DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

Draft generalized geologic map of the Chandler Lake quadrangle, north-central Alaska

by

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Open-File Report 89-495

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INTRODUCTION

Release of this map in open-file is in response to recent requests for geological information in the central Brooks Range and adjacent Arctic foothills. Upcoming State of Alaska oil and gas lease sales, the White Hills Sale Area 61 (January, 1992), the North Slope Foothills Sale Area 57 (September, 1993), and the Nanushuk Sale Area 77 (May, 1993) are stimulating interest in the geology of the central Arctic foothills. Geological field programs in preparation for lease sales are beginning this summer. Western Geophysical Company has made 800 line miles of reflection seismic data available for the upcoming lease sales, 400 line miles shot during the winter of 1986-87 and 400 line miles shot during the winter of 1988-89. The recently completed geophysical and ongoing geological surveys have prompted requests for timely release of geological information on the central Arctic foothills.

This map is an iteration of the areal geologic base for the resource assessment of the the Chandler Lake quadrangle under the Alaskan Mineral Resource Assessment Program (AMRAP). The original intent in constructing this map was to produce a geologic map that emphasizes structural patterns and depositional continuity at a scale and simplicity compatible with the areal density of geochemical and geophysical sampling for AMRAP assessments. This map is reduced, simplified, and interpreted from previous maps, principally Kelley, (1988).

The map attempts to emphasize aspects of the areal geology relevant to the structural framework of the Chandler Lake quadrangle. Thin and contiguous stratigraphic units are combined. Where combination of map units does not obfuscate structural and stratigraphic relations, contiguous map units with similar geochemical signatures are combined to enhance the usefulness of the map in interpreting geochemical data. Assemblages of lithologically diverse but spatially associated rocks, the limited and scattered exposures of which were mapped at 1:125,000 scale (Kelley, 1988), are also combined to emphasize the distribution of assemblages; depiction of the inferred distribution of assemblages rather than isolated elements of assemblages better shows the association of geochemical and geophysical signatures with particular rock assemblages. Structural geologic information from (Kelley, 1988) was selected to emphasize continuity and major structural features.

Differing degrees of interpretation are involved in compiling different parts of the map. The northern and southern portions of the geologic map are compiled from mapping of areas in which structural and stratigraphic continuity were mapped at 1:125,000 (Kelley, 1988). The intervening central part of the map is largely generated from an outcrop map in which the same assemblage of rocks occur over an extensive area.

Near-continuous outcrop south of the range front in the Brooks Range province of Wahrhaftig (1965) affords interpretation of structures and map units with considerable objectivity. Generally thin Quaternary colluvium consisting of locally derived rock debris, and tundra covered solifluction deposits are not shown on lower slopes and in larger valleys. Small faults are selectively omitted whereas larger through-going structures are emphasized by inference in the areas where generally thin colluvium masks exposure.

There is limited outcrop north of Hatbox Mountain, Tuktu Bluff, Gunsight Mountain, Banded Mountain, and Table Mountain (Tuktu Escarpment), but clear relationship between bedrock geology and topography affords confident interpretation of structural relations. A structural pattern is clearly evident from exposures of resistant-weathering sandstone and topography controlled by resistant-weathering sandstone within the Northern Foothills province of Wahrhaftig (1965).

North of the Tuktu Escarpment, the map emphasizes stratigraphic continuity. Age-equivalent and age-transgressive formations, members, and tongues are combined to form map units based on overall lithology, mainly units of principally sandstone and units of principally shale. Strata north of the Tuktu Escarpment are complexly intertonguing nonmarine and marine strata, mostly shallow marine strata. Detterman and others (1963) use a complex stratigraphic nomenclature based on rock type, depositional environment, and age ranges of transgressive and regressive depositional units; Detterman and others (1963) deal with stratigraphy in detail and Molenaar (1985) deals with the stratigraphy in a regional stratigraphic context.

Because of limited outcrop and structural complexity, considerable subjective interpretation is needed to generalize the geology within the Southern Foothills province of Wahrhaftig (1965). The area between between the Tuktu Escarpment and the range front encompasses isolated and commonly poor outcrops. This involved extrapolation from individual outcrops mapped at 1:125,000 (Kelley, 1988).

Two systems of thrust sheets occur in the southern Arctic foothills. The lower system is inferable from recognition of a poorly exposed but widely distributed areally persistent thin stratigraphic sequence repeated by imbricate faults. The upper system occurs as erosional remnants overlying the lower system. The upper system is better exposed and structurally more simple than the underlying system. West of the Anaktuvuk River, the upper system comprises structurally simple sheets overlying complexly imbricated blocks of the lower system. East of the Anaktuvuk River, the upper system comprises imbricate blocks above the lower system of thrust sheets.

MAP UNIT DESCRIPTIONS

Qal **QUATERNARY ALLUVIUM (Holocene)** (Hamilton, T.D., 1979)--This unit comprises various unconsolidated debris including boulders, gravel, sand, silt, clay and humic material. The unit includes sediments in river channels, active floodplains, bogs and swamps. See Hamilton (1979) for detailed map and descriptions of Quaternary deposits

Qd **QUATERNARY DEPOSITS (Quaternary)** (Hamilton, T.D., 1979)--This is a widely inclusive unit that comprises undifferentiated unconsolidated deposits, including glacial drift, outwash, and high-level terraces, mostly boulders, gravel, sand, silt and clay. See Hamilton (1979) for detailed map and descriptions of Quaternary deposits

Ksb **SCHRADER BLUFF FORMATION (Upper Cretaceous)** (Detterman and others, 1963)--Three members make up the Schrader Bluff Formation; they are, in ascending order, the Rogers Creek, Barrow Trail, and Sentinel Hill Members. All three members occur in the Chandler Lake quadrangle but are not discriminated. Detterman and others (1963) report about 1,800 feet (550 m) of Schrader Bluff Formation at Race Track Basin syncline

The Schrader Bluff Formation consists of shale, claystone, sandstone, and bentonite. Shale is medium- to light-gray, bentonitic, clayey, fissile, and includes tuff beds. Claystone is medium-gray, commonly well indurated, and probably at least in part tuffaceous. Sandstone is light-gray to light-brown, fine-grained, laminated, and micaceous. Bentonite beds consist of medium- to light-grayish-green bentonite that are locally silty and grade to gray tuffaceous siltstone. Formation includes shell fragments, identifiable megafossils, and coalified wood debris

Kp **PRINCE CREEK FORMATION (Upper Cretaceous)** (Detterman and others, 1963)--Only the Tuluvak Tongue of the Prince Creek Formation is recognized in the Chandler Lake quadrangle. Detterman and others (1963) report 575 feet (175 m) of Tuluvak Tongue at the type locality at Schrader Bluff about 15 miles (24 km) north of Race Track Basin. The Tuluvak Tongue appears to thicken radically in the northeastern part of the Chandler Lake quadrangle where outcrop widths and dips infer thicknesses approaching 2,000 feet (610 m) (Kelley, 1988). The character of the Prince Creek Formation changes from southwest to northeast

In the northeastern part of the quadrangle, it is principally sandstone, siltstone, mudstone, coal, and tuff. Sandstone is medium- to light-medium-gray, yellowish-gray, brownish-gray, thin- to medium-bedded, fine-to coarse-grained, locally conglomeratic, and tuffaceous in part. Sandstone is locally conglomeratic and includes conglomerate beds composed mostly of small pebbles of black chert and white quartz and quartzite. Mudstone, siltstone, and shale are end members of a continuum of lithologies that are typically medium-gray to dark-gray, fissile locally, and bentonitic in part. The formation includes plant fragments, identified leaf fossils, tuff beds, coal, and ironstone nodules

In the southwestern part of the quadrangle, the formation comprises conglomerate, sandstone, siltstone, and shale. Conglomerate is basal in the formation. Conglomerate is as much as 40 feet (12 m) thick and composed of well rounded pebbles of white to light-gray quartz, orthoquartzite, and medium- to dark-gray chert. Conglomerate has a sandstone matrix and prominent quartz cement that shines in direct sunlight. Conglomerate produces prominent positive weathering topographic features such as cuestas and rimrock. Sandstone, siltstone, and shale in upper part of the unit are very poorly exposed. Sandstone is gray, probably mostly quartz and chert, and prominently cross bedded. Siltstone and shale are gray to brownish-gray, and poorly indurated

Ks **SEABEE FORMATION (Upper Cretaceous)** (Detterman and others, 1963)--The formation comprises the Shale Wall Member and overlying Ayiyak Member in the Chandler Lake quadrangle. Detterman and others (1963) report about 1,800 feet (550 m) of Shale Wall Member along the Nanushuk River at Rooftop Ridge. Detterman and others (1963) also report 360 feet (110 m) of Ayiyak Member in the type locality along the Ayiyak River and a generally uniform thickness in the map area. Outcrop widths and dips suggest that the Seabee Formation is about 1,400 feet (425 m) thick and thins to the south, probably at the expense of the Shale Wall Member (Kelley, 1988). Differences in reported thicknesses probably are caused by structural complications in the Shale Wall Member. The members of the Seabee Formation are not discriminated in the mapping

