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Title: Geologic map of the Siksikpuk River area, Chandler Lake Quadrangle, Alaska
Publication: PIR 2007-1
URL: http://www.dggs.dnr.state.ak.us/pubs/pubs?reqtype=citation&ID=15757
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DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Qu - Surficial Deposits, undifferentiated (Quaternary)—Includes alluvium, terrace gravel, outwash, fan deposits, and glacial drift of Itkillik, Sagavanirktok, and Anaktuvuk age. See Hamilton (1979) for description and distribution.

BEDROCK DEPOSITS

SYNTECTONIC DEPOSITS AND DEPOSITS OF THE COLVILLE BASIN FOLDBELT

Nanushuk Formation—(revised nomenclature, Mull et al., 2003) Upper unit dominantly nonmarine sandstone, conglomerate, siltstone, shale, and coal. Lower unit dominantly marine sandstone, siltstone, and shale.

Knu - Nanushuk Formation, upper part (Cenomanian to Albian)—Sandstone, medium-gray to yellowish-brown, fine- to coarse-grained, thin- to thick-bedded lithic and chert arenite, and local conglomerate and conglomeratic sandstone; forms resistant beds and rubble traces. Interbedded recessive rocks, which make up the greater thickness of the upper unit, consist of dark gray clay shale, carbonaceous shale, silty shale, siltstone, and local coal beds. Framework grains in sandstones consist dominantly of quartz and chert, with lesser amounts of lithic fragments and detrital feldspar; cemented with silica and, less commonly, calcite. Conglomerate clasts are predominantly subrounded pebbles and cobbles of white quartz and black, gray, greenish-gray, and maroon chert, with local ironstone (siderite), coal, gray sandstone and quartzite, argillite, and mafic igneous rocks. Sandstones generally upward-fining and –thinning successions of sandstone with plane-parallel beds and laminae, tabular and trough cross-stratification, asymmetrical ripple cross-lamination and bedforms, and basal channel scours; upward-coarsening and -thicknening sandstone successions present locally within recessive weathering silty shale and siltstone succession. Sandstone bodies up to 30 m thick pinch out laterally over 1–2 km in silty shale and siltstone. The upper Nanushuk represents deposition in lower delta plain, fluvial, and alluvial flood-basin settings. The top of Nanushuk is not exposed in map area. Thickness: 600 m immediately north of map area (Ahlbrandt et al, 1979); up to a few hundred meters thick in northernmost part of map area.

Knl - Nanushuk Formation, lower part (Albian)—Sandstone, siltstone, silty shale, and minor clay shale. Sandstone is light- to medium green-gray to light yellowish-brown, fine- to medium-grained, thin- to medium-bedded, locally thick-bedded, lithic arenite. Mudstone and orange-brown siderite rip-up clasts are present at the base of many sandstone beds. Interbedded dark-gray, fissile to chippy weathering silty shale and medium- to dark-gray siltstone; medium-gray clay shale and dark-gray carbonaceous shale present locally. Lithologies are arranged in upward-coarsening and -thickening successions capped by sandstone with a variety of sedimentary structures, including plane-parallel lamination, current- and wave-ripple cross-lamination, and

current and wave ripple bedforms, hummocky and swaley cross-stratification, large- and small-scale trough cross-stratification and, locally, planar-tabular and tangential cross-stratification. Macrofossils are common and include marine pelecypods and ammonites. Biogenic structures are common, and include Teichichnus, Diplocraterion, Rhizocorallium, Planolites, Paleophycos, Schaubcylindrichnus, Rosselia, among others. Coalified plant fragments and impressions are locally common. The lower Nanushuk represents deposition in shoreface, delta-front, and prodelta settings. Upward intertonguing of marine and marginal-marine strata marks transition to upper Nanushuk. Sandstones generally tight, porosity <10 percent, permeability <1 md (Ahlbrandt et al., 1979). Thickness: 250–300 m.

