum**)	Unit is widespread containing a heterogeneous mix of serpentinite, peridotite, dunite, gabbro, diorite, metabasite, and minor talc schist and roddingite. Textures of the different rock types range from intrusive to metamorphic. Devonian-age dikes present north of the Denali fault system.	Moderately high.	Avoid areas of heavy alteration such as serpentinite and talc schist and pervasive fracturing for infrastructure.	Highly schistose and altered nature of unit renders it weak on slope; rockfall hazards.	None.	None documented.	Talc, olivine, and roddingite; abrasives.	None.	Unit may weather to produce iron- and magnesium-rich soils.	Unit unstable on slopes. Avoid for trail development.	Argon isotopes from hornblende dates from 465 to 536 ± 2.6 million years.
PERMIAN	Eagle Creek Formation (**Pe**)	Unit contains as much as 1,000 m of alternating sequences of marine dark gray, thin-bedded argillite, and fine- to medium-grained limestone beds. Minor lenses of gray siltstone, bioclastic limestone, calcareous siltstone, radiolarian chert, shale, limestone, and pyritic sandstone are present locally.	Moderate.	Dissolved and fractured limestones may render unit too permeable for wastewater treatment.	Limestone dissolution may render units friable with increased fracture diameter, rendering unit weak on slopes.	Corals, bryozoans, brachiopods, echinoids, crinoids, fusulinids, and algal(?) fragments; Radiolaria.	Pyrite may have been used to start early fires.	Pyrite-bearing sandstone.	Limestones may contain karst features such as dissolution holes.	Small holes and cavities may provide burrow habitat.	Avoid areas of dissolution and fracture.	Unit records environmental conditions during the Permian; may contain extinction information.
PERMIAN - PENNSYLVANIAN	Station Creek and Slana Spur Formations, and Equivalent Rocks (**PPNasc**) Strelna Metamorphic Complex (**PPNast**) Marble (**PPNaskm**)	**PPNasc** contains a lower volcanic member of submarine andesite and basalt flows with breccias and pillows, and an upper volcaniclastic member of graywacke and volcanilutite grading upwards. **PPNast** is composed of folded, faulted, and metamorphosed metasedimentary and metavolcanic rocks, including quartzofeldspathic and quartz-mica schist with lenses of marble, metachert, and orthogneiss. Volcanic layers are now greenstones. **PPNaskm** occurs as 30-m-thick lenses of white, medium- to coarse-grained marble.	Moderately high.	Heterogeneous and deformed nature of units may render them unstable on slopes. Some units may contain radon-emitting materials and shrink-and-swell clays if altered.	Units are susceptible to slope processes, including blockfall, landslides, slumping, and slope creep for finer-grained units.	Late Paleozoic bryozoans?	None documented.	Migmatite and greenstones; marble.	Marble may be susceptible to minor dissolution.	None documented.	Units are fine for most recreation unless highly fractured, altered, and/or deformed.	Unit records seafloor volcanism and conditions from Permian and Pennsylvanian.
PERMIAN - DEVONIAN	Sheep Creek Formation and Correlative Siliciclastic Units (**PDsc**)	Unit is heterogeneous mixture of sandstone, conglomerate, siltstone, and argillite with local beds of chert and limestone. Unit contains clasts of Devonian limestone.	Moderate.	Units are fine for most infrastructure unless highly heterogeneous and/or fractured.	Heterogeneous layers of these units may be prone to mass wasting.	Conodonts, fusilinids, brachiopods, corals, plant remains.	None documented.	Building material.	Some dissolution is possible in limestone layers	None documented.	Units are fine for most recreation.	Unit records deposition spanning from Permian to Devonian.
PENNSYLVANIAN	Tetelna Volcanics (**PNat**)	Unit appears greenish in outcrop composed of volcanic flows, mud, and debris flows, with lapilli-tuff interbedded with volcaniclastic rocks. Composition is mostly andesitic, and the entire unit was metamorphosed at lower greenschist facies.	Moderately high.	Unit may contain radon-emitting materials and shrink-and-swell clays if altered.	Sedimentary rocks may weather out differentially, posing a rockfall hazard.	None.	None documented.	Lapilli.	None.	May weather to produce aluminum- and calcium-rich soils.	Units are fine for most recreation.	Unit records widespread Pennsylvanian volcanism and later metamorphic-deformation conditions.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
MISSISSIPPIAN - DEVONIAN	Totatlanika Schist (**MDt**)	Unit is a mylonite assemblage of gritty semischist with intense deformation and low-grade metamorphic minerals and textures. Some chloritic quartzo-feldspathic schist and augen gneiss, phyllitic schist and semischist, phyllite, metavolcanic rocks, quartzite, marble, and greenstone are present locally with original textures often evident.	Moderate.	Altered schists and phyllite layers render these units locally unstable for heavy infrastructure.	Unit is susceptible to blockfall, landslides, slumping, and slope creep for altered, deformed, and fine-grained units.	None documented; deformation and metamorphism likely obscures any preexisting fossil remains.	Augen may have been valuable trade material.	Clear to bluish gray quartz augen ("eyes"). Marble and abrasives.	Some minor dissolution possible in marble.	None documented.	Avoid schistose areas for recreation development.	Uranium-lead isotopes in zircon provide an age of 375 million years; dates extrusive protolith.
