JURASSIC-LOWER CRETACEOUS (OXFORDIAN TO LOWER APTIAN) (A CONTRIBUTION TO THE GEOLOGICAL ATLAS OF THE NORTHERN CANADIAN MAINLAND SEDIMENTARY BASIN)

James Dixon

INTRODUCTION

Oxfordian to Aptian strata have a similar distribution to that of the underlying Bug Creek Group, except that they overlap the older Jurassic beds at the basin margins. This overlap is seen south of Rat Uplift, under northern Eagle Plain, and under southern Mackenzie Delta and the Tuktoyaktuk Peninsula. Upper Aptian-Lower Albian strata likewise overlap Jurassic and Berriasian to Lower Aptian strata, such that they underlie a much larger area of northern mainland Canada than older Mesozoic rocks (see Dixon, this volume).

The main areas of outcrop are in the British, Barn, northern Richardson, and northern Ogilvie mountains, and parts of the Keele Range (Fig. 1). In the subsurface, Oxfordian (Upper Jurassic) to Lower Cretaceous rocks are best known from the Tuktoyaktuk Peninsula and the southern part of Mackenzie Delta. A thin wedge of Jurassic and lowermost Cretaceous strata are preserved in the subsurface of the northern edge of Eagle Plain. Elsewhere, the only positively identified Jurassic-lowermost Cretaceous strata occur about 100 km east of the northern end of Tuktoyaktuk Peninsula, in the subsrface at the Horton River G-02 well. There, Upper Jurassic rocks have been identified, unconformably overlain by Aptian-Albian strata (Brideaux and Fisher, 1976, p.8). Strata identified as possibly containing Lower Cretaceous rocks have been noted from an inlier in the western Mackenzie Mountains (Blusson, 1971: ages cited in McMechan and Thompson, 1993). However, a critical evaluation of the unpublished Geological Survey of Canada paleontological reports and the regional geological setting suggest that these strata contain only Albian to Upper Cretaceous rocks, and the older ages are due to recycling of material into younger rocks, plus the misuse of long-ranging taxa for dating purposes (unpublished paleontological reports to S. Gordey, pers. comm., 1994).

As with the older Jurassic rocks, the Oxfordian to Lower Aptian succession consists of a series of alternating sandstone-dominant and shale-dominant formations at the southeastern and southern basin margin, with some of the older sandstone formations grading westward, northwestward and soutwestward into a thick shale-dominant succession.

PREVIOUS WORK

Jeletzky (1958, 1960, 1961, 1964, 1967, 1971a,b, 1972, 1973, 1974, 1975a,b, 1977, 1980, 1984) was the first to conduct comprehensive stratigraphic studies of Jurassic and Cretaceous strata in the northern mainland, presenting reports on the litho- and biostratigraphy. More detailed work followed with Young (1971, 1972, 1973, 1975), Young et al. (1976), Cote et al. (1975), Brideaux, (1976a,b, 1977), Brideaux and Fisher (1976), Brideaux and Myhr (1976), Dixon (1979, 1982a,b, 1983, 1986, 1990, 1991, 1992a,b,c, 1993), Dixon and Jeletzky (1991), Dixon et al. (1989), Fensome, (1987), Fowler (1985), Fowler and Braun (1993), and Embry and Dixon (1990).

Norris et al. (1963), Norris (1981a-l, 1982a-d, 1985) and Tempelman-Kluit (1973) have published maps showing the distribution of Jurassic-Cretaceous strata.

GEOLOGICAL FRAMEWORK

Oxfordian to Lower Aptian strata are present within the Arctic Alaska, Porcupine, and North American terranes (Gabrielse et al., 1992). The bulk of the outcrops occur mostly within the Foreland Belt of the Cordillera, with a few within the Omineca Belt.

A number of uplifts and depressions affected Jurassic and Early Cretaceous sedimentation (Fig. 2) and they are a reflection of the extensional tectonic activity prevalent during this time period (Dixon, 1993). Positive elements include the Cache Creek, White and Romanzof uplifts, Eskimo Lakes Arch, Tununuk High, and Eagle Arch. Negative elements include the Kugmallit Trough, Canoe, Rapid and Old Crow-Babbage depressions, Vittrekwa Embayment, and the Kandik Basin. Although these elements are identified on present-day structural-stratigraphic relationships most have had a long history and parts, or the whole, of each element may have had a Jurassic or Cretaceous expression in its evolution. Not all of these elements were active continuously during the Jurassic and Cretaceous, in fact some of the positive features were only extant during parts of the Early Cretaceous. Also, all of these elements have been severely overprinted by Late Cretaceous and Early Tertiary compressional and strike-slip deformation. Although erosion of some Lower Cretaceous strata can be interpreted on the east flank of the Barn Uplift (Dixon, 1991), it would appear that the erosion preceded Albian deposition but older activity, in the Jurassic and earliest Cretaceous, is less evident from the surrounding stratigraphic units. However, some thinning of units adjacent to the Barn Uplift could indicate penecontemporaneous activity.

STRATIGRAPHY

STRATIGRAPHIC NOMENCLATURE

A fairly uniform stratigraphic nomenclature has been applied to most of the Jurassic and Lower Cretaceous rocks of the northern Yukon and adjacent NWT (Fig. 3; Jeletzky, 1967, 1977; Dixon and Jeletzky, 1991; Dixon, 1992). In the northernmost areas the basin margin succession tends to consist of a series of alternating shale- and sandstone-dominant intervals that generally have been given formational rank. At some stratigraphic horizons the sandstone-dominant intervals can be shown to pass laterally into shale-dominant successions.

Oxfordian to lower Berriasian strata are present in the shale-dominant Husky Formation. Sandier lateral equivalents of the Oxfordian to Tithonian, lower Husky Formation are the Porcupine River and North Branch formations. In the latter formation the sandier facies extend at least into the lower Berriasian. All of the above formations are the basin-margin equivalents of the more distal, shale-dominnant, Jurassic to Valanginian succession of the Kingak Formation.

Upper Berriasian strata are present in the sandstone-dominant Martin Creek Formation, which also passes laterally westward into shale of the Kingak Formation. Abruptly overlying the Martin Creek Formation is the shale-dominant McGuire Formation. Locally the McGuire rests erosionally on older strata (Jeletzky, 1980; Dixon and Jeletzky, 1991; Dixon, 1993). Valanginian strata are also present in the Kingak Formation.

Gradationally overlying the McGuire Formation is the sandstone-dominant Kamik Formation, which is regionally divisible into a Lower and Upper member (Dixon, 1991). The Martin Creek, McGuire and Kamik formations are part of the Parsons Group.

Abruptly to unconformably overlying the Kamik, and older beds, is the upper Hauterivian to Barremian, shale-dominant, Mount Goodenough Formation. In the northern Richardson Mountains and under southwestern Mackenzie Delta, Mount Goodenough strata are gradationally succeeded by interbedded sandstone and shale of the upper Barremian to lower Aptian Rat River Formation. Under Tuktoyaktuk Peninsula the upper Hauterivian to lower Aptian succession is represented by the much thinner, sandstone and conglomerate succession of the Atkinson Point Formation.

Throughout mainland Northwest Territories and the northern Yukon, Upper Aptian to Lower Albian strata rest abruptly to erosionally on underlying beds (see Dixon, this volume).

STRATIGRAPHIC HISTORY

Oxfordian to Early Cretaceous history of the area can be viewed in terms of a series of regional transgressive-regressive (T-R) events, each separated by major disconformities or unconformities (Dixon, 1992b). These sedimentary cycles developed during a period dominated by extensional tectonics (Dixon, 1993) in the northern Yukon and adjacent NWT. Compressional tectonic activity was occurring in the Cordillera further to the south but its influence on sedimentation in the northwestern mainland did not manifest itself until the late Aptian-Early Albian, when foredeeps began to develop in parts of the north (Dixon, 1993).

The end of Bug Creek deposition is marked by a major transgressive event that extended depositional limits eastward and southeastward, onto the craton. Deposition of the Husky, North Branch and Porcupine River formations followed. The North Branch and Porcupine River formations represent the shoreline to inner shelf, sandstone-dominant facies of the Oxfordian to Tithonian interval. These facies are present in the Vittrekwa Embayment, along the northern flank of Eagle Arch, extending northeast along the southern and southwestern flanks of Cache Creek Uplift, and southwestward into the northernmost Ogilvie Mountains. These sandstone-rich intervals pass laterally into the shalier shelf succession of the Husky Formation to the northeast. Throughout most of the northern Ogilvie Mountains the Oxfordian to Tithonian interval is a shale-dominant succession. However, erosion at a sub-McGuire unconformity has removed considerable amounts of pre-Valanginian strata. Northwestward of the sandy facies belt are the offshore to basinal shales of the Kingak Formation. Figure 4 illustrates the interpreted reconstruction of Tithonian paleogeography.

A major transgression marks the Jurassic-Cretaceous boundary and is seen in the uppermost beds of the Arenaceous member, Husky Formation (Jeletzky, 1958; Dixon 1993). An erosional discontinuity is present in the uppermost beds of the Tithonian Arenaceous member (Dixon, 1993), overlain by a thin succession of transgressive sandstone and granulestone, in turn abruptly overlain by Berriasian shale of the Red-weathering member, Husky Formation.

The Red-weathering and Upper members of the Husky Formation represent the regressive offshore muds of a Berriasian T-R cycle. The offshore shales are gradationally succeeded by nearshore to shoreline sandstones of the upper Berriasian Martin Creek Formation (Dixon, 1991). However, the Martin Creek sandstones grade laterally westward into marine shelf shale of the Kingak Formation (Fig. 5). North of Eagle Arch and in the northernmost Ogilvie Mountains, the Berriasian transgression is reflected in the abruptness of Berriasian shale overlying Porcupine River sandstone. A thin remnant of lower Berriasian strata in the sandstone-dominant North Branch Formation (Jeletzky, 1967), preserved in the Vittrekwa Embayment, probably represents the oldest shoreline sands of the Berriasian T-R- cycle. Figure 5 is an interpretation of late Berriasian paleogeography.

The next major unconformity is between Valanginian and older strata. In most areas, shale of the Valanginian McGuire Formation rests abruptly on sandstone of the Berriasian Martin Creek Formation. However, in a few areas, such as south of McDougall Pass, in the northern Richardson Mountains (Jeletzky, 1980; Dixon 1991), and in the northern Ogilvie Mountains (Dixon, 1991), McGuire strata rest erosionally on pre-Martin Creek beds. Generally there is no distinct transgressive facies at the base of the Valanginian succession, although in the subsurface of Tuktoyaktuk Peninsula a local pebble-lag deposit has been identified in core (Dixon, 1982). Where McGuire strata rest erosionally on Husky beds there is a shale-on-shale contact with very few visual characteristics to distinguish between the two shale types.

Gradationally succeeding the marine shelf shale of the McGuire Formation are nearshore to deltaic sandstone and conglomerate beds of the Lower member, Kamik Formation (Fig. 6). Deltaic beds of the Lower member, Kamik Formation, are present under Tuktoyaktuk Peninsula and the eastern margin of the northern Richardson Mountains, grading westward and southwestward into nearshore marine sandstone. In the farthest northwestern occurrences there are inner shelf bioturbated sandstones (Fig. 6; Dixon 1991).

A transgressive surface is interpreted to separate the Lower and Upper members of the Kamik Formation, based on the regional mappability of the contact and the prominent facies change across the contact (Dixon, 1991, 1992b). The timing of this discontinuity is poorly constrained due to the lack of fossils in this interval. Based on regional considerations and dating of strata well above and below the discontinuity, it is believed to have formed some time near the Valanginian-Hauterivian boundary. The Upper member of the Kamik Formation almost everywhere consists of a series of coarsening-upward sedimentary cycles. Only in the extreme northwest, adjacent to the British Mountains, are regular coarsening-upward cycles not recognized due to the dominance of shale within this section. The Upper member is dominated by nearshore to shoreline deposits with mid-shelf sediments preserved only in the British Mountains outcrops.

A major regional unconformity separates late Hauterivian strata from older beds. This unconformity is widespread throughout northwestern mainland Canada and can be traced into adjacent northeast Alaska and an equivalent unconformity is present in the Arctic Islands (Embry and Dixon, 1990). Subcrop patterns at the sub-Mount Goodenough unconformity, especially between the Eskimo Lakes Arch and Cache Creek uplifts, reveal an erosional pattern typical of half-graben formation. This unconformity marks the end of a major period of extensional faulting.

Above the late Hauterivian unconformity there developed local, thick, coarse-grained siliciclastic transgressive beds of the Mount Goodenough Formation. In other places the transgressive beds are mostly silty shale. Above the transgressive beds the bulk of the Mount Goodenough Formation consists of marine shelf to slope, shale and siltstone, which grade upwards into inner shelf to nearshore sandstones of the Rat River Formation. Towards the basin margin the upper Hauterivian to lower Aptian succession is represented by shoreline sandstone and conglomerate, with a local fan-delta developed along the western margin of the Eskimo Lakes Arch (Atkinson Point Formation: Dixon, 1979; Dixon et al., 1989; Fig. 7),

A major Late Aptian-Early Albian transgression marks a major tectono-stratigraphic boundary, ending a period dominated by extensional faulting and the beginning of a period of both extensional and compressional tectonics, presaging the dominance of compressional tectonics throughout the Late Cretaceous and Tertiary (Dixon, 1993). The beginnings of the development of foreland basins in front of the northward migrating deformation front of the Cordilleran Orogen marks this late Aptian to Albian period of deposition. However, at the margins of the Eskimo Lakes Arch, extensional faulting continued as the proto-Arctic Ocean began to develop (Embry and Dixon, 1990).

