ALASKA DIVISION OF GEOLOGICAL REPORT OF INVESTIGATIONS 2000-2 & GEOPHYSICAL SURVEYS MULL AND OTHERS (2000)

# CORRELATION OF MAP UNITS MAP SYMBOLS Contact - dashed where approximately located. ----- Fault - arrows show direction of relative me Thrust fault - sawteeth on upper plate; dashed whe queried where inferred or doubtful. - Anticline showing trace of axial plane and directiof plunge; dashed where approximately located. Syncline showing trace of axial plane and direction of plunge; dashed where approximately locate Traceable bedding Strike and dip of beds Inclined Vertical Overturned Approximate Well - showing total depth (3) Sample locality - see tables 1 and 2 LOCATION INDEX Point Lay Utukok River Point Hope DeLong Misheguk Mountains Noatak Baird Mountains 160 Technical review by: D.W. Houseknecht' and D.L. LePain' (bedrock geology), and D.S. Pinney' (Quaternary geology) 0 3000 6000 9000 12000 15000 18000 21000 FEET Digital cartography by: Doug Lee' Edited by: Paula Davis' SEAVIEW SYNCLINE COKE BASIN IGLOO MOUNTAIN TUPIKCHAK SYNCLINE North C' METERS □ 1000 3000 — 2000 — 1000 — - 500

## GEOLOGIC MAP OF THE COKE BASIN-KUKPOWRUK RIVER AREA, DELONG MOUNTAINS D-2 AND D-3 QUADRANGLES, NORTHWESTERN ALASKA

No vertical exaggeration Quaternary units not shown

Figure 2. Diagrammatic cross section (above) and aerial view to the southwest (photo to right) of the Surprise Creek Triassic locality. This section

is along section B - B' and is not to scale.

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## FRAMEWORK GEOLOGY AND STRUCTURAL EVOLUTION OF THE COKE BASIN–KUKPOWRUK RIVER AREA

The Coke Basin-Kukpowruk River area, located in the foothills of the northwestern DeLong Mountains, is in the southern part of the Colville basin, a Cretaceous foreland basin that lies north of the Brooks Range orogenic belt (fig. 1). The Colville basin overlies a relatively thin, regionally south-dipping section of Carboniferous to earliest Cretaceous (lower Neocomian) platform rocks that are coeval with rocks exposed in thrust sheets in the DeLong Mountains, 40 km (25 mi) south of the map area. This sequence of platform rocks is succeeded upward by a Lower Cretaceous (upper Neocoman to Aptuan) section of dominantly syntection: orgenic Okpikruak Formation and lower Brockian sediments derived from the Brooks Range. These rocks, in turn, are overlain by a thick section of mid-Cretaceous Mount Kelly Graywacke (Aptian-Albian) and foreland basin deposits of the Torok Formation and Nanushuk Group (Aptian-Albian to Cenomanian) that fill the Colville basin and form most of the surface exposures of the southern part of the Brooks Range foothills foldbelt (fig. 1). On the western Arctic Slope, the Nanushuk Group consists of deltais esdimentary rocks >3,000 m thick termed the Corwin delta (Ahlbrandt and others, 1979; Huffman and others, 1985). It overlies >2,500 m of prodelta shale of the Torok Economics and Sable 1964 and 1985; Huffman and oreland basin fill extends northward and underlies most of the northern foothills belt and coastal plain of northern Alaska. (See also regional map in Mull and others, 1987 or Moore and others, 1994.)

Most of the surface exposures in the Coke Basin-Kukpowruk River area consist of the relatively competent sandstone of the Nanushuk Group and relatively incompetent shale of the Torok Formation. This succession of delta-plain deposits is regionally deformed into eries of long, linear, relatively broad, shallow synclines and tight anticlines. These structures are formed above a decollement in the nales of the Torok Formation, which is generally exposed only in the cores of the anticlines (Chapman and Sable, 1960; Mull and others,