Kt - Torok Formation (Albian to Aptian)—(Gryc et al., 1951; Patton, 1956) Silty shale, siltstone, and minor shale and sandstone. Silty shale and shale are dark-gray, fissile to chippy weathering, and commonly include mm-scale laminae and bed-parallel calcareous concretions. Interbedded siltstone and sandstone are green-gray to gray-brown weathering, thin- to medium-bedded; commonly include graded bedding, current-ripple cross-lamination and bedforms, convolute bedding, load casts, groove and minor flute casts, rip-up clasts of silty shale, and scattered coalified plant fragments < 2 cm in length. Cone-in-cone structure locally common in siltstone. Biogenic structures limited to Planolites and less common Paleophycos burrows. Thick succession of amalgamated sandstone and granule conglomerate turbidites and associated gravity flow deposits exposed on the east bank of the Chandler River in the lower half(?) of the Torok at the type section. Succession extends west and east of the Chandler River; extends east of the map area at least to Desolation Creek. Strong to faint hydrocarbon odor present in many beds from this succession and solid hydrocarbon is locally common. Sandstone and conglomerate in the amalgamated succession appear very similar to sandstone and granule conglomerate near the top of the Fortress Mountain Formation at Castle Mountain, fifteen miles to the west, a characteristic originally noted by Molenaar (1988). Oil-stained sandstone and solid hydrocarbon within an amalgamated sandstone interval is present at two localities on the west side of Autumn Creek. Similar staining in sandstone along Desolation Creek east of the map area and on the Chandler River to the west define a trend of > 15 miles lateral extent (Houseknecht and Schenk, 2006). This interval may be up to 800 feet thick (unpublished measured section by D. LePain; Mull et al., 2003), although structural detachment just to the north makes thickness estimation uncertain. The presence of hydrocarbons suggests the Torok was once a hydrocarbon reservoir but has been breached, probably during Tertiary backthrusting. This interval has further regional implications for source rock distribution and hydrocarbon migration pathways and timing. The Torok is a thick outer shelf (prodelta), slope, and basinal succession. Outer shelf deposits near the top of the unit intertongue with the lower Nanushuk in the northernmost part of the map area, at Tuktu Escarpment. Thickness: greater than 6,000 m, based on seismic data; the base of the unit is not exposed in the map area.

Kfm - Fortress Mountain Formation (Albian to Hauterivian (?))—(Patton and Tailleur, 1964) Gray to light green-gray conglomerate and sandstone interbedded with medium gray siltstone and dark gray silty mudstone. The coarser-grained facies typically form linear ridges framing broad folds with conspicuous, inwardly-plunging synclines (”thumbprint” map pattern). Maximum grain size decreases markedly to the north, grading basinward into the Torok Formation (e.g. Detterman et al., 1963). The top is nearly everywhere a Holocene erosional surface and the formation usually overlies tectonized Okpikruak mélange consisting of chaotic

blocks of chert, mafic igneous rocks and limestone. Regional relationships suggest it may also locally overlie coherent Okpikruak Formation (Mull, 1985). The basal contact is nowhere well exposed, but may represent an erosional unconformity along which a later fault is co-located. Total thickness is difficult to constrain, but <1000 m of section are probably exposed within the map area. Biostratigraphic control is limited, but regional paleontologic data have historically favored an early to middle Albian age for this formation (Molenaar et al., 1988). However, micropaleontologic data (C.G. Mull, unpublished data and M. Mickey, 2004, written commun.) suggest rocks assigned to this formation in the map area may be as old as Hauterivian. Conglomerate facies are typically framework supported, but are usually poorly sorted leading to mixed clast size populations (granule to pebble) and abundant very fine- to fine-grained lithic sandstone matrix. Moderately to excellently sorted, open-framework granule conglomerate occurs locally, but is limited in lateral and vertical extent. Clasts are typically moderate to well-rounded leading to rare imbrication, except in matrix-lean facies. Clasts are dominated by varicolored chert and siliceous mudstone (up to 90%) with lesser amounts of altered mafic volcanic rocks and greenish-gray sandstone. Other more rare clasts include organic-rich mudstone (tasmanite) and dark gray silicified limestone with probable Mississippian fauna (A. Harris, 2005, written commun.) which usually exist as "outsized" cobbles up to 20 cm. Distinctive pink granitoid clasts are seen in more southern exposures and appear to be confined to the uppermost portions of the formation (Wartes and Carroll, 2003). Conglomerate beds are typically massive and range from 1–2 meters thick. Bed boundaries are commonly diffuse, except where highlighted by interbedded sandstone; conglomerate units locally amalgamate into bedsets up to 20 m thick which can collectively record both fining- and coarsening-upward trends. Some conglomerate bodies are lenticular at the outcrop scale and curvilinear surfaces are commonly visible from a distance. Crude to well-developed trough cross-stratification is locally prominent. Large linear and sinuous crested dunes (up to 30 cm amplitude) are preserved at the tops of some granule conglomerate beds.

