Petroleum Resource Assessment, Peel Plateau and Plain, Yukon Territory, Canada

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Abstract

The Peel Plateau and Plain in the Yukon (is a potentially prospective petroleum province that lies north of the Mackenzie Mountains and east of the Richardson Mountains up to the inter-territorial boundary containing a Lower Cambrian to Upper Cretaceous stratigraphic succession up to approximately 4.5 km thick. Nineteen exploratory wells have been drilled within the region without economic reserves or production, but with some petroleum shows. A probablilistic petroleum resource assessment suggests that there is a significant potential for natural gas throughout the region with a summed mean play potential of approximately 83.428 X 10^9 m^3 initial raw gas in place (~3 TCF) in approximately 88 pools. The largest expected pool of 3.36 X 10^9 m^3 gas is expected to occur in Mesozoic clastics of the Peel Plain. In general, petroleum potential is inferred to decrease both westward and with increasing depth and stratigraphic age. The small size of gas pools will be an impediment to their development because of their location. No crude oil potential can be estimated due to an inferred lack of oil prone sources in strata of suitable maturity. Where previous work speculated that the history of petroleum systems in the Peel Plain and Plateau was distinctive from that of surrounding regions that are suitably characterized, this work finds no justification for such a distinctive petroleum system history. The resulting undiscovered potential is, therefore, considered to be consistent with the results of the exploration history.

Executive Summary

The Peel Plateau and Plain in the Yukon (Figure 1) is a potentially prospective petroleum province that lies north of the Mackenzie Mountains and east of the Richardson Mountains up to the inter-territorial boundary (Table 1). The region contains a Lower Cambrian to Upper Cretaceous stratigraphic succession up to approximately 4.5 km thick that overlies a poorly described Proterozoic succession that is currently ascribed as "economic basement". Nineteen exploratory wells have been drilled within the region. None of these wells have established economic reserves or production, but there have been several shows. One surface natural gas seep occurs in the NWT in the contiguous Mackenzie-Peel Shelf geological province. Assessment of this region suggests that there is a significant potential for natural gas throughout the region with a summed mean play potential of approximately 83.428 X 10^9 m^3 initial raw gas in place[1] (~3 TCF) in approximately 88 pools. The largest expected pool of 3.36 X 10^9 m^3 gas is expected to occur in Mesozoic clastics of the Peel Plain. In general the small size of gas pools will be an impediment to their development because of their location. In general, petroleum potential is inferred to decrease both westward and with increasing depth and stratigraphic age. The result of this study, while differing in detail from previous work (Bird, 2000; 1999), for gas, is generally similar in aggregate potential. This study differs significantly from previous with respect to crude oil potential. No crude oil potential can be estimated due to an inferred lack of oil prone sources in strata of suitable maturity. This difference occurs primarily because of a lack of hard data that could be obtained from the available wells if there were time and resources to perform suitable analysis

[1] Note: all gas volumes reported in this assessment is initial raw and in-place.

(Rock-Eval/TOC pyrolysis). Where previous work speculated that the history of petroleum systems in the Peel Plain and Plateau was distinctive from that of surrounding regions that are suitably characterized, this work finds no justification for such a distinctive petroleum system history.

The geological outcrop structure is obscured by the monotonous topography and poor outcrop of the Peel Plain physiographic region. Seismic surveys are incomplete and cover only a small portion of the region, with wide spacing. To some degree this means that the lack of exploratory drilling success is not diagnostic of the potential. None of these wells have been characterized geochemically, so that the potential and maturity of petroleum sources must be inferred from regional data and functioning of the petroleum systems is not known.

The unfavorable results of exploratory drilling in this part of the Yukon are part of a larger unsuccessful effort in the adjacent N.W.T. Most notable has been the lack of success in the Paleozoic carbonate successions of the Mackenzie Peel Platforms. The lack of additional exploration during the last quarter century, while largely due to economic considerations, must also consider lack of previous success and the unfavorable geological characteristics, including the following. These successions are dominated by carbonate ramp deposition that results in large stratiform porosity zones following a predominantly vertical succession of facies. While internal stratigraphic traps exist, most carbonate ramp settings rely on a structural component of entrapment.

Two features invoked by a previous assessment, an abrupt margin carbonate depositional model and a hydrothermal dolomitization event were examined and evaluated. There is a small probability for an abrupt carbonate margin play that could be provided by isolated carbonate build-ups growing off the drowned Hume platform, like the Horn Plateau reefs of in the N.W.T. Such reefs, generally limestone, lack porosity because burial compaction by a thick and largely eroded later Paleozoic succession. However, there is no reasonable expectation that the region was affected by hydrothermal dolomitization events during the Paleozoic, as the limit of the Manetoe Facies is about 63 degrees north, on the Mackenzie-Peel Shelf. Deep burial in limestone dominated Paleozoic successions reduces porosity by compaction destroying reservoir potential. The same deep late Paleozoic burial appears, regionally to have matured potential Paleozoic source rocks and destroyed any Paleozoic oil potential prior to the latest Cordilleran deformation.

The Mesozoic succession is shale and siltstone dominated, except for the basal Martin House Formation Sandstone. While the timing for petroleum generation from these strata is favorably related to the timing of the Cordilleran deformation of a foreland succession wherein depositional processes provide many opportunities for internal stratigraphic traps, the sedimentary facies and inferred sources are inferred to be gas-prone. Therefore it is not reasonable to attribute a crude oil potential to any plays within this region without the provision of new, currently missing, organic geochemical data. Such data could be obtained from the existing wells if they were suitably analyzed. Both thermogenic and biogenic natural gas generation may have occurred within the Mesozoic succession during the Cordilleran orogeny. The basal Mesozoic sandstone might also have been charged by gas re-migrated from Paleozoic strata by the effects of the Cordilleran deformation.

The combination of depositional and tectonic history indicate that the petroleum potential will be gas-prone, largest in the highest stratigraphic levels and, by analogy to other thrust and fold-belt to foreland basin settings, greatest in the undeformed portion of the foreland basin. These geological framework considerations influence the definition of plays and assessment regions. Despite the negative characteristics and features of the geological setting and history the inferred natural gas potential is significant, with gas of ~3 TCF in approximately 88 pools.

The Peel Plateau and Plain assessment region is divided into three structural and stratigraphic belts that do not coincide with the physiographic boundaries. From the outcrop of the Richardson and Mackenzie mountains west to the Trevor Fault is the first Assessment Region. This region lies primarily in the Peel Plain, but it is underlain by east verging Cordilleran thrust and fold structures that are similar to those of that underlie the Peel Plateau. This assessment region is referred to as the Peel Plateau – West of Trevor Fault. Most of the Peel Plateau and contiguous portions of the Peel Plain lying east of the Trevor Fault but west of the Peel River are also part of the east and north verging Cordilleran thrust and fold belt. This assessment area, from the surface trace of the Trevor Fault to the eastern limit of Cordilleran thrusting is referred to as the Peel Plateau, regardless of the physiography. The carbonate to shale transition of a persistent Paleozoic paleotopographic feature, the Richardson Trough, occurs with the region between the Trevor Fault and the eastern limit of the Cordilleran deformation. East and north of the region affected by Cordilleran diastrophism are the undeformed successions of the Mackenzie-Peel Paleozoic carbonate shelf, also known as the Mackenzie-Peel Platform, which, to the inter-territorial boundary constitutes the third assessment region of this study.

Petroleum Plays:

Peel Plateau – West of Trevor Fault:

The total petroleum potential of the Peel Plateau – West of Trevor Fault is small to negligible, as would be expected from it geological history and characteristics. In this region, dominated by Paleozoic outcrops the Cambrian to Devonian succession is composed of Road River and Imperial Formation and equivalents. Dominantly shales, no potential is inferred for the sub-Imperial succession. There is some potential for gas occurrence in the sandy intercalations within the post-Hume equivalent succession, although many of these units are near the surface and the preservation of this potential is a high risk. A single pool of 105 million cubic m initial in place resource is assessed for the upper Paleozoic (Imperial-Tuttle-Ford Lake succession). This region is the least attractive for petroleum potential in the assessment area.

Peel Plateau – East of Trevor Fault to the Eastern Limit of Cordilleran Deformation:

This region contains the temporally and geographically persistent Platform to Basin facies transition that marks the eastern margin of the Richardson trough. This facies transition is unfavorably oriented with respect to the Cordilleran structure to provide a strong trapping mechanism. Neither is there strong evidence to support a distinctive diagenetic history or events that would help to preserve reservoir quality by way of hydrothermal dolomitization. Therefore, the plays in Paleozoic carbonates of this region will be in Cordilleran structural culminations where vestigial limestone porosity and minor dolostones will constitute potential reservoirs. The potential is for dry, over mature gas generated by combinations of Foreland and tectonic burial, or for Paleozoic gas re-migrated into Cordilleran structures. The western margin of the Mackenzie-Peel Shelf constitutes a single play within Cordilleran structures. It is expected that the Peel Plateau Cambrian to Devonian Carbonate Margin will consist of about 7 gas pools with a mean potential of approximately 4.460 X 10^9 m^3 gas. The largest expected pool is 1.337 X 10^9 m^3 gas. Paleozoic clastics have a greater potential for a favorable stratigraphic component of entrapment. They have an improved potential for the preservation of the petroleum generated in the Paleozoic. It is expected that the Upper Paleozoic Clastic Play will consist of about 2 gas pools with a mean potential of approximately 7.799 X 10^9 m^3 gas. The largest expected pool is 5.517 X 10^9 m^3 gas. This is the single largest projected pool in this assessment. This play resembles deep-water sandstone plays on current oceanic margins.

Mesozoic sandstones in the Martin House and Arctic Red formations constitute the third play in the Peel Plateau Cordilleran thrust and fold belt. Although less likely to have large and thick extent, the timing of hydrocarbon generation relative to structure is favorable for Mesozoic hosted petroleum systems compared to Paleozoic ones. The Peel Plateau Mesozoic Clastic Play will consist of about 12 gas pools with a mean potential of approximately 13.157 X 10^9 m^3 gas. The largest expected pool is 2.861 X 10^9 m^3 gas. The total potential of the Peel Plateau assessment region between the Trevor Fault and the eastern limit of Cordilleran deformation is about 25.4 X 10^9 m^3 (~0.9 TCF) gas. This potential is significant, but moderated compared to that of the Peel Plain to the east.

Peel Plain East of the Cordilleran Deformation:

The remaining, and most prospective assessment region is the Peel Plain, east of the Cordilleran Deformation Front to the inter-territorial boundary. Five plays occur here. The Cambrian to Devonian Carbonate platform, all of which is dominated by carbonate ramp deposition, constitutes the largest volume of rock in any single play. Factors adversely affecting this play include: the style of porosity development and the lack of lateral seals in carbonate ramps, the preservation of reservoir porosity in the absence of pervasive dolomitization, and the timing of hydrocarbon generation relative to structure formation, Throughout the northern Interior Platform there has been a general lack of success drilling to the Hume Formation and the Ronning Group. It is expected that the Peel Plain Carbonate Platform Play will consist of a single pool of probably smaller than 0.218 X 10^9 m^3 gas.

Manetoe dolostones do not extend north of 63 degrees in the Mackenzie-Peel Shelf. This means that there is no potential in the previous defined Devonian Fractured Arnica Dolomite (Bird, 2000; 1999). Most of the Devonian is in a carbonate ramp setting in the Peel Plain. The one significant opportunity for an abrupt carbonate margin facies model accompanies the persistence of carbonate deposition following the drowning of the Hume Platform. This is similar in configuration to the Horn Plateau Play of the southern NWT. While, this play is not known to exist, neither can it be entirely discounted. It is expected that the Peel Plain Post-Hume Reef play will consist of about single gas pool with a mean potential of approximately 0.888 X 10^9 m^3 gas, should it occur.

Clastic plays in the Upper Paleozoic and Mesozoic section are the equivalent of plays in the same succession of the thrust and fold belt, but within the Interior Platform setting. The Upper Paleozoic clastic play of the Peel Plain is expected to have about 9 gas pools with a mean potential of approximately 7.26 X 10^9 m^3 gas. The largest expected pool is 1.352 X 10^9 m^3 gas. The smaller size reflects both the small available untested structures of the Plains, but also the more distal setting of this play area relative to the apparent source of these clastics. The Mesozoic Clastic play is expected to consist of about 55 gas pools with a mean potential of approximately 49.487 X 10^9 m^3 gas. The largest expected pool is 3.356 X 10^9 m^3 gas. In total the Peel Plain region, east of the limit of Cordilleran deformation constitutes the most attractive exploration region within the Peel Plain and Plateau. In total this 57.907 X 10^9 m^3 gas, or about 70% of the potential in place resource.

Introduction

Location and Physiography

The Peel Plateau assessment region lies in the northeast corner of the Yukon Territory in the region between latitudes 65°N and 667.5°N, longitudes 132°W and 136°W (Figures 1 and 2). The prospective petroleum basin occurs in the northern three quarters of that quadrangle, north of the Mackenzie Mountains and east of the Richardson Mountains. The study area comprises a prospective region of approximately 10,300 km^2, underlain by a Phanerozoic succession more than 4 km thick. The "Peel Plateau" assessment region includes portions of the Anderson Plain, the Peel Plain, Peel Plateau and the Richardson and Mackenzie Mountains physiographic provinces (Figure 2). For the purposed of this study the region as subsequently referred to generally as the Peel, Plateau, Peel Plain and Plateau, or the Peel region. The assessment region is geologically and physiographically contiguous with portions of the Anderson and Peel plains and Mackenzie Mountains of the Northwest Territories. Petroleum exploration has occurred in both the Yukon and the Northwest territories. This assessment captures the experience and data from the NWT portion of the Peel region in the analysis and discussion below. The dashed line on Figure 2 indicates the geographic boundaries of subsequent maps that illustrate the discussion below.

Tectono-stratigraphic Domains

The physiographic regions of the Peel Plateau assessment region do not follow closely, or provide clear indications of, the underlying geological structure. Three structural and stratigraphic belts that do not coincide closely with physiographic subdivisions underlie the region. Within each of these three tectono-stratigraphic domains there are generally similar stratigraphic successions and structural elements with similar tectonic and depositional histories. These similarities unify the petroleum systems and prospects within each of these domains while distinguishing the domains from one another. We employ these internal similarities and external distinctions as the basis for identifying different petroleum assessment regions defined below.

Within the Richardson Mountains east to the Trevor Fault is a region that is underlain predominantly by Upper Paleozoic and older successions (Figures 3 and 4). Phanerozoic stratigraphic successions in this region were deposited within the Richardson Trough (Figure 5), a north-northwest to south-southeast Paleozoic extensional basin that separates the Mackenzie and Peel shelves from elements of the Yukon Stable Block, such as the Porcupine Platform and the Ogilvie Arch. Tectonic controls on the Paleozoic paleogeography result from extensional tectonics that accompanied the formation of the Pale-Pacific passive margin of the North American Craton. Structural inversion of the Richardson Trough during the Laramide orogeny transformed the Richardson Trough into the Richardson Anticlinorium, of which the tectono-stratigraphic domain lying between the older Paleozoic outcrops in the core of Richardson Mountain and the Trevor Fault constitutes its eastern flank. This tectono-stratigraphic domain, is discussed below as the Peel Plateau – East of Trevor Fault assessment area, as the distinctive tectonic history and stratigraphic successions of this region distinguish it from more easterly portions of the Cordilleran Foreland thrust and fold belt.

East of the Trevor Thrust Fault bedrock outcrops are composed generally of Cretaceous successions that underlie the Peel and Anderson Plains (Figure 4) that are predominantly underlain by Paleozoic Platformal successions of the Peel and Mackenzie shelves that are overlain by Mesozoic Cordilleran Foreland Basin clastic successions. Within that region occur both the eastern marginal zone of the Cordilleran Foreland Thrust and Fold Belt, lying predominantly west of the Peel River and south of the sharp elbow in the Cranswick River, and the Interior Platform structural Province that extends south contiguously to the American border. The abrupt transition between the Mackenzie-Peel Shelf and the Richardson Trough occurs within the structures of the Foreland Belt eastern marginal domain, where both Paleozoic and Mesozoic succession are involved in east and north verging portions of the Cordilleran Foreland thrust and fold belt. Structures within this region are somewhat similar to those in the Liard Plateau, on the southern side of the Mackenzie Mountains structural and physiographic salient. The abrupt margin basin to platform facies transition in Paleozoic successions is unfavorably oriented with respect to regional dip for petroleum entrapment prior to the formation of Laramide structural closure. Neither does the region contain favorable diagenetic features, like the Manetoe Dolomite in the Liard Plateau, which might enhance the opportunity for petroleum accumulation. This tecton-stratigraphic domain is distinguished by the above-mentioned variations in geological history and it constitutes a distinctive assessment region referred to as the Peel Plateau Assessment Region.

East of major structures of the Cordilleran Foreland Belt the Phanerozoic succession deposited on the Peel and Mackenzie shelves is part of the Interior Platform structural province. The Peel Shelf is separated from the Mackenzie Shelf by an episodically active gentle epeirogenic feature, the Mackenzie-Peel Arch that lays between the Peel and Arctic Red Rivers and which generally separates Yukon portions of the Interior Platform from the Interior Platform in the Northwest Territory. The stratigraphic successions on both sides of the Mackenzie-Peel Arch are broadly similar and well correlated. The "undeformed" Paleozoic and Mesozoic successions of the Mackenzie-Peel shelves, lying east and north of the region affected by Cordilleran diastrophism constitute the third assessment region of this study, which is termed the Peel Plain Assessment region below.

Stratigraphy

An easterly tapering wedge of Phanerozoic sedimentary rock, more than 4 km thick, that unconformably overlies Proterozoic successions of varying ages and tectonic affinities, underlies the Peel assessment region (Dixon 1999; Morrow, 1999; Norris, 1997; Kunst, 1973). The Phanerozoic succession is composed to two major, unconformity bounded, sequences (Figure 2). The younger Cretaceous succession, comprises predominantly terrigenous clastics, are up to 1 km thick north of the Mackenzie Mountains and thinning to an erosional edge in the vicinity of the Mackenzie River (Dixon, 1999; 1997; 1992). The Cretaceous, predominantly Lower Cretaceous, succession was deposited in the foreland basin of the Cordilleran orogen. The Cretaceous succession overlies, unconformably, a wedge of westerly thickening Paleozoic sedimentary rocks deposited in a cratonic continental margin and platform setting.

The generally conformable Paleozoic sequence is composed of two major successions. The Lower Cambrian to Devonian succession, predominantly carbonates and shales, generally 1800-2000 m thick comprises the abrupt margin succession of the Richardson Trough and Peel-Mackenzie Platform (Morrow, 1999). During the Middle Devonian the abrupt carbonate platform – basinal clastic facies transition retreated into northern Alberta and British Columbia, drowning and starving the Peel-Mackenzie Platform. During the Late Devonian and Early Carboniferous the Peel Region was the site of rapid deposition of a southerly prograding, upwardly coarsening basin and offlapping, slope and shelf-shoreface sediments up to approximately 1500 m thick that were probably contiguous with correlative successions in the Eagle Plain (Richards, 1997; Norris, 1984; Pugh 1983). Permian to lowermost Cretaceous strata are not present in the Peel Region, although Lower Cretaceous strata, which were probably overlain by Upper Cretaceous and Tertiary successions of the Cordilleran Foreland Basin, are preserved. Upper Cretaceous and Tertiary successions preserved elsewhere are not present in the study area. Since the end of the Cordilleran orogeny the region had been a site of non-deposition and erosion.

Cambrian to Lower Silurian (Ronning Group and older and equivalent strata)

The Cambrian to Lower Silurian succession comprises strata of the Ronning Group and older strata on the Mackenzie-Peel Shelf and equivalent strata of the Road River Group in the Richardson Trough. The Ronning Group succession is unconformably underlain by generally thin, and variable eroded Cambrian successions of Saline River to Mount Clark formations (fm's), predominantly clastics, up to approximately 230 m thick in the Ontaratue H-34 well. However, across much of the Peel Shelf, in the footwall, or lower plate of the large basement controlled normal faults that bound the eastern side of the Richardson Trough the Ronning Group sits either very thin undifferentiated lowermost Paleozoic strata or directly on Proterozoic successions, similar to outcrop relationships in the Snake River Map Area. Within the Richardson Trough, generally west of the Knorr Fault, but possibly also west of the Trevor Fault, the Ronning Group and Road River Group overlie the Lower and Middle Cambrian Illtyd and Slats Creek fm's.

Morrow (1999) interprets the silty limestone and massive dolostones of the Lower Cambrian Illtyd Fm. to have been deposited accompanying the initial extension on the Knorr Fault and other, similar, structures that may include the Trevor Fault that formed the Richardson Trough. The conformably overlying Middle Cambrian Slats Creek Fm., predominantly sandstones, were probably derived from the erosion of Proterozoic strata, like Katherine Group, in the footwall of extensional faults bounding the half-grabens on the eastern margin of the Richardson Trough. The Caribou N-25 well penetrates approximately 168 m of Slats Creek Fm. (Morrow, 1999), and similar successions to those that outcrop in the Wind River Map area may be present in the area east of the Trevor Fault.

The overlying upper Middle Cambrian to Lower Silurian Ronning Group, mainly ramp and abrupt margin carbonates deposited on the Peel Shelf, passes eastward into the Road River Group, mainly fine carbonates and clastics, in the Richardson Trough. The Ronning Group, up to approximately 1100 m thick is composed of an internally disconformable succession of Franklin Mountain, Loucheux, and Mount Kindle fm's. The Upper Cambrian to Lower Ordovician Franklin Mountain Fm. predominantly dolostones is composed of informal three informal members, a basal Cyclic member of composed of silty, sandy and shaly dolostones, up to approximately 100 m thick (Setting Figure 6), overlain by the thinly laminated and rhythmically bedded dolostones of the Rhythmic member, which is overlain by the predominantly light brown cherty dolostones of the Cherty or Upper Dolostone member.

The unconformably overlying Mount Kindle Fm., predominantly dolostones, is up to approximately 443 m thick. It is also composed of lithologically distinctive members, which from the base include a Basal member, predominantly dolostones, overlain by argillaceous dolostones that become less argillaceous up section and which comprise the Middle Resistant member that is, in turn overlain by the Upper member, predominantly dolostones.

Ronning Group ramp and abrupt margin carbonates of the Franklin Mountain and Mount Kindle Fm. change facies into fine basinal clastics and carbonates of the Road River Group and its constituent formations in the Richardson Trough. The Franklin Mountain passes westward into the Rabbitkettle Fm., predominantly laminated basinal lime mudstones and argillaceous lime mudstones, of the Road River Group. That facies change occurs somewhere west of the Caribou N-25 well and the outcrops of Rabbitkettle Fm. in the Richardson Mountains (Figure 6). When Mount Kindle Fm. deposition began the basin-platform margin had back-stepped into the region east of the Trevor Fault (Figure 7), such that the Loucheux Fm., 577 m thick and predominantly calcareous shales, of the Road River Group overlies Franklin Mountain Fm. in the Caribou N-25 well (Figure 8). The correlative basinal deposits of the Road River Group and Fm. are up to 1235 m thick in the Caribou N-25 well, but the are more than 2676 m thick in outcrops on the eastern flank of the Richardson Mountain (Figure 8). The basin-platform transition remained geographically stable from the onset of Mount Kindle deposition until the Hume Fm. platform was drowned by the Canol transgression, indicating a persistent and abrupt carbonate margin from Late Ordovician until Middle Devonian time.

Upper Silurian to lower Middle Devonian

Following a widespread base level in Late Silurian time the Peel Platform was again transgressed and sedimentation resumed with the deposition of the Delorme Group, predominantly silty and sandy dolostones of the Peel Fm. and overlying green shale interbedded with shaley limestones of the Tatsieta Fm. (Figure 8). The Delorme Group is generally between 200 and 300 m thick, but it is up to about 380 m thick in the Peel F-37. The Delorme Group is conformably overlain by the Arnica, predominantly fabric replace dolostones up to 400 m thick. Arnica dolostones are conformably overlain by Landry Fm. predominantly brown pelleted limestone interbedded with the shaly limestones that is generally between 200 and 250 m thick, but up more than 500 m thick in some well (Setting Table 1). The Hume Fm., predominantly gray argillaceous limestones and calcareous shales cap the succession, generally between 100 and 150 m thick (Table 1). Most is underlain by carbonate ramp and patch reef depositional settings, but at the platform-basin transition to the Richardson trough an abrupt carbonate margin, like the Keg River Barrier existed throughout this interval. Details of this succession are discussed by Morrow (1997). Porous zones occur at several horizons in this succession, but most notably in the Arnica dolostones, as at in the Tree River F-57 well.

Upper Middle Devonian to Carboniferous

In Late Middle Devonian time a major base level rise resulted in a major back-step of the abrupt carbonate margin into northern Alberta and British Columbia where the abrupt carbonate margin was reestablished as the Keg River barrier reef. The Hume platform on the Peel and Mackenzie shelf was drowned by this event, except where platformal facies persisted as atoll and pinnacle reefs, referred to as Horn Plateau Reefs. Such reefs are have not been identified in the study region, but they may exist, where they could constitute a petroleum play, if reservoir exists.

The preceding assessment (NEB, 2000) referred to the presence of the Hare Indian Fm., predominantly fine calcareous clastics, within the study area. However, that Fm., a distinctive lobe of shale overlying more eastern and southern parts of the Hume Platform, on which Kee Scarp reefs like the one at Norman Wells are rooted does not occur in the study region. On the Peel Shelf the Hume platform is “drowned” by a major base-level rise and back-step of the carbonate margin. Hume Carbonates and Road River shales are overlain by the Canol Fm. shales, generally about 50 m thick, and containing a discontinuously developed bituminous basal limestone facies known as the Bluefish Member, an excellent potential petroleum source rock. It was within this formation that the IOE Tree River H-38 well encountered a significant show of gas.

Subsequently the Peel-Mackenzie Platform and Richardson Trough were the sites of thick deposits from a down lapping and prograding shelf and slope clastic assemblage, the Imperial Fm. The Imperial Fm. was part of a major progradational clastic wedge derived from the north and west, possibly from the Franklinian orogen. The Imperial Fm. represents shelf and slope deposits of this succession that are often characterized by prominently down lapping oblique reflections on seismic sections. The Imperial Fm. is up to 2000 m thick just north of the east-west segment of the inter-territorial boundary, but it is generally between 1500 and 750 m thick within the assessment region (Norris, 1997; Pugh, 1983). The Imperial Fm. becomes sandier westward and northward. The slope and shelf sandstones of this succession are inferred to represent significant opportunities for the structural entrapment of petroleum, following modern analogues on the Gulf Coast and Atlantic margin of the Atlantic Ocean, which are currently among the most active and rewarding petroleum plays.

Shoreface, deltaic and fluvial coarse clastics that conformably and gradationally overlie the Imperial Fm. comprise the Tuttle Fm. The Tuttle Fm. is part of the prograding clastic wedge depositional system that begins with deposition of the Imperial Fm. Tuttle Fm. is between 250-1250 m thick within the study region, although has been deeply eroded and is absent both over the Richardson Mountains and east of the Arctic Red River. The subcrop of these sandstones may provide a significant stratigraphic component of entrapment below Cretaceous rocks, where a seal exists. However, it is more likely that the erosional upper surface of Tuttle sandstones presents a preservation risk, or a conduit for petroleum migration into the basal sandstones of the Martin House Fm., that overlies them.

Tuttle Fm. sandstones are argillaceous and poorly sorted and commonly exhibit low porosities and permeabilities. The coarsest sediments occur in the Peel F-37 and L-19 wells and grain size decrease southward (Pugh, 1983). Reservoir quality follows grain size generally, and it improves southward where the overall argillaceous component of Tuttle Fm. sandstones decreases and the discrete shales are interbedded with sandstones. The Tuttle contains thick shale intervals indicative of internal sequence and parasequence boundaries, and the general transition to the Ford Lake shales in the south. Channel sandstone bodies have been observed in fluvial parts of the formation and coarsening-upwards sequences are common in shoreface settings, particularly toward the southwest.

Major clastic depositional wedges are often major petroleum systems, and the Tuttle-Imperial sequence is a reasonable depositional analogue to the Heiberg sandstones and Blaa Mountain Shales of the Sverdrup Basin in the Canadian Arctic Archipelago (Chen et al., 2000). Discoveries within the Sverdrup basin include 19 major petroleum fields, comprising 8 oil and 25 gas pools equivalent to 10% and 23%, respectively, of the remaining national reserves of conventional crude oil and natural gas as of January 1999

(CAPP, 1999). Although it is unlikely that the Peel region will be so prolific (see discussion below), the depositional setting of the Tuttle-Imperial clastic wedge, and its similarity to other productive petroleum systems provides one of the major encouragements within this assessment. Most important to this analogy are recent observations of petroleum preservation in another deeply buried and extensively eroded clastic wedge. Significant indications for petroleum preservation and potential have been recently recognized in the Jurassic and Cretaceous Bowser Lake Group in British Columbia (Hayes et al., 2004; Osadetz et al., 2003). There, despite great burial and high levels of thermal maturity and diagenesis, recent studies have found both “live” oil stains and shows of natural gas, including by-passed pay in a well. These analogues and developments, as well as the focus and success of major exploration efforts in similar prograding clastic wedges provides one of the most important reasons for attributing petroleum potential to the Peel Plateau. Correlative strata in the Eagle Plains basin, west of the Richardson Mountains host significant petroleum occurrences.

Lower Cretaceous

Unconformably overlying the deeply and differentially eroded Paleozoic succession is a Lower Cretaceous succession composed Aptian and Albian Martin House Fm., predominantly sandstone, Albian Arctic Fm., predominantly shales and siltstones, and the Albian to Turonian Trevor Fm., predominantly sandstones (Dixon, 1999). The succession is up to between approximately 250metres and 1000 meters thick in Yukon portions of the Peel Plateau, with the thickest preserved thickness occurring north of the Mackenzie Mountains.

The basal sandstone, Martin House Fm., between 50 and 125 meters thick in the study region, and it is commonly overlain by a succession of finer clastics in the Arctic Red Fm. The Martin House Fm. has a basal sandstone member overlain by thinly interbedded siltstone, sandstone, and shale, providing a distinctive response on wireline logs. In the basal member thick to very thick beds of fine- to medium-grained sandstone grade laterally and locally into thin beds of pebbly sandstone. The overlying member is composed of thin beds of very fine- to fine-grained sandstone. Martin House strata were deposited as a basal transgressive sandstone in a shallow-water, marine shelf setting as indicated by hummocky cross-stratification and marine fossils.

The Arctic Red Fm., predominantly marine shale, concretionary or silty shale and lesser sandstone and siltstone, is approximately 350 m thick at its type section near the confluence of the Peel and Arctic Red rivers and it reaches 1,500 m thick in the Arctic Red F-47 well on the Peel Plateau that are more than 100 and which approach 1000 m thickness. The section is capped by the Trevor sandstones, which are not sealed from the surface. The seismic section and well log illustrates the Cretaceous succession in the vicinity of the F-47 well. Mountjoy and Chamney (1969) subdivided the Arctic Red into a number of informal local members, but these do not appear to follow subsurface seismic and well log markers that provide informal marker units. The formation may be analogous to the younger Colorado Group in the southern Interior Platform.

The conformably and gradationally overlying Upper Albian to Upper Cretaceous Trevor Fm., predominantly fine- to coarse-grained, locally conglomeratic, sandstone interbedded with shale (Mountjoy and Chamney, 1969) extends eastward along the front of the Mackenzie Mountains as east to Hume River (Yorath and Cook, 1981). In the Arctic Red F-47 the Trevor Fm. is composed of coarsening-upward hemicycles. The top of the Trevor Fm. is everywhere eroded. In the type area the formation is 360 m thick and this increases eastward to 602 m in the Arctic Red F-47 well (Figure 9). There is probably a significant disconformity with the formation (Dixon, 1999).

Structural Geology

The structural geology of the assessment region requires a comprehensive study and revision that is beyond the scope of this report. Elements of a revised structural model have been incorporated into the characterization of petroleum play definitions and prospect parameters, but their detailed discussion will have to appear elsewhere. Previously, the structure of the Peel region were interpreted to result from complicated interactions of structural events and elements strongly linked to the formation of the Amerasian Ocean Basin (Beaufort Sea) (Norris, 1984; 1997).

At regional map scale the major structural elements include the Richardson Anticlinorium (Figure 10), a gently north-plunging structure that interacts at its north end with faults interpreted to emanate in the Mackenzie Delta and on the margin of the Amerasian Basin. The eastern flank of the Richardson Anticlinorium is marked by the Trevor Fault, east of which is the broad expanse of the Peel physiographic plain, where no diastrophic structures were mapped at outcrop. Norris (1984; 1997) interpreted the Trevor Fault to have a normal Laramide offset. The Bonnet Plume Basin, with a thick Cretaceous and possibly younger stratigraphic succession, marks the south end of the Richardson Anticlinorium. At this junction the structural trends turn sharply east in an oroclinal fashion to link with the north-verging structures of the Mackenzie Mountains. Several large, east-west trending open folds with hinges more than 40 km long were mapped in Cretaceous strata north of the Mackenzie Mountains, but south of the sharp right angled eastward bend in the Cranswick River. Norris interpreted the structures to be of variable ages and styles, inferring that the north-verging compressional structures were Early Cretaceous structures of the "Columbian" phase of the Cordilleran Orogen and that the north-south structures, which he erroneously inferred to be extensional, were formed subsequently during the "Laramide" phase of the Cordilleran deformation.

It is suspected that industrial explorers have long known the inadequacies of the structural geometry and kinematics discussed above. Among the first non-industrial geoscientists to notice the true nature of the structure were G. Morrell and M. Fortier of Indian and Northern Affairs Canada, although the analysis has not been published. The scientists, and, to be sure, others recognized that both the north-south and east-west trending structures are compressional and that most of the region west of the Peel River and south of the "elbow" in the Cranswick River are underlain by a north and east verging "thick-skinned" thrust and fold belt, the basal detachment of which occurs within the thick Proterozoic succession. The nature of the large reorientation of the thrust and fold belt about the hinge overlain by the Bonnet Plume Basin is not well understood, but it is most probable that the entire north and east verging orogen is composed of contemporaneous structures that shorten the Proterozoic and Phanerozoic succession under the controls of Proterozoic and Paleozoic structures that have been reactivated and "inverted" during Cordilleran compressive diastrophism.

The age of the deformation is not well known, but the involvement of the entire Cretaceous succession and the preservation of proximal rudaceous clastics in the Monster Fm. suggests that the deformation is temporally and mechanically linked to the Cordilleran orogen south of the Mackenzie Mountains salient. How these structures are linked or affected by the structures of the Mackenzie Delta and the passive margin on the Amerasian Basin has been discussed by Lane (2000), but much detail remains to be described and analyzed.

The continuity of the structural style in the Peel Plateaus with that of the Cordilleran Orogen to the south suggests that petroleum potential in both the allocthonous tectonic wedge of the Foreland thrust and Fold Belt and the undeformed Interior Platform could result in an emulation of the effective petroleum systems of the eastern marginal zone, or Foreland Belt of the Cordillera and its adjacent Foreland Basin in the Interior Platform structural province, accounting for the changes in petroleum system thermal history and the variations in structural style due to the changes in mechanical stratigraphy.

For the purposes of this discussion we display and discuss three interpreted reflection seismic profiles (data and interpretation courtesy of B. MacLean, GSC Calgary). The three structure sections are:

- A northeasterly trending seismic time section, the 1972 Gulf Canada Line C-11. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. The well is in the vicinity of the Caribou M-25 well. A synthetic seismic trace has been constructed from the wire-line logs of the M-25 well, and that synthetic trace is displayed on the interpreted seismic section for the purpose of assisting the structural and stratigraphic interpretation (Figure 11).
- A northeasterly trending section through the 1969 Esso Resources Line 4. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. The well is in the vicinity of the Peel River K-09 well. A synthetic seismic trace has been constructed from the wire-line logs of the K-09 well, and that synthetic trace is displayed on the interpreted seismic section for the purpose of assisting the structural and stratigraphic interpretation (Figure 12).
- A northerly trending seismic section 1970 Amoco Canada Line CKR-10. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. The well is in the vicinity of the Cranswick A-22 well. A synthetic seismic trace has been constructed from the wire-line logs of the A-22 well, and that synthetic trace is displayed on the interpreted seismic section for the purpose of assisting the structural and stratigraphic interpretation (Figure 13).

The 1972 Gulf Canada Line C-11 (Figure 11) passes through the Caribou M-25 well and crosses the Trevor Fault approximately 5 km northeast of the well. In this line the Trevor Fault is a westerly, or hinterland, verging antithetic thrust that is inferred to have developed above a larger east-verging fault that results in the open fold in the Phanerozoic succession that is the most obvious structure of the line, on the crest of which the M-25 well has been located. This suggests that the main structure is a very thick-skinned, perhaps even basement cored, east verging thrust sheet, which is responsible for the generally deeper level of exposure and erosion that occurs west of the Trevor Thrust. This structure may be a reactivation, or inversion of an early Paleozoic basement structure that controlled Paleozoic paleogeography on the eastern flank of the Richardson Trough, which now lies on the eastern flank of the Richardson Mountains. It is clear that the highest structural culmination in the immediate hanging wall (east side) of the Trevor Fault has not been tested.

The 1969 Esso Resources Line 4 (Figure 12) passes through the Peel River K-09 well and it crosses the front of the main Cordilleran deformation, approximately 25 km southwest of the K-09 well. Here the Cordilleran structure is dominated by visible and interpreted northeast-verging synthetic and southwest-verging antithetic thrusts. The obvious and interpreted structures appear to be develop on a larger and deeper detachment that counts for the broader open, although disrupted structural culmination that is the largest and characteristic features of the southwestern half of the section. While part of the rise in Paleozoic reflectors near the foreland verging thrust in the center of the section may be due to velocity effects near the leading edge of the deformation, it appears that pare of that structure is also real, perhaps due to a small tectonic wedge, or triangle zone, perhaps in the form of an antiformal stack of thinner thrust sheets that have been inserted into the otherwise largely undeformed Foreland Basin succession that dominates the eastern half of the section. Note rising of reflections toward the eastern limit of the section, where the K-09 well appears to be located on at the leading edge of a series of sharply imbricated reflections in the Upper Paleozoic succession. The imbricate reflections are interpreted to be clinobeds developed on the Late Paleozoic slope during deposition of the Imperial/Tuttle progradation. The presence of these features indicates stratigraphic opportunities for entrapment in the Upper Paleozoic succession that constitutes a major play in this assessment. Note that the K-09 well, which had one of the few encouraging tests, appears to be located on a small foreland verging thrust that is rising steeply out of an inferred detachment lying just above the Hume Fm. platform carbonate. This structure might be similar, or analogous, to structures like those developed in the Monarch Fault of southern Alberta, where small thrusts and thrust sheet antiforms are developed deep in the foreland, without obvious connection to the main limit of the deformation, which appears clearly in the center of the section.

