UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

ISOPACH MAPS OF UPPER PALEOZOIC AND MESOZOIC ROCKS, NORTHERN ALASKA

By

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Open-file report

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The accompanying maps were made to provide data on rock volumes for a report on northern Alaska to the National Petroleum Council. They are based on information in published reports, well logs, and reports placed on open-file by the U.S. Geological Survey[1/]. Other geologists working in the area have advised on the interpretation of this information.

Data for most of the rock units shown are scanty. In order to appraise as much of the province as possible, extrapolations and interpolations have been made far beyond the data points. Control for each isopach map is shown by heavy black dots at the location of measured sections in outcrops or wells, and by straight lines radiating from the Barrow area along lines of seismic profiles that were compiled for the U.S. Navy by United Geophysical Co. Isopachs based on measured outcrop sections are solid; those based on well data are dashed. Inferred isopachs and those based on seismic data are queried.

1/ A reference list may be obtained free of charge from Alaskan Geology Branch, U.S. Geological Survey, 345 Middlefield Road, Menlo Park, California 94025.

Tectonic foreshortening and superposition along thrust faults in and immediately north of the Brooks Range makes interpretation of thickness and facies relationships difficult. To simplify the interpretation, rocks believed to be completely allochthonous have been omitted entirely. The remaining rocks are shown at their present location, not palinspastically restored. The disturbed belt has been symbolized by two parallel thrust faults. One is along the north edge of the zone of complex flat to steep faults and tight folds that involve Devonian through Cretaceous rocks in the southern Foothills and DeLong Mtns. The other is at the front of the zone of broadly folded imbricate thrust faults that involve mainly the more competent Paleozoic rocks of the Brooks Range.

For most systems the rocks known in and south of the disturbed belt differ significantly in facies or thickness from the rocks known to the north. Apparently the disturbed belt coincides with a series of hinge lines or transition zones which have since been foreshortened or overridden. For this reason the northward extrapolation of Mississippian through Jurassic facies into the subsurface in and immediately north of the disturbed belt is uncertain, and has not been attempted.

The interpretations upon which these maps are based are summarized in the following notes.

Figure 1. Pre-Mississippian rocks

The pre-Upper Triassic erosion surface on argillite near Barrow is correlated with the erosion surface exposed beneath Mississippian rocks in the Romanzof Uplift, and beneath Mississippian(?) red beds in the

Colville and Topagoruk wells. A fault at the Colville Delta, parallel to gravity and magnetic trends, has been inferred to account for the greater depth of this erosion surface where it is controlled by seismic mapping on the flank of the Barrow Arch than where it was penetrated in the Colville well.

South of the Colville and Topagoruk wells direct evidence is lacking, and the erosion surface is inferred to be at the lower limit of acoustic horizons (mapped in Payne, et al, 1951) and at the top of highly magnetic rocks whose depths have been computed by Dana (in Payne, et al, 1951) and by Roland Henderson and I. Zietz (John Henderson, written commun., 1968). Although neither the magnetic rocks nor the acoustic limit necessarily mark the unconformity, the depths of both coincide within the limits of error of the depth computations. They also fit the depths determined by refraction seismic survey for a gently dipping 20,000 fps velocity layer that projects to the unconformity in Topagoruk No. 1 well.

The magnetic rocks are probably igneous and are abundant enough to form effective basement in much of the area, even though they might be Mesozoic in age and not related in time to the unconformity.

The great depth to pre-Mississippian rocks inferred in the southern Foothills exceeds the estimated stratigraphic thickness of overlying deposits and probably results from décollement in upper Paleozoic and Mesozoic rocks near the Brooks Range and in Cretaceous rocks farther north. Pre-Mississippian rocks may be faulted up in the southwest, where a seismic profile across Carbon Creek anticline indicates a fault of about 10,000

feet throw in rocks at least as old as Jurassic, and the magnetic anomaly in the upthrown block seems shallow.

The highly magnetic rocks that are abundant at depth in the subsurface are absent in the eastern Brooks Range. The abrupt eastern boundary of these magnetic rocks suggests a fault. The age of the magnetic rocks is not known. A large mass of Devonian or older volcanic rocks crops out near the south corner of the magnetic block. However in Colville No. 1, the only well drilled to basement on a large magnetic anomaly, volcanic rocks occur in the Mississippian(?) red beds above the unconformity. Their position in the well is similar to that of a post-Mississippian mafic intrusive dike exposed in the Romanzof Uplift. The intrusive penetrated the pre-Mississippian rocks but was blocked at the base of the Mississippian carbonates.

Depth to pre-Mississippian rocks is assumed to exceed 10,000 feet in a Tertiary trough north of the Romanzof Uplift. The trough is inferred from the great thickness of Tertiary rocks described there (Morris, 1955) and from a coinciding zone of steep gravity gradient which strikes northwestward across the continental shelf and is interpreted by David F. Barnes (oral commun., 1969) as a Tertiary continental margin.

Figures 2; 3; 4. Mississippian basal shale and sandstone;
Lisburne Group; Sadlerochit Formation

Red beds rest with angular unconformity on Devonian rocks in Topagoruk No. 1 well. They resemble the basal red beds in Colville No. 1 well which are interbedded upward with Mississippian limestone. The red beds in both wells are correlated with the basal Mississippian shale and sandstone above the unconformity in the northeast Brooks Range.

The absence of Lisburne Group carbonates in the wells west of the Colville River is inferred to be a local pinch-out on the flank of the Barrow Arch. Seismic profiles (Post, 1949; Woolson, 1951) by United Geophysical Co. show a wedge of pre-Triassic beds that pinches out toward these wells. This wedge is inferred to be the Lisburne; its identification west of Topagoruk No. 1 is most uncertain. The Lisburne carbonates are overlain by Permian sandstone, succeeded by the Upper Triassic, Jurassic and Lower Cretaceous beds which overlap progressively onto the pre-Mississippian rocks at Barrow. Upper Triassic and Jurassic beds also overlap onto pre-Mississippian rocks in the British Mountains of Canada (Mountjoy, 1967), where the abrupt pinch-out of upper Paleozoic beds suggests early Mesozoic erosion. Mississippian through Jurassic stratigraphy indicates a more or less continuous high along the coast east of Barrow, so pinch-out or erosion of upper Paleozoic and Lower Triassic beds at other places between Barrow and the British Mountains is likely and has been indicated on the isopach maps by a generalized zero edge.

The Lisburne Group is mainly clean shallow water carbonates. The locations of two other facies are indicated. The Lisburne shown in the Lisburne Peninsula and southern DeLong Mountains (Ml) includes two to three thousand feet of Lower Mississippian silty or quartz sandy limestone and interbedded shale and quartzite (Nasorak and Utukok Formations). The Lisburne northwest of the DeLong Mountains is mainly dark, goniatite-bearing shale, shaly limestone and chert of both Lower and Upper Mississippian age. The black chert-shale facies in clearly allochthonous blocks farther south is omitted. However Upper Mississippian rocks of this facies also occur in the northern and northwestern DeLong Mountains

interbedded with arkosic sandstones in the lower part of the Nuka Formation. These are shown in their present location; they occur mainly in fault slivers in the western and central disturbed belt among other thrust plates of the cleaner facies. South of the disturbed belt tongues of the Upper Mississippian black chert-shale goniatite facies are also interbedded in the purer Lisburne carbonates of the southern DeLong Mountains (Ml) and central Brooks Range (PMl). These tongues pinch out eastward near where the Nuka disappears eastward in the disturbed belt. Much farther east in the Davidson Mtns. a similar Upper Mississippian black siltstone, limestone and chert facies (Msl) forms the base of the Lisburne, but its areal limits are unknown.