Regional structural and stratigraphic relationships in the Brooks Range are indicative of a major north-vergent Early Cretaceous (Neocomian) orogenic event (Mull, 1982; Mayfield and others, 1988; Moore and others, 1994). However, stratigraphic data in the area of Coke Basin and Tupikchak syncline (discussed below) also suggest that this deformation may have extended into the mid-Cretaceous (Aptian-Albian). In addition, post-Cenomanian («80Ma) orogenesis is indicated by deformation of the Oreland basin deposits of the Nanushuk Group above the inferred decollement within the Torok Formation. Apatite fission track analysis of a number of Cretaceous condenses collected in the output of this magning measured to indicate somificant and Territory (iii) in the Del now, Mayatsing andstones collected in the course of this mapping project also indicates significant early Tertiary uplift in the DeLong Mountains foothills belt (John Murphy, 1997, written communication

#### The Surprise Creek anomaly and Coke Basin-Tupikchak thrust anomalous thermal maturity data at locality 14 on Surprise Creek (W 1/2 sec. 22, T 6 S, R 46 W), and stratigraphic relationships on both

the southeast flank of Coke Basin and the south flank of Tupikchak syncline suggest that movement and associated uplift along a thrust fault, here named the Coke Basin-Tupikchak thrust, was at least partly coeval with deposition of the Torok Formation and Nanushuk fault, here named the Coke Basin-Tupikchak thrust, was at least partly coeval with deposition of the Torok Formation and Nanushuk Group. At the Surprise Creek locality, near the leading edge of the Coke Basin-Tupikchak thrust, a thin section (-100 m) of Shublik Formation (Upper Triassic) and Kingak Shale (Neocomian to Jurassic) is unconformably overlain by ~80 m of the upper part of the Mt. Kelly Graywacke (Apitan) (Wartes, 1997; in press); the Shublik is folded and thrust repeatedly in a small, south-vergent, overturned anticline (fig. 2, section C-C). This exposure of Triassic and Jurassic rocks is an anomalous departure fine the characteristic structural style of the southern foothills belt. In addition, both the Kingak and Shublik have a lower level of thermal maturity than expected for rocks of this age. On the south flank of the Tupikchak syncline, the Shublik, Kingak, and Mount Kelly Graywacke crop out in close proximity to, but underlie the base of, the Nanushuk Group in a position that elsewhere appears to be occupied only by thick shale of the Torok Formation. These anomalous relationships are discussed below.

The thin-bedded, slightly siliceous, fossiliferous limestone and organic-rich black shale of the Shublik and black clay shale of the and siliceous shale of the coeval Otuk Formation and hard siliceous shale of the Kingak exposed in the thrust sheets of the western DeLong Mountains, 40–60 km (25–35 mi) south of the map area. Although the Surprise Creek rocks apparently represent thrust slivers plifted from the depths of the present Colville basin, their contrast with the coeval rocks in the DeLong Mountains thrust belt indicate that they have undergone substantially less tectonic shortening than evident in the DeLong Mountains.

hermal maturity data (table 1) show that both the Kingak and Shublik have vitrinite reflectance values of ~0.8 to ~1.3 R<sub>o</sub> (Dow and strata elsewhere in the southern part of the Colville basin are buried to a depth of >5km (>3 mi) (Mull and others, 1987; Howell and others, 1992; Moore and others, 1994; Fuis and others, 1997). Rocks buried to this depth should be thermally overmature for the eneration of oil, and well into the zone of dry gas generation and yield vitrinite reflectance values of  $R_{\rm s} \ge 2.0$  (Howell and others, 1992). hese data suggest that the Kingak and Shublik had a residence time at depth that was significantly less than for coeval rocks in the colville basin or in the thrust sheets in the Brooks Range, or were not buried as deeply as suggested by regional relationships.

the southeast flank of Coke Basin and south flank of Tupikchak syncline. In both areas, fluvial or marginal marine beds characteristic of the upper Nanushuk directly overlie the prodelta shales of the Torok. In particular, on the southeast side of Coke Basin (section A–A'), pal-bearing beds and conglomerate characteristic of the upper Nanushuk directly overlie Torok shale. Deposition of fluvial sands irectly onto prodelta shale can occur adjacent to a major river system distributary but has not been observed elsewhere in the Nanushuk On the southeast flank of Coke Basin, the local pinchout of the marine beds of the lower Nanushuk is also marked by a structura