The 1970 Amoco Canada Line CKR-10 (Figure 13) passes through the Cranswick A-22 well where it is involved in north-verging Cordilleran thrust sheets that are linked to the Mackenzie Mountains. The nearby Yukon Territory well, Cranswick A-42, well tests one of several potential structural prospects in an area that is sparsely penetrated. Two major concerns in this region are, the preservation of porosity under closure and the timing of deformation relative to hydrocarbon generation and thermal maturation of sources. Note the thick-skinned style of the deformation that involves the Proterozoic succession. Most thrust appear to terminate within detachment, or strain zones within the thick Cretaceous succession. The section shows how the style of the deformation changes in the stratigraphic succession, such that the deformation of the Proterozoic and Paleozoic successions, which is dominated by thrusting, is often manifest as a train of open upright folds within the Mesozoic succession, producing structures like those mapped by Norris.

These three seismic lines show that the overall structure in the Cordillera is compressional and that the style and timing of the deformation of the easterly and northerly verging structures is the same, resulting in a single unified structural model through the region. Many of the structures, especially the broad open folds like that tested by the Caribou N-25 are probably developed over deep detachments in the Precambrian successions or even the basement, which might include inversion of the Richardson Trough. Not all prospects have been tested nor is the structural style sufficiently well described or analyzed to clearly show that the drilling to date has diagnostically tested the Cordilleran structures, or the combined structural and stratigraphic complexities of the Foreland beyond the most obvious limits of the Cordilleran deformation. Clearly there are problems with both reservoir and seal in the Paleozoic succession. Several wells test only mud, indicating a lack of porosity, or freshwater, showing a failure of the seal and communication with the surface. However, the region is sufficiently complicated both structurally and stratigraphically that numerous exploratory opportunities remain, with some being illustrated on these three example seismic lines. Clearly the structure and tectonics should be comprehensively re-evaluated in light of the large seismic and well data set that is available.

Petroleum Systems

There are four indications for effective petroleum systems in the Peel Plateau including, potential petroleum source rocks, surface seepages, bitumen stains and residues and tests of natural gas from wells. The most important of these are the tests from wells. At least eight wells have had minor, but encouraging shows of natural gas that prove there are active petroleum systems in the region. The encouraging tests include:

ATLANTIC ET AL ONTARATUE H-34, where drill stem test number 2, run between 1351.7m and 1360.3m recovered 54.9 m gas cut mud and 167.7 m of gas cut salt water from the Devonian Arnica Fm. carbonate.

SHELL PEEL RIVER YT B-06, where drill stem test number 2, between 312.4-430.4 metres, across the base of the Cretaceous succession and the top of the Tuttle Fm. recovered gas to surface 30 seconds that was too small a volume to measure.

SHELL PEEL RIVER YT B-06A, where the only single drill stem test between 798.3-866.9 metres, in the Tuttle Fm. flowed water to surface in 55 minutes and recovered 789.4 m gas cut salt water.

IOE TREE RIVER H-38, where during drilling at about 721 m, in the Canol Fm., the well flowed sweet gas at an estimated rate of 17.7 x 106 m3 (NEB, 1995, p. 24).

MCD GCO NORTHUP TAYLOR LAKE YT K-15, where drill stem test number one, between 729.4-737.0 m recovered 30.5 m of watery mud and 121.9 m of muddy gassy

fresh water and drill stem test number 3, between 792.2-1852.0 m recovered 137.2 m of water and mud and 362.7 m of gassy salt water.
PACIFIC ET AL PEEL YT F-37, where the first test, of a porous zone in the top of the Mount Kindle Fm., between 3319.3-3368.0 m recovered 137.2 m of mud, 1388.1 m of gassy salt water and 109.7 m of gassy muddy salt water.
GULF MOBIL CARIBOU YT N-25, where the third drill stem test between 1773.9-1787.7 m in the Road River Group recovered 27.4 m of gas cut mud.
SHELL PEEL RIVER YT M-69, where the fourth test, in the lower Tuttle Fm. between 1742.8-1799.8m flowed gas to surface at rates too small to measure and recovered 94.5 m of mud.
Norris (1997) reported a surface seepage of natural gas in northern Swan Lake (106 N4/1) west of the Arctic Red River, nearby the location of the Swan Lake K-28 well. Two bitumen dykes were discovered by Stelck (1944) on Peel River between the Bonnet Plume and Snake Rivers (106E15/1 and 106E15/2) and a third "spectacular" sill-like mass of solid bitumen is reported, within the Imperial Fm., in a borrow pit on the Dempster Highway 7 km north of Rengleng River, north of the town of Arctic Red River (Norris, 1997, his Figure 15.1; his Table 15.1), well beyond the limits of this study, but within similar successions. Pugh (1983) and Kunst (1973) report other, minor shows of bitumen within the study area and in its environs. Together these tests and occurrences suggest active petroleum systems that should be effective if suitable reservoirs formed and have preserved traps with appropriate timing.

The wells have not been extensively studied for their petroleum potential, except for in proprietary reports. Bird (NEB, 200) provides a summary of one such study by Exploration Geosciences. That study examined 325 rock samples using pyrolytic techniques and it found average total organic carbon exceeding 1% in six formations, including, the Arctic Red, the Tuttle, Imperial, Canol, Hare Indian and Hume. The Paleozoic formations all contained rich zones that each exceed about 4% TOC in each of the five formations, while the maximum TOC of the Arctic Red Fm. was 1.61% TOC. The thermal maturities and organic matter type of these samples was not reported.

Like the Liard Plateau the inferred problem in petroleum systems is not the potential of the petroleum system, but the timing of generation and migration, relative to the formation of structures. In the Liard Plateau detailed studies suggest that the potential petroleum sources follows stratigraphic position and that the all Paleozoic potential sources are currently in the wet gas to over mature zone, with some oil potential in the Mesozoic succession. (Potter et al, 1993). Liard Plateau maturation models suggest a Late Devonian heating event and the generation of liquid hydrocarbons during the Late Paleozoic to Early Mesozoic interval (Potter et al, 1993). Devonian Manetoe facies reservoirs often contain pore coating bitumen that is attributed to this early hydrocarbon generation interval. Thus, the gas in Manetoe reservoirs has been attributed to catagenesis of oil in overlying Besa River Shale, when the reservoir entered the gas window approximately 280 million years ago (Morrow, 1991; Potter et al., 1993). While all of these events are well documented by authoritative study it conflicts generally with the inferred history of petroleum systems elsewhere in the Cordilleran Foreland Belt. In general, Foreland Belt Laramide structural accumulations of petroleum are inferred to have been generated syntectonically in response to tectonic burial by the stacking and thickening inherent in overthrusting and folding, often from source rocks in the footwall succession. Certainly where ever liquids are found within the southern Foreland Belt their molecular and isotopic compositions show them to be derived from footwall sources (Geological Survey of Canada, unpublished data), while the alteration of isotopic compositions in drier gas fractions by process like thermochemical sulphate reduction prevent a complete and diagnostic analysis of the source of all gases. Within the Cordilleran Foreland the syntectonic generation of reservoir charge clearly operates from Wyoming to 60o N latitude. Therefore the early gas generation model proposed for Liard Basin is a stark, but unresolved anomaly in the Foreland Belt. Fortunately, the large discovered reserve in the Liard Plateau indicates that an effective petroleum system exists, regardless of our understanding of its function and history.

Although the Peel Plateau lacks the Manetoe Dolomite event it has an otherwise similar stratigraphic history to the Liard Plateau. Like the Liard Plateau there are indications from wells and outcrops of and effective petroleum system. It would appear that some of the structures, like those tested by the wells with positive shows for petroleum, are not overly hampered by timing considerations. It would appear that reservoir quality and seal are also important considerations, which are captured by the exploratory risks of the plays assessed below.

Exploration History

Reflection Seismic Surveys

The distribution of reflection seismic surveys with in the study area is shown in Figure 14. Within NTS map sheets 106E, F, G, K, L, M, there are 2283 kilometers of reflection seismic surveys, covering the entire prospective region, in all three play areas. The data, acquired largely prior to 1977, has been used to locate the 39 wells used to test petroleum prospects in the Peel regions Cordilleran and Interior Platform settings. Three seismic lines were discussed above in the illustration of the structural style, but the focus of this discussion is on the history of drilling to which the seismic surveys contributed prospects and locations.

Exploratory Drilling

Petroleum exploration has resulted in the drilling of 39 wells in the region of the Peel Plain and Plateau between 1964 and 1977 (Table 2; Figure 16). None of these wells have resulted in a significant discovery, during thirty years of generally unsuccessful exploration, although there have been some encouraging shows. These wells and the data derived from them are key data for this study. The wells occur east of 132 degrees west longitude and south of 67.5 degrees north latitude in the region east of the Richardson Mountains and north of the Mackenzie Mountains. Nineteen of these wells were drilled in the Yukon Territory. An additional 24 wells, not all in the Peel region, were drilled in the Northwest Territories to test the petroleum plays assessed in this work. All these wells were used in the formulation of Play Parameters and Exploratory Risks. The four additional important wells lie just east and north of these geographic study limits, bounded by the Separation Point #1 A-05 well on the north the Cranswick A-22 well on the east. These wells were also used in the formulation of play parameters and risks and they are discussed below, in the context of the exploration history. A further nine wells were examined and are mentioned within the exploratory history sequence discussed below. Five of these wells lie north of the Separation Point #1 A-05 well and four lie east of the Cranswick A-22 well, all in the Northwest Territories.

Exploration for petroleum in the Peel Plain and Plateau region, relevant to this study, began in 1960. During that decade a total of 21 new field wildcat and 4 structure test holes were drilled in the study region, without significant result. The first well drilled was the RO CORP ET AL POINT SEPARATION #1 A-05 well in the Northwest Territories. This new field wildcat well was located just beyond the northern limits of this study at 67.57 north latitude and 134.00 west longitude. The well spudded on July 31, 1960 from a Kelly Bushing elevation (Kelly Bushing elevation) of 18.90 m and it was drilled to 2445.4 m in the Mount Kindle Fm. The well was determined to be dry and abandoned as of October 16, 1960. Exploratory drilling moved south into the assessment region with the spudding of ATLANTIC ET AL ONTARATUE H-34 on December 20, 1963. This Northwest Territories new field wildcat well (66.39 north latitude, 132.10 west longitude) was spudded at a Kelly Bushing elevation of 141.70 metres. It penetrated Proterozoic rocks at 3109.7 m and was drilled to a total depth of 4075.2 metres, bottoming in MAP UNIT H-1. The well cored five intervals between 1370.1 m and 3459.8 m and tested two zones. The second drill stem test, run between 1351.7m and 1360.3m recovered 54.9 m gas cut mud and 167.7 m of gas cut salt water from the Arnica Fm. carbonate. The show was non-commercial and the well was declared dry and abandoned (D&A) in April 01, 1964. The third well drilled was Imperial Oil Enterprises (IOE) CLARE F-79. This new field wildcat well was drilled on the east side of the Arctic Red River in the Northwest Territories at 67.14 north latitude, 133.24 west longitude. It was spudded on June 20, 1965 and was D&A.

The fourth well drilled in the study region, SHELL PEEL RIVER YT J-21, was the first well drilled in the Yukon Territory portion of the play area. The J-21 well was located at 66.51 north latitude and 134.07 west longitude, east of the limit of the Cordilleran folding and thrusting. Spudded on July 31, 1965 from a Kelly Bushing elevation of 45.70m the well was drilled to a total depth of 1219.2, in the Tuttle Fm., which it entered at 354.8 m depth. The well cored two intervals between 614.8-617.8m, and between 894.3-1202.1m in both Mesozoic and Paleozoic strata. A single test was run between 829.1 and 851.0 metres, which recovered 89.9 m of mud cut salt water. The well was declared D&A September 01, 1965. The fifth well drilled in the play was SHELL PEEL RIVER YT K-76. It was also drilled in the Yukon Territory (66.43 north latitude and 134.24 west longitude, Kelly Bushing elevation 76.50 m). This well was drilled southeast of the J-21 well, on the west side of the Peel River, but still east of the Cordilleran deformation. The well was spudded on October 07, 1965. It entered Paleozoic Tuttle Fm. clastics at 451 m and was drilled to a total depth of 1386.8 meters. No conventional cores were cut and it tested a single interval in the Tuttle Fm. between 1143.0-1189.0m from which 18.3 m mud and 33.5 m water was recovered. The well was D&A November 25, 1965. The next exploratory well was IOE STONY I-50, which was drilled almost due west of the Separation Point #1 well in the Northwest Territories at 67.50 north latitude and 135.38

west longitude, from December 10, 1965. The well cored three intervals and had two tests, which recovered only mud and mud cut water. Drilled to a total depth of 3343.0 m in the Devonian Landry Fm. the well was D&A May 08, 1966. The next well drilled, and the seventh in the assessment region was the SHELL PEEL RIVER YT L-01. This Yukon Territory new field wildcat well (66.51 N latitude, 134.77 W longitude) was the first well drilled in the Laramide Fold and Thrust Belt. The well was spudded on December 12, 1965 and drilled to a total depth of 1834.9m in the Devonian Imperial Fm. The well entered the Tuttle Fm. at 682.7 m depth and the Imperial Fm. at 1785 m depth. The well tested two zones. The first test between 1338.7-1394.2m recovered 914.4 m of mud cut water while the second test, run between 917.4 and 971.7 m recovered only 39.5 m of drilling mud. The well was D&A February 07, 1966.

The eighth well drilled was IOE NEVEJO M-05, a new field wildcat (67.25 N latitude and 134.03 W longitude) located west of the Arctic Red River and begun February 01, 1966. It was drilled to a total depth of 2378.7 m in the Peel Fm. It was D&A March 28, 1966. The SHELL PEEL RIVER YT I-21 new field wildcat (66.18 N latitude, 134.31 W longitude) was spudded February 20, 1966 from a Kelly Bushing elevation of 381.30m. This well drilled below the Imperial Fm., penetrating the Hume Fm. at 1451.8 m and entering the Gossage Fm. at 1571.5 m, which it drilled to a well total depth of 2072.6 m. This well had three drill stem tests. The first test, run between 668.7-710.5 m recovered 9.1 m of mud. The second test, from 767.-888.8 m recovered 418.5 m or fresh water. The third test recovered 6.1 m of mud from between 1384.4-1486.8 m depth. The well was D&A March 30, 1966.

The SHELL PEEL RIVER YT L-19 new field wildcat was the next drilled. L-19 is located in the Yukon Territory, in the Cordilleran Fold and Thrust Belt west of the Peel River, but east of the Trevor Fault (66.81 north latitude, 135.31 west longitude). This well spudded April 11, 1966 in the Tuttle Fm. It was drilled to a total depth of 1981.2 m in the Imperial Fm., which it penetrated at 1045 m depth. A single test was run in the lowermost Tuttle succession between 994.9-1012.9m that recovered 243.8 m of fresh water. The well was D&A June 12, 1966. The eleventh well, IOE MARTIN HOUSE L-50, tests an Interior Platform structure in the Northwest Territories. Spudded on April 17, 1966 this new field wildcat well was drilled to a total depth of 2407.9 m in the Mount Kindle Fm. it was D&A June 11, 1966.

SHELL PEEL RIVER YT B-06 was the 12^{th}, new field wildcat well drilled. It is inferred that this well (66^o35'09.4" 134^o45'37.5") and its succeeding test B-06A (66^o35'09.5", 134^o45'40.0") were located to test the leading edge of the Cordilleran thrust and fold belt west of Peel River. The B-06 well was spudded December 14, 1966. It drilled to a total depth of 1066.8 metres, bottoming in the Tuttle Fm. Two tests were run in the Mesozoic succession just above the Tuttle Fm., which occurs at 332.2 m depth. The first test run between 315.5-430.4 metre recovered 24.4 m mud but a second test run over the same interval, between 312.4-430.4 m recovered gas to surface 30 seconds that was too small a volume to measure. The well was D&A December 31, 1966, but it represents the first recovery of gas from the Cordilleran structures of the area and the second positive indication for petroleum since the test run at ONTARATUE H-34 in 1963. This favorable result led to the drilling of SHELL PEEL RIVER YT B-06A from essentially the same location. B-06A was begun on January 03, 1967. The well was spudded in Cretaceous shales and siltstones at surface and it penetrated the Tuttle Fm. at 333.4 m depth and it continued in that deformed succession until total depth at 1066.8 metres. A single drill stem test as run in the interval 798.3-866.9 metres. It flowed water to surface in 55 minutes and recovered 789.4 m gas cut salt water. The well was abandoned on January 25, 1967. Still these two wells indicated the presence of the structural gas play in the Cordillera, a concept that remains valid and inadequately tested.

Exploration effort was subsequently moved to the Interior Platform. The fourteenth well drilled in the study area was IOE SATAH RIVER YT G-72, which was drilled west of the L-50 well, on the NWT side of the inter-territorial boundary. This well (66^o51'28.0", 134^o13'57.0") was spudded January 13, 1967 in Cretaceous siltstones and shales and drilled to a total depth of 2286.0 m in the Devonian Arnica/Landry carbonates. No tests were run and the well was abandoned March 09, 1967. The next well, SHELL PEEL RIVER YT K-09 (66^o18'35.7", 134^o01'02.2") was located in the western reaches of the Interior Platform west of the Peel River. Spudded in Cretaceous glauconitic shales on February 06, 1967 the well was drilled to a total depth of 1554.5 meters in the Tuttle Fm., which it penetrated at 851 m depth. Two tests recovering mud, saltwater and muddy saltwater were run in the deepest formation penetrated. The well was D&A March 07, 1967.

The next well was drilled near the site of surface seepages of natural gas where Cretaceous rocks outcrop in the Interior Platform. The IOE SWAN LAKE K-28 (66^o38'17.9", 134^o39'33.1") was drilled to a total depth of 1838.2 m in the Devonian Arnica Fm. Carbonate, which it penetrates at 1801.4 m and subsequently abandoned. The next test drilled was also an Interior Platform well, but one located in the extreme western limit, almost in the Cordillera. The SHELL PEEL RIVER YT H-59 new field wildcat (66.64 N latitude, 134.66 W longitude) lies west of Peel River. It was begun March 13, 1967 in Cretaceous shales and sandstones and it penetrated the Tuttle Ss at 295.7 m to a total depth of 763.2 m. A single test was run in the Tuttle Fm. between 591.3-652.3 metres, but recovered only 91.4 of muddy water. The well was D&A April 01, 1967.

The eighteenth well, also in the Interior Platform, was IOE TREE RIVER H-38 (67^o17'21", 132o21'00"). It was drilled more than 50 km east of the Arctic Red River and spudded in Imperial Fm. shales. The well began drilling April 23, 1967 and went to a total depth of 1279.2 meters in the Arnica Fm. This well provides the most significant gas show in the region. During a loss of drilling control at about 721 m, in the Canol Fm., the well had a flow of sweet gas at an estimated rate of 17.7 million m3 (NEB, 1995, p. 24). The gas show suggests an effective hydrocarbon system in stratigraphically isoloated porosity. This is the basis for much of the optimism for gas in the inferred combined structural-stratigraphic traps in both Mesozoic and Upper Paleozoic plays, as discussed below. The well also had several zones of lost circulation and logs suggest porosity in several Paleozoic intervals. Unfortunately there were no tests and the well was abandoned April 23, 1967.

Next, Imperial moved into the Cordillera where it drilled four structure tests along structural strike from the L-19 well. These four wells, IOE STONEY F-52, IOE STONEY F-42, IOE STONEY 2F-52 and IOE STONEY CORE HOLE C-02 were drilled sequentially between July 27, 1967 and August 29th, 1967. All four were drilled to a structural marker in the Lower Cretaceous succession to total depths of 162.0 m, 310.9 m 305.7 m and 176.8 m, sequentially and respectively. These wells suggest possible problems in seismic interpretation and prospect identification, which would also be reflected by the Shell Peel River B-06 and B-06A wells.

With the drilling of the twenty-third well in this region, TOLTEC PEEL RIVER YT N-77 (65o56'46.0", 134^{o}29'12.0") exploration returned to the Yukon Territory and it moved west of the Trevor Fault, to that part of the Cordillera lying immediately east of the Richardson Mountains. The later GSC Bedrock Geology Map mistakenly shows the Trevor Fault as having a normal offset, where seismic shows clearly is a thrust in a more internal zone of the Cordilleran Foreland belt. West of Trevor thrust fault older stratigraphic units commonly crop out, due to the large amount of shortening on the Trevor thrust fault, accompanying the change in mechanical stratigraphy at the western edge of the Paleozoic carbonate Platform. This is essentially equivalent to the "Front Range-Foothills" transition in this part of the Cordillera. The well was spudded October 07, 1968 in Imperial Shales and it was drilled to a total depth of 1123.5 m in what are probably Landry Fm. carbonates, which it penetrates below the Prongs Creek-Landry contact at 483.4 m depth. The well was not tested and it was D&A July 23, 1970.

The 24th well drilled in the assessment region was MCD GCO NORTHUP TAYLOR LAKE YT K-15. It is located in an Interior Platform setting near the inter-territorial boundary east of the bite in the Snake River (65o54'39.0", 133^{o}03'00.0"). This well was spudded February 05, 1969 in the Arctic Red Fm. clastics. It encountered the Martin House Fm. at 632.2 m and passed into the Tuttle Fm. at 641.8 metres. The well penetrates a complete carbonate platform succession below the Paleozoic shales of the Imperial (1051.8 m), Canol (1314.8 m), and Bluefish (1352.8 m) fm's. The platform succession is over a thousand m thick, consisting of: Hume (1357.8 m), Landry (1523.8 m), Arnica (1904.8 m), Tatsieta (2057.8 m), Peel (2097.8 m) and Mt Kindle (2316.8 m) fm's. The well reached 2378.7 in Mount Kindle Fm. Five intervals were tested:
#1, between 729.4-737.0 m recovered 30.5 m of watery mud and 121.9 m of muddy gassy fresh water,
#2, between 860.8-915.3 m recovered 100.6 m of mud and 378.0 m of fresh water,
#3, between 792.2-1852.0 m recovered 137.2 m of water and mud and 362.7 m of gassy salt water,
#4, between 2252.5-2378.7 m recovered 277.4 m of salt water cut mud, and
#5, between 1719.1-1738.6 m recovered 387.1 m of salt water. The well was abandoned March 29, 1969.

The INC NCO MOBIL ATTOE LAKE I-06 well was drilled near the northern limit of the study region, in the Interior Platform. Located (67.43 N latitude, 133.25 W longitude) between H-38 and A-05, this well was begun December 16, 1969 and drilled to a total depth of 2257 m in the Mount Kindle Fm. before it was abandoned. This was the last well begun in the 1960's and it represented the last of a decade of tests in which 25 wells were drilled in all three major structural settings of the assessment region with only minor shows of gas and no significant discoveries.

New wells drilled in the next decade include two wells were drilled north of the study region. One of these wells is the BANFF AQUITANEARCO RAT PASS K-35 well that was begun October 21, 1970 and drilled to a total depth of 1830.0 m in the Cherty Unit of the Franklin Mountain Fm. before being abandoned December 13, 1970. The second well is BANFF AQUITANE ARCO TREELESS CREEK I-51, which was begun December 18, 1970 and drilled to a total depth of 1831.8 metres, also in the Mount Kindle Fm., before it too was abandoned January 29, 1971. Exploration resumed within the Interior Platform of the assessment region with test number 26, IOE TREE RIVER F-57 (north latitude 67.11 and west longitude 132.43). F-57 was begun December 12, 1970, and drilled to 1979.3 m in Silurian and Ordovician strata before being abandoned. The next well drilled was SHELL ARCTIC RED RIVER O-27, located east of the Arctic Red River (66.78 N latitude 132.83 W longitude). An Interior Platform test this well was begun December 26, 1970 and drilled to 2154.0 m depth in the Mount Kindle Fm. It was abandoned January 23, 1971. Shell pursued the Tree River prospect drilled by the IOE F-57 well with the SHELL TREE RIVER EAST H-57 well (67.11 N latitude and 132.41 W longitude), which was begun March 17, 1971 and which was drilled to 1981.2 metres, in Lower Paleozoic strata like the F-57 well before it too was abandoned. The 29th well drilled in the assessment region was SHELL ARCTIC RED WEST G-55, which is located on the west side of the Arctic Red River (66.74 N latitude and 133.17 W longitude). The well was begun March 31, 1971 and drilled to the Cambrian Mount Clark Fm., at the base of the Phanerozoic succession. The well was drilled to a total depth of 3322.3 m before being abandoned on May 22, 1971.

January 08, 1972 saw the spudding of the UNION AMOCO MCPHERSON B-25 well, the thirtieth well in the study region. This new field wildcat well was located Northwest Territories (67^{o} 14'00.78", 135o34'22.37), within the Cordilleran Foreland thrust and fold belt along structural strike from the SHELL PEEL RIVER L-19. This well was spudded in the Tuttle Fm. drilled to a total depth of 4136.1 m in the Franklin Mountain Fm., which it penetrated at 3992.9 m depth. The well tested four intervals, 4015.7-3986.8m, 4023.4-3996.5 m, 4136.1-2656.5m, 4136.1-2656 m, all of which were miss-run results, and the well was abandoned March 12, 1973. The SHELL SAINVILLE RIVER K-63 (66.38 N latitude, 133.20 W longitude) is an Interior Platform test that was spudded January 12, 1972 and drilled to only 790.0 m in the Imperial Fm. before being abandoned January 23, 1972.

The thirty-second well drilled is AMOCO PCP CRANSWICK A-22. This well was drilled in the Cordilleran thrust and fold belt in front of the Mackenzie Mountains, just east of the study are, in the Northwest Territories (65.52 N latitude, 131.82 W longitude). The well was begun January 25, 1972 and it drilled to a total depth of 2869 m bottoming in the Proterozoic succession where it is involved in the deformation, prior to being abandoned March 28, 1972. This well was spudded just before the AMOCO PCP

CRANSWICK YT A-42 (65o41'12.6",133^{o}07'52.1"), which penetrates a similar Foreland belt structural setting in the Yukon Territory. The A-42 well was spudded April 14, 1972 and it drilled to a total depth of 4267.2 m in the Cherty Member of the Mount Kindle Fm. The well tested six intervals, 2171.7-2210.4 m, 2510.9-2533.8 m., 2650.2-2712.7 m., 3331.8-3366.5 m., 3431.1-3474.7 m., 3435.4-3474.7 m., all of which were miss-run results. The well was abandoned March 20, 1973.

The next well drilled was SKELLY-GETTY MOBIL ARCTIC RED C-60 (66^{o}49'00.0", 133^{o}55'19.0"). This Yukon Territory new field wildcat well was located in the Interior Platform structural province near the inter-Territorial boundary. This well was spudded January 15, 1972 and drilled to a total depth of 2599.9 m in the Ronning Group. The well tested seven intervals, most of the tests having miss-run results, except for test number six, which was run in the Devonian Arnica Fm., between 2242.7-2251.9 m depth. That test recovered 82.3 m of mud and 992.4 m of salt water. The well was abandoned March 26, 1972. The next well was drilled to the north of the study area. The SKELLY-GETTY AMOCO FT MCPHERSON C-78 (67.62 N latitude, 134.24 W longitude) was begun April 09, 1972 and drilled to a total depth of 3068.1 m in the Franklin Mountain Fm. prior to being abandoned on July 17, 1972, without significant result.

A following Interior Platform test drilled just south of the inter-territorial boundary was the PACIFIC ET AL PEEL YT F-37 (66^{o}56'26.0", 134^{o}51'54.0") new field wildcat well that was drilled to a total depth of 3368.0 m in the Mount Kindle Fm. between February 13, 1972 and April 20, 1972, when it was abandoned. This well tested 6 zones. The first test, of a porous zone in the top of the Mount Kindle Fm., between 3319.3-3368.0 m recovered 137.2 m of mud, 1388.1 m of gassy salt water and 109.7 m of gassy muddy salt water. Tests two through five recovered only mud or were miss-run results. The sixth test of the Tuttle Fm. between 457.2-496.8 meters recovered only 272.8 m of muddy water. The next four Interior Platform tests were drilled north and east of the study region. The first was the DOME UNION IOE STONY G-06 north latitude 67.59 and west longitude 135.26 which was begun December 13, 1972 and which drilled to a total depth of 2529.8 m in the Franklin Mountain Fm. before being abandoned on February 17, 1973. The second was the BLUEMOUNT ET AL GULF S DELTA J-80 (67.66 N latitude and 134.73 W longitude) which was begun eight days later and which drilled to a total depth of 2895.6 m in the Cherty Member of the Franklin Mountain Fm. before abandonment on February 23, 1973. December 23, 1972 saw the beginning of the CANDEL ET AL TEXACO ARCTIC RED F-47 (65.61 N latitude, 130.90 W longitude), which drilled to a total depth of 2371.3 m in the Imperial Fm. before it too was abandoned, March 07, 1973. The next result of the 1972-1973 winter drilling season was the CANDEL MOBIL ET AL N RAMPARTS A-59 (65.47 N latitude, 130.66 W longitude) which spudded January 22, 1973 and which was abandoned June 11, 1973 at 3205.0 m to the Franklin Mountain Fm. A similar fate awaited the DECAL TRANS OCEAN EXCO ONTARATUE I-38 (66.29 N latitude, 131.85 W longitude), and the INEXCO ET AL WELDON CREEK O-65 (66.08 north latitude, 132.45 W longitude), which were begun November 6, 1972 and March 05, 1973, respectively, as the thirty-sixth and thirty-seventh wells drilled in the study area. The O-65 well reached a total depth of 2214.4 m in the Peel Fm. before abandonment on April 12, 1973. Another well drilled to the Cherty Unit of the Franklin Mountain Fm. was the 1621.8 metre deep CANDEL MOBIL ET AL S RAMPARTS I-77 well located east of the study area (65.44 N latitude, 130.97 W longitude). This well too was abandoned with significant result, on April 14, 1973.

On November 27, 1973 exploratory efforts were refocused on the Cordillera, east of the Trevor Fault. The specific test, SHELL TRAIL RIVER YT H-37 was the thirty-eight well drilled in the study area. It was located near the B-06 and B06A wells, and it was probably an attempt to capitalize on one of the few structures to provide a promising drill stem test result. The well was drilled to a total depth of 3721.6 m in the Peel Fm. of the Ronning Group, which it penetrated at 3510.2 meters. Three unsuccessful or miss-run drill stem tests were attempted before the well was abandoned March 26, 1974.

The H-37 well was followed by another unsuccessful Interior Platform test, the DOME TEXACO IMP SOUTH PEEL D-64 (65o53'04", 132o27'50"), which was drilled to 1985.5 m total depth in the Landry Fm. It tested four zones between 1921.5 m and 1689.7 meters between April 04, 1973 and March 15, 1974. Three of the four tests were run over the same interval, 1689.7-1741.9 metres, in the Hume Fm., without obtaining a successful test. This suggests a favorable indication for hydrocarbons that could not be realized or properly evaluated due to technical problems. Subsequently the ARCO SHELL SAINVILLE RIVER D-08 well (66^{o}17'07", 133^{o}31'39") was drilled very near the inter-territorial boundary between January 09, 1974 and its abandonment March 06, 1974. The well was drilled to a total depth of 2651.8 m in the Peel Fm., which it penetrated at 2506.1 m depth. The well tested six zones but recovered only mud.

The forty-first well drilled in the assessment region marked a return to the Cordilleran structural play, as tested by the next three wells. The first of these three is the GULF MOBIL CARIBOU YT N-25 (66^{o}14'46.0", 134^{o}50'04.0"). This well was the second test drilled west of the Trevor Thrust Fault, and with N-77 well (see above) they comprise the only two tests of this very large, apparently prospective region. The N-25 well was spudded in Tuttle Fm. sandstones on May 01, 1974 and it drilled to a total depth of 3600.3 meters in Proterozoic strata, which it penetrated at 3433.3 metres. Five drill stem tests were made. The first, 3014.5-3154.7 m was a miss-run result. The second test between 3014.5-3139.4 m recovered 30.5 m of water cut mud and 121.9 m mud. The third between 1773.9-1787.7 m recovered 27.4 m of gas cut mud. The fourth and fifth tests, run between 1432.6-1467.6 m and 1380.7-1414.3 meters, respectively recovered only small volumes of drilling mud. The well was abandoned August 10, 1974. The next well was drilled near the leading edge of the Cordilleran deformation east of the Peel River. The SHELL PEEL RIVER YT M-69 (66^{o}08'56.0", 133^{o}58'04.0") was begun October 06, 1974. The well performed five drill stem tests. The first two tests between 3130.9-3152.5 m and 3115.7-3146.8 were both miss-runs and the third test between 3103.8-3272.6 m recovered only 106.1 m of mud. A fourth test of the lower Tuttle Fm. between 1742.8-1799.8m flowed gas to surface at rates too small to measure and recovered 94.5 m of mud. A fifth test higher in the Tuttle Fm. between 1677.9-1724.6 m recovered only drilling mud. The well was abandoned on December 04, 1974 after having drilled to 3272.5 m total depth in the Peel Fm. The third Cordilleran test is the

MOBIL GULF PEEL YT H-71 (66°20'28.6", 134°43'34.6"). This well was drilled almost due south of the L-01 well and much closer to the surface trace of the Trevor Fault, although it still lies east of, or below, that structure. The H-71 well was begun February 03, 1977 and drilled to a total depth of 3392.1 m in the Cherty Unit of the Franklin Mountain Fm. The well had two unsuccessful overlapping tests across the lower Peel Fm. and the upper Mount Kindle fm., apparently to test the first porous zone in the latter formation. The well was abandoned June 12, 1977.

Thus, after 43 unsuccessful test, and very few modest favorable gas shows, in all three structural settings, in both Territories, the exploratory efforts in the Peel region were suspended. Most recently the Interior Platform play was revived with the drilling of the CHEVRON RAMPARTS RIVER F-46 (65.76°, 130.15°) to the east of the study area. That well was begun February 24, 1991 and it was drilled to a total depth of 1510.0 m in the Devonian Nahanni Fm. before its final abandonment July 22, 1998.

Hence a lower prospectivity should be assigned to the Peel Region, in light of what can only be described as a disappointing exploratory history. The assessment below considers the disappointing and unsuccessful results in the Peel region to date, and it uses methods and risks appropriate to the local setting. Due to the similarity in approach and analysis the results of the Peel assessment, presented here, should be directly comparable to other regions in the Western Canadian Sedimentary Basin.

Assessment Method

Methodology

This discussion illustrates the analytical resource assessment method used, in the context of alternative techniques of petroleum assessment. This facilitates the subsequent discussion, while providing an understanding of the uncertainty and validity of the assessment technique. Discussion of terminology is followed by an examination of methods of assessment and description of the specific methods used in this study. The Peel Plain and Plateau have been explored without significant economic result by talented and capable scientists. Therefore it is important to explain the method of analysis that stand in contrast to the exploration results. The results of this study are inferred to be consistent with the results of the exploration history.

Terminology

The terms *resource*, *reserve* and *potential,* as defined previously by the Geological Survey of Canada (Podruski et al., 1988; Bird, 1994), are used in this study. *Resource* is defined as all hydrocarbon accumulations that are known or inferred to exist. *Reserves* are that portion of the resource that has been discovered, and the term *potential* describes that portion of the resource that is inferred to exist but is not yet discovered. The terms *potential* and *undiscovered resources* are synonymous and are used interchangeably. The terms *prospect, pool, field,* and *play* have the following designated meanings in this study. A *prospect* is defined as a geographic region, where the combination of geological characteristics and history suggest the possibility of an underlying petroleum *pool* or *field*. A *pool* is defined as a petroleum accumulation, typically within a rock reservoir composed of a single stratigraphic interval that is hydrodynamically separate from another petroleum accumulations. Any number of discrete pools, at varying stratigraphic levels, may exist within a specific geographic region, often having some common geological characteristics, known as a *field*. A *play* consists of a family of pools or prospects that share a common history of hydrocarbon generation, migration, reservoir development and trap configuration (ibid.).

Methods of Petroleum Resource Assessment

Petroleum is an important, even strategic, commodity in modern societies. The understanding of where, when and under which economic conditions certain petroleum resources become a part of the petroleum supply is essential to the management and planning of economies. The principal origin of petroleum from kerogen and coal, its transformation by thermal and biological processes to petroleum and its principal modes of occurrence in sedimentary basins are well understood. Discrete conventional petroleum accumulations result commonly from the migration of petroleum in the complicated porosity and permeability system within a sedimentary basin. Accumulations are best located by the application of the anticlinal and stratigraphic accumulation paradigms; however, the location and size of undiscovered petroleum accumulations are not identified easily.

Petroleum resource assessment describes, the total petroleum potential of specific regions, both discovered and undiscovered resources. There are four general types of assessment methods: resource volumetric analysis, petroleum systems analysis, discovery history analysis and prospect volume analysis. The determination of “pools” and “reserves” as a function of technology and price in continuous resources requires a detailed description of the spatial variation of reservoir characteristics and an understanding of the relationship between reservoir characteristics and reservoir performance. The determination of that proportion of undiscovered petroleum resources becomes economically realizable remains a function of the technological, engineering and economic criteria for the development.

Petroleum system analysis attempts to determine the resources inherent in, derivable from and attributable to, a particular petroleum source rock as a result of the processes affecting the source rock and its resultant petroleum. Petroleum systems analysis requires a detailed description of the petroleum source, its geological history, as well as the migration and entrapment of the resulting petroleum. While, all aspects of petroleum source rock accumulation, petroleum generation, migration and entrapment can be calculated, the dependence of such calculations on the specific and detailed features of the real environment renders such calculations impossible, inaccurate or intractable. The Peel Plain and Plateau is a case in point. Insufficient geochemical data is available to adequately describe the petroleum systems, and without discoveries it is manifestly unclear which, if any, petroleum systems are effective. Even the best possible analogues, say the comparison of the Peel Plateau Paleozoic Carbonate Margin (C5570111) play to the Liard Plateau structure play in Paleozoic carbonates, is uncertain; due to the significant observed and potential differences in diagenetic and thermal history.

Discrete conventional petroleum resources, those that occur as pools, can be assessed using a disaggregated probabilistic analysis formulated on the play level. There are two such methods, each dependent on the exploration history of the plays and basins being assessed. Undiscovered resources are assessed using either discovery process analysis, where sufficient discoveries exist, or using risked prospect volume analysis, even where no discoveries have been made. The basis of these two analyses is the inference of a play based pool or prospect size distribution and a distribution of the number of pools expected in the play.