The Shale Wall Member consists mostly of medium-gray shale. Shale is typically bentonitic, clayey, and includes bentonite beds, laminated siltstone interbeds, and limestone concretions. The member includes dark-gray to black organic shale locally, clayey limestone concretions up to 8 feet (2.4 meters) across, and marine fossils. Medium- to medium-light-gray fine- to very fine grained sandstone and siltstone locally occur in the member. Calcite cement is common

The Ayiyak Member is mostly greenish-gray and olive-gray siltstone. The siltstone is typically shaly and grades to mudstone. Brownish-gray greenish-gray mostly fine-grained thin- to medium-bedded sandstone occurs in the member. Locally the sandstone is coarse-grained, conglomeratic, and includes thin lenticular beds of conglomerate composed mostly of black chert and white quartz pebbles. The member also includes impure limestone, shale, and both ironstone and calcareous concretions

Knc **NIAKOGON TONGUE OF THE CHANDLER FORMATION, AND NINULUK FORMATION (Upper Cretaceous)** (Detterman and others, 1963)--The Niakogon Tongue is principally nonmarine sandstone that interfingers with the laterally equivalent and principally marine sandstone of the Ninuluk Formation. The Ninuluk Formation crops out northeast of the Niakogon Tongue and comprises strata deposited in progressively deeper water to the northeast. Detterman and others (1963) report 1,160 feet (355 m) of Ninuluk Formation on the east fork of the upper Tuluga River. Outcrop widths and dips suggest that 1,160 feet (355 m) is a maximum thickness for the Niakogon Tongue and Ninuluk Formation (Kelley, 1988); both units are locally absent either due to erosion along an unconformity at the base of the Seabee Formation or abrupt depositional wedge out. The Niakogon Tongue of the Chandler Formation and Ninuluk Formation are not mapped as individual units

The Niakogon Tongue comprises sandstone, siltstone, and mudstone. Sandstone is light-olive-gray, greenish-gray, medium-gray, fine- to coarse-grained, thin-bedded to massive, well indurated, and locally limonite cemented. Sandstone typically weathers light-gray with a "salt and pepper" appearance or buff and yellowish-red where exposures are iron-oxide-stained. Ironstone concretions and beds of granule conglomerate and conglomeratic sandstone occur locally. Granules in conglomerate and conglomeratic sandstone are mostly dark-gray chert and quartz. Siltstone and mudstone may form as much as half of the tongue. Plastic grayish-green bentonite beds occur in the upper part of the tongue

Ninuluk Formation is mostly sandstone, siltstone, and shale. Sandstone is greenish-gray to brownish-gray, thin-bedded to massive, laminated in part, cross-bedded, friable to moderately indurated, and fine- to very fine grained. Sandstone grades to siltstone. Conglomeratic sandstone in part includes beds and lenses of granule conglomerate comprising framework clasts of varicolored chert and white quartz. Ripple marks, carbonaceous debris, marine fossils, and thoroughly carbonate-cemented lenses grading to sandy and silty limestone occur locally in the sandstone. Across the map area, sandstone beds become progressively finer grained, thinner bedded, more clayey, and more commonly carbonate cemented in a northeasterly direction. Greenish-gray hard and hackly weathering shaly siltstone and dark-bluish-gray clay shale occur in the formation. Both siltstone and shale are laminated. The formation also includes soft shale with weathering surfaces that commonly have a yellowish-gray or light-gray bloom. Siltstone and shale include ironstone concretions. Beds and partings of grayish-green plastic claystone, probably bentonite, occur in shale

Kck **KILLIK TONGUE OF THE CHANDLER FORMATION (Lower Cretaceous)** (Detterman and others, 1963; Patton and Tailleur, 1964)--Detterman and others (1963) report thicknesses of 2,570 and 2,840 feet (785 and 865 m) from measured sections in the Chandler Lake quadrangle where the Killik tongue does not interfinger with other map units. Outcrop widths and dips suggest that the Killik Tongue is about 2,600 feet (790 m) thick but thins dramatically to the northeast (Kelley, 1988), possibly due to truncation under an unconformity at the base of the Seabee Formation or possibly facies transition into marine map units

The Killik Tongue comprises sandstone, conglomerate, siltstone, shale, and coal. Sandstone and conglomerate is light-olive-gray, greenish-gray, and medium-gray but typically weathers light-gray with "salt and pepper" color patterns caused by dark gray chert and aphanitic rock fragments in contrast to very light gray weathering quartz and light-gray chert grains. Sandstone is medium-grained to fine-grained and characteristically cross bedded. Conglomeratic sandstone and conglomerate beds comprise clasts of mostly chert and quartz. Conglomerate is framework supported. Coal beds as much as 10 feet (3 m) thick occur in the upper part of the tongue and together with siltstone and shale are negative weathering and generally poorly exposed. Ironstone concretions are common in the coal-bearing part of the tongue. Sandstone and conglomerate are very prominent ledge-forming strata

Ktg **TUKTU FORMATION AND GRANDSTAND FORMATIONS (Lower Cretaceous)** (Detterman and others, 1963; Patton and Tailleur, 1964)--Tuktu and Grandstand Formations constitute the basal sandstone of the Nanushuk Group. The basal sandstone is time-transgressive to the north; the age of the Grandstand Formation is equivalent to that of the Killik Tongue of the Chandler Formation, which overlies the Tuktu Formation along the Tuktu Escarpment. The two formations are combined here, although the Grandstand Formation is younger than the Tuktu Formation, because: (1) both formations occupy the same stratigraphic position at the base of the Nanushuk Group, (2) the units are chronologic end members of a time-transgressive depositional unit, and (3) a widespread structural detachment occurs between the Tuktu/Grandstand Formations and underlying shale. The combination of map units helps demonstrate a fundamental transition from sandstone to shale that is coincident with a regional structural discontinuity

Detterman and others (1963) report the thickness of Tuktu Formation from measured sections to range from 940 to 1,030 feet (285 to 315 m). Detterman and others (1963) report 1,430 feet (435 m) of Grandstand Formation at the type section on the Anaktuvuk River. Outcrop widths and dips suggest that the Tuktu and Grandstand Formations attain thicknesses of as much as 1,500 feet (455 m) (Kelley, 1988)

The Tuktu Formation and Grandstand Formation are principally grayish-green to greenish-gray sandstone. Sandstone is typically medium-light-gray- to buff-gray-weathering, medium- to very fine grained, shaly in part, and cross bedded in part. Ripple marks, wood debris, marine fossils, conglomerate beds comprising granules and small pebbles of mostly chert and quartz, and bioturbations occur locally. Greenish-gray siltstone and mudstone make up a small part of the formations. The Tuktu and Grandstand Formations are resistant weathering and together with overlying nonmarine sandstone form prominent ridges

Kf/Kft **FORTRESS MOUNTAIN FORMATION, (Lower Cretaceous)** (Patton and Tailleur, 1964)--This unit includes 2 lithofacies: (1) nonmarine conglomerate and underlying marine sandstone (Kf) which occurs west of the Anaktuvuk River, and (2) turbidite sandstone and conglomerate (Kft) east of the Anaktuvuk River. Patton and Tailleur (1964) report between 2,500 and 10,000 feet (760 and 3050 m) of Fortress Mountain Formation at Fortress and Castle Mountains. Crowder (1987, p. 454-455) reports 12,000 feet of Fortress Mountain Formation at Castle Mountain. Outcrop widths and dips suggest that the Fortress Mountain Formation, shown west of the Anaktuvuk River on this map, is probably between 700 and 2,000 feet (215 and 610 m) thick in the Castle Mountain and Fortress Mountain area and thins to the east (Kelley, 1988). Sandstone and conglomerate east of the Anaktuvuk River is possibly about 1,000 feet (305 m) thick; structural complexity, however, limits confidence in this estimate (Kelley, 1988)

Previous workers (Patton and Tailleur, 1964, p. 458) consider the stratigraphic relations between the Fortress Mountain and Torok Formations and Nanushuk Group uncertain, but state that the Fortress

Mountain Formation is unlikely as young as middle Albian or equivalent to the Nanushuk Group. Other workers (Gryc, 1956; Patton, 1956; Jones and Gryc, 1960, p. 151; Detterman and others, 1963, p. 230; Chapman and others, 1964; Molenaar, 1981, p. 26; Molenaar and others, 1981, p. 3; Mull, 1979, p. 5; Ahlbrandt and others, 1979, p. 14; and Crowder, 1987, p. 451) describe the Fortress Mountain Formation as laterally equivalent to or below the Torok Formation, which underlies the Nanushuk Group. Fossils in marine sandstone interbeds within predominately nonmarine strata in the Fortress Mountain Formation in the Chandler Lake quadrangle (Kelley, 1988) include middle to late Albian bivalves (J.W. Miller, written commun., 1983) which are the same age as those in the lower part of the Nanushuk Group

Assignment of strata to the Fortress Mountain Formation in this map differs from previous reconnaissance mapping (Patton and Tailleur, 1964) in the Chandler Lake quadrangle. Patton and Tailleur (1964) included 2 sets of outcrops in the Fortress Mountain Formation. The first set includes prominent erosional remnants of conglomerate and sandstone lying on complexly deformed rocks and melange and includes the type section of the Fortress Mountain Formation. The other set of outcrops consists of sandstone and minor conglomerate that occur as positive-weathering lenses within strata largely indistinguishable from the Torok Formation. In this map, the term Fortress Mountain Formation applies only to the first set which includes Lower Cretaceous sandstone and conglomerate that lie on structurally complex Lower Cretaceous and Upper Jurassic clastic rocks, radiolarian ribbon chert, and mafic igneous rocks