Creek, marine sandstones that typically form the base of the Nanushuk appear to pinch out near the Coke Basin-Tupikchak thrust along

anomaly. In this area, the basal beds in the Nanushuk, which consist of nonmarine conglomeratic sandstone, are locally vertical to slightly overtured. The steep dip of this section of the basal Nanushuk at this locality progressively decreases upsection to  $-20^{\circ}$  northwest, as well as along strike both to the north and southwest (fig. 3). Aerial photographs of the southeast flank of Coke Basin also the Kukpowruk River valley and the area of overturned outcrops to the northeast. Stratigraphic, structural, and thermal data suggest nlap and deposition of fluvial clastics and coals of the Nanushuk onto a relatively positive area. Significant changes in thickn anushuk over a relatively short distance are also clearly evident in the mapping of laterally persistent beds of the upper Nanushuk ir National Western end of Tupikchak syncline and northeast Coke Basin. Numerous resistant beds in both areas clearly pinch out latera in a pattern that cannot be explained simply as a function of variable dip, but may be suggestive of tectonic control on depositive Changes in thickness of similar magnitude over short distances have not been observed elsewhere in the Nanushuk outcrop belt.

have important implications for potential hydrocarbon exploration plays elsewhere along the southern part of the Brooks Range foothills belt. North-vergent thrust sheets containing organic-rich source rocks of the Shublik Formation may have been emplaced elsewhere along the foothills belt into proximity with potential Cretaceous reservoir rocks at maturity levels suitable for the generation of

## Evolution of the Coke Basin-Kukpowruk River area

- Late Triassic: Deposition of thin-bedded limestone and organic-rich shales of Shublik Formation.
   Jurassic: Deposition of black shales of the lower part of the Kingak Formation.
   Early Necomian (Berriasian-Valanginian): Thrust faulting in DeLong Mountains south of map area. Deposition of upper part of Kingak Shale exposed in Surprise Creek area and syntectonic clastic deposits of the Okpikruak Formation to the south, derived
- from Brookian orogenic belt.

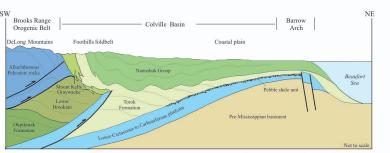
  4. Late Neocomian (Hauterivian–Barremian): Deposition of distal lower Brookian sediments south of map area coeval with upper kpikruak Formation derived from thrust belt. 5. Early Aptian: Deposition of northward prograding, thickening and coarsening upward sequence of lower Brookian sediments
- derived from thrust belt, mostly south of map area. Possible beginning of thrusting from the south and uplift of thrust sheet of Shublik and Kingak formations.

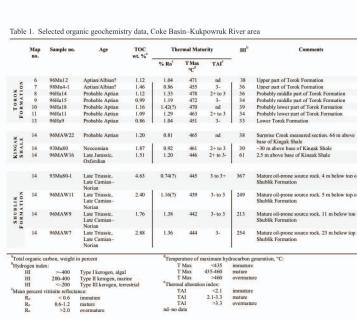
  Mid-Aptian: Deposition of northward prograding Mt. Kelly Graywacke Tongue of Fortress Mountain Formation, mostly south of
- map area. Probable ongoing north-vergent movement of Coke Basin-Tupiskeak thrust of Shablik and Kingak formations, and deposition of upper part of Mt. Kelly Graywacke on thrust plate. Late Aptian: Deposition of eastward prograding prodelts shale of Torok Formation, syndepositional with continued movement and
- Late Aptian: Deposition of eastward programing procerts anale of torox Formation, syndepositional with continued movement and uplift of leading edge of Coke Basin—Tupickhak thrust.

  Late Aptian to Albian: Prograding deposition of lower Nanushuk Group marine to locally nonmarine sandstones and coal syndepositional with and overlapping Coke Basin—Tupikchak thrust. Deposition of thick lower Nanushuk marine sandstones in lates Mountain press to contribute the programment of the Company of the Company

Early Tertiary: Renewed regional deformation and development of regional folds in Nanushuk above decollement in Torok Shale.
 Formation of local backthrust at triangle zone on south flank of Tupikchak syncline, and south-vergent deformation of Shublik,

Kingak, and upper part of Mt. Kelly Graywacke at Surprise Creek.