The upper part of the Nuka Formation includes beds similar and probably equivalent to the Lower(?) Permian Siksikpuk Formation, but also includes thick fossiliferous Upper Permian conglomerates, arkoses and arenaceous limestone with much fresh microcline. The conglomerates are lithogenetically like the Permian conglomerates in Topagoruk No. 1 well, and like the Permian or Triassic conglomerates in the Sadlerochit Formation north of the Romanzof Uplift. The source of those conglomerates is to the north, but the arkose in the Nuka Formation is unique, and its granitic source area is unknown. Some detrital microcline also occurs in unfossiliferous rocks like the Siksikpuk Formation (Ps?) just southeast of the map area near a granite pluton dated radiometrically as Mississippian (J. von Essen, written commun., 1968). A similar granite occurs in the disturbed belt in the Davidson Mtns. (see fig. 1). Rhyolite is associated with both granites and continues sporadically westward along the disturbed belt. Although the Nuka is involved in flat thrust plates in the DeLong

Mtns., it is a common Paleozoic marker on the steeper thrusts in the central part of the disturbed belt. Since it may also be related to felsic intrusives within the belt, it is shown in its present location in the disturbed belt.

Figures 5; 6; 6A. Jurassic Kingak Shale; Lower Cretaceous shale

No isopachs are shown for the Triassic Shublik Formation because it is a fairly uniform blanket only 200-800 feet thick mainly of Upper Triassic age. Facies changes that do exist are similar to those in Permian and Jurassic rocks. Chert is common in and south of the disturbed belt, but not to the north. Sandstone, glauconite and oolite occur locally on the northern Romanzof Uplift and Barrow Arch.

The Jurassic-Lower Cretaceous stratigraphic boundary is indefinite. Faunal boundaries in the outcrop have been revised (Jones and Grantz, 1964), and some microfaunal correlations in the wells are in conflict (Bergquist, 1966, p. 189-190). For the isopachs the boundary in the subsurface is arbitrarily taken at the base of a "pebble shale" that contains distinctive floating quartz grains and pebbles, overlies Middle Jurassic and older rocks, and seems mainly of Lower Cretaceous age (Collins and Robinson, 1967). A seismic horizon traced by United Geophysical Co. correlates conveniently with this pebble shale (fig. 6A).

The maximum 4,000-foot thickness of Kingak Shale estimated in outcrop and subsurface may be excessive, but does mark an apparent east-west trend of greatest thickness. Local thinning of the Kingak in a zone that strikes northwest across this trend is suggested by the scant data. This zone would coincide with the zone of thinning in Lower Cretaceous rocks and also with the area of Cretaceous truncation of Kingak Shale mapped in the outcrops.

Northward thinning of Lower Cretaceous shale formations seems to be due in part to pinch-out of Neocomian and Lower Albian beds against the Barrow Arch. Middle Albian beds overlap the arch in full thickness but are truncated near the coast by a Late Cretaceous unconformity which cuts out 4,000 feet of beds, locally at the rate of 1,000-2,000 feet per mile (Robinson, 1959; Collins and Robinson, 1967). Northeast thinning may be controlled by the same factors, but may also represent in part the sloping initial face of a deltaic pile of Middle Albian sediments.

The thickness shown for Lower Cretaceous shales at Oumalik No. 1 is less than that indicated in the well, because a seismic profile (Post, 1949) suggests local overthickening in Oumalik anticline through décollement of the Lower Cretaceous rocks.

Figures 7; 8. Nanushuk Group

Data on the Nanushuk Group are more complete than for any other units. However, thinning on the Barrow Arch is exaggerated because the top of the sections there is incomplete. The average shoreline trend near the arch may be biassed for the same reason.

A northeast zero edge is evident locally and may be continuous with that on the Barrow Arch. Northeastward thinning probably results both from shaling of the Nanushuk and from Late Cretaceous erosion. In addition, the pronounced thinning of the Albian part of the Nanushuk at Umiat suggests a local late Albian or Cenomanian high (see cross section, Figure 6).

Correlations within the Albian beds of the Nanushuk Group are based on lithofacies; the microfauna also seems to be facies controlled. The Grandstand Formation as shown on the map is defined by its relation to the nonmarine beds. It includes only those marine sandstones which form the uppermost part of the Albian sequence, underlain, but not overlain by Albian nonmarine rocks.

The greatest volumes and highest percentages of sandstone are nearest the probable source areas along the south and southwest edge of the outcrop. The other areas of high sand-shale ratio near Umiat and Barrow are too poorly defined to determine whether they represent separate local highs or are part of a continuous northwest trending sandy zone. The higher porosity of the sandstone at Umiat and the Barrow Arch than in adjacent areas (Collins and Robinson, 1967) suggests winnowing on local highs.

Figure 9. Colville Group

Because of regional dip away from the Meade Arch only the lower units of the Colville Group are preserved west of Umiat, and the youngest unit is known in only a few available sections. Therefore, sandy zones have been mapped for the two intervals that are known over the largest area--the Turonian and the lower Senonian--and the thickness of Turonian rocks is separately mapped.

The base of the Colville Group is an angular unconformity on the Barrow Arch and in the foothills south of Umiat (Detterman, et al, 1963), and may be an unconformity west of the Meade Arch (Smiley, 1966). A major shift in deposition is indicated by the eastward thickening of Turonian rocks. This is opposite to the direction of thickening of older Cretaceous rocks, and is in the same direction as the present regional dip of the whole Colville Group east of the Meade Arch.

Shorelines may locally have trended north, parallel to the Meade Arch (Brosgé and Whittington, 1966), but in general the Colville Group becomes

more marine and less sandy northward. A shoreline east of the arch need not imply separate basins on both sides of the arch, inasmuch as the rocks west of the arch are entirely nonmarine (Smiley, 1966).

The northward and northeastward extent of the Colville Group beneath the overlying Tertiary rocks is not known. A restored section suggests deep Tertiary erosion of the Colville Group near the present coast.

The area of very sandy Turonian rocks near Umiat coincides approximately with the local high inferred for the Nanushuk Group and also with the area of largest oil and gas discoveries in Cretaceous rocks. It lies on the flank of the thickest known deposits of Turonian shale. The Turonian rocks seem to become sandier again east of this shale basin but data are not sufficient to map their facies or thickness farther east.

