Structural Geometry and Geological History of the Northern Canadian Cordillera

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Abstract

The deformed rocks of the Canadian Cordillera northeast of the Tintina Fault in Yukon Territory and northwestern District of Mackenzie can be divided into ten tectonic elements, each characterized by specific structural or stratigraphic attributes or trends. The region is flanked on the east by the generally flat-lying, eastward-tapering miogeoclinal wedge of sediments of the northern Interior Platform. On the west some of these elements contine into northern Alaska. Beneath are the crystalline rocks of the Hudsonian and older basement which are not exposed but which may have been melted to constitute local, lower Paleozoic, granitic intrustions. All Phanerozoic Systems as well as Proterozoic rocks are represented in this part of the orogenic system and they contain regional unconformities. Two major events are identified in the stratigraphic sequence, the one marking the end of stable shelf deposition by the close of the Paleozoic, and the other marking the fundamental reorganization of distribution of land and sea in the Late Jurassic and the Early Cretaceous.

A relatively flat gravity field in the Interior Platform contrasts with the steep gradient and curvilinear trends of the Bouguer anomalies paralleling the eastern flank of the orogenic system and identifying a thickening of the sedimentary sequence

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there. The free-air gravity map has a positive high paralleling the outer edge of Beaufort Shelf and is explained in the literature as a thinning of the sedimentary cover and a ridge in the basement rocks.

The problem of the origin of the Canada Basin and of the source of sediments for the Canadian Arctic Archipelago and for the mainland west of Mackenzie Delta in the middle and late Paleozoic has been answered in the literature by variations of two fundamentally different concepts. The first is that Canada Basin was closed prior to the Mesozoic so that the mainland was juxtaposed with the Archipelago and an upland between shed sediments bilaterally. The second is that Canada Basin is a geologically ancient feature antedating Atlantic rifting and the source of middle and late Paleozoic sediments was from the continental shelf and adjacent margins. The writer favours the second concept and considers the first with all its ramifications as unfounded in scientific fact. The Atlantic separation of the North American and Eurasian plates with concomitant reduction in the size of the Pacific plate was accomplished on the one side through drift from the Mid-Atlantic and Gakkel Ridges, and on the other through drift, collision in Siberia, longitudinal buckling and finally transcurrent faulting, first on the Kaltag Fault in the Late Cretaceous and then on the DeGeer transform in the Tertiary. There was no Alaskan Orocline, no associated pivot points within the North American continental plate and no Arctic Sphenochasm so that Canada Basin is an ancestral feature, at least in existence since the early Paleozoic.

Introduction

The accelerating pace of geological exploration for minerals and hydrocarbons has led to significant advances in our knowledge of the geology of the northern mainland of Canada. Of necessity this knowledge is divided among the experts of the many companies and universities as well as of the federal and territorial governments participating in this exploration. Extreme complexity in structure and stratigraphy compounded by paucity of good exposure has led to a diversity of assessments of the structural geometry and geological history of the region. It is hoped that by airing these interpretations in colloquia such as this, much progress can be made toward acceptable solutions to the geological problems there.

The purpose of this paper is to present one such assessment of the geology of the Canadian Cordillera in Yukon Territory and northwestern District of Mackenzie north of Tintina Trench. It is based largely upon the investigations of government scientists participating in Operations Porcupine and Mackenzie, supplemented by data on adjacent areas from the literature. In addition, the writer has benefited from unpublished data provided by E. W. Bamber, T. P. Chamney, D. G. Cook, R. W. Macqueen, A. W. Norris and C. J. Yorath. M. Churkin, H. P. Trettin and C. J. Yorath critically read the paper in manuscript and offered valuable commentary. It is necessarily a progress report and subject to modification in the light of new data and theories. Hopefully, however, some of the basic premises may withstand the test of time.

The Geological Elements of the Northern Cordillera

The deformed rocks of the northern Canadian Cordillera are flanked on the east by the generally flat-lying, eastward-tapering wedge of miogeoclinal sediments of the northern Interior Platform (*see* Fig. 1). On the west some of them continue into northern Alaska. Collectively they comprise a complexly faulted and folded, intruded and variably metamorphosed belt of layered rocks forming the structural and stratigraphic link between the Rocky Mountains of northeastern British Columbia and that part of the orogen in Alaska northeast of Tintina Fault. The structural style of the belt, therefore, contrasts with its continuation much farther south in Alberta. In Alberta, thrust faults with sub-parallel and curvilinear traces, some of great lateral extent, predominate whereas in Yukon Territory and District of Mackenzie, curvilinear and arcuate thrust, high-angle or transcurrent faults and folds vary in prominence from one region to the other.

The region may be subdivided into ten tectonic elements, each characterized by specific structural or stratigraphic attributes or trends. Beneath are the crystalline rocks of the lower Proterozoic and older basement which is not exposed although it may have been remobilized to constitute localized acid and basic igneous intrusions in several of the elements.

Selwyn Fold Belt

This element is herein defined to embrace that part of the orogenic system in Yukon Territory coinciding with the Selwyn Basin of Gabrielse (1967, Fig. 1) and lies within the Columbian Orogen.

It is bounded on the southwest by the linear trace of Tintina Fault (Fig. 1) and on the north and east by the curvilinear western limit of the Mackenzie Fold Belt. Upper Proterozoic clastic sediments, middle and lower Paleozoic stable platform carbonates with associated deep water graptolitic shales, and Upper Cretaceous granitic intrusions predominate.

According to Gabrielse (op. cit., p. 290) the northwestern part of the belt is characterized by northwesterly to northerly directed thrust faults and associated folds, and foliation is developed locally to a high degree so that bedding is obscured. Metamorphic rocks northeast of Tintina Fault display large, recumbent folds, and foliation dips gently except near the fault. In the southeastern part of the belt, upright to overturned folds are common, particularly in the incompetent strata. Where overturned, the folds display a northeasterly directed asymmetry.

Stockwell (1968) indicates that the Selwyn Fold Belt was folded during the Ellesmerian orogeny, then refolded and intruded with granitic rocks in the Late Jurassic to latest Early Cretaceous. The complexity of structures resulted from an initial heterogeneity of the deformed rocks, the interruption of structures by discordant granitic intrusions and from the superposition of several phases of deformation (Gabrielse, op. cit., p. 288).

Mackenzie Fold Belt

The Mackenzie Fold Belt in western District of Mackenzie and Yukon Territory embraces that part of the Cordilleran orogenic system between Selwyn Fold Belt and the western margin of the northern

Interior Platform (Fig. 1). The arcuate length of the belt is about twice that of the Jura (see Heim, 1919). A generalized columnar section (D. G. Cook and R. W. Macqueen, pers. com., 1973) representing rock units and their contact relationships within the belt in the vicinity of Arctic Red River is shown in the first column on the left in Table 1. There, the section is similar to that in the Selwyn Fold Belt. Two angular unconformities and at least five disconformities interrupt the succession. Those at the base of the Cambrian and between the Middle and Upper Devonian appear to be widespread in the northern Cordillera.

In contrast with some of the other elements under discussion, a fold bundle dominates the structural style of the Mackenzie Fold Belt. The bundle swings in a great arc as it trends north from the 60th parallel to about the latitude of Norman Wells (Fig. 2) and then west to its termination against the Richardson Anticlinorium. The folds are flexural-slip, cylindrical and, in contrast with those of the Front Ranges and Foothills of the Rocky Mountains in Alberta, they commonly have curviplanar axial surfaces dipping either steeply toward or away from the Interior Platform. Some are symmetrical. Associated with them are steeply and shallowly dipping faults which also may be inclined either toward or away from the Platform and can have reverse as well as strike-slip displacement.

Characteristic of this and other fold bundles in the northern Cordillera is the arrangement of individual folds into en échelon arrays (Norris, 1972a) which are systematically right- and left-handed depending upon their position in the fold belt. Thus, arrays on the north-trending flank of Mackenzie Fold Belt are right-handed, and on the west-trending flank, left-handed (see Norris, op. cit., Fig. 1). Longitudinal buckling and shortening of fault blocks, as in Camsell and Nahanni Ranges, moreover, suggest that the underlying faults may have significant right-lateral displacement, compatible with the causal couples of the associated en échelon arrays. Around the nose of the arcuate belt opposite Norman Wells the folds are not arrayed en échelon and the contraction faults (Norris, 1958) are interpreted to have predominantly dip-slip displacement because they trend perpendicular to the mean direction of differential transport of the fold belt. On the west-trending flank the faults may have significant left-lateral displacement.

Transverse faults and reversal in asymmetry of folds are common. On the north-trending flank of Mackenzie Fold Belt several faults cut across the regional structural grain at angles of approximately 30 degrees, analogous to those recognized and mapped in the Jura (Heim, op. cit., Pl. 20). They appear to be essentially vertical structures and separations on them are commonly right-lateral, kinematically and dynamically compatible with the right-hand en échelon fold arrays and right-hand overlap on fault blocks in this structural position in the belt. Some serve to link contraction faults of opposing dips. Thus, Spirit transverse fault in northern Root River map-area (Douglas and Norris, 1961) connects east-dipping Painted Mountain Fault with west-dipping Dusky Fault (see Fig. 2) and east-dipping Tundra Fault is connected in similar fashion with an unnamed, west-dipping contraction fault in the vicinity of North Nahanni River.

Thrust plates on strike with one another, but with opposed dips and linked at the changeover by a transverse fault have been studied by Cook and Aitken (1972, p. 159) in Franklin Mountains in the vicinity of Norman Wells. Concurrent longitudinal and transverse shortening of the St. Charles Range fault block, moreover, appears to be analogous to that observed in Camsell Range (Norris, 1972a, Fig. 5) and may well be due to the same right-hand, Laramide force couple operating in this flank of the fold belt.

Many of the folds on the flanks of the bundle exhibit reversals in asymmetry along their sinuous strike so that they lean steeply to the one side and then the other, occasionally in conjunction with an underlying contraction fault, and independently of contiguous folds in the bundle. Imperial Anticline (*see* Fig. 2) on the north flank of the bundle, for example, has an axial surface which reverses from a north to a south dip as the fold is traced eastward in the vicinity of Mountain River (Yorath and Cook, 1972, p. 28, 29). This style contrasts with the predominantly eastward leaning of folds in the southern Canadian Rocky Mountains and Foothills.

Richardson Anticlinorium

This is the broad, north-trending anticlinal structure essentially confined to Yukon Territory between Mackenzie and Taiga-Nahoni Fold Belts. Its east boundary is defined by the Treeless Creek Fault (Fig. 2) whereas its west flank is arbitrarily taken as the base of the Upper Devonian Imperial Formation. The anticlinorium corresponds in position and outline to the lower Paleozoic Richardson Trough. Deep water, graptolitic shales with resistant limestone breccia interbeds composed of material shed from carbonate banks adjacent to the Trough (_see_ Plate 1) are the dominant lithology on the flanks of the anticlinorium whereas lower and middle Paleozoic carbonates preponderate southwards. Because of the gentle north plunge, however, progressively younger rocks are exposed in general as one proceeds from south to north. Thus, in the core of the anticlinorium a thick Proterozoic, clastic succession overlies with angular unconformity phyllitic argillites south of Peel River and Lower Cambrian limestones are exposed in an equivalent structural position north of it.