Tupikchak thrust and pinchout of lower Nanushuk marine sandstones on locally overturned flank of Coke Basin adjacent to thrust. Kukpowruk River flows from right to left across center of photo. Knu-upper Nanushuk, Knl-lower Nanushuk, Kto-Torok Formation, Kmku-upper Mount Kelly Graywacke

### DESCRIPTION OF UNITS

- SURFICIAL DEPOSITS Surficial deposits were interpreted from 1:63,360-scale aerial photographs, incorporating limited field observations made during traverses while mapping bedrock units, and by aerial reconnaissance. Published data (Chapman and Sable, 1960; Rawlinson, 1983) served as a guide for interpretation. No glacial deposits are recognized in the Kukpowruk River area, as Quaternary glaciation apparently did not occur on the north side of the western DeLong Mountains.
- ALLUVIUM, UNDIFFERENTIATED—Silt, sand, and gravel deposited in active, typically meandering stream and river channels; including intermittent tributaries active during seasonal runoff and flood events. Unit includes abandoned channels and floodplain deposits which may be mantled by fluvial silt overbank deposits with little or no vegetation. Unit may also include low terraces above the active floodplain that locally support dwarf willows adjacent to the rivers.
- TERRACE DEPOSITS—Terrace gravels up to 4 m above modern stream level consisting of clast-supported, moderately sorted Coat cobble and pebble gravel with minor silt and sand deposited along modern rivers and streams. Terraces are tundra covered.
- QUATERNARY DEPOSITS, UNDIFFERENTIATED-Fine-grained colluvial deposits of reworked silt, with minor sand, pebbles, cobbles, and thin bedrock slabs, typically found on gentle slopes as apron-like features or a blanketing mantle over low hills and ridges. Material is derived from underlying or nearby topographically higher bedrock unit and transported by frost creep and gelifluction. Unit is gradational with other surficial deposits. Often exhibits horsetail drainage patterns from ephemeral streams. In areas of poor drainage, surface is typically characterized by broad expanses of grass tussocks.
- PERENNIALLY FROZEN SILT, UNDIFFERENTIATED—Irregular blankets of massive, homogeneous, unconsolidated silt and sand largely retransported from original hillside sites to lower slopes and valley bottoms by mudflows, slopewash, and gullying. Surface is generally smooth to gently sloping and mantled by tundra and broad expanses of grass tussocks. Permafrost in valley
- bottoms creates poor drainage manifesting as local bogs (unit Qs). SWAMPS AND BOGS—Low-lying areas of swampy tundra, bogs, small ponds, and beaded drainage, commonly contains local low-center ice-wedge polygons and typically mantled by tundra mat, tussocks, or peaty deposits.

#### BEDROCK UNITS

Geomorphology of the map area is characterized by prominent upland cuestas and mesas composed of resistant rocks of the Nanushuk Group, which is folded into broad synchlines separated by narrow shale cored anticlines. Rounded bedrock ridges in the southeastern part of the map area are composed of the Mount Kelly Graywacke. Lowland areas, which comprise—40 percent meap area, are underlain by the recessive and highly deformed shales of the Torok Formation, which is generally poorly exposed beneath thin tundra cover or nantled by Quaternary deposits. Traceable beds of resistant strata in upland bedrock units are clearly evident on aerial photographs although outcrops on the uplands are limited to discontinuous ridges and commonly are covered by a thin veneer of frost-shattered bedrock, rock rubble, and tundra (fig. 3). Upland areas are thus shown as continuous bedrock on the basis of the persistent bedding traces Good outcrops are numerous in river and stream bluffs, particularly along the Kukpowruk River, which is deeply incised through Coke Basin and Tupikchak Syncline.