Where sufficient numbers of discoveries exist, the discovery process analysis infers the pool size distribution and number of pools from the discovery history of the play; the prospect volume analysis infers the same distributions from the description and enumeration of geological and physical features and characteristics of the play. Once the characteristics of petroleum accumulations within the play are inferred, specific resource models can be predicted. These models can be further conditioned against the set of discovered accumulations to constrain the characteristics of the undiscovered resource. Such calculations provide a reliable and useful method for the inference of undiscovered resource potential. The method is useful because it predicts the economically most critical play characteristic: undiscovered pool size. The method is amenable to historical vindication, as illustrated below, and the predictions of the discovery process and prospect volume methods are directly comparable.

Method

This study uses a statistical method developed by the Geological Survey of Canada (Lee and Wang, 1983a, 1983b, Lee and Tzeng, 1993, 1995). We employ a play-oriented petroleum assessment method, PETRIMES (Petroleum Resource Information Management and Evaluation System) computer program (Lee and Tzeng, 1993). PETRIMES allows both discovery process and volumetric methods of assessment. Where there few or no accumulations are discovered the prospect size distribution must be estimated using a reservoir volume approach and the Multivariate Discovery Process model (Lee, 1999). This is the approach followed in this report. However it is useful to discuss petroleum assessment generally to understand the process of determining the undiscovered resource, to have a greater confidence in its results.

PETRIMES (Petroleum Resource Information Management and Evaluation System)

This assessment was performed using the PETRIMES computer program. Since the early 1980s, the system has been applied to petroleum plays and mineral deposits from various settings worldwide. Some assessments have been verified by either subsequent exploration activities, or by the historical analysis of established plays Lee and Tzeng (1995), like the example illustrated below. The following sections describe the basic statistical principles employed by PETRIMES that is later illustrated by a historical analysis of a mature play, with many discoveries. This provides insight into the method and technique, which is then compared to the prospect volume method that is employed for this assessment.

Discovery Process Module and Input Data

Discovery process models infer the characteristics of the pool size and number pools distribution from the analysis of the historical record of discovered pools, their sizes and other reservoir characteristics as compiled or calculated by regulatory agencies. The standard input data for this method includes the discovery date and original raw in place reserve estimate and the specific reservoir parameters used to calculate that reserve. Oil or gas pool sizes can be plotted sequentially as a function of discovery dates to produce a time series, or discovery sequence (Figure 17). The vertical axis (Figure 17) represents the pool size, plotted on a logarithmic scale, and the horizontal axis shows the discovery date or sequence. This set of oil or gas discoveries is the sample to be used for the inference of the conditional accumulation size distribution, which is combined with the risked number of accumulations to infer the petroleum potential. Note the general decline of pool size over time, which indicates that the exploration process produces a statistically biased sample, since the larger pools are commonly discovered relatively early in the exploration history.

On one hand, the sample bias causes a statistical problem, because statistical procedures commonly assume random sampling. On the other hand, the biased sample contains other information useful for the estimation of undiscovered resources. PETRIMES employs a new statistical model that considers samples biased by purposeful selection of larger prospects to estimate pool populations assuming that the probability of discovering a pool is proportional to either its size or some other pool parameter; and that a pool can be discovered only once. The mathematical analysis of the discovery sequence that infers the conditional accumulation size probability distribution and the number of accumulations is the discovery process model (Lee and Wang, 1985, 1986, 1990; Lee, 1993). PETRIMES contains two discovery process models. One employs a lognormal pool size distribution assumption and the other employs a nonparametric approach.

Figure 18 is a result of the discovery process model. The vertical axis represents the log likelihood value and the horizontal axis indicates the total number of discovered and undiscovered pools in a play, N. The more favorable the log-likelihood value, the more plausible the value of N. In Figure 18, the most likely number of pools is 140. The application of the nonparametric discovery process model to this example data set yields almost the same result.

Where no discoveries have been made there are no pool size inputs. However, combinations of geological parameters can be combined to formulate a prospect size distribution that serves the same function as the pool size distribution. Such a risked prospect volume method is used in this study. The formulation of a accumulation size distributions, as used in this study is discussed below.

Estimating pool, or prospect, size probability distribution

After estimating the N, or number of accumulations, value, the corresponding pool size distribution was used. The statistics of the inferred pool size distribution were used to generate the pool size distribution of a play. Discovery process models contain an unknown variable, the exploration efficiency coefficient, which is estimated from the discovery sequence. The discovery process is proportional to the magnitude of the pool size, as well as other factors (e.g., commercial objectives, land availability, pool depth, and exploration techniques). Where there are no discoveries the pool size distribution is replaced by the prospect size distribution and the number of inferred accumulations are determined as the product of that distribution and the prospect level risks.

Estimating play potential distribution

A play resource distribution (Figure 19) can be estimated from the N value and the pool size distribution (Lee and Wang, 1983a). Furthermore, a play potential distribution (Figure 20) can be derived from the play resource distribution, given that the sum of all discoveries of the play is used as a condition. The potential values of the 95th and 5th upper percentiles and the expected values are used in this report as a 0.9 probability prediction interval for undiscovered potential.

Uncertainties and the Historical Vindication of Assessment Methods

All estimates contain uncertainties, which can be evaluated and expressed as probabilities. Uncertainties can be expressed in terms of a probability distribution and evaluated by comparison with historical discoveries. The following estimates, e.g., play potential, individual pool size for undiscovered pools and potential are all expressed as probability distribution. All these distributions are derived by formal statistical procedures. The same is not true for certain types of previous assessments, both regionally and locally (i.e. Bird, 2002).

An important feature of sequential sampling or discovery process resource assessments is their amenity to historical analysis and vindication derived from the analysis of the total data set by a prediction made from a historical subset of the data. If the truncated data set successfully predicts all of the discovered accumulations not used in the input data set then the residual unidentified resource can be confidently considered to represent the currently undiscovered potential. Such a vindication is, where possible to calculate, an essential criterion for accepting a resource assessment. **History and historical analysis shows that geoscientists habitually underestimate the number of accumulations, often significantly.** We present, as an example, the historical vindication of another thrust and fold belt anticlinal play to illustrated the manner in which the number of accumulations changes and how it affects the estimated resource potential as a function of play history.

Figure 21 illustrates an example of a well-behaved Foreland Belt play, the Jumping Pound Rundle Play, as it was analyzed in the 1992 Geological Survey of Canada Foreland Thrust and Fold Belt assessment (Lee, 1998). This play, in which the first discovery was made more than 80 years ago, should behave like the Peel Plateau Paleozoic Carbonate Margin (C5570111) play, once discoveries are made. This approach allows us to examine the limitations of PETRIMES when it is applied to a play that has gone through the immature to established exploration stages. The illustrated play lies immediately west of Calgary. The Jumping Pound Rundle Play has been analyzed at three different stages of its exploration history, 1966, 1974 and 1991 (Figure 21, top). The three resulting petroleum resource estimates for the three discovery sequence subsets is shown in the middle diagram of Figure 21, middle, and a prediction of the range of discovered (circles) and undiscovered (boxes) accumulation sizes from the pre-1966 data set, conditioned against the discoveries at that time, is also illustrated (Figure 21, bottom).

Only 15 accumulations were discovered in this play between the first Rundle Group discovery and 1962. Still, from that data set, which is very comparable, in number of discoveries to the data set for the Liard Plateau Play (which serves as a type of model against which the Peel Plateau Paleozoic Carbonate Margin (C5570111) play, it was possible make a prediction of the total potential that was comparable to the total potential estimate in 1991 (Figure 21, middle), when 94 discoveries had been made after another three decades of exploration had elapsed in a region of easy access and logistics. The effect of small sample size on the resource distribution estimation is minimal, as can be observed from the similarity in the resource distributions for all time windows. The sum of the discovered and expected potential values is almost the same for all time windows. If the sums are compared to the 1991 value, the maximum difference is 16% for the 1966 time window and 3% for the 1974 time window. More important is the observation that the pre-1966 dataset successfully predicts the Quirk Rundle A and Clearwater Rundle A pools (Figure 21, bottom), the sixth and seventh largest accumulations in the play. The two largest pools predicted by the 1966 time window data set are the Quirk Creek Rundle A pool and the Clearwater Rundle A pool. The former was discovered in 1967 and the latter pool was discovered in 1980. Since then, no pools larger than these two pools have been discovered. However, several pools with sizes smaller than the Clearwater Rundle have been discovered (Figure 21).

The impact on resource assessments due to a small number of discoveries is evident in estimating of the total number of pools, N. The numbers of discovered accumulations and the number of predicted accumulations in each of the three calculations are, 15 and 100; 21 and 100; 94 and 173, respectively (Figure 21, middle). Through time the total number of predicted accumulations has increased through the addition of a number of accumulations of smaller size, without major impact on the total resource potential, while the prediction of the largest individual accumulations has remained unchanged. Whether the Jumping Pound Rundle Play is a good analogue for the Peel Plateau Paleozoic Carbonate Margin (C5570111) play can be debated, but what cannot be debated is the efficacy of the discovery process method in predicting both play potential and number of accumulations from a small number of discoveries, early in the exploratory history of the play.

Reservoir volume methods

A second, independent assessment can be obtained using a risked prospect volumetric approach and the Multivariate Discovery Process model in PETRIMES (Lee, 1999). If there are few or no discoveries it is necessary to assess undiscovered potential volumetrically using such a Model. This is the method used herein. Where discovery process methods use discovered accumulation parameters as a biased sample of the accumulation (pool) size distribution, volumetric methods infer the accumulation (prospect) size distribution using combinations of, observations, analogy and inference. Observed parameters include reservoir material and physical characteristics that incorporate well and seismic data, corrected for sampling biases, expressed as probability distributions, however, there are practical problems associated with the availability and comprehensiveness of required data. Typically the geoscience data is incomplete and observations must be augmented by extrapolations or supplemented by analogies and inferences. Geographically comprehensive seismic and well data sets are not generally available. Aspects of prospect volumes, reservoir parameters and trap fill proportion must be estimated either from geographically limited data sets or appropriate analogues. The volumetric method requires an independent estimation of the number of accumulations. This number is commonly formulated as the product of the total number of prospects, many of which must be inferred because of the geometry of the seismic grid, and the prospect level risks, which are commonly estimated subjectively in the absence of discoveries.

The volumetric method used in this study consists of a three-step procedure:

- Estimation of the distributions of reservoir volumetric parameters and possible number of prospects and exploratory risks, as constrained by available geological and well data;
- Estimation of oil and gas accumulation size distributions from unbiased reservoir parameters; and

- Computation of the oil and gas potential distributions and construction of individual accumulation size by rank plots.

The accumulation (prospect) size distribution can be expressed using the reservoir

$$Z = C * A * T * \phi * S * G * HVF \qquad (3)$$

engineering equation:

Petroleum Resource Assessment

Assessment Regions:

The Peel Plateau and Plain assessment is divided into three structural and stratigraphic belts that do not coincide with the physiographic boundaries of the Peel Plain and Plateau (Figure 22):

1. The Peel Plateau - West of Trevor Fault Assessment Region,
2. The Peel Plateau Assessment Region, and
3. The Peel Plain Assessment Region.

The first assessment region, Peel Plateau - West of Trevor Fault extends eastward from the outcrop of sub-Carboniferous successions in the Richardson and Mackenzie mountains west to the Trevor Fault. This region lies primarily in the Peel Plain, but it is underlain by east verging Cordilleran thrust and fold structures that are similar to those of that underlie the Peel Plateau. A broad outcrop of Carboniferous strata characterizes this region and it is underlain by a thick succession of basin facies in Cambrian and Carboniferous successions. It lies generally west of the thick Paleozoic carbonate platform succession. The Peel Plateau - west pf Trevor Fault assessment region contains a single play in Upper Paleozoic clastics, predominantly combined structural and stratigraphic traps in the Imperial formation clastics and overlying Ford Lake and Tuttle successions. The region is also underlain by very deeply buried Cambrian clastics, which outcrop farther west. These clastics may have some petroleum potential, but they were not assessed in this study.

Most of the Peel Plateau and contiguous portions of the Peel Plain lying east of the Trevor Fault but west of the Peel River are also part of the east- and north-verging Cordilleran thrust and fold belt (Figure 22). This assessment area, from the surface trace of the Trevor Fault to the eastern limit of Cordilleran thrusting is referred to as the Peel Plateau, regardless of the physiography of the region. The carbonate to shale transition of a persistent Paleozoic paleogeographic feature, the Richardson Trough, occurs within this assessment region between the Trevor Fault and the eastern limit of the Cordilleran deformation. This region is dominated by structures of the Laramide orogeny, in which occur three major potential reservoirs, each of which is a play assessed in this report. The three stacked reservoir intervals include porous zones in the Cambrian to Devonian Carbonate Platform succession, clastics in the basinal succession of the same age, but where it is expected that significant reservoirs will occur only in Imperial formation clastics and overlying Ford Lake and Tuttle successions, and potential coarse clastic reservoirs in the Mesozoic Foreland Basin succession where it is involved in the Cordilleran deformation.

East and north of the region affected by Cordilleran diastrophism are regions underlain by the undeformed successions of the Mackenzie-Peel Paleozoic carbonate shelf, also known as the Mackenzie-Peel Platform, that are overlain by a succession like that which has been deformed in the Cordillera (Figure 22). This region, to the inter-territorial boundary constitutes the third assessment region of this study, called the Peel Plain assessment region. Similar major reservoir intervals constitute plays in the Cambrian to Devonian Carbonate Platform succession, the Upper Paleozoic clastic succession of Imperial, Ford Lake and Tuttle formations, and potential coarse clastic reservoirs in the Mesozoic Foreland Basin succession where it is has not become involved in the Cordilleran deformation. It is also possible that abrupt margin carbonate reefs, similar to Horn Plateau reefs, grew rooted on the Hume Platform after the Devonian carbonate platform margin back-stepped to the region of the Keg River Barrier. This is treated as a speculative play, although no clear indications that such reefs occur has been identified. Within each of the assessment regions there is a characteristic, and broadly similar, assemblage of stratigraphic successions and structural styles that are inferred to control both petroleum system, migration, and trap reservoir/seal that provides the basis for defining petroleum plays to be assessed. The assessment follows a pool-based, rather than a field-based approach. This is done for several reasons. The reservoirs within each of the three major successions analyzed are distinctive, while the similarity of structural style in each of the three regions is internally similar. Therefore the combinations of reservoir parameters are quite distinctively characteristic of each play, and strongly distinguished from other successions in the same assessment region/structural province. To combine these successions in a field-based approach would have not been appropriate, and it would have resulted in two other major problems. First it would have prevented the direct comparison between different successions, which could impact the depth focus of exploratory drilling. If large reserves are predicted it is useful to know at what stratigraphic level they occur, so that needless drilling to less prospective successions can be avoided. This is very much the result here. Second, as there are no discoveries, it is important to be able to compare the predictions of the assessed plays to potential play analogues. Since the analogues are characterized and assessed on a pool-based structure, it would have been impossible to make this important comparison and validation if a field-based approach had been used. Below, each of these eight plays is defined, characterized and assessed, from oldest to youngest, from the undeformed Foreland Basin into progressively more westerly portions of the Cordillera.

Peel Plateau West of Trevor Fault Sub-Region

C5580111 - Upper Paleozoic Clastics - conceptual

Structural or stratigraphic traps in the arenaceous to rudaceous clastics of the Imperial, Ford Lake and Tuttle formations, lying west or in the hanging wall of the Trevor Fault, constitute a significant conceptual play for natural gas in the Richardson Mountains region. This play is designated Peel Plateau West of the Trevor Fault Upper Paleozoic Clastics - C5580111 (Figure 22). Play parameters (Table 3) are difficult to infer because of the lack of data. However, the play parameters and play-level and prospect-level risks can be inferred from the Upper Paleozoic Clastic Play (C5540111, Figure 22; Table 27) in the adjacent deformed region to the east. This play is a slope-basin sandstone play.

Prospect Volume Characteristics

As for the other two Upper Paleozoic clastic plays, above, all of the prospect volume characteristics of this play are based, as far as possible, on locally derived play and prospect parameters, much from the adjoining analogous plays (Table 3). All prospects are inferred to exceed 0.4 km^2 in area. The lower value is inferred to represent the approximate limits of a structure that can be resolved within this frontier region, while considering that this play will have strong stratigraphic components of entrapment, such that reservoir is not likely to cover the entire structure. It is consistent with lower limits of prospect size used in previous assessments (Bird, 2000; 1999; Hannigan, 2001) and it about the area of a standard oil spacing unit (0.64 km^2) in established producing areas, which also provides an approximate lower limit on pool area definition. The size of more than half of the prospects is based on, constraints from the geological map, observations of seismic data in the adjacent Peel Plateau Assessment Area (Play C5570111), and the estimates derived are from the data sources of previous assessments (Bird, 2000; 1999; Hannigan, 2001). The upper limits on prospect area 50 km^2, at one percent probability and 90 km^2 at zero probability are derived in a similar way and are likewise comparable with previous work (Table 3).

Within this play average net pay is again controlled by the thickness of individual sandstone reservoir intervals. It is inferred that sandstone layers will vary between 5 and 40 m thickness, base largely on bedding characteristics of the target formations in field photographs and measured stratigraphic sections. The setting is inferred to be more distal than that of the Upper Paleozoic clastic play in Peel Plateau to the east of the Trevor Fault, and for this reason the average sandstone thickness in this play area is thinner than to the east. The diagenetic history of reservoir sandstones is not well known, but the range of prospect average porosities is consistent with facies and burial depths for both this depositional environment and tectonic setting. Formation Volume Factor parameters express expected values considering the geological and tectonic setting of this play, including its great potential depth.

Derived Prospect Size

The characteristics of the derived prospect size distribution are given in Table 4 as a cumulative probability distibution. The expected prospect size is 794 million cubic m with a standard deviation of 762 million cubic metres.

Number of Prospects

The number of prospects is estimated to be between 20 and 200, with a greater than 50% probability that the number of prospects exceeds 100 (Table 3). This is a difficult play parameter to infer. Two things complicate the estimate. There is little objective data on which to base the estimate, while the strength of the analogy to current slope-basin plays has some associated uncertainties. As inferred for the other plays in this succession there is a strong likelihood that all pools will have a component of stratigraphic entrapment. The inference made here considers the size of the first order inversion structure lying above the Trevor Thrust, which defines the limits of the play, while relying strongly on reference to other inversion settings to estimate the number of prospects. However, when the complications due to a stratigraphic component of entrapment are considered, it is likely that we have significantly underestimated the total number of prospects. It is strongly believed that this play, if it is demonstrated to exist, has been significantly underestimated in number of potential accumulations. The included estimates point to the existence of the play. Results could be revised if discoveries were made.

Play and Prospect Level Exploration Risks

Inferred play and prospect level risks (Table 3) are onerous, but not prohibitive. Seismic show clearly that the Trevor Fault is a large thrust fault rather than a normal fault, as mapped. The uncertainties in the tectonic history and structural interpretation - as there is no structural data other than the map, which is wrong, serve only to increase the risks on this play. The problems of structural interpretation encumber the analysis of the play as it is suspected that this play may persist to great depth, but it is also possible that there are both seal and formation volume factor risks, as it could be that many potential reservoirs are near the surface and the preservation of potential is at high risk. Mitigating factors provided by the play analogue and the observations in the Bowser Basin are as discussed above.

Resource Potential

To the west of the Trevor Fault the outcrop is dominated by Paleozoic outcrops of the Cambrian to Devonian succession composed of Road River and Imperial Formation and equivalents. The succession below the Imperial formation is dominantly shales and no potential is inferred, at this time, for the sub-Imperial succession.

The potential prospect size is governed by local structural and stratigraphic characteristics and largely subjective play and prospect level risks. Exploratory risks are onerous because of the many uncertainties, which range from the incorrectly mapped nature of the play bounding Trevor Fault, to the appropriateness of the play analogues and the lack of data on reservoir and prospect characteristics directly derivable from the play region.

The play potential calculation suggests that between 0 and 5 pools could occur, but that a single pool is expected (Table 5). The play potential is between zero and 5873 million cubic m of initial raw gas in place (Figure 23). The expected value of the undiscovered pool size is 105 million cubic m of initial raw gas in place (Figure 24; Table 6). Note that the expected play potential lies between 99% and 95% on the predicted pool size and the expected predicted pool size is 822 million cubic meters, but that the standard deviation of the expected pool size is 780 million cubic meters. Where the analysis predicts only a single pool we employ the description of the expected play potential to describe both the mean play potential and the undiscovered pool sized.

The total petroleum potential of the Peel Plateau - West of Trevor Fault as portrayed here is small to negligible, as would be expected from it geological history and characteristics. The analytical results rate this as the least attractive in the assessment. Therefore, the assessment of this play should seen more as an indicator that potential may exist and that the play should be reassessed if a discovery in similar strata, to east, under the Peel Plateau and Plain.

Cambrian-Devonian Play (speculative)

A dominantly fine clastic Cambrian to Devonian succession, equivalent to the base of the Canol Formation, occurs west of Trevor Fault, primarily in its hanging wall (Figures 6 and 22). This succession, which is not well known between the Knorr and Trevor faults, carries unknown and unestimated petroleum potential. In this region there is insufficient data to allow inference of play parameters, play-level risks and prospect-level risks. The most prospective reservoir horizons in this part of the succession are expected to occur in the sub-Road River Fm. succession. The potential reservoir formations are best developed west of the Knorr Fault (Morrow, 1999, his Figure 12), but they may extend between the Knorr and Trevor faults, especially to the north, where this succession occurs below the very thick Road River to Imperial succession and its equivalents. The most prospective horizons are inferred to occur in the Middle Cambrian and older Iltyd and Slats Creek formations, both of which had a mature provenance in Precambrian footwall rocks (regions lying east) of the Trevor fault during its initial extension. The protracted extension and subsequent inversion, combined with deep burial, all increase the risk for the preservation of both petroleum and reservoir. These risks are currently not quantified, however recent discoveries of natural gas at depths greater than 5 km, in a number of regions of the continental United States suggest that this play should be considered to have a real, but currently unknown potential for natural gases.

Peel Plain

C5560111- Paleozoic Carbonate Platform Play

Structural or stratigraphic traps in the platform carbonates of the Hume Formation and older Paleozoic carbonate successions lying east of the limits of Laramide thrusting and folding in the Peel Plain constitute a possible, but notably unsuccessful, conceptual play for natural gas. This play is designated Peel Plain Paleozoic Carbonate Platform - C5560111 (Figure 22). Play parameters (Table 7) are inferred from a combination of map, well and seismic data; however, some play parameters and all prospect-level risks must be inferred subjectively because of the lack of discoveries, and the reasonable, but still reconnaissance scale of the geoscience data set.

This play occurs within a relatively shallow water carbonate platform succession of Cambrian to Devonian age. The play characteristics are broadly similar to that of the thick, extensive carbonate platform successions that are major producing horizons in the central, or Mid-continent, and Rocky Mountain regions of North America. However, there are distinctive differences because of the change in structural setting. Four features of the Mid-continent and Rocky Mountains plays result in the very large reserves that are associated with that setting:

* reservoir, predominantly dolostone;
* source, including the Ordovician kukersitic/kerogenite beds;
* large basement controlled structure, such as the Cedar Creek Anticline; and *
* favorable timing of hydrocarbon generation and structural formation. The failure to establish production in similar successions in north of 60 degrees latitude is a major disappointment, which is expected to repeat in the Peel Plain.

Prospect Volume Characteristics

All prospects are inferred to exceed 0.4 km^2 in area, with more than half of the prospects inferred to exceed 5.0 km^2 (Table 7). The analysis of this parameter follows a rational similar to that discussed above. The size of more than half of the prospects is based on constraints from the geological map (see above). The estimates are derived generally from similar data sources used by previous assessment studies (Bird, 2000; 1999; Hannigan, 2001). The upper limits on prospect area are 20 km^2, at one percent probability and 45 km^2 at zero probability, approximately half of that expected in the analogous play in the same succession in the Cordillera. These estimates are derived from similar data to, and are likewise comparable with previous work.

Within this play average net pay is controlled by the thickness of ramp-type stratiform porous intervals that are developed within each of the carbonate formations. It is inferred that porous layers will vary between 2 and 40 m thickness, based on data inferred from wells. The possibility of thicker porous intervals cannot be precluded, and thinner intervals are not likely to be tested or completed. The diagenetic history of reservoirs is not well known, but it is known that Manetoe dolostones do not extend into the assessment region. Therefore the development of porous intervals will be predominantly stratiform, typical of ramp depositional settings. The range of prospect average porosities, 2-20%, is consistent with facies and burial depths for both this depositional environment and tectonic setting. Formation Volume Factor parameters including gas composition (compressibility) and reservoir factors (temperature and pressure) capture expected values that consider the geological and tectonic setting of this play (Table 7).

Derived Prospect Size

The expected prospect size is 211.7 million cubic m with a standard deviation of 191.5 million cubic m (Table 8).

Number of Prospects

The number of prospects is estimated to be between 30 and 300, with a greater than 50% probability that the number of prospects exceeds 150 (Table 7). There is little objective data on which to base the estimate, as the wells represent but a small sample of the play volume and the relationships between stacking of porous layers within individual prospects and the distribution of potential relative to structures within the Peel Plain does not follow a predictable model, as in the Cordillera. There is a strong likelihood that all accumulations will have a component of stratigraphic or diagenetic entrapment, which is inherent from the depositional environment of these sediments and their Interior Platform setting. The long distance between seismic lines makes it impossible to map individual prospects between points of control. It is, however, unlikely that the total number of prospects is underestimated..

Play and Prospect Level Exploration Risks

The total risk (Table 7) placed on this play is justifiably very high. There have been several hundred wells drilled to test, at least in part, the Paleozoic carbonate platform of the Northern Interior platform, with little success. None of the previously listed factors that affect the productive of plays is most favorably developed in this assessment region. The Manetoe dolostones that are so important to the formation of dolostones reservoirs in the Devonian succession of the Liard Basin are not known to occur north of 63 degrees north latitude, a fact not correctly portrayed in one of the earlier studies of the Peel region (Bird, 2001). Although there are many dolostones intervals within this succession the total volume of favorable reservoir is small compared to the thickness and extent of the Paleozoic platform carbonates. The presence of rich source rocks like those of the Ordovician succession is inferred, but not known. Although there are large structures controlled by basement features, such as Keele Arch, they have not been shown to be productive, despite considerable analysis and drilling (Morrell, 1995; Williams, 1987; Feinstein et al., 1996; 1991; 1988). The major risks include timing and closure. Carbonate ramp depositional environments often develop stratiform porous zones that require structure to provide the trap. Since large structural traps exist elsewhere in this succession, although not in the assessment region, it is inferred that the problem is most likely timing. The prospect level risks strongly reflect these concerns as justifiably high risks that are the product of many unsuccessful wells drilled to test the potential of this succession elsewhere. The assigned play and prospect level risks are strongly subjective, but are also the consensus of exploration experience (Table 7).

Resource Potential

The Cambrian to Devonian Carbonate Platform in the Peel Plain, all the units of which are dominated by carbonate ramp deposition, constitutes the largest volume of rock of any single play. Factors that adversely affect this play include: the style of porosity development and the lack of lateral seals, the preservation of limestone reservoir porosity in the absence of pervasive dolomitization, and the timing of hydrocarbon generation relative to structure formation. Throughout the northern Interior Platform there has been a most notable lack of success drilling to the Hume Formation and the Ronning Group. The analysis suggests that between 0 and 11 pools could occur, but only a single pool of about 0.218-0. $X10^9$ m^3 initial raw gas in place is expected (Table 9). The play potential is between zero and 2.780 $X10^9$ m^3 of initial raw gas in place, with an expected value of 272 million cubic m of initial raw gas in place (Figure 25).

The description of the expected pool in this play (Table 10; Figure 26) is predicted, by the pool size by rank analysis to be 278.72 million cubic m of gas. Instead, because only a single accumulation is expected, we employ the expected play potential, 272 million cubic metres, rather than the mean of the pool size by rank prediction to describe the largest pool. The value employed occurs at about 40% probability in the predicted largest pool size distribution above. The total petroleum potential of this play is not considered attractive, because of the small-undiscovered pool size and the high exploratory risk. This play is an immense rock volume, but to date it has defied considerable efforts to establish production with the drilling of several hundreds of wells that, at least in part, attempted to test this succession.

C5550111- Horn Plateau Reef Play

Stratigraphic traps in Horn Plateau reefs that are rooted on the Devonian Hume Formation platform, lying east of the limits of thrusting and folding in the undeformed Peel Plain constitute a speculative, and elsewhere notably unsuccessful, conceptual play for natural gas in the Peel Plain region. This play is designated Peel Plain Horn Plateau Reef - C5550111 (Figure 22). Play parameters are inferred by analogy to Horn Plateau reefs elsewhere (Table 11); however, some play parameters and prospect-level risks must be inferred subjectively. The subjective assessment of play potential occurs because of the lack of discoveries, and the reliance on parameters derived largely outside of the assessment area, where Horn Plateau reefs have been identified and drilled.

Horn Plateau reefs represent large stromatoporoid atolls or pinnacles, that represent the restricted development of abrupt margin shallow water carbonate facies that persisted after the general drowning of the Hume Formation ramp-platform in Devonian time, as the platform margin migrated south to the Keg River and Slave Point margins in northern Alberta and the southern Northwest Territories. In contrast to the Norman Wells Kee Scarp reef, numerous Horn Plateau reefs have been drilled, without success. This play is not a Kee Scarp Formation (Norman wells) analogue, as it is expected that reefs in the Peel Plain would be rooted directly on the Hume Platform. The play definition assumes not only the presence of Horn Plateau reefs in the area, something that is possible, but unsubstantiated, but also that such reefs might have porosity to provide a reservoir. The failure to establish production in these reefs has been a major disappointment, elsewhere, especially in the adjacent N.W.T.

Prospect Volume Characteristics

Prospect volume characteristics of this play are based, as far as possible, on analogously derived play and prospect parameters (Table 11). If discoveries are made and the analogy is strengthened then it is reasonable to review the assessment of this play and the possibility of using analogous pool and prospect size parameters from model Devonian reef pools elsewhere in the Interior Platform.

All prospects are inferred to exceed 1 km^2 in area, with more than half of the prospects exceeding 5.0 km^2. The lower value represents the approximate limits of a reef that could be resolved within this region. It is consistent with lower limits of prospect size for reefs elsewhere in the basin. It is similar to the area of a standard oil spacing unit (0.64 km^2) in established producing areas, which also provides an approximate lower limit on petroleum pool area definition. The upper limits on prospect area are 8 km^2, at one percent probability and 10 km^2 at zero probability, otherwise it is expected that these reefs would have been detected on seismic in this area. Within this play average net pay is controlled by the thickness of the reef and the percentage of fill. The reefs can be very thick, up to 250 metres, but it is rare for large atoll reefs to be filled to spill point, even in the most effective petroleum systems, like the Frasnian reefs of central Alberta. Other prospect parameters are extracted from the main development of Horn Plateau reefs north of the Keg River/Slave Point platform margins.

Derived Prospect Size

The expected prospect size is 755.76 million cubic m with a standard deviation of 927.39 million cubic m (Table 12). If the play could be proved to exist it could include very large prospects.

Number of Prospects

The number of prospects is estimated to be between 1 and 40, with a greater than 50% probability that the number of prospects exceeds 10 (Table 11). This play parameter is difficult to infer. There is no objective data on which to base the estimate, as these reefs have not been identified in the assessment area and the play is based entirely on analogy to non-productive reefs outside of the assessment area. The play potential here is strongly controlled by the degradation of reservoir potential that is inferred to result from the lack of favorable diagenesis or timing of important geological processes, which is the nature of exploratory risk in Horn Plateau reefs elsewhere (Table 11).

Play and Prospect Level Exploration Risks

The total risk placed on this play is justifiably very high (Table 11). The diagenetic history of Horn Plateau reef reservoirs is not known, as reefs have not been drilled locally, but it is expected to marginal to unfavorable, based on experience elsewhere. As mentioned in the Paleozoic carbonate platform play, Manetoe dolostones do not occur north of 63 degrees north latitude (Morrow, 1999 and Morrow et al. 1990). Compaction quickly reduces limestone porosity, so that without anomalous diagenesis it is unlikely that reservoir quality survives burial. However, the presence of a Horn Plateau reef in this part of the Hume Platform would itself be an anomaly, so the play is strictly, but not prohibitively risked. The risks reflects this concern, with a combination of favorable exploratory risks significantly tempered by only a 10% chance that reservoir will occur, since this risks both the occurrence of the reef facies and its diagenesis. The assigned play and prospect level risks are, therefore, strongly subjective, but consistent with exploration experience.

Resource Potential

Most of the Devonian succession is in a carbonate ramp setting in the Peel Plain. The one significant opportunity for an abrupt carbonate margin facies model accompanies the persistence of carbonate deposition following the drowning of the Hume Platform. This is identical in configuration to the Horn Plateau Play of the southern NWT. While, this play is not known to exist, neither can it be entirely discounted. The play potential calculation suggests that between 0 and 37 pools could occur, but only a single pool is expected (Table 13). The play potential is between zero and 32.38 $X10^9$ m^3 of initial raw gas in place, but with an expected value of 888 million cubic m of initial raw gas in place (Figure 27). Note that because only a single accumulation is expected we employ the expected play potential, 888 million cubic metres, rather than the mean of the pool size by rank prediction, 2.381 $X10^9$ m^3 to describe the size of the largest pool (Table 14, Figure 28). The value employed occurs at about 80% probability in the predicted largest pool size distribution above. The petroleum potential of the Peel Plain Horn Plateau Reef - C5550111 is a speculative "long shot". The analytical results rate this as an unattractive play to pursue because of the smaller undiscovered pool size and the very high exploratory risk. While the reef itself is volumetrically attractive, much effort to find a reservoir and reserve in these reefs elsewhere has met with persistent failure.

C5530111 - Upper Paleozoic Clastics

Structural or stratigraphic traps in the arenaceous to rudaceous clastics of the post-Canol Paleozoic succession of the Imperial, Ford Lake and Tuttle formations, lying east of the limits of thrusting and folding in the undeformed Peel Plain constitute a significant conceptual play for natural gas in the Peel Plain region. This play is designated Peel Plain Upper Paleozoic Clastics - C5530111 (Figure 22). Play parameters described above from the reconnaissance scale geoscience data set (Table 15). This play is a shoreface, slope-basin sandstone play that includes depositional settings that may be similar to what are among the most attractive plays in the current exploration portfolio of major oil companies, in the Gulf of Mexico and on the passive margin of the South Atlantic Ocean. The play is also the stratigraphic analogue of the two Upper Paleozoic Clastic plays in the Cordilleran part of this assessment.

Prospect Volume Characteristics

The characteristics of this play are broadly similar to that of the two other Upper Paleozoic Clastic plays in this assessment (C-5580111 and C-5540111; Figure 22, Tables 3 and 27). However, there are distinctive differences because of the change in the structural setting. The possibilities for structural stacking and the component of closure due to Laramide diastrophism are much reduced. The net impact on this play is complicated, but in general it results in smaller prospects, with a greater component of stratigraphic entrapment and with what are probably degraded reservoir characteristics. The affect of change in tectonic history and setting on reservoir characteristics may at first appear counter intuitive, however, the lack of Laramide thrusting and folding reduces the possible contributions of fracturing to reservoir storage and transmissibility. Due to the probable deep late Paleozoic burial of the this part of the succession, in comparison to Cretaceous burial, and the time for diagenetic processes to work at the reduction of reservoir quality, it is inferred that better reservoir quality will be found in the Cordillera than in the Interior Platform for this succession. The situation is analogous to the Liard Plateau and Plain to the south, where diastrophic fracturing in some units is an important contribution to reservoir quality.

All of the prospect volume characteristics of this play are based, as far as possible, on locally derived play and prospect parameters. An alternative would have been to use the pool parameters of the current slope-basin sandstone plays of the Atlantic and Gulf Coast passive margins as an analogue for this play. However, the strength of the analogue is unproven and it is likely that prospects will be evaluated on the basis of their local characteristics. It is inferred that this decision strongly depreciated the play potential, the number of expected pools and the size of the largest undiscovered pool. However, it is responsible considering the uncertainties in the play analogy. If discoveries are made and the analogy is strengthened then it is reasonable to review the assessment of this play and the possibility of using analogous pool and prospect size parameters from the passive margin setting, especially where stratigraphic components of entrapment are demonstrated.

Minimum prospect sizes are based on rational given in the discussion of other plays above (Table 15) The size of more than half of the prospects is based on, constraints from the geological map, and observations of seismic data within the Cordilleran thrust and fold belt of the Peel Plateau (see above). The upper limits on prospect area are 10 km^2, at one percent probability and 20 km^2 at zero probability, approximately half of which are expected in the play on the same succession in the Cordillera. These estimates are derived from similar data and are likewise comparable with previous work.

Within this play average net pay is controlled by the thickness of individual sandstone reservoir intervals, fewer of which might be stacked in an individual prospect, compared to the Cordillera, but each of which is, by virtue of its stratigraphic components an individual prospect. Therefore, in comparison to the Cordillera it is expected this play will have a significantly higher number of prospects, because of the greater component of stratigraphic entrapment and the absence of the diastrophic deformation. It is inferred that sandstone layers will vary between 2 and 20 m thickness, based largely on bedding characteristics inferred from wells. The sandstone thickness in this part of the play are inferred to be, on average thinner than those west of the Trevor Fault, due to the more distal nature of the depositional setting. Thinner sandstone intervals are observed, but they are not likely to provide exploratory targets at this stage of exploration. The possibility of thicker sandstones cannot be entirely precluded, but they could not be adequately documented.

The diagenetic history of reservoir sandstones is not well known. The prospect average porosities are reduced compared to the most prospective parts of the Cordillera because of the uninterrupted period for, and general tendency of diagenesis to reduce reservoir quality with time. It is also likely that a tectonic component of diastrophic porosity enhancement, especially fracturing, will be lower here than in the Cordillera. The range of prospect average porosities, 5-15%, is consistent with facies and burial depths for both this depositional environment and tectonic setting. Formation Volume Factor parameters are consistent with the geological and tectonic setting of this play.

Derived Prospect Size

The derived expected prospect size distribution for this play is 772 million cubic m with a standard deviation of 395 million cubic m (Table 16).