West of the Anaktuvuk River, the Fortress Mountain Formation as used in this report comprises nonmarine and marine strata that occur in unimbricated shallow-dipping slab-like structural blocks that lie on complexly imbricated blocks of Mississippian to Lower Cretaceous strata, melange, and locally Torok Formation. Outcrops are mostly massive-weathering nonmarine conglomerate and sandstone but include marine sandstone, especially in the lower part of the section. Most outcrops are erosional remnants of broad basin-shaped synclines comprising ridges underlain by beds of erosion-resistant conglomerate and sandstone arranged in a circular or ellipsoidal pattern and dipping toward a central point. Outcrops are remnants of structural sheets in probable fault contact, probably a fault superimposed along a pre-existing unconformity, with underlying older rocks including graywacke, ribbon chert, mafic igneous rocks and melange

West of the Anaktuvuk River, thin wedges of the Torok Formation occur below the Fortress Mountain Formation on the north flank of Fortress Mountain and east of Fortress Mountain in T. 10 S., R. 2 W., U.M.

Isolated occurrences of Fortress Mountain Formation probably occur outside the mapped areas of Fortress Mountain Formation, especially west of the Anaktuvuk River. Mudstone and sandstone that probably would be assigned to the Fortress Mountain Formation if relations to underlying rocks were exposed are mapped as Jurassic and Cretaceous shale or undifferentiated strata (Kelley, 1988). These strata are depositionally consanguineous with the Fortress Mountain Formation but where structurally detached and intermixed with older underlying graywacke and mudstone are very difficult to discriminate from the older strata, owing to their similar lithology and the paucity of fossils in both the older strata and the Fortress Mountain Formation

Areas mapped as Fortress Mountain Formation west of the Anaktuvuk River, especially the larger areas, probably include some older rocks. There probably are unrecognized erosional breaches in the Fortress Mountain Formation that expose underlying older rocks. The Fortress Mountain Formation is locally very thin and infolded and possibly imbricated with underlying rocks, which increases the difficulty in discriminating Fortress Mountain Formation from older strata

The Fortress Mountain Formation east of the Anaktuvuk River differs in some respects from the Fortress Mountain Formation west of the Anaktuvuk River. Submarine gravity flow deposits rather than nonmarine and marine deposits crop out along upper Cobblestone and May Creeks. Torok Formation is not recognized beneath the Fortress Mountain Formation along upper Cobblestone and May Creeks although Torok Formation lies adjacent to the Fortress Mountain Formation and rocks that underlie the Fortress Mountain Formation along May Creek. Along upper Cobblestone and May Creeks, the Fortress Mountain Formation occurs in imbricate south-dipping blocks in contrast to the extensive shallow dipping slab-like blocks west of the Anaktuvuk River

However, the Fortress Mountain Formation on both sides of the Anaktuvuk River are broadly similar. In both areas, it lies in fault contact on mostly structurally complex ribbon chert, mafic igneous rock, Mesozoic clastic rock, and melange. Occurrences on both sides of the Anaktuvuk River include wood debris and framework compositions rich in chert clasts

Kf Nonmarine and marine deposits, mostly found west of the Anaktuvuk River, consist principally of conglomerate and sandstone. Conglomerate is mostly light-greenish-gray-weathering, greenish-gray, framework-supported pebble conglomerate that characteristically occurs in beds that range from 0 to 4 feet (1.2 m) thick. Beds are lenticular and cross bedded with locally prominent pebble imbrication. Rip-up clasts, scarce mudcracks in thin and discontinuous mudstone intervals, and plant debris ranging from small carbonized wood debris to coalified logs occur in predominately conglomeratic strata. Conglomerate clasts include greenish-gray, bright greenish-gray, gray, reddish-brown, and light-gray translucent varieties of chert, greenish-gray aphanitic, porphyritic vesicular, and nonvesicular mafic igneous rocks, light-gray to medium-light- gray limestone and dolomitic limestone, silicified argillite, organic shale, and granitic rocks. Although most conglomerate clasts are well rounded, clasts of sedimentary rock are typically elongate parallel to bedding. Conglomerate is interbedded with bioturbated marine sandstone and mudstone that contains local ripple and wave cross bedding, gravel lenses with abundant wood debris, and locally marine mollusks

Conglomerate at Castle Mountain overlies and may grade abruptly to marine sandstone including fine- to coarse-grained thin-bedded to laminated sandstone with very prominent parting lineation and a flaggy weathering character. Sandstone includes scarce shell and wood debris, some of which occur in small accumulations with current crescents about them

Kft Turbidite sandstone and conglomerate not associated with recognized shallow marine or nonmarine deposits occurs east of the Anaktuvuk River. Sandstone is medium-greenish-gray, mostly fine- to medium-grained, but grades to very coarse grained sandy granule conglomerate. Sandstone beds are up to 5 feet (1.5 m) thick, but most beds range from 1-foot to 2 feet (0.3 to 0.6 m) in thickness. Thicker sandstone intervals are generally composed of amalgamated beds. Sandstone beds are massive, graded, laminated, and locally wispy cross bedded. Sole marks on sandstone beds include flute casts and tool marks. Sandstone locally includes much carbonized wood debris, some of which is up to 1-foot (0.3 m) long. Most larger sand grains and granules are chert, including light-gray, light-greenish-gray, dark-gray, and very light gray tripolitic chert. Sandstone is interbedded with siltstone and silty mudstone

Kto **TOROK FORMATION (Lower Cretaceous)** (Detterman and others, 1963)--Detterman and others (1963) report 6,120 feet (1865 m) of Torok Formation in the type section along Torok Creek north-northeast of Castle Mountain. The monotonous character, obscure imbrication, mechanical incompetence, and incomplete exposure of this unit make estimates of thickness based on outcrop width and dip alone unreliable

Assignment of strata to the Torok Formation in this map differs from previous usage in reconnaissance mapping in the Chandler Lake quadrangle (Patton and Tailleur, 1964). Previous workers recognized two map units, elements of which are largely incorporated into the Torok Formation in this map. Patton and Tailleur (1964, pl. 50) recognized a unit composed of Torok Formation and Fortress Mountain Formation undifferentiated and a set of prominent outcrops of sandstone in shale that they recognized as Fortress Mountain Formation. Kelley (1988) and this map discriminate sandstone and shale in both units of Patton and Tailleur (1964); the sandstone is assigned to an informal map unit in the lower part of the Torok Formation and the shale is assigned to the Torok Formation undifferentiated

The Torok Formation comprises shale, mudstone, siltstone, and sandstone. The formation is mostly and characteristically bluish-gray, dark-greenish-gray, medium-dark-gray, and dark-gray shale, mudstone, and clayey siltstone. Shale is fissile in part, mostly very thin bedded, and includes partings and thin interbeds of siltstone and fine-grained sandstone. Sandstone is medium-light-gray and greenish-gray, very fine to very coarse grained, silty and shaly, and in part conglomeratic. Sandstone also includes lenses of granule conglomerate, most granules of which are chert

Kcs **COBBLESTONE SANDSTONE UNIT (Lower Cretaceous)**--Cobblestone sandstone unit is a new and informal lithostratigraphic name proposed for mappable and discrete bodies of Lower Cretaceous sandstone and conglomerate in the lower part of the Torok Formation. The unit comprises lenticular and discontinuous bodies of sandstone and conglomerate that form in structurally complex and south-dipping imbricate fault blocks. Outcrops occur discontinuously in a trend that parallels and lies south of the Tuktu Escarpment

Recognition of the informal Cobblestone sandstone unit refines previous stratigraphy. Previous workers (Patton and Tailleur, 1964, pl. 50) map strata herein assigned to the Cobblestone sandstone unit and enclosing shale as Fortress Mountain Formation. The Cobblestone sandstone unit as proposed here discriminates coarse-grained submarine gravity flow deposits from fine-grained strata, shale, mudstone, siltstone, and fine-grained sandstone. The fine-grained strata are herein mapped with the Torok Formation undifferentiated. The Cobblestone sandstone unit also discriminates gravity flow deposits in the lower part of the Torok Formation from Fortress Mountain Formation strata as used in this report

Cobblestone sandstone unit strata are probably older than Fortress Mountain Formation west of the Anaktuvuk River. The Cobblestone sandstone unit occurs in the lower part of the Torok Formation whereas the Fortress Mountain Formation locally overlies Torok Formation strata on the north flank of Fortress Mountain and east of Fortress Mountain in T. 10 S., R. 2 W. Additionally, fossils near the base of the Fortress Mountain Formation in T. 12 S., R. 2 W. are middle and late Albian (J.W. Miller, 1983, written commun.) and age correlative with fossils in the Nanushuk Group which overlies the Torok Formation along the Tuktu Escarpment