# (Albian–Cenomanian) (Detterman, 1956; Ahlbrandt and others, 1979)

The Nanushuk Group is a thick, clastic succession originally defined on the central Arctic Slope (Gryc and others, 1956). On the western Arctic Slope, it is characterized by two regionally mappable generalized units: (1) a basal interval of d sandstone gradationally overlain by (2) marginal-marine to nonmarine sandstone, conglomerate, and coal. These broad, mappable genetic units were previously termed the Kukpowruk and Corwin Formations, respectively (Chapman and Sable, 1960), but subsequent vorkers (Ahlbrandt and others, 1979; Huffman and others, 1985) did not use this nomenclature because of the difficulty in delineating

The upper Nanushuk is here distinguished from the lower Nanushuk by a lower sand:shale ratio, the presence of coal seams, carbonaceous shale, a greater abundance of plant remains, a general absence of marine fossil fauna, and a higher percentage of iron-weathering products. Sediments of the upper Nanushuk record a fluvial-dominated environment with episodes of he lower Nanushuk records a complex history of overall progradation of deltaic and shallow-marine depositional nvironments onto a storm-dominated shelf. In the map area, the upper Nanushuk is exposed in the axial areas of major synclines, where it forms a more subdued topography with less persistent bedding traces than in the lower Nanushuk, which has a higher sand:shale ratio an arbitrary boundary between upper and lower Nanushuk is drawn at a position above which persistent marine sandstone beds appear to be relatively uncommon within the overlying dominantly marginal-marine to nonmarine section.

NANUSHUK GROUP, UPPER PART (Albian to Cenomanian)—Sandstone, medium-gray to yellowish-brown, fine- to coarse-grained, thin- to medium-hedded little and the grained of the coarse-grained of the coars NAUSHUK GROUP, UPFER PART (Albian to Cenomanian)—Sandstone, medium-gray to yellowish-brown, fine-to coarse-grained, thin- to medium-bedded lithic and chert arenite, and sparse conglomerate and conglomeratic sandstone; forms resistant beds and rubble traces. Interbedded recessive rocks, which make up the greater thickness of beds, consist of dark gray silty shale, clay shale, black carbonaceous shale, siltstone, and local coal beds. Sand grains consist dominantly of quartz and chert, with lesser amounts of calcite, feldspar, and lithic fragments. Conglomerate clasts are predominantly sub-rounded pebbles and cobbles of white quartz and black, gray, greenish-gray, and maroon chert, and local ironstone, coal, gray sandstone, quartzite, argillite, and mafic igneous rocks. Generally upward-fining and -thinning successions show plane-parallel lamination tabular sets of planer and inclined gross-staffication, assumentical impacts cross-lamination and bedforms trough lamination, tabular sets of planar and inclined cross-stratification, asymmetrical ripple cross-lamination and bedforms, trough cross-bedding, and basal channel scours. Sandstone and siltstone beds are lenticular and pinch and grade laterally to shale. omerate is commonly exposed as large-scale multilateral and/or multistory channel fills. Unit contains well-preserved Albian plant fossils and rooted tree stumps at localities along Kukpowruk River (Herman and Spicer, in press) (table 2). Sandstones are generally tight, with measured porosity <11 percent, average  $\sim5$  percent, and permeability <1 md (Ahlbrandt and others, 1979). Top of Nanushuk not exposed in map area; base of upper Nanushuk interfingers with lower Nanushuk.

Thickness: ~1,300 to ~2,500 m, varying markedly in some areas of Coke Basin and Tupikchak Syncline.

 $Age: Regionally\ dated\ as\ Albian\ to\ Cenomanian\ (Chapman\ and\ Sable, 1960; Herman\ and\ Spicer,\ in\ press;\ table\ 2)\ but\ probably$ 