Number of Prospects

The number of prospects is estimated to be between 60 and 500, with a greater than 50% probability that the number of prospects exceeds 250 (Table 15). This play parameter is difficult to infer. Two things complicate this estimate. There is little objective data on which to base the estimate, as the wells represent but a small sample of the play volume and the relationships between stacking of sandstone layers within individual structural prospects and the distribution of these sandstones relative to structures within the Peel Plain does not follow a predictable model, as in the Cordillera. Furthermore, the strength of the analogy to current slope-basin plays currently being exploited on the Atlantic and Gulf of Mexico passive margins has greater uncertainties and applicability in what should have been generally shallow water setting over the Hume Platform, than would be expected over the Richardson Trough. There is a strong likelihood that all pools will have a strong component of stratigraphic entrapment, which is inherent from the depositional environment of these clastic sediments and the lack of diastrophic structure. It is less likely that we have may have underestimated the total number of prospects here compared to the two plays in the same succession in the Cordillera. The play potential here is strongly controlled by the degradation of reservoir potential that is inferred to result from the lack of tectonic porosity enhancement and the reduction in focused migration that is more typical of the strongly deformed rocks in the Cordillera. Results should be revised to reflect an improved data set and reduced play level risks if discoveries are made in this play.

Play and Prospect Level Exploration Risks

The total risk placed on this play is high, but not as high as in either of the two plays in the Cordillera equivalents of this succession (Table 15). Neither are there any play level risks, i.e., it is considered certain that some of these accumulations exist, based on shows in wells such as the three Shell Peel River wells (see petroleum systems and exploration history sections). The complexity, duration and uncertainties in the diagenetic and tectonic history serve to depreciate the potential of this play by increasing the number potential points of failure and the duration over which reservoir and seal could be degraded. Seismic shows clearly that a component of structural closure that was important in defining prospects in the Cordillera is not present east and north of the deformation front. This has implications for the timing of reservoir diagenesis, hydrocarbon migration and up-dip seal. Whether there was a significant charge of petroleum migrated out of the Cordillera during the Laramide orogeny is uncertain, but this could serve to increase the potential for charge at later times, while the strong components of stratigraphic entrapment provide better opportunities for seals, even if the quality of the reservoir is adversely affected by the lack of tectonic fracturing. Several of processes remain poorly understood in this lightly explored region, however, the variations of possibilities are hopefully captured in the prospect level risks used in this analysis.

This play analogue of deep-water slope and basin sandstone play like those being exploited currently in the Gulf of Mexico and on both the South American and African portions of the Atlantic passive margin, may be different here due to the setting and its impact on depositional processes. There are obvious differences in tectonic setting between Peel Plain and the Atlantic passive margin, but the general similarities of the depositional setting are preserved in the Upper Paleozoic succession. The cratonic and terrestrial setting of this play makes it more attractive than the same play in thousands of m of water depth, but the access to small prospects is adversely offset by the age of the reservoirs and their longer exposure to processes of reservoir degradation that would generally be interpreted to increase exploratory risks and decrease the size and number of accumulations.

The slope-basin sandstones of the Ritchie-Alger Assemblage in the Bowser Basin have had, like this play, a complicated diagenetic and tectonic history. Recent work by British Columbia Energy and Mines staff have shown that one of only two wells (Amoco Ritchie a-3-J/104-A-6) drilled in the Bowser Basin contains by-passed petroleum pay, probably gas (Hayes et al. 2004). This discovery has profound implications for the analogous deep-water clastic play in the Peel Plateau. It demonstrates that conditions for the preservation of both reservoir and petroleum can occur in the cratonic analogues of the passive margin deep-water plays, despite their complicated diagenetic and tectonic history. Local details of the diagenetic history for the Peel Plain Upper Paleozoic Clastics - C5530111 are not known, but they could be the subjects of future study. Once a discovery be made in this succession, in this region it would be necessary to make intensive study to more adequately determine the levels of exploratory risks. The high risks imposed here are considered valid due to the uncertainties, or risks, associated with the appropriateness of the analogies discussed above. All of these factors considered, the play is still considered to have potential largely because even more complicated settings appear to have not only preserved reservoir, but to have demonstrable evidence for hydrocarbon accumulation.

Resource Potential

Paleozoic clastics, although comprising a thinner succession dominated by non-reservoir facies, than in the Cordillera, have a greater potential for a favorable stratigraphic component of entrapment. Therefore they have an improved potential for the preservation of the petroleum generated in the Paleozoic, as some petroleum system analyses suggest, with an uncertain gathering potential for petroleum generated during the Cordilleran deformation that could have also migrated north and east into the Foreland in front of the deformation.

The play potential is suggests that between 0 and 36 pools could occur, but that 9 pools are expected (Table 17). The play potential is between zero and 27.6 $X10^9$ m^3 of initial raw gas in place, with an expected value of 7.260 $X10^9$ m^3 of initial raw gas in place (Figure 29). The largest expected pool is 1.352 $X10^9$ m^3 initial raw gas in place (Table 18, Figure 30). The smaller size here reflects both the small available structures of the Plains, but also the more distal setting of this play area relative to the apparent source of these clastics. The total petroleum potential of the Peel Plain Upper Paleozoic Clastics - C5530111 is significant. Compared to the other two plays in this succession, as they occur in the Cordillera, much less of the expected play potential is predicted to occur within the largest pool, which has a median size of 1.352 $X10^9$ m^3. This may be an undesirable result, since the wider distribution of potential among a larger number of pools might result in a situation where no pool is economically viable, in comparison to the large undiscovered potential attributed to the single undiscovered pool within the Cordillera.

The characteristics of the undiscovered resource are consistent with geological history and play characteristics, although they may be conservative considering play analogues, should those analogies hold in the Peel Plain. The combinations of geological characteristics for this play are favourable, but the exploratory risks are high. The lack of structure and the possibility of early hydrocarbon generation could significantly depreciate the potential of this play. Therefore the possibility that numerous accumulations will be found is unlikely, and it is also unlikely that any of the accumulations will be very large. The analytical results rate this as a less attractive play to pursue compared to the same succession in the Cordillera largely because of the smaller undiscovered pool sizes. The lack of structure that is inferred to both enhance porosity and focus petroleum migration in the Cordillera contrasts with the longer duration for reservoir degradation by diagenesis that reduces the potential of this play in the Peel Plain. Therefore, the assessment of this play should be seen as an indicator of a realizable potential, even if the undiscovered pool sizes are smaller than in the Cordillera. The possibility of stacked pay zones from several plays in different succession could help make this play economic on a field level.

Mesozoic Clastics - C5520111

Structural or stratigraphic traps in the arenaceous to rudaceous clastics of the Mesozoic succession of the Martin House, Arctic Red and Trevor formations, lying east of the limits of thrusting and folding in the undeformed Peel Plain constitute a significant conceptual play for natural gas in the Peel Plain region. This play is designated Peel Plain Mesozoic Clastics - C5520111 (Figure 22). Play parameters are inferred from a combination of map, well and seismic data; however, some play parameters and prospect-level risks must be inferred subjectively because of the lack of discoveries, and the reasonable (Table 19). This play is a fluvial-shoreface and shallow shelf sandstone play that includes depositional settings similar to what are among the most active natural gas plays in the Saskatchewan, Alberta and northeastern British Columbia.

Prospect Volume Characteristics

The characteristics of this play are broadly similar to that of the other Mesozoic Clastic play in this assessment (C-5510111, Figure 22, Table 31) accounting for the change in the structural setting. The possibilities for structural stacking and the component of closure due to Laramide diastrophism are not present in this play. The net impact of tectonic setting on this play is complicated, but in general it results in smaller prospects, with a greater component of stratigraphic entrapment. However, it probably enhances reservoir characteristics in the Mesozoic succession, as illustrated by the marked difference between the Mesozoic reserves in the Cordillera south of the Nahanni River and that in the facing Interior Platform of the south. Much more gas occurs in the Interior Platform, due to lower burial depths and tectonic compaction, which preserves reservoir quality, and because of the presence of a unique biogenic source for natural gases, as at Medicine Hat. Therefore it is inferred that better reservoir quality will be found in the Interior Platform than in the Cordillera for Mesozoic succession, although the effects of fracturing could have a beneficial effect in the Cordillera.

All of the prospect volume characteristics of this play are based, as far as possible, on locally derived play and prospect parameters (Table 19). An alternative would have been to use the pool parameters from the southern Foreland. However, the strength of the analogue is unproven and it is likely that prospects will be evaluated on the basis of their local characteristics. If discoveries are made and the analogy to the southern Foreland Basin is strengthened, then it is reasonable to review the assessment of this play and the possibility of using analogous pool and prospect size parameters from existing discovered pool analogues.

The lower prospect size (Table 19) was inferred following rationales similar to that of previously discussed plays. The size of more than half of the prospects is based on inference and constraints from the geological map and observations of seismic data (see above). The upper values are approximately half that which are expected in the play on the same succession in the southern Cordillera. The generally consistent pool area throughout this analysis results from the stratigraphic layering in structures that affect the complete succession.

Within this play average net pay is again controlled by the thickness of individual sandstone reservoir intervals, which might occur stacked in an individual structural prospect. Therefore it is expected this play will have a significantly higher number of prospects in the Peel Plain than in the Cordillera, because of the greater component of stratigraphic entrapment and the absence of the diastrophic deformation. It is inferred that sandstone layers will vary between 2 and 20 m thickness, based largely on bedding characteristics inferred from wells. This thickness is also characteristic of gas pays in the Mesozoic succession, to the south, where there are abundant discoveries. The diagenetic history of reservoir sandstones is not well known. The prospect average porosities of 5-20% are consistent with facies and burial depths for both this depositional environment and tectonic setting as is the formation volume factor.

Derived Prospect Size

The derived prospect size distribution for this play resulting from input play parameters and is an expected prospect size of 920 million cubic m with a standard deviation of 728 million cubic m (Table 20).

Number of Prospects

The number of prospects is estimated to be between 50 and 400, with a greater than 50% probability that the number of prospects exceeds 200 (Table 19). These estimates are conservative compared to southern productive portions of the Foreland where even high prospect densities occur. It is less likely that we may have underestimated the total number of prospects here compared to other plays in this assessment. However, results could be revised to reflect an improved data set and stronger comparisons to southern producing regions if discoveries are made in this play.

Play and Prospect Level Exploration Risks

The total risk placed on this play is moderate, but higher than that for the same succession in the Cordillera (Table 19). Neither are there any play level risks, i.e., it is considered certain that some of these accumulations exist, both because of the seepage through these rocks at Swan Lake in the Northwest Territories and due to the analogy with the southern Foreland Basin succession. Seismic shows clearly that a component of diastrophic structural closure that was important in defining prospects in the Cordillera is not present east and north of the deformation front. This has implications for the degree of compaction and the degradation of reservoir quality accompanying burial diagenesis. Whether there was a significant charge of petroleum migrated out of the Cordillera and into the Peel Plain, or across the sub-Mesozoic unconformity in the Peel Plain itself is uncertain, but this could serve to increase the potential in this succession. Several of these processes remain uncertain in this lightly explored area, however, the variations of possibilities are hopefully captured in the prospect level risks used in this analysis.

The play analogue/comparison to producing portions of the southern Foreland Basin in the Interior Platform is considered well founded and appropriate. The lower risks imposed here are considered valid due to the observations in other parts of the Foreland Basin. The play is among the most attractive and it has more than half of the total potential of the entire assessment region.

Resource Potential

Gas occurs ubiquitously in the Mesozoic Foreland succession of the Cordillera, as indicated by the discovery of more than 2 trillion cubic m of initial reserves in thousands of Mannville Group pools in Alberta, Saskatchewan and Northeastern British Columbia. There is no reason to believe that the Mesozoic Foreland Basin succession in the Peel Plain would not also have a significant potential gas resource. Like the more southern producing region the accumulations will be expected to be predominantly stratigraphic, but like the south, it is expected that non-diastrophic structure, including compaction drape will provide both the method for identifying these prospects as well as a component of the entrapment.

The play potential is between zero and 139 $X10^9$ m^3 of initial raw gas in place, with an expected value of 49.487 $X10^9$ m^3 of initial raw gas in place (Figure 31). The play potential calculation suggests that between 0 and 138 pools could occur, but that 55 pools are expected (Table 21). The accumulations can be inferred to be primarily of smaller size due to the small available structures and the complexity of the internal stratification that controls the stratigraphic components of entrapment (Figure 32). The largest expected pool is 3.633 $X10^9$ m^3 initial raw gas in place (Table 22).

The total petroleum potential of the Peel Plain Mesozoic Clastics - C5520111 is significant. Compared to the other plays in this assessment a small amount of the expected play potential is predicted to occur within the largest pool, but that this is compensated for by the large play potential. The median size of the largest undiscovered pool is estimated to be 3.356 $X10^9$ m^3 eters, or three times that in the largest pool expected in the next prospective play in the Peel Plains, the Upper Paleozoic Clastics - C5530111. In fact, the first fifteen pools in this play have median potentials that would suggest they are larger or of comparable size to the deeper plays in this region. Clearly the undiscovered potential in the Peel Plain is inferred to occur primarily within the Mesozoic succession.

The characteristics of the undiscovered resource are consistent with geological history and play characteristics. The situation is similar to that of the southern Alberta, where important accumulations occur within the Foothills, as at Waterton; but where the potential in the Plains occurs largely in the Mesozoic succession of the Foreland Basin, as at Medicine Hat, with very little petroleum potential or reserves proved in the underlying Paleozoic succession of the Interior Platform. This similarity, although unanticipated, provides an important confirmation of the assessment process, which has been successfully applied in the producing regions of the Cordillera and the Foreland Basin. The size of the largest projected pools is also consistent with the size of the largest discovered pools in southern Alberta. If the Martin House Formation is seen as comparable to the Lower Manville Formation, in stratigraphic position, as the lowest coarse clastic unit in the Foreland succession we see that the largest pool in that succession in southern Alberta is the Long Coulee, Sunburst G pool, with a discovered initial in-place reserve of 2.666 X 10^9 m^3.

Therefore, we conclude that the combinations of geological characteristics for this play are favourable, and that the exploratory risks are moderate, with an opportunity not unlike that of southern Alberta. The results rate this as among the most attractive plays, even in comparison to the same succession in the Cordillera largely because of the smaller total resource and undiscovered pool sizes west of the deformation limit. It is however unlikely that any of the accumulations will be very large, considering current models. The possibility that numerous accumulations will be found is good and this might facilitate the production of groups of geographically associated pools. The possibility of stacked zones from plays in different parts of the succession could also make this play economic at the field level. The appropriateness of the play analogue to southern Alberta is strong, both in setting and in pool size characteristics. Therefore, the assessment of this play should be seen as an indicator of a realizable potential. The lack of underlying potential in the Paleozoic succession makes it essential that the focus of exploration be on the Cretaceous succession itself, east of the deformed belt.

Peel Plateau

C5570111 - Paleozoic Carbonate Margin

Structural or stratigraphic traps in the ramp carbonates of the Hume Formation and older Cambrian to Devonian carbonate succession, lying within the Cordillera of the Peel Plateau constitute a possible, but speculative conceptual play for natural gas in the Peel Plateau region. This play is designated Peel Plateau Paleozoic Carbonate Margin - C5570111 (Figure 22). Play parameters are inferred from a combination of map, well and seismic data; however, some play parameters and prospect-level risks must be inferred subjectively because of the lack of discoveries, and the reasonable, but still reconnaissance scale of the geoscience data set (Table 23).

This play includes regions where the Cambrian to Devonian carbonate margin and adjacent platform were deformed within the eastern thrust and fold belt of the Cordillera. The margin east of the surface trace of the Trevor Fault is characterized by thick and laterally extensive Paleozoic platformal carbonates that pass abruptly into the basinal facies of the Road River Group. While this facies change probably affects the mechanical stratigraphy and structural style, the stratigraphic component of entrapment related to the carbonate facies change is considered unimportant to the potential of this play. This is largely because the facies change is unfavorably oriented with respect to Paleozoic depositional slope and Laramide tectonic dip to provide a major trap. Before the formation of Laramide structures, hydrocarbons migrating into the abrupt carbonate margin would have been lost into the persistent carbonate platform, probably during the widely accepted Late Paleozoic phase of petroleum generation. To the east or north of this facies transition and structure the Hume and older carbonate platform and overlying clastic dominated formations are involved in the thrusts and folds of the Laramide diastrophic deformation of the Cordillera. The play can be considered to be the rough analogue of the Liard Plateau overthrust play, developed on the eastern flank of the northernmost Cordillera.

Prospect Volume Characteristics

All prospects are inferred to exceed 0.4 km^2 in area, with more than half of the prospects inferred to exceed 5.0 km^2. The lower value is inferred to represent the approximate limits definable structures consistent with lower limits of prospect size used in previous assessments (Table 23). The size of more than half of the prospects is based on, constraints from the geological map, and observations of seismic data within the Cordilleran thrust and fold belt of the Peel Plateau (Table 23). The estimates are derived from similar data to that used by previous assessment studies (Bird, 2000; 1999; Hannigan, 2001), although the seismic interpretation used here is much different. The upper limits on prospect area are 10 km^2, at one percent probability and 20 km^2 at zero probability, approximately half that which are expected in the play on the same succession in the Cordillera.

Within this play average net pay is controlled by the thickness of ramp-type stratiform porous intervals that are developed within each of the carbonate formations. There is no clear evidence for a thick platform margin reef build-up and no certainty that even if it existed, that it would be suitably located in the deformed structure. It is inferred that porous layers will vary between 2 and 40 m thickness, based largely on data inferred from wells in the deformed and undeformed platform successions. The diagenetic history of reservoirs is not well known, but it is know that the Manetoe dolostones do not extend north into the assessment region. Therefore the development of porous intervals will be typically stratiform, as is typical of ramp depositional settings. The range of prospect average porosities, 2-20%, is consistent with facies and burial depths for both this depositional environment and tectonic setting. Formation Volume Factor parameters capture reasonably expected values considering the geological and tectonic setting of this play.

Derived Prospect Size

The characteristics of the derived prospect size distribution for this play resulting from the analysis of input play parameters and their combination is provided below, in millions of cubic metres, as a function of cumulative probability. The expected prospect size is 676 million cubic m with a standard deviation of 694 million cubic m (Table 24).

Number of Prospects

The number of prospects is estimated to be between 10 and 200, with a greater than 50% probability that the number of prospects exceeds 100 (Table 23). There is insufficient data to truly map the prospects in the play. The long distance between seismic lines makes it impossible to map individual structures between points of control. It is likely that we have may have underestimated the total number of prospects, due to the internal complications of the structure.

Play and Prospect Level Exploration Risks

The total risk placed on this play is high, especially with respect to timing (Table 23). All of the concerns expressed for the Carbonate Platform Play - C5560111 in the Interior Platform are generally valid here also. Trap is provided by the Laramide structure. The advantage of this play is that the risk of having closure is greatly reduced. After locating seismic anomalies relative to the position of the wells drilled in this area, it is clear that some wells were not optimally located with respect to structure, either due to insufficient seismic data, or access and logistics problems. Many of the wells appear to have barged or transported on "Winter Roads" up the rivers in the region, "as close as possible" to the structure. The facies transition is unfavorably oriented with respect to trapping migrating hydrocarbons, but the impact of Laramide diastrophism reduces this risk by providing structural closure and its own charge of hydrocarbons, from the footwall succession. For these reasons the exploratory risks of the carbonate Paleozoic platform in the Cordillera are less compared to similar plays in the Platform.

It may be that concerns about the timing of hydrocarbon generation relative to trap formation could have been reduced compared to the Interior Platform, but they were not. It appears that there is a general syntectonic generation of hydrocarbons in the footwall of thrust faults that accompanies the deformation. Elsewhere, fracturing may have improved reservoir porosity or provided communication between stratiform porous zones. In this fashion the play can be considered an analogue to the Liard Plateau play, without the regional reservoir diagenesis. However, the possibility of syntectonic hydrocarbon generation would have to be documented before that risk could be reduced.

Resource Potential

This region contains the temporally and geographically persistent Platform to Basin facies transition that marks the eastern margin of the Richardson trough. This facies transition is unfavorably oriented with respect to the Cordilleran structure to provide a distinctive trapping mechanism for early-generated hydrocarbons. Neither is there strong evidence to support a distinctive diagenetic history that would help to preserve reservoir quality by way of hydrothermal dolomitization. Therefore, the plays in Paleozoic carbonates of this region will be in Cordilleran structural culminations where fractured stratiform limestone and dolostone porosity will constitute potential reservoirs in a petroleum system that experienced its first peak generation during the late Paleozoic. The remaining potential is for dry, over mature gas generated by combinations of Foreland and tectonic burial, or for gas generated in the Paleozoic to be re-migrated into Cordilleran structures.

The play potential calculation suggests that between 0 and 29 pools could occur, with an expected seven pools (Table 25). The play potential is between zero and 22.28 $X10^9$ m^3 of initial raw gas in place, with an expected value of 4.46 $X10^9$ m^3 of initial raw gas in place (Figure 33). It is expected that the Peel Plateau Cambrian to Devonian Carbonate Margin play will consist of 7 gas pools with a mean potential of approximately 4.460 $X10^9$ m^3 initial raw gas in place (Figure 34). The largest expected pool is 1.604 $X10^9$ m^3 initial raw gas in place (Table 26).

The total petroleum potential of the Paleozoic Carbonate Margin - C5570111 is significant. The largest pool predicted for the play is generally comparable to the largest pool predicted for the Mesozoic play in the Cordillera. The number of medium and large pools is, however, small. The play is significantly affected adversely by the large prospect level risks on both reservoir and timing, as is appropriate considering the general results exploring this succession in both the Cordillera and the Plains north of the Nahanni River and the absence of a Manetoe dolostones to improve reservoir quality. However, once a discovery is made it is expected that the very sizeable prospect level risks on reservoir and timing could collapse and that the potential of this play would revise upward significantly.

C5540111 - Upper Paleozoic Clastics

Structural or stratigraphic traps in the arenaceous to rudaceous clastics of the post-Canol Paleozoic succession of the Imperial, Ford Lake and Tuttle formations, lying east, or in the footwall, of the Trevor Fault, but which are involved in Laramide structures west of the limits of thrusting and folding constitute a significant conceptual play for natural gas in the Peel Plateau region. This play is designated Peel Plateau U. Paleozoic Clastics - C5540111 (Figure 22). Play parameters (Table 27) are measured and inferred as for other plays above. This play is a shoreface, slope-basin sandstone play that includes depositional settings similar to what are among the most attractive plays in the current exploration portfolio of major oil companies, on passive margins, as mentioned above.

Prospect Volume Characteristics

All of the prospect volume characteristics of this play are based, as far as possible, on locally derived play and prospect parameters. The alternative would have been to use the pool parameters of the current slope-basin sandstone plays of the Atlantic and Gulf Coast passive margins as an analogue for this play. However, this was not done for the same reasons discussed above (C5530111, Figure 22; Table 15), recognizing that this strongly depreciated play potential. If discoveries are made and the analogy is strengthened then it is reasonable to review the assessment and the possibility of using analogous pool and prospect size parameters from the passive margin setting.

The size of more than half of the prospects is based on, constraints from the geological map, and observations of seismic data within the Cordilleran thrust and fold belt of the Peel Plateau. The upper limits on prospect area 20 km^2, at one percent probability and 40 km^2 at zero probability are derived from similar data and are likewise comparable with previous work.

Within this play average net pay is controlled by the thickness of individual sandstone reservoir intervals, many of which may be stacked in an individual structural prospect, but each of which is, by virtue of its stratigraphic components an individual prospect. It is inferred that sandstone layers will vary between 15 and 40 m thickness, base largely on bedding characteristics of the target formations in field photographs. The sandstone thickness in this part of the play are inferred to be, on average thicker than those west of the Trevor Fault, discussed below, due to the more proximal nature of the depositional setting. Thinner sandstone intervals are observed, but they are not likely to provide exploratory targets at this stage of exploration. The possibility of thicker sandstones cannot be entirely precluded, but they could not be adequately documented to allow for quantitative analysis.

The diagenetic history of reservoir sandstones is not well known, but the range of prospect average porosities, 9-20%, is consistent with facies and burial depths for both this depositional environment and tectonic setting. Formation Volume Factor parameters including gas composition capture reasonably expected values considering the geological and tectonic setting of this play.

Derived Prospect Size

The derived expected prospect size distribution for this play prospect size is 4852 million cubic m with a standard deviation of 3114 million cubic m (Table 28).

Number of Prospects

The number of prospects is estimated to be between 40 and 400, with a greater than 50% probability that the number of prospects exceeds 200 (Table 27). Two things complicate this estimate. There is little objective data on which to base the estimate, as the wells represent but a small sample of the play volume and the relationships between stacking of sandstone layers within individual structural prospects and the distribution of these sandstones relative to structural shape, as a function of mechanical stratigraphy is unknown. There is a strong likelihood that all pools will have a component of stratigraphic entrapment, which is inherent from the depositional environment of these clastic sediments, especially within deeper water slope environments typical of the Imperial Formation.

The long distance between seismic lines makes it impossible to know how structural culminations and thrusts are linked between points of control. However, when the complications due to a stratigraphic component of entrapment are considered, it is likely that we have may have underestimated the total number of prospects. The discussion below shows that the role of number of pools, as a function of exploration risks, is a dominant control on the size of individual accumulations and the potential of the play. Results should be revised to reflect an improved data set and prospect level risks if discoveries are made in this play.

Play and Prospect Level Exploration Risks

The total risk placed on individual prospects is high, but not prohibitive (Table 27). There are no play-level risks, indicating the play is inferred to exist, due to shows in wells, which suggest that the petroleum system has operated, and that it is only the number and size of accumulations that must be inferred. Seismic shows clearly that a component of structural closure may exist and that the general structural style is similar to that of other regions in the Cordillera where production is established. The complexity, duration and uncertainties in the diagenetic and tectonic history would typically serve to depreciate the potential of this play, by increasing the number potential points of failure and the duration over which charge, reservoir and seal could be degraded. However, the standard analysis of the Liard Plateau petroleum system would suggest that hydrocarbon generation was early in that region also, while others might suggest that the actual petroleum system functioning in this part of the play is like that found elsewhere in the Cordillera and that footwall sources might provide the majority of the charge syntectonically. This question cannot be resolved within the scope of this study, but the variations of possibilities are captured in the prospect level risks used in this analysis.

Should a discovery be made in this succession, more intensive study would be necessary to adequately determine the levels of exploratory risks.

Resource Potential

Paleozoic clastics, although comprising a thinner succession than the Paleozoic carbonates and being dominated by non-reservoir facies, have a greater potential for a favorable stratigraphic component of entrapment. Therefore they have an improved potential for the preservation of the petroleum generated in the Paleozoic, without depreciating the potential to trap petroleum generated during the Cordilleran deformation.

The play potential curve and pool size by rank diagram describe the petroleum potential of this play in additional detail, however, the play potential is essentially captured by characteristics of the two predicted pool and it discussion of exploratory risk above. The play potential is described by the expected, or mean, play potential, the number of expected pools and the median of the expected pool sizes. The play potential calculation suggests that between 0 and 13 pools could occur, but that two pools are expected (Table 29). The play potential is between zero and 62.13 X10^9 m^3 of initial raw gas in place, with an expected value of 7.799 X10^9 m^3 of initial raw gas in place (Figure 35). The largest expected pool is 5.517 X10^9 m^3 initial raw gas in place (Table 30). This is the single largest projected pool in this assessment. It is likely to occur as a slope-basin sandstone body, in an accumulation that resembles deep-water sandstone plays on current oceanic margins. Note that the individual median and mean pool sizes do not sum to the

statistically inferred Play Potential, due to the different statistical calculations used to determine play potential compared to the calculation of undiscovered pool sizes.
The analytical results rate this as an attractive play to pursue for its likely large individual undiscovered pool. The total petroleum potential of the Peel Plateau Upper Paleozoic Clastics - C5540111 is significant. Most of the expected potential is predicted to occur within the largest pool, which has a median size of 5.517 $X10^9$ m^3, and which is the largest undiscovered pool predicted for this entire assessment (Figure 36, Table 30). The characteristics of the undiscovered resource are consistent with geological history and play characteristics, although they may be conservative considering the play analogues.

Mesozoic Clastics C5510111

Structural or stratigraphic traps in the arenaceous to rudaceous clastics of the Mesozoic succession of the Martin House, Arctic Red and Trevor formations, lying in the allocthonous Cordillera, west or south, of the limits of thrusting and folding in the Peel Plateau constitute a significant conceptual play for natural gas. This play is designated Peel Plateau Mesozoic Clastics C5510111 (Figure 22). Play parameters are inferred as above; however, some play parameters and prospect-level risks must be also inferred subjectively because of the lack of discoveries (Table 31). This play occurs in fluvial-shoreface and shallow shelf sandstones play that includes depositional settings similar to active natural gas plays in the southern Cordillera. Equivalent successions, in the south, have proven reserves, accounting about 15% of the volume in equivalent successions of the Interior Platform. In the southern Cordillera pools in the Mesozoic succession are the second identified, and first commercially productive interval, however, it has been more common for pools in the Cretaceous succession to be discovered, as additional up-hole pays, that are encountered fortuitous during the development of deeper Devonian, Carboniferous and Triassic reservoirs.

Prospect Volume Characteristics

The characteristics of this play are broadly similar to that of the other Mesozoic Clastic play in this assessment (C-5520111, Figure 22, Table 19). However, there are distinctive differences because of the change in structural setting. The possibility for structural stacking and the closure due to Laramide diastrophism increases within the Cordillera. The net impact on this play is complicated, but in general it results in larger prospects, although there are higher risks on closure even where there is a strong component of stratigraphic entrapment. Within the Cordillera deeper burial and greater compaction degrades reservoir characteristics in the Mesozoic succession. Therefore it is inferred that better reservoir quality will be found in the Interior Platform than in the Cordillera for Mesozoic succession, although the effects of fracturing could have a beneficial effect in the Cordillera.
About half of the prospects are in using constraints from the geological map, and observations of seismic data (see above). The upper limits on prospect area 20 km^2, at one percent probability and 105 km^2 at zero probability reflects the structural style and the tendency for the higher stratigraphic units to have much more volume under closure than do deeper horizons closer to the thrust faults. The upper values are approximately that of the closures that expected in the play on the same succession in the Foreland Basin, east of the deformation.

Within this play average net pay is controlled by the thickness of individual sandstone reservoir intervals, which might occur stacked in an individual prospect, or distributed across portions of Laramide structures. Structural depressions and footwall closures are unlikely to be drilled in a frontier setting so is expected this play will have a significantly lower number of prospects in the Cordillera than in the Peel Plain. It is inferred that sandstone layers will vary between 2 and 30 m thickness, based largely on data from wells. Thinner sandstone intervals are observed, but they are not likely to provide exploratory targets at this stage of exploration. Even if sandstones were thicker it is unlikely that net pays would be greater, as is commonly the case in the southern Cordillera.

The diagenetic history of reservoir sandstones is not well known. The prospect average porosities of 2-10% are consistent with facies and burial depths for both this depositional environment and its tectonic setting. Note the significantly lower porosity expected in these successions in the Cordillera compared to the Foreland Basin.

Derived Prospect Size

The expected prospect size is 1050 million cubic m with a standard deviation of 1138 million cubic m (Table 32).

Number of Prospects

The number of prospects is estimated to be between 30 and 90, with a more than 50% probability that the number of prospects exceeds 45 (Table 31). The analogy to southern productive portions of the Cordillera supports these prospect densities. There is a strong likelihood that all pools will have a component of stratigraphic entrapment, which is inherent from the depositional environment of these clastic sediments and the analogues in the southern Cordillera. The play potential here is strongly controlled by the size of prospects, which are comparable to known southern Cordillera accumulations.

Play and Prospect Level Exploration Risks

The total risk placed on this play is low, comparable to that of the same succession in the Foreland Basin (Table 31). There are no play level risks because of the seepage through these rocks in the Foreland Basin portion and due to the analogy with the southern Cordillera. Where the association of differential compaction and bending folds often influences patterns of sedimentation east of the deformation, such a coincidence is commonly lacking between Cretaceous reservoirs and Laramide structures. This has the impact of increasing exploratory risk for the presence of closure as reflected in the play input data sheet. There is an enhanced possibility for charge, especially from syntectonically maturing successions. The play analogue/comparison to producing portions of the southern Cordillera is well founded and appropriate. The lower risks imposed here are considered valid due to the observations in other parts of the Foreland Basin.

Resource Potential

Mesozoic sandstones in the Martin House and Arctic Red formations constitute the primary reservoir horizons the Peel Plateau Cordilleran thrust and fold belt. Although less likely to have great thickness and large extent, as do the Paleozoic plays in the Cordillera, the timing of hydrocarbon generation relative to structure is much more favorable for Mesozoic hosted petroleum systems compared to those in Paleozoic strata. The play potential calculation suggests that between 0 and 39 pools could occur, but that 12 pools are expected (Table 33). The play potential is between 507 million cubic meters and 51.76 $X10^9$ m^3 of initial raw gas in place, with an expected value of 13.157 $X10^9$ m^3

of initial raw gas in place (Figure 37). The largest expected pool is 3.393 X10^9 m^3 initial raw gas in place (Figure 38, Table 34).

The total petroleum potential of the Peel Plateau Mesozoic Clastics C5510111 is significant. The play is among the most attractive and it has the second largest total potential in the entire assessment. Compared to the other plays in this assessment a small amount of the expected play potential is predicted to occur within the largest pool, which is compensated for by the larger play potential. The median size of the largest undiscovered pool is estimated to be 2.861 X10^9 m^3, or about one half of that in the largest pool expected in the next prospective play in the Peel Plateau, the Upper Paleozoic Clastics - C5540111. In fact, the first four pools in this play have median potentials that would suggest they are larger or of comparable size to the sub-Imperial plays of this region. Clearly the undiscovered potential in the Peel Plateau is inferred to occur within the Paleozoic and Mesozoic clastic succession, rather than in the carbonate successions. This is different than the resource distribution in the southern Cordillera.

Discussion

The Peel Plateau and Plain in the Yukon is a prospective petroleum region bounded to the south by the Mackenzie Mountains and to the west by the Richardson Mountains (Figure 4). It is comprised of a Lower Cambrian to Upper Cretaceous stratigraphic succession up to approximately 4.5 km thick overlying a poorly described, unprospective Proterozoic succession. There are several shows including a surface seep of natural gas that occurs in the NWT in the contiguous Mackenzie-Peel Shelf geological province (Figure 14; Norris, 1997). Nineteen exploratory wells have been drilled within the assessment region, none of which have established economic reserves or production (Figure 15). The Mackenzie-Peel Shelf/Platform has had, with the exception of Norman Wells, a similarly disappointing exploratory history (Figure 16).

This study determines that significant undiscovered petroleum potential remains in the Peel Plateau and Plain despite the failure of previous exploration efforts. It appears, for example, that several wells were not drilled in optimal locations, particularly within the Cordilleran portion, due to difficulties defining (geophysical) and testing (logistical) the prospects. Although the details are neither described nor clear, regional studies of thermal maturation indicate that there might be two stages of petroleum system function. The first, in late Paleozoic time, generated petroleum prior to the creation of effective stratigraphic traps. The second, during the Laramide orogeny, generated petroleum predominantly in the Mesozoic succession and may have subsequently provided some footwall charge in overthrust structures, but probably without effectively charging Paleozoic successions east of the Cordillera. This situation is analogous to southernmost Alberta, where petroleum occurs in both Paleozoic and Mesozoic reservoirs in the Cordillera, but where only the Mesozoic succession is highly prospective in the undeformed portions of the Foreland Basin.

This report differs from previous petroleum assessments for the Peel Plateau and Plain in that it is based on:

- Indications that Cordilleran portions of the Peel Plain and Plateau have not been diagnostically tested by wells;
- Improved play analogues and comparisons; and
- Improved appraisals of exploratory risks.

Natural Gas Potential.

The depositional and tectonic histories of the Peel Plateau and Plain suggest it is gas-prone, due to generally higher thermal maturity levels, especially in the Paleozoic successions. Assessment of the Yukon portion suggests that there is a significant potential for natural gas (Figure 39), with a summed mean play potential of approximately 2.950 trillion cubic feet (TCF) or 83.428 X 10^9 m^3 initial raw gas-in-place[2] in 88 pools (Figure 40, Table 35, Note that the arithmetic sum of the individual play potentials and the probabilistic total play potential are slightly different in size). In comparison, the proven initial gas-in-place for the Mackenzie-Delta and Beaufort Sea is about 12 TCF.

The study indicates that uncertainties in reservoir quality, trap preservation and timing significantly depreciate the potential of the Paleozoic carbonate reservoir plays within both the Cordillera and the Foreland Basin (Figure 39). The plays, historically the main targets of exploration, have an aggregate potential of only 198 billion cubic feet (bcf) (5.620 X 10^9 m^3) in 9 pools, or about 6% of the expected potential in the whole Peel region and have greatest potential in plays where the Paleozoic carbonate platform succession is deformed in the Cordillera. The Paleozoic carbonate play in the Cordillera is expected to contain 158 bcf (4.460 X 10^9 m^3) in 7 pools, the largest of which is predicted to have a median pool size of 47.2 bcf (1.337 X 10^9 m^3).

Better opportunities are inferred to occur in the Paleozoic and Mesozoic clastic successions. The Paleozoic clastic plays are expected to contain 536 bcf (15.164 X 10^9 m^3), or about 18% of the potential in 12 pools. The largest pool in this play, in the Peel Plateau, is predicted to have a median pool size of 195 bcf (5.517 X 10^9 m^3) and is the largest pool in the regional assessment. The Upper Paleozoic clastic plays are analogous to deep-water sand plays actively explored along the Atlantic and Gulf Coast passive margins currently. Such slope sandstone 'valley-fills' are among the most attractive petroleum plays globally, as indicated by the discovery, relatively recently, of the Thundershorse Field in the Gulf of Mexico, which is the second largest American oil field after Prudoe Bay. Despite a complicated geological history, these plays retain their petroleum potential typically due to a component of stratigraphic entrapment in the submarine incised valley fill. Recent studies in the Bowser Basin of British Columbia show that deep-water sandstones can retain both reservoir potential and entrapped hydrocarbons despite complex tectonic and thermal histories (Hayes et al., 2004).

Most of the potential gas for the Peel Plateau and Plain is predicted to occur within the Mesozoic clastic plays. One of these plays lies within the Foreland Belt region and has a potential of 1,750 bcf (49.487 X 10^9 m^3) in 55 pools, with a largest median pool size of 119 bcf (3.356 X 10^9 m^3). A smaller Mesozoic gas play occurs in the Cordillera with 465 bcf (13.157 X 10^9 m^3) expected in 12 pools, the largest of which having a median predicted pool size of 101 bcf (2.861 X 10^9 m^3). Together, these plays contain an expected resource of 2.210 TCF (62.64 X 10^9 m^3), or 75% of the total undiscovered resource for the Peel Plateau and Plain. The combined potential for the largest pools is

[2] Note: all gas volumes reported in this assessment is initial raw and in-place.

