THE GEOLOGY OF THE BEAUFORT-MACKENZIE BASIN

by

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[redacted]

The Beaufort-Mackenzie Basin comprises an area of about 36,000 square miles out to the 600 foot isobath as shown on ~~the slide to your left~~ Figure 1. It is situated between the Romanzof Uplift and Brooks Geanticline to the west and southwest, the several components of the Aklavik Arch Complex to the southeast, and the continental margin. Within these structural limits approximately 53,000 cubic miles of Phanerozoic sediments are enclosed, of which about 87% comprise clastics of Mesozoic and Cenozoic age.

The basin lies at the confluence of several major tectonic elements and the history of each has had an important influence on its development. Of particular interest in this regard is the ongoing debate apposite to drift or no drift. As a general guide we assume that the Canada Basin is underlain by oceanic crust of Jurassic and younger age.

[redacted]

Figure 2 is a stylized map of the principal tectonic elements of northwestern mainland Canada and Figure 3 is its associated legend. From Figure 3 patterns E and F represent basinal regions that are, or were covered by Mesozoic rocks. The differences in pattern are intended to show relative differences in stratigraphic thickness between immediately adjacent areas. For example, the Richards Island Basin (7) has a thicker section of Mesozoic and Cenozoic rocks than the pattern F area adjacent to the continental margin, but does not have an equivalent thickness to the pattern E region underlying the Horton Platform (Area 6). This latter region contains relatively thicker Mesozoic sediments than the immediately surrounding area (Pattern F-Area 6). [redacted]. In like manner pattern D and C areas are structural culminations, covered by Mesozoic and Cenozoic sediments in the pattern D areas. Pattern C regions represent areas of pre-Mesozoic bedrock exposed with the direction of structural grain illustrated (Pattern B).

The Horton Platform (6) is underlain by essentially undeformed Proterozoic and lower and middle Paleozoic carbonates and clastics overlain by Mesozoic clastics that extend in a northwesterly dipping homoclinal succession from the

Coppermine Arch in the east to the Aklavik Arch Complex in the west. A minor basin, the Anderson Plain Syncline, is situated on the southeast flank of the Aklavik Arch Complex and contains about 3,000 feet of Cretaceous strata (Pattern E-Area 6).

The Aklavik Arch Complex comprises an intricate series of faulted culminations, cored by Proterozoic and Paleozoic rocks, and, for the most part, arranged in a right-hand en échelon fashion. Between the uplifts and on their flanks are structural depressions containing rocks as young as Tertiary. Possibly five angular unconformities and as many disconformities interrupt the stratigraphic succession in the Arch and attest to a prolonged and intermittent tectonic history extending from Proterozoic to Tertiary time. The diagram shows a number of components to the Arch, some of which are well recognized by formal names; these include the Dave Lord Arch (2a) and the Rat (2b) Cache Creek (2c) and Campbell Uplifts (2d). Others are imperfectly known and have been given informal names to facilitate discussion. These are the Harrowby Bay (2e) and Cape Dalhousie Highs (2f). The two culminations on the central arm (Pattern C) are parts of the Eskimo Lakes horst.

Compounding the complexity of the Aklavik Arch is a series of high angle faults that extend from the Richardson Anticlinorium in the south to beneath the proximal rim of the Beaufort-Mackenzie Basin. The Eskimo Lakes Fault Zone (ELFZ), as it was named by Gulf Geologists, beneath the Mackenzie Delta and Tuktoyaktuk Peninsula comprises a set of mainly down-to-basin faults of variable stratigraphic separation and periodicity of movement. The principal fault of the zone extends southward to link up with the Trevor Fault which is believed to have both right lateral and vertical separation.

The Romanzof Uplift (1), defined by Payne in northern Alaska, continues into Canada and includes the British and, in this paper, the Barn Mountains. One major angular unconformity and at least four disconformities partition the stratigraphic sequence and lower Paleozoic granitic intrusions occur locally. The principal Paleozoic unconformity reflects Ellesmerian movements beneath the Mississippian Kekiktuk conglomerate whereas Columbian and Laramide deformation in the uplift is reflected by the Jurassic, Cretaceous and Tertiary clastic wedges that overlie the upper Paleozoic and Triassic succession on Beaufort Shelf.

A tectonic element which may have played a major roll in the development of the basin is the Kaltag Fault (KF). According to Patton and Hoar, Tailleur and Brosgé, the Kaltag Fault has been traced and extrapolated northeastward from Bering Sea to where it enters Canada on the south side of the Old Crow granites (5), and which, in central Alaska has been identified as a major, right-lateral strike-slip fault with between 40 and 80 miles of post-Early Cretaceous separation. Don Norris has mapped a major, northerly trending fault system in northern Yukon, on trend with and probably dynamically related to the Kaltag Fault. This he named the Rapid Fault Array. One of the components of the array forms the north boundary of the Aklavik Arch Complex and closely approaches the Yukon Fault (YF), a thrust which transects the Arch. From there, towards the offshore, the array consists of a set of nearly vertical north-trending faults with substantial east-side-down vertical separation and probable right lateral displacement. Seaward, the array is on line with a substantial gravity anomaly, and it has been suggested that the Kaltag-Rapid Fault Zone extends to the landward flank of the uplifted rim of the continental margin as defined by the large, positive free air anomaly. More will be said about this later in the paper.

[illegible]

[illegible]

The stratigraphic framework of the region is illustrated on ~~your left~~ Figure 4 and the areal designation of each column is shown on ~~the slide to your right~~ Figure 1. [illegible]

[illegible]

[illegible] Notice that a new nomenclature, soon to be published, is applied to the Cretaceous rocks of Anderson Plain. The Lower Cretaceous Langton Bay and Horton River Formations replace "Silty Zone" and "Bentonitic Zone" respectively, and the Upper Cretaceous informal names "Bituminous Zone" and "Pale Shale Zone" are likewise renamed as Smoking Hills and Mason River Formations.

The Jurassic and early Lower Cretaceous succession from Anderson Plain in the east to the northern Richardson Mountains in the west is expressed as an epicontinental sequence, the development of which was influenced by tectonic activity along cratonic arches. The late Early Cretaceous rocks consist of shallow marine shales on the craton to the east and thick, foredeep flyschoid deposits in northern Yukon. Between these two regions fluvial to neritic clastics developed along the basinward flank of the Aklavik Arch Complex.

The hiatus separating the Lower and Upper Cretaceous series represents erosion and/or non-deposition induced by early Late Cretaceous Columbian orogenic and epeirogenic movements. The overlying Upper Cretaceous cratonic rocks comprise restricted marine shales and mudstones, which are noted for their physical, and chemical characteristics and vertebrate fauna.

The latest Cretaceous to Miocene sequence consists of a series of delta fans and interstratified marine shales and mudstones.

The next series of ~~slides~~ figures will illustrate the more detailed stratigraphy of the Jurassic through Lower Cretaceous interval. This will be followed by a number of paleogeographic reconstructions within the same span of time. Later, the Late Cretaceous through Tertiary succession will be discussed in the same manner.

For all intents and purposes the basal sediments of the Beaufort-Mackenzie Basin are Jurassic in age. No Triassic rocks have been reported from the subsurface of the region, however, patchy occurrences of Triassic Shublick equivalents are known in northern Yukon.

[redacted]

~~The slide on your left~~ Figure 5 summarizes the Jura-Cretaceous stratigraphy on the west side of Mackenzie Delta along the line of profile shown ~~to your right~~ on Figure 6. Lower and Middle Jurassic sediments are generally confined to paleotopographic lows and thicken into Kugmallit Trough. The trough is confined between the Cache Creek and Rat Uplifts, each of which are parts of the Aklavik Arch Complex. The sequence thins over these flanking arches where mature quartz sandstones of the Bug Creek Formation overlie Paleozoic and older rocks. Basinward the coarse arenites pass into mudstones and shales of the Kingak and Husky Formations, the latter straddling the Jurassic - Cretaceous boundary.

[redacted]

~~The illustration on your left~~ Figure 7 shows the Jura-Cretaceous sequence on the east side of Mackenzie Delta along the profile indicated ~~to your right~~ in Figure 6.

The Jurassic rocks, like those of the west side consist of mudstones and shales that overlie Paleozoic and older rocks of the Aklavik Arch Complex.

The Lower Cretaceous arenaceous wedge is the principal package of interest in this section and is divisible into regressive and transgressional phases which bracket a Neocomian ~~delta wedge~~ deltaic complex. Uplift along the northeast trending Aklavik Arch Complex and Peel Landmass during mid-Neocomian provided much of the material for the construction of the delta lobes which prograded basinward during the regressional phase. The intra-Cretaceous hiatus includes parts of the Valanginian and Hauterivian stages and is drawn to reflect the relationship of the deltaic complex to tectonic activity along the cratonic arch.

The Upper Shale-Siltstone Division of Late Hauterivian to Aptian age represents a continuation of marine transgression that terminated deltaic sedimentation and culminated in the widespread deposition of the Albian shale-siltstone division. The Upper Shale-Siltstone Division is variable in thickness due in part to pre-Late Cretaceous erosion and possibly pre-Albian erosion as suggested by recent biostratigraphic studies in the Reindeer C-38 and Parsons F-09 well~~s~~. Vertical faults of the Eskimo Lakes Fault Zone on the flank of the Aklavik Arch Complex also may account for local missing section.

[redacted]

~~The slide on your left~~ Figure 8 shows the Jura-Cretaceous profile from Anderson Plain to the flank of Kugmallit Trough along a profile oblique to the trend of the Aklavik Arch Complex as shown ~~to your right~~ in Figure 6.

In Anderson Plain the Lower Cretaceous succession is preserved within the Anderson Plain Syncline bounded by the Coppermine Arch to the east and the Aklavik Arch Complex to the northwest. The Late Jurassic to Aptian sequence is represented by the nonmarine Gilmore Lake Member of the Langton Bay Formation, the source for which was the Coppermine Arch. The fluvial succession passes laterally and vertically into shallow then open marine mudstones and shales of the Crossley Lakes Member and Horton River Formation respectively.

The Late Neocomian to Aptian rocks beneath Tuktoyaktuk Peninsula consist of sandstone and conglomerate of variable thickness, maxima of which are preserved in paleotopographic lows above Paleozoic and older rocks which appear to have been the sources for the overlying coarse arenites. These deposits pass laterally and vertically into transgressive marine sandstones and thence into shallow marine Albian siltstones, and shales which are widespread over the arch complex and northern Interior Plains.

SLIDE 11 LEFT = JURASSIC LITHOFACIES

SLIDE 12 RIGHT = STRATIGRAPHIC INTERVAL

The Jurassic lithofacies and paleogeography of the area are illustrated ~~to~~ on Figure 9. ~~[illegible]~~ [redacted] The facies legend for all paleogeographic maps is the same as that shown on the correlation chart (Figure 4). The numbers on all maps are isopach values for the intervals ~~being~~ described (in 1000s of feet). In Early Jurassic time transgression across the shelf initiated a period of relatively continuous sedimentation that lasted until the end of the Albian. Early Jurassic black, marine shales were deposited over the site of Romanzof Uplift in a basin whose shoreline probably followed the northern flank of the Aklavik Arch Complex across the modern Mackenzie Delta. Sandstones comprised an eastern near-shore facies which pass basinward into shales in the northwestern Richardson Mountains.

Following a brief period of local uplift along the Aklavik Arch Complex in the late Early Jurassic, the sea again advanced towards the east and south. A strait was formed along the axis of the present Dave Lord Ridge and connected Mackenzie Basin with the Kandik Basin. Three major Middle Jurassic clastic facies are recognized, including mature quartz sandstones in northern Richardson Mountains, marine siltstones beneath Mackenzie Delta and black shales in the Blow River area. Carbonaceous debris, conglomerate and relatively immature sandstones in the Vittrekwa Embayment attest to a major river estuary in this region. Sands from this source were spread northerly by marine currents and deposited, perhaps as contourites over and around local arches such as Cache Creek Uplift. The marine siltstone facies represents rapid deposition upon a subsiding outer shelf marginal to a region of deep water shale accumulation.

In Late Jurassic time the eastern shoreline of Mackenzie Basin transgressed eastward, Keel Strait widened and the Vittrekwa Embayment enlarged. The Old Crow Landmass, an eastward projection of the Brooks Range Geanticline, continued to expand. Black shale, siltstone and quartz sandstone remained the dominant facies but their areal distribution shifted to the southwest towards Eagle Plain, and probably only thin marine sands accumulated beneath Mackenzie Delta. Terrigenous clastics continued to be delivered to Vittrekwa Embayment but also developed along the eastern shore of Keel Strait. A dominant northeasterly flowing current in the strait reworked the sands into offshore bars, resulting in a 2,000 foot stack of shallow-water sands near Porcupine River.

[redacted]

The Neocomian paleogeography is shown in Figure 10 [illegible]

In Early Cretaceous time further shoaling around the southern margin of the Mackenzie Basin resulted in widespread deposition of sandy sediments. Progradational deltaic wedges, developed on the flank of the Aklavik Arch and extended northwesterly into northern Richardson Mountains and Mackenzie Delta. Because of relatively slow subsidence of the platform area, deltaic lobes were widespread and avulsion of main distributary systems developed many times. Altough more paleontological dating is necessary, lithostratigraphic evidence suggests that a depocenter in Early Hauterivian time was in the region north of Inuvik, resulting in the gas-bearing Parsons sandstone. In latest Hauterivian time however, the depocenter switched to the northern Yukon area, resulting in the accumulation of quartzitic sandstones and coal. The transgressive sequence in the east delta subsurface is probably its equivalent. During this time the southern shoreline gradually transgressed over northern Eagle Plain and the flank of the Aklavik Arch. The Old Crow Landmass expanded and pushed the shoreline and associated near shore sediments towards the northeast.

Expansion of the Brooks Range Geanticline resulted in erosion of the Neocomian section along its positive leading edge, and the development of an adjacent foredeep. Late Hauterivian movements along the Yukon and Kaltag - Rapid fault systems resulted in substantial contrasts in thickness and facies across these faults. These contrasts are preserved beneath Barremian marine shales which in turn were involved in later dislocations during the mid-Aptian. In view of these observations it has been suggested that the Kaltag Fault in Alaska was born in Early Cretaceous time. Late Hauterivian tectonic movements also occurred along portions of the Aklavik Arch Complex, resulting in truncation of the Early Neocomian succession.

In Anderson Plain a fluvio-deltaic succession developed adjacent to the flank of the Coppermine Arch. Lower delta-plain coals, mudstones and point-bar sandstones grade northwesterly into shallow marine siltstones and shales. The paleotopographical and environmental connection represented by neritic sands between this region and Mackenzie Delta is uncertain and is so indicated on Figure 10

[redacted]

Figure 11 [redacted] illustrates Aptian paleogeography and lithofacies.

Following Late Hauterivian uplift along the Aklavik Arch Complex, marine transgression resulted in widespread deposition of Barremian marine shale and siltstone which overstep the older delta wedge. By the end of this stage the southern shoreline extended across most of Eagle Plain, however, the western margin probably remained static against the flank of the Brooks Geanticline. The foredeep axis became colinear with the depositional maximum of the later Aptian - Albian flyschoid clastics. Along the southeastern margin of the basin arenaceous sediments continued to accumulate in the Vittrekwa Embayment and Kugmallit Trough.

During the Aptian, shoaling of the basin accompanied by shoreline regression resulted in the deposition of neritic sands. Shallow marine sandstones and siltstones of this unit occur widely throughout the northern Richardson Mountains and shale-out towards the north and northeast. The Aklavik Arch Complex again became positive and appears to have influenced the distribution of sediments although

Late Aptian erosion obscured the original depositional record over paleotopographic highs. Coarse arenites consisting of microconglomerates and sandstones were deposited by braided streams in paleotopographic lows in the vicinity of Atkinson Point and probably elsewhere. The western margin of the basin was influenced by Aptian tectonic activity in the eastern Brooks Range, partly localized along the Kaltag - Rapid Fault Zone. The relatively uplifted western block supplied lithic and carbonate detritus to the adjacent trough which culminated in Albian time with the development of the Aptian-Albian flyschoid Division.

In Anderson Plain Late Aptian marine transgression terminated deltaic deposition and thereafter shallow to open marine conditions prevailed until the close of the Early Cretaceous.

[redacted]

Figure 12 [redacted] illustrates the Albian paleogeography and lithofacies.