ANUSHUK GROUP, LOWER PART (Albian)—Sandstone, light-gray to medium- to yellowish-gray, fine- to medium-grained, generally thin- to medium-bedded, lithic arenite, and less commonly conglomerate lenses. Contains interbedded dark-gray fissile to silty shale, medium- to dark-gray siltstone, and carbonaceous shale. In map area, closely spaced and laterally persistent dark yellowish-brown-weathering lower Nanushuk sandstone beds form prominent resistant cuestas that rim the synclines. Sandstones dominantly consist of quartz and chert, with lesser amounts of calcite, feldspar, and lithic fragments. Conglomerate clasts are predominantly sub-rounded pebbles of white quartz and black, gray, or greenish chert. Upwardcoarsening and -thickening successions are capped by sandstones with a variety of sedimentary structures, including plane-parallel lamination, current- and wave-ripple bedforms, large- and small-scale trough cross-stratification, hummocky crossstratification and swaley cross-stratification. Biogenic structures are locally common and include Teichichnus, Diplocraterion stratification and swaley cross-stratification. Biogenic structures are locally common and include Techichmus, Diplocraterion, Rhizocorallium, Planolites, Paleophycos, among others. Locally contains common marine pelecypods, coalified plant fragments, and plant impressions. Upward intertonguing of marine and marginal-marine to nonmarine sediments marks transition to the upper Nanushuk. Sandstones generally tight with porosity <10 percent and permeability <1 md (Ahlbrandt and others, 1979). The base of Nanushuk is gradational and intertongues with the underlying recessive shales from fronk Formation; contact is mapped at the base of the stratigraphically lowest laterally persistent sandstone trace visible on aerial photographs. Shale at the top of Torok Formation is usually covered by tundra or undifferentiated Quaternary deposits. On the map this results in the appearance of pinch-out of basal Nanushuk sandstone beds into the undifferentiated Quaternary unit (Qu), but is consistent with intertonguing of the basal Nanushuk with the Torok, which underlies the Quaternary cover.

Thickness: 0 to ~500 m, locally pinches out on southeast flank of Coke Basin and on south flank of Tupikchak syncline, best

Age: Albian, based upon marine pelecypods and microfauna (Chapman and Sable, 1960).

Map Sample no. Fossil age range

3 Locality 96-4 Early-Middle Albian Plants: Birisia alata (Prynada) Samyl

Jurassic-Cretaceous

Early Middle Albian

Jurassic-Cretaceous

Barremian-Aptian

14 96MAW12 Late Triassic, Carnian— Foraminifera Norian Norian Blade September 14 93 Mu80-1 Late Triassic, Late Carnian—Norian Habbits sp. 14 96MAW10 Late Triassic, Late Monotés sp., Halobia sp. Carnian—Norian Late Triassic, Late Monotés sp., Halobia sp. Carnian—Norian Carnian—Norian Monotés sp., Halobia sp. Carnian—Norian

12 96Ha10 Possible Antian-Albian Palvnomorphs

98Mu4 96Ha14 96Ha18

91Mu102

Jurassic-Early Cretaceous Jurassic-Early Cretaceous Early-Middle Albian

Cretaceous
Late Early Cretaceous.
Late Cretaceous
Jurassic-Cretaceous
Plants: Ginkuo ex er.
adiantoides (Uneer) He
plants: Privophyllum e

Plants: Birisia alata (Prynada) Samyl Plants: Equisites ex gr. burevensis (Heer) Krvsh Plants: Birisia alata (Prvnada) Samvl

Palvnomomhs.

lower part of Torok Mickey and Haga, 1998

32 m above base of Kingak Mickey and Haga, 1998

Formation

4 m below too of Shublik

Formation
7 m below top of Shublik

Formation
8 m below top of Shublik

C.G. Mull, field identification.

Bivalves: Buchia sublaevis ~20 m above base of Kingak C.G. Mull, field identification

part of Torok Mickey and Haga. 1998

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KINGAK SHALE (Lower Cretaceous [Valanginian] to Lower Jurassic)—Silty shale to clay shale, dark gray to black; fissile, brittle, and rusty weathering in part; contains thin bentonite horizons, scattered siliceous manganese(?) and/or ironstone concretions, and a 25-cm-thick sandstone bed with pale green clay-shale ripup clasts and large horizontal burrows. Near top of unit, shale becomes slightly micaceous with visible silty laminae. Interpretation of depositional environment from the faunal data suggests that the Kingak Shale may be shallow marine and may record deepening of the Colville Basin prior to onset of Brookian deposition (Mickey and Haga, 1995). Unit is exposed in map area only at the Surprise Creek locality (W½ Sec. 22 ToS, R46W) in stiphtly folded assymmetrical south-vergent articiling (fig. 2). Tono the Kingak Shale appears to be Sec. 22, T 6 S, R 46 W) in a tightly folded, asymmetrical, south-vergent anticline (fig. 2). Top of the Kingak Shale appears to be unconformably overlain by the Mount Kelly Graywacke; base disconformably overless the Shublik Formation. Unit is characterized by anomalously low thermal maturity of R<sub>o</sub> 0.8 to 1.2 and contains up to ~2 percent total organic carbon (table 1). Thickness: ~70 m at Surprise Creek.