220 bcf (6.217 X 10^9 m^3), which is 7.4% of the total potential and greater than the expected gas in all the Paleozoic carbonate plays combined.

Distribution of Gas Plays and Potential

The distribution of undiscovered natural gas potential is expected to occur within 3 sub-regions of the Peel Plateau and Plain (Figure 40, Table 35):

Peel Plateau – West of Trevor Fault

The total petroleum potential of this sub-region is small to negligible, as would be expected from it geological history and characteristics and it is the least prospective. Some gas is predicted to occur in sandy intercalations of the upper Paleozoic Imperial-Tuttle-Ford Lake succession within this region, although many of these units are near surface and the preservation probability of the trap is low. A single pool of 3.71 bcf (105 million m^3) is predicted for this play (Figure 39).

Peel Plateau

This sub-region contains the temporally and geographically persistent platform-to-basin facies transition that marks the eastern margin of the Richardson Trough. The orientation of this facies transition is unfavorable with respect to the Cordilleran structure and is not expected to provide a distinctive trapping mechanism. There is also a lack of strong diagenetic evidence for the preservation of reservoir quality by hydrothermal dolomitization. Therefore, the Paleozoic carbonate plays in the Peel Plateau are anticipated to occur in Cordilleran structural culminations where vestigial limestone porosity and minor dolostones constitute the potential reservoirs and by peak gas generation during the late Paleozoic. Additional potential exists for dry, over mature gas generated by Foreland and tectonic burial or the remigration of Paleozoic gas into Cordilleran structures. The western margin of the Mackenzie-Peel Shelf comprises a single play within Cordilleran structures.

In this region (Figure 39), the total undiscovered potential is 898 bcf (25.416 X 10^9 m^3) in 21 pools. It is expected that Cambrian to Devonian carbonate succession will have a natural gas resource of about 7 gas pools with a mean potential of approximately 158 bcf (4.460 X 10^9 m^3). The largest expected pool is 47.2 bcf (1.337 X 10^9 m^3). Paleozoic clastics, although comprising a thinner succession dominated by non-reservoir facies, have a greater potential for a favorable stratigraphic component of entrapment. Therefore they have an improved potential for the preservation of gas generated in the Paleozoic. It is expected that the upper Paleozoic clastic play in this sub-region will consist of about 2 gas pools with a mean potential of approximately 275 bcf (7.799 X 10^9 m^3). The largest expected pool is 158 bcf (5.517 X 10^9 m^3), the single largest projected pool in the entire Peel Plateau and Plain, and is likely to occur as a turbiditic sandstone body. This play resembles deep-water sandstone plays on current oceanic margins, similar to Shell's current successful exploration on the margin of the African continent.

Mesozoic sandstones in the Martin House and Arctic Red fms. constitute the third play in the Cordilleran thrust and fold belt of the Peel Plateau. Although less likely to have large and thick extent, the timing of hydrocarbon generation relative to the structure is much more favorable for Mesozoic hosted petroleum systems than Paleozoic ones. It is expected that the Peel Plateau Mesozoic Clastic Play consists of about 12 gas pools with a mean potential of approximately 465 bcf (13.157 X 10^9 m^3). The largest expected pool is 101 bcf (2.861 X 10^9 m^3. It is significant to compare the thrust and fold belt in the Peel region with that of the Southern Cordillera where only about 15% of the conventional petroleum potential occurs in the thrust and fold belt, as compared to the undeformed Plains (not accounting for the tar sands and heavy oils). In the Peel region, about 30% of the estimated potential is attributed to the thrust and fold belt. This, however, does not represent a real difference as only a portion of the Peel Plain petroleum potential occurs within the Yukon.

Peel Plain

The remaining, and most prospective assessment region is the Peel Plain, which, for this assessment extends east of the Cordilleran Deformation Front to the inter-territorial boundary. Five plays were defined here (Figure 39). In total, this area constitutes the most attractive exploration region within the Peel Plateau and Plain, with 2.040 TCF (57.907 X 10^9 m^3), or about 70% of the potential in place resource, expected to occur in 66 pools.

The Cambrian to Devonian carbonate platform play contains the largest volume of rock of all plays in this assessment. The style of porosity development and the lack of lateral seals in carbonate ramps, the preservation of limestone reservoir porosity in the absence of pervasive dolomitization, and the timing of hydrocarbon generation relative to structure formation significantly affect the probability of this play. Throughout the northern Interior Platform, there has been a most notable lack of success drilling to the Hume Fm. and the Ronning Group. It is expected that the Peel Plain Carbonate Platform Play will consist of a single pool of about 7.7 bcf (0.218 X 10^9 m^3).

Manetoe dolostones do not extend north of 63 degrees in the Mackenzie-Peel Shelf. This means that there is no potential for the previous defined Devonian Fractured Arnica Dolomite (Bird, 2000; 1999). Most of the Devonian deposition in the Peel Plain occurs in a carbonate ramp setting. Persistent carbonate deposition following the drowning of the Hume Platform provides a significant opportunity for an abrupt carbonate margin facies play. This play is identical in configuration to the Horn Plateau Play of the southern NWT. While this play is not known to exist, neither can it be entirely discounted. A major risk for this play is the lack of reservoir, something that should also depreciate the play potential in the Peel Plain. It is expected that the Peel Plain Post-Hume Reef play will consist of about single gas pool with a mean potential of approximately 31.4 bcf (0.888 X 10^9 m^3).

Clastic plays in the Upper Paleozoic and Mesozoic section are the equivalent of plays in the same succession of the thrust and fold belt, but within the Interior Platform setting. The Upper Paleozoic clastic play of the Peel Plain is expected to consist of about 9 gas pools with a mean potential of 256 bcf (7.26 X 10^9 m^3). The largest expected pool is 47.7 bcf (1.352 X 10^9 m^3). The smaller pool size reflects both the size of the available structures of the Plains, but also a more distal setting relative to the apparent source of these clastics. The Mesozoic clastic play of the Peel Plain is expected to consist of about 55 gas pools with a mean potential of approximately 1.750 TCF (49.487 X 10^9 m^3). The largest expected pool is 119 bcf (3.356 X 10^9 m^3).

Conclusions

Assessment of this region suggests that there is a significant potential for natural gas throughout the region with a summed mean play potential of approximately 83.428 X 10^9 m^3 initial raw gas in place[3] (~3 TCF) in approximately 88 pools (Figure 40, Table 35). The largest expected pool of 3.36 X 10^9 m^3 gas is expected to occur in Mesozoic clastics of the Peel Plain. In general, the small size of gas pools will be an impediment to their development because of their location. In general, petroleum potential is inferred to decrease both westward and with increasing depth and stratigraphic age. The results of this assessment consider and are inferred consistent with the results of nineteen exploratory wells, none of which have established economic reserves or production, despite the presence of several petroleum shows. The result of this study, while differing in detail from previous work (Bird, 2000; 1999), for gas, is generally similar in aggregate potential.

This study differs significantly from previous with respect to crude oil potential. No crude oil potential can be estimated due to an inferred lack of oil prone sources in strata of suitable maturity. This difference occurs primarily because of a lack of hard data that could be obtained from the available wells if there were time and resources to perform suitable analysis (Rock-Eval/TOC pyrolysis). Where previous work speculated that the history of petroleum systems in the Peel Plain and Plateau was distinctive from that of surrounding regions that are suitably characterized, this work finds no justification for such a distinctive petroleum system history.

The results of this assessment refocus exploratory efforts away from the traditional Paleozoic targets and onto the Upper Paleozoic and Mesozoic clastic successions and out of the Cordillera into the undeformed Foreland Basin succession in the Interior Platform. Individual pool sizes are not large and pool numbers are not numerous, but several potentially attractive exploratory targets can be identified. By avoiding drilling to the historically unproductive and less prospective Paleozoic carbonate succession exploration costs can be reduced. The stacking of pools, particularly in the Cordillera, or the discovery of geographically associated accumulations, particularly in the Peel Plain, might reduce development costs.

Acknowledgements

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[3] Note: all gas volumes reported in this assessment is initial raw and in-place.

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Figure Captions

Figure 1: Location map showing the distribution of Yukon's oil and gas regions in relation to Peel Plateau and Plain. Modified from http://www.emr.gov.yk.ca/Publications/OilandGasPublications/yukon_stratigraphic_chart2003.pdf

Figure 2: Major physiographic subdivisions within the Peel Plateau and Plain Assessment Region including, portions of Anderson Plain, Peel Plateau, Peel Plain, Richardson Mountains and Mackenzie Mountains (from Morrow, 1999). The dashed line indicates the geographic boundaries of subsequent maps.

Figure 3: Time-stratigraphic column of the Peel Plateau showing age relationships of the Phanerozoic succession. Modified from http://www.emr.gov.yk.ca/Publications/OilandGasPublications/yukon_stratigraphic_chart2003.pdf

Figure 4: Simplified geological map of the assessment area in the Yukon and adjacent regions of the Northwest Territories. The location of exploratory petroleum wells and the eastern limit of the Cordilleran deformation are also show (after Morrow, 1999).

Figure 5: Major early Paleozoic paleogeographic elements that repeatedly influenced Phanerozoic sedimentation and tectonic fabric in the region. Areas of predominantly shallow water carbonate deposition are filled with a modified brick pattern, while the shaded regions are predominately regions of basinal shale deposition, including the Richardson Trough (after Morrow, 1999).

Figure 6: A southeast to northwest stratigraphic cross-section of lower Paleozoic strata across the Mackenzie-Peel Shelf, illustrating the inferred lateral continuity of the stratigraphic of the carbonate platform successions, including the stratigraphic subdivisions of the Franklin Mountain and Mount Kindle formations (from Morrow, 1999). Well locations as indicated in Figures 4 and 15.

Figure 7: An east-west cross-section of lower Paleozoic strata across Richardson Trough (from Morrow, 1999). Well locations as indicated in Figures 4 and 15.

Figure 8: A north-south stratigraphic cross-section of lower Paleozoic strata across the Mackenzie-Peel Shelf (from Morrow, 1999) that illustrates facies relationships at the margins of the Richardson Trough. Well locations as indicated in Figures 4 and 15.

Figure 9: A Peel Plateau reflection seismic profile that intersects the Arctic Red F-47 well. The section exhibits five seismo-stratigraphic units that are recognized in the Upper Aptian to Albian succession and can be correlated to sonic log markers in the F-47 well. Units 1 to 4 correspond to the Arctic Red Formation and unit 5 to the Trevor Formation (from Dixon, 1999). Well locations as indicated in Figures 4 and 15.

Figure 10: The major structural elements of the Peel Plateau and Plain including the Richardson Anticlinorium. The Anticlinorium is marked by the Trevor Fault, on its eastern side and by the Bonnet Plume Basin in the south. The Figure also illustrates the reflection seismic lines illustrated in Figures 11, 12 and 13. Well locations as indicated in Figures 4 and 15.

Figure 11: The 1972 Gulf Canada Line C-11 northeasterly trending seismic time section. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. A synthetic seismic trace that has been constructed from the wire-line logs of the nearby Caribou N-25 well is displayed on the interpreted seismic section to assist the structural and stratigraphic interpretation. Well locations as indicated in Figures 4 and 15.

Figure 12: A northeasterly trending section through the 1969 Esso Resources Line 4. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. A synthetic seismic trace has been constructed from the nearby wire-line logs of the Peel River K-09 well, and that synthetic trace is displayed on the interpreted seismic section to

assist the structural and stratigraphic interpretation. Well locations as indicated in Figures 4 and 15.

Figure 13: The northerly trending seismic section 1970 Amoco Canada Line CKR-10. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. A synthetic seismic trace has been constructed from the wire-line logs of the nearby Cranswick A-22 well, and that synthetic trace is displayed on the interpreted seismic section to assist the structural and stratigraphic interpretation. Well locations as indicated in Figures 4 and 15.

Figure 14: Geographic references and locations of encouraging shows of petroleum system function and accumulations as discussed in the text. The Figure also illustrates the reflection seismic lines illustrated in Figures 11, 12 and 13. Well locations as indicated in Figures 4 and 15.

Figure 15: Distribution of petroleum exploration wells with respect to reflection seismic surveys in Peel Plateau and Plain, of all vintages.

Figure 16: Distribution and historical sequence of petroleum exploration wells drilled in the Peel Plateau and Plain region. The numbers beside the well locations include the well name and the order in which the wells were drilled (in brackets). All forty-three exploratory petroleum wells were dry and abandoned.

Figure 17: An example petroleum accumulation discovery sequence taken from the Carboniferous Jumping Pound Rundle Play of the southern Alberta Foothills. The logarithm of pool sizes is plotted sequentially as a function of discovery date, producing the time series or discovery sequence, which forms the basis for a sequential sampling assessment of petroleum potential as discussed in the text. The vertical axis represents the pool size, plotted on a logarithmic scale, and the horizontal axis shows the discovery date.

Figure 18: This figure illustrates the result of the lognormal discovery process model. The vertical axis represents the log likelihood value and the horizontal axis indicates the total number of discovered and undiscovered pools in a play, N. The higher the log likelihood value, the more plausible the value of N. In this example the most likely number of pools is 140.

Figure 19. A play total resource distribution can be estimated from the N value and the pool size distribution (either lognormal Distribution A, or nonparametric distribution Distribution B) (Lee and Wang, 1983a).

Figure 20: Undiscovered play potential distribution for both the lognormal, Distribution A, and nonparametric, Distribution B models displayed in Figure 19. The undiscovered potential is conditioned against the discovered volume, which has been discounted from these distributions.

Figure 21: An example discovery history analysis and its historical vindication, by using subsets of the data to make predictions of the total resource, including that portion of the discovery history not used as input data for a well-behaved Foreland Belt play, the Jumping Pound Rundle Play (following Lee, 1998). The Jumping Pound Rundle Play has been analyzed at three different stages of its exploration history, 1966, 1974 and 1991 (Top). The three resulting petroleum resource estimates for the three discovery sequence subsets (Middle). A prediction of the range of discovered (circles) and undiscovered (boxes) accumulation sizes from the three data subsets as conditioned against the discoveries at that time, which provide a historical vindication for the method (Bottom).

Figure 22: Play area map illustrating the geographic extent, name and unique assessment identifier numbers referred to for each of the petroleum plays assessed in this report.

Figure 23:Play potential plot for the Upper Paleozoic Clastics Natural Gas Play (C5580111) in the Peel Plateau region, west of the Trevor Fault. The play potential is between zero and 5873 million cubic m of initial raw gas in place. The play potential is between zero and 5873 million cubic m of initial raw gas in place. The expected value of the undiscovered pool size is 105 million cubic m of initial raw gas in place.

Figure 24: Accumulation-size-by-rank plot for the Upper Paleozoic Clastics Natural Gas Play (C5580111) in the Peel Plateau region, west of the Trevor Fault. Details of individual pool size distributions are given in Table 6.

Figure 25: Play potential plot for the Paleozoic Carbonate Platform Play Natural Gas Play (C5560111) in the Peel Plain region. The play potential is between zero and 2.780 $X10^9$ m^3 of initial raw gas in place, with an expected value of 272 million cubic m of initial raw gas in place.

Figure 26: Accumulation-size-by-rank plot for the Paleozoic Carbonate Platform Play Natural Gas Play (C5560111) in the Peel Plain region. Details of individual pool size distributions are given in Table 10.

Figure 27: Play potential plot for the Paleozoic Horn Plateau Reef Play Natural Gas Play (C5550111) in the Peel Plain region. The play potential is between zero and 32.38 $X10^9$ m^3 of initial raw gas in place, but with an expected value of 888 million cubic m of initial raw gas in place.

Figure 28: Accumulation-size-by-rank plot for the Paleozoic Horn Plateau Reef Play Natural Gas Play (C5550111) in the Peel Plain region. Details of individual pool size distributions are given in Table 14.

Figure 29: Play potential plot for the Upper Paleozoic Clastics Natural Gas Play (C5530111) in the Peel Plain region. The play potential is between zero and 27.6 $X10^9$ m^3 of initial raw gas in place, with an expected value of 7.260 $X10^9$ m^3 of initial raw gas in place.

Figure 30: Accumulation-size-by-rank plot for the Upper Paleozoic Clastics Natural Gas Play (C5530111) in the Peel Plain region. Details of individual pool size distributions are given in Table 18.

Figure 31: Play potential plot for the Mesozoic Clastics Natural Gas Play (C5520111) in the Peel Plain region. The play potential is between zero and 139 $X10^9$ m^3 of initial raw gas in place, with an expected value of 49.487 $X10^9$ m^3 of initial raw gas in place.

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Figure 39: Summary of Peel Plateau and Plain petroleum resource assessment indicating key inferred characteristics of the undiscovered petroleum potential resulting from this analysis.

Figure 40: Summary petroleum potential for all of the plays combined in the Peel Plateau and Plain petroleum resource assessment. 83.428 $X\ 10^9$ m^3 initial raw gas in place (~3 TCF) in approximately 88 pools. The largest expected pool of 3.36 $X\ 10^9$ m^3 gas is expected to occur in Mesozoic clastics of the Peel Plain.

Note also that the arithmetic sum of the mean play potentials differs slightly from the statistical total potential derived by a probabilistic summation of the contributing play potentials, as quoted in the text.

Figure 1: Location map showing the distribution of Yukon's oil and gas regions in relation to Peel Plateau and Plain. Modified from http://www.emr.gov.yk.ca/Publications/OilandGasPublications/yukon_stratigraphic_chart2003.pdf

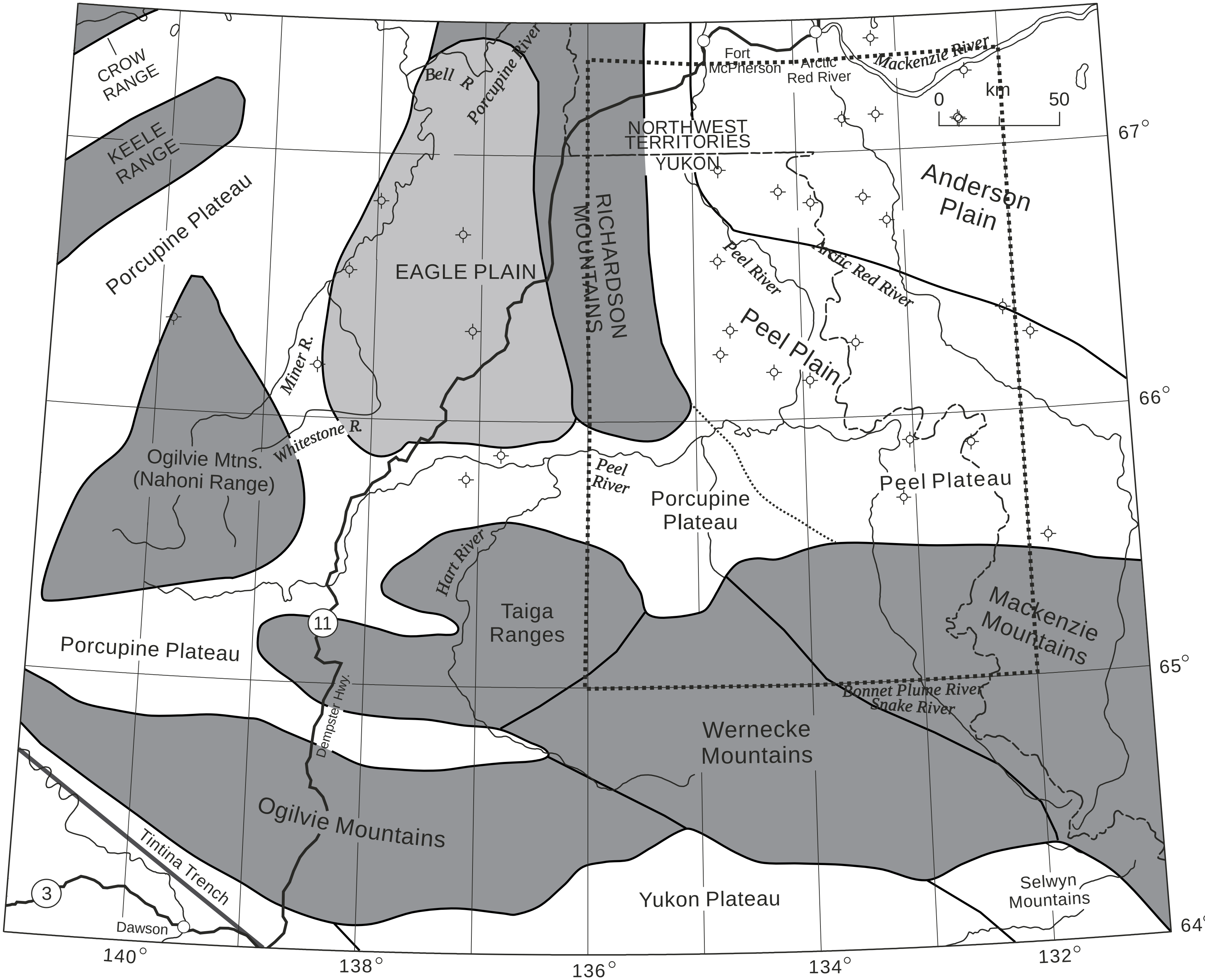


Figure 2: Major physiographic subdivisions within the Peel Plateau and Plain Assessment Region including, portions of Anderson Plain, Peel Plateau, Peel Plain, Richardson Mountains and Mackenzie Mountains (from Morrow, 1999). The dashed line indicates the geographic boundaries of subsequent maps.

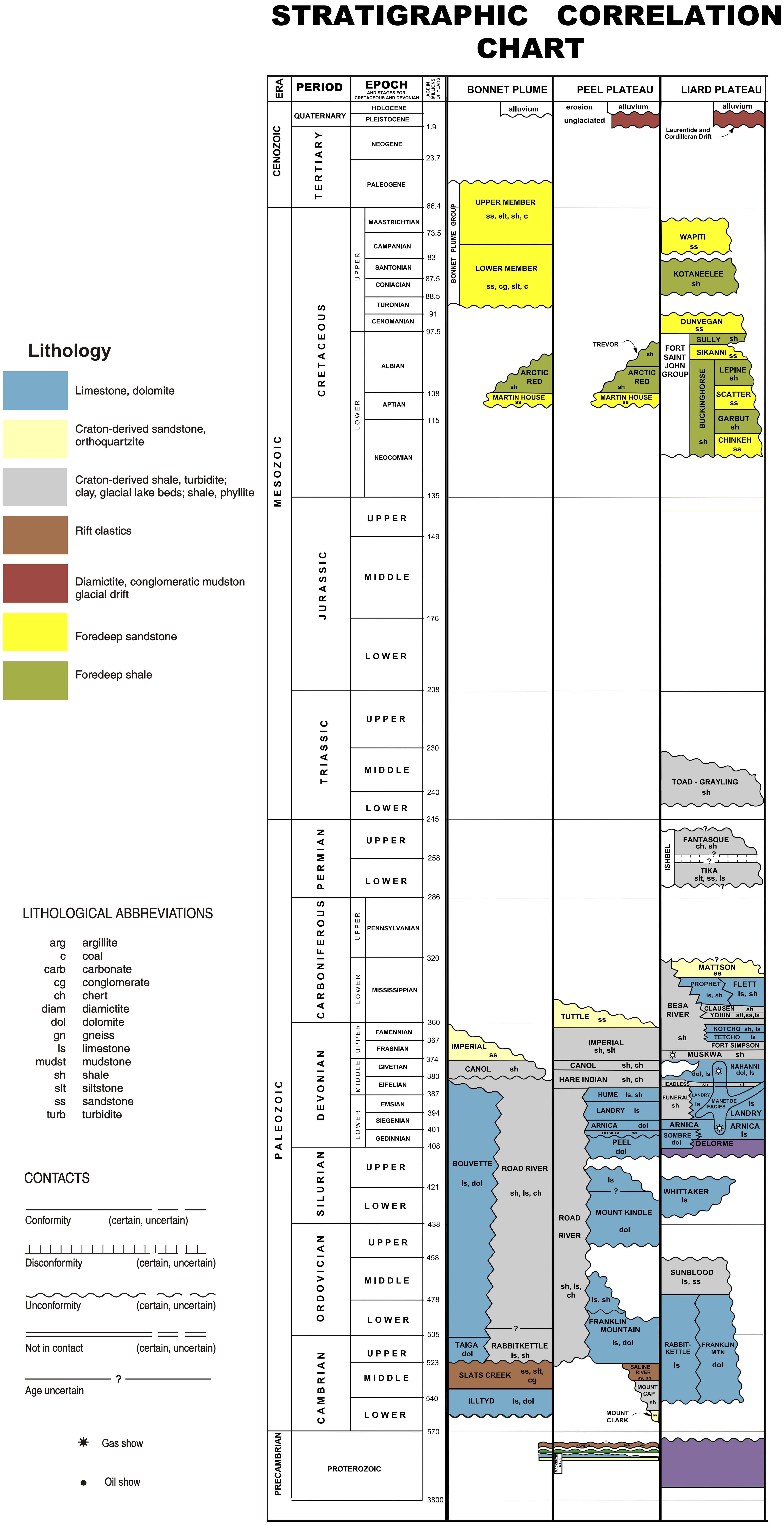


Figure 3: Time-stratigraphic column of the Peel Plateau showing age relationships of the Phanerozoic succession. Modified from http://www.emr.gov.yk.ca/Publications/OilandGasPublications/yukon_stratigraphic_chart2003.pdf

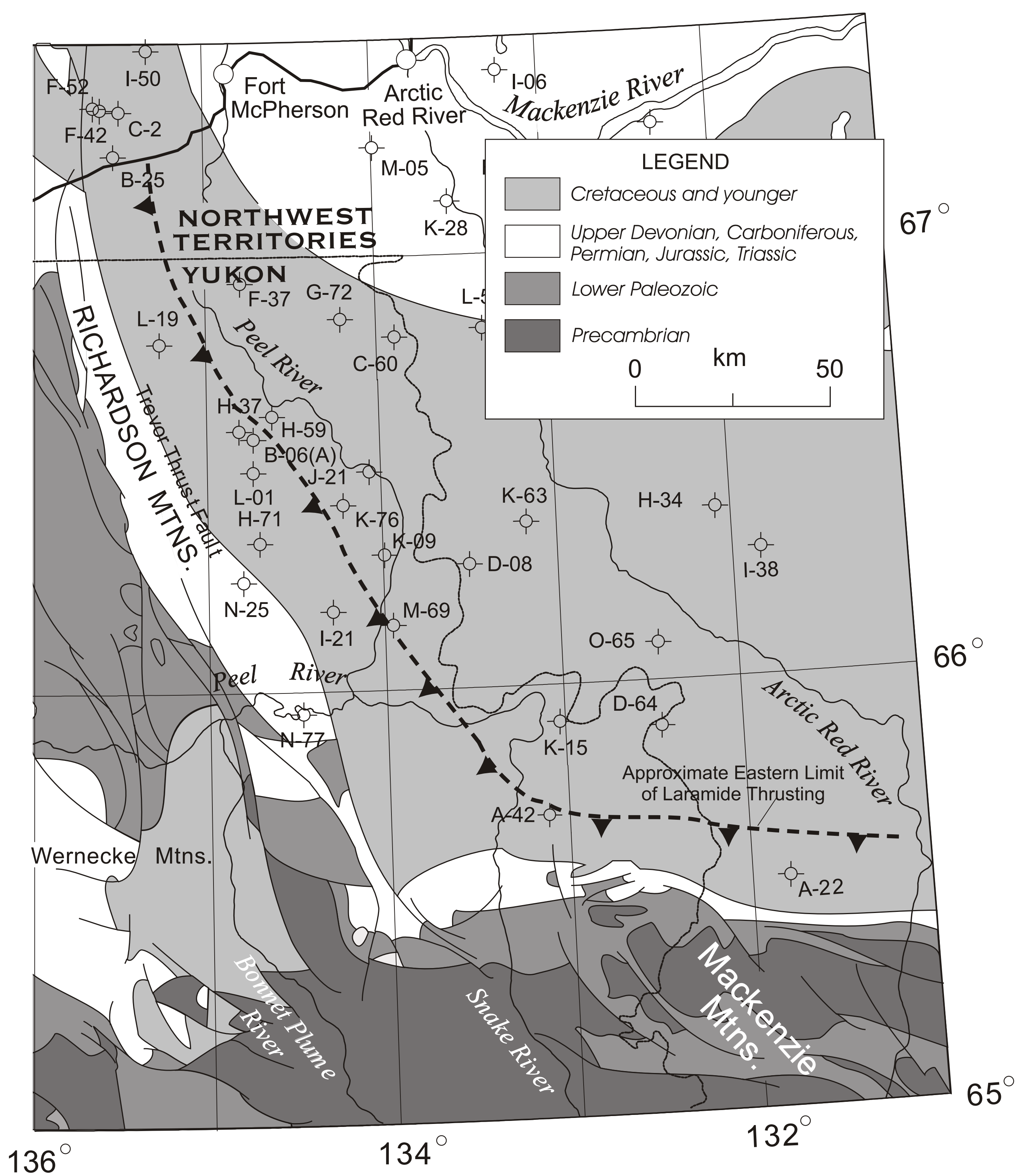


Figure 4: Simplified geological map of the assessment area in the Yukon and adjacent regions of the Northwest Territories. The location of exploratory petroleum wells and the eastern limit of the Cordilleran deformation are also show (after Morrow, 1999).

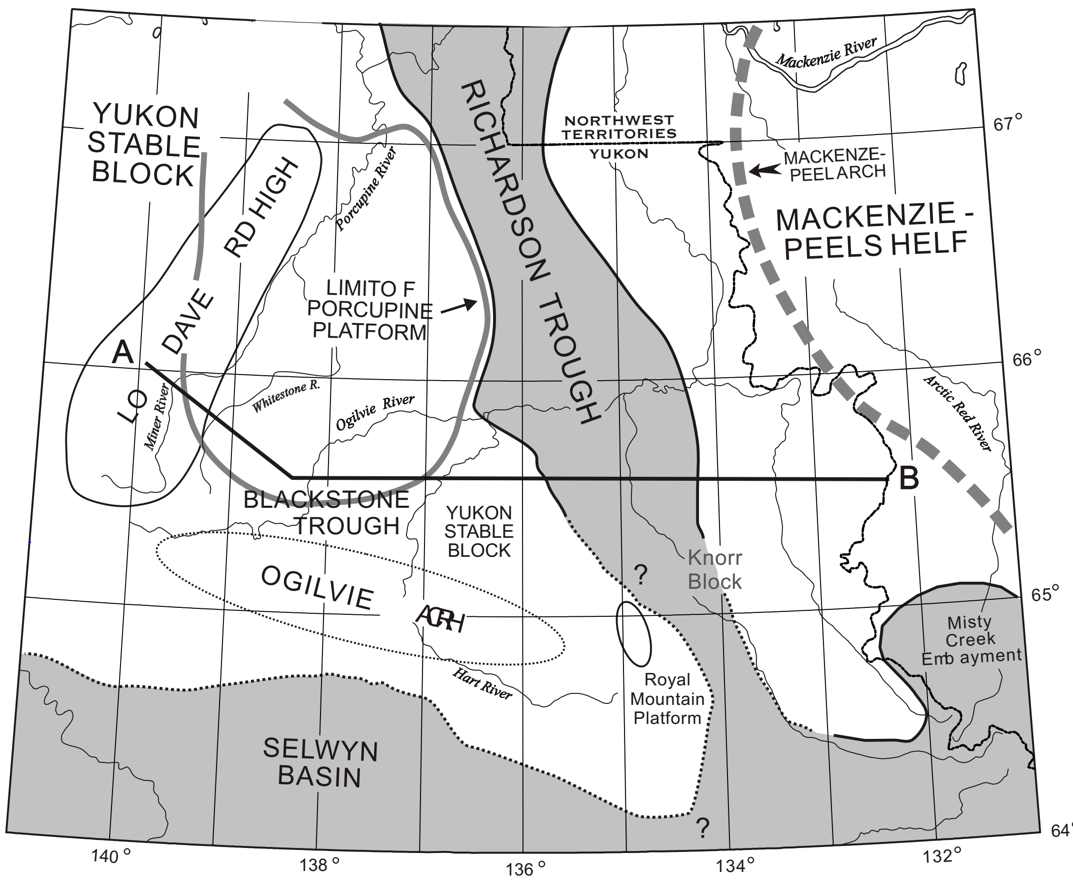


Figure 5: Major early Paleozoic paleogeographic elements that repeatedly influenced Phanerozoic sedimentation and tectonic fabric in the region. Areas of predominantly shallow water carbonate deposition are filled with a modified brick pattern, while the shaded regions are predominately regions of basinal shale deposition, including the Richardson Trough (after Morrow, 1999).

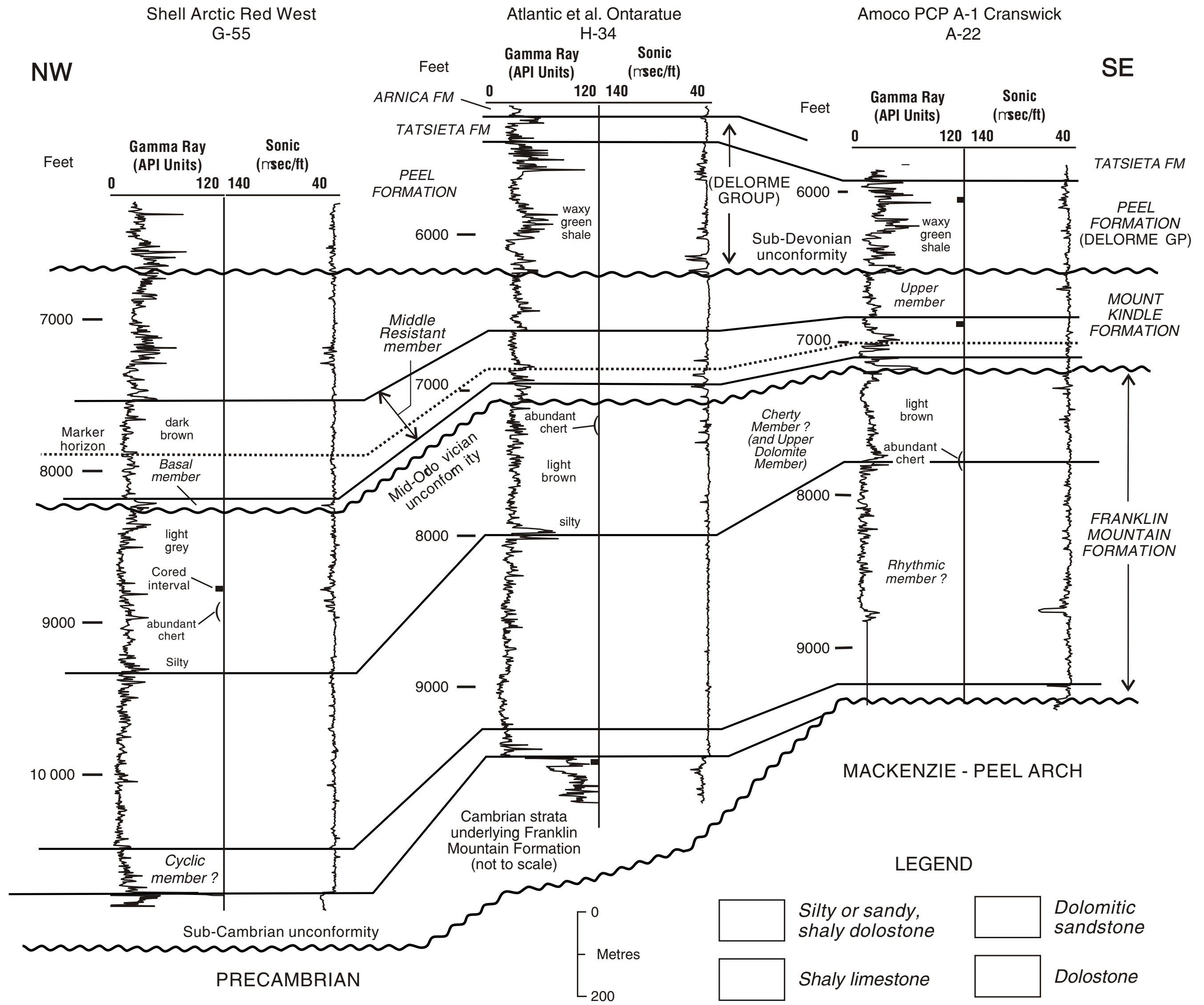


Figure 6: A southeast to northwest stratigraphic cross-section of lower Paleozoic strata across the Mackenzie-Peel Shelf, illustrating the inferred lateral continuity of the stratigraphic of the carbonate platform successions, including the stratigraphic subdivisions of the Franklin Mountain and Mount Kindle formations (from Morrow, 1999). Well locations as indicated in Figures 4 and 15.