The anticlinorium is cut by a cluster of essentially vertical faults running parallel to its long axis. A few are shown in figure 2. Regionally the cluster is observed to swing northeast to intersect Aklavik Arch and continue beneath Kugaluk Homocline east of Mackenzie Delta (Fig. 1). A major, northeast-trending fault reported by Pamenter (1972, p. 11) from the subsurface there appears to be the strike continuation of the Treeless Creek Fault (_see_ Plate 2 and Fig. 2) which flanks the anticlinorium, and still others in the cluster may join up as well. Some of the faults are observed to have right-lateral separations whereas within and northeast of Mackenzie Delta they have been demonstrated only to be down-dropped toward Beaufort Shelf.

Southward the fault cluster passes behind or structurally west of Mackenzie Fold Belt. There the faults trend sub-perpendicular to the mean direction of regional tectonic transport in the orogen, dip more steeply and are assumed to have predominantly dip-slip displacement.

Stratigraphic omissions at unconformities in the anticlinorium are indicative of intermittent uplift and depression from the Proterozoic to the Tertiary (Table 1). This crustal activity was apparently along some of the faults of the cluster because significant omissions are observed in direct association with them. Thus on the east flank of the anticlinorium near the headwaters of Caribou River, Upper Triassic limestones are in juxtaposition with middle and lower Paleozoic shales and carbonates on the Caribou Fault (Fig. 2), and they rest disconformably on Mississippian shales (Norris _et al_., 1963). The east block must have been elevated in the late Paleozoic to produce the disconformity at the base of the Triassic strata and then differentially depressed, possibly in Laramide time, to place the Triassic against the middle and lower Paleozoic. Still farther south, in the region where Mackenzie Fold Belt impinges on the anticlinorium, a very thick upper Proterozoic clastic succession lies beneath Lower Cambrian carbonates on the east flank of Bonnet Plume Basin, whereas on the southwest flank of the basin the Lower Cambrian rests with spectacular angular unconformity on much older Proterozoic, phyllitic argillites. Clearly the Basin was uplifted prior to the Cambrian to strip the younger Proterozoic and then was depressed to receive Phanerozoic sedimentary rocks, including the Bonnet Plume Formation now covering the Basin (_see_ Table 1). The Bonnet Plume is a successor basin straddling the anticlinorium. It received detritus from peripheral, uplifted fault blocks beginning in the late Early Cretaceous and was in turn mildly deformed in the early Tertiary.

Taiga-Nahoni Fold Belt

This Belt comprises the west- and north-trending fold bundles of the Taiga and Nahoni Ranges respectively, and forms the deep recess (King, 1969, p. 66) in northern Yukon Territory between the great arcs of the Mackenzie Mountains and the Brooks Range of Alaska. Its northern limit is taken arbitrarily as the generalized surface trace of the top of the Paleozoic section and its western and southern limits are the Kandik Thrust and the Selwyn Fold Belts.

Two major angular unconformities and at least six disconformities interrupt the stratigraphic section in this element (Table 1). Locally, rocks as old as the Proterozoic phyllitic argillites occur in outcrop as seen for example beneath the right-angular unconformity on Hart River (Plate 3). Again, stable carbonate bank deposits characterize the lower and middle Paleozoic succession, and clastic sediments characterize the Carboniferous and younger rocks.

Folds are the dominant structural feature of the belt. From east to west along Taiga Range the anticlines and synclines are arranged left-hand _en échelon_ and the mountain front steps systematically southward to the headwaters of Ogilvie River. There, in a plunge depression, the fold belt turns through a right angle and continues northward in Nahoni Range where right-hand _en échelon_ folds predominate. The reversal from left- to right-hand _en échelon_ arrays is identical with that observed as one proceeds clockwise around the arc of the Mackenzie Fold Belt.

The folds are cylindrical, flexural-slip and are commonly cut by contraction faults which parallel them and dip either toward or away from the concave side of the arc formed by the Taiga and Nahoni bundles (Plate 4). Their axial surfaces may be vertical or dip steeply to the one side or other as in the Mackenzie and Selwyn Fold Belts, and there is no preferred direction of asymmetry.

Eagle Fold Belt

This fold belt lies within the concavity of the Taiga-Nahoni Fold Belt; it is flanked on the east by Richardson Anticlinorium and it is truncated on the north by Aklavik Arch (Fig. 1). Its surface is underlain largely by Upper Cretaceous clastic sedimentary rocks (Eagle Plain Formation) so that knowledge of older rocks within the belt has been obtained only from bore holes. The principal unconformity in the succession is at the base of the upper Lower Cretaceous and progressively older Permian, Carboniferous and Devonian strata are bevelled from south to north (Table 1).

As in Taiga-Nahoni Fold Belt, flexural-slip, cylindrical folds dominate the structural style. They are Late Cretaceous or early Tertiary in age, they trend slightly west of north, they are commonly linked right-hand en échelon, and where asymmetrical, their axial surfaces dip steeply eastward. Some folds have great length and can be traced for distances up to 75 miles across the belt. Locally, they are cut by east- or west-dipping contraction faults of lengths commonly less then 20 miles and stratigraphic separations less than the thickness of the Eagle Plain Formation (2,500 feet, approximately).

Kandik Thrust Belt

The Kandik Thrust Belt is defined to include the faulted and folded Lower Cretaceous and older rocks between the Nahoni fold bundle on the east, the Aklavik Arch on the northwest, and the Tintina Fault on the southwest (Fig. 1). It is the eastward continuation of the Kandik Basin (Churkin and Brabb, 1969) in Alaska. The rock succession ranges from the Proterozoic Tindir Group to the lower Tertiary Monster Formation and, although interrupted by several unconformities, it is by far the most stratigraphically complete among those listed for the northern Canadian Cordillera in table 1. The middle and lower Paleozoic stable carbonate platform deposits rest unconformably on the Tindir and are, in turn, overlain by a succession composed predominantly of clastic rocks. Among the latter the upper Lower Cretaceous conglomerates and shales (flysch) are tectonically the most important because they signal rising land masses to the west in Alaska in Early Cretaceous time and they record late geosynclinal foredeep deposition in advance of the northeastward migrating Laramide deformation front.

The structural style of the belt is characterized by west-dipping thrust faults which, at the surface, are observed to repeat the upper Paleozoic and the Mesozoic cover rocks. Where the faults involve Carboniferous and Permian limestones or other diagnostic units they are readily recognized. In the monotonous, clastic successions of the Jurassic and Cretaceous, however, they can be identified more readily by repetition of faunizones.

Aklavik Arch

The term Aklavik Arch is applied to the composite, northeast-trending tectonic element extending in Canada from the Alaska border to the east side of Mackenzie Delta (Fig. 1). From southwest to northeast it comprises a fault-bounded block of Proterozoic and lower Paleozoic rocks (Keele Range) and a series of three right-hand, *en échelon* components with cores as old as Proterozoic (Dave Lord-Cache Creek, Rat and Campbell Uplifts of Norris, 1973, Fig. 1). Between the uplifts are structural depressions containing rocks as young as Cretaceous.

Five angular unconformities and as many disconformities interrupt the stratigraphic succession in the arch and attest to intermittent and prolonged tectonic activity (*see* Table 1). In Keele Range, for example, the angular unconformity between the Tindir Group and the shoreline quartzites and shales assigned to the Middle Cambrian identifies late Proterozoic orogeny, uplift and erosion in this part of the Cordilleran orogenic system. The Proterozoic dolomite and clastic succession exposed in Campbell Uplift at the northeast limit of surface expression of the arch, on the other hand, is less deformed and although the contact with gently dipping to flat-lying, middle and lower Paleozoic strata has not been seen, it is presumed that it is angular also because of the generally steep dips in the Proterozoic rocks. The next period of deformation along the arch is recorded in Rat Uplift in northern Richardson Mountains where an unnamed clastic unit of Early or Middle Permian age rests with angular unconformity on deformed Imperial and Road River Formations. This deformation coincides with the Ellesmerian Orogeny of the Arctic Archipelago.

On Porcupine River seven miles above its junction with the Driftwood, Knipping (1960, p. K3) reported (Road River) shales and chert with *Monograptus*. These rocks have most recently (Lenz, 1972, p. 326) been assigned an age as young as Early Devonian. Knipping (idem), and in turn Norford (1964, p. 119), Bassett and Stout (1968, p. 750) and Lenz (op. cit., p. 361) considered the conglomerates unconformably overlying the shales at this locality to be of still younger Paleozoic age (Late Devonian, Pennsylvanian or Permian). The fact that these conglomerates have not been dated definitively, that neither conglomerates nor angularity can be found at the base of the known Permian succession in the immediate area, that lithologically identical conglomerates are widespread and are Early Cretaceous (Albian) in age (Jeletzky, 1972) and that the sub-Albian unconformity cuts down section through the Permian and Upper Devonian in the direction of the Porcupine River exposure, would suggest to the writer that an alternative age for these conglomerates is Early Cretaceous. If true, the number of conglomerates in the area is reduced to two, that at the base of the Mississippian System (Kekiktuk Formation) and that in the upper Lower Cretaceous. The deformation observed in the Silurian and Devonian shales on the Porcupine may, therefore, be latest Devonian to earliest Mississippian in age, coinciding with that observed in the northern Richardsons with an overprint of an early Mesozoic tectonism.

An early Mesozoic event is revealed by the angular unconformity at the base of the Jurassic System on Dave Lord Ridge and identifies the third tectonic episode to affect the arch. The fourth, representing local uplift, then foredeep depression and flysch sedimentation in the late Early Cretaceous, is recognized by the hiatus and angular unconformity at the base of the Albian conglomerates on the southeast flank of the arch in the vicinity of Sharp Mountain, and the fifth by the unconformity beneath the Tertiary on the north flank of Campbell Uplift (Plate 5). The latter event is inferred also from the presence of amygdaloidal, basic volcanics on top of the Proterozoic Tindir Group on Lone Mountain, near the Alaska border a few miles south of the Porcupine River. These volcanics are considered to be Tertiary in age, because of their structural position and their proximity to basic volcanics of Cenozoic age in Porcupine River valley immediately west of the Yukon-Alaska boundary (Brosgé and Reiser, 1969). The writer suggests that these volcanics may represent Tertiary fissure eruptions along the Kaltag Yukon Porcupine Fault of Tailleur and Brosgé (1970).

It is apparent from the preceeding discussion that the Aklavik Arch is anything but a "broad, open anticlinal fold of a regional scale" (definition of an arch; Glossary of Geology, Am. Geol. Inst., 1972, p. 35). It is a tectonic association of uplifted and depressed components which were active independently and intermittently, and is geologically one of the most complex elements in the northern Canadian Cordillera. Compounding the complexity of this right-hand, <u>en échelon</u> array of components is the fact that it is cut transversely by the cluster of faults extending northeast from Richardson Anticlinorium across Mackenzie Delta, and by the Kandik fault system extending north to Beaufort Shelf west of the Delta. The juxtaposition of the Keele Range block and Dave Lord-Cache Creek Uplift, and of the Rat and Campbell Uplifts may, therefore, be due to right-lateral displacement on some of the faults of these two transverse systems.