REGIONAL CROSS SECTIONS

Figures 8 to 10 illustrate the stratigraphy, thickness and general lithology of the Jurassic to Lower Aptian succession in the northwest mainland. Figure 8 represents a transect from the Eskimo Lakes Arch, across the Eskimo Lakes Fault Zone, along the Kugmallit Trough, to the eastern margin of the Cache Creek Uplift. This transect clearly illustrates the rapid thickening of strata across the fault zone, in part depositional, but also due to pre-Mount Goodenough/Atkinson Point erosion. Pre-Mount Goodenough erosion also is seen in the Aklavik A-37 well, which is on eastern flank of the Cache Creek Uplift. Also illustrated in Figure 8 is the eastward overlap of Bug Creek strata by the Husky Formation.

Figure 9 is a line of section from the Vittrekwa Embayment into the Rapid Depression, along the southern flank of the Barn Uplift to the Romanzof Uplift. Significant pre-Mount Goodenough erosion is evident in the southeast, adjacent to the eastern bounding faults of the Richardson Mountains, and in the northeast, adjacent to Romanzof Uplift. Also illustrated is the facies change in the Jurassic to Berriasian succession, from a sandstone-dominant interval (North Branch and Porcupine River formations) in the southeast to a shale-domnant succession in the northwest (Kingak Formation).

The third cross section (Fig. 10) extends from the eastern flank of Kandik Basin, northwards into the northern Ogilvie Mountains. Major thickening of the succession to the north is evident. Some of the thickness change in the Kingak Formation is due to an intra-Kingak unconformity in the southern section (Dixon, 1991, 1992c). Also seen on this section is the north-to-south facies change from the sandstone and shale succession of the Porcupine River Formation to the shale-dominant Kingak Formation.

REFERENCE LOGS AND STRATIGRAPHIC SECTIONS

The most complete and readily described Oxfordian to Lower Aptian sections are present in the subsurface of Mackenzie Delta and Tuktoyaktuk Peninsula. There, the Parsons N-10 well is used to illustrate the succession (Fig. 11). Husky strata rest unconformably on lower Paleozoic chert and carbonate. The subsurface Lower member, Husky Formation (Dixon, 1982) is equivalent to Jeletzky's (1967) Lower and Arenaceous members and consists of a series of thin shale-to-siltstone or sandstone, coarsening-upward cycles, of which the most prominent is the uppermost cycle. The latter cycle is probably equivalent to the Arenaceous member. The contact between the subsurface Lower and Upper members of the Husky Formation approximates the Jurassic-Cretaceous boundary, and is a readily identified log marker that can be correlated with ease throughout the subsurface. (Dixon, 1982, 1991; Braman, 1985).

The Upper member, Husky Formation is gradationally overlain by the coarsening-upward, sandstone-dominant, Martin Creek Formation. McGuire strata are thin in the N-10 well and abruptly overlie Martin Creek sandstones and are abruptly overlain by the Kamik Formation. Kamik strata are readily seen to be divisable into a Lower and Upper member based on the gamma-ray log signature and lithological succession. A blocky log trace is characteristic of the Lower member, whereas the Upper member has a more ragged log response. In adjacent wells the Upper member has several well-defined coarsening-upward intervals (e.g., Kamik D-58, Parson L-43; Dixon, 1982, 1991).

Abruptly overlying Kamik strata is the shale-dominant Mount Goodenough Formation. In the subsurface, a distinct shale interval between the top of the Kamik and the base of an intra-Mount Goodenough sandstone has been identified as the Siku Member (Dixon et al., 1989; originally defined as a formation by Dixon 1982).

The Rat River Formation and/or Atkinson Point Formation, which usually overlies Mount Goodenough Formation, cannot be identified in the Parsons N-10 well because of the silty shale character of the equivalent interval. The contact between the Upper Aptian to Albian Arctic Red Formation and the underlying Mount Goodenough Formation is a readily correlated log marker (Dixon et al., 1989), even though the two units are predominantly shale.

To illustrate the lithological succession and gamma-ray signature of the Atkinson Point Formation, the Atkinson H-25 well is used (Fig. 12). Atkinson Point strata in the H-25 well consist of thinly interbedded conglomerate and sandstone in the lower two-thirds of the formation overlain by a sandstone interval (Dixon, 1979). The gamma-ray log is typically blocky in its signature. Abruptly overlying Atkinson Point strata are shales of the Arctic Red Formation.

The character of the Rat River Formation is illustrated by the gamma-ray log trace and lithological succession in the Fish River B-60 well (Fig. 13). In this well the Rat River Formation consists of a series of coarsening-upward cycles, the lowest of which gradationally overlies Mount Goodenough shale. The uppermost Rat River beds consist of thinly interbedded sandstone and shale. These upper beds are abruptly overlain by ironstone-rich shale of the Albian Rapid Creek Formation. This succession in the B-60 well is very similar to the outcrop of Rat River Formation about 25 km to the south, on Fish River (see fig. 23, in Dixon 1992c).

Descriptions of the type and/or reference sections in outcrop and subsurface for the various Berriasian to Lower Aptian formations can be found in Jeletzky (1967 - Husky and North Branch formations; 1977 - Porcupine River Formation), Dixon (1989 - Atkinson Point Formation), Dixon (1991 - Kamik Formation), and Dixon and Jeletzky (1991 - Martin Creek, McGuire, Mount Goodenough and Rat River formations).

STRUCTURE

As previously indicated, the Early Cretaceous was a period dominated by extensional faulting. Although much of the northern mainland outcrops of Lower Cretaceous strata now occur within the foldbelt of the Cordillera there is sufficient evidence based on patterns of erosion at various unconformities, interpretation of the stratigraphy and structure of reflection seismic data along the Eskimo Lakes Arch, and local thickness variations, to interpret the extensional fault regime for the Early Cretaceous. By far the best evidence comes from reflection seismic data along the Eskimo Lakes Arch (see seismic lines illustrated in Embry and Dixon, 1990; Dixon et al., 1992). Because there has been very little overprinting of the earlier structures along Eskimo Lakes Arch by compressional forces, the large extensional faults forming the northwest margin of the arch are readily imaged on reflection seismic. Also, the relative abundance of exploratory wells along this part of the arch ensures precise stratigraphic control on the seismic interpretations.

Associated with one of the main bounding faults along Eskimo Lakes Arch is a rollover anticline at Parsons Lake which contains large reserves of natural gas (Cote et al., 1975). The main Lower Cretaceous stratigraphic units in this structure exhibit thinning on the crest of the anticline, indicating that the structure grew during sedimentation.

Although most of the Early Cretaceous extensional faulting has been masked in the Cordillera by thrust faults, strike-slip faults and folds, it is highly probable that some of the major Late Cretaceous and Tertiary faults are reactivated extensional faults. Such may be the case for the Rapid Fault Array, between the Barn and northern Richardson mountains. This fault array follows an Early Cretaceous depocentre (Rapid Depression) and the eastern faults in the array form the western boundary of the Cache Creek Uplift, a feature that was a tilted fault block during some periods of the Early Cretaceous (based on the subcrop patterns below a regional late Hauterivian unconformity).

THICKNESSES AND LITHOLOGY

Some of the thickest sections of Jurassic and Lower Cretaceous strata occur in the Kugmallit Trough, Rapid Depression and Kandik Basin, where about 1500-2000 m of Jurassic to Lower Aptian strata occur. However, the thickest succession probably occurs at the northern end of the Ogilvie Mountains where there may be in the order of 3000 m or more of strata. At this location, however, possible structural repetition may exaggerate thicknesses. Thickness data for the various Jurassic and Lower Cretaceous formations is reasonably well documented for the subsurface occurrences in the Mackenzie Delta area but less well constrained for the mountain regions.

Husky Formation

The Husky Formation is predominantly shale, with significant amounts of siltstone and very fine to fine grained sandstone in the Lower and Arenaceous members. Shale is predominant in the beds above the Arenaceous member, with increasing amounts of thin interbeds of siltstone and very fine grained sandstone in the upper part of the unit. In the northern Richardson Mountains the lowermost Berriasian beds are rich in ironstone concretions which weather a distinct rusty red colour, hence the named Red-weathering member of Jeletzky (1967). These beds are gradationally succeeded by grey to black shale with thin siltstone interbeds of the Upper member.

In the nearby subsurface occurrences, the Husky Formation is divided into two members (Dixon, 1982; Braman, 1985). The lithological succession and log signatures show similar vertical facies trends to those seen in outcrop. The Lower member consists of interbedded shale, siltstone and sandstone, abruptly overlain by the shale-rich Upper member.

A gradational lithological change marks the Husky to Martin Creek boundary. The gradational interval between the Husky and Martin Creek formations usually consists of thinly interbedded siltstone and sandstone. Most beds tend to be thoroughly bioturbated, although finely laminated beds become increasingly more common close to the contact with the Martin Creek Formation.

Thicknesses up to 750 m for the Husky are known in the subsurface of Mackenzie Delta-Tuktoyaktuk Peninsula and up to 640 m have been reported from outcrop (Jeletzky, 1967; Fig. 14). Regional trends indicate that thicknesses up to 1000 m are possible on the western flanks of the Richardson Mountains.

North Branch Formation

North Branch strata are present only in the central Richardson Mountains (Jeletzky, 1967; Dixon 1992c) where they consist of fine to coarse grained sandstone with some interbeds of conglomerate, siltstone and shale. At the type section, on the eastern slopes of the central Richardson Mountains, there is 160 m of North Branch Formation (Jeketzky's, 1967, type section) that is now known to contain equivalents of the Mount Goodenough Formation in the uppermost beds (see Dixon, 1992c, p.16). The amount of interbedded coarse grained sandstone and conglomerate declines to the northwest and northeast as the formation passes laterally into the Porcupine River and Husky formations.

Porcupine River Formation

Porcupine River strata extend from the western slopes of the central Richardson Mountains, along the Keele Range into the northernmost Ogilvie Mountains. These strata grade laterally into Husky and Kingak shales to the west, northwest, northeast and southwest, and into the North Branch Formartion to the southeast. At the type section in Salmon Cache Canyon on Porcupine River, the Porcupine River Formation consists of very fine to fine grained sandstone with some interbedded silty shale and siltstone. Northwest and southwest of the type area the amount of intercalated shale increases as the facies change and pass laterally into the Husky Formation.

Jeletzky (1977) divided the type section into a lower nonmarine succession and an upper marine succession. The identification of the nonmarine facies was based on the carbonaceous to coaly nature of the sandstones and siltstones, and the presence of some questionably nonmarine bivalves. The marine facies are more definitive in their identification, being replete with marine bivalve coquinas. Also, northeast and southwest of the type area, hummocky cross stratified beds are very common in the upper strata of the Porcupine River Formation (personal observation by Dixon).

Jeletzky (1977) measured 529 m of strata at the type section but in the headwaters of Waters River, to the northeast of the type section, there is in excess of 1000 m of Porcupine River strata (Jeletzky, 1977; Fig. 14).

Martin Creek Formation

Martin Creek sandstone tends to gradationally succeed the Husky Formation but in a few localities there is a more abrupt lithological change. The sandstones are very fine to fine grained and subparallel laminae, hummocky cross stratification and ripple laminae are the most common sedimentary structures. Vertical burrows and bivalve shell accumulations are a common feature of many beds.

Under southern Mackenzie Delta and southwestern Tuktoyaktuk, and the eastern slopes of the northern Richardson Mountains the Husky to Martin Creek succession is a single coarsening-upward cycle, locally capped by a thin interval of interbedded shale and sandstone in the subsurface (Dixon 1982, 1991). However, on the western slopes of the northern Richardson Mountains and in the northern Ogilvie Mountains, the Martin Creek Formation contains a series of coarsening-upward cycles, where each sandstone interval is separated by a shale interval (Dixon, 1991).

Up to 150 m of Martin Creek strata have been measured, with up to 200 m projected to be present, in the Kugmallit Trough (Dixon, 1991; Fig. 15). Martin Creek strata thin toward the basin margin largely due to sub-McGuire erosion, although some thinning can be attributed to depositional trends. Westward and northwestward, Martin Creek strata thin because of a facies change to the equivalent shale interval in the Kingak Formation.

McGuire Formation

Abruptly to erosionally overlying the Martin Creek Formation are shales of the McGuire Formation. The lowermost beds are almost entirely shale with some local concretion-rich horizons. However, there is a gradual upward increase in the amount and thickness of interbedded siltstone and very fine grained sandstone. The majority of the coarser siliciclastic beds are thoroughly bioturbated, although some subparallel, horizontal laminae and ripple laminae may be locally preserved. Some beds contain bivalve shells.

Thicknesses are highly variable, even over short distances. Under Mackenzie Delta-Tuktoyaktuk Peninsula it is up to 50 m thick, yet on the adjacent eastern slopes of the northern Richardson Mountains it is only 7 to 17 m thick. At the type section, on the western slopes of the Richardson Mountains it is about 260 m thick (Dixon and Jeletzky, 1991). In the northern Ogilvie Mountains it varies between 40 and 100 m (Fig. 16). In parts of the British and Barn Mountains, the Martin Creek Formation cannot be identified as a distinct sandstone formation, consequently the McGuire-equivalent interval is part of the shale-dominant Kingak Formation (Fig. 16).