MISSISSIPPIAN? – DEVONIAN?	Keevy Peak Formation (**PZk**)	Unit is a heterogeneous mixture of phyllite, meta-argillite, quartzite, metachert(?), and lesser amounts of calcareous phyllite, marble, and mafic and felsic metavolcanic rocks. Unit is multiply deformed and metamorphosed at greenschist facies.	Moderate.	Altered schist layers, as well as brittlely deformed layers, render these units locally unstable for heavy infrastructure.	Unit is susceptible to blockfall, landslides, slumping, and slope creep for altered, deformed, and fine-grained units.	None documented; deformation and metamorphism likely obscures any preexisting fossil remains.	None documented.	Phyllite; marble.	Some minor dissolution possible in marble.	None documented.	Altered and deformed areas of units should be avoided for most forms of recreation.	Uranium-leab isotopes in zircon dates extrusion age at 346 ± 1 million years.
DEVONIAN	Serpentinite, Basalt, Chert, and Gabbro (**Dsb**) Phyllite, Slate, Siliceous Siltstone, and Argillite (**Dps**) Yanert Fork Sequence and Correlative Rocks (**Dy**)	**Dsb** contains sheared and altered serpentinite, chert, and pillow basalt forming lenticular blocks. **Dps** contains gray to silvery phyllite, slate, siliceous siltstone, and argillite with some thin limestone and calcareous siltstone interbeds. **Dy** contains metasedimentary and metavolcanic rocks of varying grade and fabric, including argillite, slate, phyllite, phyllonite, semischist, impure quartzite, schistose stretched-pebble conglomerate, banded metachert, felsic metatuff, and metabasalt. Some original pillows and layering present locally.	Moderate.	Sheared and altered areas should be avoided for heavy infrastructure; heterogeneous nature of units render them locally unstable.	Large blocks of massive to intact rock surrounded by sheared and/or altered rock pose blockfall hazards. Schistose cleavage may cause large slides locally, depending on orientation with slope.	Radiolaria.	None documented.	Blocky building material and copper-bearing minerals.	Some dissolution possible in limestone layers.	Limestone dissolution holes may provide burrow habitat. Units may weather into nutrient-rich soils.	Units are fine for most recreation unless highly fractured.	**Dsb** was part of a dismembered ophiolite assemblage. **Dy** records a volcanic-bearing turbiditic marine sequence on a continental slope.
DEVONIAN AND SILURIAN	Unnamed Limestone (**DSmdl**) Whirlwind Creek Formation and Unnamed Correlative Units (**DSwc**) Limestone (**DSl**) Tolovana Limestone (**DSt**)	**DSmdl** contains light gray to brown limestone, some meta-limestone locally. **DSwc** is shallow marine limestone and dolostone with minor fossils. **DSl** contains gray, massive recrystallized limestone with sandy, silicified limestone and dolostone interbeds. Some brecciated and micritic limestones present locally. **DSt** contains alternating green and maroon limey mudstone grading upward into yellowish-brown silty and shaly lime mudstone and wackestone, grading into gray peloid and ooid-rich lime packstone and grainstone and scant dolostones present locally.	Moderate, depending on degree of alteration and dissolution of carbonate layers.	Unit may be friable and too permeable for wastewater treatment infrastructure.	Dissolution may pose sinkhole hazard; susceptible to rockfall if highly dissolved on slopes.	Graptolites, *dasclydacean* algae, corals, stromatoporoids, brachiopods, conodonts, Ostracodes.	Caves possible in this unit; may have been settlement areas.	Ooids; limestone building material.	Karst features such as dissolution holes and caves are possible for **DSwc** and **DSt**.	If caves are present, they may provide habitat for bats and other cave dwellers.	Caves if present may attract speleologists.	Unit records Silurian deep-water conditions and Late Devonian shallow-water depositional environment.
DEVONIAN - CAMBRIAN	Dillinger Sequence, Undivided (**DCd**)	Unit contains mixtures of shales, siltstones, cherts, and silty limestones as slope or basinal deposits	Moderate; lower for very hetero-geneous areas.	Heterogeneous nature of unit may render it unstable on slopes.	If carbonate cements are dissolved, integrity of unit may be compromised; possible slope processes hazards.	Conodonts, graptolites, corals.	Chert layers may have provided tool material.	None documented.	Some dissolution possible in limestone layers.	Unit supports wide variety of habitats.	Unit is fine for most recreation.	Unit contains turbidites from an ancient marine slope environment.