Previous workers (Gryc, 1956; Patton, 1956; Jones and Gryc, 1960, p. 151; Detterman and others, 1963, p. 230; Chapman and others, 1964; Patton and Tailleur, 1964, p. 458; Molenaar, 1981, p. 26; Molenaar and others, 1981, p. 3; Mull, 1979, p. 5; Ahlbrandt and others, 1979, p. 14; and Crowder, 1987, p. 451) recognized continuity between strata assigned herein to the Cobblestone sandstone unit and the Fortress Mountain Formation by assigning both units to the Fortress Mountain Formation. The present mapping and nomenclature points out: (1) discontinuous nature of tongues of sandstone within the lower part of the Torok Formation, (2) diachronous relations between sandstone in the lower part of the Torok Formation and the Fortress Mountain Formation, and (3) restricts the Fortress Mountain Formation to conglomerate and sandstone overlying complexly deformed Mississippian to Lower Cretaceous rocks including Torok Formation. The present work does not preclude depositional consanguinity between strata assigned to the Cobblestone sandstone unit and the Fortress Mountain Formation; if consanguinity exists however, the present work suggests structural telescoping of younger and more proximal facies over older more distal facies west of the Anaktuvuk River

Map pattern suggests that sandstone bodies of the Cobblestone sandstone unit range between 0 and 1,000 feet (305 m) thick and from 1-mile (0.6 km) to more than 10 miles (16 km) in lateral continuity (Kelley, 1988). Structural complexities too small to be shown at 1:125,000 and likely to produce repeated section suggest that the estimated thickness is a maximum value

The Cobblestone sandstone unit comprises sandstone, siltstone, mudstone, and conglomerate. Sandstone is mostly yellowish-brown-weathering, olive- to greenish-gray, coarse- to very fine grained, very thin to massive-bedded, partly laminated, and partly small-scale and wispy cross bedded. Sandstone includes locally abundant small carbonized plant debris, carbonaceous films, flute marks, load casts, and tool marks. Sandstone beds typically include incomplete turbidite sequences and are locally organized into thinning upward cycles consisting of amalgamated sandstone and gritty sandstone progressively overlain by thinner and fewer amalgamated sandstone beds interbedded with siltstone and mudstone. By hand specimen inspection, sandstone comprises moderately sorted subangular to subrounded clasts of chert, quartz and rock fragments. Siltstone is yellowish-brown-weathering, olive- to greenish-gray, mostly thin-bedded to laminated, and grades to very fine grained sandstone. Siltstone includes locally common plant debris. Mudstone is medium-dark-gray to medium-greenish-gray, mostly thin-bedded, very silty and very sandy in part, and locally includes sandstone partings. Conglomerate is framework-supported and consists mostly of well rounded clasts that range from granule to cobble size but are mostly pebble size. Conglomerate clasts are mostly chert but include common various silicified aphanitic rock fragments, mafic igneous rock fragments, and carbonate rock fragments

The Cobblestone sandstone unit includes distinctive iron-stained and granule- to small-pebble-bearing shale, mudstone, and siltstone. Some outcrops of pebbly strata are deeply iron-stained with goethite coatings that give some beds a metallic appearance. Clasts in pebbly beds are scattered, well rounded, percussion-marked and mostly chert and mafic igneous rock. Iron-stained and pebbly units include ironstone lenses. The unit includes some thin beds which are tough, fissile, and carbonaceous

KM **FOOTHILL ASSEMBLAGE (Lower Cretaceous to Mississippian)**--This unit comprises seven previously recognized map units (Kelley, 1988) that occur in the Arctic Foothills (Wahrhaftig, 1965) of the central Brooks Range. The assemblage includes: coquinoid limestone (Lower Cretaceous), Cretaceous and Jurassic strata undivided, mafic igneous rocks (Jurassic), Triassic and Permian chert, Nuka Formation (Pennsylvanian(?) and Mississippian), marble, and melange.

Fragmentary evidence provides a basis for inferring stratigraphic and structural relations within the Foothill assemblage in the Chandler Lake quadrangle. Contacts between units within the assemblage are not extensively exposed in the Chandler Lake quadrangle. However, distribution over an area greater than 1,000 sq. mi. (2,600 sq. km) of the assemblage which comprises units that collectively may be as thin as 2,000 feet (610 m) infers shallow dip or structural repetition; steep dips and fold and thrust belt setting of the Arctic Foothills makes the latter interpretation more likely

Stratigraphic relations between all of the units in the Foothills assemblage in the Chandler Lake quadrangle are not clear. Most of the Foothills assemblage probably is a structurally repeated complexly deformed and tectonically disrupted depositional sequence consisting of Triassic to Permian chert containing intrusions and possibly interbeds of mafic igneous rocks overlain by Upper Jurassic to Lower Cretaceous strata. Stratigraphic relations between this depositional sequence and the Nuka Formation, marble, coquinoid limestone, and melange are to differing degrees uncertain. Nuka Formation and marble could be metamorphic equivalents of one another. Melange consists of structural blocks of the Foothills assemblage in a sheared matrix of Upper Jurassic to Lower Cretaceous strata, mostly shale. Most melange is the extreme case of the structural disruption of the depositional sequence that makes up most of the Foothills assemblage but locally blocks of coquinoid limestone occur in the melange.

Blocks of coquinoid limestone unit probably are tectonically derived from strata adjacent to the Foothills assemblage. The Foothills assemblage structurally overlies an Upper Devonian to Lower Cretaceous sequence of strata that is not intruded by the mafic igneous rocks that occur in the overlying Foothills assemblage. Along upper Peregrine, Cobblestone, May, and Tiglukpuk Creeks, blocks of coquinoid limestone in the Foothills assemblage crop out within 1 mi. (0.6 km) of outcrops of strata from which the blocks were likely derived and less than 500 ft. (150 m) structurally above strata from which the blocks were likely derived.

Structural and stratigraphic relations of the units of the Foothills assemblage exposed in the adjacent Killik River quadrangle to the west support inferred stratigraphic and structural relations in the Chandler Lake quadrangle. Contacts between equivalents of Permian to Triassic chert and Upper Jurassic to Lower Cretaceous clastic rocks in the Chandler Lake quadrangle are exposed in the Killik River quadrangle. The chert, locally extensively intruded by mafic igneous rocks, unconformably underlies Upper Jurassic and Lower Cretaceous clastic rocks. A regional sole thrust underlies the chert and mafic igneous rocks; subsidiary thrusts produce imbricate blocks of both (1) chert and mafic igneous rocks and (2) chert and mafic igneous rocks and Upper Jurassic to Lower Cretaceous clastic rocks

Tectonic blocks of the coquinoid limestone unit (Lower Cretaceous, Valanginian) occur in melange in the Foothills assemblage. The coquinoid limestone occurs as slabbly blocks, indicated by ■ on the geologic map, in highly sheared and disrupted Upper Jurassic and Cretaceous shale and sandstone. Blocks are typically brownish-gray and reddish-brown-weathering limy siltstone, mudstone, and impure limestone including abundant bivalves, typically *Buchia sublaevis*, algae, and shell hash. See map unit description of coquinoid limestone unit for more complete lithologic description

Upper Jurassic and Cretaceous strata undivided (Kelley, 1988) is a unit including a variety of bedded clastic rocks of uncertain aggregate thickness. Patton and Tailleur (1964, p. 447) report between 1,800 (550 m) and possibly 2,200 feet (670 m) of Berriasian and Valanginian strata in the Cretaceous and Jurassic strata undivided unit used here. Unmapped structural complexity, generally poor and discontinuous exposure, lack of reliable marker beds, and poor biostratigraphic control limit accurate estimation of thicknesses.

The Upper Jurassic and Cretaceous strata of Kelley (1988) includes four recognizable facies: (1) sandstone and shale, (2) conglomerate, (3) tuffaceous sandstone, and (4) volcaniclastic breccia. The sandstone and shale facies make up the bulk of the unit and range from shale with subordinate turbidite sandstone to amalgamated turbidite sandstone with subordinate shale. The sandstone and shale facies includes the Okpikruak Formation of Patton and Tailleur (1964). The Upper Jurassic and Cretaceous unit probably includes unrecognized occurrences of Torok and Fortress Mountain Formation that probably unconformably overlay Okpikruak Formation and other elements of the Foothill assemblage; structural mixing and poor exposure make these occurrences difficult to recognize. Upper Jurassic and Cretaceous strata as used herein also probably include tectonically detached and unidentified shale and sandstone that was originally in depositional continuity with the coquinoid limestone unit

Sandstone and shale facies is mostly light-olive-gray and greenish-gray sandstone, siltstone, mudstone, and shale. Sandstone is mostly medium- to fine-grained subangular to subrounded and composed of quartz, feldspar, chert, and greenish-gray rock fragments in a chloritic matrix. Grain boundaries are typically obscure in more matrix-rich sandstone. Graded bedding and incomplete turbidite sequences are common. Wood debris, prod marks, and flute and load casts are common. Sandstone is locally conglomeratic with granules of mainly chert and aphanitic rock fragments. The facies includes medium-greenish-gray siltstone, mudstone, and shale