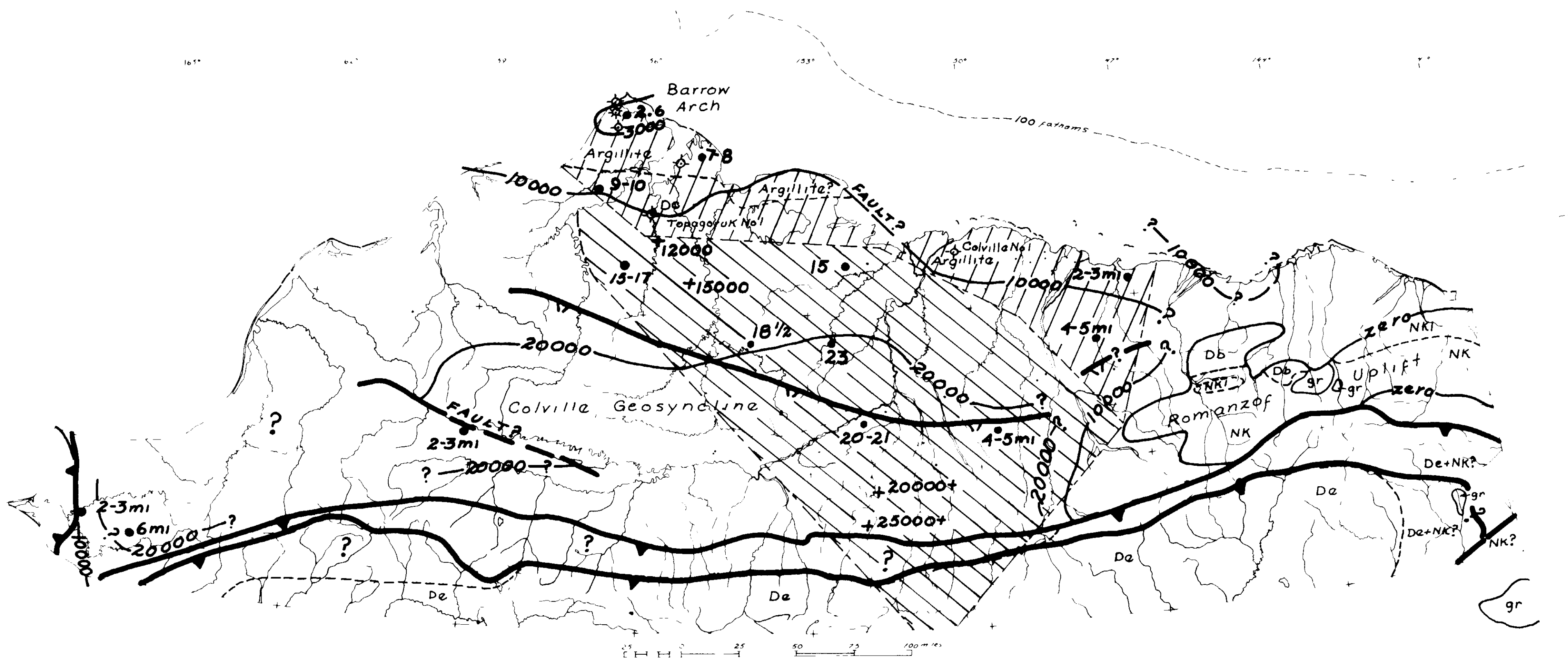


Fig. 1 Pre-Mississippian rocks

De: Endicott Group (Kanayut Conglomerate and Hunt Fork Shale; Upper Devonian)

Db: Baird Group (dolomite and limestone; Middle Devonian or older)

Dc: Middle(?) Devonian conglomerate

NK: Neruokpuk Formation; phyllite and quartzite-schist

NK1: Neruokpuk Formation; limestone and phyllite

gr: Granite of Mississippian and possible Devonian age

—10000— Inferred depth in feet below sea

• 15-17 Calculated depth of magnetic anomaly in thousands of feet (Dana, Henderson, Zietz)

• 2-3mi Estimated depth of magnetic anomaly

+15000 Depth in feet to high velocity rocks from seismic surveys

Well penetrates pre-Mississippian rocks

Thrust zone involving pre-Mississippian rocks

Probable northern limit of decollement in Mesozoic rocks

Area of large NW trending magnetic anomalies

Area of large NE trending magnetic anomalies

Area to east of these is mostly nonmagnetic

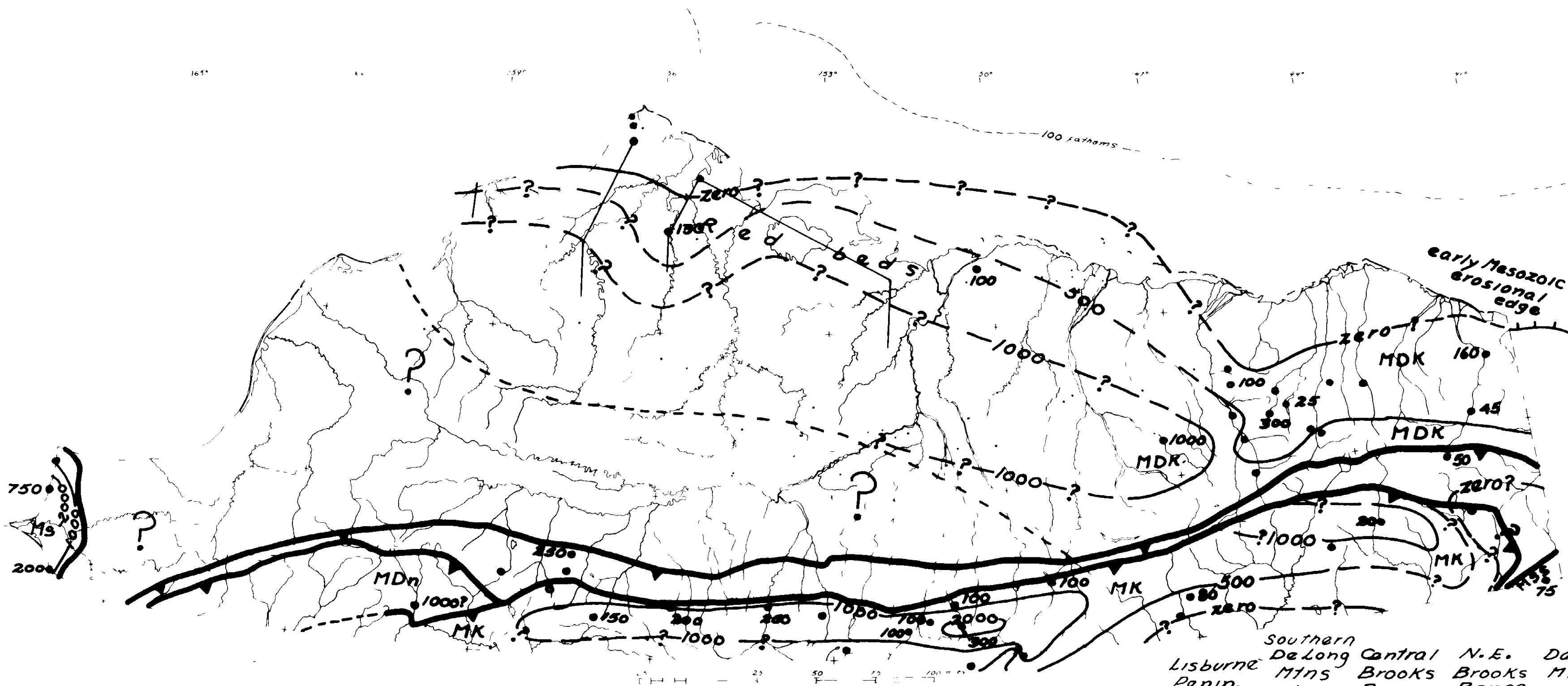


Fig. 2 Mississippian basal shale and sandstone

—1000— total thickness in feet

200• total sandstone in feet

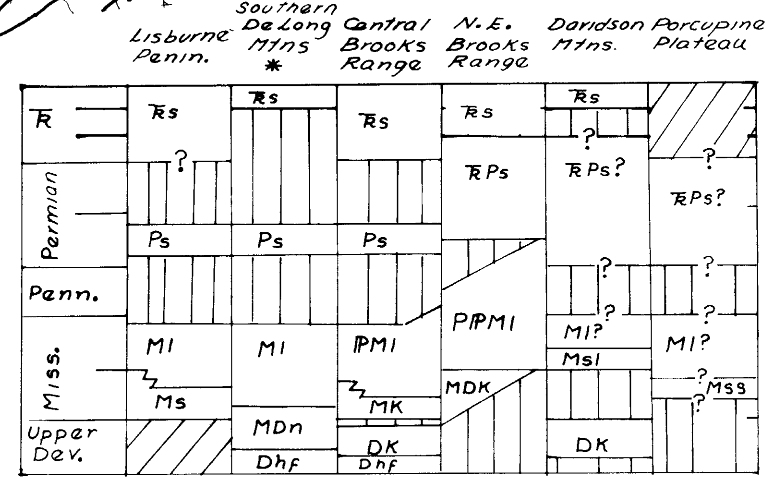
Ms: unnamed shale, s.s., coal

MDn: Noatak Fm.