Kugaluk Homocline

This structure is defined as the southeast-tapering wedge of Upper Cretaceous and Tertiary sediments east of Mackenzie Delta between the northern Interior Platform and Beaufort Shelf (Norris, 1973). It dips seaward beneath a cover of Quaternary sands and gravels. This wedge of marine and nonmarine clastic rocks thickens rapidly to the northwest and would appear in large part to cause the -40 milligal gravity low (*see* Fig. 1) over Kugmallit Bay and Richards Island at the northern extremity of the modern delta of the Mackenzie River.

Marine seismic reflection surveys (Accurate Exploration Ltd., 1960) reveal a system of northeast- and east-trending, steep faults in and beneath the homocline. These and additional structures have subsequently been verified by drilling and reported by Pamenter (1972, p. 11). They constitute a cluster of northeast-trending faults that cuts the Kugaluk wedge into a number of elongate blocks, downdropped as much as a few thousand feet, generally in the direction of Beaufort Shelf. Associated folds interpreted from the above mentioned reflection surveys appear to be arranged right-hand *en échelon*, suggesting right-lateral, strike-slip components on at least some of the faults.

Interbedded (Proterozoic?) phyllites and quartzites intersected at a drilling depth of approximately 5,920 feet in the I.O.E. Atkinson H-25 bore hole, would indicate strong uplift and stripping of the pre-Cretaceous succession from blocks prior to deposition of the Lower Cretaceous braided stream and shoreline reservoir rocks. Faulting would appear, therefore, to have taken place before the late Early Cretaceous and to coincide in a general way with that observed on the strike continuation of this cluster southwest of the Delta in Richardson Anticlinorium. Pamenter (op. cit., p. 10) reports that the age of the faults, deduced from seismic and well data, ranges from pre-Cretaceous to Recent.

Romanzof Uplift

Defined by Payne (1955) in northeastern Alaska, this uplift continues into Canada in the region of British Mountains and, in this paper, includes Barn Mountains at its southeastern extremity. As a Tertiary feature, its southern boundary is taken arbitrarily as the limit of outcrop on Old Crow Plain. Its northern boundary, however, is commonly a fault contact with Beaufort Shelf.

One major angular unconformity and at least four disconformities partition the stratigraphic succession (Table 1), and lower Paleozoic, granitic intrusions occur in Old Crow Range and at Mounts Fitton and Sedgwick. Minor basic dykes cut the oldest Neruokpuk rocks exposed in the uplift.

The principal unconformity at the base of the Mississippian Kekiktuk Formation (Plate 6) is widespread and, as mentioned previously, is recognized in Aklavik Arch. Beneath it are the argillites, quartzites and limestones of the Neruokpuk Formation and above it is the southward progression from coal-bearing, nonmarine shales of the Kayak Formation to shallow water marine shales and limestones to stable shelf carbonate banks of the Lisburne Group. This unconformity is interpreted to identify Middle or Late Devonian tectonism in Barn Mountains at the southeast extremity of Romanzof Uplift as it does in the Aklavik Arch.

In British Mountains, however, the deformation beneath the Kekiktuk Formation may have been much earlier. A volcanic agglomerate and limestone formation containing Lower as well as Upper Cambrian trilobites (Dutro et al., 1972, p. 813) appears to overlie the Neruokpuk with angular unconformity. Thus, not only would the Neruokpuk be a Proterozoic formation but also it must have been deformed prior to the deposition of the agglomerates and limestones. The lower Paleozoic Road River Formation, if deposited in the region, was, therefore, stripped because of epeirogenic uplift and erosion in the Late Devonian and was a principal source of sediments for the Imperial Formation.

The Lisburne Group is followed in turn by the dominantly clastic sequence representing parts of the upper Paleozoic and Mesozoic Systems (Table 1). Of primary significance in the upper part of the column is the marine shale and sandstone sequence of the Jurassic and Lower Cretaceous capped by upper Lower Cretaceous lithic arenites. This Mesozoic clastic wedge sequence records the onset of the Laramide Orogeny (s.l.) as it haltingly but progressively migrated northeastward onto Beaufort Shelf. With orogeny and uplift taking place to the west in Alaska in the Early Cretaceous there was significant, fundamental and wholesale restructuring of the seas and land masses so that the principal source of clastics was now from the west and southwest rather than from the east and northeast. The coarse clastic sediments of the late Early Cretaceous are foredeep (flysch) deposits related to this orogeny. They are overlain with possible disconformity on Beaufort Shelf by a regressive sequence of fluviatile, delta and prodelta clastics of Late Cretaceous and early Tertiary age shed from orogenic uplands to the west and southwest and interpreted to thicken considerably on the shelf because of two large negative Bouguer anomalies observed west of Mackenzie Delta, opposite the mouths of Fish and Babbage Rivers (see Fig 1).

Two economically important overstepping relationships are observed on the north flank of Romanzof Uplift, the one at the base of the Triassic Shublik Formation and the other at the base of the Jurassic Kingak Formation (Norris, 1972b, p. 96 and Fig. 1). They represent intermittent uplift and depression on Beaufort Shelf and contiguous parts of Romanzof Uplift. From southwest to northeast the Shublik littoral limestones overstep the Permian and Carboniferous formations to rest upon the Neruokpuk (Plate 7). In turn, the black, concretionary, marine shales of the Kingak overstep the Shublik (Plate 8). Thus the lateral extension of the Permian and Triassic reservoir rocks at Prudhoe Bay, 240 miles along strike to the northwest, has been removed by pre-Jurassic erosion and the presence of these rocks on Beaufort Shelf would appear to be fragmentary at best.

Romanzof Uplift comprises two structural styles stacked one on top of the other at the unconformity at the base of the Mississippian succession (see Plate 6). The older, Precambrian? style is confined to the Neruokpuk in the uplift and comprises open to collapsed, cylindrical, flexural-slip folds with axial surfaces either vertical or dipping steeply to the southwest or northeast, and high-angle reverse faults (Norris, 1973). The style is clearly and abundantly displayed in the canyons of Firth River. The contorted, truncated and intruded Neruokpuk is the basement for the Phanerozoic rocks which were deformed by a Cretaceous orogeny into contrasting style.

Imbricate thrust faulting and open folding characterize the younger Cretaceous style. On the crest and north flank of the uplift, Carboniferous, Permian and Triassic rocks unfortunately lack areal continuity so that only isolated fault and fold structures can be identified. On the southwest flank, however, these rocks are widespread and a belt of imbricate structure can be traced readily southeast from Alaska into Yukon Territory, the faults decreasing in number and stratigraphic separation in that direction. In the vicinity of Barn Mountains they characteristically turn southwards, and give way to a region of essentially vertical, strike-slip faults with right-lateral separations (see Fig. 2). It will be noted that the senses of relative motion on the thrusts and strike-slip faults are mechanically congruent and that they cause relative motion in the uplift toward Beaufort Shelf.

Beaufort Shelf

Beaufort Shelf is the northernmost tectonic element in the Canadian Cordillera and may be regarded as the connection between the Cordilleran and Innuition orogenic systems (Fig. 1). Its northern limit is defined at the marked change in slope on the continental shelf and coincides approximately with the hundred fathom line. East of Mackenzie Delta its southern limit is taken arbitrarily as the shoreline of Beaufort Sea so that the element is structurally and stratigraphically continuous with Kugaluk Homocline. West of the Delta it extends onshore to the flank of Romanzof Uplift.

Information on the geology of Beaufort Shelf is limited. It comes from onshore studies of the rocks in the lower Babbage River area west of Mackenzie Delta, from bore holes such as I.O.E. Y.T.-N58 Spring River well and from gravity data of the Hudson 70 cruise. No column for Beaufort Shelf has been included in Table 1 and the Cretaceous formations are incorporated in the Romanzof Uplift stratigraphic succession.

On Babbage River immediately north of the frontal fault of Romanzof Uplift, the Lower part of the Mesozoic sequence contains grey, concretionary shales of Jurassic and ?Cretaceous ages. Triassic formations are absent from outcrop. Laterally discontinuous, argillaceous rocks and siltstones occur high in the succession and appear to be equivalents of the Lower Sandstone Division of Aklavik Range. The succession is overlain by a thick shale and, in turn, by a prominent, ridge-forming, clean quartz, littoral sandstone (White Quartzite Division). Overlying this is a monotonous interval of platy siltstone and shale grading upward into quartz sandstones and siltstones equivalent to the Aptian Upper Sandstone Division (Norris, 1972b, p. 97). The latter grade horizontally as well as vertically into an upper Lower Cretaceous flysch sequence comprising mostly covered, rusty weathering, concretionary shales with resistant intervals of siltstone and lithic arenites. Two prominent sets of clastic dykes composed of these arenites intrude the siltstones and shales on lower Babbage River.

Still younger rocks are exposed best north of Barn Mountains (Norris, idem). They comprise a very thick sequence of grey, marine shales of Late Cretaceous (Senonian) age which rests, presumably disconformably, on the Lower Cretaceous flysch. Their contact is not exposed. Discontinuous conglomerate and lithic sandstone beds occur in the upper part of these Senonian shales. They are characterized by deeply weathered, acid igneous pebbles similar to those reported (Norris, 1970, p. 233) from immediately west of Fish River, and they suggest an Alaskan provenance. The overlying crossbedded, lithic sandstone, shale and conglomerate succession (Moose Channel Formation, Table 1) contains coal seams of latest Cretaceous age (Norris, 1972b, p. 97) and the assemblage is strongly suggestive of distributary channel fill and backswamp organic accumulations on the lower reaches of a post-Laramide delta plain. Seaward they should grade into prodelta mudstones and shales continuous with the Senonian shales upon which they accumulated. They are the youngest rocks exposed west of Mackenzie Delta and seaward they are thought to thicken markedly and to be overlain by still younger Tertiary sediments (Yorath, 1973, Fig. 5) coeval with the Reindeer Formation in Kugaluk Homocline (Table 1).

The limited view of the structural style of Beaufort Shelf revealed from outcrop in the lower Babbage River area and from the single published profile across the shelf (Hofer and Varga, 1971) would suggest a stack of southwest-tapering wedges of Mesozoic and Tertiary sediments cut by northeast-dipping contraction and extension faults. The basement is the deformed Neruokpuk.

The Cretaceous clastic succession near the mouth of Babbage River commonly dips northeast at shallow to moderate angles. Evidence from outcrops and from air photographs would suggest repetition and thickening of the wedges on northeast-dipping contraction faults. There is, therefore, an abrupt reversal in asymmetry at the boundary with Romanzof Uplift, with southwest-dipping contraction faults characterizing the uplift, and northeast-dipping contraction faults, the shelf (Fig. 2). Seaward, the number of faults appears to decrease and the number of broad, open folds to increase (see Yorath, idem). According to Hofer and Varga (idem) some of these folds are piercement structures but whether they have cores of shale or salt remains to be proven with the drill.