Kamik Formation

Gradationally to locally abruptly overlying the McGuire Formation are sandstones of the Lower member, Kamik Formation. Under southern Mackenzie Delta-Tuktoyaktuk Peninsula the Lower member consists of very fine to very coarse grained sandstone, and some conglomeratic beds, interbedded with thin shale and coaly shale units (Dixon, 1982, 1991). These lithotypes are commonly arranged in fining-upward cycles of fluvial channel origin, although some marine strata are present in the upper beds of the Lower member. Similar facies are seen on the eastern slopes of the northern Richardson Mountains (Dixon, 1991). On the western slopes of the northern Richardson Mountains, the northern Ogilvie Mountains and the British and Barn Mountains, the Lower member is more uniform in appearance, consisting of finely laminated to thoroughly bioturbated, very fine to fine grained sandstone.

Throughout its area of occurrence, the Upper member, Kamik Formation, is less uniform in appearance than the Lower member. The typical characteristic of the Upper member is the presence of a series of shale-to-sandstone, coarsening-upward cycles. Sandstones within these cycles are very fine to fine grained, with some local thin beds of medium grained sandstone. The number of such cycles varies, with a few well defined cycles present under Tuktoyaktuk Peninsula, increasing in number westward into the Richardson and Ogilvie mountains. On the southeastern slopes of the British Mountains, the Upper member is shale rich and the cyclicity becomes less well defined (Dixon, 1991).

Kamik strata vary in thickness between 500 and 800 m throughout most of its known area of occurrence (Fig. 17). The thickest section on the southeastern flanks of British Mountains is up to 800 m thick (Dixon, 1991) but it is not known if local structural repetition is present in this area. Likewise, in the northernmost Ogilvie Mountains an 1800 to 2000 m thick section may have unidentified structural repetitions (Dixon, 1991). The Lower member tends to be between 100 and 200 m thick, whereas the upper member is much more variable in thickness, in part due to sub-Mount Goodenough truncation but also due to depositional trends. The Upper member is usually in the order of 500 to 700 m thick but a section in the northern Ogilvie Mountains contains in excess of 1700 m of the Upper member. However, as previously indicated, at the latter location there may be some unidentified structural repetition.

Mount Goodenough Formation

Abruptly to erosionally overlying the Kamik or older formations is the Mount Goodenough Formation. Shale with ironstone concretions is the dominant lithology although thin interbeds of siltstone and very fine grained sandstone are locally common, especially in the upper part of the formation. At the type area the formation is divisible into two members (Dixon and Jeletzky, 1991), a lower, shale-dominant member and an upper member that contains a significant amount of interbedded sandstone. However, this division into two members has not been carried into other areas of Mount Goodenough occurrence.

Locally developed basal coarse-grained siliciclastics are present, consisting of fine to very coarse grained sandstone and some thin granulestone and conglomerate beds (Dixon, 1992c). These coarser siliciclastics tend to occur on and adjacent to paleo-uplifts (e.g., Cache Creek High). Trough cross beds, planar cross beds, ripple laminae, and large vertical and U-shaped burrows, are present in these basal beds.

Thicknesses range from about 200 m in the northern Ogilvie Mountains, to between 300 and 500 m in the northern Richardson Mountains and an estimated 1000 m in Kugmallit Trough (Fig. 18).

Rat River Formation

Gradationally to abruptly overlying the Mount Goodenough Formation is the sandstone-rich Rat River Formation. This latter formation is present only in the northern Richardson Mountains and parts of the subsurface of southern Mackenzie Delta. On the eastern slopes of the northern Richardson Mountains the formational contact is abrupt and erosional, elsewhere it is gradational (Dixon, 1992c). Throughout most of its area of occurrence, the Rat River Formation typically consists of a number of shale-to-sandstone coarsening-upward cycles (Dixon, 1992c). The sandstones typically are replete with hummocky cross strata and bivalve shell debris. However, the sandstone facies tend to become more bioturbated to the west, and west of Rapid Depression, Rat River strata are either eroded or laterally replaced by shale of a stratigraphically extended Mount Goodenough Formation.

The known complete thicknesses of Rat River strata vary from about 200 m in the subsurface near the type area of Rat River (Dixon, fig. 32, 1992) to about 600 m on the east flank of Rapid Depression (Fig. 18).

Atkinson Point Formation

In the subsurface under central Tuktoyaktuk Peninsula, there is a relatively thin succession of conglomerate and sandstone that is laterally equivalent to both the Mount Goodenough and Rat River formations - the Atkinson Point Formation. This latter unit consists of interbedded sandstone and conglomerate at its southern margin, grading laterally to sandstone and argillaceous sandstone in a radial direction to the northwest (Dixon, 1979, 1992c).

The formation is up to 170 m thick, thinning rapidly southeastward to a depositional zero-edge, and northwestward due to a facies change to a shale-equivalent succession (Dixon, fig. 33, 1992c; Fig. 18).

DISCUSSION

Dixon (1992b) described and interpreted the significance of a number of regional unconformities within the Cretaceous succession of northwest Canada, indicating that a significant number apparently were tectonically induced. This would be consistent with the active extensional tectonics that prevailed during the Jurassic and Early Cretaceous (Dixon, 1993). In fact the extensional regime was a continuation of similar tectonic activity that apparently began in the Carboniferous. This Jurassic-early Cretaceous period of sedimentation and tectonics was identified as an epicontinental phase of sedimentation by Young (1973c).

The most prominent coarse clastic sediment pulse is that of the Kamik Formation, deposited during the late Valanginian to Hauterivian. Kamik sandstones were deposited over a large area of the northern Yukon and adjacent NWT, in contrast to other sandstone-rich intervals, which were restricted to the basin margin. This difference is interpeted to be a response to widespread faulting and uplift of the basin margins and, to a lesser extent, local tectonic features, resulting in increased sediment supply during Kamik deposition. The termination of this tectonic activity is marked by the profound regional unconformity at the base of the Mount Goodenough Formation.

A common feature of the Jurasic to Lower Cretaceous sandstones is their quartz-arenite composition. Most sandstones are texturally and mineralogically mature, indicating a mature source terrain and/or recycling of pre-existing sandstone bodies. This is consistent with the predominantly southeast to east source area, from the craton and Shield, not from an active foldbelt with volcanism, as was common in the post-late Aptian succession (Dixon, 1993).

REFERENCES

Brideaux, W.W.

1976a: Taxonomic notes and illustrations of selected dinoflagellate cyst species from the Gulf Mobil Parsons N-10 well. *In* Report of Activities, Part B, Geological Survey of Canada, Paper 76-1B, p.251-257.

1976b: Berriasian dinoflagellate assemblage, Martin Creek, northwestern District of Mackenzie. *In* Report of Activities, Part C, Geological Survey of Canada, Paper 76-1C, p.115-130.

1977: Taxonomy of Upper Jurassic-Lower Cretaceous microplankton from the Richardson Mountains, District of Mackenzie, Canada. Geological Survey of Canada, Bulletin 281, 89p.

Brideaux, W.W. and Fisher, M.J.

1976: Upper Jurassic-Lower Cretaceous dinoflagellate assemblages from Arctic Canada. Geological Survey of Canada, Bulletin 259, 53p.

Brideaux, W.W. and Myhr, D.W.

1976: Lithostratigraphy and dinoflagellate cyst succession in the Gulf Mobil Parsons N-10 well, District of Mackenzie. *In* Current Research, Part B, Geological Survey of Canada, Paper 76-1B, p.235-249.

Cote, R.P., Lerand, M.M., and Rector, R.J.

1975: Geology of the Lower Cretaceous Parsons Lake gas field, Mackenzie Delta, Northwest Territories. *In* Canada's Continental Margins, C.J. Yorath, E.R. Parker and D.J. Glass (eds.); Canadian Society of Petroleum Geologists, Memoir 4, p.613-632.

Dixon, J.

1979: The Lower Cretaceous Atkinson Point Formation (new name) on the Tuktoyaktuk Peninsula, N.W.T.: A coastal fan-delta to marine sequence. Bulletin of Canadian Petroleum Geology, v.27, p;.163-183.

1982a: Jurassic and Lower Cretaceous subsurface stratigraphy of the Mackenzie Delta-Tuktoyaktuk Peninsula, N.W.T. Geological Survey of Canada, Bulletin 349, 52p.

1982b: Sedimentology of the Neocomian Parsons Group in the subsurface of the Mackenzie Delta area. Bulletin of Canadian Petroleum Geology, v.30, p.9-28.

1983: (Abstract) Hydrocarbon potential of Jurassic and Lower Cretaceous rocks in the Beaufort-Mackenzie Basin. Canadian Society of Petroleum Geologists, Reservoir, v.10, October, p.1-2.

1986: Cretaceous to Pleistocene stratigraphy and paleogeography, northern Yukon and District of Mackenzie. Bulletin of Canadian Petroleum Geology, v. 34, p. 46-70.

1990 (editor): Stratigraphic tops in wells from the Beaufort-Mackenzie area, northwest Canada. Geological Survey of Canada, Open File Report 2310 (also available on a disk).

1991: The Neocomian Parson Group, northern Yukon and adjacent Northwest Territories. Geological Survey of Canada, Bulletin 406, 54p.

1992a: Mesozoic stratigraphy, Eagle Plain area, northern Yukon. Geological Survey of Canada, Bulletin 408, 58p.

1992b: Regional unconformities in the Cretaceous of northwest Canada. Cretaceous Research, v.14, p.17-38.

1992c: A review of Cretaceous and Tertiary stratigraphy in the northern Yukon and adjacent Northwest Territories. Geological Survey of Canada, Paper 92-9, 79p.

1993: Cretaceous tectonics and sedimentation. *In* Evolution of the Western Interior Foreland Basin, W.G.E. Caldwell and E.G. Kaufman (eds.), Geological Association of Canada, Special Paper 39, p.119-130.

Dixon, J. and Jeletzky, J.R.

1991: Stratigraphic nomenclature of Lower Cretaceous rocks in the northern Yukon and adjacent District of Mackenzie, Northwest Territories. Geological Survey of Canada, Paper 90-21, 41p.

Dixon, J., McNeil, D.H., Dietrich, J.R., and McIntyre, D.J.

1989: Barremian to Albian stratigraphy, Tuktoyaktuk Peninsula and south Mackenzie Delta, Northwest Territories. Geological Survey of Canada, Paper 89-15, 16p.

Embry, A.F. and Dixon, J.

1990: The breakup unconformity of the Amerasia Basin, Arctic Ocean: Evidence from Arctic Canada. Geological Society of America Bulletin, v.12, p.1526-1534.

Fensome, R.A.

1987: Taxonomy and biostratigraphy of schizaealean spores from the Jurassic-Cretaceous boundary beds of the Aklavik Range, District of Mackenzie. Palaeontographica Canadiana, no.4, 49p, Canadian Society of Petroleum Geologists-Geological Association of Canada.

Fowler, S.P.

1985: Lower Cretaceous foraminiferal microfaunas and biostratigraphy of the Richardson Mountains, Yukon and Northwest Territories. Unpublished PhD thesis, University of Saskatchewan, Saskatoon, 394p.

Fowler, S.P. and Braun, W.

1993: Hauterivian to Barremian foraminifera and biostratigraphy of the Mount Goodenough Formation, Aklavik Range, northwestern District of Mackenzie. Geological Survey of Canada, Bulletin 443, 82p.

Hedinger, A.S.

1979: Late Jurassic foraminifera from the Aklavik Range, Northwest Territories. Unpublished MSc thesis, University of Alberta, Edmonton, 426p.

1993: Late Jurassic (Oxfordian-Volgian) Foraminifera from the Aklavik Range, Northwest Territories. Geological Survey of Canada, Bulletin 439, 172p.

Jeletzky, J.A.

1958: Uppermost Jurassic and Cretaceous rocks of Aklavik Range, northeastern Richardson Mountains, Northwest Territories. Geological Survey of Canada, Paper 58-2, 84p.

1960: Uppermost Jurassic and Cretaceous rocks, west flank of Richardson Mountains between Stony Creek and lower Donna River, Northwest Territories. Geological Survey of Canada, Paper 59-14, 31p.

1961: Uppermost Jurassic and Lower Cretaceous rocks, west flank of Richardson Mountains between the headwaters of Blow River and Bell River, Yukon Territory. Geological Survey of Canada, Paper 61-9, 42p.

1964: Lower Cretaceous marine index fossils of the sedimentary basin of western and Arctic Canada. Geological Survey of Canada, Paper 64-11, 100p.

1967: Jurassic and (?)Triassic rocks of the eastern slopes of Richardson Mountains, northwestern District of Mackenzie. Geological Survey of Canada, Paper 66-50, 171p.

1971a: Stratigraphy, facies and paleogeography of Mesozoic rocks of northern and west-central Yukon. *In* Report of Activities, Part A, Geological Survey of Canada, Paper 71-1A, p.203-221.

1971b: Marine Cretaceous biotic provinces and paleogeography of western and Arctic Canada: Illustrated by a detailed study of ammonites. Geological Survey of Canada, Paper 70-22, 92p.

1972: Stratigraphy, facies and paleogeography of Mesozoic and Tertiary rocks of northern Yukon and northwest Mackenzie District, N.W.T. (NTS-197B, 106M, 117A, 116O (N1/2)). *In* Report of Activities, Part A, Geological Survey of Canada, Paper 72-1A, p.212-215.

1973: Biochronology of the marine boreal latest Jurassic, Berriasian and Valanginian. *In* The Boreal Lower Cretaceous, Geological Journal Special Issue No. 5, p.41-80.

1974: Contribution to the Jurassic and Cretaceous geology of northern Yukon Territory and District of Mackenzie, Northwest Territories. Geological Survey of Canada, Paper 74-16, 52p.

1975: Jurassic and Lower Cretaceous paleogeography and depositional tectonics of Porcupine Plateau, adjacent areas of northern Yukon and those of Mackenzie District. Geological Survey of Canada, Paper 74-16, 52p.