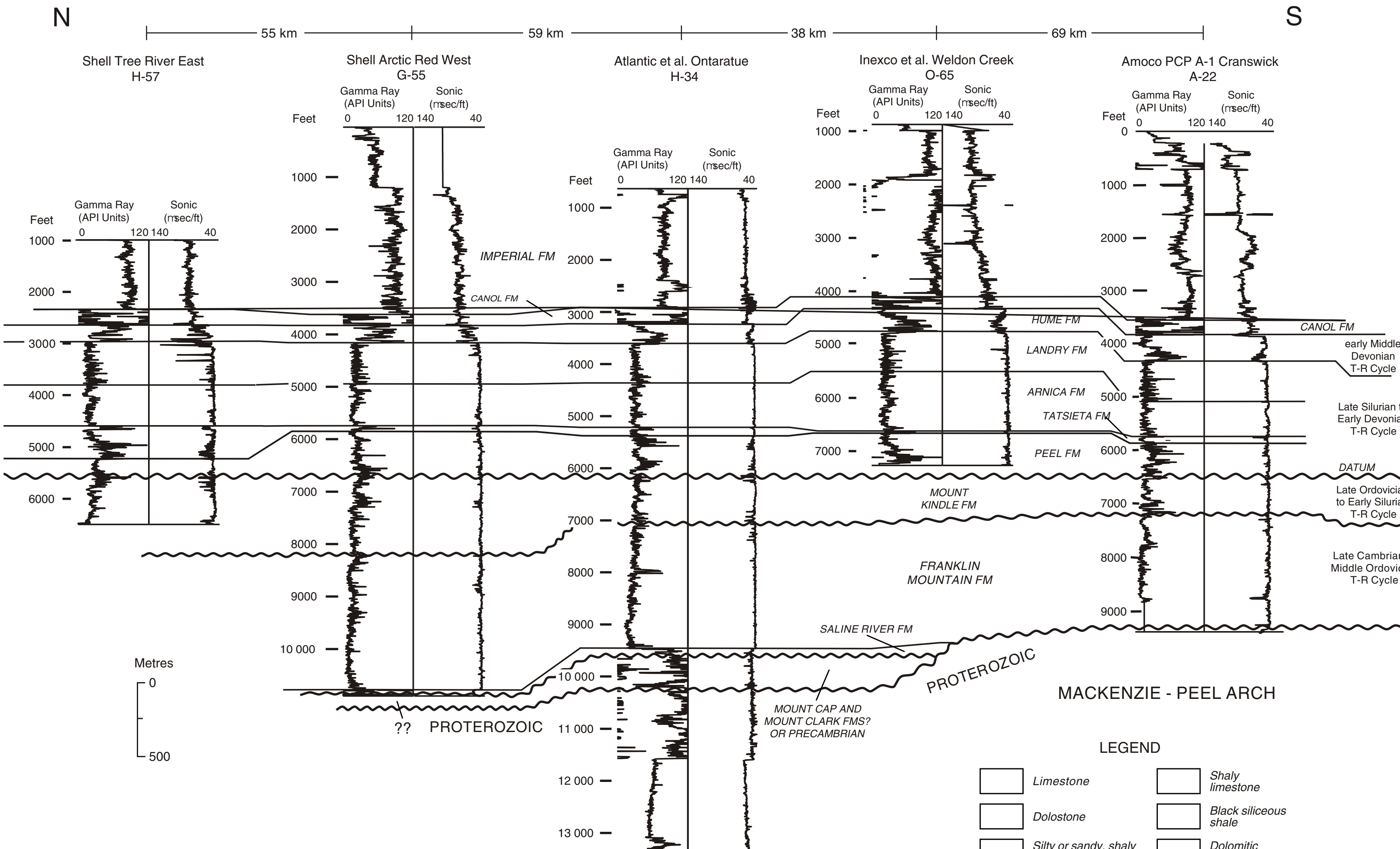


Figure 7: An east-west cross-section of lower Paleozoic strata across Richardson Trough (from Morrow, 1999). Well locations as indicated in Figures 4 and 15.

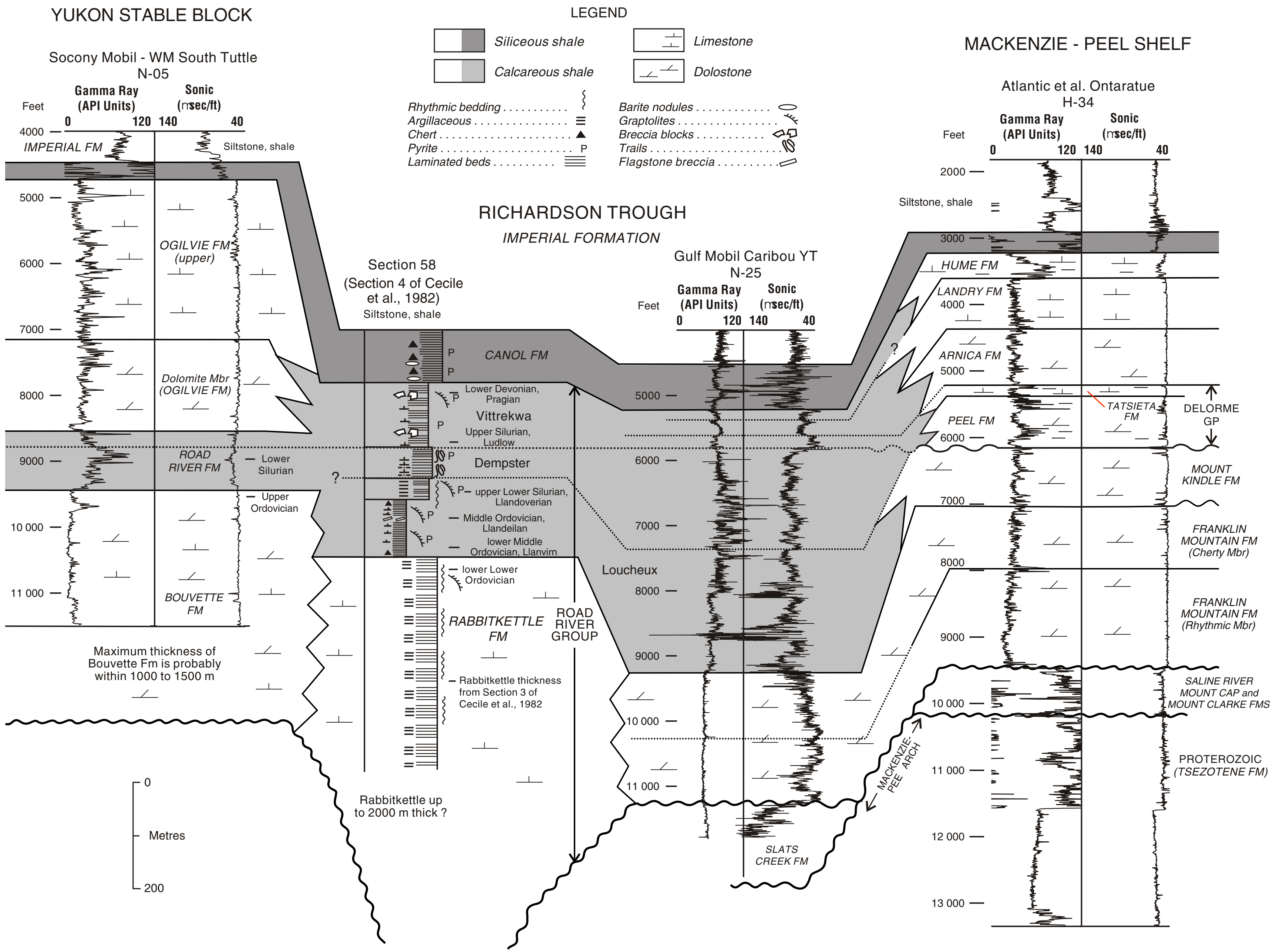


Figure 8: A north-south stratigraphic cross-section of lower Paleozoic strata across the Mackenzie-Peel Shelf (from Morrow, 1999) that illustrates facies relationships at the margins of the Richardson Trough. Well locations as indicated in Figures 4 and 15.

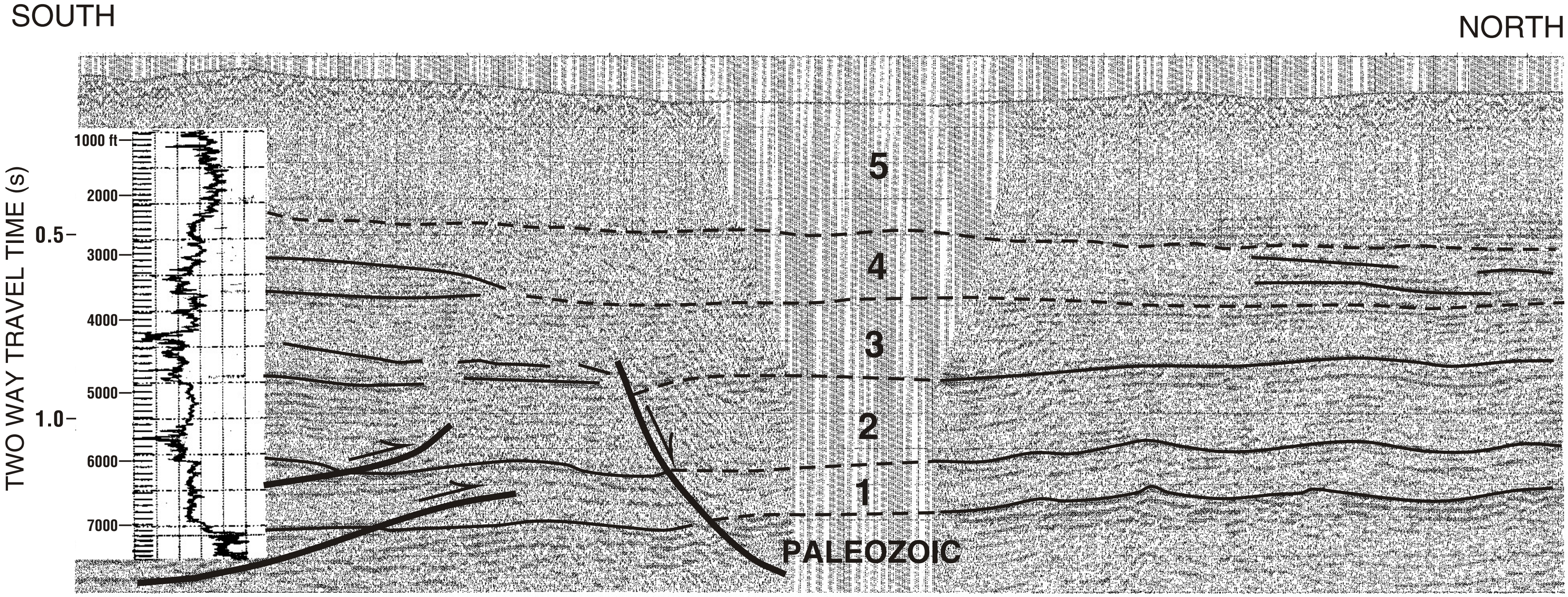


Figure 9: A Peel Plateau reflection seismic profile that intersects the Arctic Red F-47 well. The section exhibits five seismo-stratigraphic units that are recognized in the Upper Aptian to Albian succession and can be correlated to sonic log markers in the F-47 well. Units 1 to 4 correspond to the Arctic Red Formation and unit 5 to the Trevor Formation (from Dixon, 1999). Well locations as indicated in Figures 4 and 15.

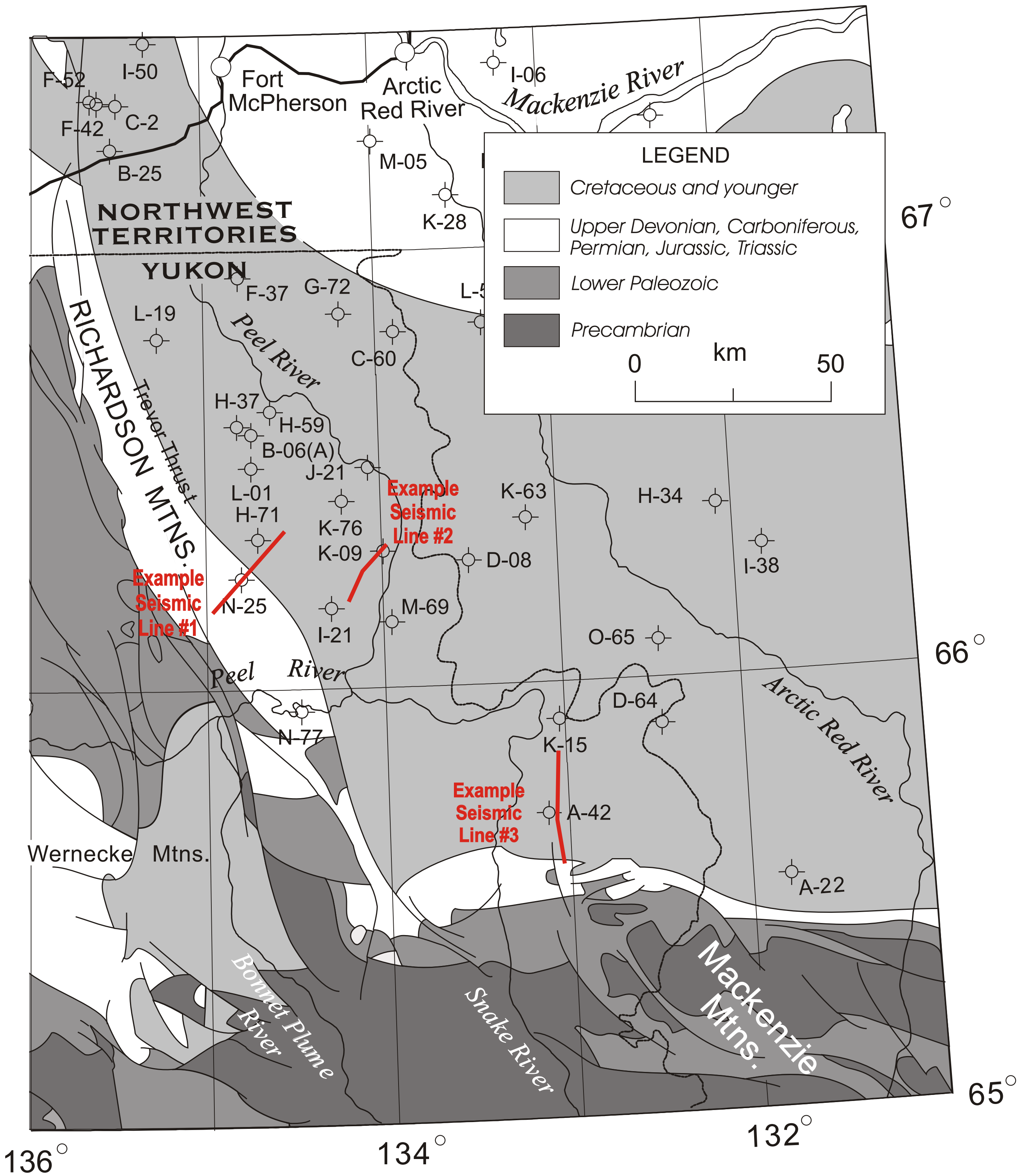


Figure 10: The major structural elements of the Peel Plateau and Plain including the Richardson Anticlinorium. The Anticlinorium is marked by the Trevor Fault, on its eastern side and by the Bonnet Plume Basin in the south. The Figure also illustrates the reflection seismic lines illustrated in Figures 11, 12 and 13. Well locations as indicated in Figures 4 and 15.

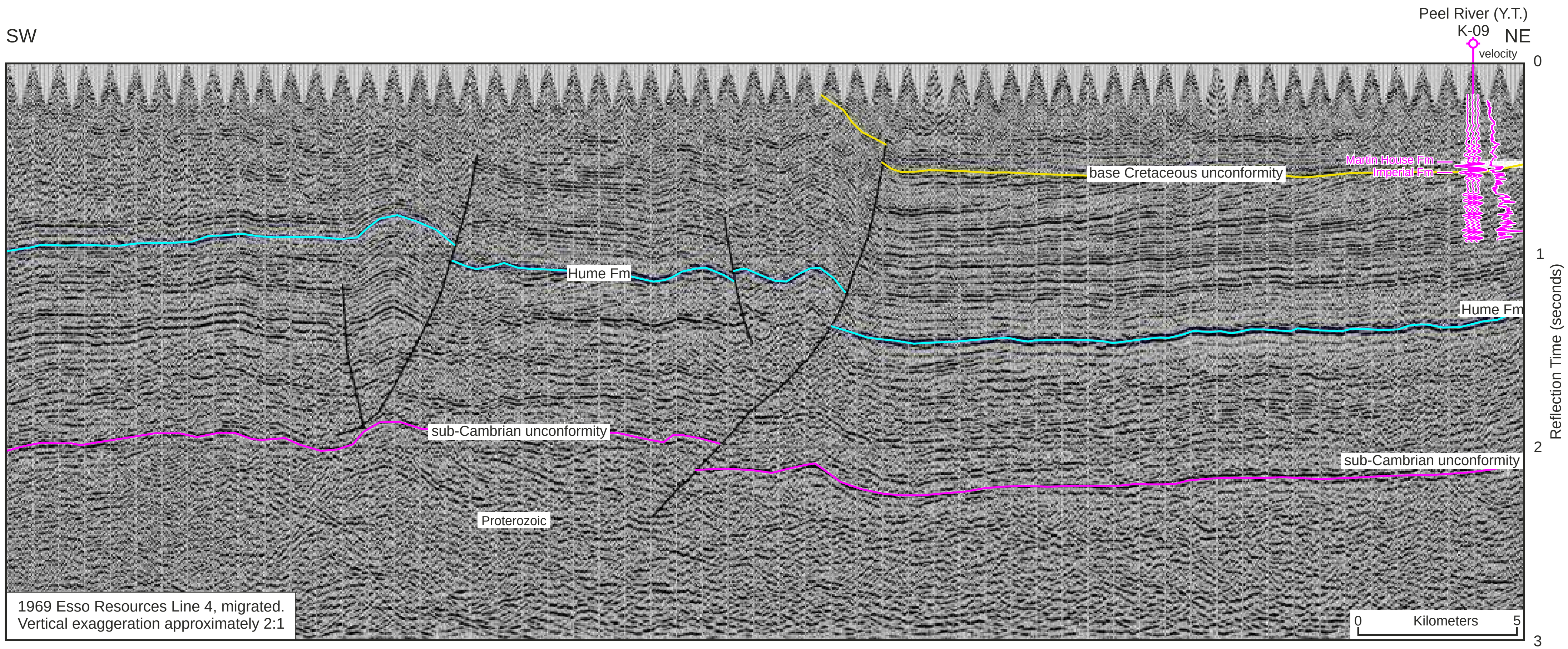


Figure 11: The 1972 Gulf Canada Line C-11 northeasterly trending seismic time section. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. A synthetic seismic trace that has been constructed from the wire-line logs of the nearby Caribou N-25 well is displayed on the interpreted seismic section to assist the structural and stratigraphic interpretation. Well locations as indicated in Figures 4 and 15.

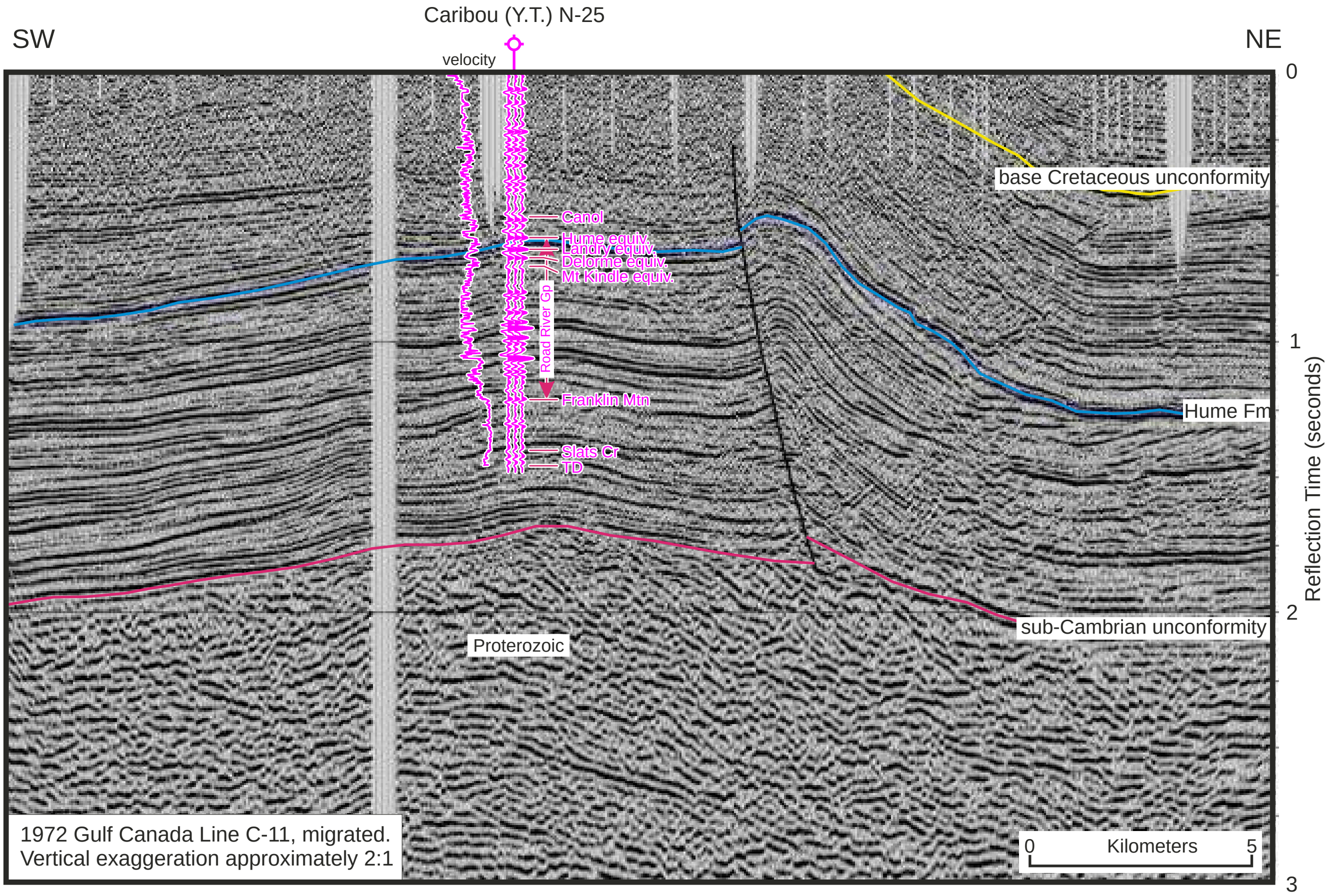


Figure 12: A northeasterly trending section through the 1969 Esso Resources Line 4. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. A synthetic seismic trace has been constructed from the nearby wire-line logs of the Peel River K-09 well, and that synthetic trace is displayed on the interpreted seismic section to assist the structural and stratigraphic interpretation. Well locations as indicated in Figures 4 and 15.

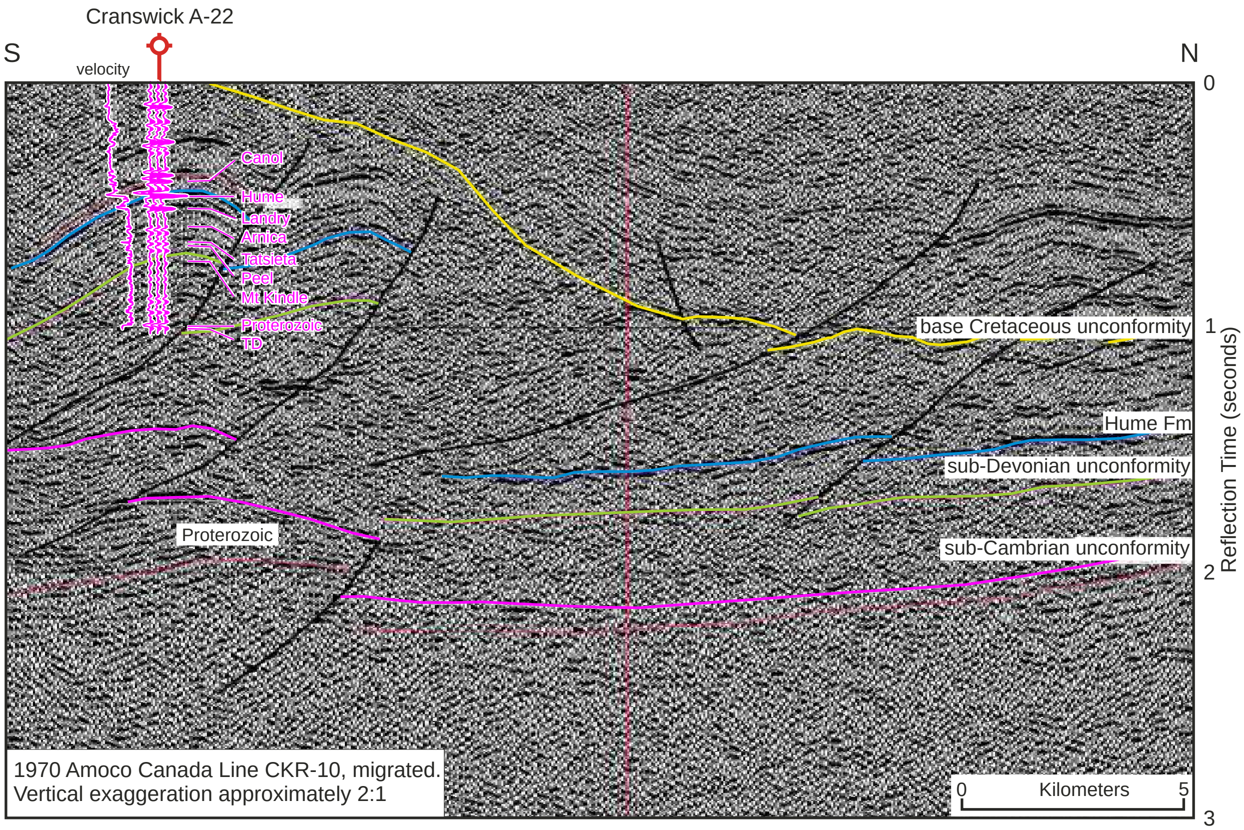


Figure 13: The northerly trending seismic section 1970 Amoco Canada Line CKR-10. The line is migrated and displayed with a vertical exaggeration of approximately 2:1. A synthetic seismic trace has been constructed from the wire-line logs of the nearby Cranswick A-22 well, and that synthetic trace is displayed on the interpreted seismic section to assist the structural and stratigraphic interpretation. Well locations as indicated in Figures 4 and 15.

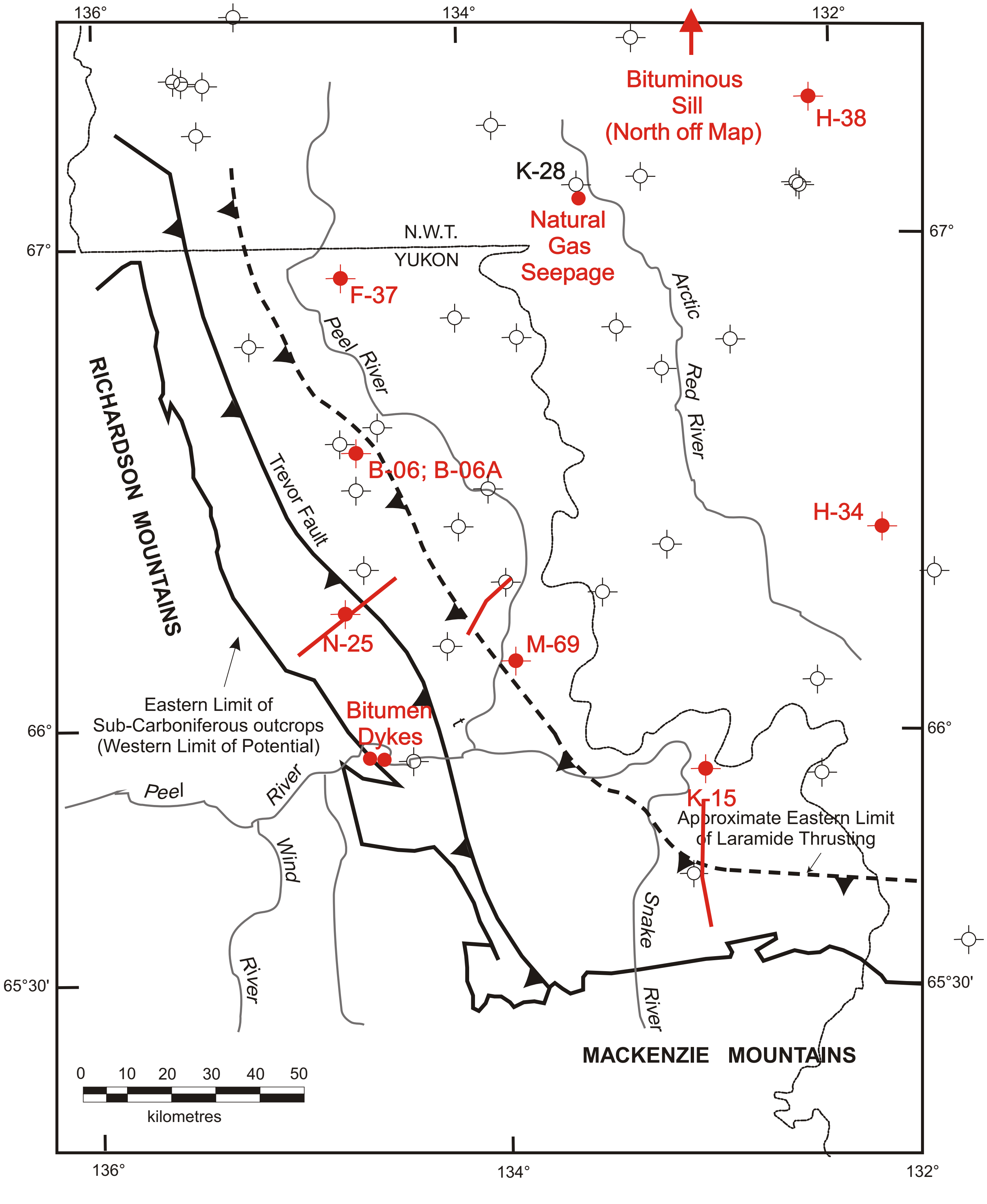


Figure 14: Geographic references and locations of encouraging shows of petroleum system function and accumulations as discussed in the text. The Figure also illustrates the reflection seismic lines illustrated in Figures 11, 12 and 13. Well locations as indicated in Figures 4 and 15.

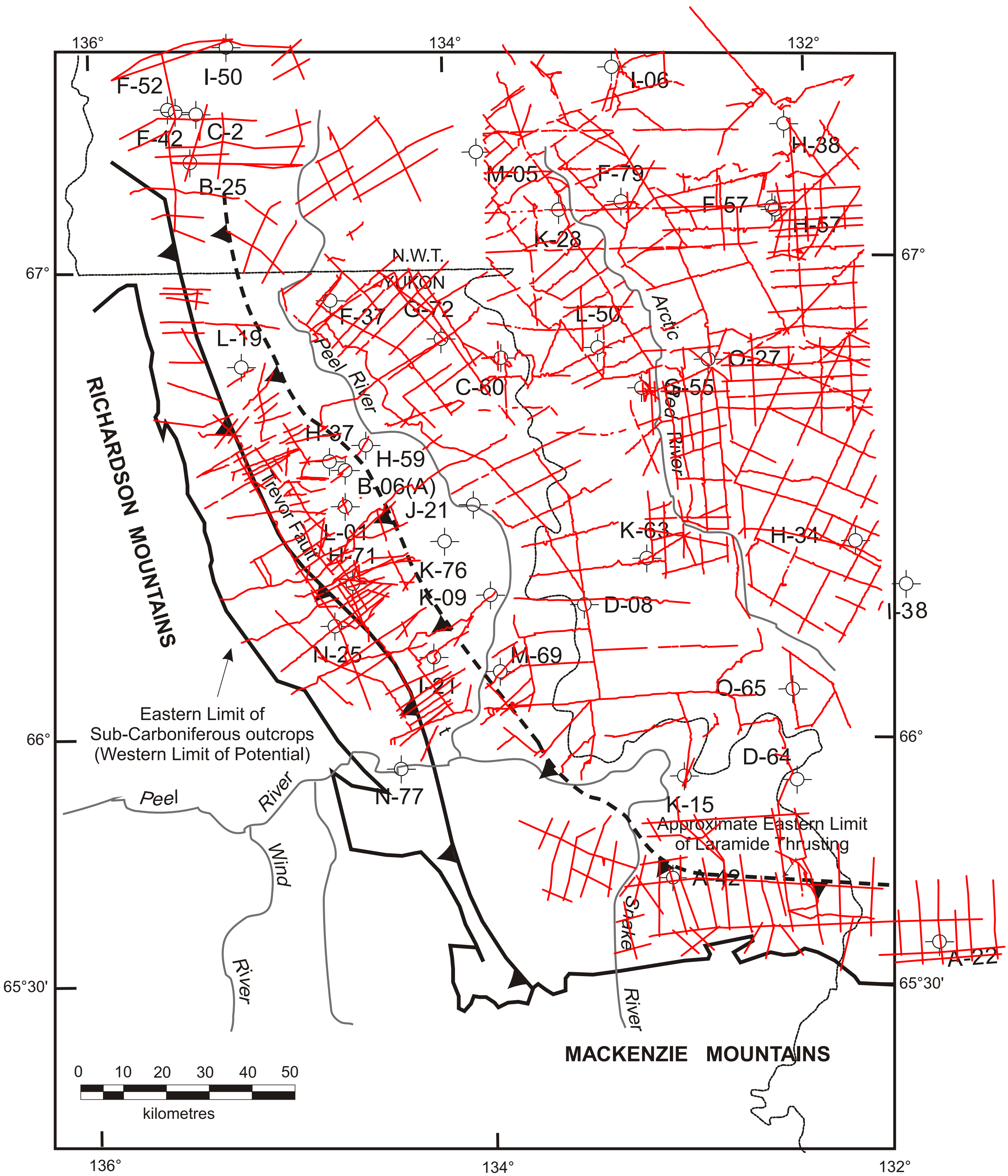


Figure 15: Distribution of petroleum exploration wells with respect to reflection seismic surveys in Peel Plateau and Plain, of all vintages.

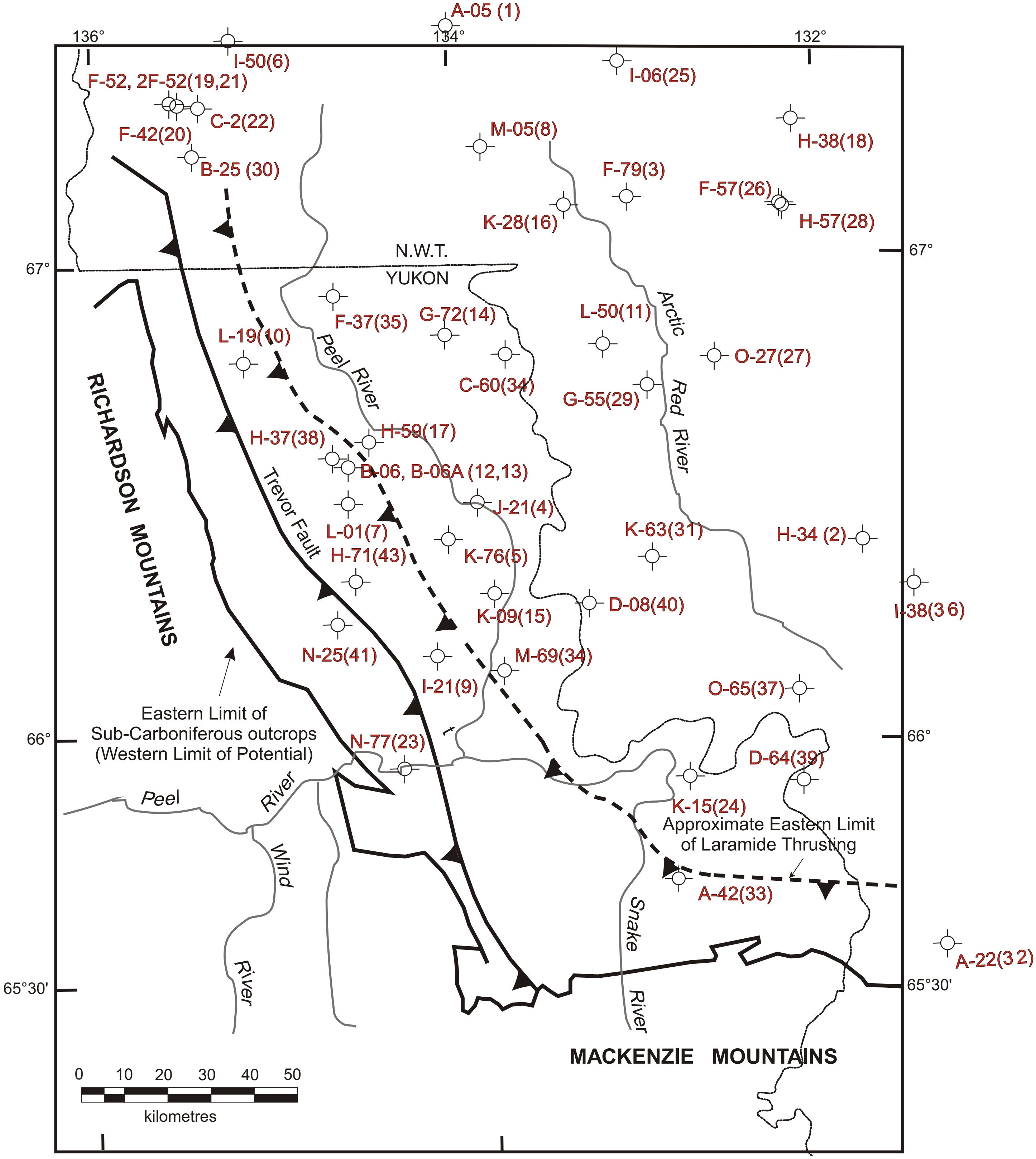


Figure 16: Distribution and historical sequence of petroleum exploration wells drilled in the Peel Plateau and Plain region. The numbers beside the well locations include the well name and the order in which the wells were drilled (in brackets). All forty-three exploratory petroleum wells were dry and abandoned.