Conglomerate facies include framework-supported conglomerate that typically occurs as beds and lenses in association with turbidite sandstone. Conglomerate is composed of well rounded to subangular granules and small pebbles of quartz, chert, and rock fragments. Chert includes greenish-gray, light-gray, and dark-gray varieties. Most rock fragments are greenish-gray to dark-gray, aphanitic, and silicified. Framework-supported conglomerate also typically occurs in isolated bodies, some of which appear to fill channels cut in sandstone and shale. Isolated outcrops of the heterolithic conglomerate include subrounded to subangular pebbles of greenish-gray and variously colored chert, yellowish-gray-weathering silicified limestone or mudstone, and organic shale

Tuffaceous sandstone facies is mostly grayish-green fine- to coarse-grained tuffaceous sandstone and interbedded siltstone and shale. Most grain boundaries in the tuffaceous sandstone are indistinct. The sandstone is typically very chloritic. The sandstone includes chloritized rock fragments and locally relict glass shard textures in thin section. Bedding ranges from 0.5 to 1 foot (0.15 to 0.3 m) thick and is commonly graded but also massive or obscure. Chlorite development and grain obliteration is especially prominent along broken and slickensided surfaces. Tuffaceous sandstone is interbedded with greenish-gray to olive-gray to medium-dark-gray siltstone and shale

The volcaniclastic breccia facies include grayish-green breccia and grayish-green graywacke. Breccia is composed of mostly granule to pebble size clasts of greenish-gray rock fragments in grayish-green chloritic matrix. Breccias are both framework- and matrix-supported. Volcanic rock fragments are mostly chloritized aphanitic rock fragments but some fragments include fine-grained plagioclase laths. Few clasts are of vesicular and amygdaloidal mafic igneous rocks. Scattered chert clasts occur locally in the breccias. The matrix of most breccias is typically a dense felted mass of chlorite

Mafic igneous rocks (Jurassic) (Patton and Tailleur, 1964) locally make up a large part of the Foothills assemblage. Some are sills, although most are pod-like masses in structurally disturbed contact with their host rock; undisturbed chilled margins are rare. S. W. Karl (oral commun., 1986) reports observing pillow structures in mafic igneous rocks on Tiglukpuk Creek. Outcrops of the mafic igneous rocks are typically poor and scattered and indicated on the map by an * in the Foothills assemblage

Mafic igneous rocks include dark-greenish-gray, olive-gray, and light-olive-gray rocks with a variety of textures. Most rocks are fine-grained and equigranular, but the unit also includes aphanitic, porphyritic, and coarse-grained varieties. Porphyritic varieties include plagioclase laths in a grayish-green groundmass of chloritized mafic minerals, mostly pyroxene. Some varieties have a diabasic texture. Some are amygdaloidal and vesicular. Some are autoclastic, consisting of fine-grained to aphanitic clasts in a crystalline groundmass of apparently similar composition

Triassic and Permian chert is widely distributed in the Foothills assemblage in the Chandler Lake quadrangle. Patton and Tailleur (1964, p. 439) report ribbon chert bodies as much as 300 feet (90 m) thick in the Chandler Lake quadrangle. Although structural complexity, poor and discontinuous outcrop, and general lack of stratigraphic control from outcrop to outcrop, limit confidence in estimating the thickness of Triassic and Permian chert, the chert appears to be as much as 500 feet (150 m) thick east of the Anaktuvuk River and appears in general to thin eastward towards the Cobblestone Creek area (Kelley, 1988). Chert occurs as structural blocks that range from hand specimen-size clasts in melange to large blocks that probably include the original depositional thickness of the chert. Occurrences are indicated by a Λ in the Foothills assemblage on the map

Chert in the Foothills assemblage is radiolarian ribbon chert. It is medium-light-gray, grayish-green, very light gray, and moderate-yellowish-green to grayish-green, very finely laminated in part, locally obscurely graded, evenly parallel bedded, and occurs in beds that range from 1 inch to 6 inches (2.5 to 15 cm) thick with most beds between 2 to 2.5 inches (5 to 6 cm) thick. Radiolarians are locally abundant and especially conspicuous in light-greenish-gray chert. Siliceous shale and black-carbonaceous shale partings, some of which are locally deeply iron-stained on weathered surfaces, occur between chert beds. Chert is locally very limy suggesting alteration from a carbonate protolith

Nuka Formation (Pennsylvanian(?) and Mississippian) occurs in isolated outcrops in the eastern part of the Foothill assemblage. The formation consists of sandstone and limestone. Sandstone is light-gray to yellowish-gray, and fine- to very coarse grained but mostly coarse- to very coarse grained. The sandstone is composed mostly of subangular quartz and feldspar, most of which appears to be microcline. Glauconite is an abundant accessory mineral locally. Limestone is light- to light-medium-gray, very coarse grained to fine-grained, and composed mostly of crinoid debris and lime mud. Limestone is thin bedded and cross bedded. Outcrops of Nuka Formation are small, poor, and typically rubbly

Marble occurs in a few isolated and scattered outcrops in the western part of the Foothills assemblage. Marble is light-gray to light-yellowish-gray, mostly coarsely crystalline, but grades to medium-grained limestone. Relict thin bedding is locally present. Outcrops are friable, highly fractured, and rubbly. Some parts of the unit consist of mixtures of large single crystal calcite grains in a recrystallized finer-grained matrix, possibly recrystallized encrinite limestone

Melange occurs extensively in the Foothills assemblage and includes blocks of Permian and Triassic ribbon chert, mafic igneous rocks, Jurassic and Cretaceous sandstone, coquinoid limestone, and probably marble in a thoroughly sheared and disrupted matrix of greenish-gray and olive-gray shale and mudstone. The matrix and sandstone blocks are indistinguishable from strata elsewhere assigned in this report to Upper Jurassic and Cretaceous strata

Kcl **COQUINOID LIMESTONE UNIT (Lower Cretaceous, Valanginian)**--The coquinoid limestone unit occurs in both structural and stratigraphic settings in the Chandler Lake quadrangle. The unit occurs in depositional contact with the Otuk Formation and the Otuk and Shublik Formations undifferentiated, as tectonic blocks in melange in the Foothill assemblage, in tectonically disturbed depositional contact with the Otuk and Shublik Formations undifferentiated along Erratic Creek, and in undisturbed depositional contact with the Otuk Formation along Ekokpuk Creek. Tectonic blocks of coquinoid limestone in the Foothills assemblage are likely stripped from depositional sequence with the Otuk Formation and Otuk and Shublik Formations undifferentiated

The coquinoid limestone is typically brownish-gray and reddish-brown-weathering limy siltstone, mudstone, and impure limestone comprising abundant bivalves, typically *Buchia sublaevis*, algae, and shell hash. Outcrops typically weather to slabby blocks. Surfaces perpendicular to bedding have a distinctive plicate differential weathering pattern reflecting deposition as shell and algal mats. Bedding surfaces commonly have orbicular weathering patterns reflecting the large number of whole or nearly whole bivalve shells that made up the algal and shell mats from which the rock formed

J₹ **OTUK AND SHUBLIK FORMATIONS (Jurassic to Triassic)**--This unit includes three map units recognized by Kelley (1988). The Otuk Formation (Mull and others, 1982), Shublik Formation (Patton and Tailleur, 1964), and Otuk and Shublik Formations undifferentiated (Kelley, 1988). The probable overall thickness of the unit based on correlation and projection of sections of Otuk Formation measured by Bodnar (1984, fig. 10) is about 425 feet (130 m). The unit includes a decollement zone along the range front (Kelley and Bohn, 1988) and has structurally induced variations in thickness

Map units recognized in previous mapping but combined here have restricted distributions (Kelley, 1988). The Shublik Formation is restricted to outcrops east of the Anaktuvuk River. Otuk and Shublik Formations undifferentiated occur along the range front between the Anaktuvuk River and Cobblestone Creek. Otuk Formation occurs along the range front west of the Anaktuvuk River and in isolated outcrops along Ekokpuk Creek in the southwestern part of the quadrangle

The Otuk Formation includes shale, chert, and limestone members, and Blankenship Member in ascending order. The shale member comprises dark-gray, grayish-black, and greenish-gray shale and mudstone, thin beds of dark-gray limestone, and dark-gray to black chert. Much of the shale member has a sooty appearance in outcrop and is locally phosphatic. The chert member is characterized by dark-gray to black chert, silicified micritic limestone, and dark-gray to black soft sooty silty shale. Chert in the chert member is rhythmically bedded, thin bedded, laminated in part, and locally fossiliferous with abundant *Halobia* and *Monotis*. The limestone member is mainly rhythmically interbedded yellowish-gray, light-brownish-gray, and tan-weathering dark-gray fine-grained and very impure limestone with partings and interbeds of dark-gray and black shale. The limestone member includes coquina composed mostly of *Monotis* and *Halobia*. The Blankenship Member is mostly dark-gray to black carbonaceous shale with brownish-gray-weathering pliable laminated oil shale and thin chert interbeds

The Shublik Formation is mostly shale and impure limestone. Shale is mostly dark- to very dark gray, soft, sooty, fissile in part with paper-like weathering character, locally calcareous, and includes apatite concretions. Limestone is dark-gray, medium-dark-gray, and brownish-gray. Limestone typically weathers in positive relief and lighter shades of gray than associated shale and includes abundant thin-shell bivalves including *Halobia* and *Monotis*. Unit includes ferruginous-weathering shale and mudstone. Unit locally includes yellowish-gray-weathering silicified beds and grades to Otuk Formation