1977: Porcupine River Formation: A new Upper Jurassic sandstone unit, northern Yukon Territory. Geological Survey of Canada, Paper 76-27, 55p.

1980: Lower Cretaceous rocks of McDougall Pass area and some adjacent areas of north-central Richardson Mountains, northern Yukon Territory and northwest

District of Mackenzie, N.W.T. (NTS-116P/9 and 116P/10): A reappraisal. Geological Survey of Canada, Paper 78- 22, 35p.

1984: Jurassic-Cretaceous boundary beds of western and Arctic Canada and the problem of Tithonian-Berriasian stages in the boreal realm. *In* Jurassic-Cretaceous Biochronology and Paleogeography of North America, G.E.G. Westerman (ed.), Geological Association of Canada, Special Paper 27, p.173-255.

McIntyre, D.J. and Brideaux, W.W.

1980: Valanginian miospores and microplankton assemblages from the northern Richardson Mountains, District of Mackenzie, Canada. Geological Survey of Canada, Bulletin 320, 57p.

Myhr, D.W.

1974: A shallow shelf coastal environment interpreted from lithostratigraphy of Lower Cretaceous cores in the Gulf Mobil East Reindeer G-04 borehole, N.W.T. *In* Report of Activities, Part B, Geological Survey of Canada, Paper 74-1B, p.282-286.

Myhr, D.W. and Gunther, P.R.

1974: Lithostratigraphy and coal reflectance of a Lower Cretaceous deltaic succession in the Gulf Mobil Parsons F-09 borehole, N.W.T. *In* Report of Activities, Part B, Geological Survey of Canada, Paper 74-1B, p.24-28.

Myhr, D.W. and Young, F.G.

1975: Lower Cretaceous (Neocomian) sandstone sequence of Mackenzie Delta and Richardson Mountains area. *In* Report of Activities, Part C, Geological Survey of Canada, Paper 75-1C, p.247-266.

Norris, D.K.

1981a: Geology: Herschel Island and Demarcation Point, Yukon Territory. Geological Survey of Canada, Map 1514A.

1981b: Geology: Mackenzie Delta, District of Mackenzie. Geological Survey of Canada, Map 1515A.

1981c: Geology: Blow River and Davidson Mountains, Yukon Territory-District of Mackenzie. Geological Survey of Canada, Map 1516A.

1981d: Geology: Aklavik, District of Mackenzie. Geological Survey of Canada, Map 1517A.

1981e: Geology: Old Crow, Yukon Territory. Geological Survey of Canada, Map 1518A.

1981f: Geology: Bell River, Yukon Territory - Northwest Territories. Geological Survey of Canada, Map1519A.

1981g: Geology: Fort McPherson, District of Mackenzie. Geological Survey of Canada, Map 1520A.

1981h: Geology: Arctic Red River, District of Mackenzie. Geological Survey of Canada, Map 1521A.

1985c: Geology of northern Yukon and northwestern District of Mackenzie. Geological Survey of Canada, map 1581A

Norris, D.K., Price, R.A., and Mountjoy, E.W.

1963: Geology: Northern Yukon Territory and northwestern District of Mackenzie. Geological Survey of Canada, Map 10-1963.

Young, F.G.

1971: Mesozoic stratigraphic studies northern Yukon Territory and northwestern District of Mackenzie. *In* Report of Activities, Part A, Geological Survey of Canada, Paper 71-1A, p.245-247.

1972: Cretaceous stratigraphy between Blow and Fish rivers, Yukon Territory. *In* Report of Activities, Part A, Geological Survey of Canada, Paper 72-1A, p.229-235.

1973a: Jurassic and Cretaceous stratigraphy between Babbage and Blow rivers, Yukon Territory. *In* Report of Activities, Part A, Geological Survey of Canada, Paper 73-1A, p.277-281.

1973b: Mesozoic epicontinental, flyschoid and molassoid depositional phases of Yukon's North Slope. *In* Canadian Arctic Geology, J.D. Aitken and D.J. Glass (eds.), Geological Association of Canada-Canadian Society of Petroleum Geologists, p.181-202.

1973c: Mesozoic epicontinental, flyschoid and molassoid depositional phases of Yukon's north slope. *In* Geology of the Canadian Arctic, J.D. Aitken and D.J. Glass (eds.). Geological Association of Canada-Canadian Scoiety of Petroelum Geologists, p.181-204.

1974: Cretaceous stratigraphic displacements across Blow fault zone, northern Yukon Territory. *In* Report of Activities, Part B, Geological Survey of Canada, Paper 74-1B, p.291-296.

1978 (editor): Geological and geographical guide to the Mackenzie Delta area. Canadian Society of Petroleum Geologists, Calgary, 158p.

Young, F.G., Myhr, D.W. and Yorath, C.J.

1976: Geology of the Beaufort-Mackenzie Basin. Geological Survey of Canada, Paper 76-11, 63p.

LIST OF FIGURES

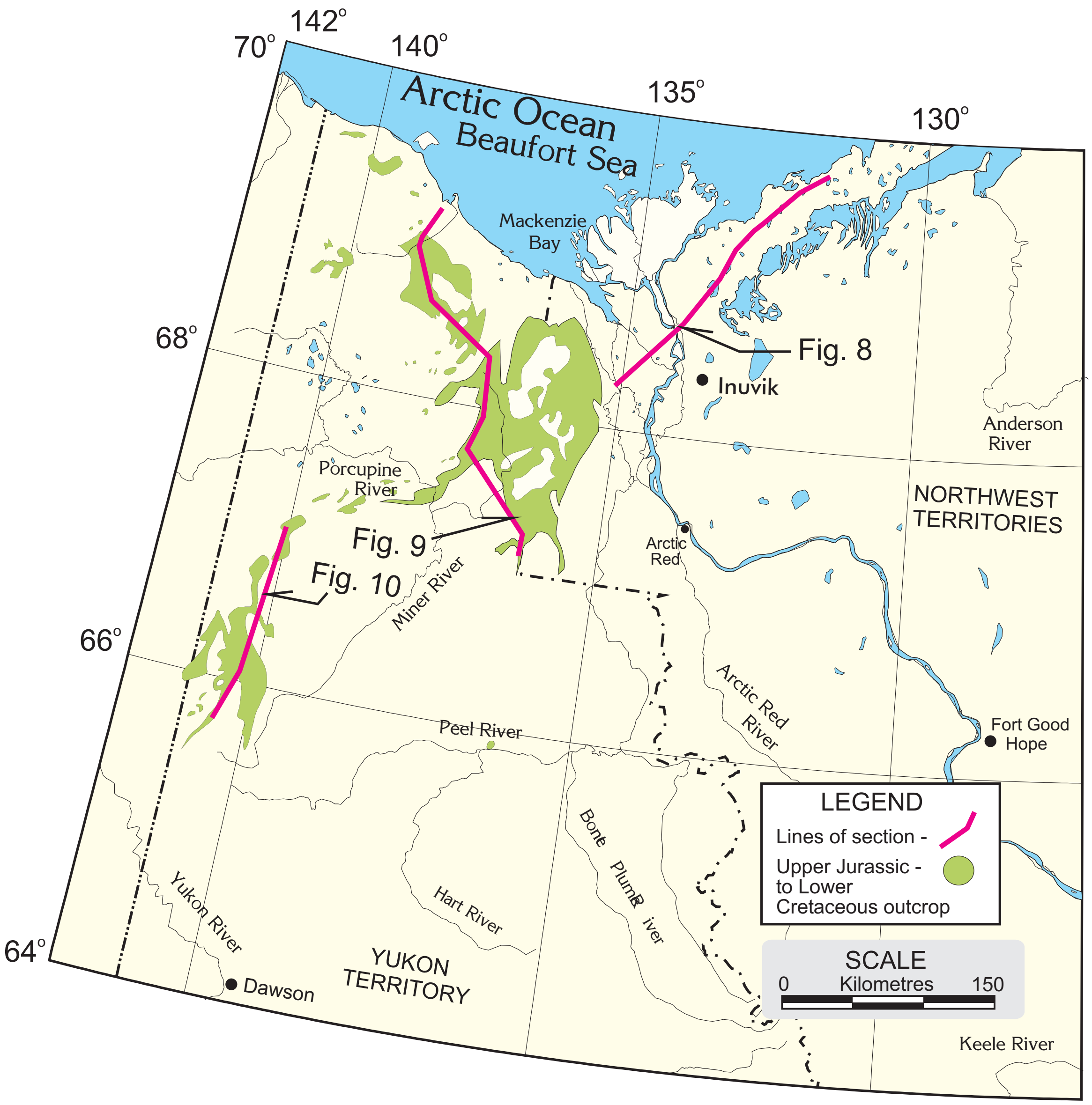

Figure1. Distribution of Berriasian to Lower Aptian strata and location of cross sections (Figs. 8,9 10).

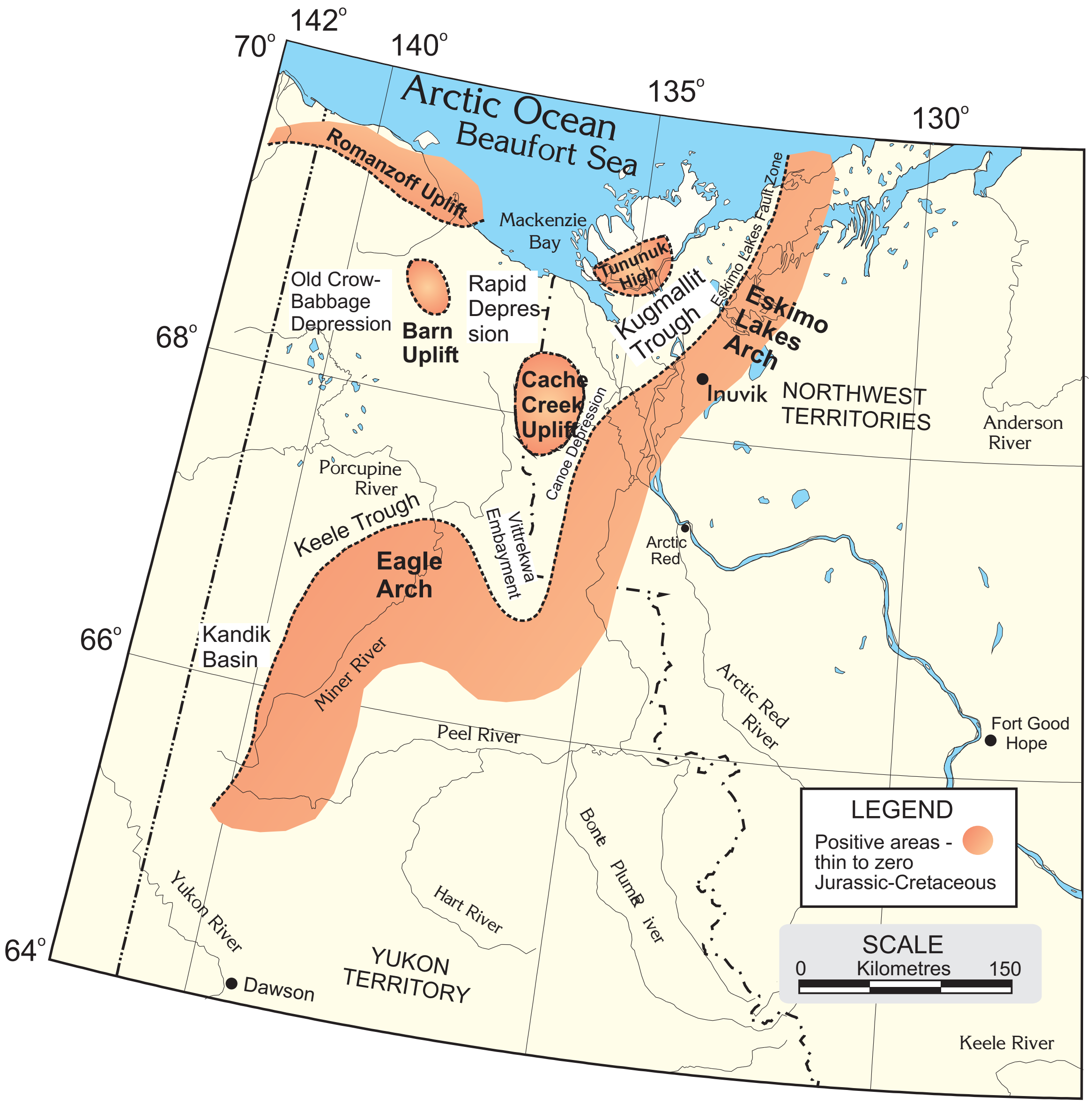

Figure 2. Tectonic elements affecting Late Jurassic and Early Cretaceous deposition.