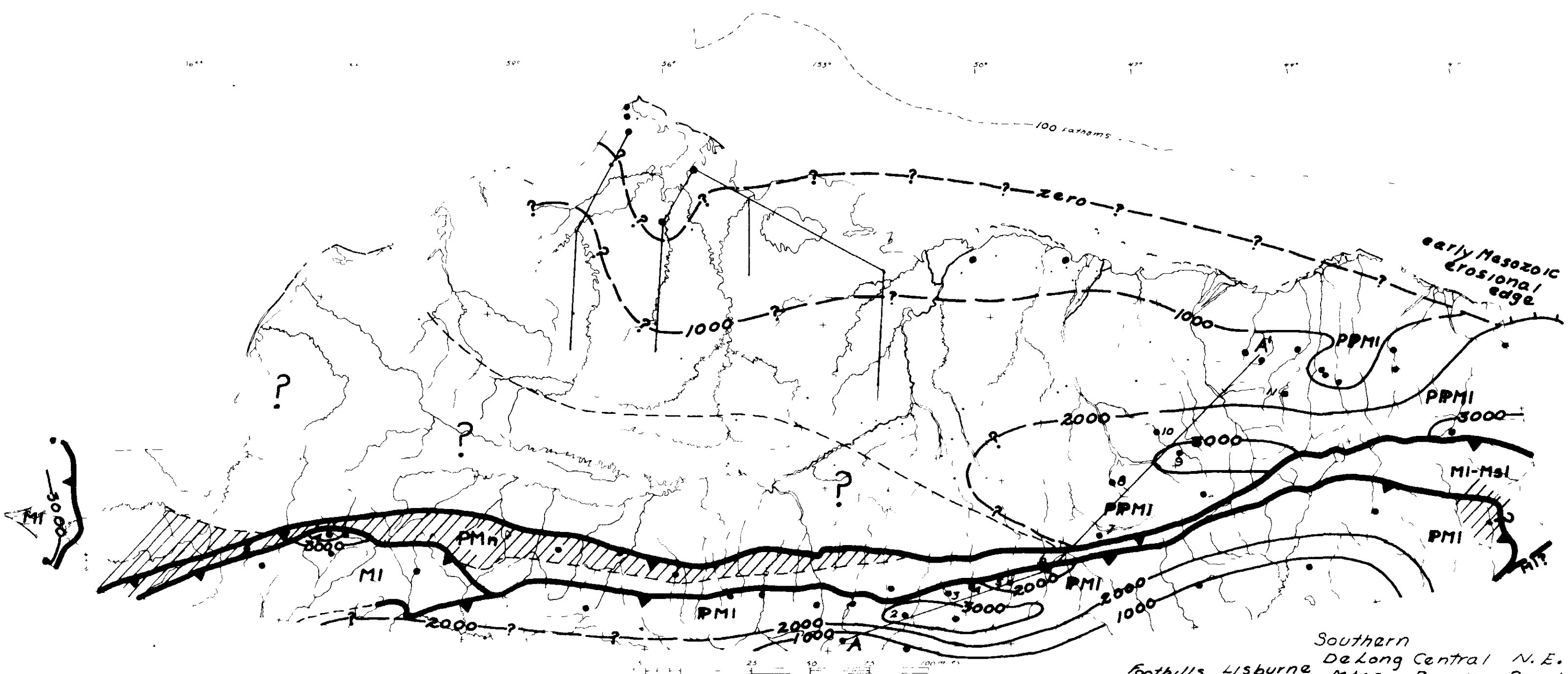
MK: Kayak Shale

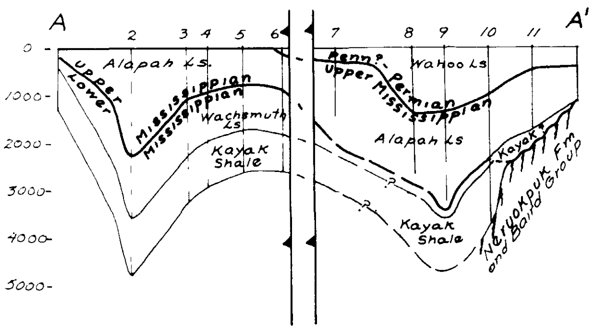
MDK: Kayak (?) Shale and Kekiktuk Conglom.

Mss: unnamed s.s.



* Least allochthonous rocks only





Restored section; datum is base of Permian clastic rocks

Fig. 3 **Lisburne Group**

—1000— Thickness in feet

Ml: Nasorak, Kogruk and Tupik Formations; Lisburne Peninsula

Ml: Utukok, Kogruk and Tupik Formations; De Long Mtns.

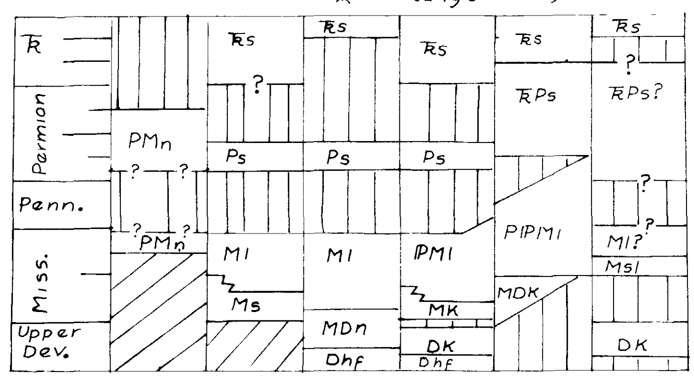
PMl: Wachsmuth, Alapah and locally, lower Wahoo Limestones

PPMl: Alapah and Wahoo Limestones

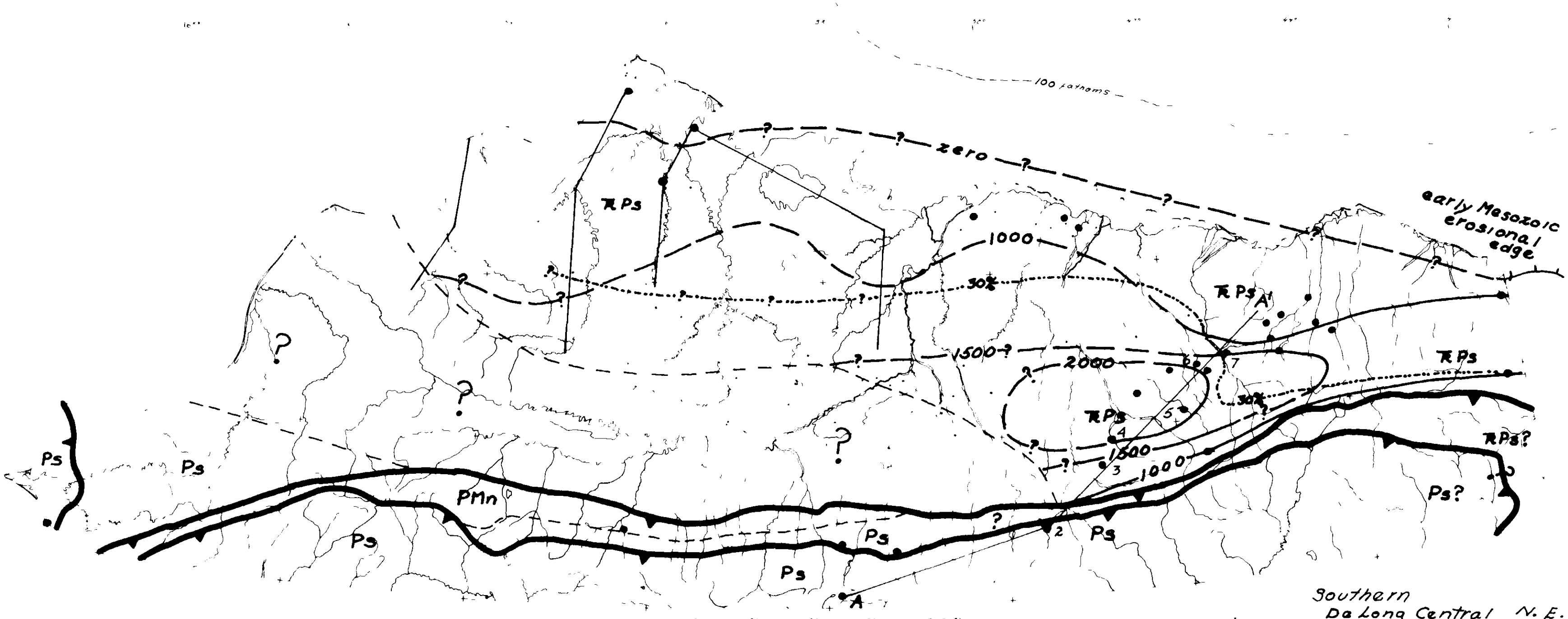
Ml?-Msl: Alapah(?) Limestone and unnamed Upper Mississippian black siltstone-limestone