Interpretation of the ages of the wedges offshore is facilitated by the abrupt step to the right or northeast of the flank of Romanzof Uplift and adjacent Beaufort Shelf in the vicinity of lower Babbage River. Northwest from Barn Mountains the structural grain in the Cretaceous assemblage swings through a re-entrant and a salient and all units are displaced sufficiently to the northeast that some project offshore to intersect the landward end of Hofer and Varga's profile near Herschel Island. The data suggest, therefore, that rocks within reach of the drill offshore will be Late Cretaceous and early Tertiary in age and that seaward thickening of these clastic wedges has depressed prospective reservoirs in older rocks accordingly.

Bouguer Anomaly Field

The Bouguer anomaly field in the northern Interior Platform and immediately adjacent parts of the Cordilleran orogenic system, the lower Proterozoic and older basement and of the Innuition orogenic system is included in figure 1 to illustrate regional differences in the gravity field and to facilitate geological interpretations on Beaufort Shelf. The data are transferred directly from the gravity map series of the Earth Physics Branch of the Department of Energy, Mines and Resources (Hornal et al., 1970; Stephens et al., 1972), and from unpublished Hudson 70 data (Geological Survey of Canada, Open File Rept. No. 91).

Although gravity measurements were confined largely to the country east and north of the orogen, it is apparent immediately that two basic patterns of anomalies are present. The one is the patchwork of relatively small positive and negative anomalies on the Interior Platform and on Banks Island where the shelf and miogeoclinal sedimentary veneer is relatively thin. The other comprises two laterally continuous sub-patterns, that of strong negative anomalies on the east flank of the orogen attributed to a thickened sedimentary sequence and a deeper crust-mantle boundary (Hornal et al., op. cit., p. 1), and that of strong positive anomalies on Beaufort Shelf and Canada Basin reflecting increasing water depth

(Sobczak and Weber, 1970, p. 12). The free-air gravity map (Wold et al., 1970) over the shelf, on the other hand, has a positive (100 mgal) high approximately paralleling the defined edge of Beaufort Shelf explained by Wold et al. (op. cit., p. 861) as a thinning of the sediment cover and a ridge of basement rocks.

The Bouguer anomalies on the flank of the Cordillera follow the arcuate form of Mackenzie Fold Belt and the north trend of Richardson Anticlinorium. They turn abruptly northeast to confirm suggestions of structural and stratigraphic continuity of Aklavik Arch beneath Mackenzie Delta. The contours identify, moreover, a relatively large negative anomaly on the east flank of the modern delta of Mackenzie River (Fig. 1), interpreted by Hornal et al. (op. cit., p. 9) as a possible thickening of the Cretaceous and Tertiary rocks there. The number of wells surrounding this anomaly emphasizes the economic interest in it. Two similar negative anomalies occur on Beaufort Shelf west of the Delta, one at the mouth of Fish River and one near the mouth of the Babbage. They identify significant thickening of the Late Cretaceous and early Tertiary depositional sequences which may well prove to be economically important when technology allows for offshore drilling.

Alaskan Fields and Promising Reservoirs in Northwestern Canada

The discovery of oil at Prudhoe Bay in 1968 has stimulated interest greatly in the hydrocarbon potential of the Arctic Slope of Alaska and in the possible continuation or equivalence of the rocks southeast into Beaufort Shelf and Kugaluk Homocline. For these reasons the stratigraphic column for Prudhoe Bay as interpreted from Rickwood (1970) and Morgridge and Smith (1972) has been included in Table 1.

The Prudhoe Bay structure* is a west-plunging anticlinal nose, faulted on the north, and truncated by a major unconformity at the base of the Cretaceous. The reservoirs in the field occur in the pre-Cretaceous sequence near their erosional edge. The up-dip truncation of the reservoirs by the northeast dipping unconformity and the seal provided by the overlying Lower Cretaceous shale furnish the critical trapping mechanism. The major part of the reserves is in the sandstones and conglomerates representing southwardly prograding, braided stream deposits in the upper part of the Permian and Triassic Sadlerochit Formation. Additional reserves are known to occur in limestones and dolomites of the Lisburne Group, limestones and sandstones of the Triassic Shublik Formation, dolomitic sandstones of the Jurassic Sag River Formation, and in shales and sandstones of the Upper(?) Jurassic Kuparuk River Formation (Table 1). Late Albian shoreline sandstones near the top of the Lower Cretaceous sequence provide the reservoirs for oil in the Alaskan Umiat and Simpson fields, and Senonian shoreline sandstones near the base of the Upper Cretaceous-Tertiary sequence are the reservoirs for gas in the Gubik field.

The overstepping of the Mississippian to Triassic sequence occurs in the subsurface of the Prudhoe Bay area whereas it occurs on Romanzof Uplift in northern Yukon Territory. Thus the chances of preservation of stratigraphic equivalents of the Prudhoe Bay

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*All data in this paragraph are abstracted from Rickwood (1970) and Morgridge and Smith (1972).

reservoirs on Beaufort Shelf in Canada are not good. The shelf lies structurally north of the overstep and Jurassic shales and sandstones rest on the Neruokpuk basement (Norris, 1972b, p. 96). A 330-foot interval of dark grey, argillaceous limestones and calcareous shales at the bottom of the I.O.E. Spring River bore hole, however, appears to be an erosional remnant of the Triassic Shublik Formation. No macrofossils and no conodonts were recovered from it (T. T. Uyeno, pers. com., 1973). Thus neither a definitive age for the unit nor the local preservation of potential reservoir rocks of pre-Jurassic age could be ascertained.

The skeletal and skeletal-micritic limestones of the Carboniferous Lisburne Group are overlapped northeastward, first by the Triassic (see Plate 7) and then by the Jurassic (see Plate 8) along the northeast margin of Romanzof Uplift. A line defining their northern limit would trend southeast along the flank of the uplift, then swing in arcuate fashion north of White and Richardson Mountains to intersect Aklavik Arch. They would not, therefore, appear to be present either in Beaufort Shelf or Kugaluk Homocline.

The westerly prograded, porous, quartz-rich sandstones equivalent to the Upper(?) Jurassic Kuparuk River Formation, although variable in thickness, are widespread on the northwest flank of Aklavik Arch and on structural depressions within the arch. They appear to be delta-front sheet sands pinching out westwards into a Late Jurassic shale basin and their fluviatile equivalents on the flanks of the arch beneath Mackenzie Delta hold considerable promise as stratigraphic traps.

Upper Lower Cretaceous shoreline sandstones provide the reservoirs for oil in the Umiat and Simpson fields in northern Alaska (Morgridge and Smith, 1972, p. 491) and serious consideration should be given their stratigraphic equivalents both east and west of Mackenzie Delta. East of the delta they appear to be overstepped on the northwest flank of Aklavik Arch by uppermost Lower Cretaceous shales (Norris, 1973); west of the delta, in the vicinity of lower Babbage River, they may be projected beneath a suitable cover of Upper Cretaceous (Senonian) shales. The latter, the reader will recall, contain shoreline gas sands in the Gubik field.

The youngest rocks in the delta region to show promise are reported (Oilweek, Dec. 11, 1972, p. 8) to be Tertiary in age and to have been penetrated in the I.O.E. Mallik L-38 and the Shell Niglintgak H-30 wells. They may be part of the Lower Tertiary Reindeer Formation (Table 1) and indicate additional potential at suitable depths on southern Beaufort Shelf and adjacent Kugaluk Homocline.

The Kaltag Fault and Global Tectonics

The Kaltag Fault has been traced northeast across Alaska from Bering Sea to the junction of Yukon and Tanana Rivers, a distance of 275 miles (440 km). According to Patton and Hoare (1968, p. D147) reconnaissance evidence suggests that it is a major fault having right-lateral offset of between 40 and 80 miles (64 and 128 km) since Cretaceous time. At its southwest extremity in Alaska it splays (see King, 1968), one branch cutting diagonally across Koyukuk Basin into Norton Sound (Fig. 3), and the other trending more southwesterly to skirt the basin and enter the continental shelf of Bering Sea a little farther south. Northeastward it has been extrapolated across Yukon Flats Basin (Tailleur and Brosgé, 1970, Fig. 12) to enter Canada on the south flank of the Old Crow granites. The latter authors named the total feature the Kaltag Yukon Porcupine Fault and recognized that the sense of motion on it (and on the Tintina Fault) was that required if Arctic Alaska had become detached from the rest of the state and was being shortened during late Mesozoic and Cenozoic time.

A major, northeast-trending fault system has been mapped by the writer in Yukon Territory on trend with the Kaltag Fault. One of the components entering Canada immediately south of Porcupine River forms the north boundary of Aklavik Arch (Fig. 2). A highly sheared, basic intrusion occurs on it in Canada and the Cenozoic, basic lavas in immediately adjacent Alaska may be the result of fissure eruptions along it. At the headwaters of Driftwood River it has a kink like that in the San Andreas fault on the southwest flank of the Mojave Block, and it appears to merge with one of the major faults transecting the Aklavik Arch. From there onto Beaufort Shelf it is an array of nearly vertical, north-trending faults. The possibility that the Kaltag Fault extends across Beaufort Shelf to the southern edge of Canada Basin is suggested by the marked kink in the Bouguer anomaly field on the shelf (see Fig. 1). The kink indicates a relatively positive feature on trend with the fault array and may identify dense intrusions, like those along the north flank of the Aklavik Arch, on the fault.

The boundary between the North American and Eurasian continental plates commonly has been drawn or inferred in the Bering Sea region and in various parts of northeastern U.S.S.R. (Wilson, 1963; Heezen and Tharp, 1965; Le Pichon, 1968; Morgan, 1968; Hamilton, 1970; Ross and Ingram, 1970; and Churkin, 1971). Some authors emphasized the considerable evidence for long-established geological connections across the Bering-Chukchi Seas, and Churkin (1970, p. G3) concluded that Alaska and northeast U.S.S.R. have been connected since Paleozoic and probably since Precambrian time. It was apparent, therefore, that the North American and the Eurasian continental plates were joined across Bering Strait during the time of relative westward Atlantic drift of North America away from Eurasia and of Pacific drift toward toward Eurasia, and that the boundary between the two plates lay inland either to the east or west of Bering Strait.

The principle of sea-floor spreading and concomitant drifting of North America from Eurasia is now generally accepted, but there appear to be at least two contrasting views as to how these plate motions were accommodated in Arctic polar regions. The one view, proposed by Carey (1958, p. 198-201) suggests that the two continental plates separated from one another about a pivot in North America (in the region of Mt. McKinley) and that the great arcuate bend in the orogen in Alaska (the Alaskan "orocline") and the opening of the Canada Basin were direct results of these plate motions. Canada Basin was accordingly a tension rift originating in the Mesozoic. The other view (see for example, Wilson, 1963) is that the two plates separated about a pivot in Siberia (New Siberian Islands) and that the Canada Basin is an ancestral feature in existence in mid-Mesozoic time.