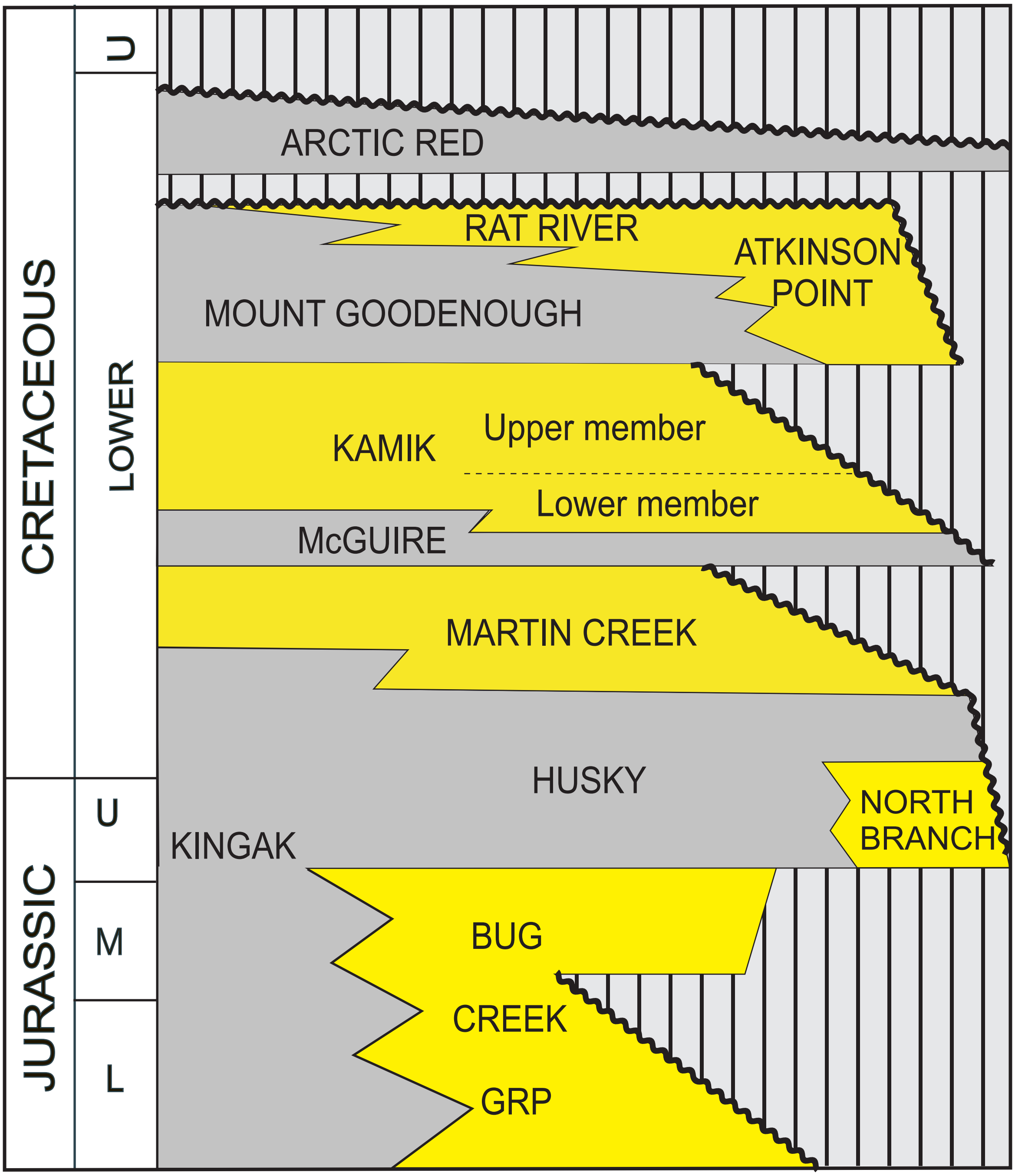

Figure 3. Table of Formations and stratigraphic correlation chart for Jurassic and Lower Cretaceous strata.

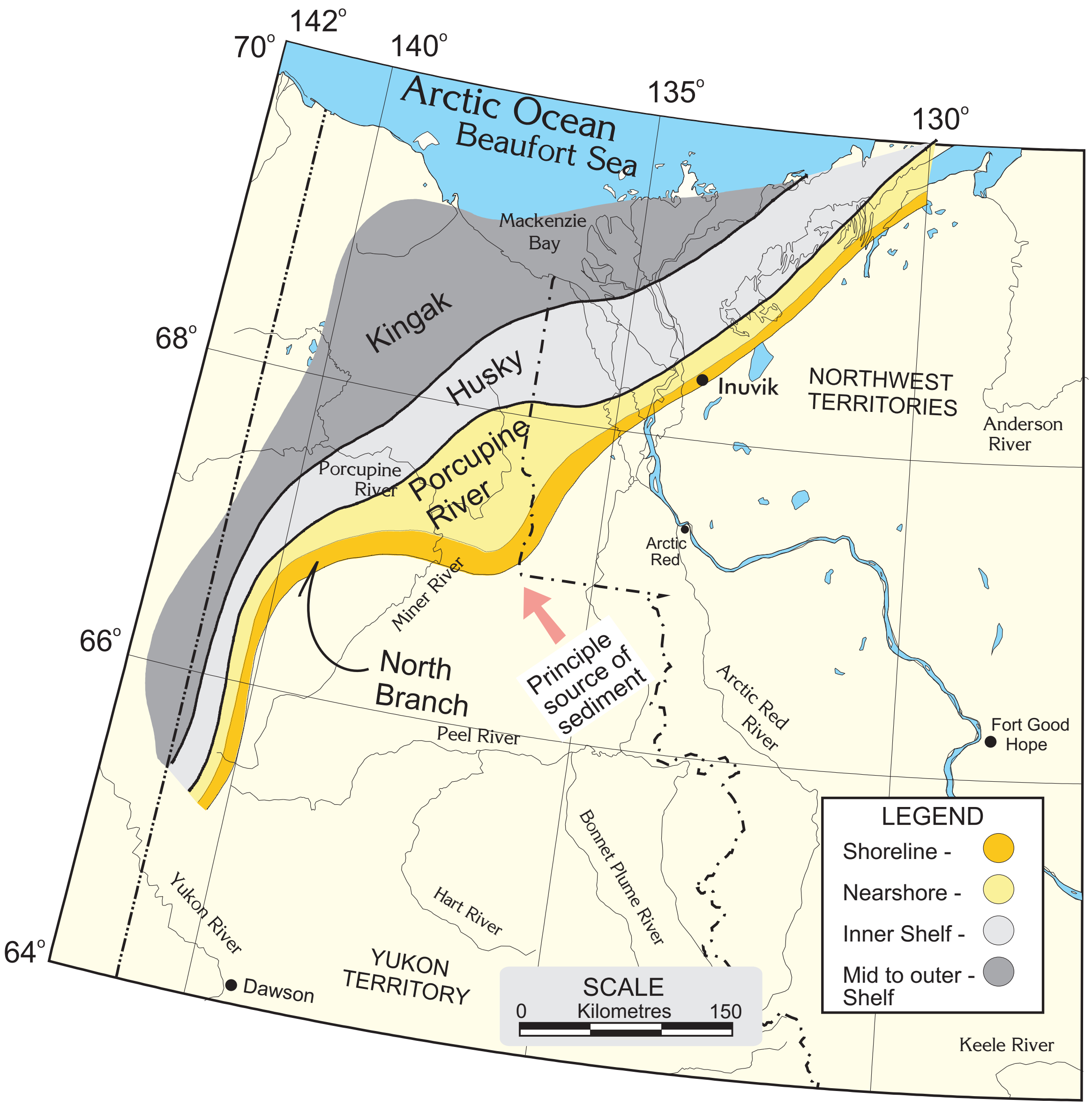

Figure 4. Reconstruction of Tithonian (latest Jurassic) paleogeography.

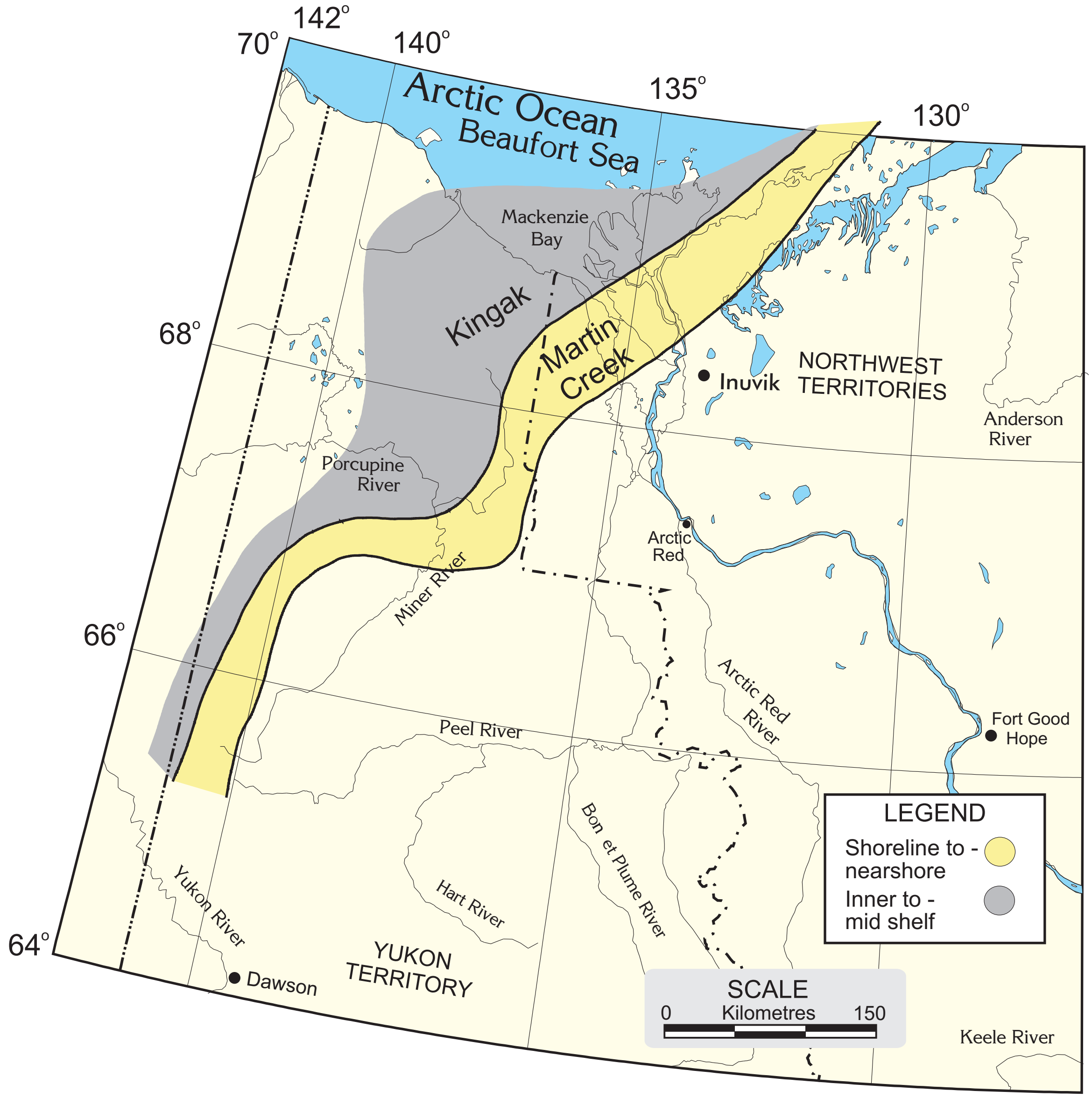

Figure 5. Reconstruction of late Berriasian (earliest Cretaceous) paleogeography.

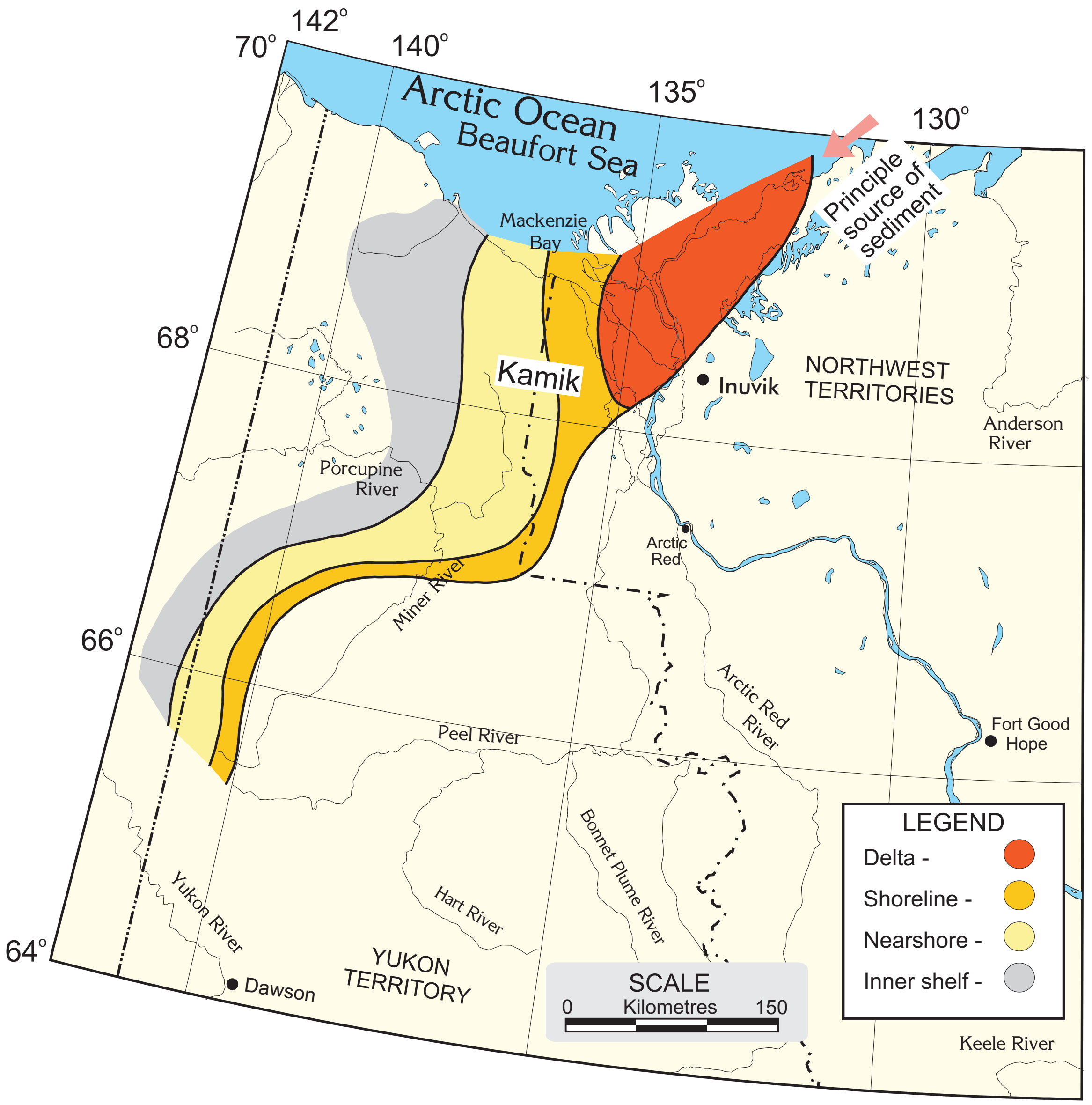

Figure 6. Reconstruction of late Valanginian (Early Cretaceous) paleogeography.