By Early Albian time the flyschoid trough was well established above a structural depression created by the Rapid Fault Array. The trough was filled predominantly with marine shales but also included turbidites, the immature coarse clastics of which were derived from the western highlands. Strong axial bottom currents prevented much sediment from reaching the eastern side of the trough where raised submarine platforms became the site of precipitated phosphatic iron carbonates. Siltstone and shale were swept onto the subdued Aklavik Arch Complex beneath Tuktoyaktuk Peninsula.

In mid-Albian time the flyschoid trough had been filled with up to 10,000 feet of sediments and the southern shoreline had transgressed over the craton far to the south and southeast. Little sedimentary record of mid-Albian to mid-Upper

Cretaceous time exists in northernmost Yukon and District of Mackenzie. Lower Cretaceous sedimentation in the Mackenzie Basin was terminated by epeirogeny and the latter stages of Columbian orogenesis, leaving only restricted narrow inlets and straits.

[redacted]

Figure 13 [redacted] is a fence diagram illustrating the uppermost Cretaceous and Tertiary stratigraphy along the profiles shown on Figure 14 [redacted]. The basic elements of this succession include thick, progradational fluvio-deltaic wedges constructed during episodes of marine regression over delta-front sandstones and siltstones and prodeltaic mudstones and shales. The latter commonly developed during stages of marine transgressions which divide the delta complexes into mappable units such as the Moose Channel, Reindeer and Beaufort Formations. Depositional environments within this succession, like those of the Neocomian delta complex, are recognizable on the basis of internal sedimentary structures and regional stratigraphic criteria. Biostratigraphic studies of these units are often severely constrained by only locally correlative assemblages which are commonly contaminated by derived and inverted components. These and other vicissitudes have plagued micropaleontologists since Reindeer D-27 was drilled in 1966. With this in mind we acknowledge that the relationships illustrated are somewhat tentative, particularly between the Reindeer, Ellice and Taglu boreholes.

[redacted]

The Late Cretaceous Maestrichtian paleogeography and lithofacies are shown on Figure 15. [redacted]

In latest Cretaceous time the Beaufort-Mackenzie Basin was the site of deposition of a molassoid, terrigenous clastic wedge that reached 6 to 10,000 feet in thickness in northern Yukon, and about 1,000 feet beneath Tuktoyaktuk Peninsula. The Moose Channel delta complex is characterized by intertonguing marine mudstones and fluvio-deltaic coarse clastics with coals in the axial portion of the basin. Correlative strata to the east include marine shales and mudstones.

The regressive arenaceous wedge advanced basinward consequent upon rapid deposition on a coastal plain lying adjacent to highlands to the west, rejuvenated by Laramide tectonic movements. The coarser clastics are texturally and mineralogically immature and paleocurrent dispersal trends suggest depocenters located beneath Yukon Coastal Plain and the distal end of the modern Mackenzie Delta.

[redacted]

Figure 16 [redacted] illustrates the Paleogene lithofacies and paleogeography.

Following a brief interval of marine transgression in northern Yukon which was preceded by local uplift and erosion along the Aklavik Arch Complex north of Inuvik, rapid regression and vigorous Laramide tectonism in source areas to the west and south allowed for the progradation of up to 5,000 feet of the Reindeer delta complex. Although several regressional and transgressional cycles occurred, the net result of this phase was the seaward progradation of the delta wedge beyond the limits of the earlier Moose Channel delta complex. Beneath north-central Tuktoyaktuk

Peninsula, local pre-Paleocene and later uplift resulted in the development of an additional lobe, the limits of which are unknown. In the Mackenzie Delta area this phase of delta development was terminated in the Late Eocene when widespread marine transgression advanced over the coastal plain.

[illegible]

[illegible]

Consequent upon an episode of regional uplift and erosion about the proximal rim of the basin, the last phase of delta wedge development occurred during Oligocene to Miocene time as shown on Figure 17 [illegible]. This Neogene wedge, represented in part by the Beaufort Formation is principally located beneath the distal end of the modern Mackenzie Delta and adjacent offshore. The latter stages of this phase are displayed as alluvial deposits on Anderson Plain from where distributary channels draining Horton Platform transported their loads towards the northwest.

[illegible]

[illegible]

The modern physiography of the Mackenzie Delta developed in latest Tertiary to Recent time when regional uplift of the craton caused the old Eocene Mackenzie River to incise its earlier deposits and deliver its suspended load to the Beaufort Sea via Mackenzie and Kugmallit Bays.

[illegible]

[illegible]

Figure 18 [illegible] shows the simplified geology of the region with its associated legend shown on Figure 19 [illegible]. The contours in the offshore area represent the free air anomaly field. The basic structural elements as expressed by surface relationships include:

1. The Northern Interior Platform, underlain by a homoclinal succession of Proterozoic, Paleozoic and Mesozoic clastics and carbonates;
2. The Aklavik Arch Complex, represented by the Campbell and Cache Creek Uplifts enclosing structurally and stratigraphically discordant rocks of Proterozoic and Paleozoic age;
3. The Rapid Fault Array and younger structures dislocating Mesozoic clastics in northern Richardson Mountains;
4. The British and Barn Mountains; the former underlain by Precambrian rocks of the Neroukpuk Formation and the latter containing rocks of Paleozoic age;
5. The Mackenzie Delta; and
6. The Continental Margin.

[illegible]

[illegible]

Figure 20
[illegible] shows a structure section extending from the southwest flank of the Romanzof Uplift to link up with Arcticquest seismic line 6 in the Beaufort Sea (Figure 18). The section is located on the west side of the Rapid Fault Array, the westernmost component of which is defined as the continuation of the Kaltag Fault for purposes of discussion. The folded and faulted Neroukpuk Formation is shown to be disconformably overlain by late Paleozoic rocks and intruded by Devonian or older granites. In northern Yukon the early Mesozoic epicontinental sequence rests unconformably upon the Neroukpuk which is believed to lie deeply buried beneath Beaufort Shelf. In the offshore portion of the profile structural discontinuities are suggested by discontinuous rotated reflectors beneath the sub-Late Cretaceous unconformity. These discontinuities suggest southward directed

thrust faults within the Lower Cretaceous and older succession that resulted from continental restructuring which began in Jurassic time and which accompanied right-lateral movements along the Kaltag - Rapid fault system during Neocomian and Aptian time. Similar southward directed thrust faults have been mapped on shore by ~~Don~~ D.K. Norris whose detailed structural studies of northern Yukon have encouraged this interpretation. Following uplift, compression and erosion which resulted in the development of the Aptian-Albian flyschoid ~~trough above~~ sequence within the depression created by the Rapid Fault Array, the Upper Cretaceous molassoid succession was deposited. It in turn suffered Laramide deformation concurrently with folding, rotation and possibly reactivation of the earlier Columbia thrusts. In response to Laramide uplift and erosion in western and southern source areas, the Late Cretaceous and Tertiary fluvio-deltaic successions prograded basinward towards the edge of the continental margin.

[redacted]

Figure 21 [redacted] is a restored pre-Late Aptian section across the Rapid Fault Array in northern Yukon. The line of profile is shown on the geological map (Figure 18). The section has its datum on the Late Aptian unconformity and shows that major vertical separation, in the order of 6,000 feet, occurred in Late Hauterivian and mid-Aptian time across the array. This faulting resulted in the northward plunging trough into which the turbidites of the Aptian-Albian flyschoid division were deposited. The numbers in brackets on this and following structure sections refer to the legend numbers on Figures 18 and 19.

[redacted]

Figure 22 [illegible] is an ERTS photograph of the region traversed by the Rapid Fault Array. The profile line of Figure 21 and 18 is shown for reference. The Kaltag Fault enters on the south side of the Old Crow granites, in the lower left hand corner. From there the fault turns north and splays into an array of vertical faults whose expression is seen as a series of north-trending mountain lineaments lying to the east of the southward curving structures of the British and Barn Mountains.

[illegible]

[illegible]

Figure 23 [illegible] is structure section X-X' along the profile shown on Figure 18. It extends from the Campbell Uplift across the Mackenzie Delta through the wells indicated and links up with Arcticquest Lines 4 and 5 in the offshore. In the Campbell Uplift, structurally and stratigraphically discordant Proterozoic and Phanerozoic rocks are partitioned by a series of vertical faults which have had several periods of movement in response to deformations within the Aklavik Arch Complex. Subsurface correlations in the pre-Mesozoic succession are largely based upon lithologic similarity to surface exposures in the region. Precise identifications and correlations within this older succession are fundamental to an understanding of the structural style and regional dynamics of the area as this is a region where facies changes within the Proterozoic and Paleozoic sequences may help to explain the locus of the Eskimo Lakes Fault Zone where it transects the Arch.

Seaward, across the Aklavik Arch Complex, the Mesozoic wedge thickens into Kugmallit Trough and thence across the Cache Creek Uplift into the Richards Island Basin. This thickening is accomplished by a number of syn-tectonic faults of the Eskimo Lakes Fault Zone which are shown schematically without reference to their precise position; and are drawn to show multiple movements through differences in stratigraphic separation on individual faults.

Within the Richards Island Basin the Lower Cretaceous Aptian-Albian flyschoid division is conceptually shown to be broken by a number of faults of the offshore extension of the Rapid Fault Array. Within the structural depression created by the array, Late Cretaceous molassoid and Tertiary fluvio-deltaic successions are more than 20,000 feet thick and are shown to be intruded by pro-deltaic shale diapirs of lutokinetic origin. Stratigraphic and structural relationships shown in the Richards Island Basin are conceptual only and for description of this area we have relied upon written and oral presentations by Monti Lerand, Keith Sirrine, Imperial Oil geologists, and analogy with other areas. Not shown, but of substantial importance to petroleum exploration are sedimentary growth faults which developed at the distal ends of the prograding deltaic sands.

The Kaltag Fault is shown to have normal separation, however as has been suggested, right lateral movements also occurred. The time multiplicity of movement is not shown. In the offshore the presence of the fault is suggested by the basinal thickening of what we interpret to be the Tertiary sequence above and across the fault in Arcticquest line 4 although the dotted line indicates the lowest level of interpreted record.

On the northwest side of the Kaltag Fault the Late Cretaceous and Tertiary succession is thinner and is shown to be intruded by tectono-kinetic diapirs that have resulted from a horizontally applied maximum compressive stress upon Lower Cretaceous and older shale masses. This stress field is believed to be that which folded the Late Cretaceous molassoid section and underlying sub-Late Cretaceous unconformity and thrusts, and which is related to the right-lateral motion of the Kaltag - Rapid Fault System. As such, the stress field originated externally to the strained offshore succession as opposed to the lutokinetic diapir field of the Richards Island Basin where the illustrated strain is intrinsic to the nature of progradational delta wedge development.

[redacted]

Figure 24 [redacted] is a structure section extending from the Coppermine Arch to the southeast of the map area (Figure 18), across the Horton Platform to the Elf Horton River G-02 well and thence to link up with Arcticquest line 8 in the Beaufort Sea. The section shows lower and middle Paleozoic clastics and carbonates and Mesozoic clastics extending northwestwards in an essentially platform to homoclinal succession from the flank of the Coppermine Arch to the extrapolated and schematically represented Harrowby Bay High, a part of the Aklavik Arch Complex. Across the high, the succession is broken by numerous faults which have undergone multiple movements and which have thickened the Lower Cretaceous succession as a result of syn-tectonic movements. A characteristic feature of these faults is that in a seaward direction the faults reach progressively higher into the section, and as they were active during deposition the footwall blocks probably acted as local sources of sediment to the adjacent hanging walls. In the seaward-most part of the profile considerable uplift, erosion and downfaulting occurred accounting for the seaward truncation of the Upper Cretaceous rocks beneath Lower Tertiary sediments. The cause is probably related to block fault movements on the flanks of the Cape Dalhousie High, another component of the Aklavik Arch Complex as defined by the 10 milgal anomaly north of the Tuktoyaktuk Peninsula (Figure 18).

[redacted]

The petroleum potential of the Beaufort-Mackenzie Basin is here considered with respect to structural provinces or sub-provinces as shown on Figure 25 [redacted]. Figure 26 [redacted] summarizes the geology of these regions as it applies to some generalized concepts of petroleum occurrence and is coded in terms of the future prospects for additional hydrocarbon discoveries; the code ranging from A for excellent [redacted] to E for nil. The relative potentials are with reference to the status of the geoscience base that is available to the geoscientific community as a whole and does not reflect information not so available. The base is classified at the top of Figure 26 for each column, ranging from good, through fair to poor.

In area 6, which is the Anderson Plain, petroleum prospects in the Mesozoic succession are confined to small subsurface traps related to fault closures or permeability barriers owing to the breached nature of the sequence over much of the region. Within the lower and middle Paleozoic however, good combination traps may occur on the flank of the Anderson Plain syncline, particularly in Franklin Bay where geomorphic traps beneath unconformities may cause accumulations within porous Hume, Bear Rock, Mount Kindle and Franklin Mountain carbonates.

In area 5, the region landward of the continental margin, thick Cretaceous and Tertiary clastics resulting from erosion of the uplifted margin subsequent to sea floor spreading away from an oceanic accretion ridge, may interfinger with sediments of similar age and lithology derived from the craton. If present, these sediments may be involved in numerous trapping configurations, and thus enhance the overall offshore potential.

In northern Yukon, area 1, structural deformation and widespread breaching of potential source and reservoir rocks reduces the future potential of the area. Jurassic and Cretaceous epicontinental clastics may provide reservoirs on the flanks of the Cache Creek Uplift if permeability barriers of one type or another are present.

Beneath the Tuktoyaktuk Peninsula (area 2), hydrocarbon discoveries in epicontinental clastics have been found in association with roll-over anticlines above faults of the Eskimo Lakes Fault Zone. The prospects for future discoveries of this type are good.

Within the lutokinetic diapir field of the Richards Island Basin, area 3, the hydrocarbon potential associated with high pressure shales, growth and antithetic faults and facies fronts is well established. Because of the substantial terrigenous organic contribution to this area, the basin is expected to be gas prone. Lower Cretaceous and older horizons in this area are expected to be too deep to be considered as viable major contributors to the overall potential of the Richards Island Basin.

The tectono-kinetic diapir field (area 4) is considered to have equally good prospects as the Richards Island Basin. If anticlines, faults and diapirs in this area are indeed related to wrench tectonics associated with the Kaltag-Rapid

Fault System, then such structures, being dynamically congruent, may have enormous potential. Wilcox and others have recently alluded to the great potential of en échelon folds associated with large scale wrench faults such as the Barisan Mountains Fault of Sumatra, the El Pilar Fault of Venezuela and Trinidad and the San Andreas - San Gabriel Faults of California. Within this same region Prudhoe Bay productive equivalents might occur in structural culminations west of the pre-Jurassic overstep of the Shublik carbonates and Upper Paleozoic rocks.