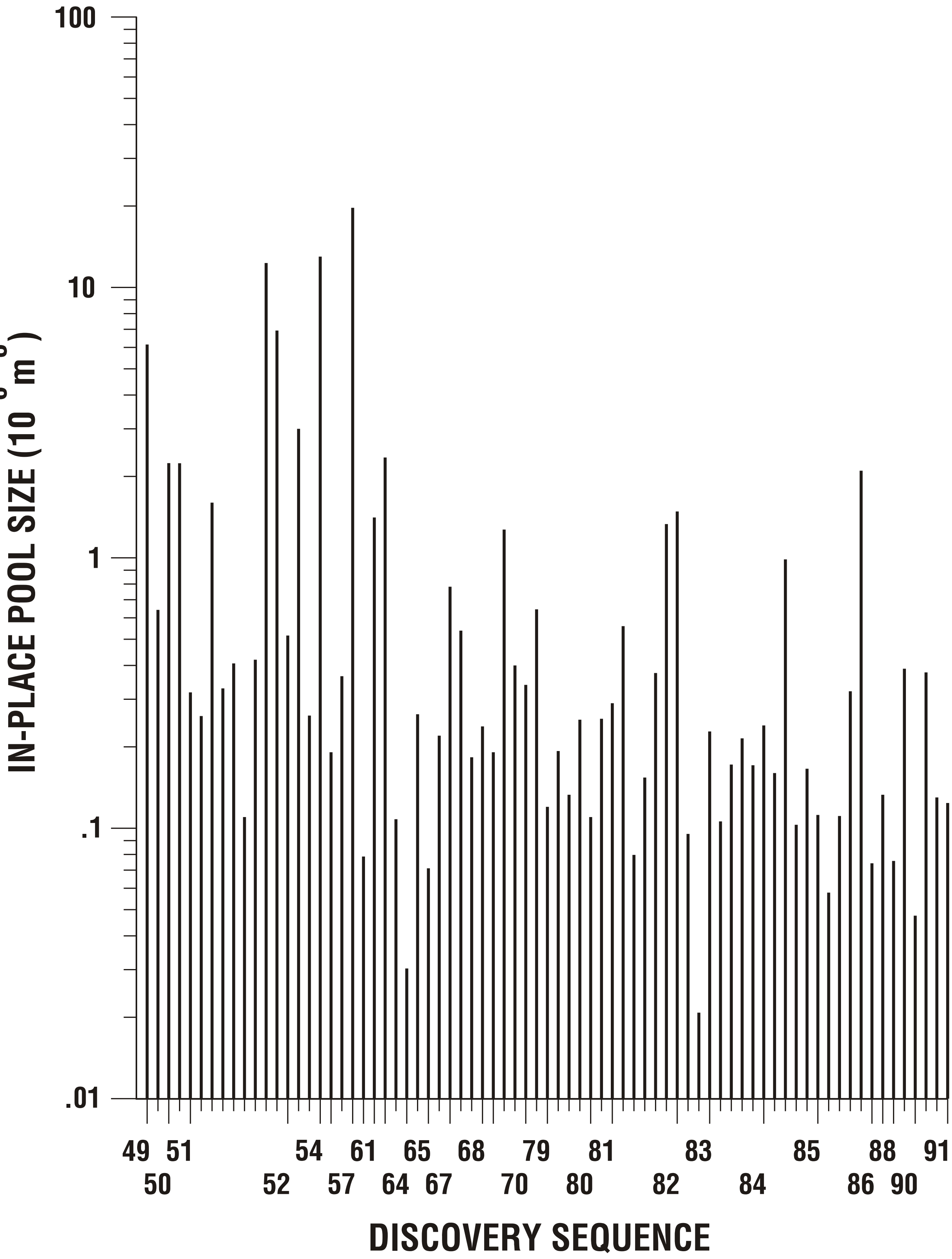


Figure 17: An example petroleum accumulation discovery sequence taken from the Carboniferous Jumping Pound Rundle Play of the southern Alberta Foothills. The logarithm of pool sizes is plotted sequentially as a function of discovery date, producing the time series or discovery sequence, which forms the basis for a sequential sampling assessment of petroleum potential as discussed in the text. The vertical axis represents the pool size, plotted on a logarithmic scale, and the horizontal axis shows the discovery date.

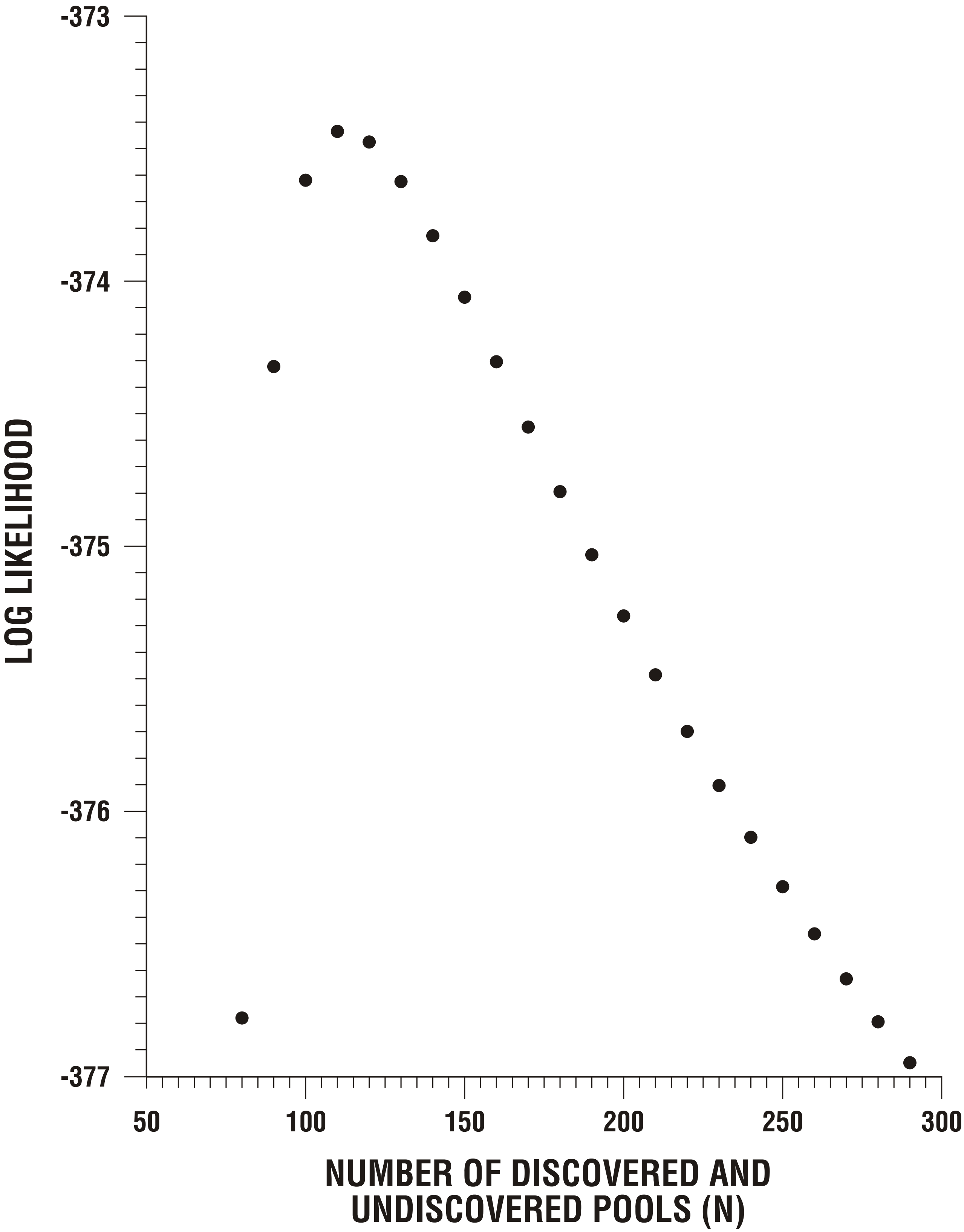
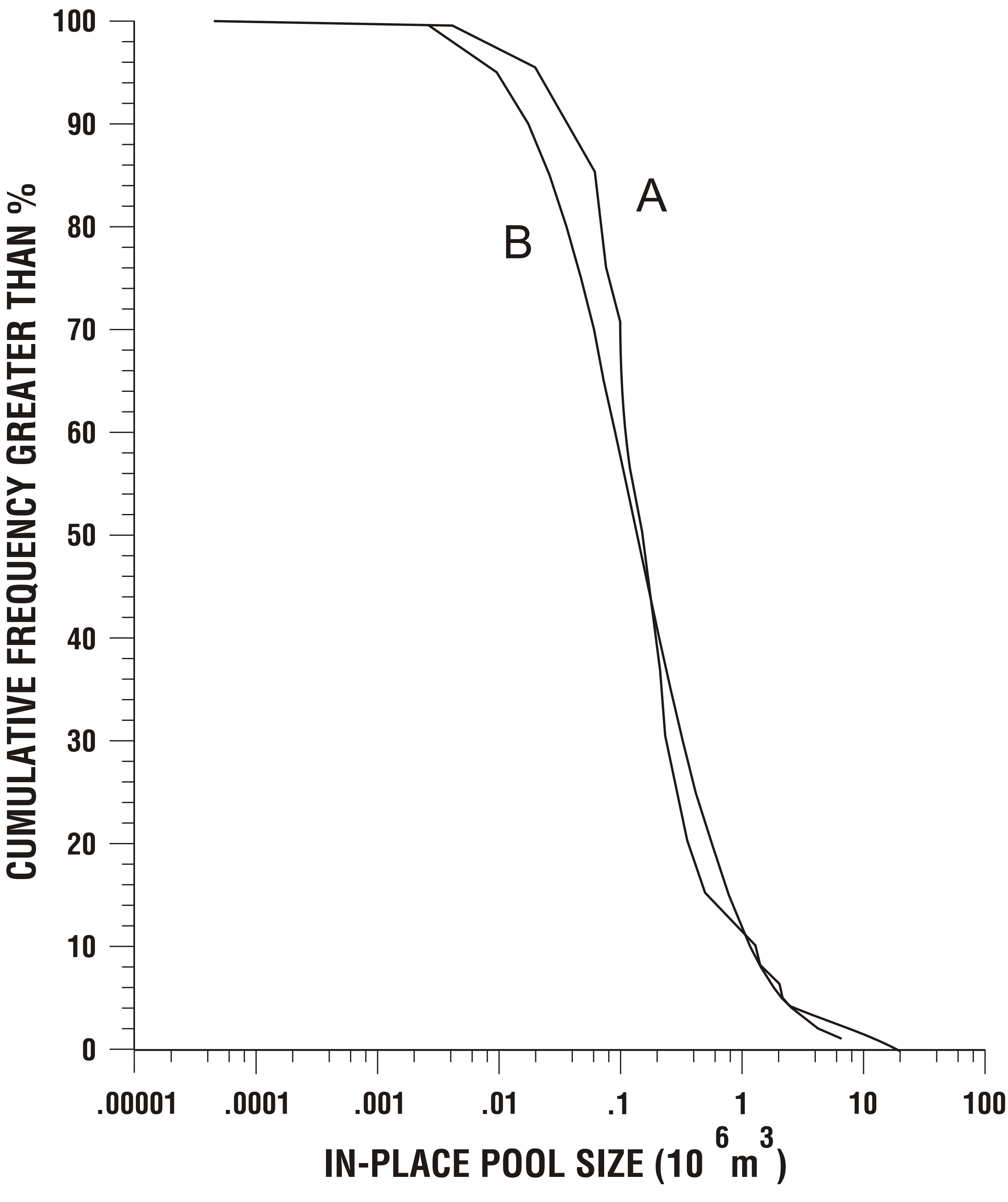


Figure 18: This figure illustrates the result of the lognormal discovery process model. The vertical axis represents the log likelihood value and the horizontal axis indicates the total number of discovered and undiscovered pools in a play, N. The higher the log likelihood value, the more plausible the value of N. In this example the most likely number of pools is 140.



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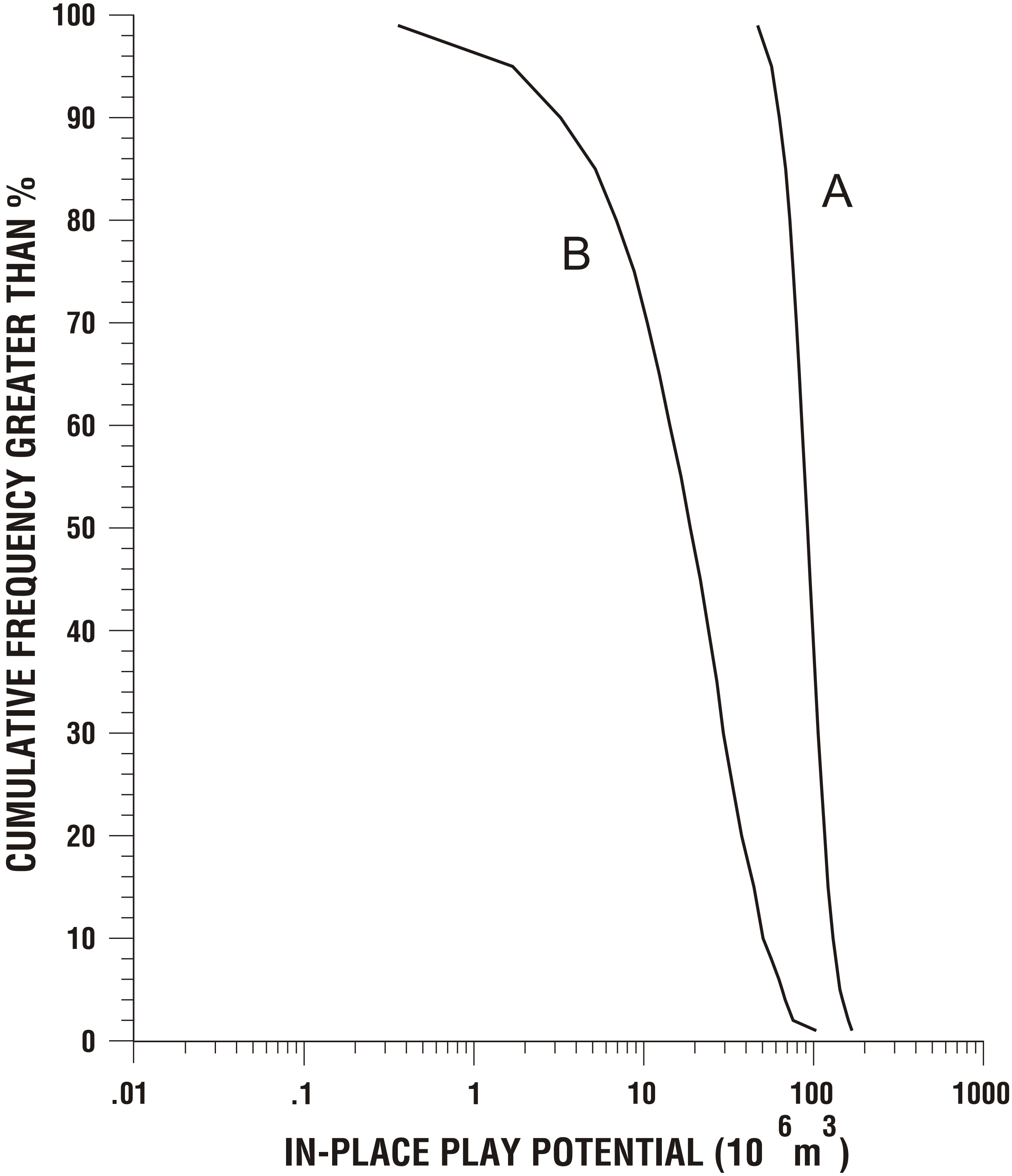

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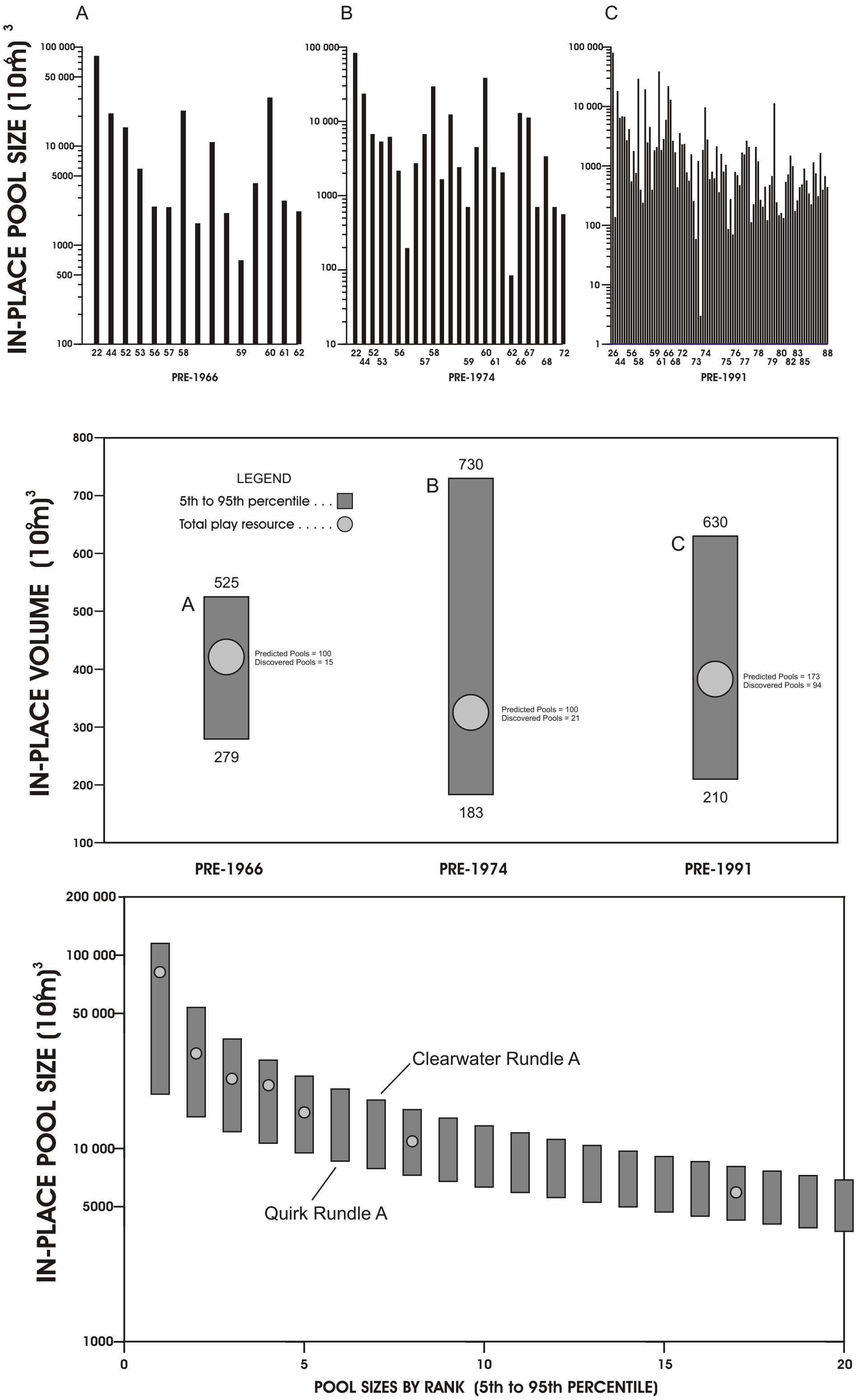

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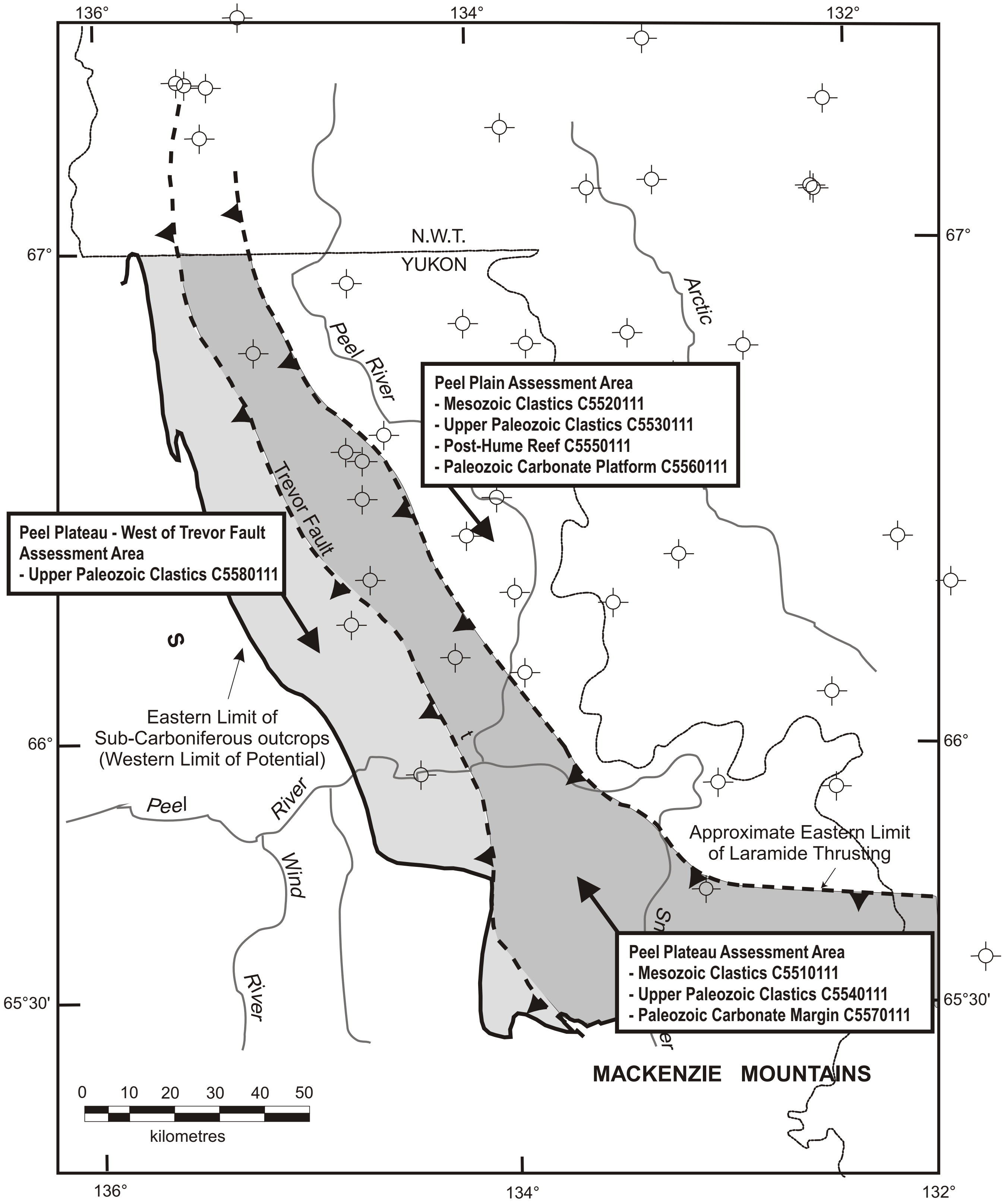

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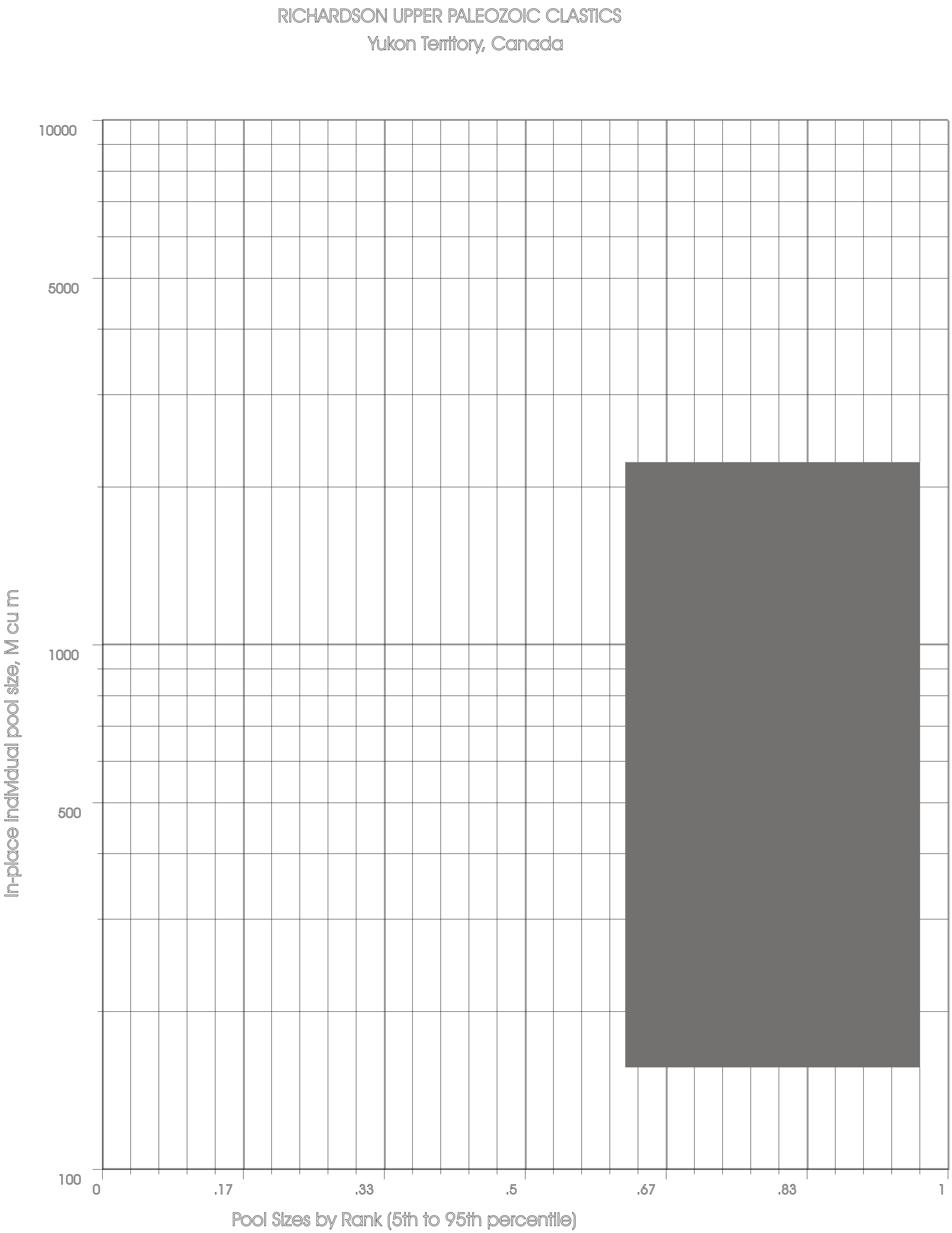

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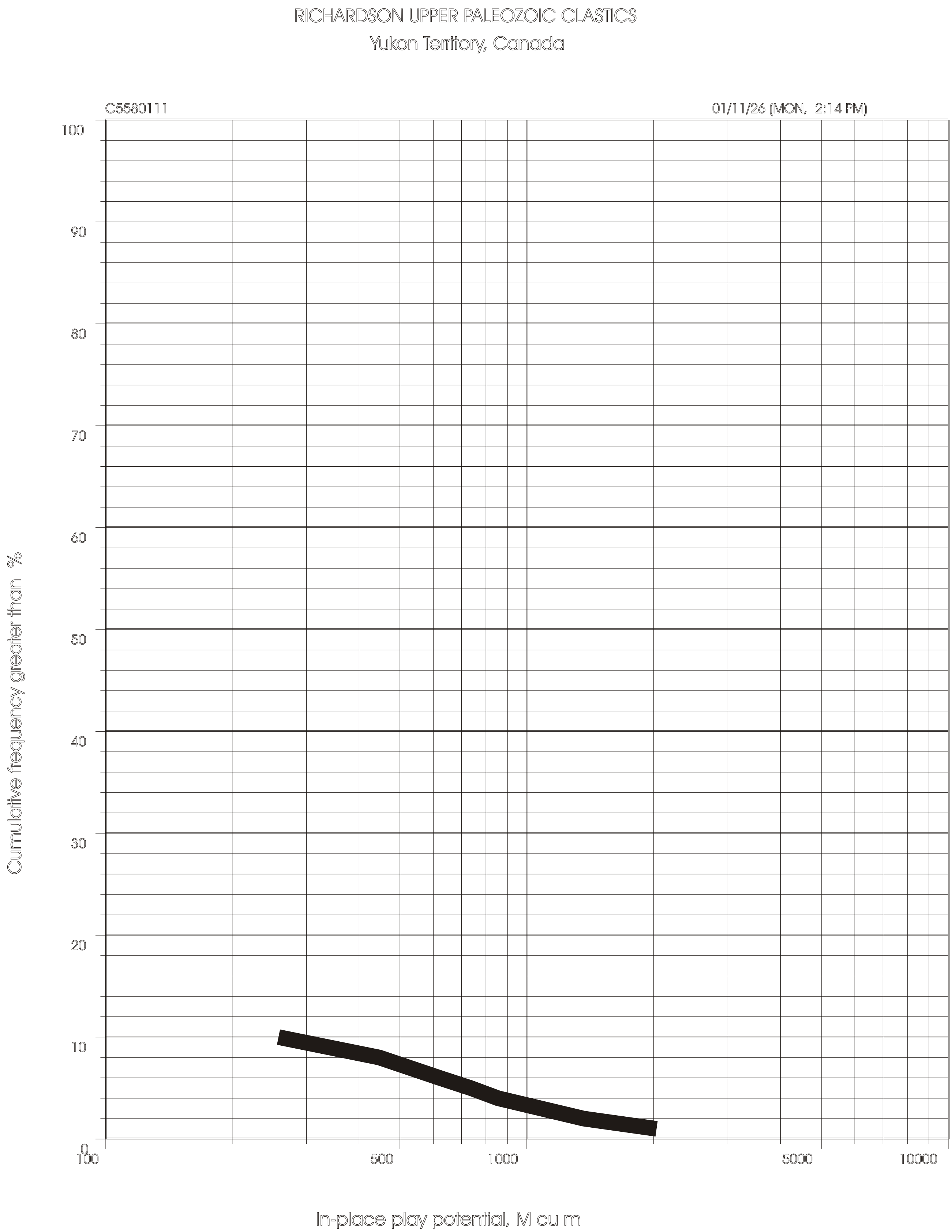

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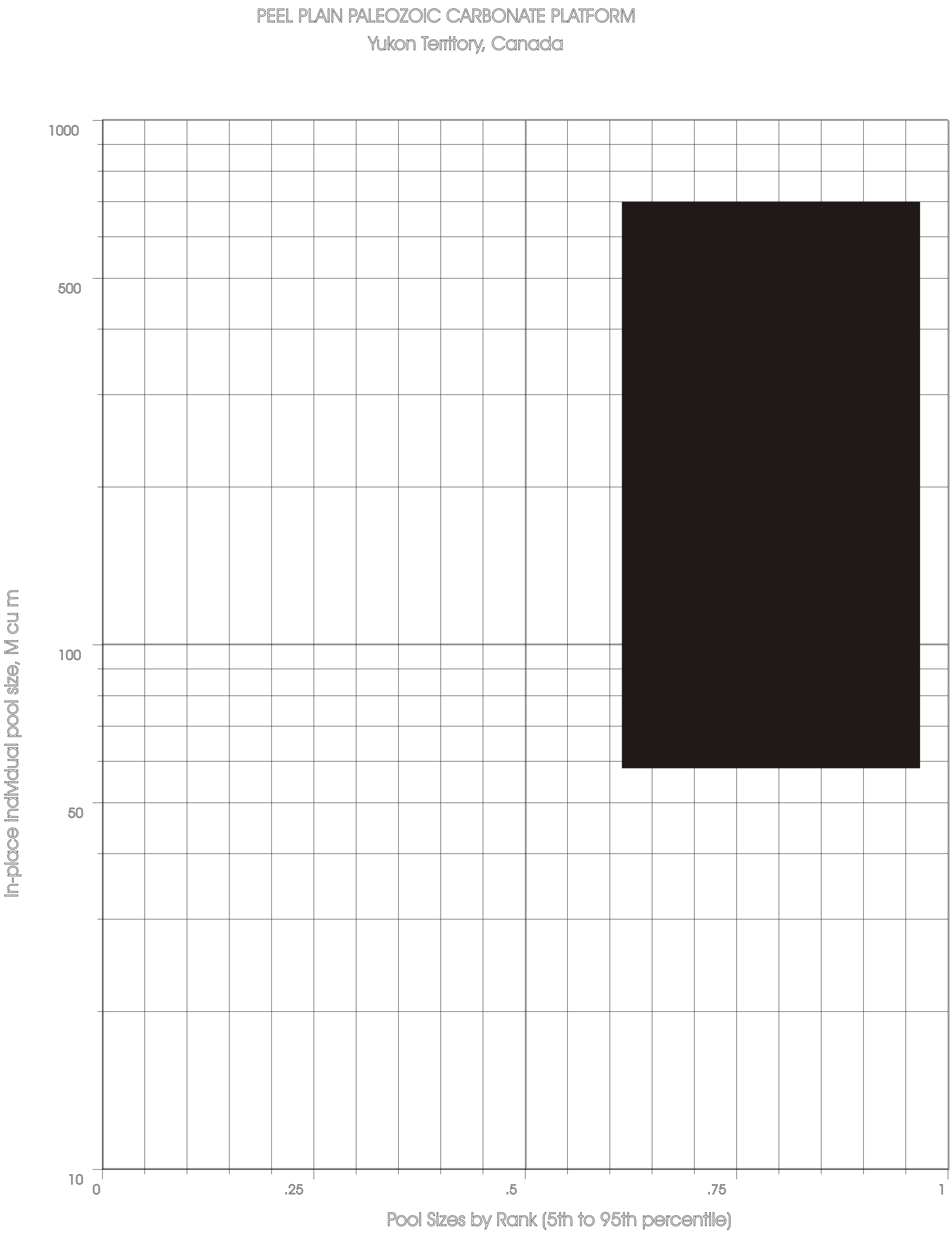

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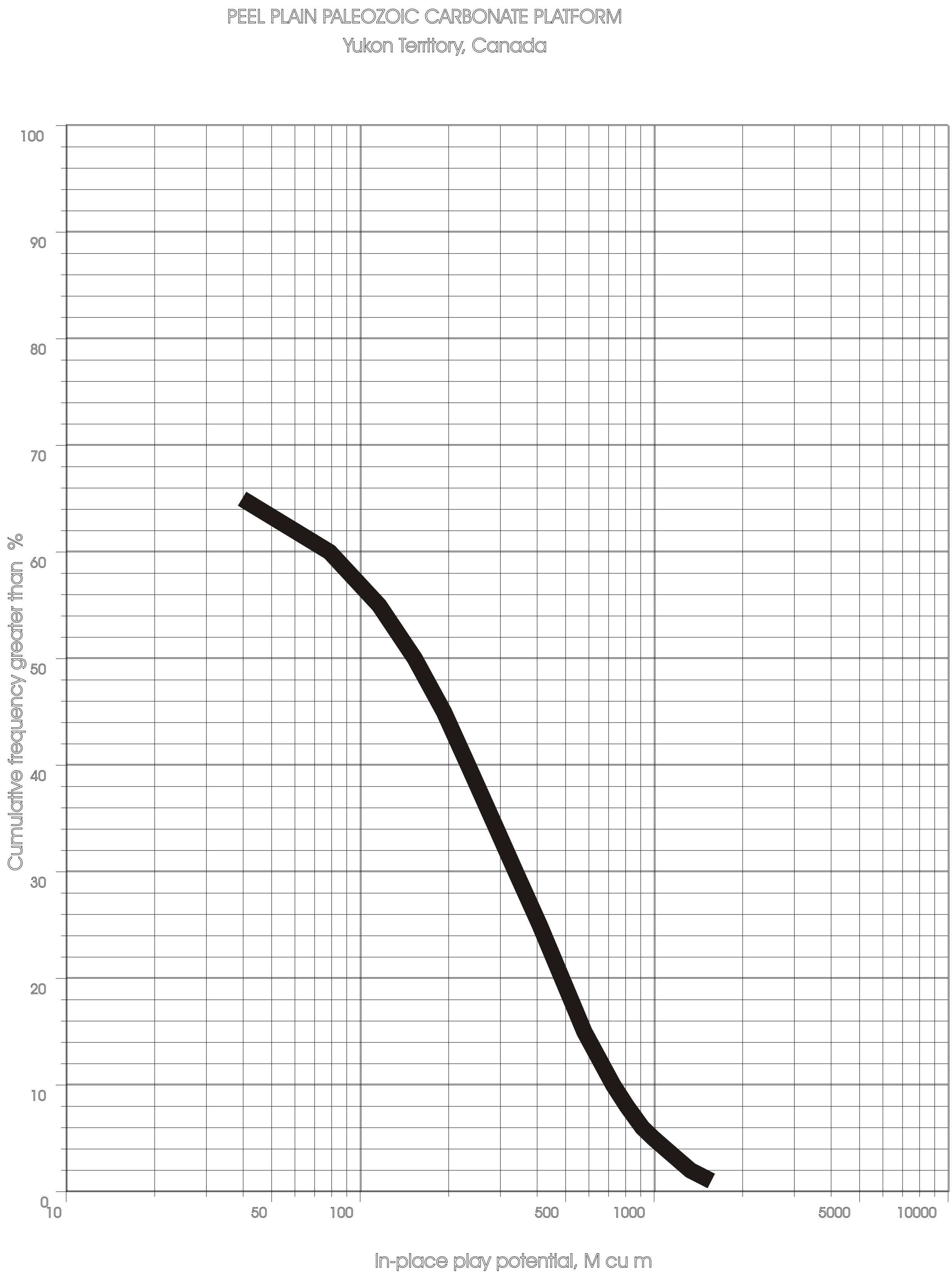

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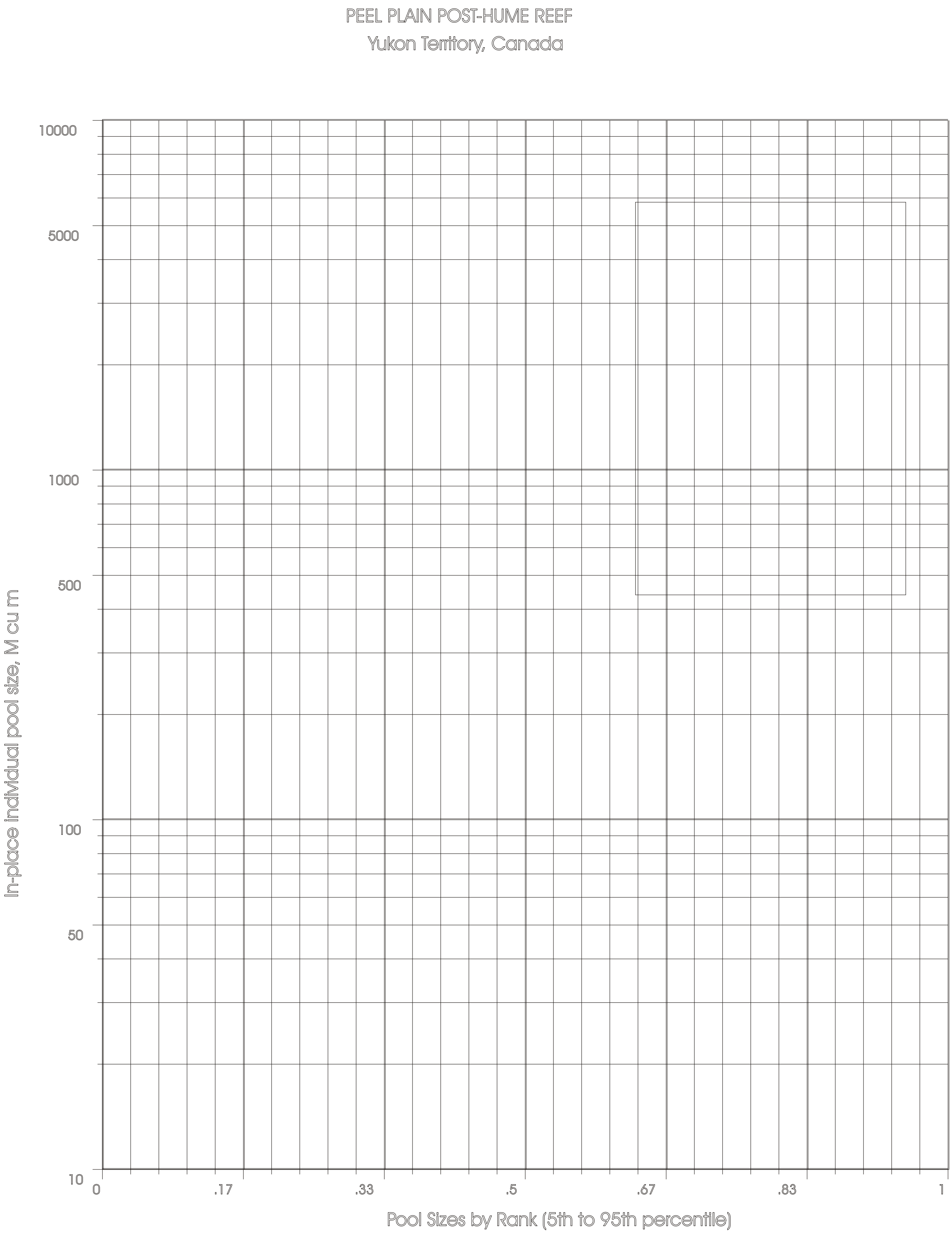