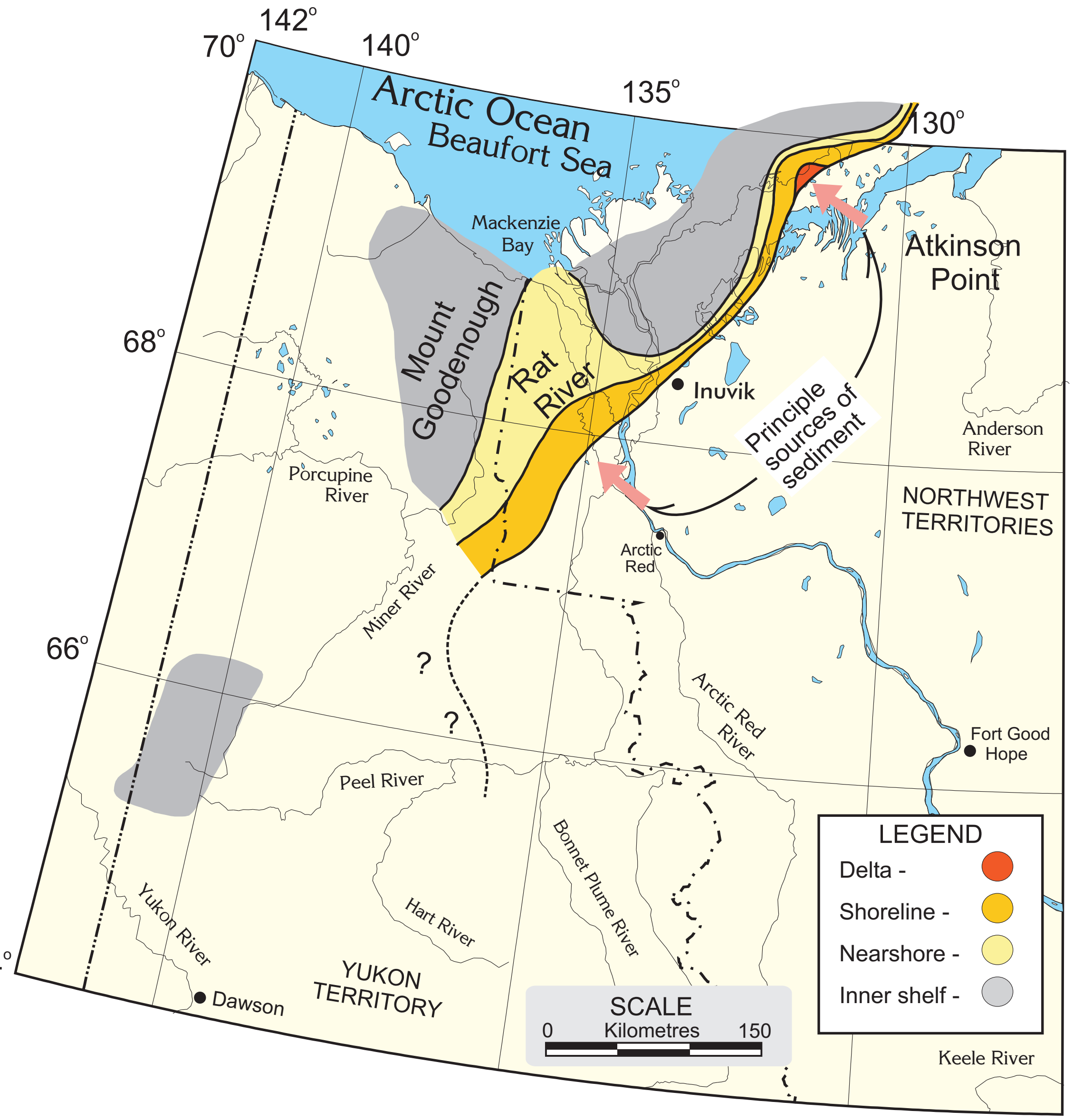

Figure 7. Reconstruction of late Barremian (Early Cretaceous) paleogeography.

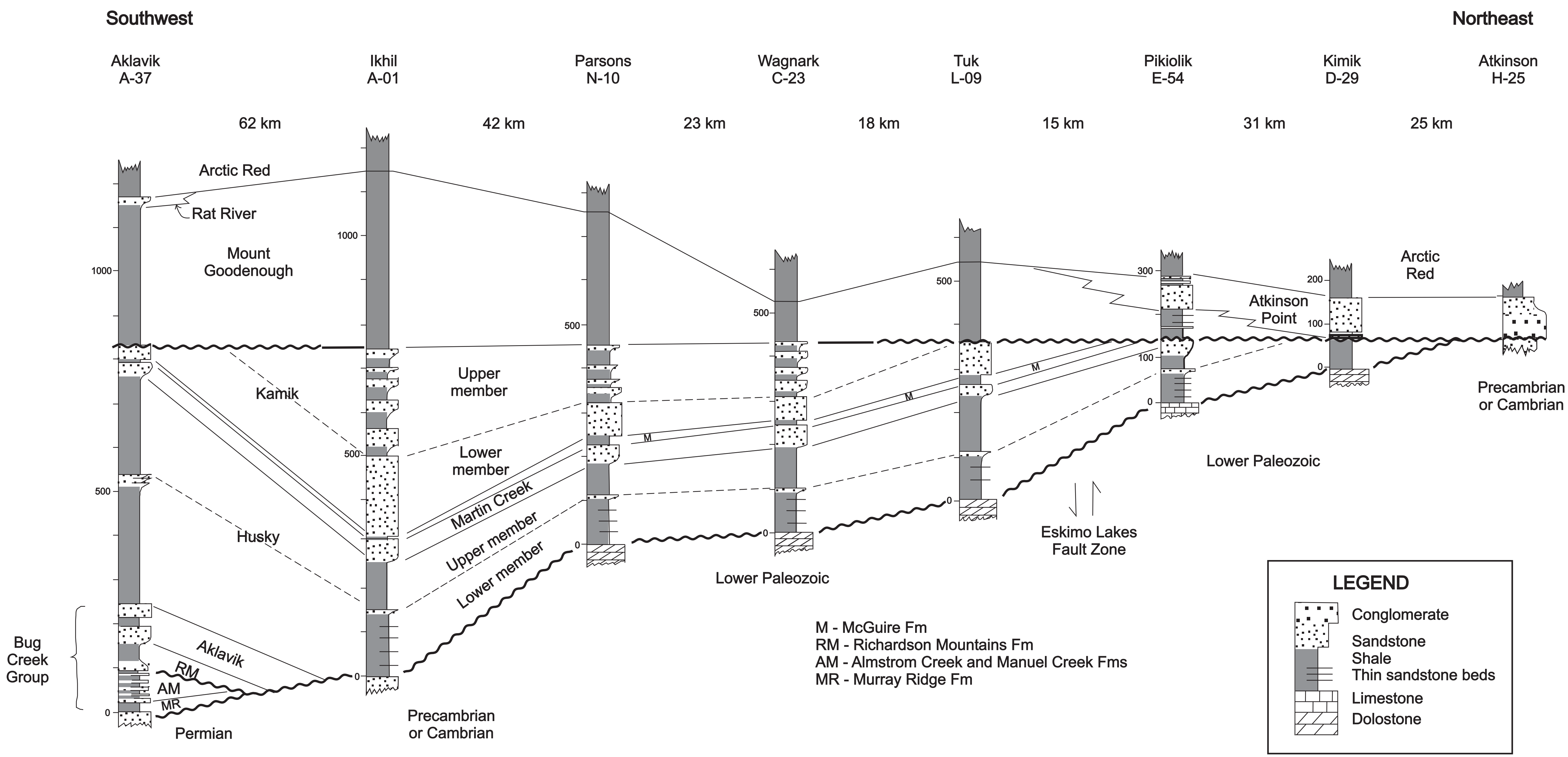

Figure 8. Cross section from the Atkinson H-25 to Aklavik A-37 wells, Tuktoyaktuk Peninsula-south Mackenzie Delta.

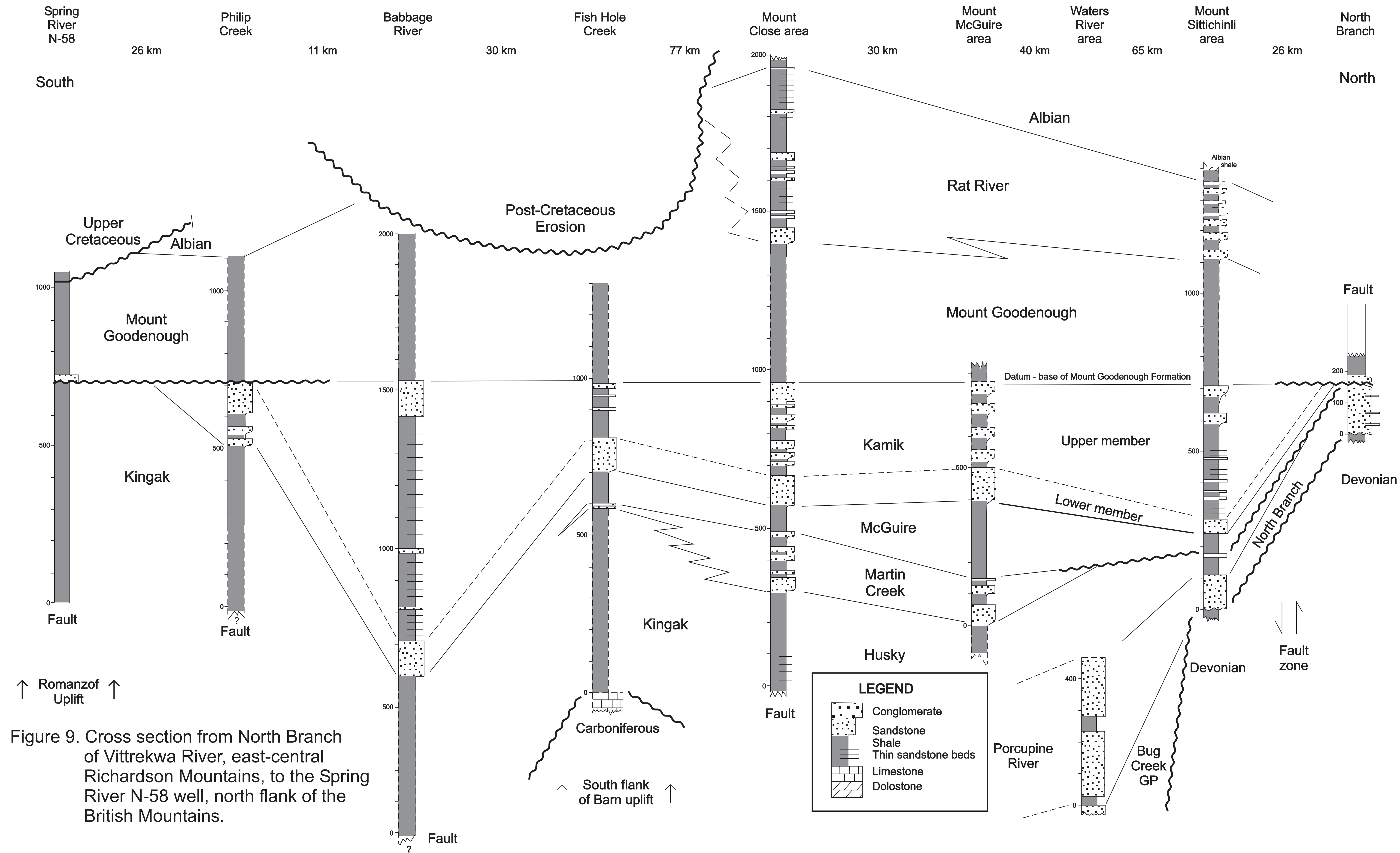

Figure 9. Cross section from North Branch of Vittrekwa River, east-central Richardson Mountains, to the Spring River N-58 well, north flank of the British Mountains.