[redacted]

[redacted]

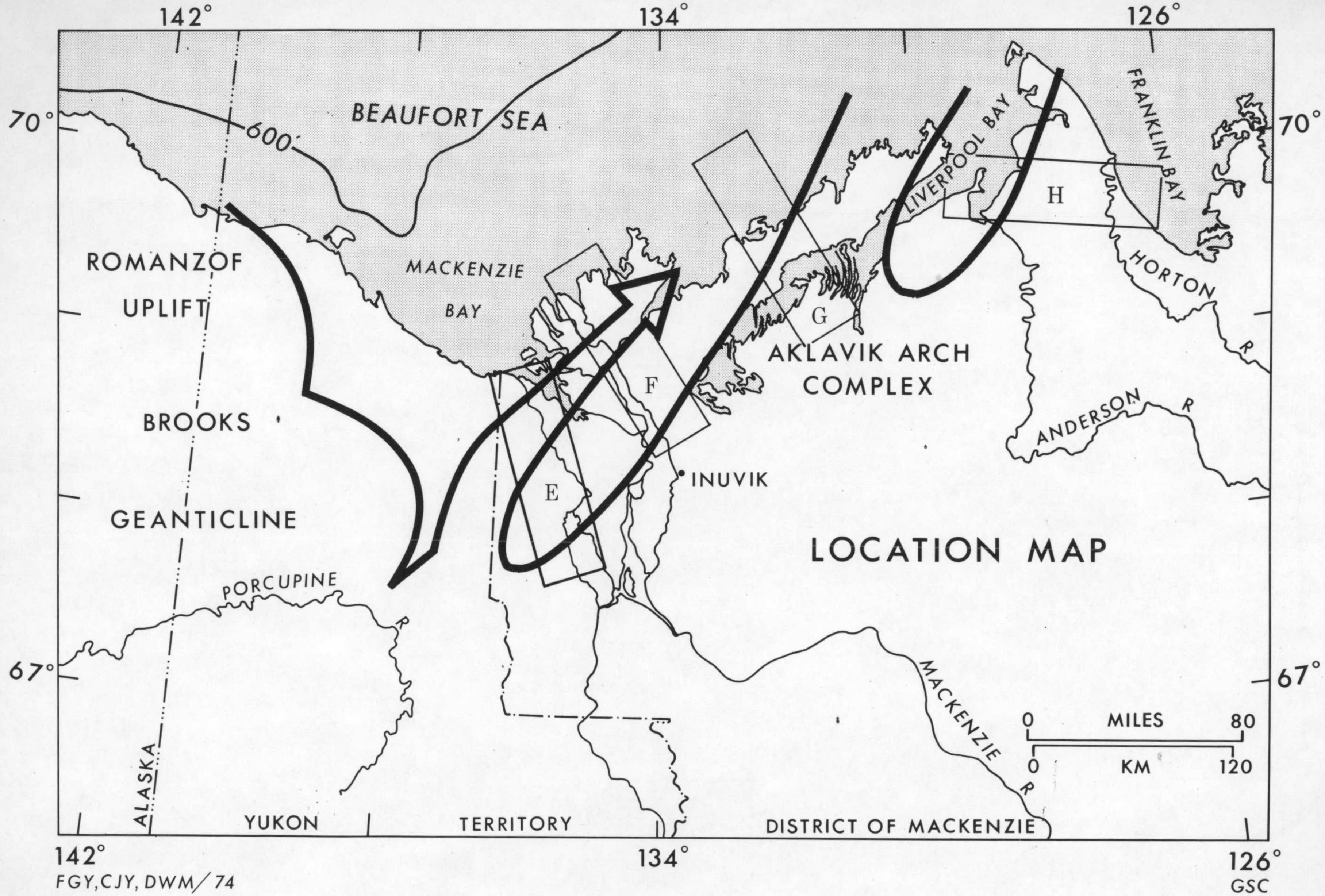
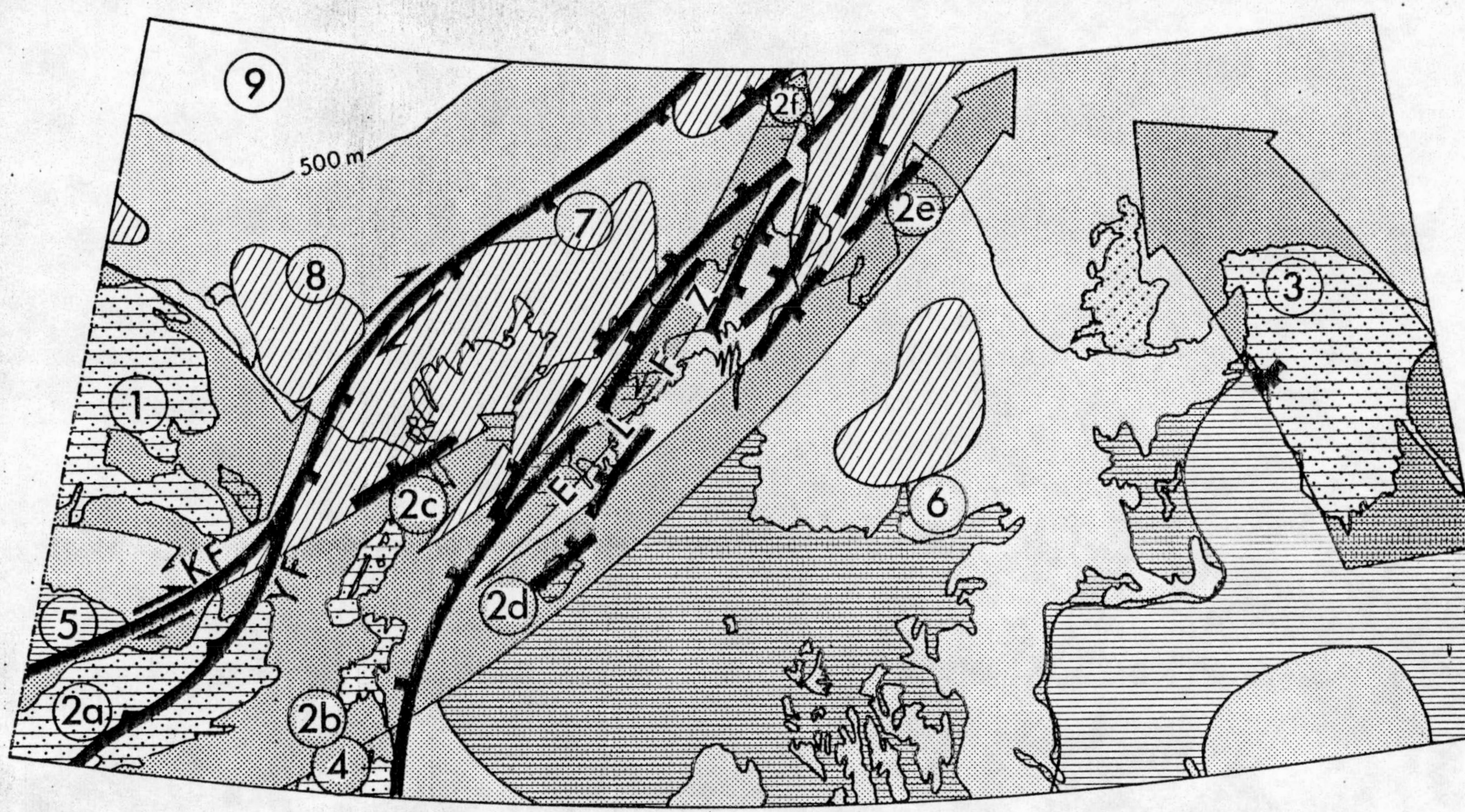


FIGURE 1. LOCATION MAP AND AREAL DESIGNATION FOR STRATIGRAPHIC COLUMNS OF FIGURE 4



TECTONIC ELEMENTS

CJY, FGY, DWM '74

FIGURE 2. TECTONIC ELEMENTS FOR EXPLANATION SEE FIGURE 3.

LEGEND

AREAS OF PRE-MESOZOIC EXPOSURE

- A — NO TECTONIC GRAIN OBSERVED
- B — TECTONIC GRAIN INDICATED

ARCHES

- C — RELATIVELY HIGH STRUCTURAL RELIEF
- D — RELATIVELY LOW STRUCTURAL RELIEF GENERALLY COVERED BY THIN MESOZOIC & CENOZOIC CLASTICS

MESOZOIC & CENOZOIC BASINS

- E — RELATIVELY THICK CLASTICS
- F — RELATIVELY THIN CLASTICS

1. ROMANZOF UPLIFT
2. AKLAVIK ARCH COMPLEX
   - a- DAVE LORD ARCH
   - b- RAT UPLIFT
   - c- CACHE CREEK UPLIFT
   - d- CAMPBELL UPLIFT
   - e- "HARROWBY BAY HIGH"
   - f- "CAPE DALHOUSIE HIGH"
3. COPPERMINE ARCH
4. RICHARDSON ANTICLINORIUM
5. OLD CROW STOCK
6. HORTON PLATFORM
7. "RICHARDS ISLAND BASIN"
8. "HERSCHEL ISLAND BASIN"
9. CANADA BASIN

KF - KALTAG FAULT

YF - YUKON FAULT

ELFZ - ESKIMO LAKES FAULT ZONE

FIGURE 3. LEGEND FOR FIGURE 2.

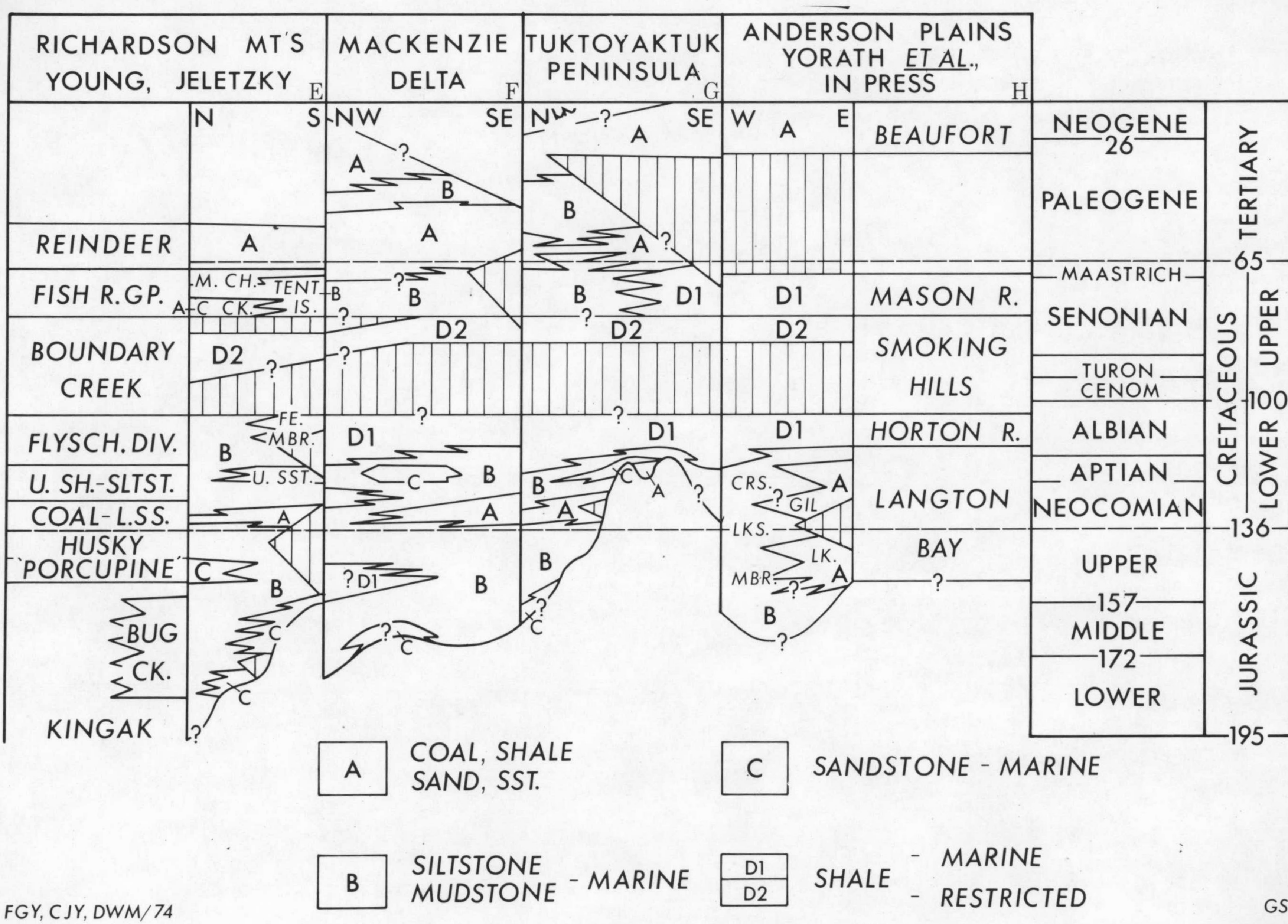
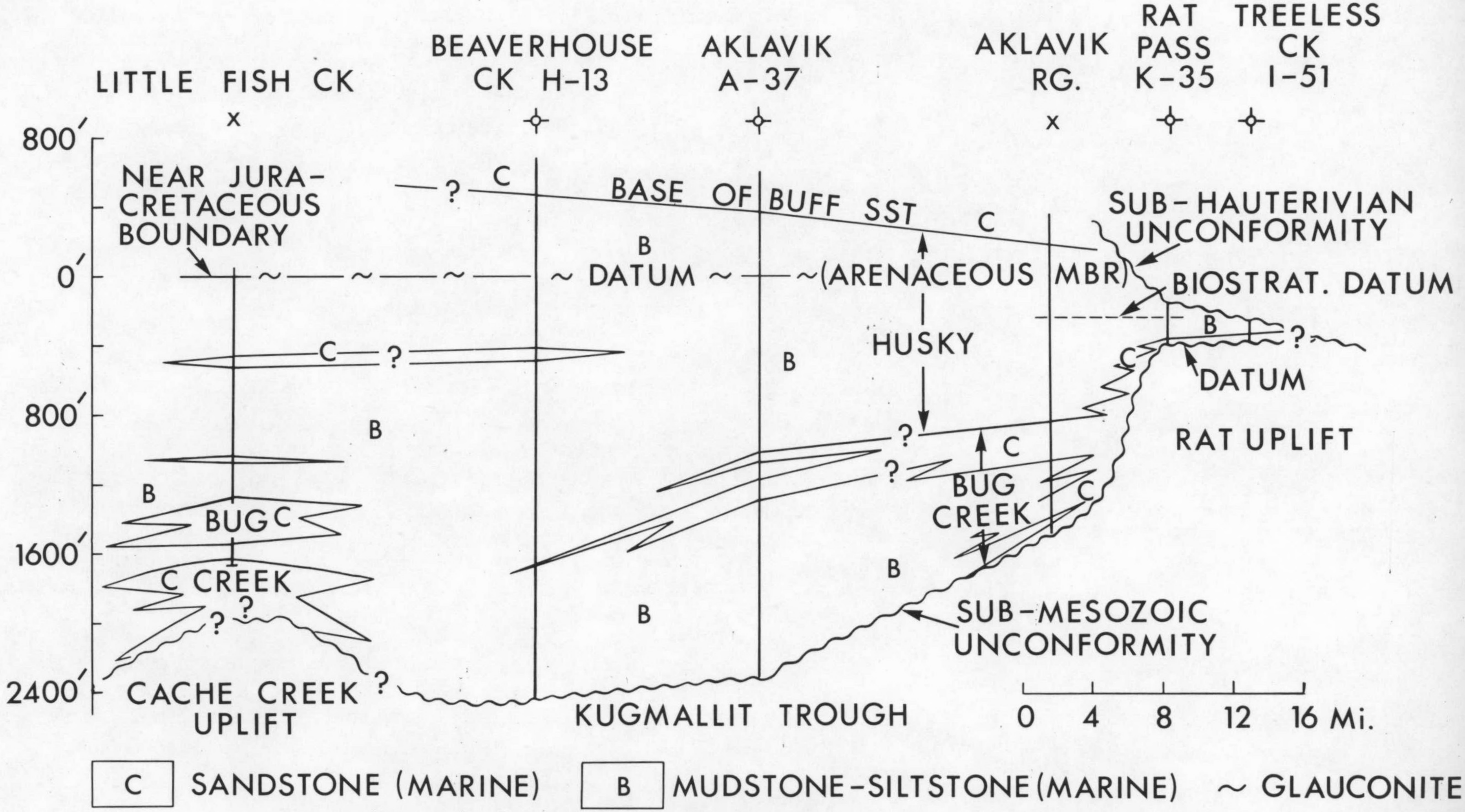