Sandstone facies are lithic rich and dominantly very fine- to fine-grained. Beds are typically 5–10 cm thick, commonly weathering in a distinctive slab or "flagstone" rubble. Beds are usually massive, although faint plane-parallel lamination is common, particularly in association with low-angle cross-stratified facies. Sandstone is locally rippled, including rare, but distinctive oscillatory and interference bedform geometries. Floating coarse to very coarse sand grains are common and locally form planar discontinuous stringers. Carbonaceous and woody debris is common. Trace fossils are rare and typically include non-diagnostic, simple bedding parallel feeding traces. Solitary occurrences and thin coquinas of marine pelecypods are observed, but rare.

Recessive weathering siltstone and silty mudstone are only exposed in stream-cuts and gullies, although they probably represent the dominant facies within this formation. These fine-grained rocks are commonly massive and weather in small hackly chips. Bedding is defined by abundant bedding-parallel, hard calcareous concretions which form a distinctive "dot-dash-dot" pattern. Some of these concretions are preferentially located along very-fine grained sandstone beds which locally preserve excellent sedimentary structures typical of the Bouma sequence (scour, grading, ripples, etc., Bouma, 1962). Numerous yellow to yellow-green bentonites occur in the lowermost exposures of this facies. Load casts, flutes, or flame structures are not common within

this unit, probably due to the dearth of actual shale or claystone. Almost no body fossils have been recovered from this facies and evidence for biogenic reworking is rare.

Kfmv - Eo-Fortress Mountain, Informal Member of the Fortress Mountain Formation (Aptian (?) to Valanginian (?))—Informal name applied to a clastic interval of light green-gray sandstone and conglomerate rich in tan to beige to light green tuffaceous grains. Medium to dark gray siltstone may be interbedded with sandstone. The unit appears to underlie the Fortress Mountain Formation, although similar facies and petrology may indicate a shared genetic history. Locally appears structurally interleaved with more intensely deformed allochthonous chert, igneous, limestone, and sandstone blocks. Total thickness is unknown due to structural disruption, but is probably less than 300 m thick. Age is uncertain, but map relationships suggest it is older than typical Fortress Mountain Formation. The lighter gray green hue imparted by the tuffaceous grains is reminiscent of the Cobblestone Member of the Fortress Mountain Formation, a unique sandstone that was informally recognized by Kelley (1990) and adopted and defined by Mull et al., 2003 for rocks exposed in the eastern Chandler Lake Quadrangle (May and Cobblestone Creeks), forty miles east of this map.

Conglomerate beds are poorly to very poorly sorted, and locally supported in a sandstone matrix. Varicolored chert and altered mafic igneous clasts are common, usually moderately rounded. The unit is distinguished by a matrix-supported breccia facies association of subangular to angular light tan to light green (chloritized?) aphanitic tuffaceous clasts and abundant pale to turquoise green chert or siliceous mudstone. Lapilli grains and reworked plagioclase phenocrysts are locally observed in the tuffaceous component. Dark gray mudstone rip-up clasts are locally abundant. Sandstone beds locally include the distinctive tan to green angular granules, and appear to be slightly lighter colored than typical Fortress Mountain Formation, but otherwise occur in a similar motif of thin bedded (5–10 cm) tabular units.

SYNTECTONIC TURBIDITES, MÉLANGE AND OLISTROSTROMAL DEPOSITS

Kou - Okpikruak Formation, undifferentiated—(Patton and Tailleur, 1964) Medium to dark gray and green-gray, interbedded lithic sandstone, siltstone, and shale. The best and most continuous exposures occur within a broad synclinorium along Tiglukpuk Creek between the mountain front and Tiglukpuk Anticline. Due to structural complexity, discontinuous exposures, and the absence of fossils, it is often not possible to distinguish which belt of Okpikruak to assign to a particular exposure (i.e., melange, turbidites, or olistostromes).