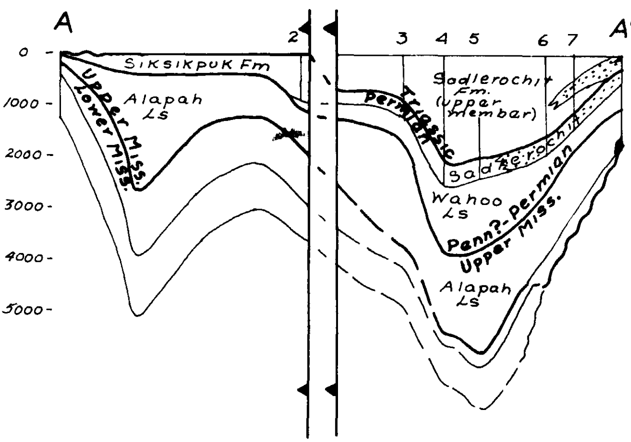
PMn: Nuka Formation, lower part

///// Mississippian black shale-chert-limestone facies; includes lower Nuka Fm.



* Least allochthonous rocks only





Restored section
datum is base of Shublik Fm.

Fig. 4 **Permian and Lower Triassic Sadlerochit Formation**

—1000— Thickness in feet

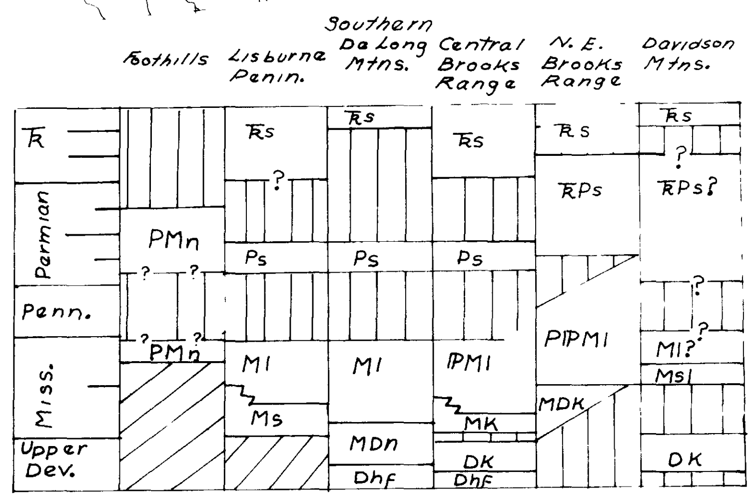
.....30%... Southern limit of area of 30% or more sandstone in Sadlerochit Formation

TRPs: Sadlerochit Formation

Ps: Siksikpuk Formation; 200-1000 feet thick

PMn: Nuka Formation, upper part

TRs: Shublik Formation; not mapped



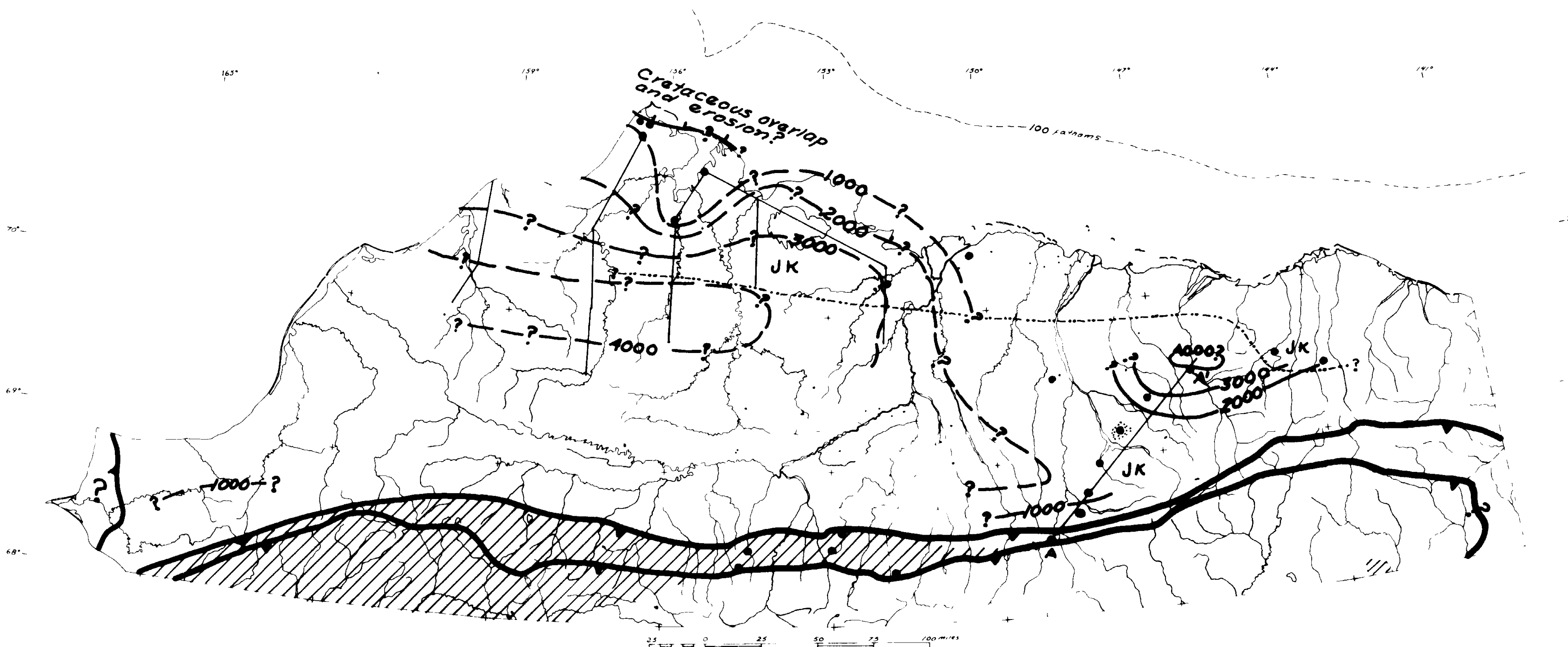


Fig. 5 Jurassic Kingak Shale

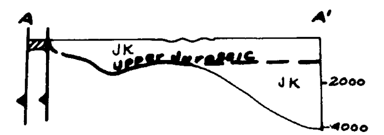
—1000— Thickness in feet

-·-·-·-· Southern limit of area of known sandstone beds 50–150 feet thick

/ / / / / / Area of Jurassic mafic rocks, tuff, chert, shale and oil shale; in part allochthonous