Proponents of Carey's concept must assume the responsibility for documentation of compressive features on the concave side of the "orocline" and of tensional or relaxational features on the convex side. In addition, they must continuously bear in mind compelling evidence that Alaska and easternmost Siberia were one structurally and stratigraphically continuous province during the time of drifting. A careful examination of the Tectonic Map of North America (King, 1968) does not convince the writer that there could have been a pivot point either near Mt. McKinley as indicated by Carey (idem) or in northern Canada as suggested by Tailleur and Brosgé (1970, Fig. 14). The writer sees neither evidence of wholesale tension or relaxation transverse to the Cordilleran trend on the outside of the arc, nor of wholesale compression on the inside of the arc compatible with bending the orogen about a vertical axis. The impressively arcuate form of the Denali Fault System might conceivably be considered concrete evidence of compression and slip inside the "orocline" in much the manner of slip on curviplanar, flexural-slip surfaces in a cylindrical fold, but the sense of slip on the faults should be expected to reverse about the surface of symmetry of the "orocline". Abundant geophysical and geological evidence is quite to the contrary.

The major faults of this system are regionally dextral, compatible with counterclockwise rotation of the Pacific plate and not with bending of the orogen about some pivotal axis in Alaska or Canada.

Proponents of the concept of a pivot point in Siberia realistically transfer the problem to still more remote regions. Wilson (1963, p. 927), in suggesting the New Siberian Islands, at the apex of the triangular Siberian Basin, as the pivot acknowledged that differential spreading of Lomonosov Ridge from Barents Shelf provided adequate extension on the one side of the pivot, and compressive folding in Verkhoyansk Mountains in eastern Siberia provided opportune transverse shortening on the other.

Churkin (1972, p. 1033) proposed that the plate junction lay between the Cherskiy and Verkhoyansk fold belts in eastern Siberia (Fig. 3) rather than within the Verkhoyansk Mountains as suggested by Wilson (1963, Fig. 1). According to Churkin (op. cit., p. 1031) "Large-scale displacements of geologic trends, overturned folds, thrust faults, mélanges, great transcurrent faults, and associated high-pressure metamorphism and igneous activity that are to be expected along compressional plate boundaries have not been found here". The edge of the major fault zone comprising Cherskiy Mountains, Churkin added, marks the western limit of the Paleozoic geosyncline in the Cherskiy Mountains and is the fossil boundary along which the Eurasian and North American continental plates were sutured by Early Cretaceous time. Continued Atlantic drift after suturing, especially during the Late Cretaceous and early Tertiary, produced internal deformation resulting in sharp bends in the structures of Alaska and northeast U.S.S.R. (Churkin, 1970, p. G5).

Norris (1972b, p. 98) conveyed the concept that the Kaltag Fault might possibly be a plate junction because it cuts through the Cordilleran Orogenic System from Bering to Beaufort Seas (Fig. 3). It has displacement measurable in several tens of miles, its sense of movement is right-lateral, compatible with the differential motion of the two plates in the Tertiary, and because it would appear to link the curvilinear escarpment flanking southern Canada Basin and the (DeGeer) transform fault between the Mid-Atlantic and Gakkel Ridges with the circum-Pacific fold belt. The Kaltag Fault was postulated, therefore, to extend from Bering Strait to the Mid-Atlantic Ridge, and its northeastern part was destined to become the DeGeer transform fault. Whether or not the cluster of northeast trending, down-to-basin faults cutting Kugaluk Homocline is genetically part of this plate junction remains to be proven.

The Kaltag Fault and its continuations to the northeast and southwest have many of the earmarks of a fossil plate boundary as quoted from Churkin. In addition to offset of gross geologic trends (Patton and Hoare, 1968, p. D149) in western Alaska, Carboniferous sedimentary facies appear to be offset right-hand to the northeast in northern Yukon Territory (see Bamber and Waterhouse, 1972, Fig. 13) as does also the shale-carbonate transition on the west flank of the lower Paleozoic graptolitic basin in the same area (Norris, D. K., unpublished maps). Moreover, the close association of thrust and strike-slip faults in the Kandik Thrust Belt and the Aklavik Arch strongly resembles that between the Pine Mountain, the San Andreas and other faults in southern California (see King, 1968). Also the basic intrusions along the Kaltag Fault as well as the intimate spatial relation between the fault and the Cenozoic basic volcanics in eastern Alaska support the premise of a major geological discontinuity crossing Alaska and Canada onto Beaufort Shelf. To the southwest the boundary conceivably might extend beneath Bering Sea to connect with the circum-Pacific rim (see Fig. 3). The protracted and complex geological history of the Aklavik Arch, including Devonian or older granitic intrusions in the Old Crow area, may, in addition, identify early tectonic activity associated with plate motion and interaction.

Conclusions

The structural geometry and geological history of northern Yukon Territory and northwestern District of Mackenzie are among the most complicated in the Cordilleran Orogenic System. The complexity may be related to interaction of the North American and Eurasian continental plates. Initially the plates were separated by a seaway in eastern Siberia. In mid-Mesozoic (possibly Early Jurassic) seafloor spreading on the Mid-Atlantic Ridge (Fig. 3) caused the ancestral North American plate, including Canada Basin, to drift westward. Collision of the plates by the Early Cretaceous (Churkin, 1972, p. 1035) resulted in suturing along a north-trending line between the Cherskiy and Verkhoyansk fold belts, and orogeny and thrusting in Romanzof Uplift and Kandik Thrust Belt.

Continued westward drift of the ancestral North American plate resulted in internal deformation on both sides of the suture. The Verkhoyansk, Kamchatka, Chukotka and Brooks Range fold belts buckled, and in the Late Cretaceous it is postulated that the ancestral North American plate failed in shear on the Kaltag Fault from Bering Strait to the Mid-Atlantic Ridge. The boundary, therefore, may have been transferred from one of compression in eastern Siberia in the Early Cretaceous to one of right-lateral shear in northern Alaska and Canada in the Late Cretaceous. The Canada Basin was now detached from the North American plate.

The fact that the latest Cretaceous and early Tertiary molasse depocentres west of Mackenzie Delta on either side of the Kaltag Fault are juxtaposed would suggest, however, that large-scale motion on the fault ceased by the end of the Cretaceous Period. Subsequent relative westward drift of the North American plate, including Canada Basin, was accomplished in the Tertiary by spreading on both the Mid-Atlantic and Gakkel Ridges (Fig. 3), with concomitant right-lateral motion on the DeGeer Fault.

The model requires simple westward drift of the North American plate and does not require simultaneous rotation of Alaska and adjoining parts of Siberia out of a position adjacent to the Canadian Arctic Archipelago. The constraints imposed by the hypothesis of an Alaskan orocline are unnecessary complications and are not founded in geological fact. True oroclines in the northern Cordillera and their structural and stratigraphic continuations into Siberia, if they exist at all, are confined to the buckled ranges between and adjacent to the old and new plate boundaries.

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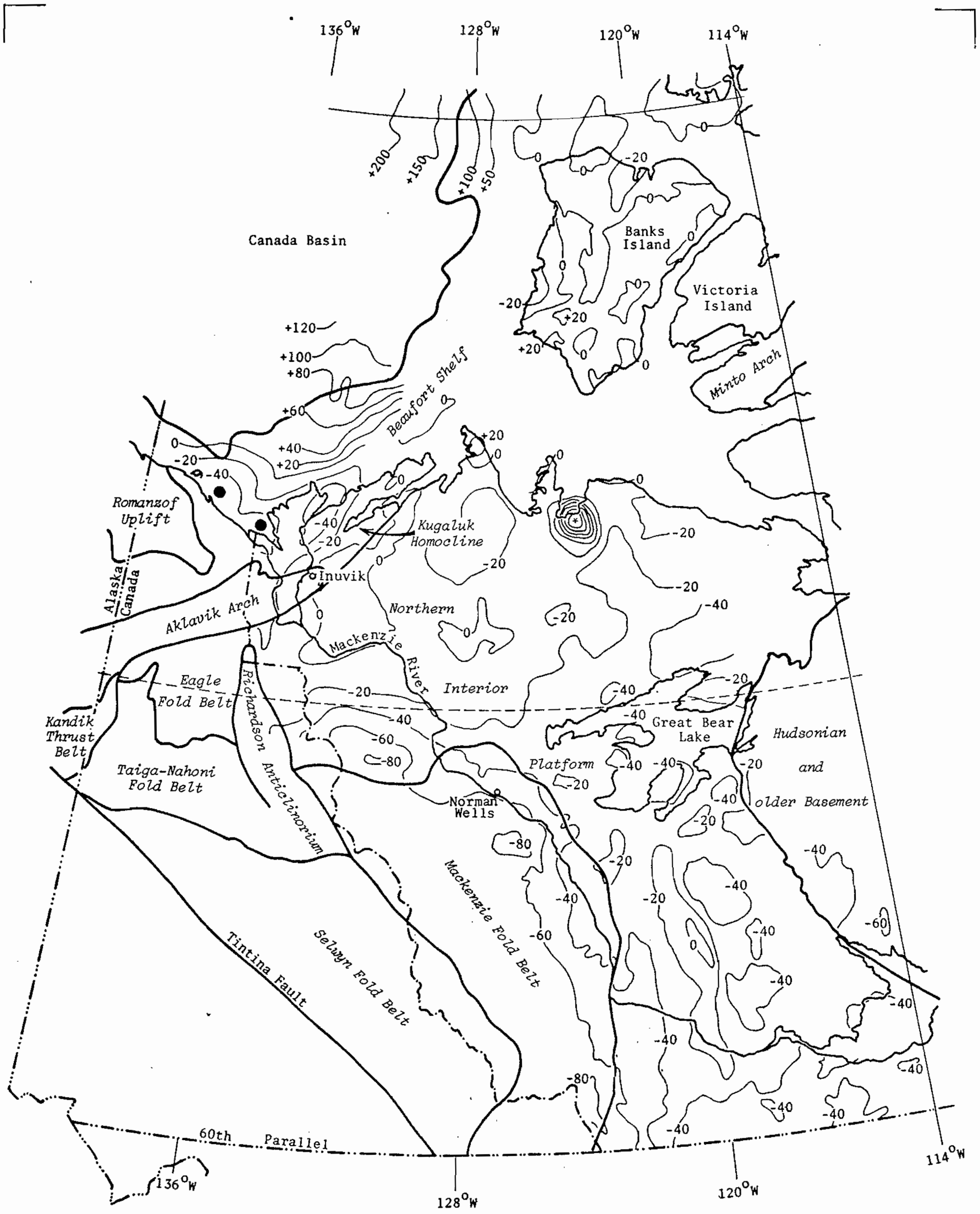
Figure and Table Captions

Figure 1. The principal tectonic elements (heavy outlines) in the northern Canadian Cordillera and Bouguer gravity field over adjacent Interior Platform and Beaufort Shelf. Late Cretaceous and Tertiary depocentres on Beaufort Shelf opposite the mouths of Fish and Babbage Rivers are shown as solid circles (•).