Kom - Okpikruak Formation, mélange (Valanginian)—Sandstone, siltstone, and shale, commonly intensely deformed into “broken formation” and mixed in tectonic mélange that includes sheared blocks of Imnaitchiak chert, mafic igneous rocks, and local limestone with probable Carboniferous fauna (J. Dumoulin, 2005, written commun.). This structurally disrupted association was formerly assigned to the Tiglukpuk Formation (Patton, 1956), but is here included in the Okpikruak Formation. Most biostratigraphic data, especially the locally abundant bivalve Buchia sublaevis, indicate a Valanginian age. Deformation commonly obliterates primary sedimentary features and sandstone bodies become dislocated into strongly fractured and offset structural lenses separated by dark gray to black, vitreous, sheared mudstone. Distinctive spherical, slightly calcareous concretions are concentrated in a few exposures and range from 1–20 cm in diameter. Several thin poorly sorted matrix-supported conglomerate beds

are present and include clasts of chert, diorite, basalt, and fossiliferous Mississippian limestone (J. Dumoulin, 2005, written commun.). Clasts range from subangular to rounded and are locally as large as cobbles. Nearby large chert and mafic igneous blocks may be olistoliths that represent a continuum of disorganized sedimentary deposits. Olistoliths (described below) occur as isolated exposures ranging from meters to tens of meters in their maximum dimension.

Kot - Okpikruak Formation, turbidites (Berriasian)—Petrologically similar to Okpukruak mélange (Kom), but differentiated here based on stratigraphic coherency and apparent age difference suggested by the presence of the bivalves Buchia okensis, B. subokensis, B. uncitoides, and B. volgensis (W. Elder, 2006, written commun.). Best known from a structurally coherent section of approximately 400 meters of interbedded lithic sandstone, siltstone, and shale that is well exposed along the east bank of Tiglukpuk Creek. This section is dominated by monotonous, rhythmically interbedded siltstone and very fine-grained sandstone. Individual sandstone beds are tabular, laterally continuous, typically about 5 cm thick, and vary from internally massive with sharp grain size breaks to more normally graded beds. Beds exceeding a meter in thickness are rare and commonly exhibit flute and groove casts and preserve large ball and pillow, flame, and other soft sediment loading features. Some buff-orange to tan weathering sandstone beds concentrate discontinuous calcareous concretions that preserve fine sedimentary details such as scouring, lamination, ripples, and bioturbation—all of which cannot be discerned in unaltered facies. Planolites trace fossils are observed locally. Some bedding planes preserve distinctive concentrations of finely disseminated mica. Siltstone and lesser shale typically weather in a nodular, hackly fabric and are commonly inter-laminated at 2–5 mm scale with very fine-grained sandstone.

OLISTOLITHS FROM HIGHER ALLOCHTHONS

JPi - Imnaitchiak Chert (Jurassic to Pennsylvanian)—(Mull et al., 1987) Dominated by varicolored, thin bedded chert, siliceous mudstone, siltstone, and thin organic-rich shale. Most exposures within the map area are small isolated rubble-crops, limiting knowledge of the relationship with adjacent units. These small exposures occur within map-scale “broken formation” in which many different units are juxtaposed, presumably by protracted thrusting during emplacement of far-traveled thrust sheets. The common association with mafic igneous blocks may suggest an affinity with the Ipnavik River Allochthon, recognized to the west in Killik River and Howard Pass quadrangles (e.g. Mull et al., 1994). All exposures are intensely deformed, often by disharmonic folding and tightly spaced imbricate faulting. The most complete exposure, near the confluence of Tiglukpuk Creek and the Siksikpuk River, suggests the unit is less than 100 m thick. At this locality, the Imnaitchiak is immediately overlain by the Fortress Mountain Formation, although the nature of the contact (unconformity or fault) is unclear.

The Imnaitchiak Chert typically weathers a buff-yellow to yellow-orange color; the most common colors in fresh surfaces are light to medium greenish-gray, bluish-gray, reddish-brown, and dark gray. Bright turquoise green chert is somewhat rare and appears to be in close association with altered mafic igneous bodies, and, in one locality just east of the map area along Natvakruak Creek, underlies a volcanic tuff. In select exposures, a unique sooty, organic-rich, desiccated, fissile black shale is observed. This shale weathers a distinctive sulfur-yellow to yellow-green color. Cross-cutting zones of reddish-brown weathered horizons appear to mark

fault gauge. Rare fragmented pectinoid pelecypods have been observed in the map area and wispy bioturbation fabrics in many cherts and siliceous mudstones suggest some biogenic activity.