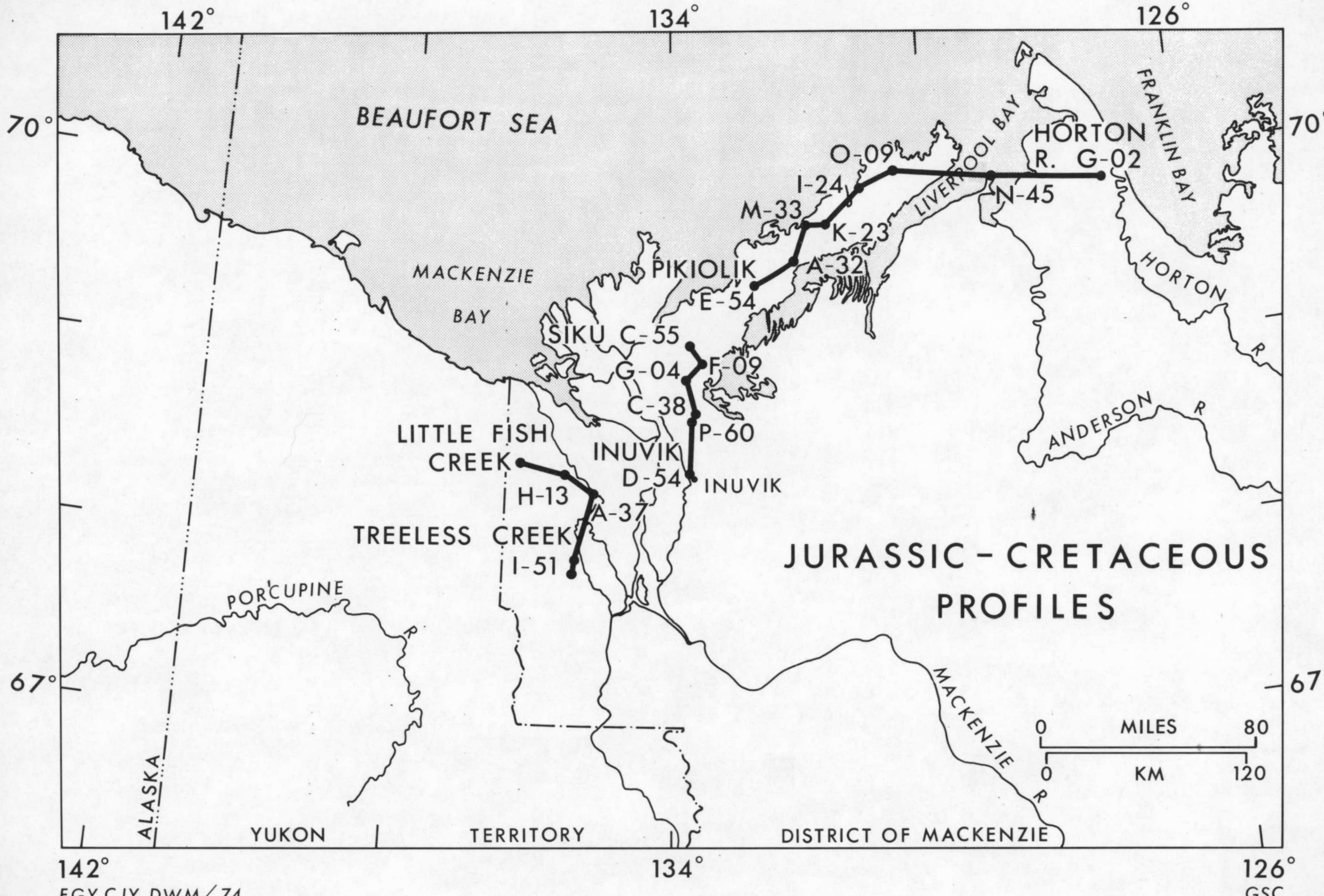
FIGURE 4. GENERALIZED STRATIGRAPHY FOR AREAL COLUMN LOCATION REFER TO FIGURE 1.



RESTORED JURA-CRETACEOUS PROFILE WEST FLANK MACKENZIE DELTA

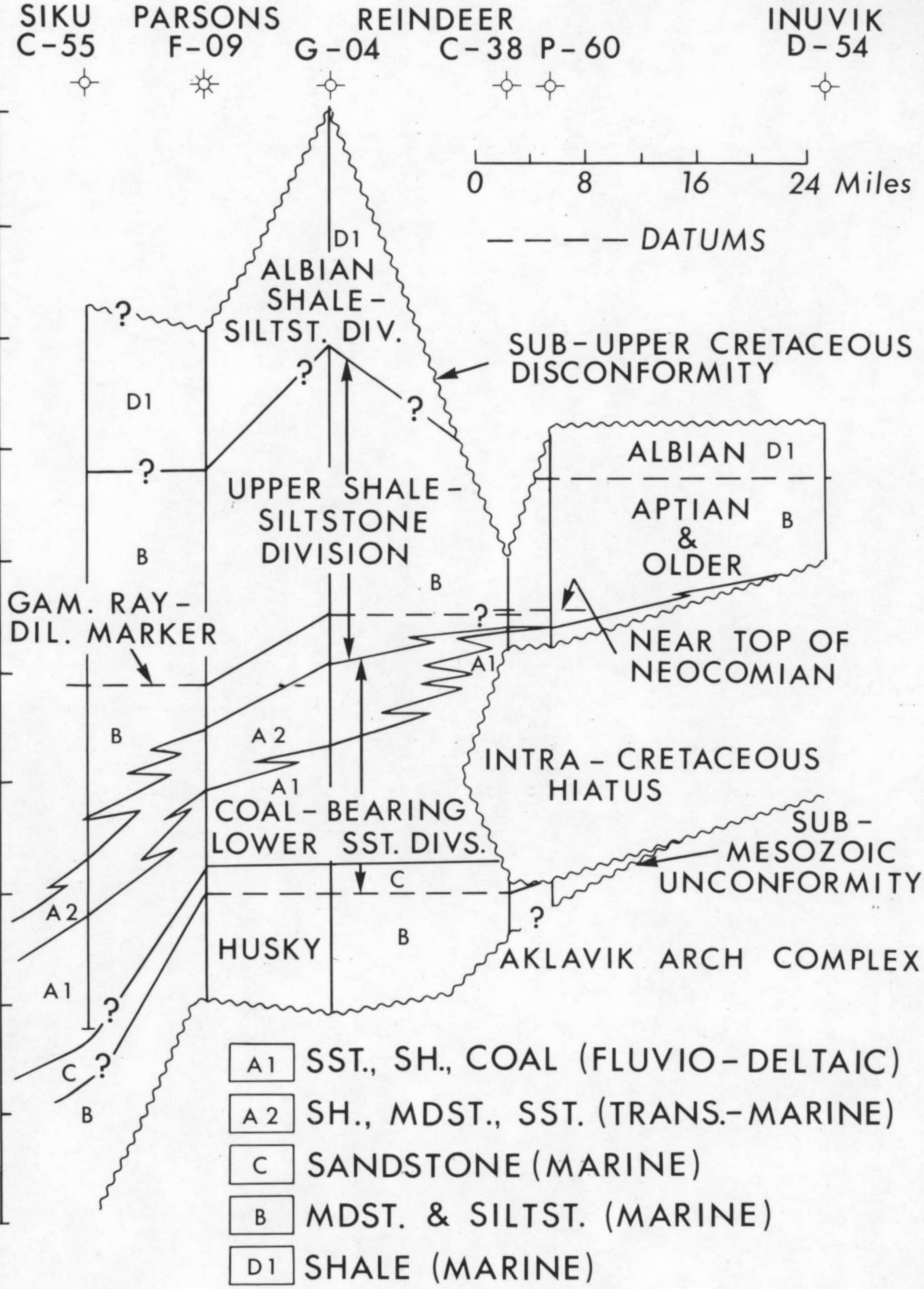
CJY, FGY, DWM '74

FIGURE 5.



142°
134°
126°
70°
67°
BEAUFORT SEA
MACKENZIE
BAY
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R. G-02
N-45
O-09
I-24
M-33
K-23
PIKIOLIK
A-32
E-54
SIKU C-55
F-09
G-04
C-38
P-60
LITTLE FISH
CREEK
INUVIK
D-54
INUVIK
H-13
A-37
TREELESS CREEK
I-51
HORTON
R
ANDERSON
R
PORCUPINE
R
MACKENZIE
R
JURASSIC – CRETACEOUS
PROFILES
0 MILES 80
0 KM 120
ALASKA
YUKON
TERRITORY
DISTRICT OF MACKENZIE
FGY, CJY, DWM/74
GSC

FIGURE 6.



JURA-CRETACEOUS PROFILE
CJY, DWM SOUTH TUKTOYAKTUK PENINSULA '74

FIGURE 7.

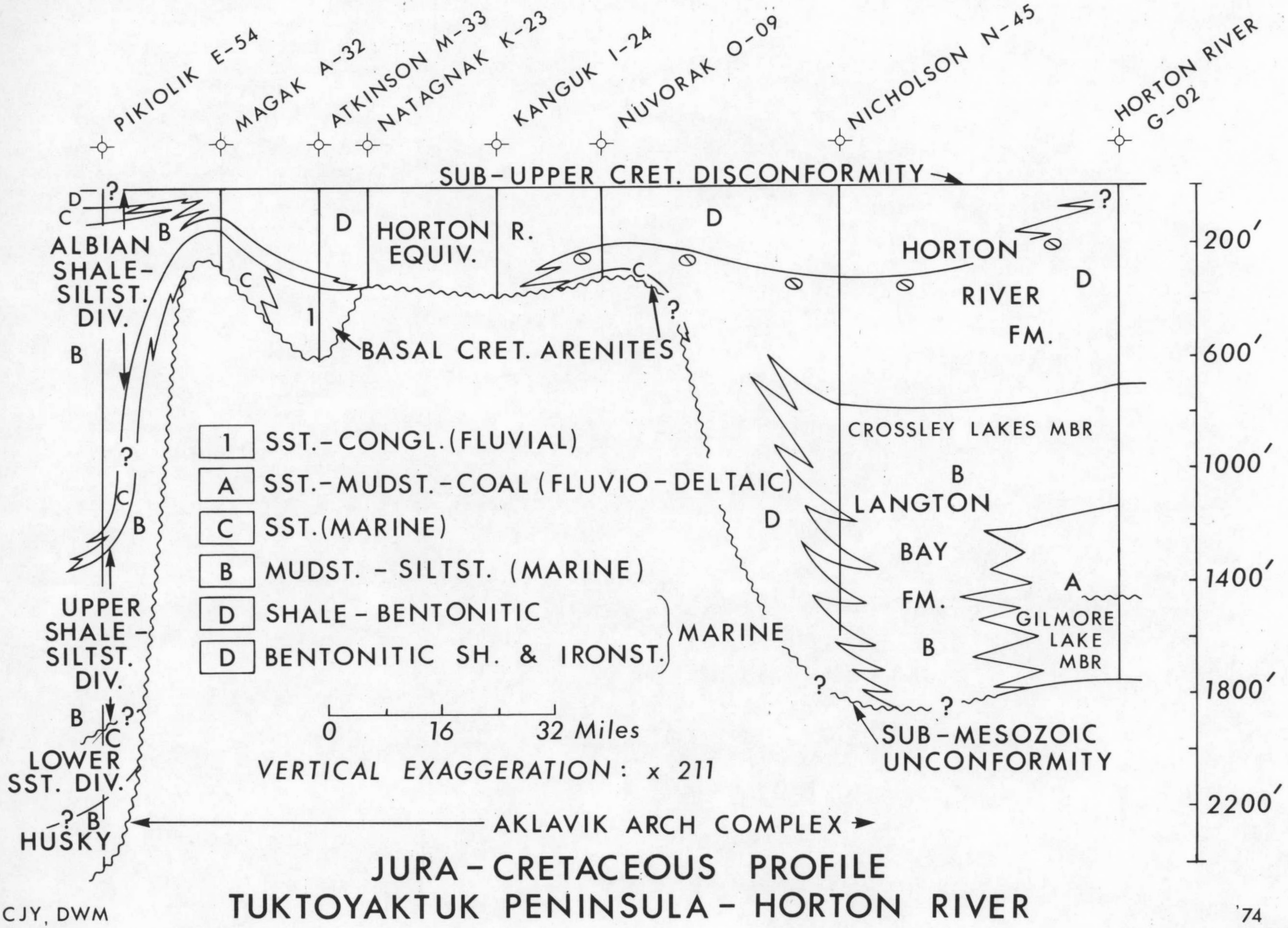
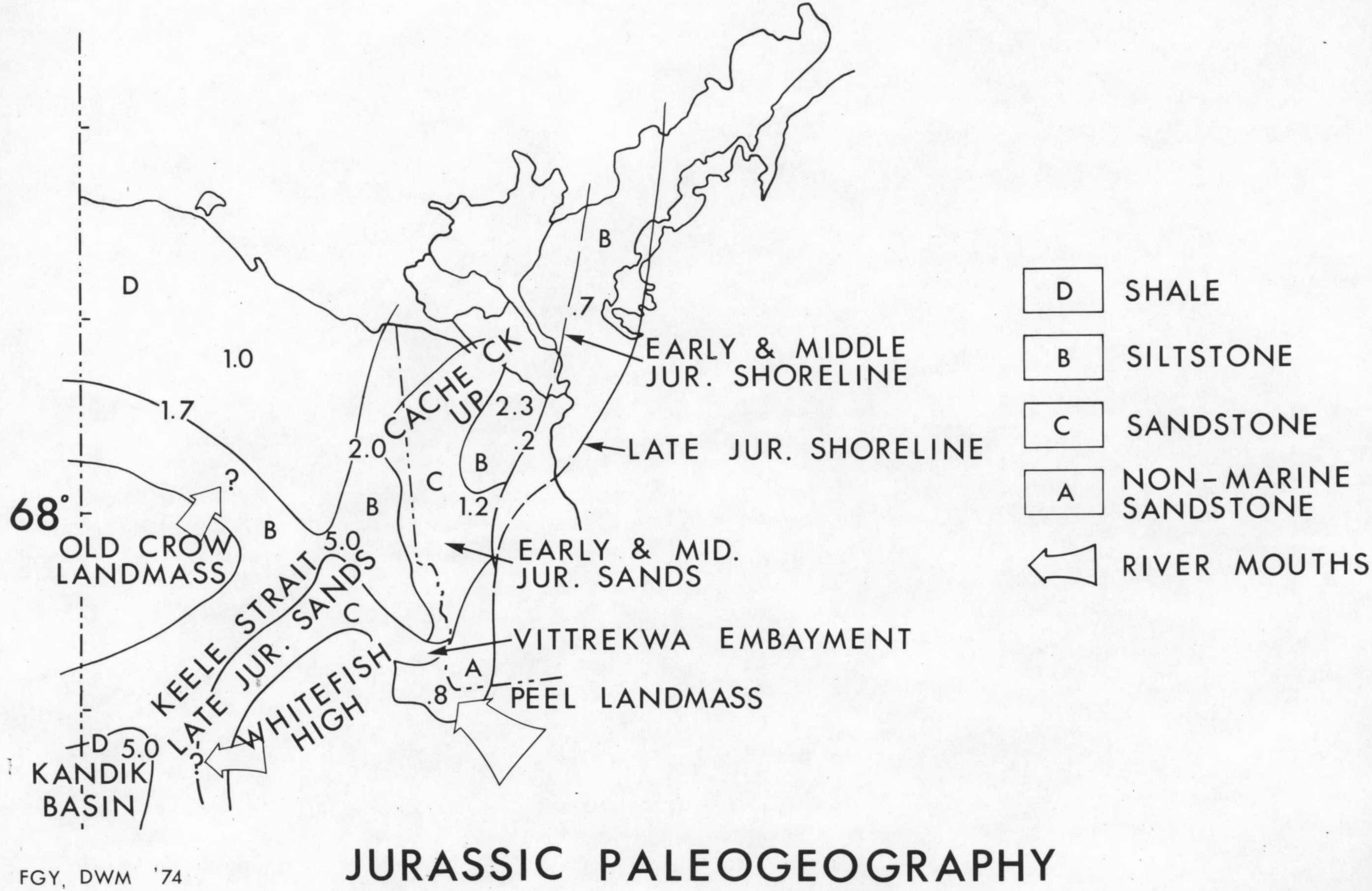

PIKIOLIK E-54
MAGAK A-32
ATKINSON M-33
NATAGNAK K-23
KANGUK I-24
NUVORAK O-09
NICHOLSON N-45
HORTON RIVER G-02
SUB-UPPER CRET. DISCONFORMITY
HORTON EQUIV.
HORTON R.
HORTON RIVER FM.
ALBIAN SHALE-SILTST. DIV.
BASAL CRET. ARENITES
CROSSLEY LAKES MBR
LANGTON BAY FM.
GILMORE LAKE MBR
UPPER SHALE-SILTST. DIV.
LOWER SST. DIV.
HUSKY
1 SST.-CONGL.(FLUVIAL)
A SST.-MUDST.-COAL (FLUVIO-DELTAIC)
C SST.(MARINE)
B MUDST. - SILTST. (MARINE)
D SHALE - BENTONITIC
D BENTONITIC SH. & IRONST.
MARINE
0 16 32 Miles
VERTICAL EXAGGERATION : x 211
SUB-MESOZOIC UNCONFORMITY
AKLAVIK ARCH COMPLEX
200′
600′
1000′
1400′
1800′
2200′
JURA-CRETACEOUS PROFILE
TUKTOYAKTUK PENINSULA - HORTON RIVER
CJY, DWM
'74

FIGURE 8.