Figure 2. Outline map of northwestern Canada showing some structures characterizing or outlining the following tectonic elements: 1. Hudsonian and older basement; 2. northern Interior Platform; 3. Selwyn Fold Belt; 4. Mackenzie Fold Belt; 5. Richardson Anticlinorium; 6. Taiga-Nahoni Fold Belt; 7. Eagle Fold Belt; 8. Kandik Thrust Belt; 9. Aklavik Arch; 10. Kugaluk Homocline; 11. Minto Arch; 12. Romanzof Uplift; 13. Beaufort Shelf. Spirit, Caribou, Treeless Creek, and Kaltag Faults, and Imperial Anticline are marked SF, CF, TCF, KF and IA, respectively.

Figure 3. Major tectonic features of the Arctic (with permission after Churkin, 1972), with the Kaltag Fault and its extrapolations superposed.

Table 1. Stratigraphic correlation chart for the northern Canadian Cordillera and Prudhoe Bay, Alaska.



Contours of equal Bouguer anomalies in milligals
*Darnley Bay High is +119 mgals

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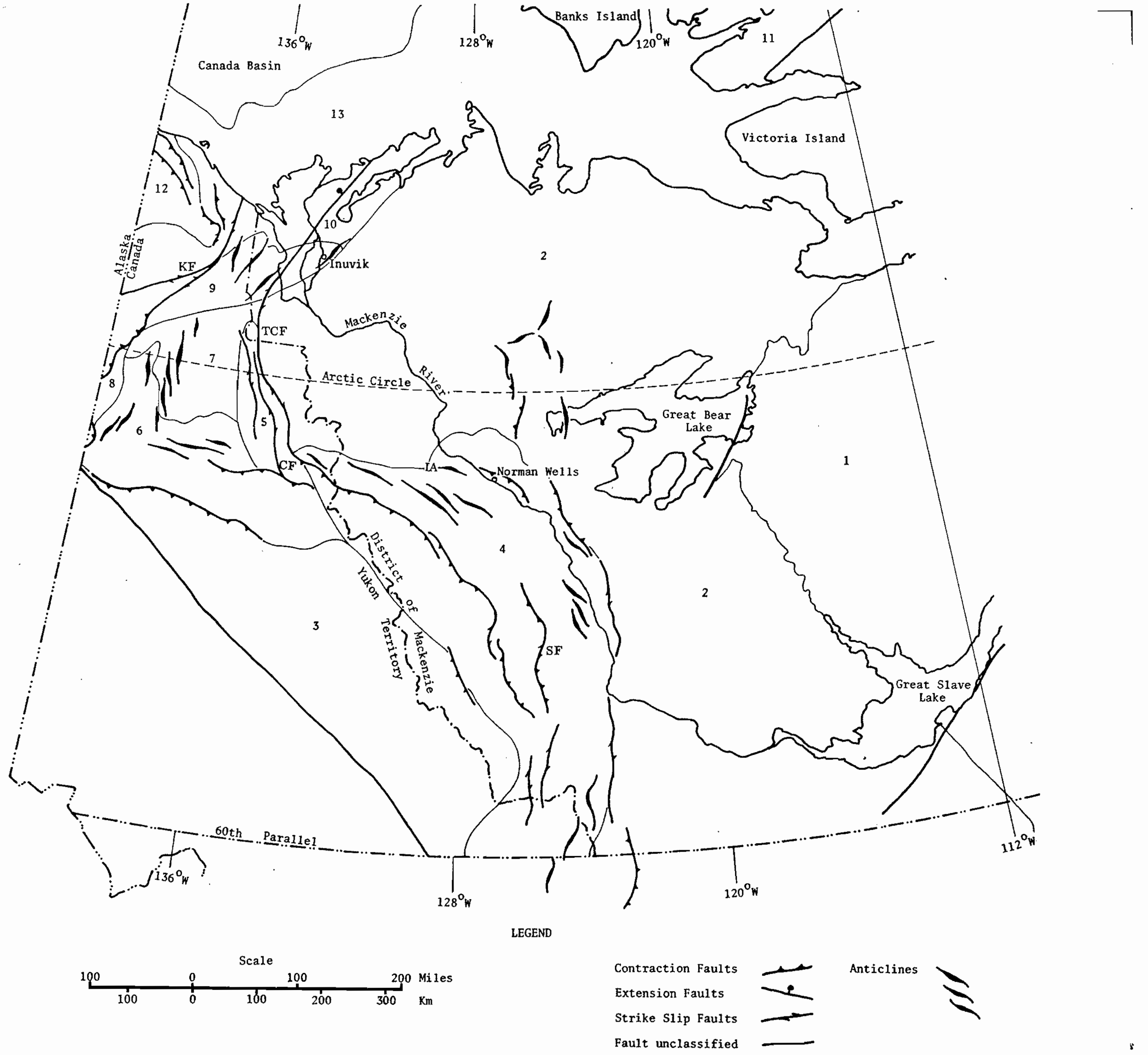
Figure 1


Canada Basin
136°W
128°W
Banks Island
120°W
11
13
Victoria Island
12
10
Inuvik
2
Alaska
Canada
KF
9
TCF
Mackenzie
7
Arctic Circle
River
8
Great Bear
Lake
1
6
5
CF
LA
Norman Wells
4
2
District of Mackenzie
Yukon Territory
3
SF
Great Slave
Lake
60th Parallel
136°W
128°W
120°W
112°W
LEGEND
Scale
100
0
100
200 Miles
100
0
100
200
300
Km
Contraction Faults
Extension Faults
Strike Slip Faults
Fault unclassified
Anticlines

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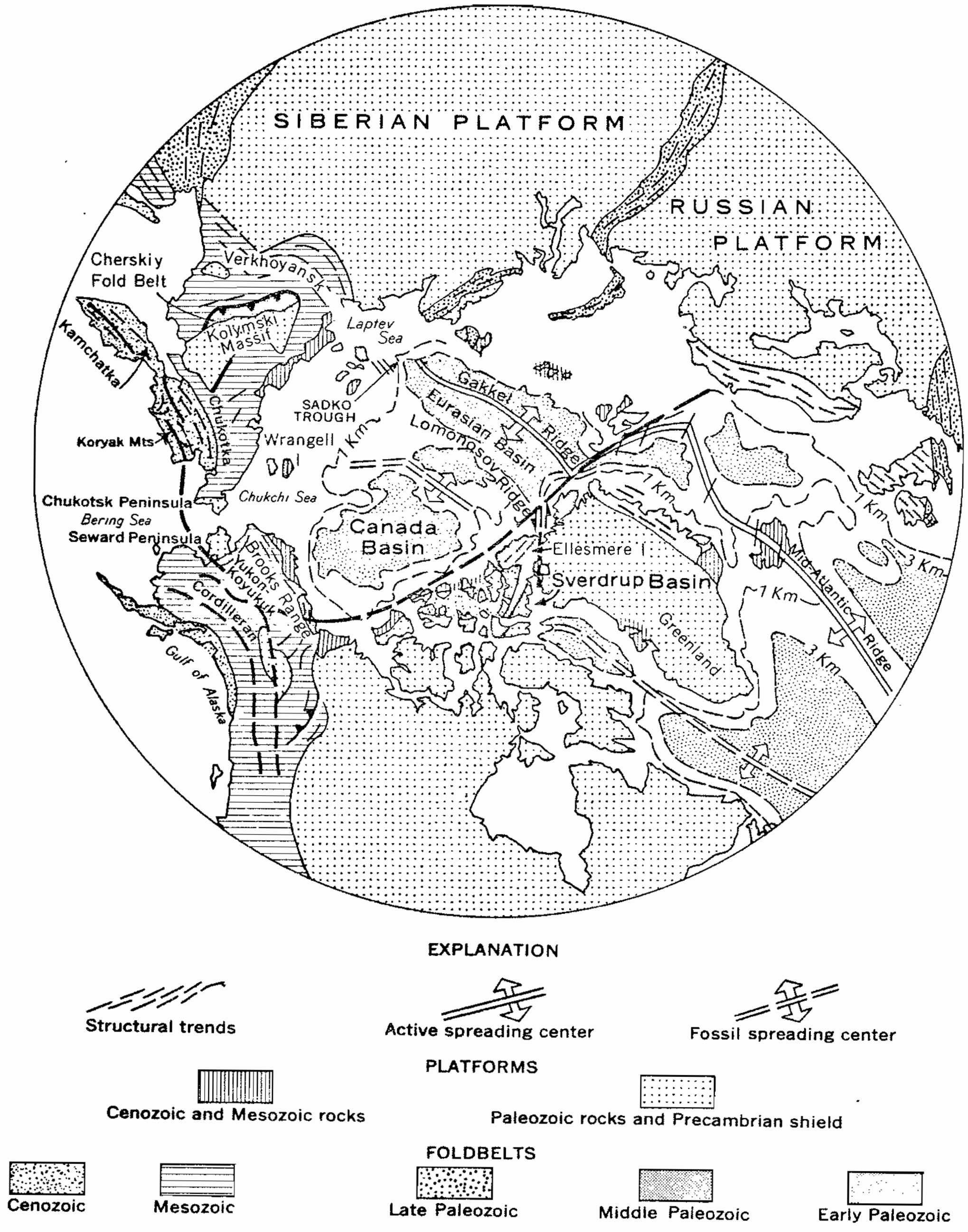
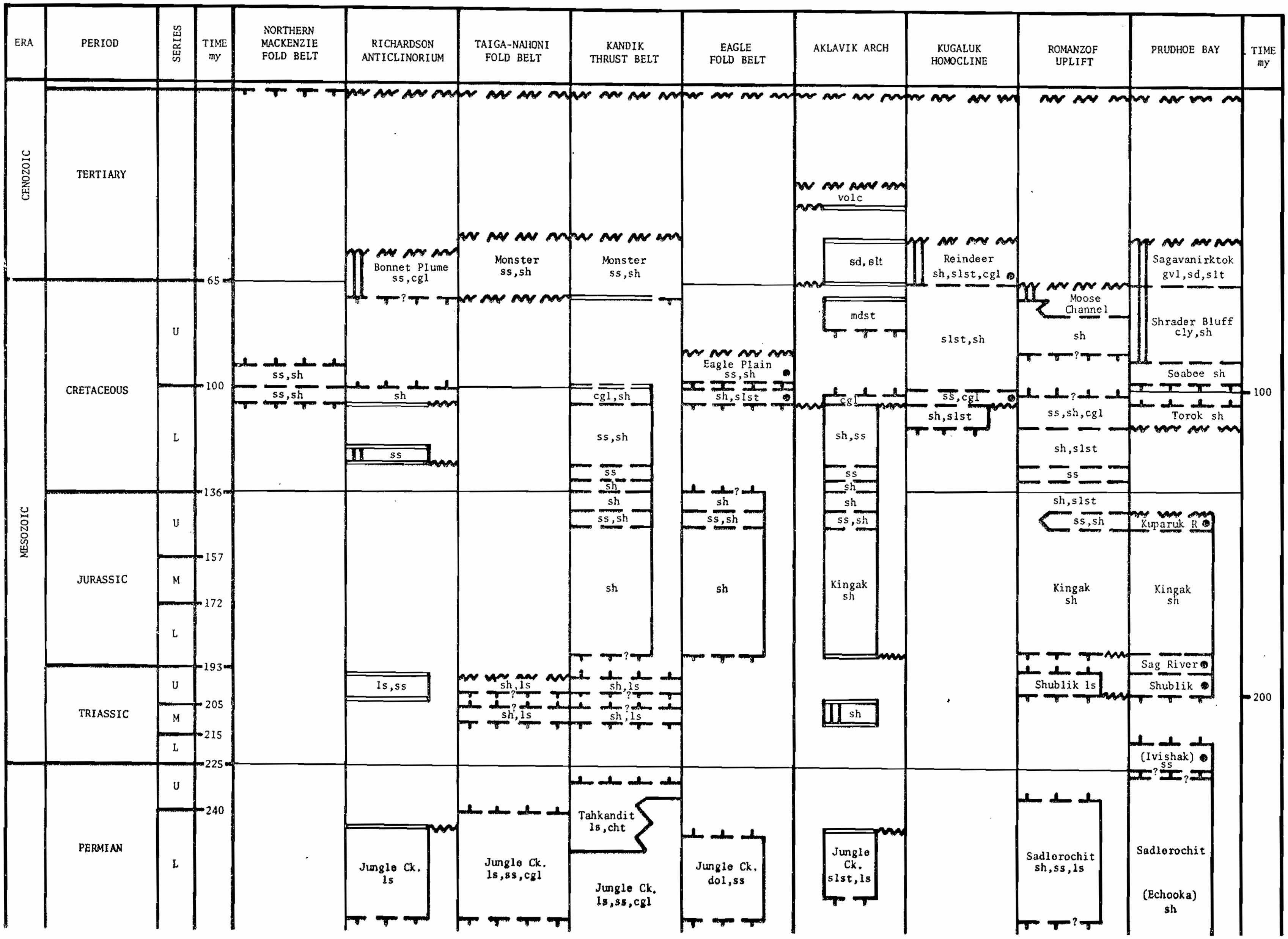