Ps **SIKSIKPUK FORMATION (Permian)** of Mull and others (1987) Siksikpuk Formation of Mull (1987) in this report is consistent with the type section of Patton (1957), usage of Patton and Tailleur (1964), and age of Siok (1985) and Mull and others (1987). Patton (1957) first suggested the term Siksikpuk Formation for outcrops of Lower(?) Permian strata along Skimo and Tiglukpuk Creeks in the central Chandler Lake quadrangle. Patton and Tailleur (1964) subsequently traced the Siksikpuk Formation across the Chandler Lake quadrangle and referred to the formation as Permian(?). Mull and others (1982, p.357) suggested that the Siksikpuk Formation was Pennsylvanian, Permian, and Early Triassic based on fossil collections from widely scattered localities. Siok (1985, pl. 7) reported Early Permian fossils in two measured sections of Siksikpuk Formation along the range front between Confusion and Firestone Creeks in the Chandler Lake quadrangle. Mull and others (1987) restricted Siksikpuk Formation to Permian strata west of the Chandler Lake quadrangle

The Siksikpuk Formation of Mull and others (1987) is between 200 and 575 feet (61 and 175 m) thick. Patton and Tailleur (1964) reported between 200 and 350 feet (61 to 107 m) in the Chandler Lake quadrangle. Siok (1985) reported 575 and 475 feet (175 and 145 m) in measured sections in the Chandler Lake quadrangle. The top of the Siksikpuk Formation of Mull and others (1987) is not exposed in either section measured by Siok (1985) but outcrops of the overlying Otuk Formation occur near the top of both measured sections and are especially close to the 475 feet (145 m) thick section measured by Siok (1985)

The Siksikpuk Formation of Mull and others (1987) includes three lithofacies in the Chandler Lake quadrangle (Kelley, 1988). These lithofacies are end members of a continuum partially obscured by erosion. Lithofacies 1 occurs along the range front between the western boundary of the map area and the Anaktuvuk River, lithofacies 2 occurs east of the Nanushuk River along the range front, and lithofacies 3 occurs near the head of Ekokpuk Creek in the southwestern map area

Lithofacies 1 is mostly mudstone and siltstone with smaller amounts of shale, and limestone. Mudstone and siltstone are variegated reddish-brown, grayish-red, light- to dark-greenish-gray, and medium-dark-gray to black, laminated in part, thin- to medium-bedded, calcareous in part with gradational relations to very silty and shaly limestone, locally reddish-orange-weathering, and locally pyritic. Mudstone and siltstone includes barite veins and nodules, carbonate nodules, and reddish-orange claystone partings and thin interbeds. Limestone is medium-dark-gray to black, very impure, very shaly and silty, and locally fossiliferous. Shale is black to dark-gray, fissile, and sooty in part. Shale includes siltstone and mudstone partings. The lithofacies includes medium-dark-gray to black and greenish-gray to dark-greenish gray wispy laminated and resistant weathering siliceous mudstone

Lithofacies 2 is mostly shale and mudstone with smaller amounts of very impure limestone. Shale and mudstone is medium-gray, black, dark-greenish-gray, fissile in part, silty in part, and calcareous in part. The lithofacies includes soft fissile dark-gray to black shale and sooty silty mudstone with obscure bedding. Mudstone and shale includes prominent barite nodules with radiating crystal structure and barite veins. Limestone makes up a very small part of the section and typically is very impure, mostly shaly, and nodularform. Some of the limestone beds are ferruginous weathering. Siok (1985) reports *Zoophycos* on bedding surfaces near the base of the section

Lithofacies 3 is siltstone and shale. Siltstone is light-gray, dark-to very dark gray, and brownish-gray. The siltstone is characteristically, hard, siliceous, very uniform in texture but with faint color laminations, conchoidally fracturing but blocky weathering, thin- to medium-bedded, and partly rhythmically bedded. The siltstone grades to porcelaneous chert. Shale is dark-gray to black, soft, sooty in part, and poorly exposed. Rare barite concretions and veinlets are up to 3 inches in greatest dimension

Psl **SADLEROCHIT GROUP (Triassic and Permian)**--Only the basal and Permian part of the group is present. Slab-like bodies of Sadlerochit Group strata up to 50 feet (15 m) thick occur in imbricate fault blocks composed mostly of Lisburne Group carbonate strata east of and adjacent to the head of the Nanushuk River. Strata in the group are mostly siltstone, sandstone, and mudstone. Siltstone and mudstone are reddish-brown, iron-oxide cemented, and deeply iron-stained on weathered surfaces. Greenish-gray varieties of siltstone and mudstone without much iron-stain also occur in the group. Sandstone is very fine to fine-grained, ripple-scale cross bedded, and grades to siltstone. The group includes coquina of brachiopods, gastropods, echinoderm debris, bryozoans, and shell debris. Large *Zoophycos* are prominent

Ml/Mlc **LISBURNE GROUP (Mississippian)** (Bowsher and Dutro, 1957; Armstrong and Mamet, 1977, 1978; and Mull and others, 1982)--This map unit only discriminates two of the three map units previously recognized in the Chandler Lake quadrangle (Kelley, 1988). Previous mapping showed the distribution of: (1) platform carbonates of the Alapah and Wachsmuth Limestones, (2) prominent shaly intervals within the platform carbonate strata, and (3) chert replacement of a greatly thinned section of the platform carbonate strata

Strata of the Lisburne Group in the Chandler Lake quadrangle are herein assigned to the Alapah and Wachsmuth Limestones, consistent with previous mapping (Kelley, 1988). The Lisburne Group includes two facies that Mull and others (1982) suggested were part of the Kuna Formation. These shale and a chert facies were identified but not assigned to the Kuna Formation in previous mapping (Kelley, 1988). In this map, the chert facies is a separate map unit within the Lisburne Group and the shale facies is described but not differentiated from the Lisburne Group

The chert facies is herein interpreted as part of the Alapah and Wachsmuth Formations because bedding characteristics and likely protolith of these strata are more akin to platform carbonate strata than strata assigned to the Kuna Formation. The chert facies is commonly massive bedded whereas very prominent bedding, ranging from rhythmic to uneven, is characteristic of the Kuna Formation. Protolith of the chert facies, at least in part, is very coarse grained grainstone more typical of platform carbonate strata than the fine-grained clastic strata, possibly mudstone turbidites, which is the most likely protolith of much of the Kuna Formation

Although not included with the Kuna Formation, the chert facies in the Chandler Lake quadrangle is probably part of a regional transition from Alapah and Wachsmuth Limestones to Kuna Formation. The transition is from shelf carbonate on the northeast to chert and possibly to Kuna Formation on the southeast and takes place across a linear zone that extends southeast from the range front in the Outwash Creek area about 50 miles (90 km) west of the Chandler Lake quadrangle, through the Ekokpuk Creek area in the southwestern Chandler Lake quadrangle, and thence south of Doonerak Mountain, about 10 miles (18 km) south of the Chandler Lake quadrangle. In the transition zone, the Lisburne Group is anomalously thin. Chert replaces grainstone and wackestone in the Outwash Creek area, especially silica-spiculitic limestone, and grainstone and wackestone in the Ekokpuk Creek area. Bedded chert of the Kuna Formation occurs on upper Otuk Creek, about 15 miles (28 km) west of the Outwash Creek at the range front, and probably is the facies southwest of the chert facies in the Chandler Lake quadrangle

The shale facies of Kelley (1988) is not herein assigned to the Kuna Formation (Mull and others, 1982) because occurrences of the facies lack lateral persistence, consistent stratigraphic position, or unique lithology. In the extensive occurrences of Lisburne Group northwest of Anaktuvuk Pass, two intervals of shaly facies occur, separated by as much as 400 feet (120 m) of Alapah Limestone. The upper interval is transitional to Permian shale of the Siksikpuk Formation of Mull and others (1987) and the lower interval was previously identified as the black chert and shale member of the Alapah Limestone (Patton and

Tailleur, 1964, p. 419). The lower interval, which is locally phosphate-bearing, does not have a locally persistent stratigraphic position probably due to intertonguing of subtle facies. Not all workers recognize an interval in the lower part of the Alapah Limestone lithologically distinctive enough to be indicated in measured sections; along Skimo Creek, Patton and Tailleur (1964) report a lower shaly interval within the Alapah Limestone whereas Armstrong and Mamet (1977, pl. 40 and 41) fail to recognize the same interval as distinctive in measuring the same section

Ml **ALAPAH and WACHSMUTH LIMESTONES of the LISBURNE GROUP (Mississippian)** (Bowsher and Dutro, 1957; Armstrong and Mamet, 1977, 1978)--Mostly light-brownish-gray packstones and wackestones composed of bioclastic framework clasts and interstitial lime mud; abundantly fossiliferous including brachiopods, foraminifera, echinoderms, corals, bryozoans, and gastropods. In most places, the clastic character of the limestone is apparent, but dolomitization obscures the grain fabric. Bedding ranges from thin to massive and includes cross-bedded and cross-laminated beds. Dark-gray shale, carbonaceous limestone, shaly limestone, and limy shale make up between 10 and 30 percent of the section. Dark-gray to light-medium-gray chert occurs as nodules and nodularform beds. Ferruginous-weathering and especially fossiliferous beds occur near the base of the Wachsmuth Limestone. The Alapah and Wachsmuth Limestones are about 3,340 feet (1018 m) thick (Bowsher and Dutro, 1957; Armstrong and Mamet, 1977, 1978) in aggregate throughout the quadrangle except in the Ekokpuk Creek area, southwest of confluence of Ekokpuk Creek and the John River, and between the John River and upper Inukpasugruk Creek, where the Lisburne Group is hundreds rather than thousands of feet thick