Area of Early Cretaceous erosion of Kingak Shale

JK: Kingak Shale



Restored section
datum is base of Lower
Cretaceous rocks

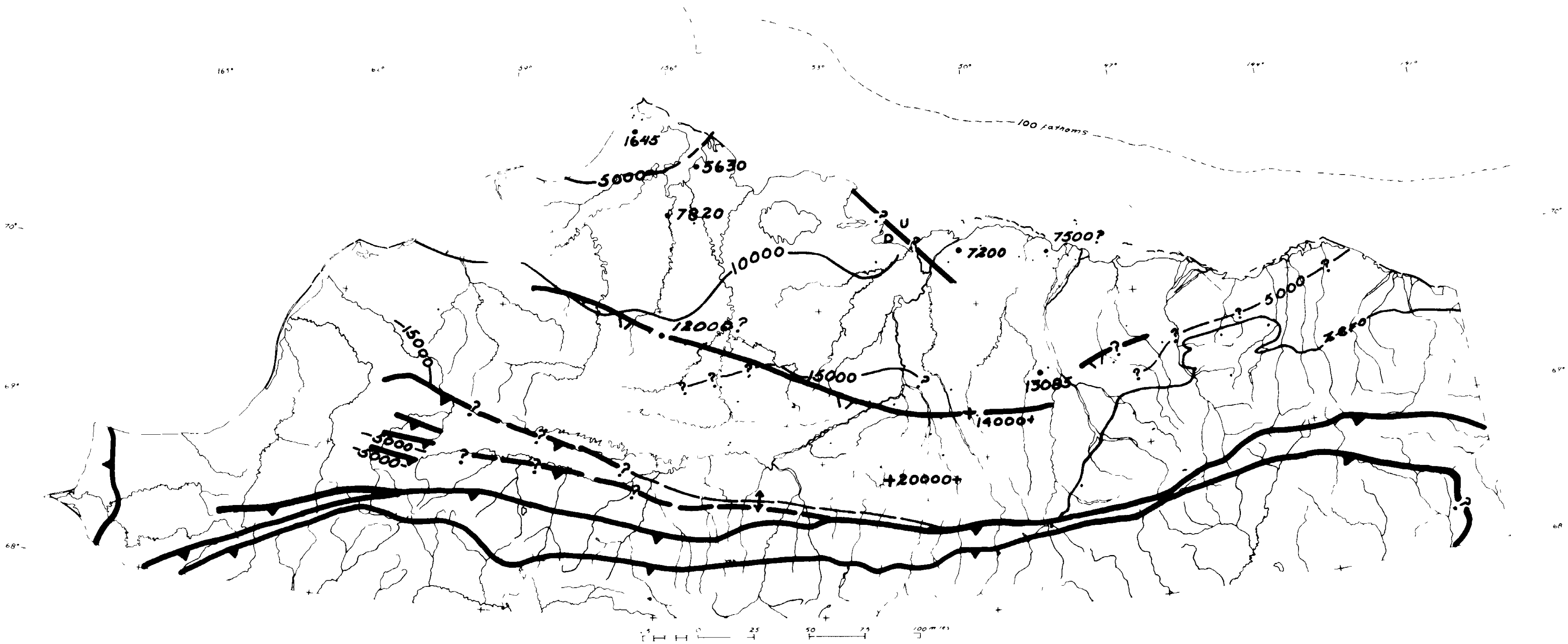


Fig. 6A Depth to base of Cretaceous rocks

—5000— Depth in feet below sea level from seismic surveys (after Woolson, 1962)

?—5000—? Inferred depth in feet below sea level.

•7820 Depth in well; queried where inferred

+14000+ Minimum depth from seismic survey

D/U Fault displaces base of Cretaceous rocks; queried where inferred

Probable northern limit of decollement in Mesozoic rocks.