Mafic igneous rocks—Isolated outcrops of vesicular basalt and diorite. Commonly forms sills in the Imnaitchiak Chert and the Rim Butte Unit of the Lisburne Group. One outcrop shows unambiguous pillows. Believed to have intruded the lower Etivluk Group, which includes Imnaitchiak Chert (J_i), and into the Rim Butte unit, both of the Ipnavik River allochthon. Pillow basalts are likely from the Copter Peak allochthon.

Tuffaceous graywacke—Named by Patton and Tailleur (1964) for isolated exposures of tuffaceous graywacke and associated units within the now abandoned Tiglukpuk Formation. Sandstone is light green-gray and visibly lighter colored than nearby Okpikruak Formation sandstone. Grain size ranges from fine- to very coarse-grained sandstone. Most framework grains are volcanic lithics surrounded by up to 50% nondescript clay matrix. In contrast to other Brookian units, there is very little quartz and detrital chert grains are also very rare. The unit is locally poorly sorted and bears outsized mud rip-ups and possible tuff fragments. Bedding is typically not graded, suggesting mass flow deposition. Some flow tops exhibit weak planar lamination and ripple cross lamination, suggesting some late stage tractional processes may have reworked the tops of some beds. Interbedded mudstone is also unique and typically siliceous, brittle and hard, dark gray to black, and exhibits a distinctive iridescent hue on some bedding planes (manganiferous?). Deformation is locally concentrated in this lithology and displays "pencil cleavage," a fabric not observed in other Brookian mudstone.

Although this unit was originally thought to be Upper Jurassic (Patton and Tailleur, 1964), subsequent paleontologic work revised the age to Middle Jurassic (Jones and Grantz, 1964; Imlay and Detterman, 1973). New pelecypod specimens (Retroceramus lucifer and Retroceramus ambiguus) collected during our mapping confirmed the older age interpretation (W. Elder, 2006, written commun.). This unit was recognized in two localities within the map area, south of Tiglukpuk Anticline, along Tiglukpuk and Confusion Creeks. Both exposures occur within a tectonized belt of Okpikruak Formation mélange (Kom) and probably represent olistoliths. Although presently known from a small number of localities in the western half of the Chandler Lake Quadrangle (Patton and Tailleur, 1964), it remains likely that more exposures exist but are presently grouped under the Okpikruak Formation or the now abandoned Tiglukpuk Formation.

Mrb - Lisburne Group, Rim Butte unit (Mississippian)—(Dumoulin et al., 1993) Thick-bedded to laminated, commonly color-banded succession of variably siliceous, mainly very fine grained clastic limestone and chert; light to dark gray to grayish black but weathers medium gray, yellowish brown, grayish orange, and grayish red. Rhythmic and well-defined 2–75 cm beds, locally separated by mudstone selvages. Bioclasts include pelmatozoan debris and sponge spicules. Contains early Late Missisippian (Meramecian to early Chesterian) conodonts from a range of shallow to relatively deep marine environments, as well as redeposited older conodonts of Early Mississippian (Kinderhookian and Osagean) age (A. Harris, 2005, written commun.). Conodont taphonomy indicates post-mortem hydraulic transport and supports interpretation of limestone beds as fine-grained turbidites. Commonly intruded by mafic dikes and sills. Present only as isolated blocks up to 25 m maximum dimension.

Mlu - Undifferentiated limestones (Mississippian)—Partially silicified limestone of unknown affinity. Several occurrences consist of skeletal-peloidal grainstone and packstone that contain pelmatozoan and bryozoan debris, foraminifers, conodonts of Early Mississippian age (A. Harris, 2004, written commun.), and local volcanic lithic clasts. Lithofacies and age are consistent with derivation from various allochthons.

Dlu - Undifferentiated limestones (Upper Devonian (Famennian))—Partially silicified limestone of unknown affinity; isolated outcrops are observed in the Fortress Mountain fold belt in the east-central portion of the map area. Several occurrences consist of skeletal packstones that contain abundant calcispheres and (or) algal clasts as well as conodonts of late Late Devonian (Famennian) age (A. Harris, 2006, written commun.). Lithofacies and age are consistent with derivation from various allochthons.