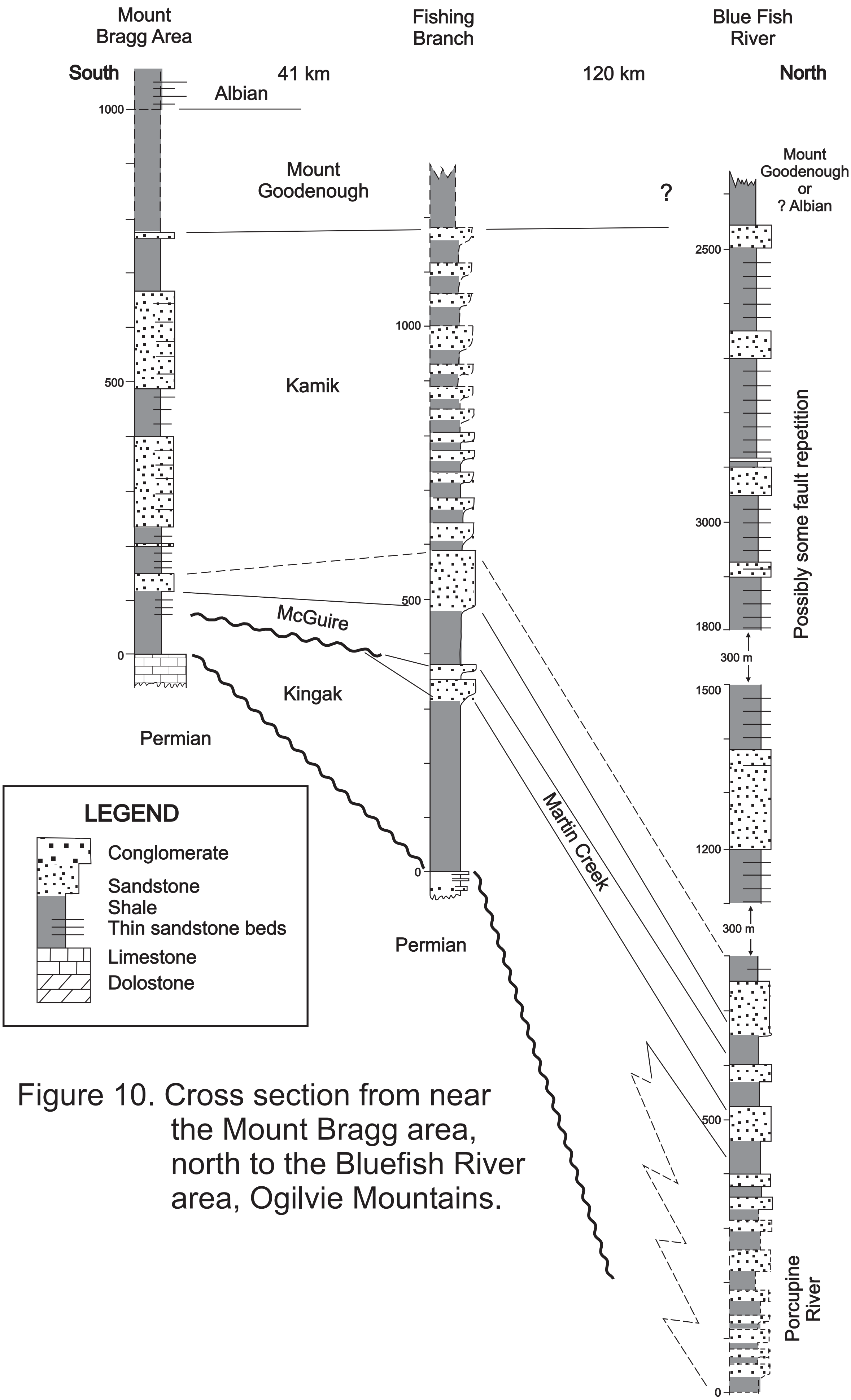

Figure 10. Cross section from near the Mount Bragg area, north to the Bluefish River area, Ogilvie Mountains.

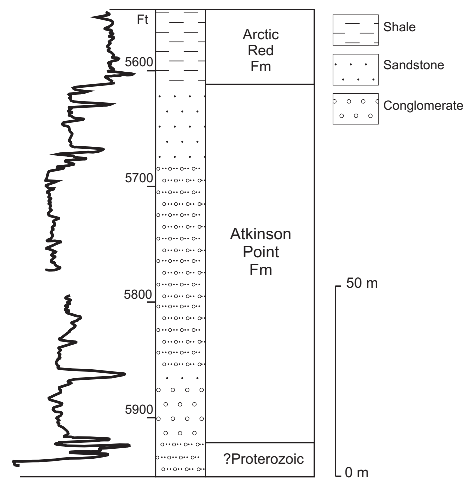

Figure 12. Barremian to Lower Aptian succession (Atkinson Point Formation) in the Atkinson H-25 well (gamma-ray log).

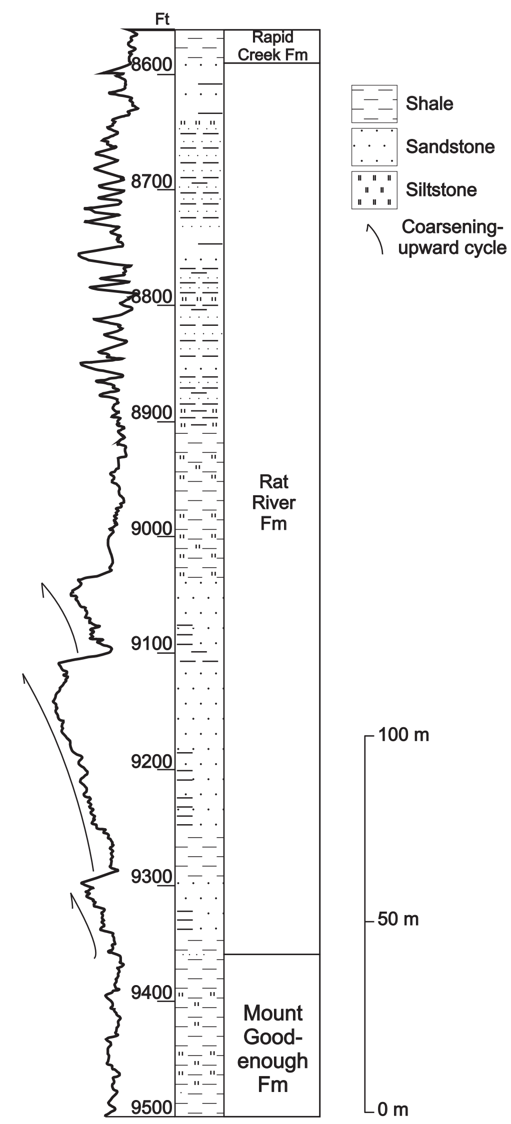

Figure 13. Upper Barremian to Lower Aptian Rat River Formation in the Fish River B-60 well (gamma-ray log).

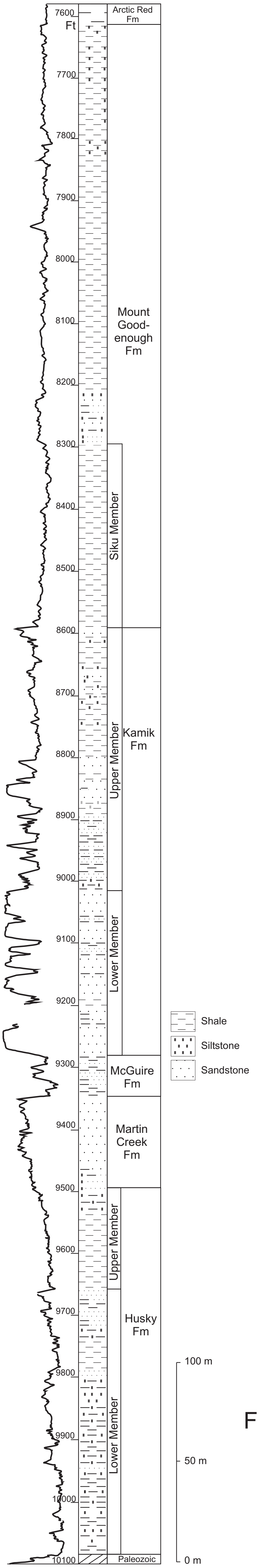

Figure 11. Berriasian to Lower Aptian succession in the Parsons N-10 well (gamma-ray log).

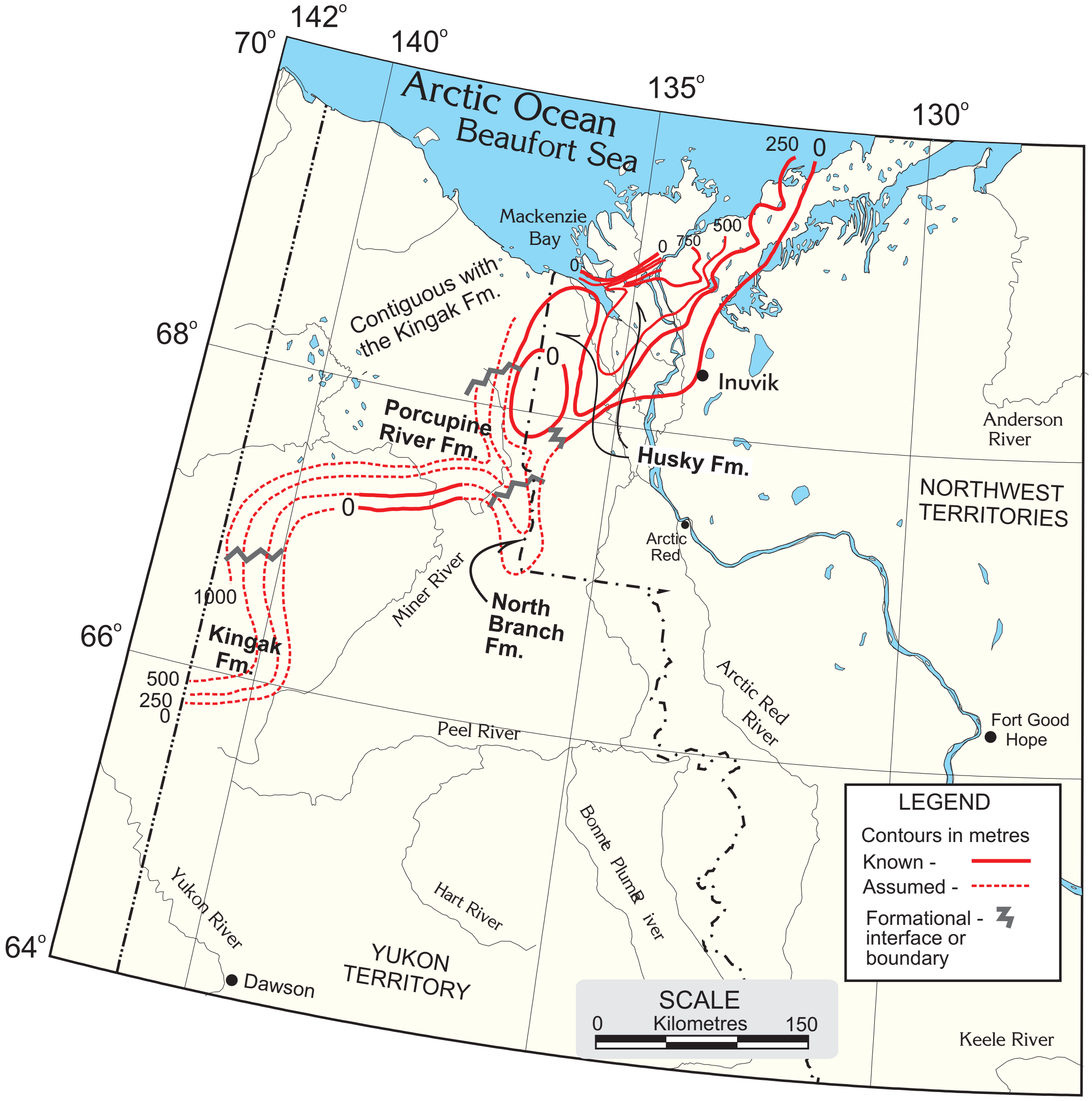

Fig. 14. Isopach map of the Husky, Porcupine River and North Branch formations.

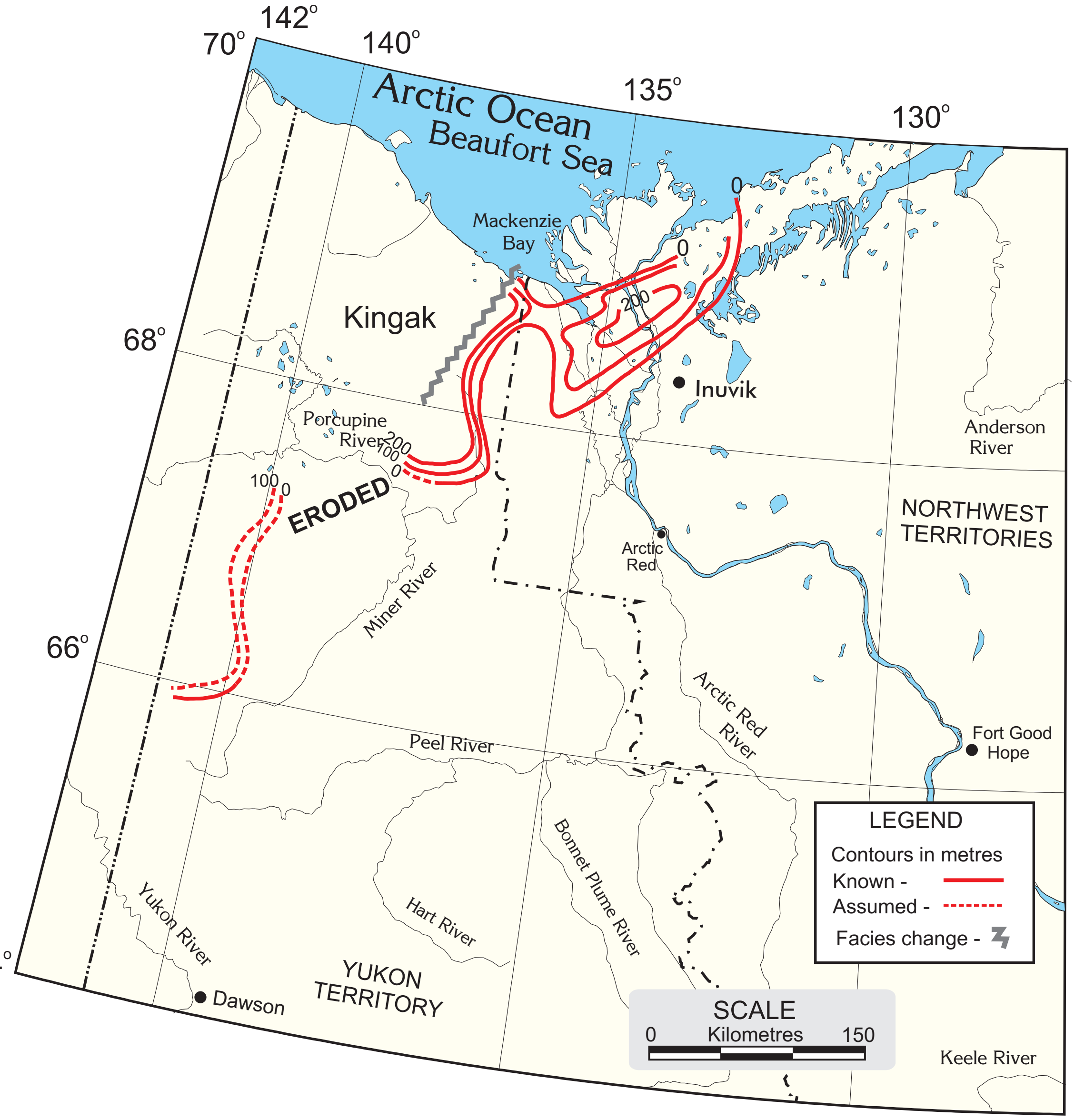

Figure 15. Isopach map of the Martin Creek Formation.