Map Unit Properties Table: Denali National Park and Preserve (Small Scale [1:250,000] Map Units)

Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
SILURIAN - CAMBRIAN	Post River Sandstone, Lyman Hills Formation, and Correlative Units (**SCpl**)	Unit contains sequences of shale, siltstone and chert, grading into silty limestone and shale with cross lamination textures.	Moderate.	Suitable for most infrastructure unless highly fractured.	If massive units are underlain by shale units, a hazardous rockfall situation can exist.	Cambrian conodonts, Ordovician and Silurian graptolites.	Chert layers may have provided tool material.	None documented.	Minor dissolution possible in limestone layers.	None documented.	Unit is fine for most recreation.	Unit records basinal – slope depositional setting with turbidity currents.
ORDOVICIAN	Chert (**Oc**)	Unit contains dark gray to black chert layered with siliceous slate, argillite, and some greenstone, impure limestone, and dolostone.	Moderately high.	Suitable for most infrastructure unless highly fractured.	Slate layers may undermine unit stability on a slope causing a blockfall hazard. If carbonate cements are dissolved, unit may be prone to failure.	Graptolites.	Chert layers may have provided tool material.	Slate.	Minor dissolution possible in limestone layers.	None documented.	Avoid slate-rich layers due to sharp surfaces.	Unit records Ordovician depositional setting in open basin.
CAMBRIAN? AND PROTEROZOIC	Wickersham Grit, Undivided (**CZw**) Argillaceous Upper Unit (**CZwa**)	**CZw** is a poorly sorted sequence of quartzite, feldspathic quartzite, grit, calcareous siltstone, and fine-grained sandstone, and some scant dark limestone and chert layers. Unit is brittlely deformed and recrystallized with imbricate structures. **CZwa** is argillaceous with tan-weathering calcareous siltstone and sandstone, with some quartzite and chert present locally. Some dark limestone thin beds interlayered locally.	Moderate; deformed areas are more susceptible to erosion.	Pervasive deformation compromises stability of unit for heavy infrastructure. Avoid fractured areas for wastewater treatment facilities.	Pervasive fracturing incites a likely blockfall hazard.	None documented; deformation and metamorphism likely obscures any preexisting fossil remains.	None documented.	Cataclasite. Quartzite building materials.	Minor dissolution possible in limestone layers.	None documented.	Avoid unit for most recreation due to high fracture density.	Unit records deposition in nearshore environments as well as nature of deformation during orogenesis and uplift.
PALEOZOIC	Spruce Creek Sequence and Correlative Rocks (**PZsc**) Volcanic and Sedimentary Rocks (**PZvs**) Calcareous and Phyllitic Rocks (**PZkcp**)	**PZsc** contains mafic to felsic metavolcanic rocks, some minor greenstone (altered basalt) sills. Mafic layers are dark, massive; and schistose with metabasalt, andesitic, and amphibolitic layers with minor quartz to mafic schist, pelitic schist, phyllite, metasiltstone, metatuff, and minor chert and marble. Felsic layers contain blastoporphyritic metarhyolite and felsic schist. **PZvs** contains dark, greenish-gray mafic volcanic rocks and black phyllite, chert pebble conglomerates, tuffs, and graywackes. Basalt pillows, breccias, and flows present in volcanic rocks. **PZkcp** contains greenschist facies calc-phyllite, marble, and phyllite.	Moderate.	Units contain heterogeneous assemblages that may weaken rock columns on slopes; altered volcanic units may contain shrink–and-swell clays.	Mass wasting, blockfall, and landslides are a potential hazard associated with these heterogeneous units.	None.	Phenocrysts may have attracted trade interest and historic mining activity.	Quartz, orthoclase, and plagioclase phenocrysts; stibiconite; kermesite; stibnite; pyrite; boulangerite; cervantite; and arsenopyrite. Marble, building materials, copper-bearing minerals, polymetallic vein deposits, tactite, and stratiform occurrences; support placer gold deposits.	Some minor dissolution is possible in marble.	Units may weather to produce nutrient-rich soils.	Units are fine for most recreation unless altered and/or heavily fractured.	Uranium-lead isotopes provide dates between 364 and 375 million years.