Very dark gray to medium-dark-gray argillaceous limestone, limy shale, and nodular chert occur in the lower Alapah Limestone. The beds include abundant phosphatic nodules and/or ooids. Most of the limestone and limy shale is fine-grained, carbonaceous, thin bedded to laminated, and platy weathering. Carbonaceous shale partings are common. Some outcrops have a sooty carbonaceous bloom on weathered surfaces. The facies grades to medium-gray bioclastic limestone and dolomitized limestone. Mull and others (1982) suggest that the shale facies in this map probably is the easternmost tongue of the black chert and shale facies of the Kuna Formation

Mlc **CHERT FACIES OF ALAPAH AND WACHSMUTH LIMESTONES (Mississippian)**--This unit comprises mostly very dark gray to black chert. The chert is dense, nearly opaque, mostly massive, and conchoidal fracturing. Out crops of chert are typically highly fractured and white quartz veined. The chert includes locally abundant medium-light-gray dolomitized micrite to very coarse grained grainstone in lenses, layers of dark to very dark gray argillaceous siltstone and medium-gray limestone, and faint wispy structures which may be relict bedding. The chert facies is a replacement of anomalously thin Alapah and Wachmuth Limestones undifferentiated

Mk **KAYAK SHALE (Lower Mississippian)** (Bowsher and Dutro, 1957; and Nilsen and Moore, 1984)--The formation is predominantly shale with interbedded bioclastic limestone and finely crystalline limestone. Shale is dark-gray to grayish-black, carbonaceous, generally micaceous and fissile, clayey to very silty, and soft to brittle. The formation is negative weathering in comparison to overlying and underlying formations. The shale grades to mudstone and siltstone and includes thin quartz-rich and commonly bioturbated sandstone beds near the base of the formation. Bioclastic limestone beds are generally less than 6 feet (1.8 m) thick and composed of reddish- and yellowish-brown-weathering accumulations of megafossil hash including abundant crinoid parts with smaller amounts of brachiopod, bryozoan, and coral debris. Argillaceous limestone consists of fine-grained crystalline limestone that is dark-gray to grayish-black, carbonaceous, and generally positive weathering. Reiser and others (1979) report beds of andesitic tuff and volcanic conglomerate in the Kayak Shale at the head of Inukpasugruk Creek. The formation is between about 270 and 870 feet (82-265 m) thick. The Kayak Shale is a regional decollement zone (Kelley and Bohn, 1988) and ranges radically in apparent rather than true depositional thickness. Where the formation is best exposed and least disturbed, it is about 560 feet (171 m) thick

MDku **KANAYUT CONGLOMERATE, UPPER PART (Lower Mississippian(?) and Upper Devonian)**--This unit includes the Stuver Member (Lower Mississippian(?) and Upper Devonian) (Bowsher and Dutro, 1957; Nilsen and Moore, 1982, 1984; Nilsen and others, 1980, 1981; Porter, 1966), Shainin Lake Member (Upper Devonian) (Nilsen and Moore, 1982, 1984; Nilsen and others, 1980, 1981; Nilsen, 1981), and upper part (Mississippian(?) and Devonian) (Kelley, 1988). The thickness of the upper part of the Kanayut Conglomerate as used in this map is uncertain but probably ranges between 2,500 feet (750 m) and 1,000 feet (300 m)

The Stuver Member of the Kanayut Conglomerate extends from the Chandler River to the eastern boundary of the quadrangle and from the Toyuk Mountain thrust to the range front (Kelley, 1988). The Stuver Member changes facies to the south and southwest. The laterally equivalent map unit, which includes the underlying Shainin Lake Member, is about 1,000 feet (305 m) thick in the southeastern part of the quadrangle (Kelley, 1988)

The Stuver Member comprises sandstone, siltstone, conglomerate and shale. Variously iron-stained sandstone ranging from very fine grained to very coarse grained and conglomeratic, orthoquartzite to quartz-rich sandstone is the principal rock type. The sandstone consists of very light gray quartz, chert, and siliceous rock fragments. Sandstone beds, commonly cross bedded range up to about 3 feet (1 m) thick and typically occur as elements of fining upward cycles. Cross bedding is common in the sandstone. The member includes conglomerate consisting of granules and small pebbles of chert, quartz, and siliceous rocks typically in a matrix of quartz sandstone. The member also includes dark-gray to grayish-black shale and argillaceous siltstone which are micaceous, very silty, and sandy. The siltstone and shale grade to silty sandstone. The Stuver Member contains Devonian and Early Mississippian(?) plant fossils

The Stuver Member locally includes Mississippian(?) grayish-black to dark-gray shale at its top (Kelley, 1988). The Mississippian(?) shale is carbonaceous and includes plant debris, local ironstones and partings of siltstone and very fine grained quartzose sandstone. Dark-gray commonly carbonaceous shaly quartz sandstone beds occur as positive-weathering tabular bodies in the Mississippian(?) shale. The Mississippian(?) shale crops out along the belt of Stuver Member extending from T. 15 S., R. 7 E. west across the Nanushuk River and the head of Alapah Creek to the Kanayut River. Other outcrops occur in T. 13 S., R. 6 E. between Erratic Creek and the Nanushuk River and T. 15 S., R. 7 E.

The Shainin Lake Member of the Kanayut Conglomerate underlies the Stuver Member and has a similar areal extent. The Shainin Member extends from the east side of the Chandler River to the eastern boundary of the quadrangle and from the Toyuk Mountain thrust to the range front (Kelley, 1988). The Stuver Member changes facies to the south and southwest, at least in part by wedge-out. Lcally, southward thinning in the Shainin Lake Member is abrupt (Kelley, 1984b). Mapping further suggests that the Shainin Lake Member thins and probably wedges out to the northeast

The Shainin Lake Member comprises mostly conglomerate and sandstone. Conglomerate is as much as half of the member. The conglomerate is principally framework-supported and composed of generally well rounded pebbles and cobbles of mostly chert, quartz and quartzite. Matrix of the conglomerate consists of quartz- and chert-rich sandstone and granules. The conglomerate occurs in hard and resistant intervals up to 15 feet (4.5 m) thick. Conglomerate is typically silica-cemented although calcareous and iron-oxide cements are present. Sandstone is hard, resistant, cemented to varying degrees with silica, carbonate, and iron-oxide, and composed of moderately to poorly sorted quartz, chert, and silicified rock fragments. Sandstone beds are commonly cross bedded. The sandstone is moderately to poorly sorted, conglomeratic in part, and includes pebble trains. Much of the conglomerate and sandstone is organized into fining upward sequences. The Shainin Lake Member includes reddish-brown, greenish-gray, and dark-gray to grayish-black, silty, sandy shale, siltstone, and argillaceous sandstone in various amounts

The positive-weathering character of the Shainin Lake Member contrasts sharply with the relatively recessive weathering of the overlying and underlying members of the Kanayut Conglomerate. The massive weathering character of the Shainin Lake Member also contrasts with the alternating recessive and resistant weathering character of overlying and underling members

The upper part of the Kanayut Conglomerate (Kelley, 1988) crops out east of the Chandler River and south of the Toyuk Mountain thrust and is laterally equivalent to the Stuver and Shainin Lake Members of the Kanayut Conglomerate

The upper part of the Kanayut Conglomerate as used in Kelley (1988) comprises sandstone, conglomerate, and shale. Sandstone is light-brownish-gray, reddish-brown, and light-olive-gray. Sandstone is typically iron stained to various degrees, cross bedded, very fine grained to very coarse grained but mostly coarse-grained, and granular conglomeratic in part. Sandstone grains are mostly chert, quartz, and silicic rock fragments. Conglomerate is framework supported and mostly consists of granules and small pebbles of chert, quartz, and siliceous rock fragments. Sandstone and conglomerate are organized into fining upward sequences. Shale is dark-gray, carbonaceous locally, very silty, sandy, and iron-stained in part. The upper part of the Kanayut Conglomerate is characterized by iron-stained outcrops of differentially weathering sandstone-conglomerate intervals and shaly intervals. One or more massive weathering intervals consisting of amalgamated sandstone and conglomerate are present, but are generally less than 200 feet (60 m) thick and probably discontinuous

Dkln **LOWER PART OF THE KANAYUT CONGLOMERATE AND NOATAK SANDSTONE (Upper Devonian)**--This unit consists of the Ear Peak Member of the Kanayut Conglomerate (Nilsen and Moore, 1982, 1984; Nilsen and others, 1980, 1981; and Nilsen 1981) and Noatak Sandstone undifferentiated. Map information (Kelley, 1988) suggests that the Ear Peak Member and Noatak Sandstone undifferentiated may be as much as 2,500 feet (760 m) thick and thins abruptly to the northeast