ENDICOTT MOUNTAINS ALLOCHTHON

Kc - Buchia limestone coquina (Valanginian)—Distinctive reddish-brown weath-ering, thin-bedded limestone, with thin interbeds and partings of dark gray to black, fissile shale, composed entirely of the pelecypod Buchia sublaevis. Commonly structurally infolded with upper part of the underlying Otuk Formation. Undeformed stratigraphic thickness unknown, but probably <100 cm. Exposure is limited to the south flank of Tiglukpuk Anticline.

JTRo - Otuk Formation (Middle Jurassic to Lower Triassic)—(Mull et al., 1982). Interbedded fossiliferous black chert, limestone, and organic-rich black sooty shale in four lithogenetic units, in ascending order: 1) a basal poorly exposed shale member–black organic shale (Middle and Lower Triassic); 2) the "chert" member–black silicified mudstone, chert and shale (Middle and Upper Triassic); and 3) the limestone member–thinly interbedded shale and thin-bedded black- and light-gray banded limestone and silicified limestone commonly with abundant pelecypods Monotis sp. and Halobia sp., weathers yellowish-tan (Upper Triassic); 4) Blankenship Member (Middle and Lower Jurassic)–organic-rich black shale is poorly exposed in this map area. Unit is commonly intensely deformed in the map area but a coherent section is present on the east and west banks of Tiglukpuk Creek along the south flank of Tiglukpuk anticline (Bodnar, 1984 and Kelley, 1990).

Informal shale, chert, and limestone members all exposed in mapping area. Shale member consists of rhythmically interbedded light green silty shale with few gray-weathering limestone beds or nodules, black shale and (or) light green silty dolomitic shale; very little evidence of bioturbation. Chert member composed of intervals of resistant black chert and silicified limestone interbedded with black sooty shale; Monotis sp. and Halobia sp. pelecypods present on bedding planes; wispy laminations and banded weathering patterns. Limestone member consists of cycles of limestone and shale; beds are very even and continuous; abundant Monotis sp. pelecypods. Disconformable contact with underlying Siksikpuk Formation is well exposed on the west bank of Tiglukpuk Creek.

Ps - Siksikpuk Formation (Permian)—(Patton, 1957) Informal units A, B, C, and D (Siok, 1985) are recognized on Skimo, Tiglukpuk, Firestone, and other creeks, in descending order: A) yellowish-brown weathering calcareous siltstone; B) maroon to greenish-gray silty shale with

barite and siderite; C) greenish-gray silicious siltstone or chert; and D) gray clay shale. Age is Wolfcampian to Leonardian (Adams et al., 1997) based on megafossils and conodonts. Contact with the overlying Otuk Formation is exposed on the west side of Tiglukpuk Creek. Disconformable contact with the underlying Lisburne Group is well exposed on the east bank of Skimo Creek at the mountain front.

Lisburne Group (Lower Pennsylvanian (Morrowan) to Lower Mississippian (Osagean))—(Bowsher and Dutro, 1957) Dominantly massive, light- to dark gray weathering, cliff-forming crinoidal limestone and dolostone. Contains light gray to black chert nodules, lenses, and beds that vary from sparse to abundant throughout the section. Local leached pinpoint to vuggy porosity filled with solid hydrocarbon, especially in dolostone. Distinctive interval of sooty black shale, phosphorite, and limestone (Mlp) in upper part; locally exposed dark limestone, siltstone, and shale (_Ml) at top. Crops out in series of folded thrust sheets forming northern flank of Endicott Mountains. Stratigraphy varies in detail both from east to west and north to south; overall thickness apparently increases southward in higher thrust sheets. Section at Skimo Creek is most thoroughly studied in the map area and is more than 900 m thick. Locally divided into:

PMl - Lisburne Group, Pennsylvanian to Mississippian section (Lower Pennsylvanian and Upper Mississippian)—Limestone, siltstone, and shale. Distinctive dark-weathering, recessive interval that locally forms uppermost part of Lisburne Group. Brownish-gray-weathering, dark-gray to black lime mudstone and calcareous shale overlain by reddish-brown-weathering, dark-gray, non-calcareous shale, silty shale, and spiculitic siltstone. Unit best exposed along Skimo Creek, where it is 40 m thick and about 7 m above the base of the unit, contains a distinctive 45-cm thick bed of burrowed skeletal grainstone that is glauconitic, pyritic, and phosphatic. Conodonts of late Late Mississippian (Chesterian) age found in glauconitic grainstone bed near base of unit, but spiculitic siltstone at top of unit yields conodonts of early Morrowan (early Early Pennsylvanian) age (A. Harris, 2004, 2005, written commun.). Upper contact with Siksikpuk Formation is sharp and apparently disconformable. Unit apparently thins and disappears west of Encampment Creek and south of the headwaters of Skimo Creek in higher thrust sheets outside the map area.