D.K. Norris Fig. 3

CORRELATION CHART

NORTHERN YUKON TERRITORY, NORTHWESTERN DISTRICT OF MACKENZIE AND PRUDHOE BAY



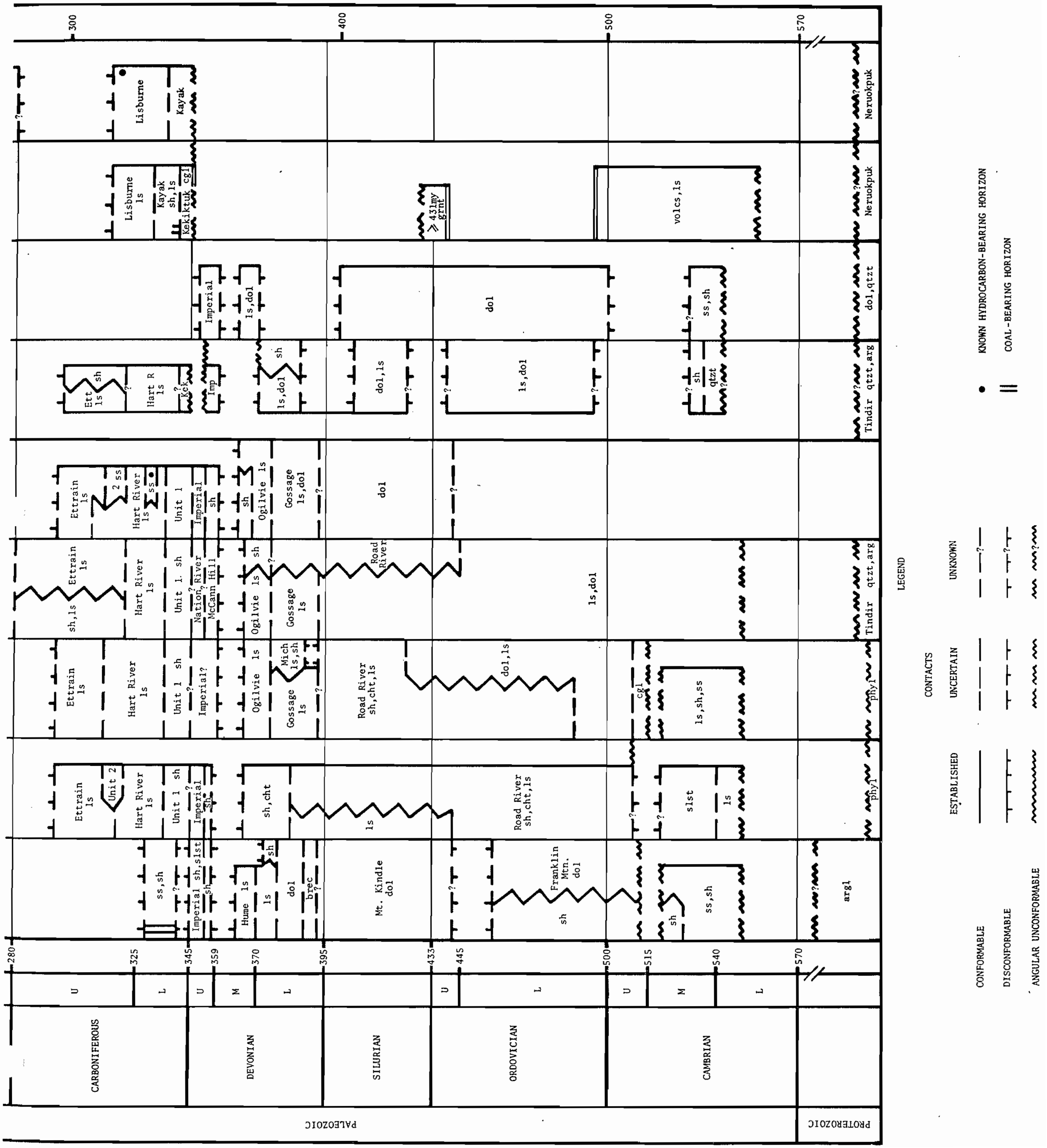

PALEOZOIC
PROTEROZOIC
CARBONIFEROUS
DEVONIAN
SILURIAN
ORDOVICIAN
CAMBRIAN
U
L
M
280
325
345
359
370
395
433
445
500
515
540
570
300
400
Lisburne
Kayak
Neruokpuk
Lisburne ls
Kayak sh,ls
Kekiktuk cgl
≥ 431my grnt
volcs,ls
Imperial
ls,dol
dol
ss,sh
dol,qtzt
Ett ls
sh
Hart R ls
Kek
Imp
ls,dol
dol,ls
ls,dol
qtzt
Tindir qtzt,arg
Ettrain ls
2 ss
Hart River ls
ss
Unit 1
Imperial
Ogilvie ls
Gossage ls,dol
Road River
sh,ls
Unit 1. sh
Nation River
McCann Hill
Gossage ls
Unit 1 sh
Imperial?
Mich ls,sh
Road River sh,cht,ls
dol,ls
cgl
ls,sh,ss
phyl
Unit 2
sh,cht
Road River sh,cht,ls
slst
ss,sh
Imperial sh,slst
Hume ls
brec
Mt. Kindle dol
Franklin Mtn. dol
argl
LEGEND
CONTACTS
ESTABLISHED
UNCERTAIN
UNKNOWN
CONFORMABLE
DISCONFORMABLE
ANGULAR UNCONFORMABLE
KNOWN HYDROCARBON-BEARING HORIZON
COAL-BEARING HORIZON

Plate Captions

1. The western margin of stable shelf carbonates of the Franklin Mountain Formation (FM) at the termination of Mackenzie Mountains near the headwaters of Noisy Creek, northern Yukon Territory. Coeval graptolitic shales of the Road River Formation (RR) occur on the northeastern flank of Knorr Range (NAPL oblique photograph no. T4-100R).

2. Treeless Creek Fault (TCF) trending south on the east flank of Aklavik Range (foreground) and Richardson Anticlinorium (background), western District of Mackenzie (NAPL oblique photograph no. T3-15L).

3. Angular unconformity between bedded, slaty argillites of Proterozoic age, and quartzite pebble- and cobble-conglomerate of Late Cambrian age on the right bank of Hart River, southern Taiga Ranges, Yukon Territory. Photo taken looking northeast.

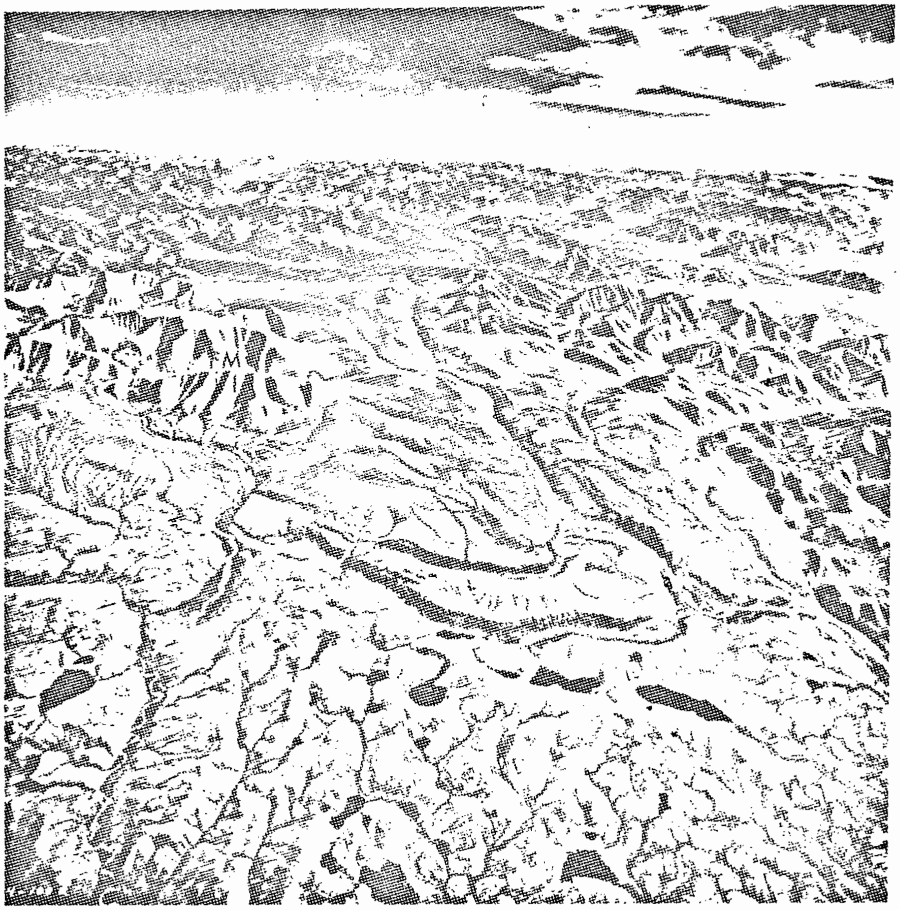
4. South-dipping fault thrusting siliceous dolomites of Cambrian and/or Ordovician age over Middle Devonian limestones in Taiga Ranges, Yukon Territory, immediately east of Blackstone River. Photo taken looking east.