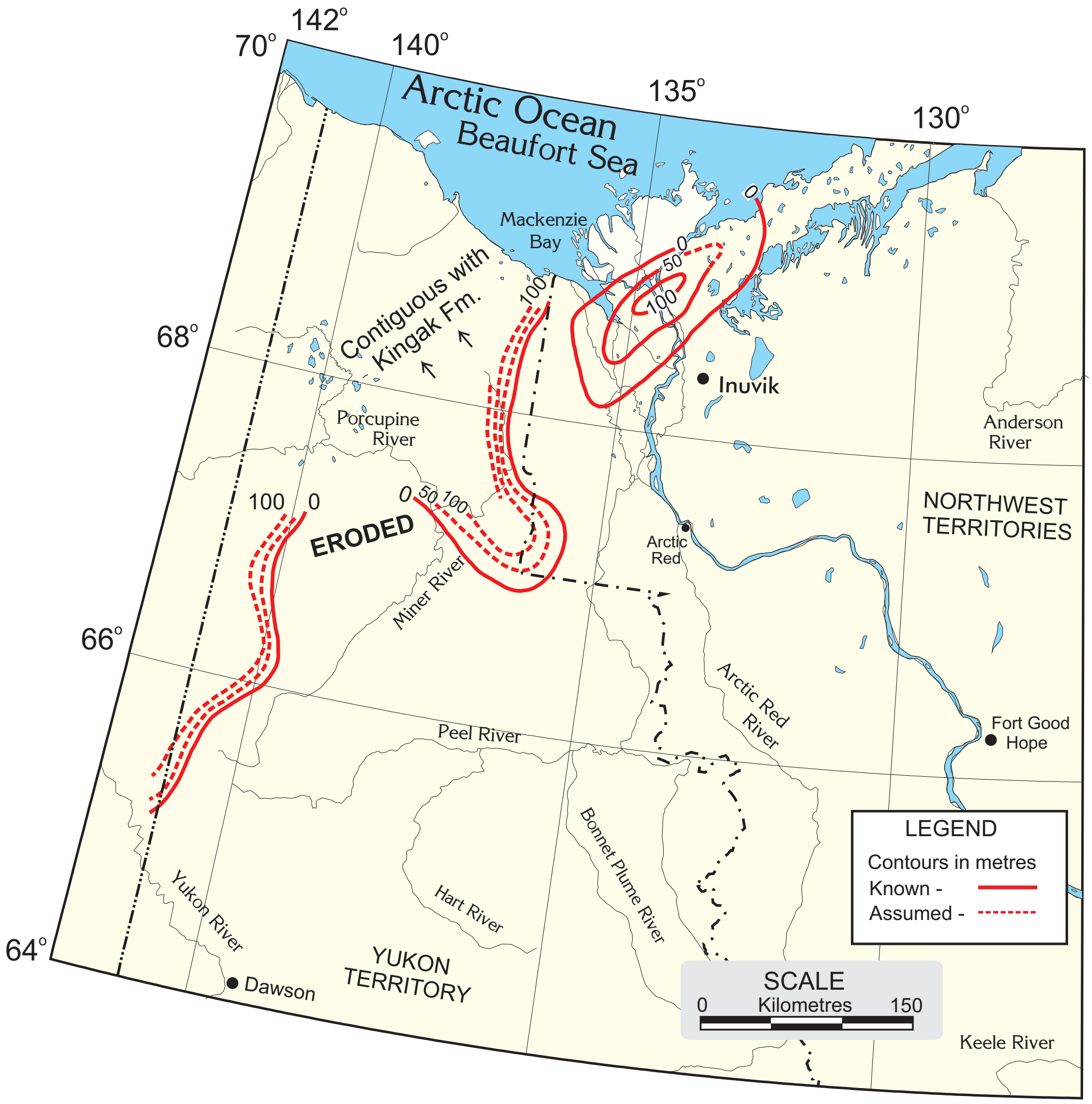

Figure 16. Isopach map of the McGuire Formation.

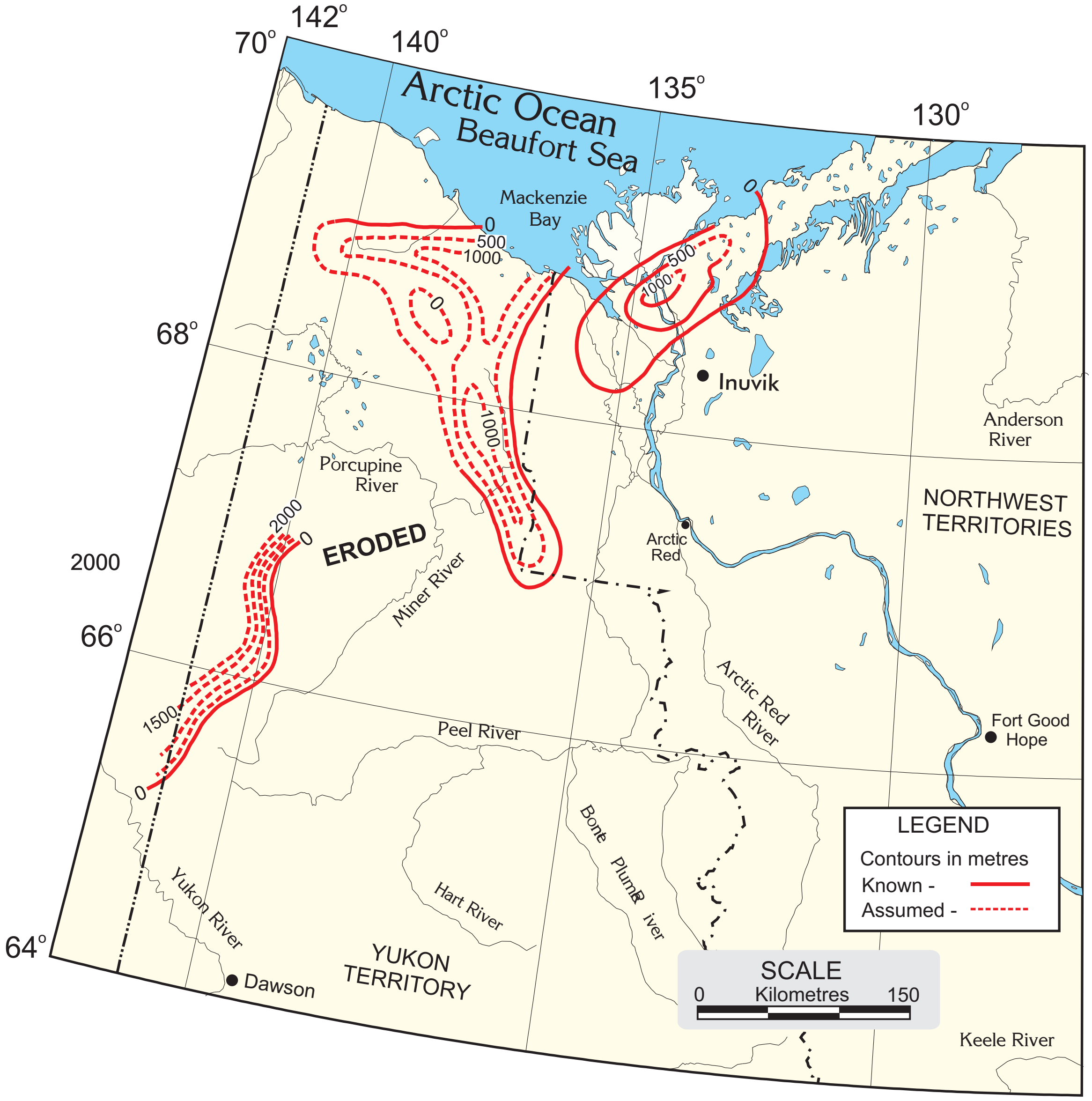

Figure 17. Isopach map of the Kamik Formation.

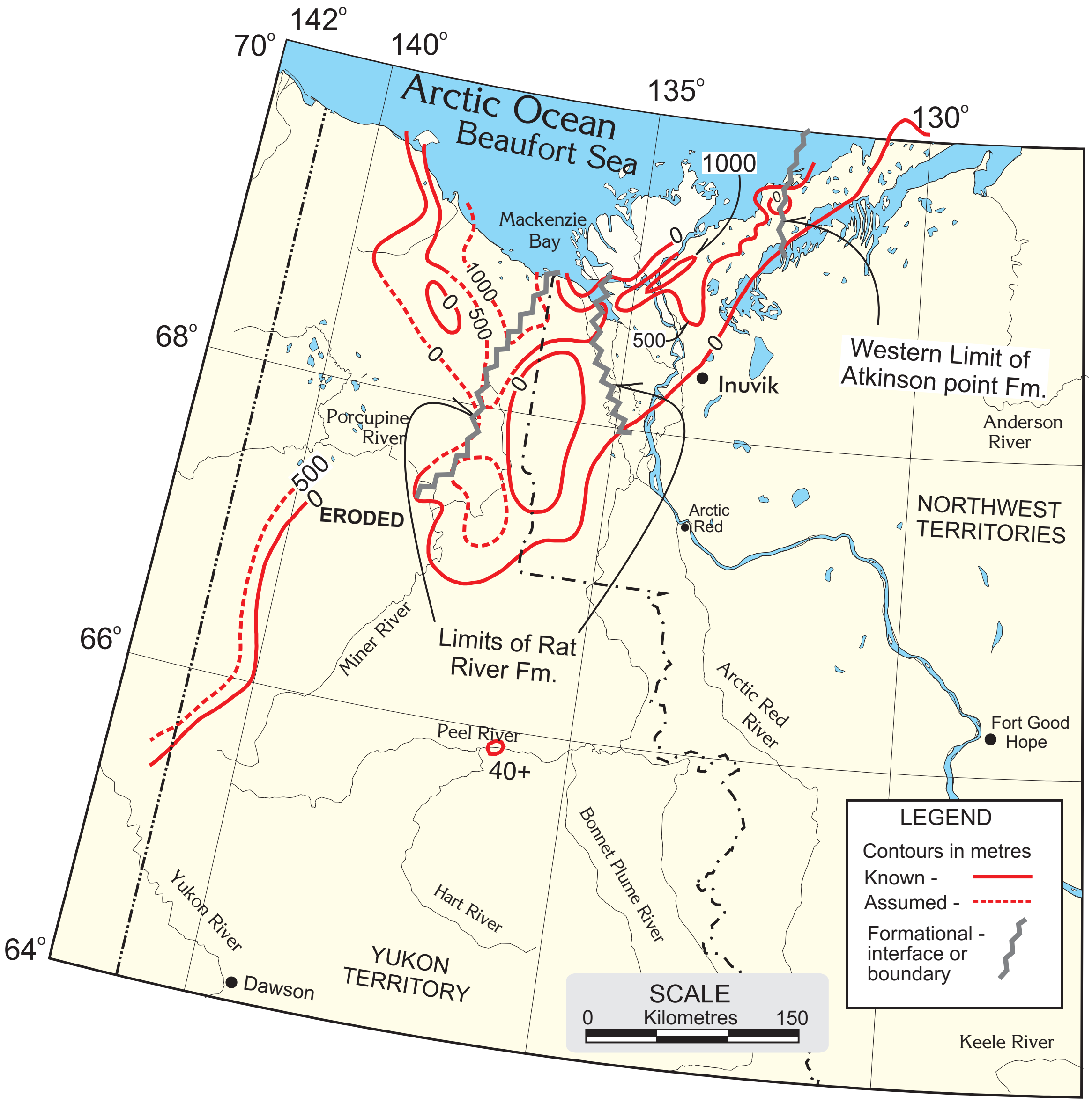

Figure 18. Isopach map of the Mount Goodenough, Rat River, and Atkinson Point Formations.