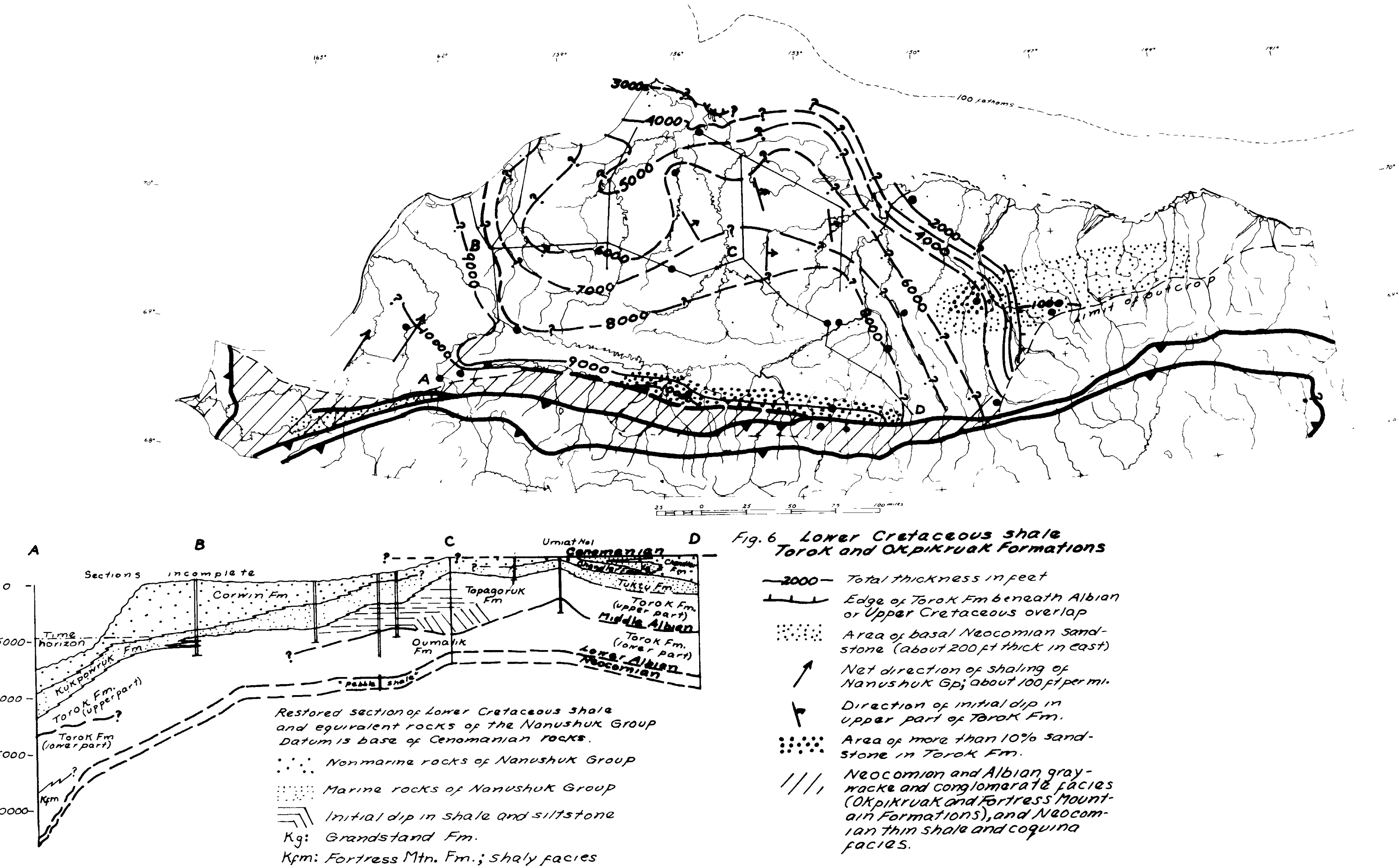


Fig. 6 Lower Cretaceous shale Torok and Okpikruak Formations

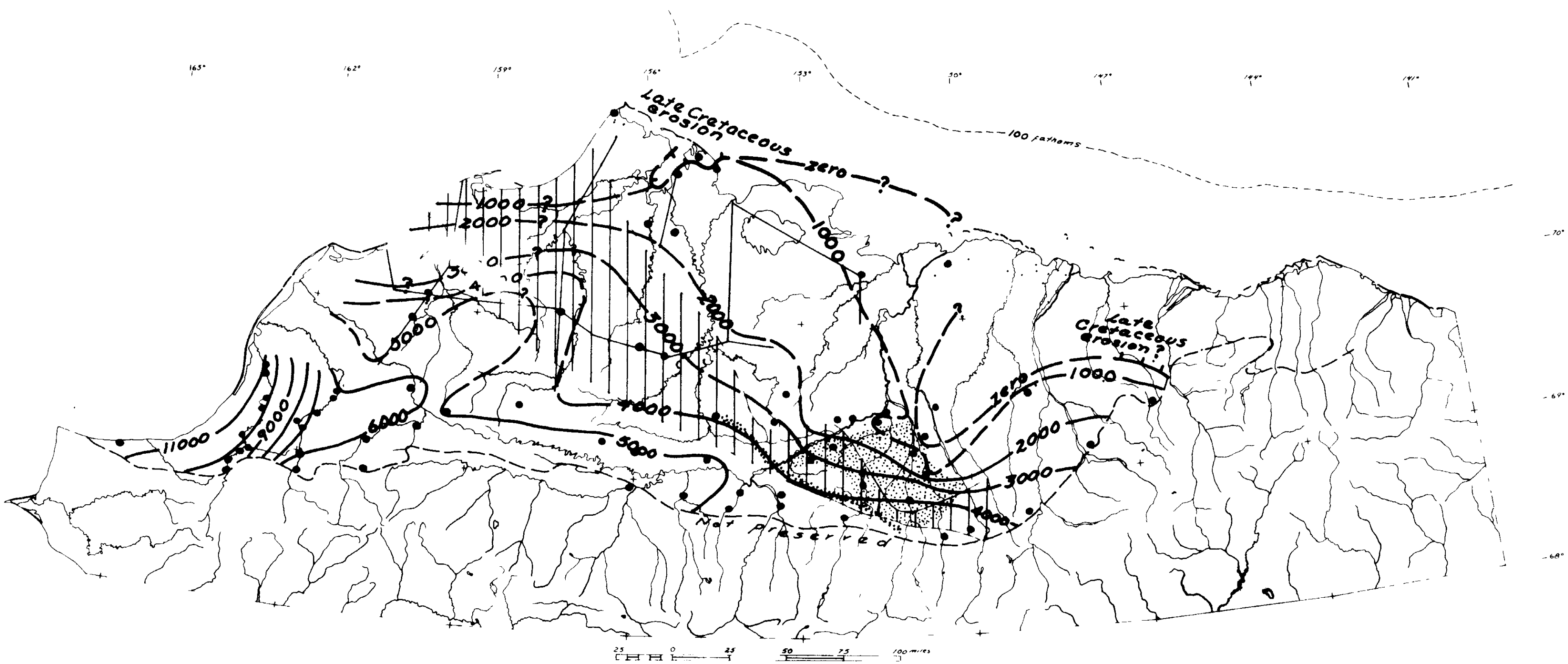


Fig. 7 Nanushuk Group
Albian and Cenomanian
marine and nonmarine sandstone and shale

—1000— Thickness in feet

Average shoreline. Rocks mostly marine to north, mostly nonmarine to south

Axis of greatest thickness of Cenomanian rocks, as much as 1150 ft thick

Area of Albian marine transgression over nonmarine rocks. Youngest Albian rocks are marine Grandstand Fm. (See restored section, Fig 6)

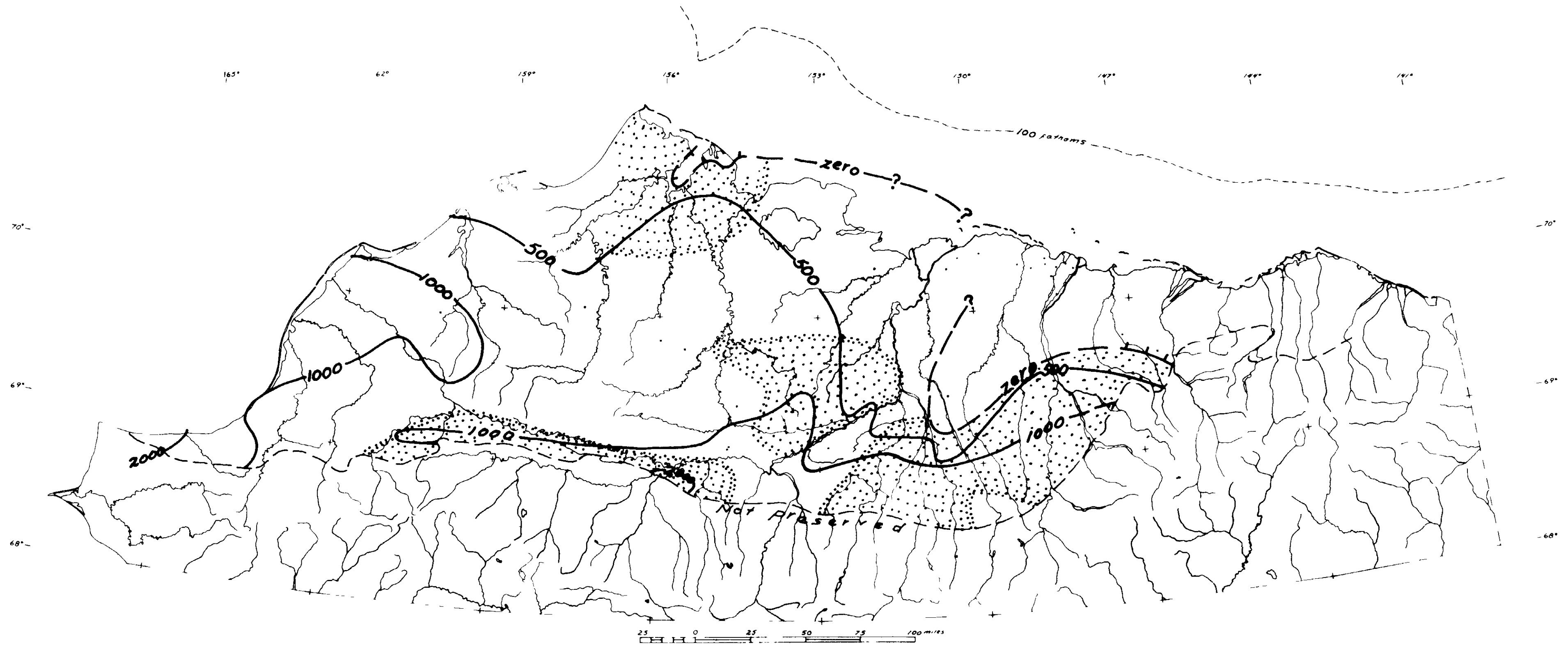


Fig. 8 **Nanushuk Group sandstone**

—500— Total cumulative thickness of preserved sandstone beds in feet; generalized