JURASSIC PALEOGEOGRAPHY

FIGURE 9.

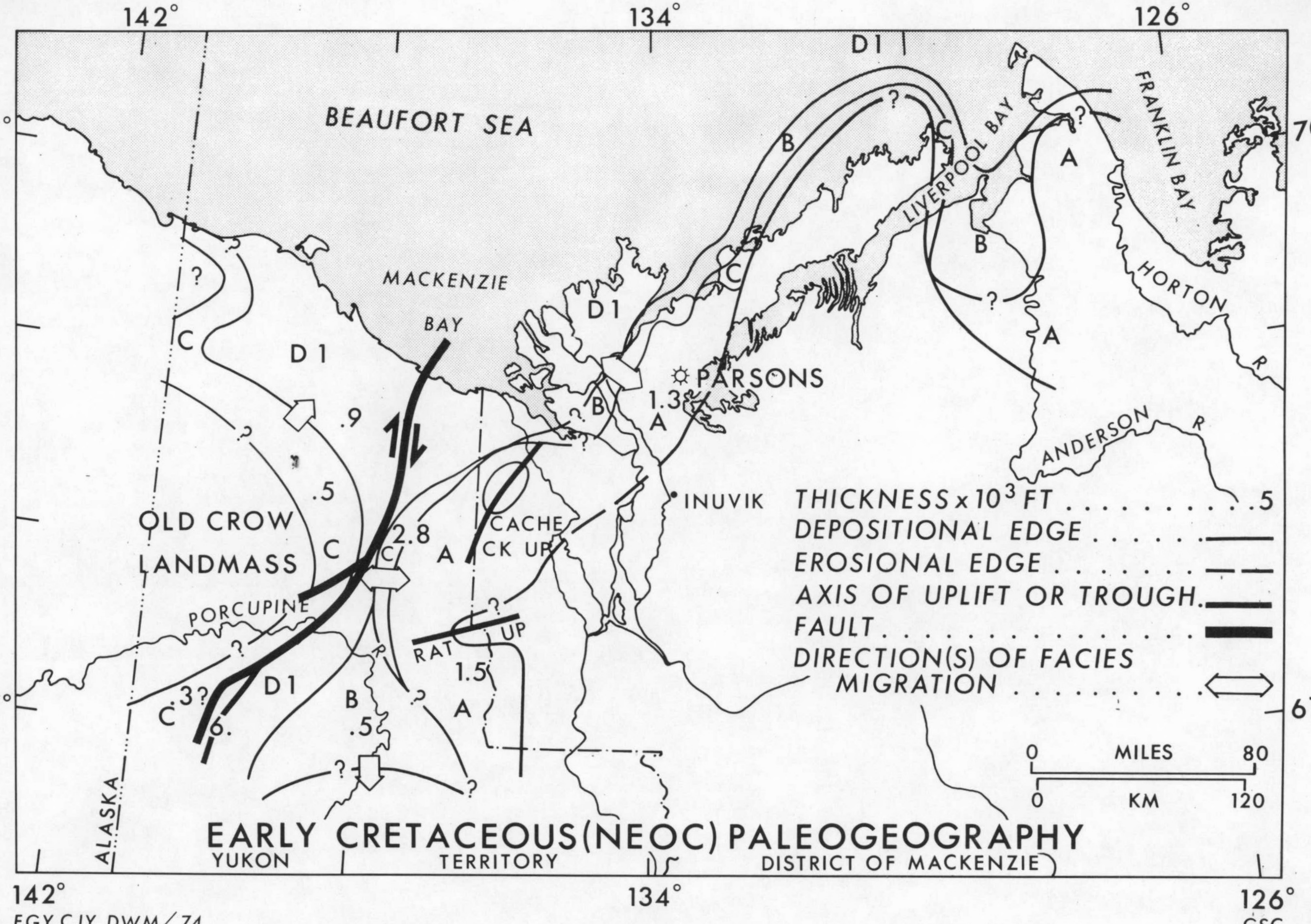

142°
134°
126°
70°
67°
BEAUFORT SEA
MACKENZIE
BAY
D1
B
C
A
?
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R
PARSONS
1.3
ANDERSON
R
INUVIK
.9
.5
OLD CROW
LANDMASS
2.8
CACHE
CK UP
PORCUPINE
RAT
UP
1.5
3?
6.
.5
ALASKA
THICKNESS x 10^3 FT 5
DEPOSITIONAL EDGE ......
EROSIONAL EDGE ....
AXIS OF UPLIFT OR TROUGH.
FAULT ....
DIRECTION(S) OF FACIES
MIGRATION ....
0 MILES 80
0 KM 120
EARLY CRETACEOUS(NEOC) PALEOGEOGRAPHY
YUKON
TERRITORY
DISTRICT OF MACKENZIE
FGY,CJY, DWM/ 74
GSC

FIGURE 10.

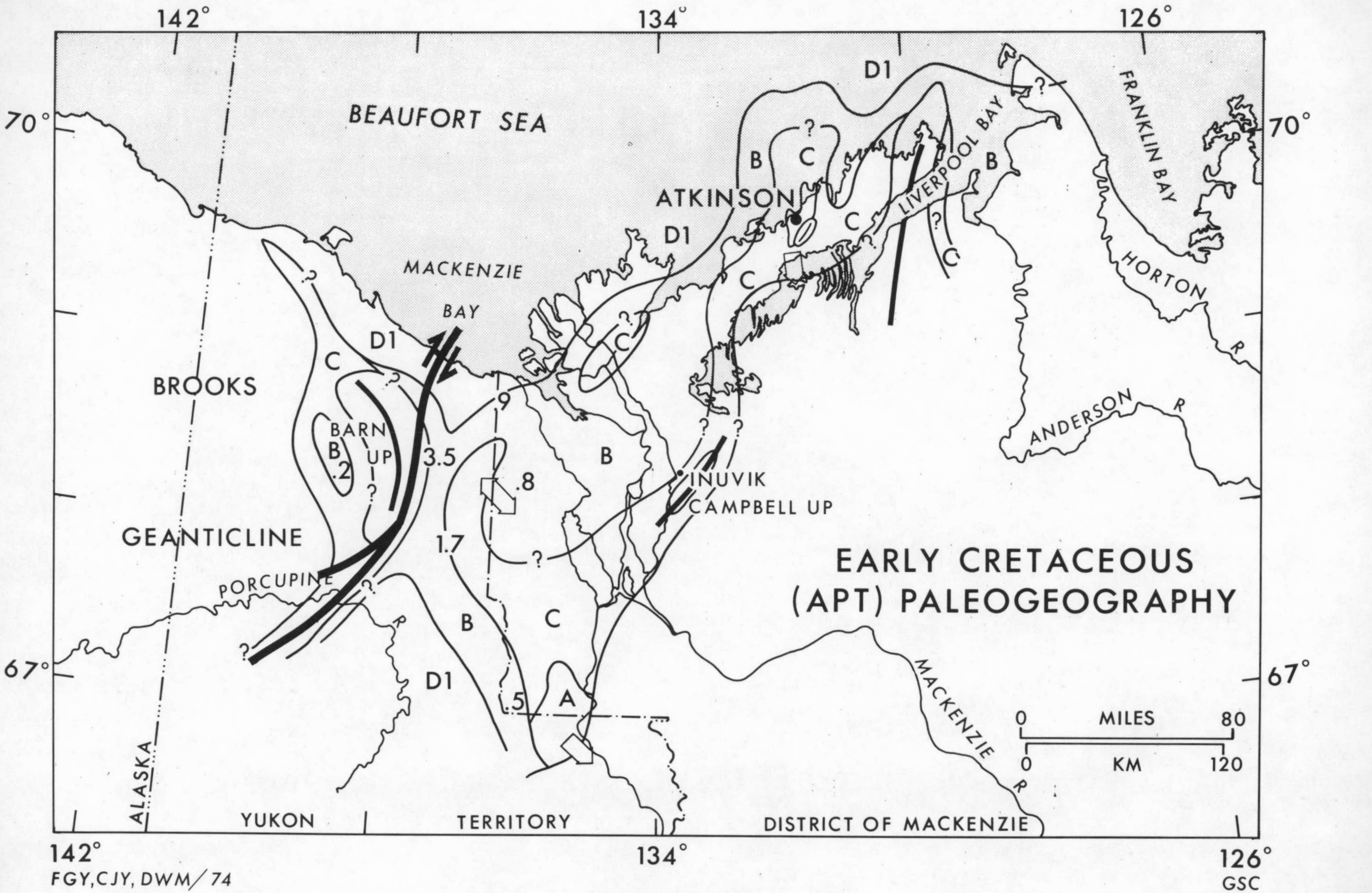

142°
134°
126°
70°
67°
BEAUFORT SEA
ATKINSON
D1
B
C
?
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R
MACKENZIE
BAY
BROOKS
GEANTICLINE
BARN
UP
3.5
.2
9
.8
1.7
INUVIK
CAMPBELL UP
ANDERSON
PORCUPINE
R
A
.5
EARLY CRETACEOUS
(APT) PALEOGEOGRAPHY
MILES
0
80
KM
0
120
MACKENZIE
ALASKA
YUKON
TERRITORY
DISTRICT OF MACKENZIE
FGY, CJY, DWM/74
GSC

FIGURE 11.

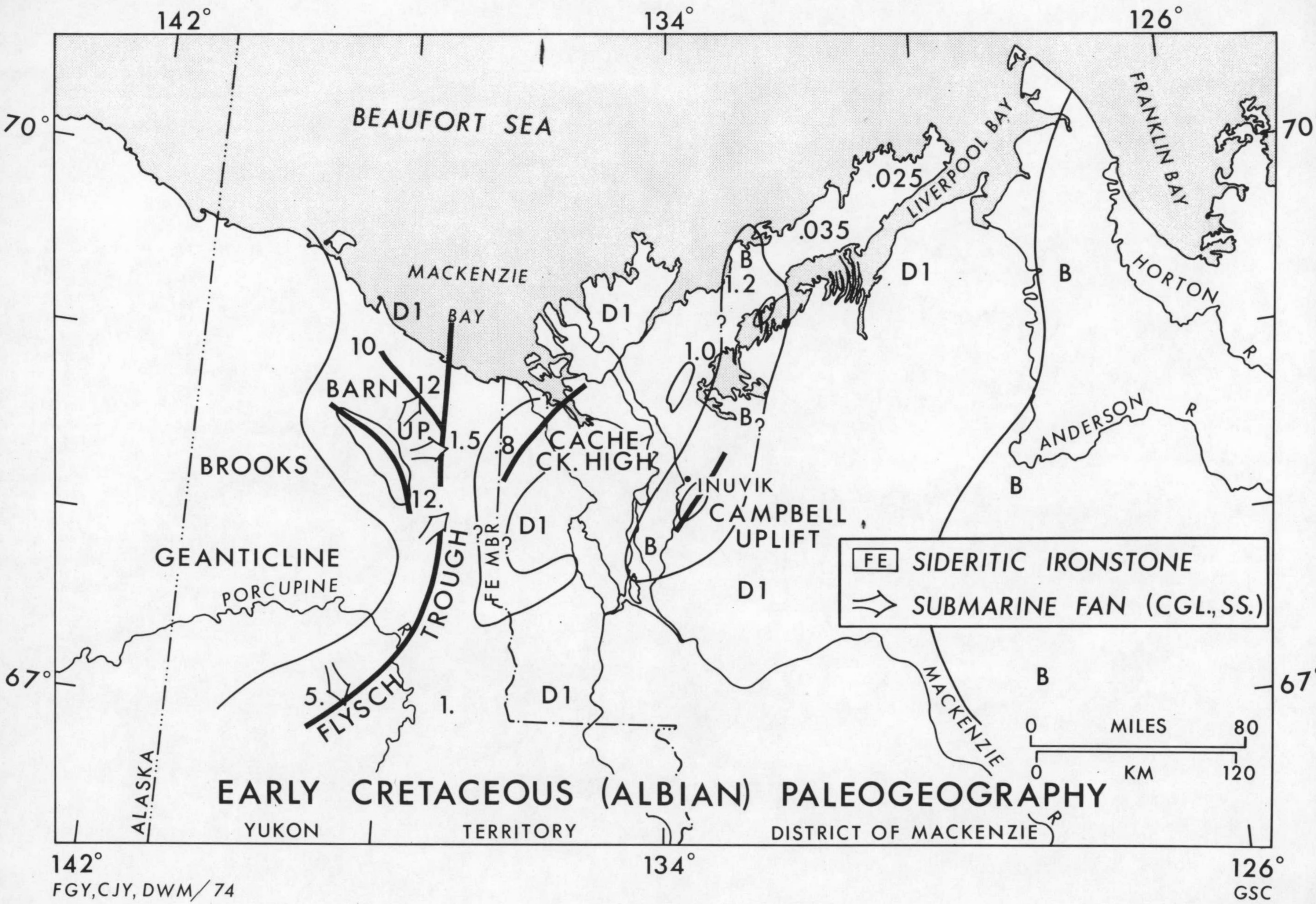
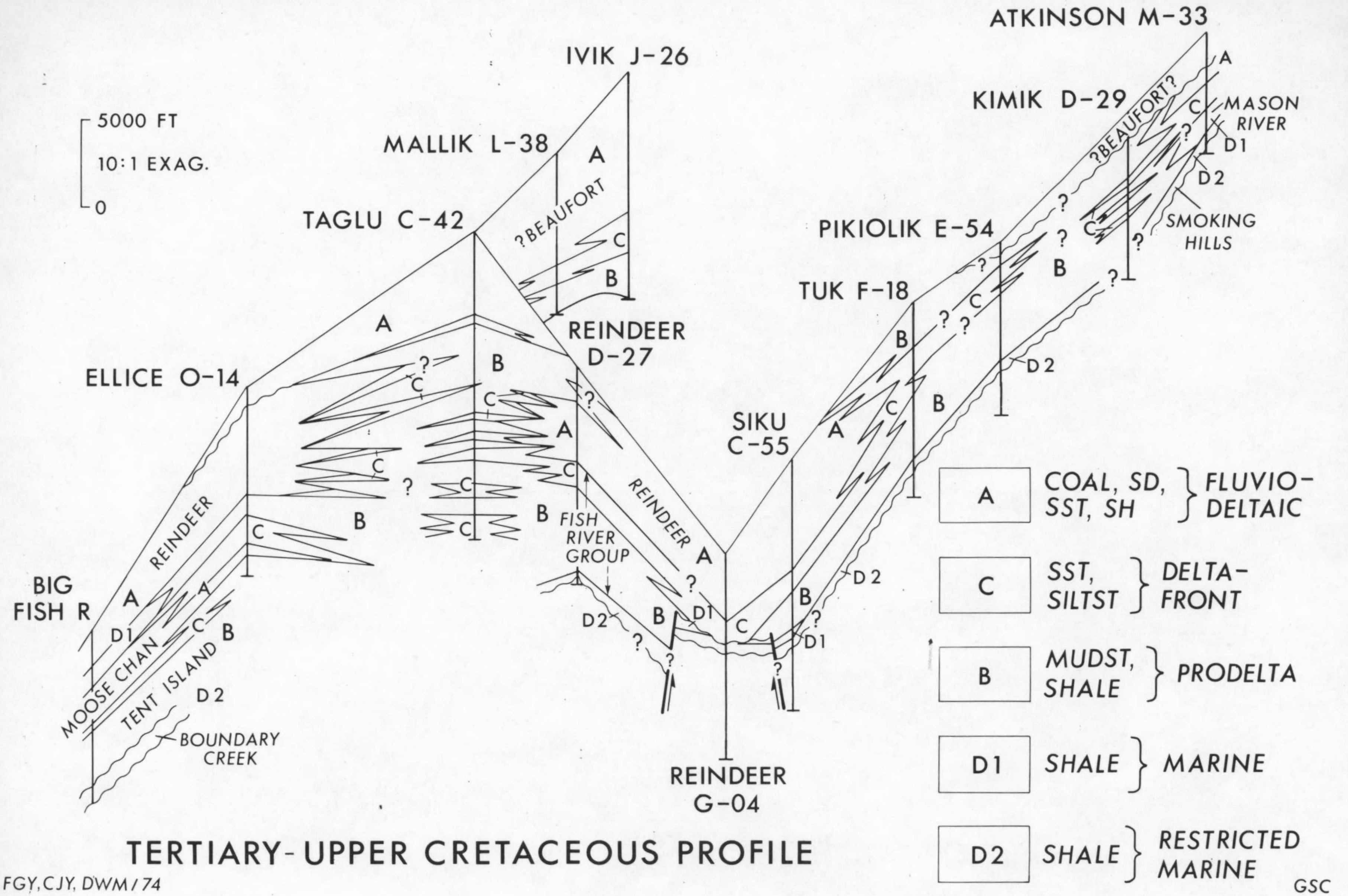

142°
134°
126°
70°
67°
BEAUFORT SEA
MACKENZIE
BAY
D1
10
12
BARN
UP
1.5
12.
BROOKS
GEANTICLINE
PORCUPINE
R
TROUGH
FLYSCH
5.
1.
FE MBR
.8
CACHE
CK. HIGH
D1
D1
.025
.035
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R
B
1.2
1.0
B
INUVIK
CAMPBELL
UPLIFT
B
D1
ANDERSON
R
B
B
MACKENZIE
R
FE SIDERITIC IRONSTONE
SUBMARINE FAN (CGL., SS.)
0 MILES 80
0 KM 120
ALASKA
EARLY CRETACEOUS (ALBIAN) PALEOGEOGRAPHY
YUKON
TERRITORY
DISTRICT OF MACKENZIE
FGY, CJY, DWM/74
GSC

FIGURE 12.