Ml - Lisburne Group, Mississippian section, Ml (Upper and Lower Mississippian)—Light to dark gray to brownish gray limestone, lesser dolostone, and nodular, lenticular, and layered replacement chert. Variations in color, bed thickness, and resistance to erosion throughout section define markers that can be mapped in local areas. Light to medium gray weathering intervals typically are thicker bedded (up to ~2 m) and contain less abundant chert than dark gray to black weathering intervals; both include highly resistant, cliff-forming intervals and less resistant, rubble-prone intervals. Conodonts and foraminifers indicate that most of the section is Late Mississippian (Meramecian and Chesterian) but the lowermost 150 m are late Early Mississippian (Osagean) (Armstrong and Mamet, 1977; Whalen et al., 2006). Dolostone intervals (10–20 m thick) at several levels in unit contain 5–10 percent intercrystalline, moldic, and vuggy porosity. Conformable basal contact with Kayak Shale is gradational over ~10 m. Shale, limestone, and phosphorite, Mlp (Upper Mississippian)—Thinly interbedded black, sooty, calcareous shale, lime mudstone, phosphatic limestone, and phosphorite forms distinctive recessive unit ~30 m thick in upper part of Lisburne. Calcareous concretions common up to 0.5 m in diameter. At Skimo Creek, top of unit is 170 m below base of Siksikpuk Formation. Black

shale has total organic carbon contents as high as 6–8 percent as well as elevated values of Zn, V, Ni and other metals. Limestone contains locally abundant sponge spicules and radiolarians. Phosphatic rocks (Patton and Matzko, 1959) found mainly in five or more intervals, ~5 to 40 cm thick, distributed through 4–12 m of section near top of unit. Phosphate occurs as bright blue to lilac sand to pebble sized grains, many with oolitic layering, in matrix of carbonate or silica cement; some beds contain as much as 30% P2O5 (Kurtak et al., 1995). Conodonts and goniatite cephalopods (Gordon, 1957; Dumoulin et al., 1997) indicate an age of Late Mississippian (late Meramecian-early Chesterian) for this unit. Observed at least locally to western edge of map area; may disappear to south.

Mk - Kayak Shale of the Endicott Group (Lower Mississippian)—(Bowsher and Dutro, 1957) Dominantly recessive, slope-forming, uniform black fissile shale. Mostly clay shale to silty shale that forms shiny, planar plates 1-2 mm thick. Bare shale outcrop or scree on steep slopes, tundra on gentle slopes. Local 1 cm interbeds of laminated to ripple cross-laminated siltstone to very fine-grained sandstone. Common 20–40 cm thick lenticular beds of rusty orange-weathering bioclastic limestone. Broken and abraded fossil debris includes crinoids, brachiopods, bryozoans, and rugose corals. Local isolated 1.5–3 m thick beds of limestone, especially near top of unit. Similar in composition to lenticular interbeds, but gray to orange-gray weathering, massive to platy, locally cross bedded. These limestone beds commonly are folded and faulted. Unit is at least 165 m thick, but base is not exposed in map area. Basal detachment for thrust sheets commonly within Kayak Shale.

MDk - Kanayut Conglomerate of the Endicott Group (Lower Mississippian to Upper Devonian)—(Bowsher and Dutro, 1957) Present only in subsurface on cross section interpretations, but present in outcrop just south of the map area. Thick (up to 3,000 m) clastic sequence of shale, sandstone and conglomerate. In descending order: Stuver Member, interbedded sandstone and chert-pebble conglomerate, minor siltstone and shale deposited in meandering fluvial channels. Shainin Lake Member, massive chert-pebble conglomerate and chert-grain sandstone deposited in braided streams. Ear Peak Member, interbedded sandstone, siltstone, and shale deposited in meandering fluvial channels and alluvial plains.

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