Age: Lower Cretaceous (Valanginian) to Lower Jurassic, based on palynology and foraminifera (Mickey and Haga, 1995)

TOROK FORMATION (Aptian or Aptian-Albian) (Patton, 1956)-Silty shale and clay shale, predominately dark gray,

TORIC FORMATION (Aptian or Aptian—Albian) (Patton, 1956)—Silty shale and clay shale, predominately dark gray, interbedded with medium gray siltstone and minor amounts of medium gray to tan, fine-grained sandstone. Shale is thin-bedded and finely laminated, has characteristic nodular fracture. Interbedded siltstone and sandstone is thin-to medium-bedded, with platy to blocky fracture; slightly to moderately calcareous; contains graded bedding, wave- and current-ripple bedforms, sole markings, load casts, shale ripups, horizontal burrows, and scattered carbonaceous plant graments. Sandstone beds most common in the upper parts of formation and appear to lack lateral continuity. The unit is a thick prodelta deposit; and is gradational and intertonguing with both overlying and underlying units. The Torok is relatively incompetent and acts as a detachment surface for decollement folding of the overlying competent Nanushuk Group. Torok occupies the lowlands of the map area, commonly has thin tundra cover, but in some areas forms bare unvegetated slopes with white powdery, calcareous weathering surface that is constrictions on a aerial photographs. Good outcoms are limited to scattered stream cuthanks.

weathering surface that is conspicuous on aerial photographs. Good outcrops are limited to scattered stream cutbanks.

Thickness: Probably >2,500 m in map area, based upon projection of dips in overlying and underlying units; probably thicker

Age: Aptian or Aptian—Albian in map area, based upon palynomorphs from a number of localities (Mickey and Haga, 1995, 1998, 2000) (table 2).

Rocks here mapped as the Mount Kelly Graywacke Tongue of the Fortress Mountain Formation were formerly mapped by earlier investigators as Fortress Mountain Formation (Sable, 1956; Chapman and Sable, 1960). In the foothills of the western DeLong

Mountains, these rocks consist dominantly of calcareous graywacke consisting of chert, quartz, lithic rock fragments, and abundant

he Mount Kelly Graywacke gradationally underlies and interfingers with the Torok Formation, and occupies the stratigraphic position

of the Fortress Mountain Formation. In the map area the unit unconformably overlies Triassic to Neocomian rocks, but regionally may

gradationally overlie other Aptian-Albian shales. However, it contrasts markedly with the type Fortress Mountain, which is

carbonate grains. The Mt. Kelly Graywacke was delineated in order to appropriately recognize the distinctive compositional characteristics of this calcareous graywacke unit, which probably reflects a unique provenance or tectonic history that is apparently not recorded in the Fortress Mountain Formation elsewhere in the Brooks Range foreland belt.

The Mount Kelly Graywacke was probably deposited synchronous with ongoing deformation in the DeLong Mountains thrust belt. Its apparent thickness varies markedly, probably in part as a result of variations in depositional setting associated with syn-depositional folding and faulting. No complete sections are known, however a thick section is present on a regional southwest-plunging anticlinal nose that extends from the southeastern corner of the map area into adjacent quadrangles. On this structure, the formation is divided into

apper and lower clastic units separated by a significant shale interval that to the northwest apparently acts as a detachment surface for

Previous interpretations suggested turbidite deposition in a deep-water setting (Mull, 1985), but recent studies suggest a storm-

MOUNT KELLY GRAYWACKE, UPPER PART (Aptian) - Sandstone, fine- to medium-grained, dark brownish-gray to greenish-