(dotted pattern) Nanushuk Group is 30% or more sandstone; area generalized

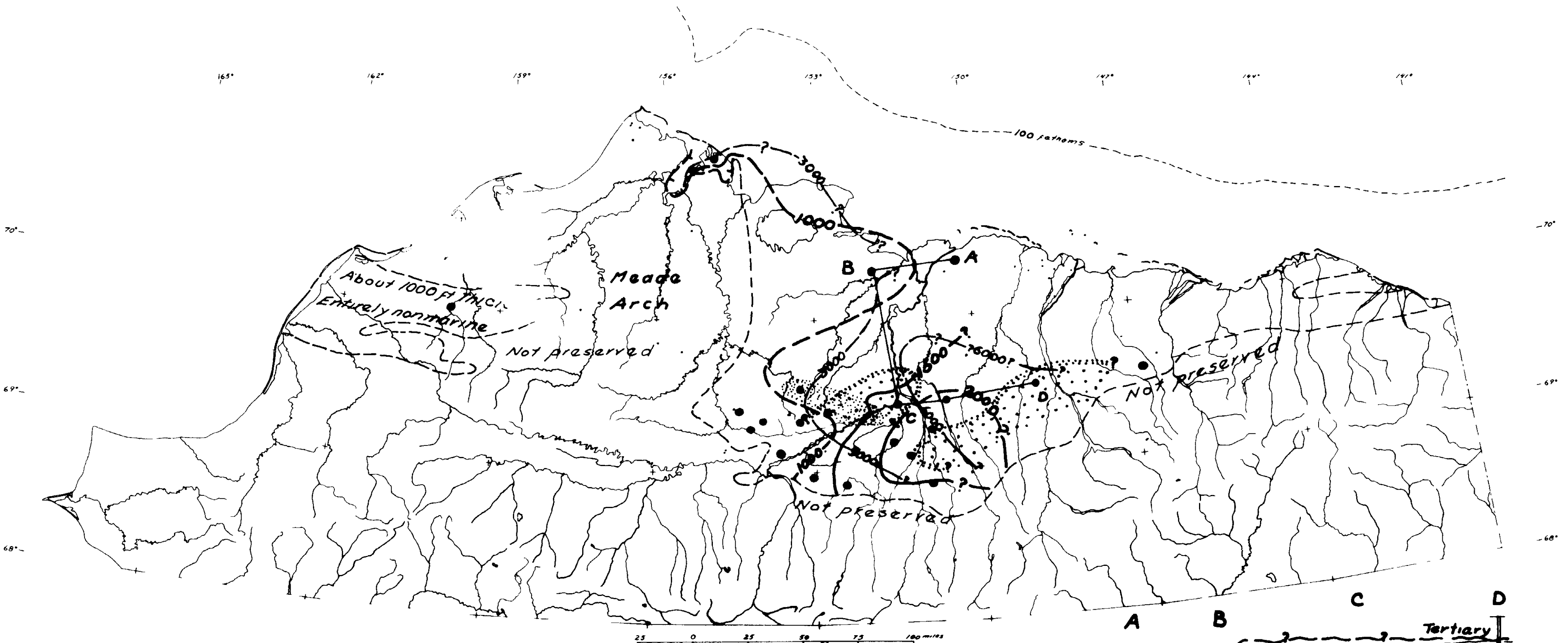


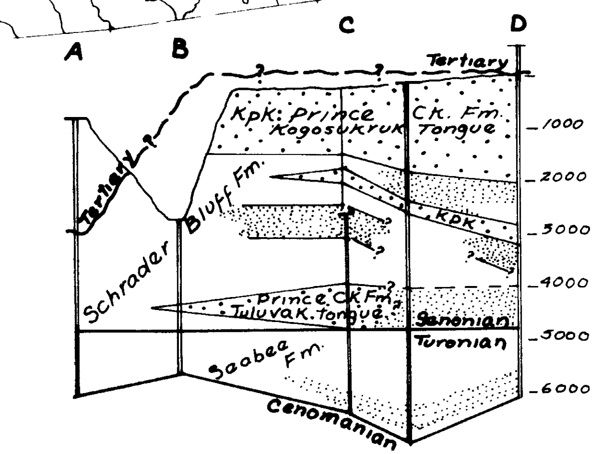
Fig. 9 **Turonian and Senonian Colville Group**

—3000— Thickness in feet of Colville Gp remaining beneath Tertiary and Quaternary unconformity. Most sections are incomplete

—1000— Thickness in feet of Turonian Seabee Fm. Not shown east of long. 150°

Area of 20% or more sandstone in Seabee Fm.

Area of 20% or more sandstone in Senonian rocks below the Kogosukruk tongue



Restored section of Colville Group
Datum is top of Turonian rocks

Nonmarine sandstone and shale

Marine sandstone and shale

Marine shale

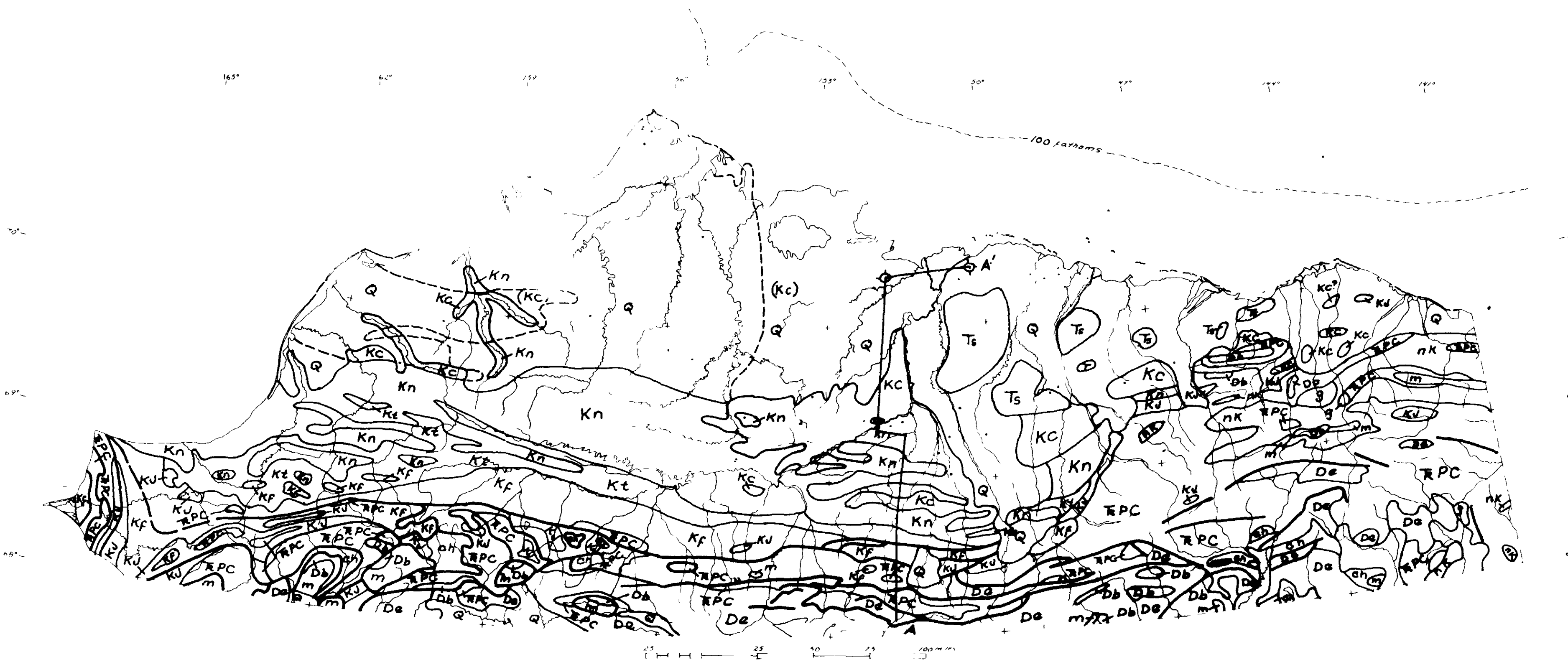


Fig. 10 Generalized geologic map

QUAT.	Q	Unconsolidated sediments
TERT.	Ts	Sagavanirktok Fm
CRET.	Kc	Colville Gp
	Kn	Nanushuk Gp.
CRETACEOUS	Kt	Torok Fm
	Kf	Fortress Mountain Fm
JURASSIC AND CRET.	KJ	Jurassic and Neocomian shale units, undiff.
CARBONIFEROUS, PERMIAN AND TRIASSIC	₮PC	Upper part of Endicott Gp; Lisburne Gp; Shublik Fm and Sadlerochit Fm in N.E; Siksikpuk Fm in Endicott and De Long Mtns; Nuka Fm. in De Long Mtns
DEVONIAN	De	Endicott Gp (lower part)
	Db	Baird Gp
PRE-MISS.	nK	Neruokpuk Fm.
PALEOZOIC or MESOZOIC	ch	Chert
	g	Granite
JURASSIC(?)	m	Mafic rocks

Geologic contact; dashed where concealed

Fault; dashed where approximately located