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Age	Map Unit (Symbol)	Unit Description	Erosion Resistance	Suitability for Infrastructure	Hazards	Paleontological Resources	Cultural Resources	Mineral Occurrence	Karst Issues	Habitat	Recreation	Geologic Significance
PALEOZOIC AND(OR) PROTEROZOIC?	Quartz and Pelitic Schist of the Yukon-Tanana Upland (**PZZYqs**) Schist and Amphibolite (**PZZYsa**)	**PZZYqs** contains multiply metamorphosed quartzite, schistose quartzite, and quartz-mica schist with minor gritty quartzite, chlorite schist, calc-silicate schist, marble, magnetite-biotite schist, amphibolite, and greenstone. **PZZYsa** contains pelitic schist containing subordinate quartzite, quartz-schist, calc-silicate rocks and calc-schist, marble, amphibolite, graphitic schist, and augen gneiss interlayers. Unit is largely fault-bounded. Unit contains local augen gneiss.	Moderately high.	Avoid schistose layers for heavy infrastructure.	Schistose nature of units renders them friable, and—when combined with layers of more resistant, hard rock—a dangerous rockfall situation occurs.	None.	Augen may have provided valuable trade materials; historic mining activity.	Augen gneiss. Marble, magnetite, graphite, and polymetallic mineral deposits.	Some minor dissolution possible in marble.	Some high calcium soils could be derived from these units.	Avoid friable schistose layers for heavy recreation.	Uranium-lead isotopes in zircon provide dates of 365 million years for protolith, potassium-argon isotopes providing dates ranging from 105 to 120 million years for metamorphic event timing.
PALEOZOIC OR PRECAMBRIAN	Pelitic and Quartzose Schist of the Alaska Range (**PZZaqs**) Pelitic and Quarzitic Schist (**PZZrqs**)	**PZZaqs** contains pelitic and quartzose schist with local calc-schist and feldspathic layers at greenschist to amphibolite facies metamorphic grade. **PZZrqs** is composed mostly of muscovite- and quartz-rich schist, and lesser calc-schist, quartzofeldspathic schist, gneiss, amphibolite, and quartzite, with scant marble interbeds. Metamorphic history includes greenschist, blueschist, granulite, and amphibolite facies conditions overprinting each other.	Moderate.	Avoid schistose layers for heavy infrastructure.	Schistose nature of units renders them friable and prone to rockfall and failure on a slope.	None.	None documented.	High temperature and pressure metamorphic minerals. Thin marbles and abrasives.	Some minor dissolution possible in thin marble interbeds.	Quartzite may form spires attractive to goats and birds.	Avoid friable schistose layers for heavy recreation.	**PZZrqs** records conditions during extreme pressure and temperature of orogenesis.
PROTEROZOIC	Gritty Lower Unit (**Zwg**) Metamorphic Basement Rocks of the Nixon Fork Sequence, Undivided (**ZYnm**)	**Zwg** contains poorly sorted quartzite and gritty quartzite with conspicuous granule conglomerate (contains white to blue quartz augen in a cherty, quartzofeldspathic-wacke matrix). **ZYnm** is metamorphosed (greenschist facies) quartz and pelitic schists with some heterogeneous pods, lenses, and layers of calc-schist, quartzofeldspathic schist, marble, schistose felsic metavolcanic rocks, greenstone, and gneissic and schistose plutonic rocks.	High to moderately high for schistose layers.	Avoid highly fractured areas for infrastructure; fine for most light infrastructure.	Blockfall and landslides are a potential hazard associated with these heterogeneous units.	None documented; deformation and metamorphism likely obscures any preexisting fossil remains.	Augen may have provided valuable trade materials.	Single-crystal milky white to blue quartz augen. Marble, abrasives and attractive building stones.	Some minor dissolution possible in marble.	None documented.	Units are fine for most recreation. Avoid micaceous areas for climbing.	Unit records beach deposits? Potassium-argon isotope ages date metamorphism at 296 to 291 million years; Uranium-lead isotopes in zircon provide ages of 1,250 ± 50 million years.
UNKNOWN	Bedrock of Unknown Type or Age (**UNKbu**) Ultramafic and Associated Rocks (**UNKmlu**)	**UNKmlu** contains serpentinized (altered) ultramafic rocks, as well as altered basalts, tuffs, and recrystallized chert. Unit appears green to maroon in a small sliver of outcrop. **UNKbu** contains a mixed rubble of metasiltstone and chert, as well as unknown bedrock areas.	Moderate.	Avoid areas of heavy alteration and/or a high concentration of fractures and joints.	Units are altered and poorly consolidated in areas, rendering them susceptible to rockfall and mass wasting.	Fossils possible, but none were specified.	None documented.	Secondary mineralization in basalt vesicles. Attractive green and red stones.	Unknown.	Unit supports development of iron- and magnesium-rich soils.	Units are fine for most recreation, although high iron content may interfere with compass reading.	Unit presents future research possibilities to determine precise timing and provenance.