ATKINSON M-33
IVIK J-26
KIMIK D-29
MALLIK L-38
TAGLU C-42
PIKIOLIK E-54
TUK F-18
REINDEER D-27
ELLICE O-14
SIKU C-55
BIG FISH R
REINDEER G-04
5000 FT
10:1 EXAG.
0
?BEAUFORT
?BEAUFORT?
MASON RIVER
SMOKING HILLS
REINDEER
FISH RIVER GROUP
MOOSE CHAN
TENT ISLAND
BOUNDARY CREEK
A
B
C
D1
D2
A | COAL, SD, SST, SH | FLUVIO-DELTAIC
C | SST, SILTST | DELTA-FRONT
B | MUDST, SHALE | PRODELTA
D1 | SHALE | MARINE
D2 | SHALE | RESTRICTED MARINE
TERTIARY-UPPER CRETACEOUS PROFILE
FGY, CJY, DWM / 74
GSC

FIGURE 13.

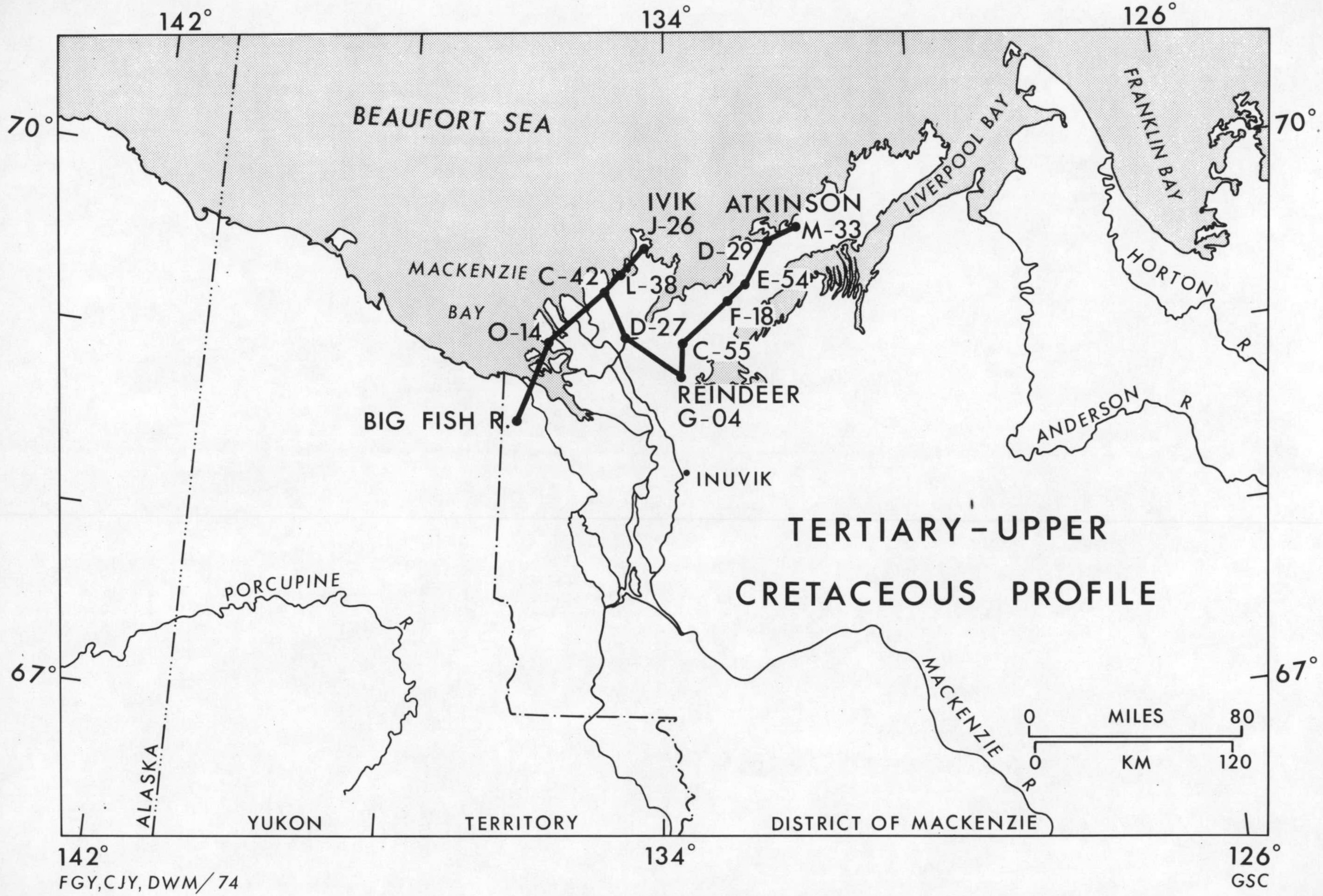

142°
134°
126°
70°
67°
BEAUFORT SEA
MACKENZIE
BAY
IVIK
J-26
ATKINSON
M-33
D-29
E-54
F-18
C-42
L-38
O-14
D-27
C-55
REINDEER
G-04
BIG FISH R.
INUVIK
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R
ANDERSON
R
PORCUPINE
R
MACKENZIE
R
ALASKA
YUKON
TERRITORY
DISTRICT OF MACKENZIE
TERTIARY - UPPER
CRETACEOUS PROFILE
0
MILES
80
0
KM
120
FGY, CJY, DWM/ 74
GSC

FIGURE 14.

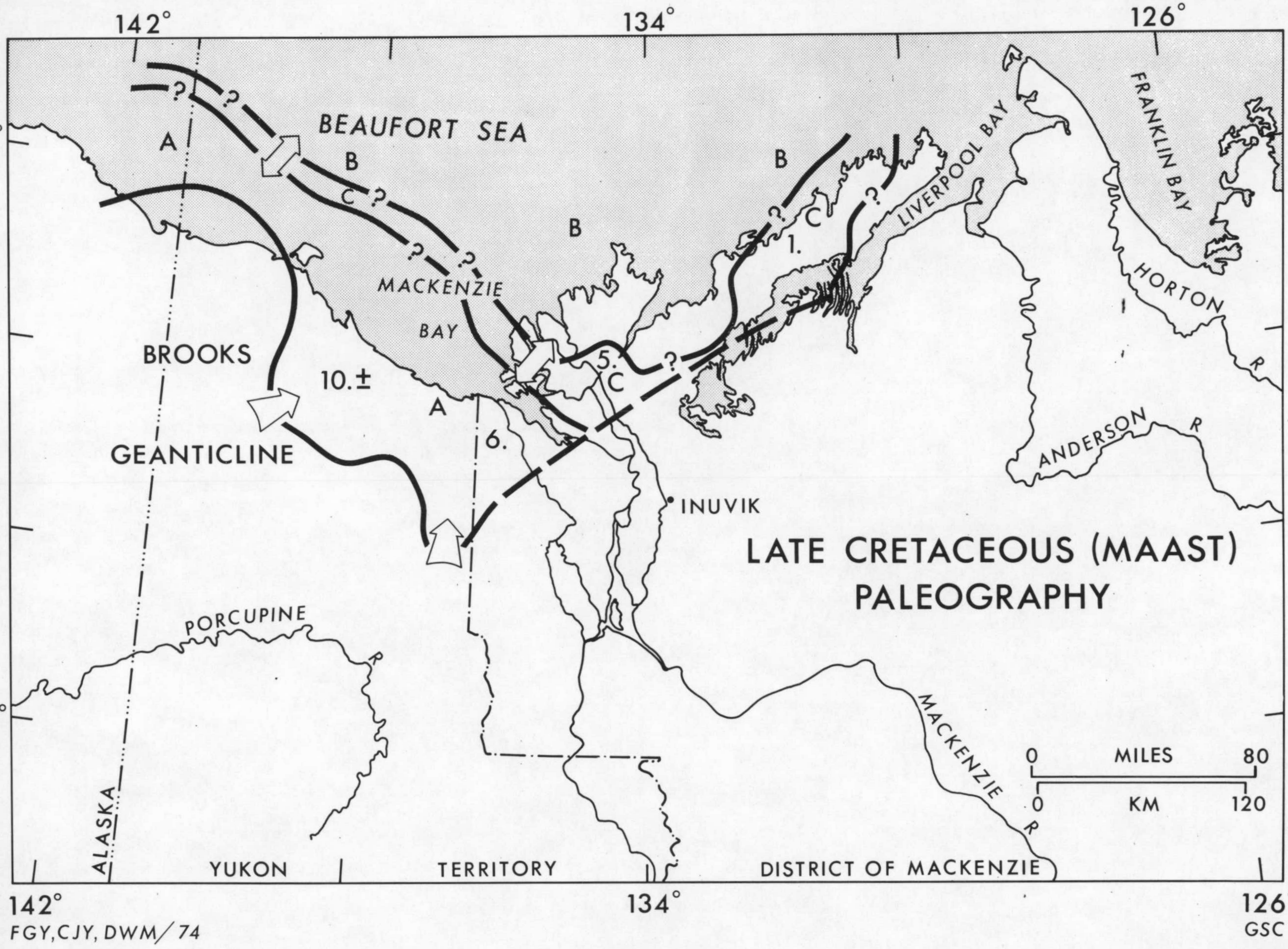

142°
134°
126°
70°
70°
67°
67°
BEAUFORT SEA
A
B
C
B
B
1.
C
LIVERPOOL BAY
FRANKLIN BAY
HORTON R
MACKENZIE
BAY
BROOKS
10.±
GEANTICLINE
A
6.
5.
C
ANDERSON R
INUVIK
LATE CRETACEOUS (MAAST)
PALEOGRAPHY
PORCUPINE R
MACKENZIE R
0 MILES 80
0 KM 120
ALASKA
YUKON
TERRITORY
DISTRICT OF MACKENZIE
142°
134°
126°
FGY, CJY, DWM/ 74
GSC

FIGURE 15.

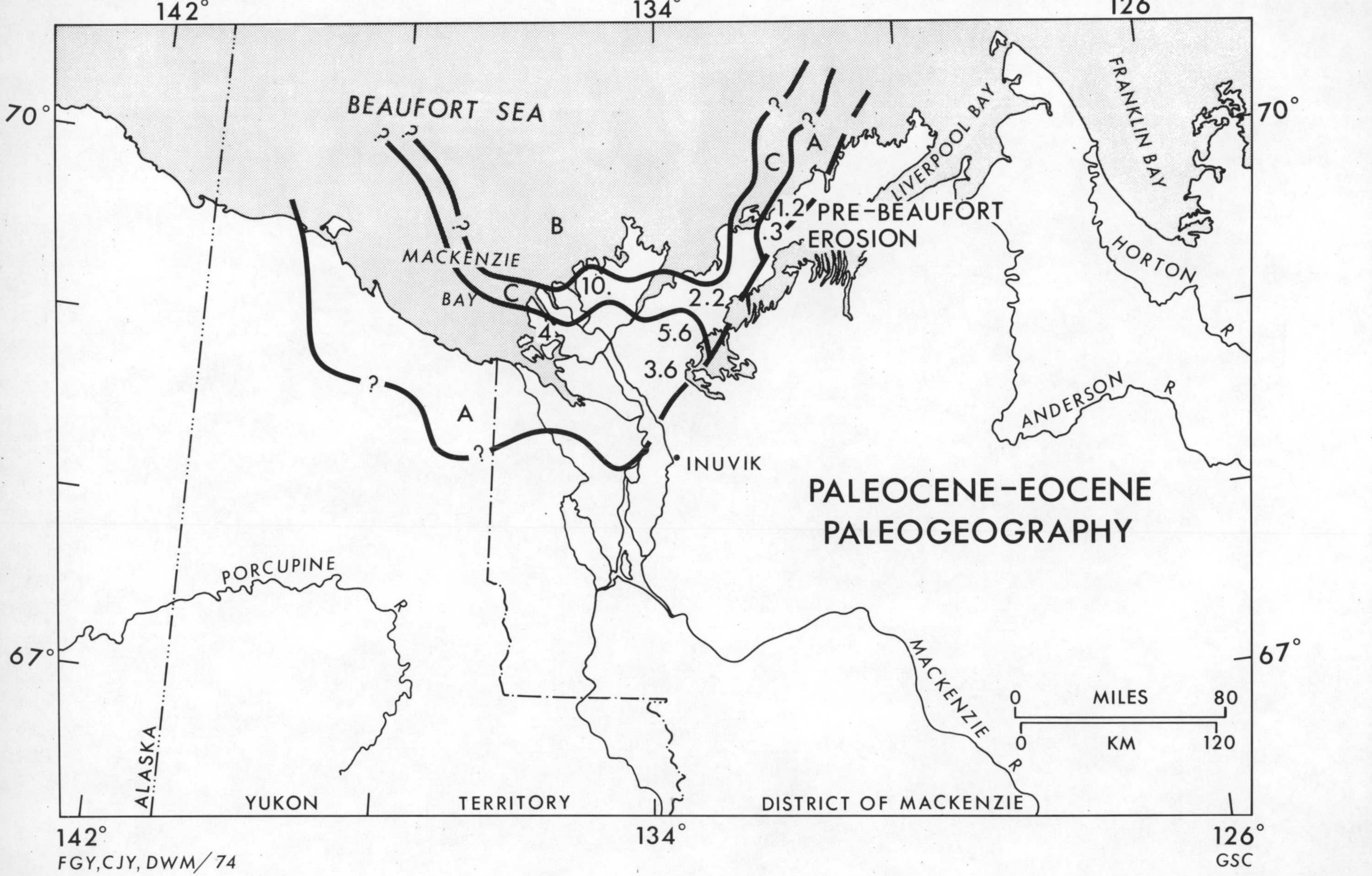

142°
134°
126°
70°
70°
67°
67°
BEAUFORT SEA
MACKENZIE
BAY
B
C
A
C
A
10.
2.2
4
5.6
3.6
1.2
.3
PRE-BEAUFORT
EROSION
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R
ANDERSON
R
INUVIK
PALEOCENE-EOCENE
PALEOGEOGRAPHY
PORCUPINE
R
MACKENZIE
R
0
MILES
80
0
KM
120
ALASKA
YUKON
TERRITORY
DISTRICT OF MACKENZIE
142°
134°
126°
FGY,CJY, DWM/ 74
GSC

FIGURE 16.