MOUNT KELLY GRAWNACKE, UPPER PART (Aptian)—Sandstone, tine- to medium-grained, dark brownish-gray to greenish-gray with interbedded poorly exposed, slightly micaceous slity shale, generally forms poorly exposed, slightly micaceous slity shale, generally forms poorly exposed slightly micaceous than the lower part of the Mount Kelly Graywacke. Sandstone bedding is generally massive and homogeneous and generally thickens upward, with poorly exposed interbedded sitty shale intervals up to 2 m thick. Some beds have small-scale trough and tabular sets of planar cross-bedding, dish structures, possible convolute dewatering structures. Butters and groove easts and symmetrical wave-ring bedforms. Near its contact with overlying Torok

dewatering structures, flutes and groove casts and symmetrical wave-ripple bedforms. Near its contact with overlying Torok

Age: Probably Aptian, based upon age of the gradationally overlying Torok Formation, which yields probable Aptian

MOUNT KELLY GRAYWACKE, LOWER PART (Aptian)-Predominantly sandstone, fine- to medium-grained, some coarse-

otive-brown; forms rounded rubble-covered ridges and hills marked by resistant conglomerate and sandstone bedrock traces that are often unreliable for determining bedding attitudes due to forst disruption. Sandstone beds are thin-to thick-bedded and organized in generally fining- and thinning-upward sequences. Includes massive, homogeneous beds, parallel lamination, planar and trough cross-bedding, climbing ripples, wave ripple and wave-modified current ripple bedforms on bed tops, hummocky cross-stratification, convolute bedding, fluid-escape structures, shale ripups, and bi-directional and multi-directional sole markings. In the map area, the lower part of Mount Kelly Graywacke is exposed only on the northwest limb of the southwest plunging anticlinal nose in the extreme southeast corner of the map area.

Age: Probably Aptian, based upon age of the gradationally overlying Torok Formation, which yields probable Aptian

Thickness: ~1,000 m, includes shale interval separating it from the underlying main body of Mount Kelly Graywacke.

Formation, unit contains scattered channelized lenticular pebble to cobble conglomerate beds to 2 m thick.

ominated shelf setting (T.H. Nilsen, written communication, 1996), mainly on the basis of wave-general abundant detrital muscovite and carbonate grains suggest a provenance in the southern Brooks Range schist belt.

Outcrops typically intensely folded, making thickness of unit difficult to determine.

detrital muscovite and carbonate grains (Wartes and Reifenstuhl, 1998).

thrust faults, including the Coke Basin-Tupikchak thrust.

Thickness: Probably > 2,000 m

in areas beyond the depositional limit where the Mt. Kelly Graywacke pinches out into shale.

SHUBLIK FORMATION (Upper Triassic)—Thin-bedded black limestone and rhythmically interbedded black organic-rich paper shale, and light green and less commonly black silicified mudstone; limestone dominates the top of the unit and weathers buff to light gray. Contains scattered phosphate nodules. Mottled texture of the mudstone suggests bioturbation. Unit is

interpreted to record deposition in a low-energy, restricted marine environment characterized by high organic productivity. In the map area, the unit is exposed only at the Surprise Creek locality in the faulted core of a tightly folded and faulted, slightly overturned, south-vergent anticline (fig. 2). Top of the unit is disconformably overlain by the Kingak Formation; base is not exposed. Organic-rich shale and limestone contain up to -4 percent total organic carbon characterized by Type I and II kerogen, and constitute excellent potential hydrocarbon source beds. Thermal maturity of R<sub>s</sub> 0.8 to 1.3 indicates that the Shublik Formation at Surprise Creek ranges from thermally mature for generation of liquid hydrocarbons, to slightly Thickness: ~25 m exposed at Surprise Creek.

Age: Upper Triassic, based upon pelecypods *Monotis* sp. and *Halobia* sp. (table 2), which are abundant in the limestone and in some of the shale beds.

KINGAK SHALE/SHUBLIK FORMATION, UNDIFFERENTIATED—Unit locally undifferentiated due to map scale. See diagrammatic cross section C – C of the Surprise Creek locality (fig. 2).

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