The Ear Peak Member of the Kanayut Conglomerate is mostly shale, mudstone, sandstone, and conglomerate. Shale is reddish-brown, grayish-green, brownish-gray, and grayish-black, typically very silty and micaceous, and grades to siltstone. Sandstone is quartz-rich and ranges between orthoquartzite and quartz-rich sandstone with various amounts of silica, carbonate, and iron-oxide cements. Sandstones are granule to pebble conglomeratic in part and grade to conglomerate. Cross bedding is common in sandstone beds and ranges from large scale to ripple laminae. Conglomerate is framework-supported with framework clasts consisting of granules, pebbles, and cobbles of mostly quartz and chert. Sandstone consisting principally of quartz and chert makes up the matrix in the conglomerates. The principal rock types of the Ear Peak Member typically are organized into fining upward cycles with conglomerate or massive sandstone at the base grading upward to finer-grained and cross-bedded strata

Lithology of the Ear Peak Member varies across the map area. Sandstone is most abundant in the north and east parts of the outcrop area, mostly north of the Toyuk Mountain thrust. Dark-gray shale is most abundant south of the Toyuk Mountain thrust fault

The Noatak Sandstone is principally sandstone and mudstone. Pinkish-gray, light-brownish-gray, and light-gray calcareous-cemented sandstone is typical of the formation. Sandstone is mostly fine- to coarse-grained with scattered occurrences of granules and small pebbles of quartz and chert. Sandstone is laminated in part, ranges from thin- to thick-bedded and in part cross-bedded. Load casts, marine fossils, and scattered plant debris occur locally in sandstone. Mudstone is dark-gray and brownish-gray. Principal distinguishing characteristics of the Noatak Sandstone include: pinkish-gray weathering outcrops, continuous and tabular-weathering beds, moderate or good sorting, and carbonate cement

The Noatak Sandstone changes character across the map area. In the Mount Thibodeaux area, the Noatak Sandstone is much iron-stained, granular conglomeratic with granules of quartz, chert, and ironstone, and includes conglomerate beds and lenses. It includes deeply iron-stained shale partings, prominent cross bedding, possible rain drop structures, possible paleosols, and marine fossils in deeply iron-stained lenses. Conglomerate and conglomeratic sandstone are most common in the Mount Thibodeaux area. The sandstone/shale ratio decreases south and west of the Mount Thibodeaux area. Indication of nonmarine sedimentation such as mud cracks and possible rain prints occur in the Mount Thibodeaux area. The Noatak Sandstone occurs discontinuously in the map area. The Noatak Sandstone probably interfingers with the Hunk Fork Shale locally but, structural detachment (Kelley and Bohn,1988) and thrusting greatly obscure the interfingering

Dkn **KANAYUT CONGLOMERATE and NOATAK SANDSTONE UNDIVIDED (Upper Devonian)** (Nilsen and Moore, 1984; and Brosgé and others, 1979)--The thickness of this map unit is very poorly constrained but probably around 2,500 feet (760 m). The Kanayut Conglomerate and Noatak Sandstone undivided comprises sandstone, shale, and conglomerate. Sandstone is typically reddish-brown-weathering, reddish-brown to brownish-gray, iron stained, thin- to medium-bedded, and prominently cross bedded. Most sandstone is fine-to coarse-grained, moderately to poorly sorted, and granule conglomeratic locally. Ferruginous, silica, and carbonate cements occur in sandstones in various amounts in different localities. Reddish-brown and dark-gray shale is very silty, sandy in part, carbonaceous in part, and ferruginous in part. Conglomerate is framework-supported, granule to pebble in size, and composed of chert, quartz, and silicic rock fragments. Stuver, Shainin Lake, and Ear Peak Members are obscure, if present. Dark-gray Mississippian(?) shale is not present, or unrecognized. Much of the formation appears transitional to the Noatak Sandstone, especially in the southwestern part of the map area

Dhw **WACKE MEMBER of the HUNT FORK SHALE (Upper Devonian)** (Brosgé and others, 1979)--Outcrop widths and dip from previous mapping (Kelley, 1988) suggest that the wacke member is around 2,500 feet (760 m) thick. The wacke member appears to thin to the northeast

The wacke member consists of siltstone, mudstone, and sandstone. Siltstone and mudstone are greenish-gray, brownish-gray, olive-gray, and medium-dark-gray. Siltstone and mudstone are typically brownish-gray-, yellowish-brownish-gray-, and hackly weathering. Manganiferous films on weathered surfaces are common on siltstone and mudstone. Siltstone is very shaly and mudstone grades to siltstone. Sandstone is light- to medium-olive-gray, fine-to medium-grained, and conglomeratic locally. Sandstone is also commonly limonitic, ferruginous-weathering in part, and locally fossiliferous. Conglomeratic sandstone includes small pebbles and granules of chert, argillite, and ironstone. Fossils typically occur in conglomeratic lenses with plant debris. Sandstone occurs in beds up to 3 feet thick and ranges from wackes containing quartz, chert, mica, and aphanitic rock fragments to quartzites composed of quartz and chert. Load casts and bioturbation are locally common. The wacke member locally interfingers with the overlying Noatak Sandstone but structural complexities obscure the gradational relations between the wacke member and Noatak Sandstone (Kelley and Bohn, 1988)

Dhs **SHALE MEMBER of the HUNT FORK SHALE (Upper Devonian)** (Brosgé and others, 1979)--Map information suggests that the shale member attains a maximum thickness of 2,000 feet (610 m) and probably thins to the northeast (Kelley, 1988). The shale member comprises mudstone, shale, and sandstone. Mudstone and shale are medium- to medium-dark-gray, very silty, fissile, and interbedded with sandstone. Mudstone and shale grade to siltstone, argillite, and slate. Sandstone is brownish-gray and greenish-gray, fine- to medium-grained, mostly fine-grained, laminated, low-angle cross-bedded, and wavy laminated in part. Sandstone beds include ripple marks, load casts, and a few rip-up clasts of dark-gray shale. Sandstones consist of generally well sorted grains of quartz, chert, argillite?, feldspar, and white mica. Sandstone/shale ratios range from 1:5 to 2:3. The unit is structurally thickened and locally repeated by imbricate fault blocks

The shale member appears to be slightly metamorphosed. Mudstone and shale commonly have a poorly developed axial plane cleavage in the cores of mesoscopic folds. Bedding and cleavage surfaces have a micaceous sheen and shale and mudstone are gradational to slate and argillite

Dh **HUNT FORK SHALE (Upper Devonian)** (Brosgé and others, 1979)--This unit comprises wacke and shale members undifferentiated. On the map, occurrences of especially shaly strata, possibly shale member, are indicated by the same map pattern as for the shale member of the Hunt Fork Shale but without contact boundaries or unit 'Dhs' labels. The thickness of the Hunt Fork Shale undifferentiated unit is unknown

The undifferentiated unit comprises mostly shale and sandstone. Shale is medium-dark-gray and olive-gray. The unit includes argillite with poorly developed cleavage. Most fine-grained and argillaceous rocks have a poorly developed phyllitic sheen on partings and include sandstone partings and interbeds. Sandstone is grayish-green and greenish-gray, mostly fine- to medium-grained, micaceous, and ripple cross bedded in part. Sandstone beds are locally graded. Much of the outcrop area in which the wacke and shale members are undiscriminated is underlain by shaly strata. Unresolved structural complication precludes determining whether the shale member thickens or the wacke member wedges out to the southwest; shaly strata are more prominent in the southeastern parts of the map area

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EXPLANATION OF MAP SYMBOLS

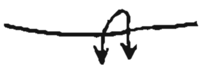
 Depositional contact

 Anticline, trace of axial plane, arrow shows direction of plunge

 Overturned anticline, trace of axial plane, arrow shows direction of plunge

 Syncline, trace of axial plane, arrow shows direction of plunge, dashed trace of axial plane shows inferred position where the strata that form the syncline occur in an upper thrust plate and have been removed by erosion

 Strongly asymmetrical syncline, trace of axial plane, double dip arrow identifies steeper dipping limb

 Overturned anticline, trace of axial plane

 Overturned syncline, trace of axial plane

 Thrust fault, teeth on upper plate

 Detachment surface, teeth on upper plate, approximately located

 Fault, nature uncertain, dip ticks indicate hanging wall block

 20 Strike and dip of bedding

sz Shear zone, melange, zone of pervasively sheared and structurally mixed strata

∧ outcrops of radiolarian ribbon chert and very cherty rhythmically bedded limestone

* outcrop of basalt, locally pillowed

■ tectonic block of coquinoid limestone in melange

⌖ well drilled for oil and gas, abandoned

ACKNOWLEDGEMENTS

The writer wishes to acknowledge the contribution of previous mappers. Although the present map is a distillation of concepts and syntheses generated from Kelley (1988), compilation of Kelley (1988) relied heavily on previously published maps. Detterman and others (1963), Brosgé and others (1960), and Brosgé and others (1979) were especially important map contributions. Patton and Tailleur (1964), Bowsher and Dutro (1957), and Porter (1966) also made important map contributions to Kelley (1988).