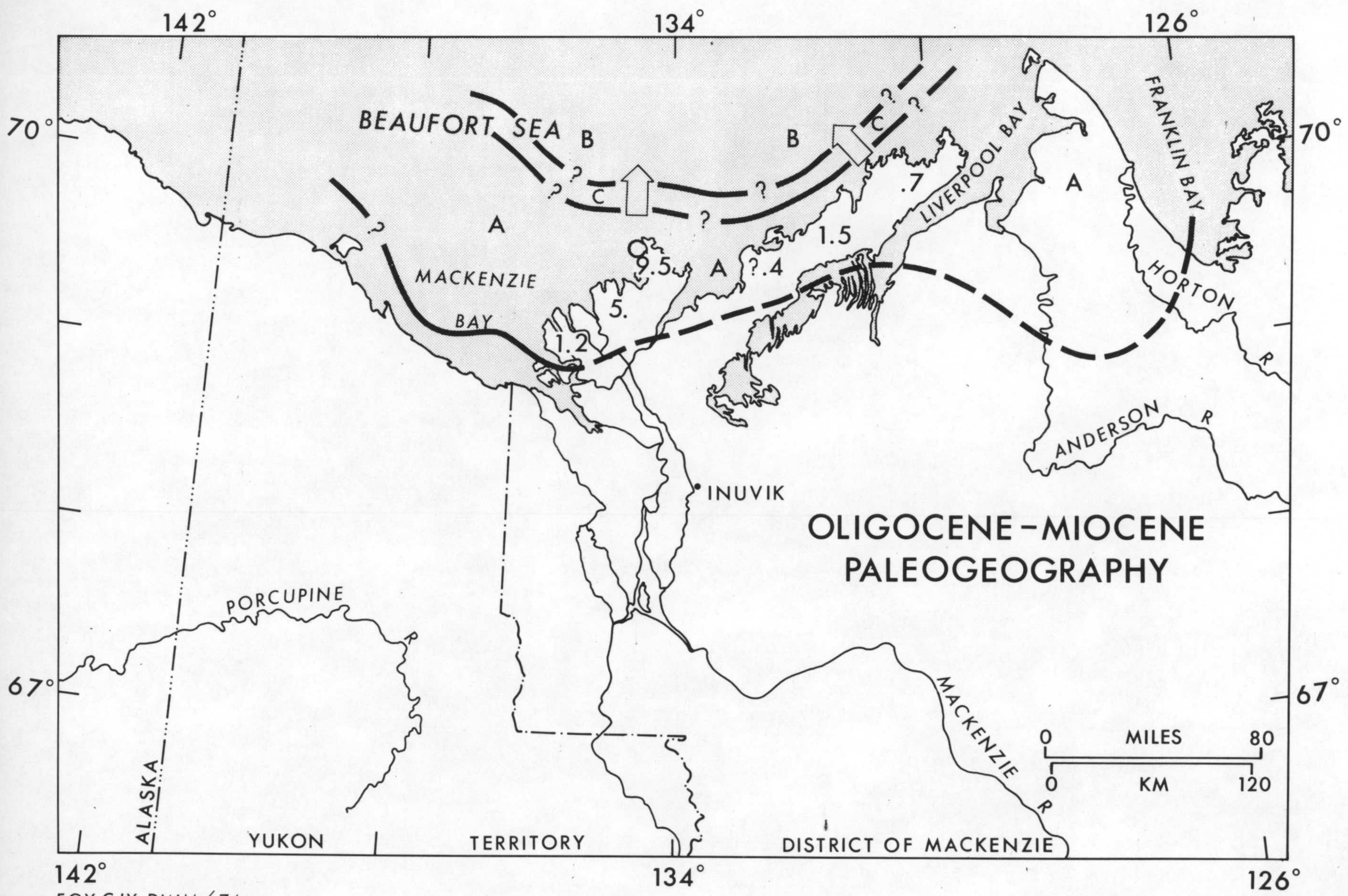

142°
134°
126°
70°
67°
BEAUFORT SEA
B
B
C
C
A
A
A
?
9.5
?.4
1.5
.7
5.
1.2
MACKENZIE
BAY
LIVERPOOL BAY
FRANKLIN BAY
HORTON
R
ANDERSON
R
INUVIK
OLIGOCENE – MIOCENE
PALEOGEOGRAPHY
PORCUPINE
R
MACKENZIE
R
0
MILES
80
0
KM
120
ALASKA
YUKON
TERRITORY
DISTRICT OF MACKENZIE
FGY, CJY, DWM/ 74
GSC

FIGURE 17.

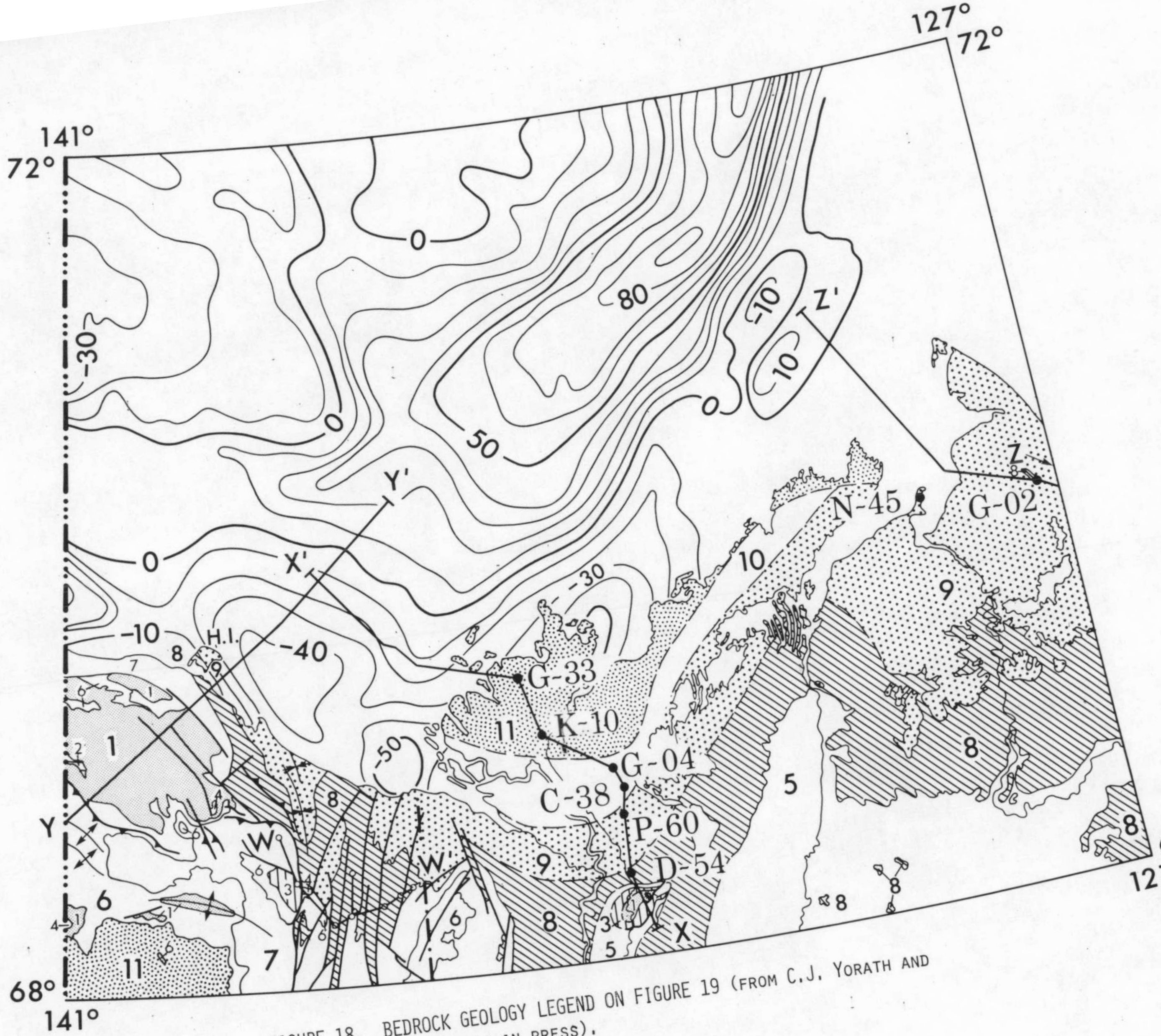


FIGURE 18. BEDROCK GEOLOGY LEGEND ON FIGURE 19 (FROM C.J. YORATH AND D.K. NORRIS IN PRESS).

CJY/74

LEGEND

11	LATE TERTIARY AND QUATERNARY DELTAIC, ALLUVIAL, LACUSTRINE CLASTICS
10	EARLY TERTIARY DELTAIC CLASTICS
9	LATE CRETACEOUS 'MOLASSE'
8	LATE EARLY CRETACEOUS 'FLYSCH'
7	EARLY MESOZOIC EPICONTINENTAL SEQUENCE
6	LATE PALEOZOIC CARBONATES AND CLASTICS
5	DEVONIAN CARBONATES AND CLASTICS
4	DEVONIAN OR OLDER GRANITES
3	EARLY PALEOZOIC CLASTICS AND CARBONATES
2	CAMBRIAN VOLCANICS AND CARBONATES
1	PROTEROZOIC AND ? YOUNGER CARBONATES AND CLASTICS

NORMAL FAULT..............................

THRUST FAULT..............................

ANTICLINE..............................

SYNCLINE..............................

FREE AIR GRAVITY ANOMALY.................. —50—

LINE OF CROSS-SECTION.................. X——X'

EXPLORATORY WELL.................. G-33•

HERSCHEL ISLAND.................. H.I.

FIGURE 19. LEGEND TO FIGURE 18.

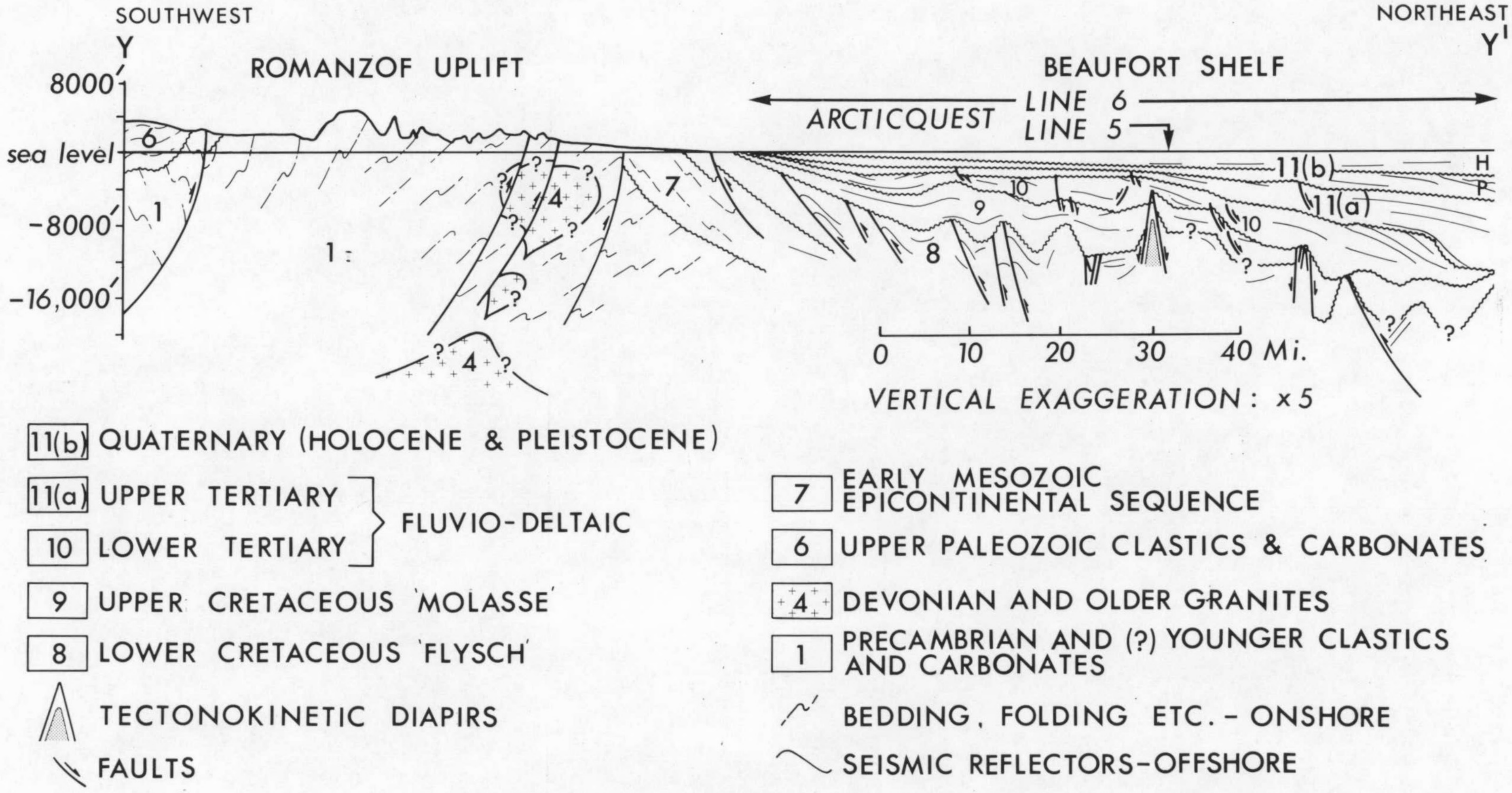


FIGURE 20. STRUCTURE SECTION $Y-Y^1$ LOCATION ON FIGURE 18 (FROM C.J. YORATH AND D.K. NORRIS IN PRESS).