5. Angular unconformity between Lower Cretaceous shales and lower Tertiary sands and silts on the right bank of unnamed tributary to Campbell Lake, east of Mackenzie Delta. Photo taken looking northeast.

6. Angular unconformity between slaty argillites and quartzites of the Proterozoic Neruokpuk Formation (PNe), and gently north-dipping clastics and carbonates (CL) of Carboniferous age. Photo taken looking northwest across lower Malcolm River, northern Yukon Territory.

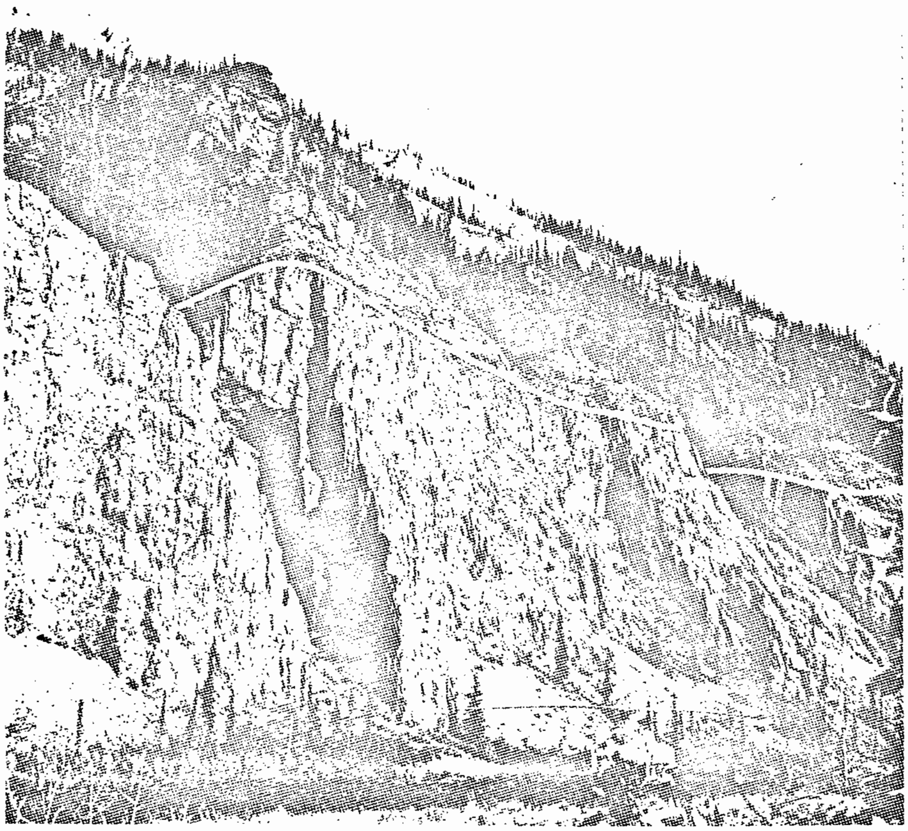
7. Locally disconformable contact between Upper Triassic Shublik limestone (TRSh) and pale red, Proterozoic Neruokpuk argillites (PNe) on a small tributary of Loney Creek on the north flank of Romanzof Uplift, northern Yukon Territory. Photo taken looking southeast.

8. Angular unconformity between slaty argillites and quartzites of the Proterozoic Neruokpuk Formation (PNE) and Jurassic Kingak shales (JK) on Beaufort Shelf near Spring River, northern Yukon Territory. Photo taken looking southeast.



D.K. Norris Plate 1

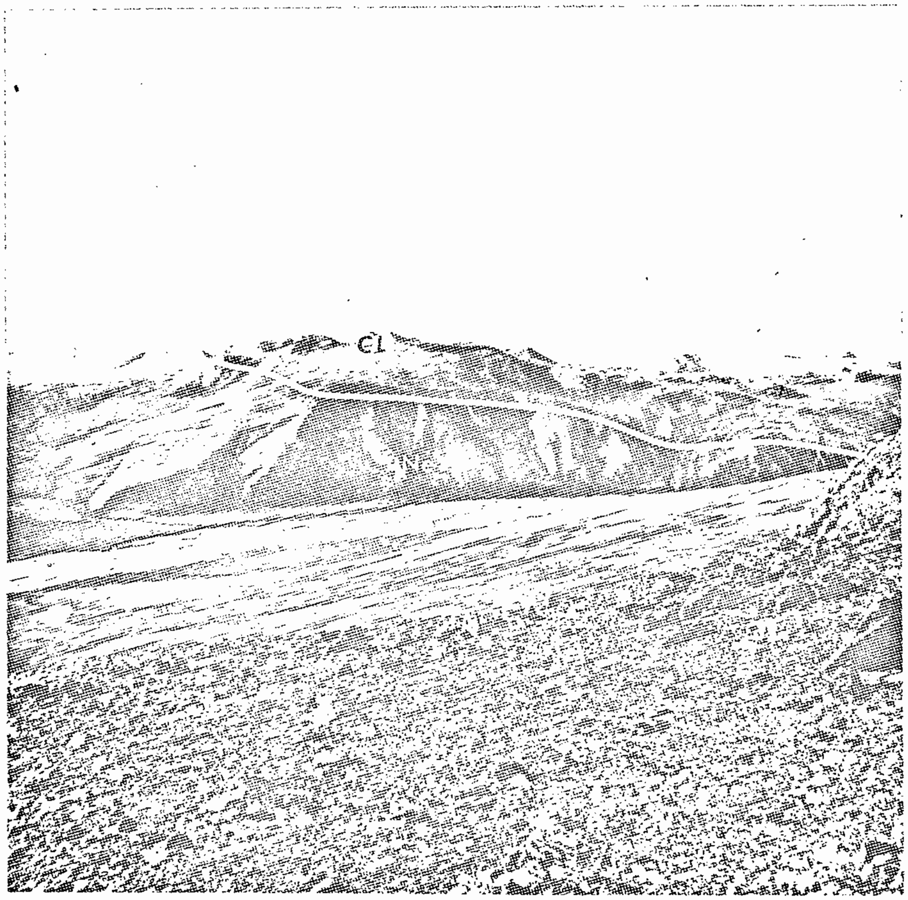
D.K. Norris Plate 2



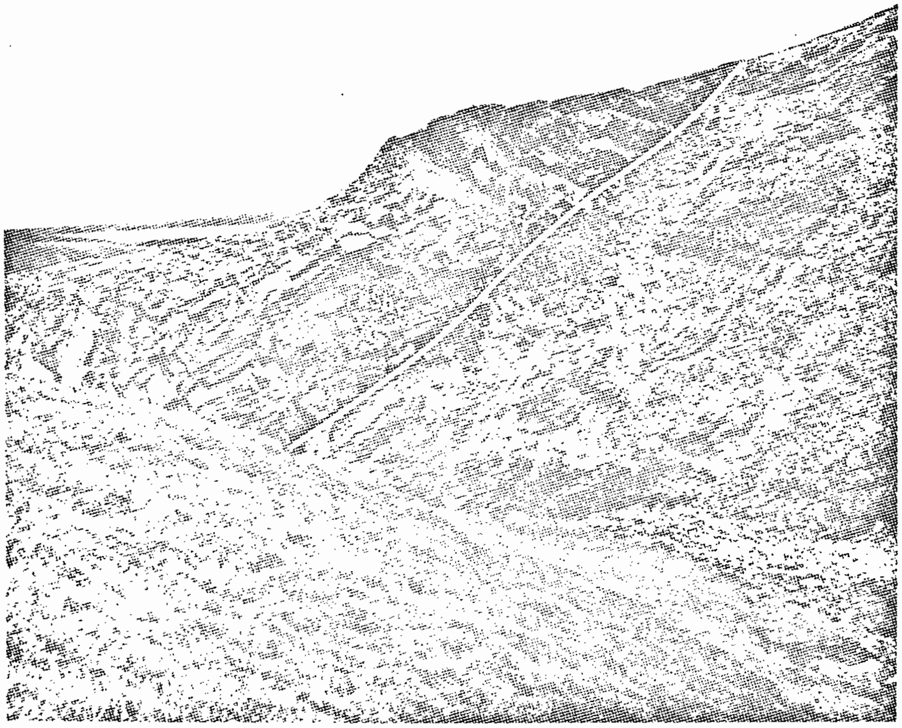
D.K. Norris Plate 3

D.K. Norris Plate 4

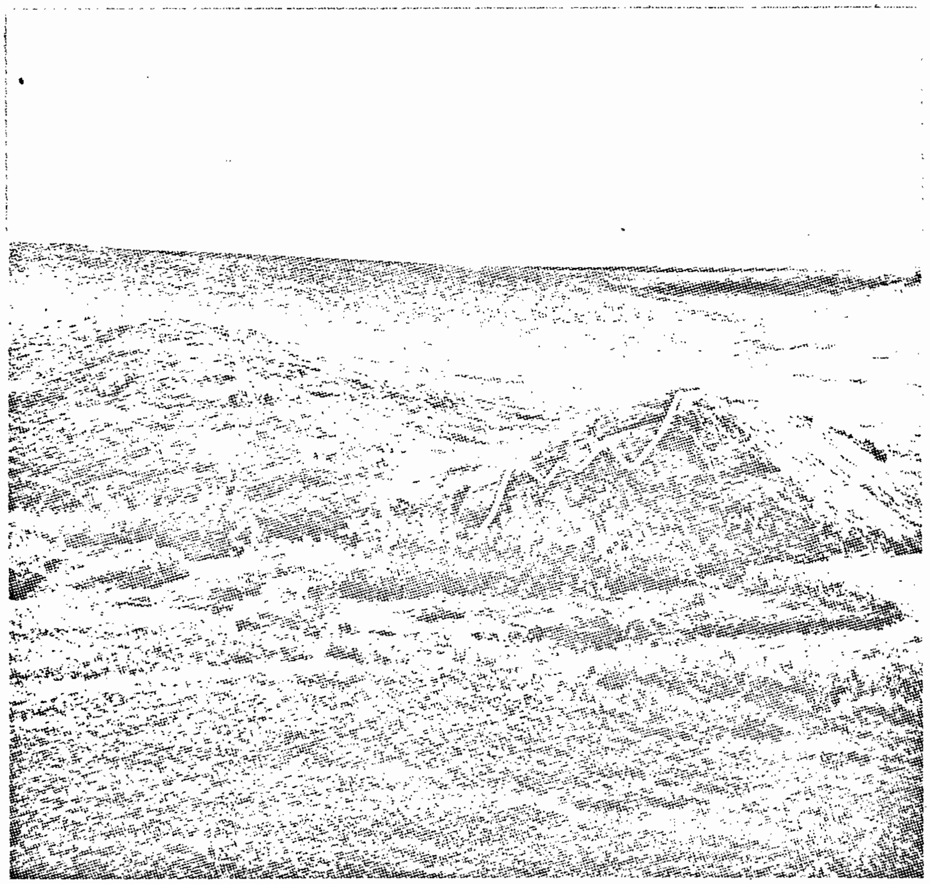
D.K. Norris Plate 5



D.K. Norris Plate 6



D.K. Norris Plate 7



D.K. Norris Plate 8