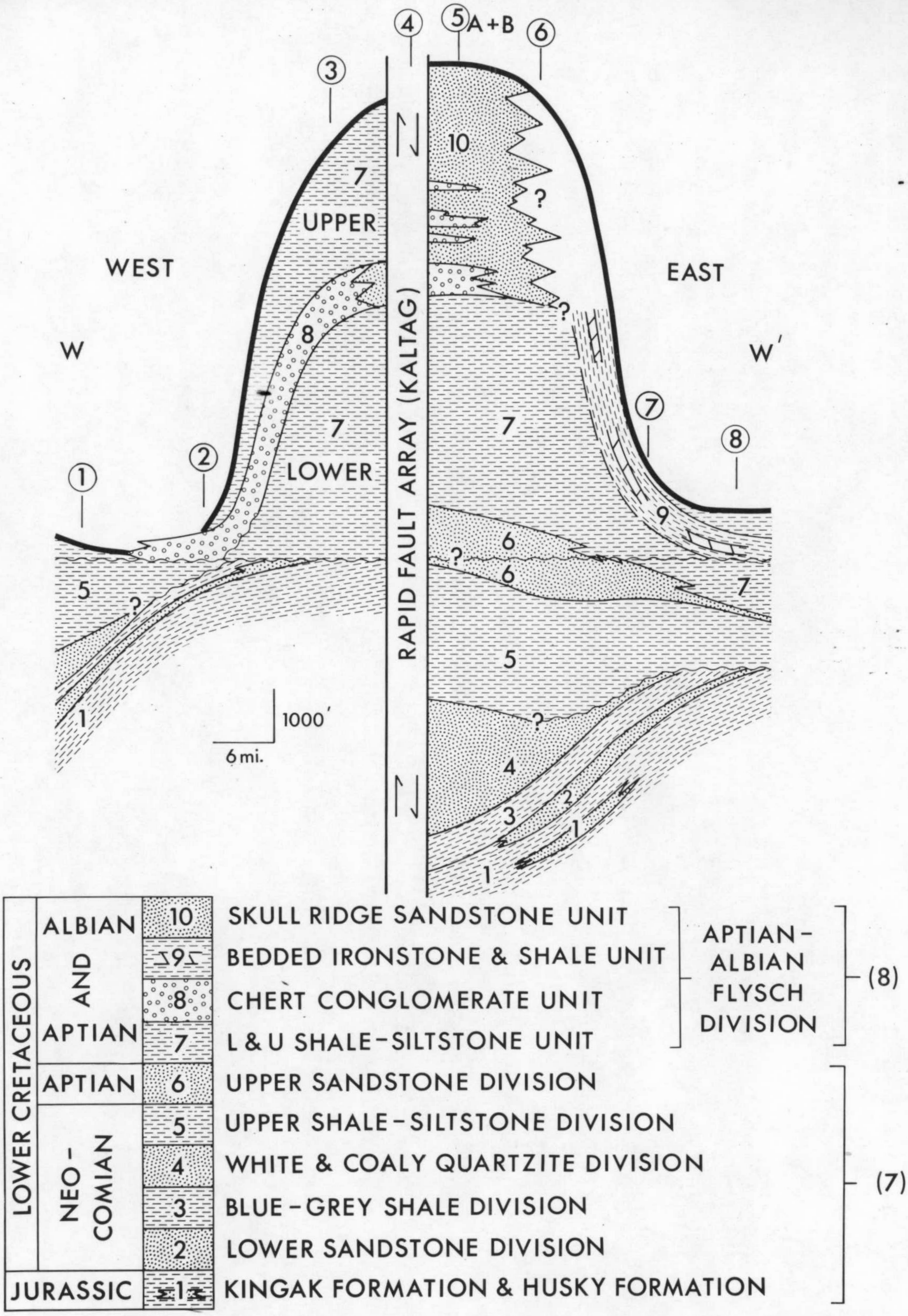
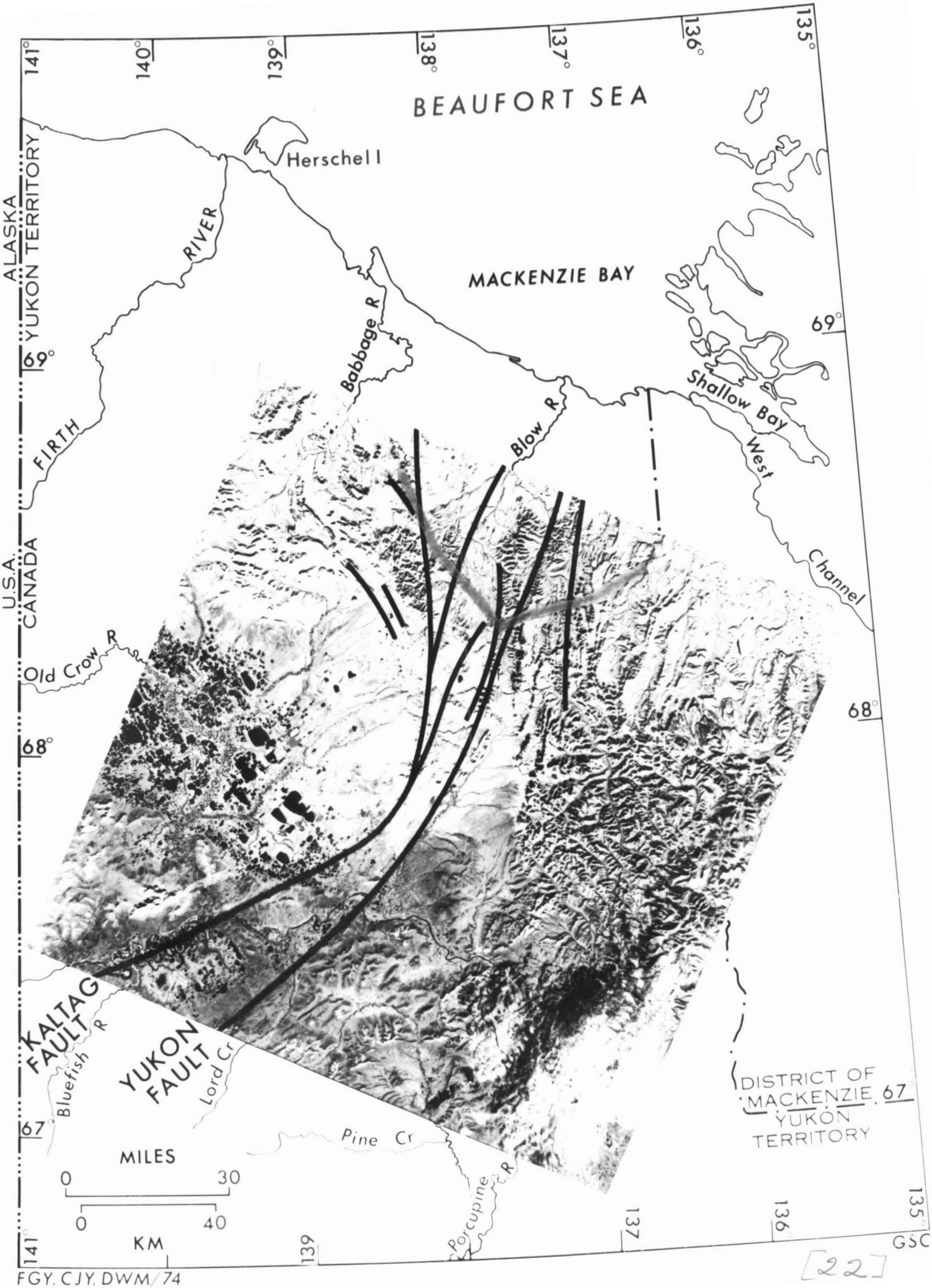


FIGURE 21. RESTORED PRE-LATE APTIAN SECTION W-W[1] LOCATION ON FIGURE 18 (AFTER F.G. YOUNG, 1974).



BEAUFORT SEA
Herschel I
MACKENZIE BAY
Shallow Bay
West Channel
Babbage R
Blow R
FIRTH RIVER
ALASKA
YUKON TERRITORY
U.S.A.
CANADA
Old Crow R
KALTAG FAULT
YUKON FAULT
Bluefish R
Lord Cr
Pine Cr
Porcupine R
DISTRICT OF MACKENZIE
YUKON TERRITORY
MILES
0 30
0 40
KM
141° 140° 139° 138° 137° 136° 135°
69° 68° 67°
GSC
FGY. CJY. DWM/74

[22]

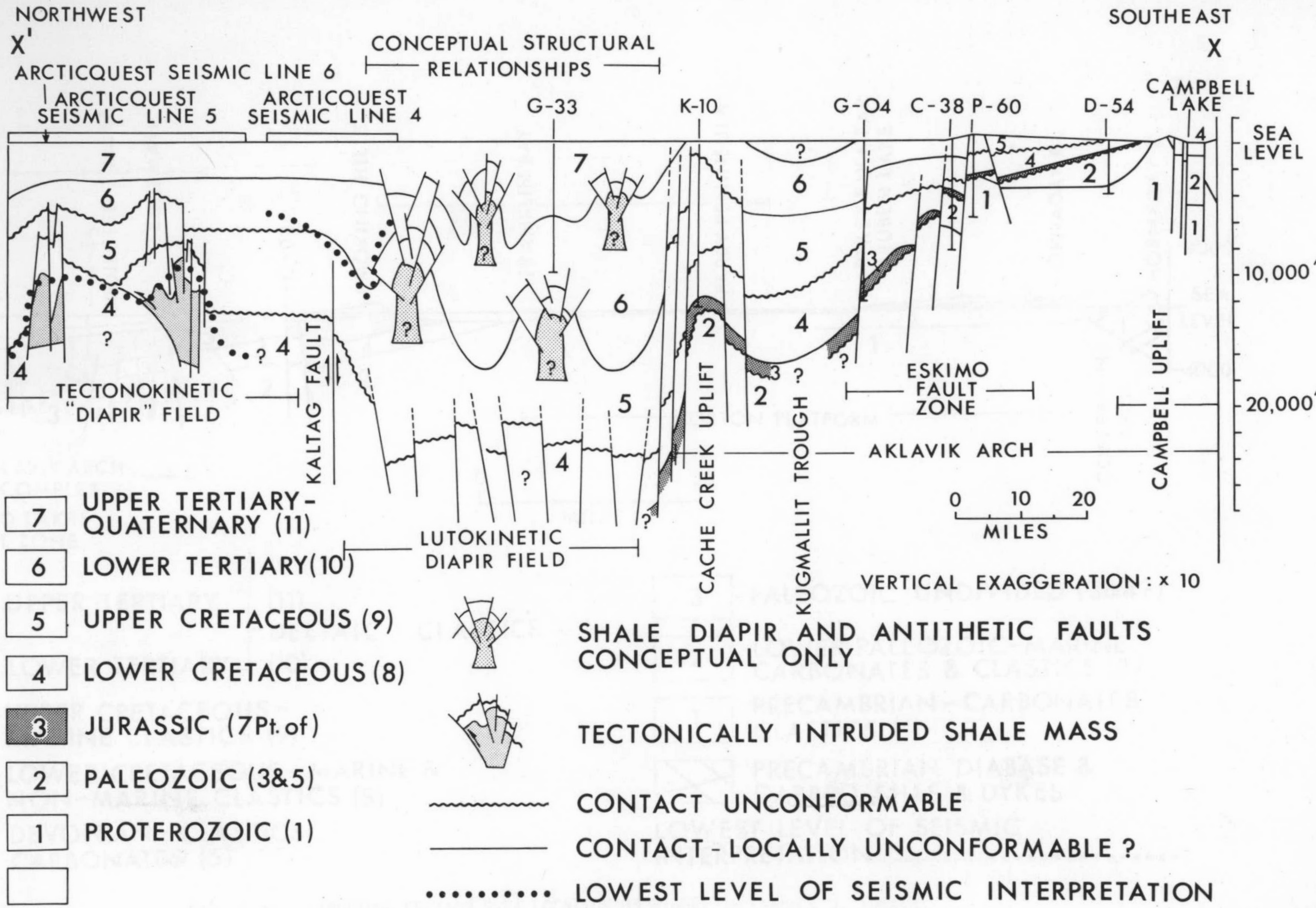


FIGURE 23. STRUCTURE SECTION X-X[1] LOCATION ON FIGURE 18 (FROM C.J. YORATH AND D.K. NORRIS IN PRESS).

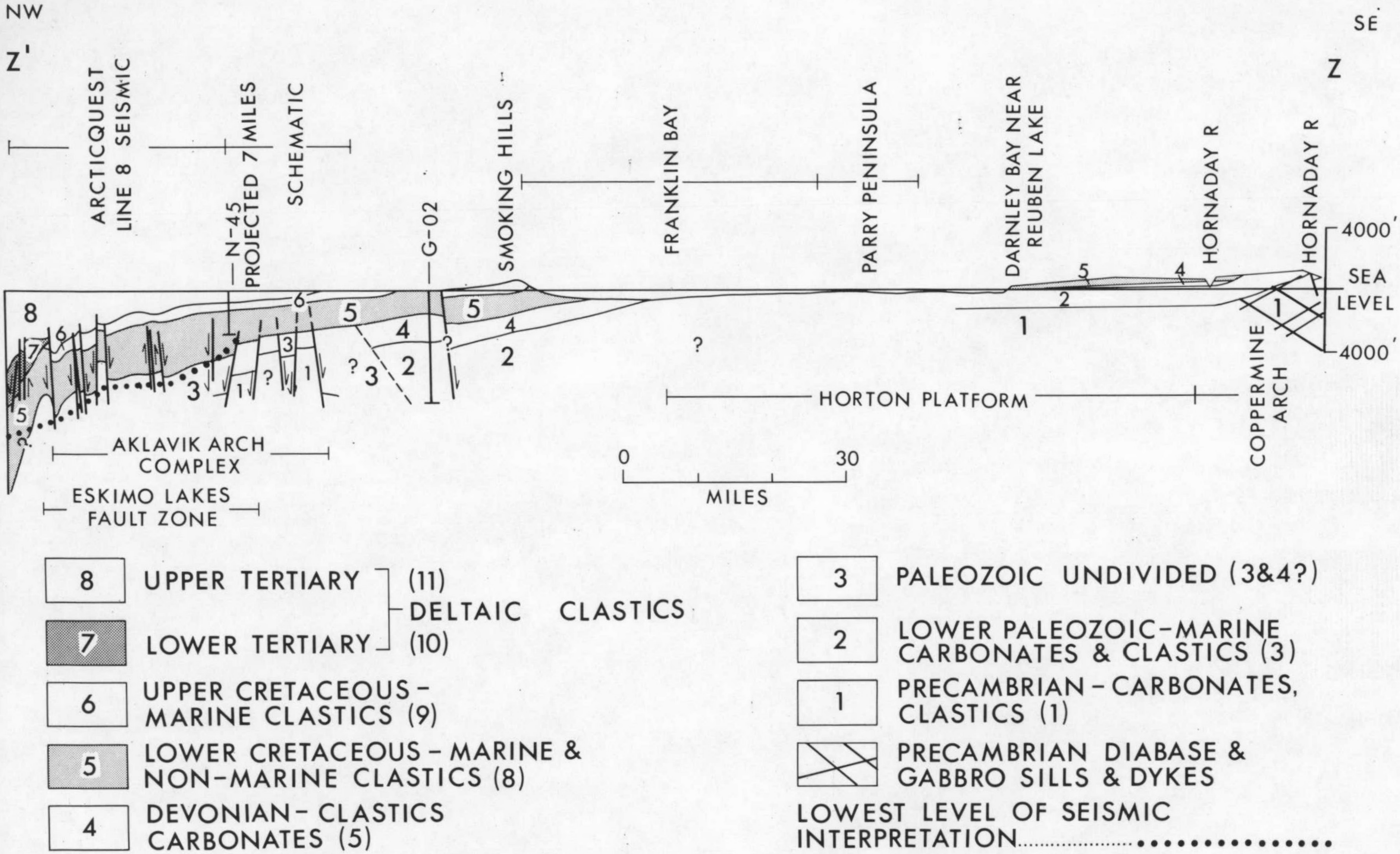
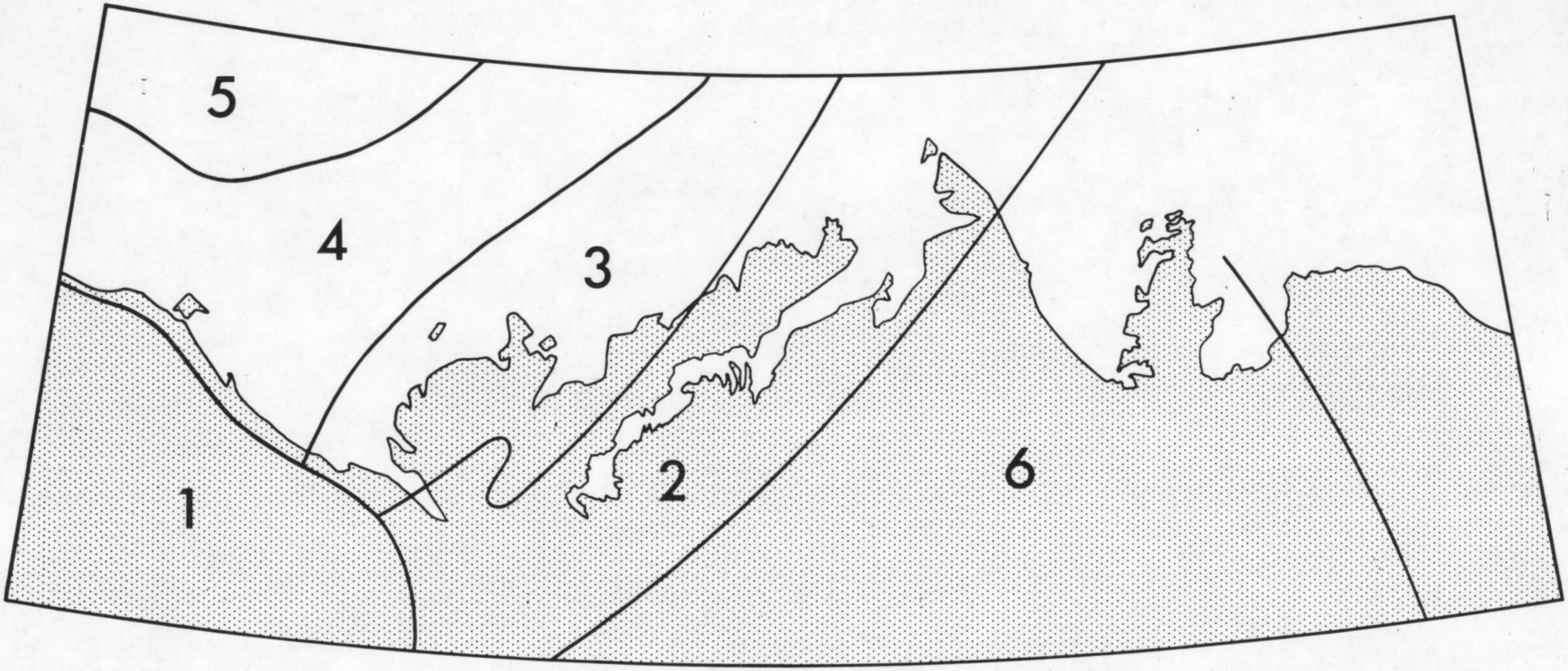


FIGURE 24. STRUCTURE SECTION Z-Z[1] LOCATION ON FIGURE 18 (FROM C.J. YORATH AND D.K. NORRIS IN PRESS).



1. NORTH YUKON
2. AKLAVIK ARCH
3. LUTOKINETIC FIELD
4. TECTONOKINETIC FIELD
5. CONTINENTAL MARGIN
6. HORTON PLATFORM

EXPLORATION AREAS

FIGURE 25.