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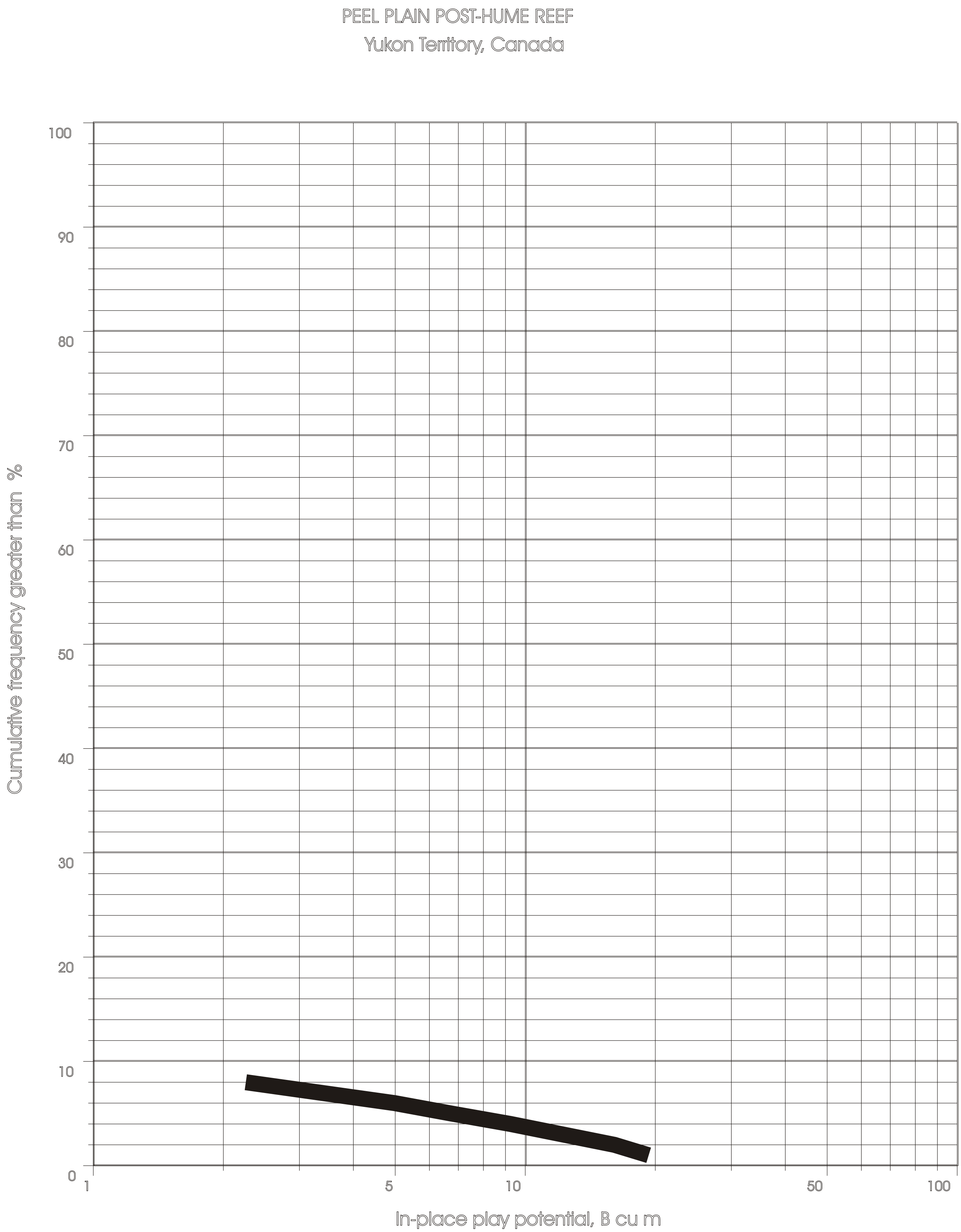

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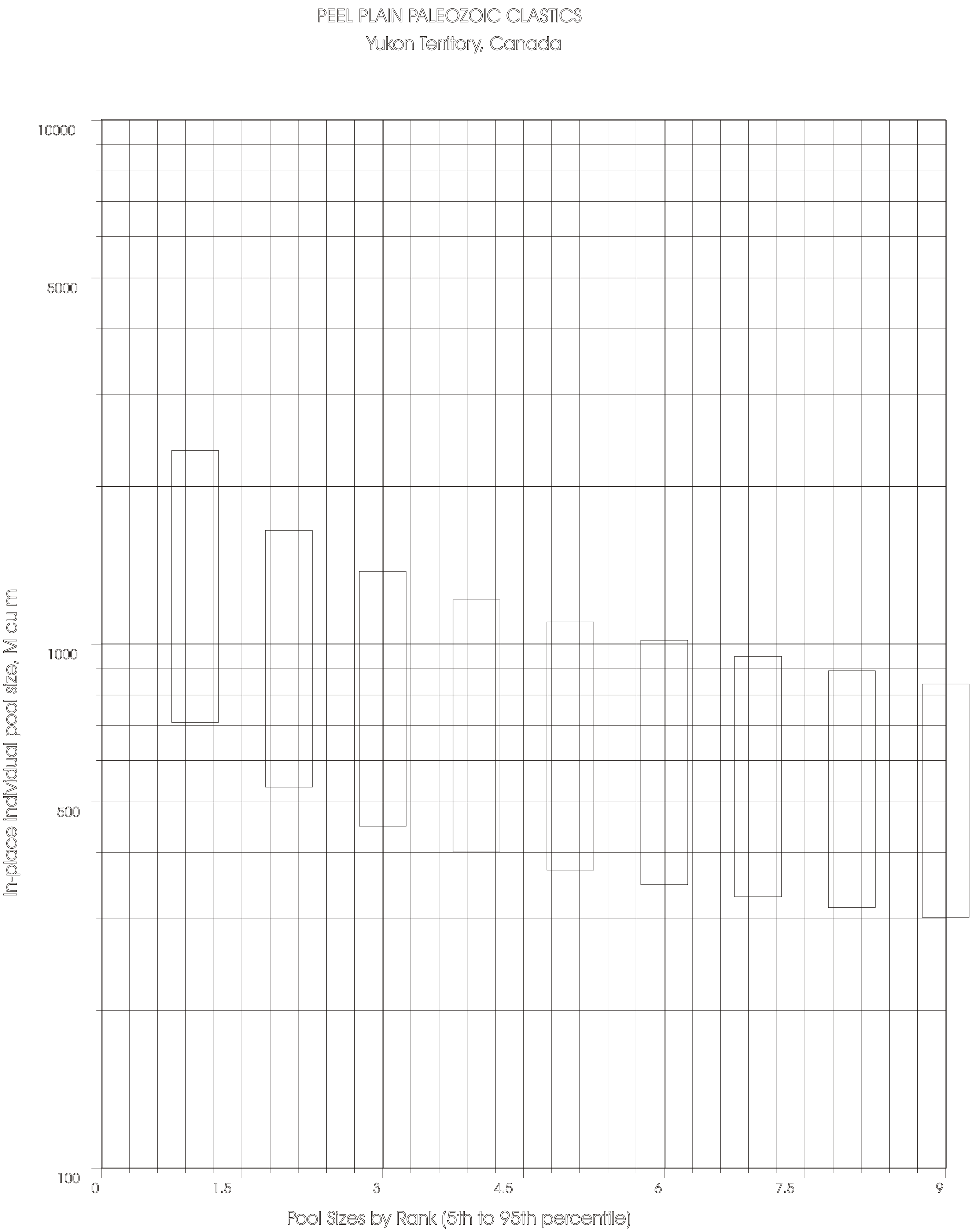

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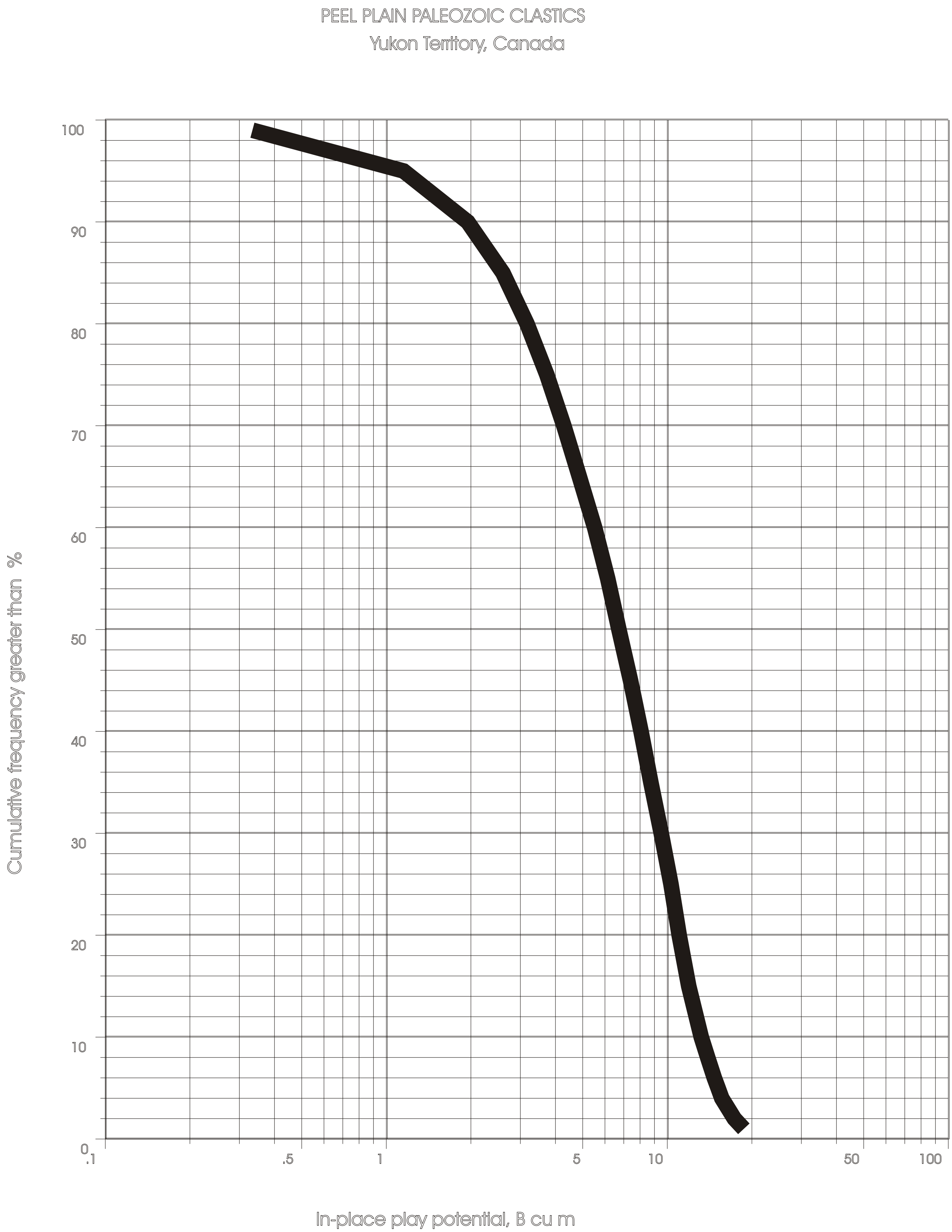

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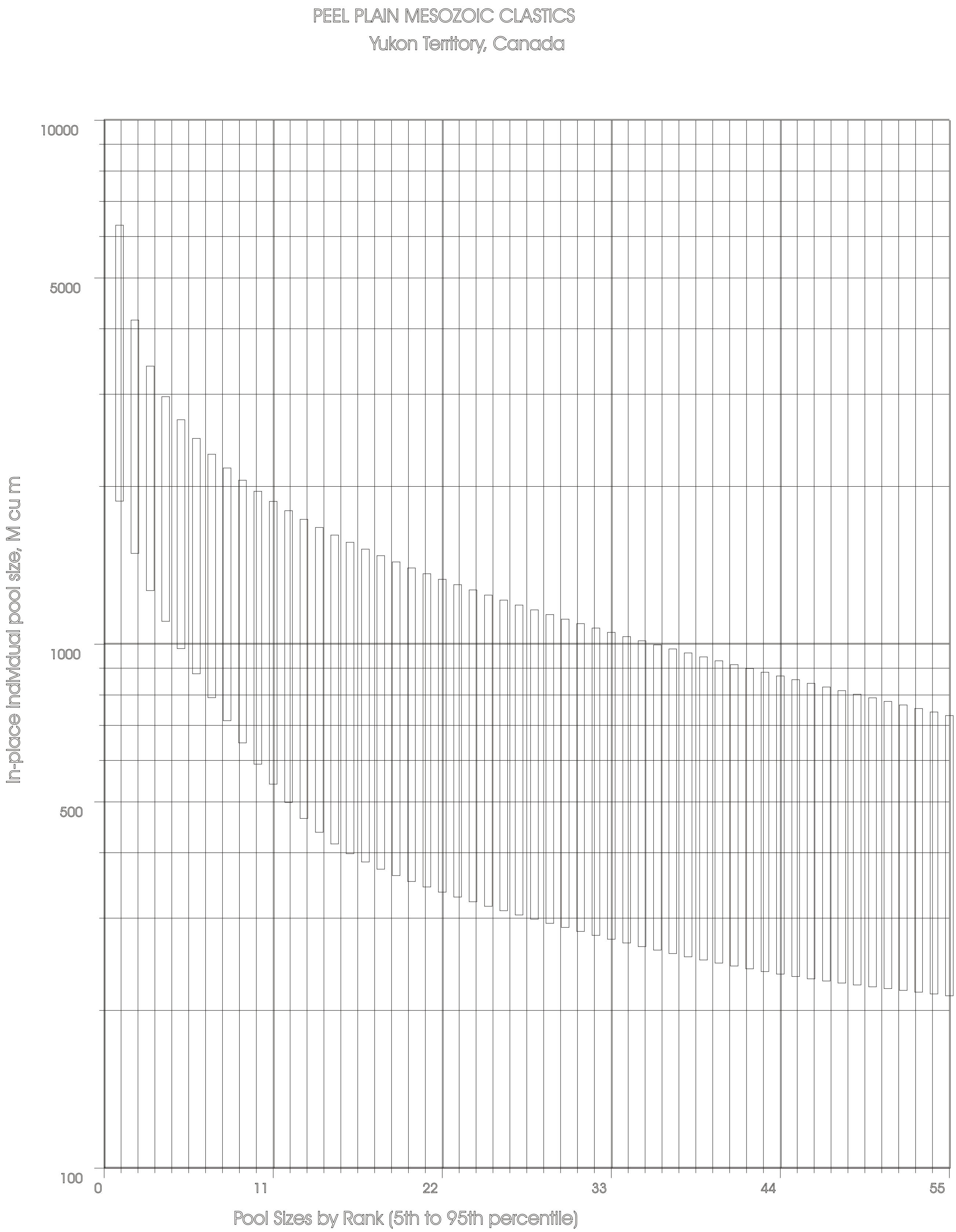

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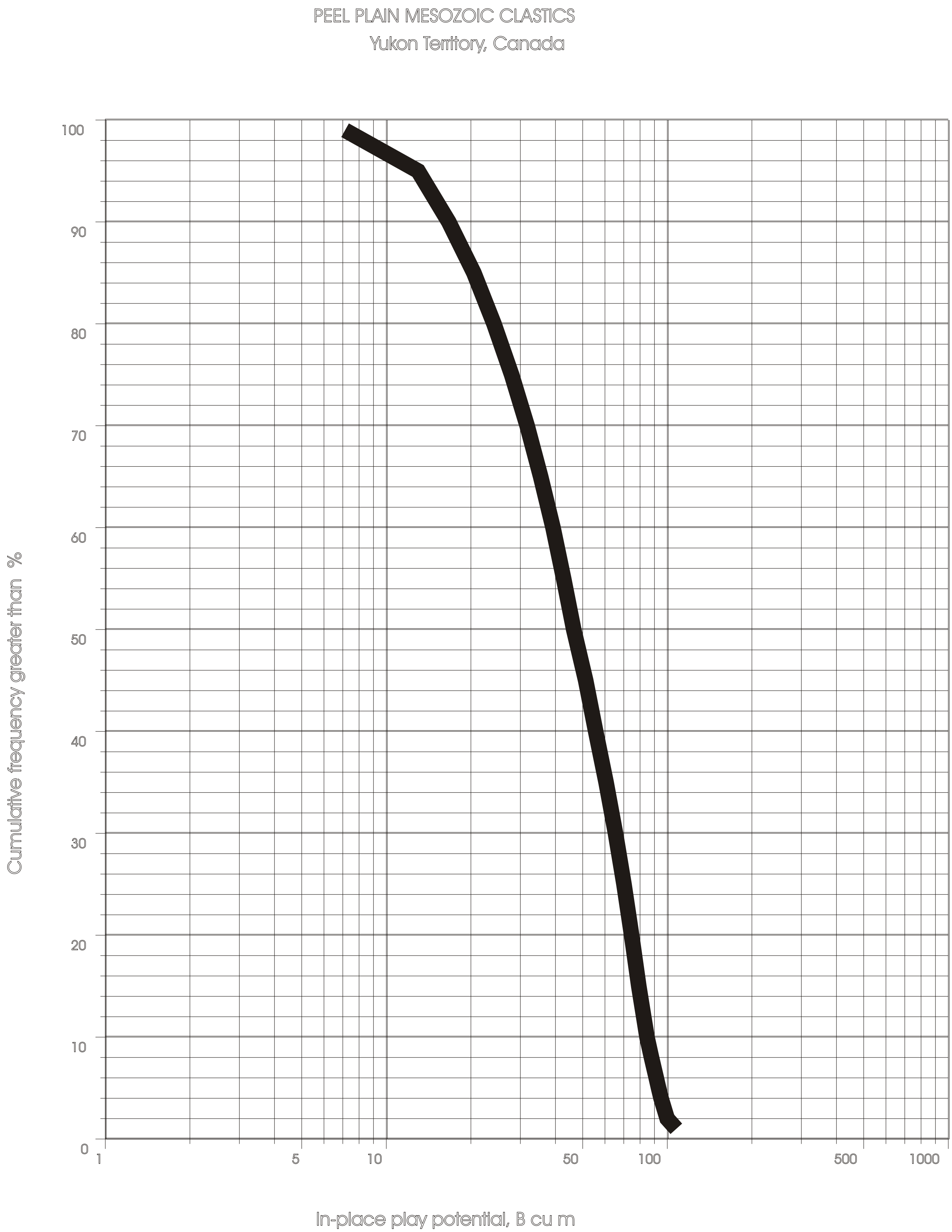

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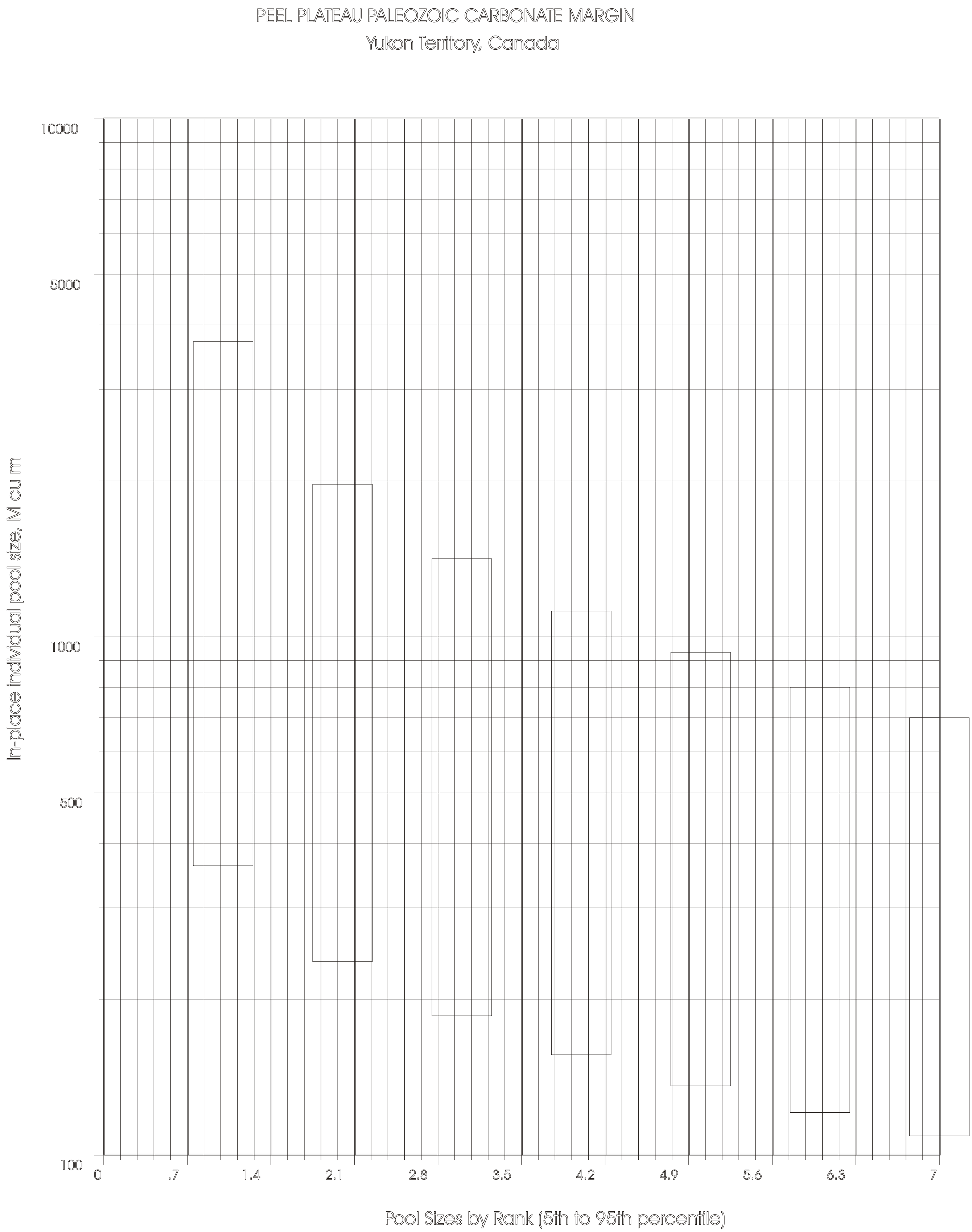

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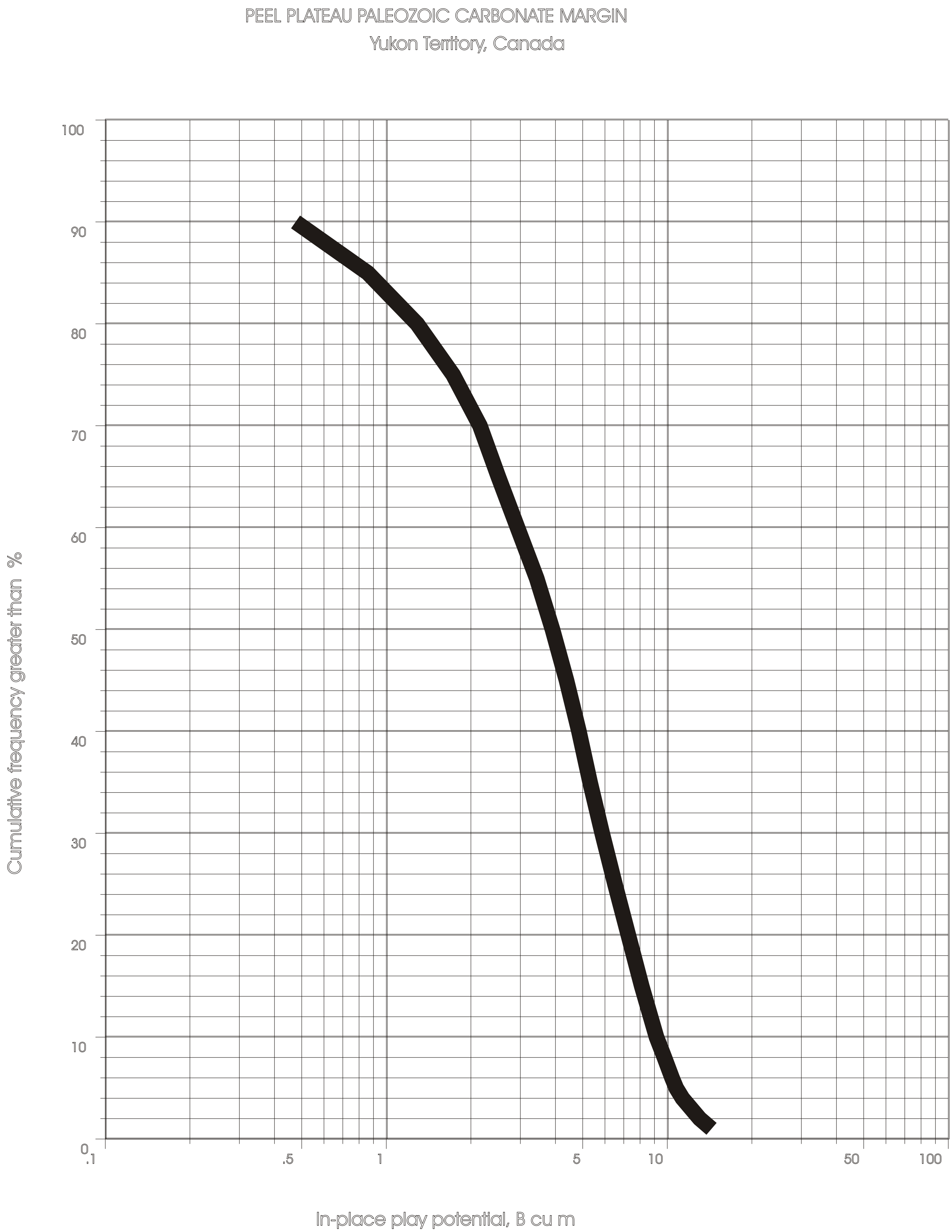

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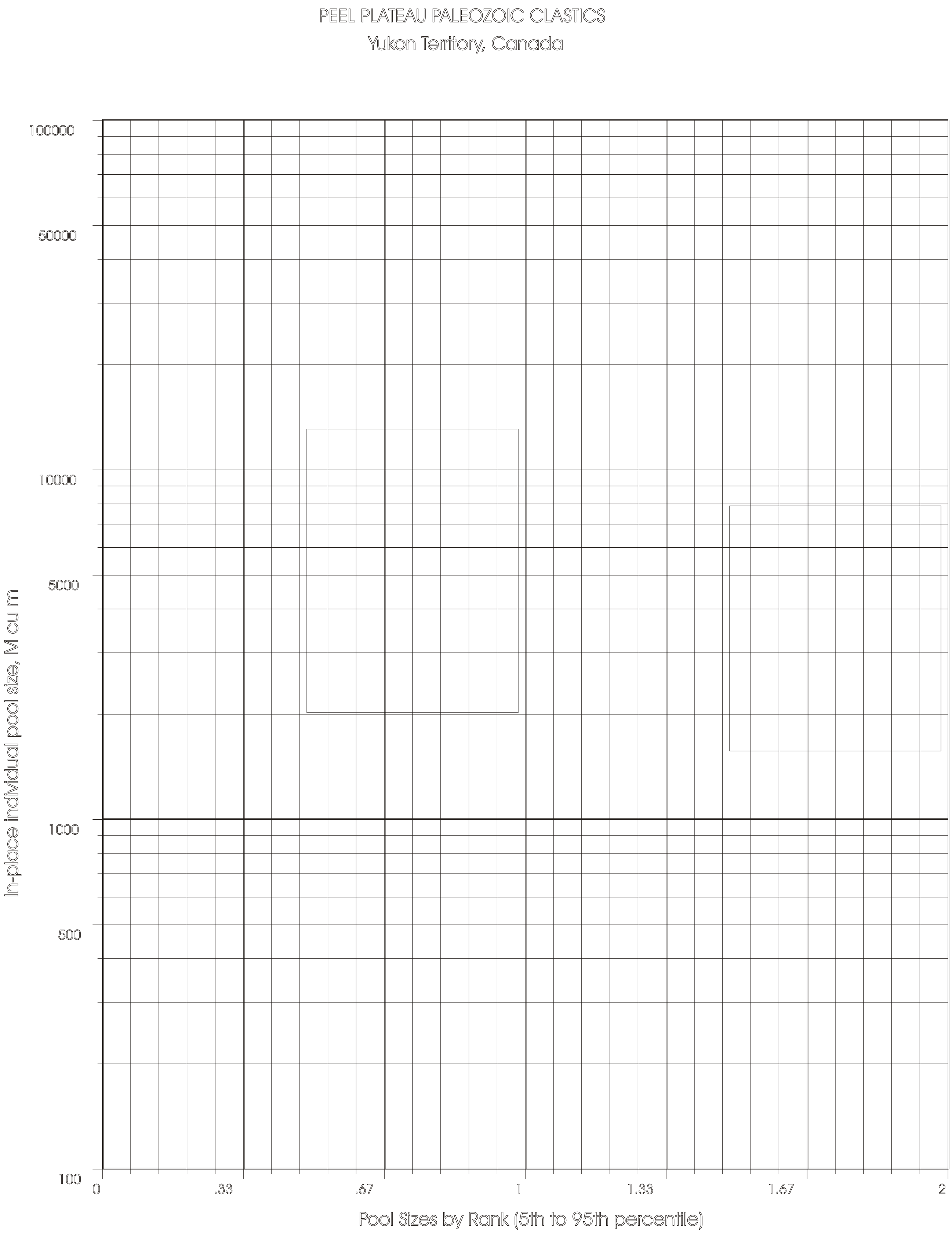

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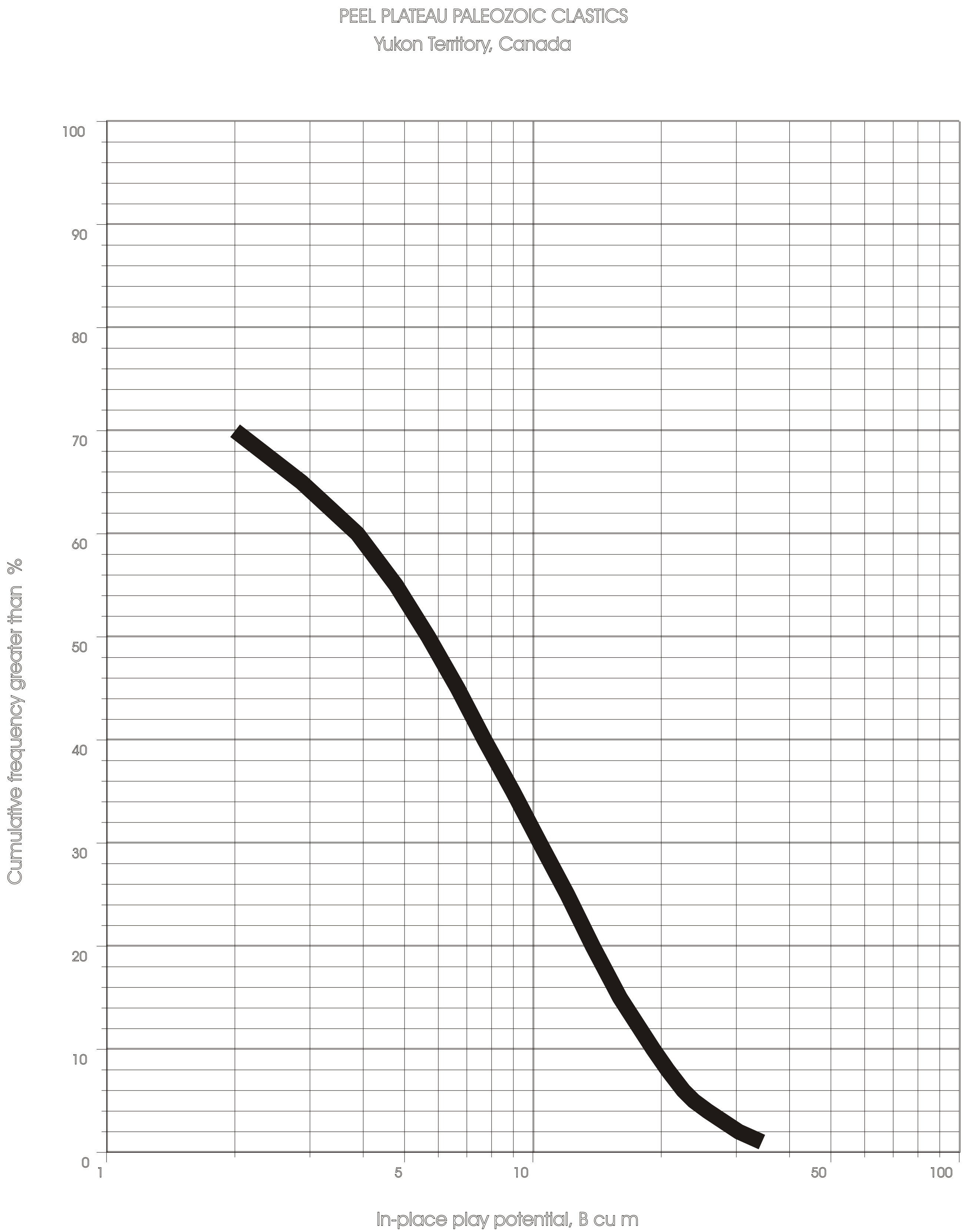

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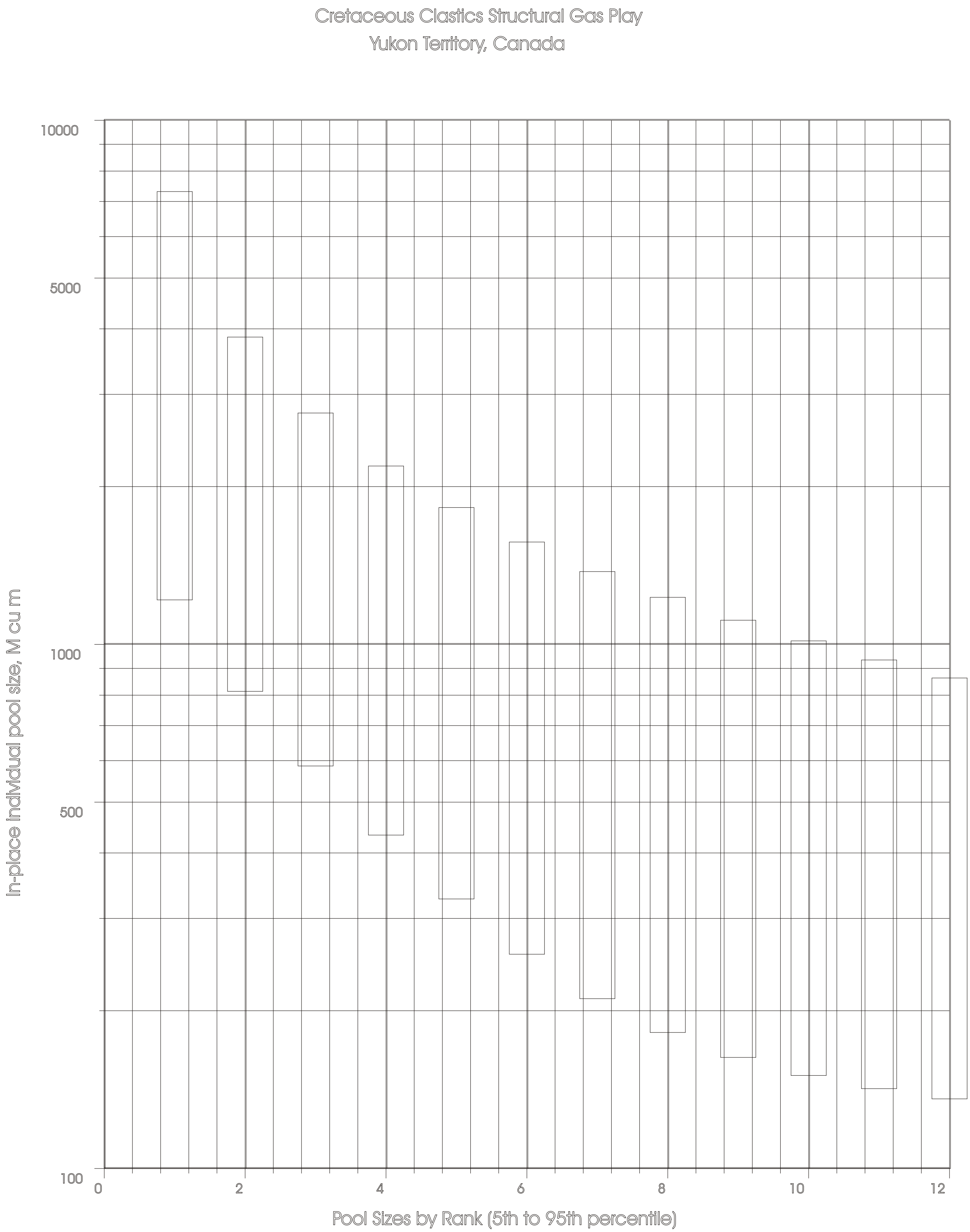

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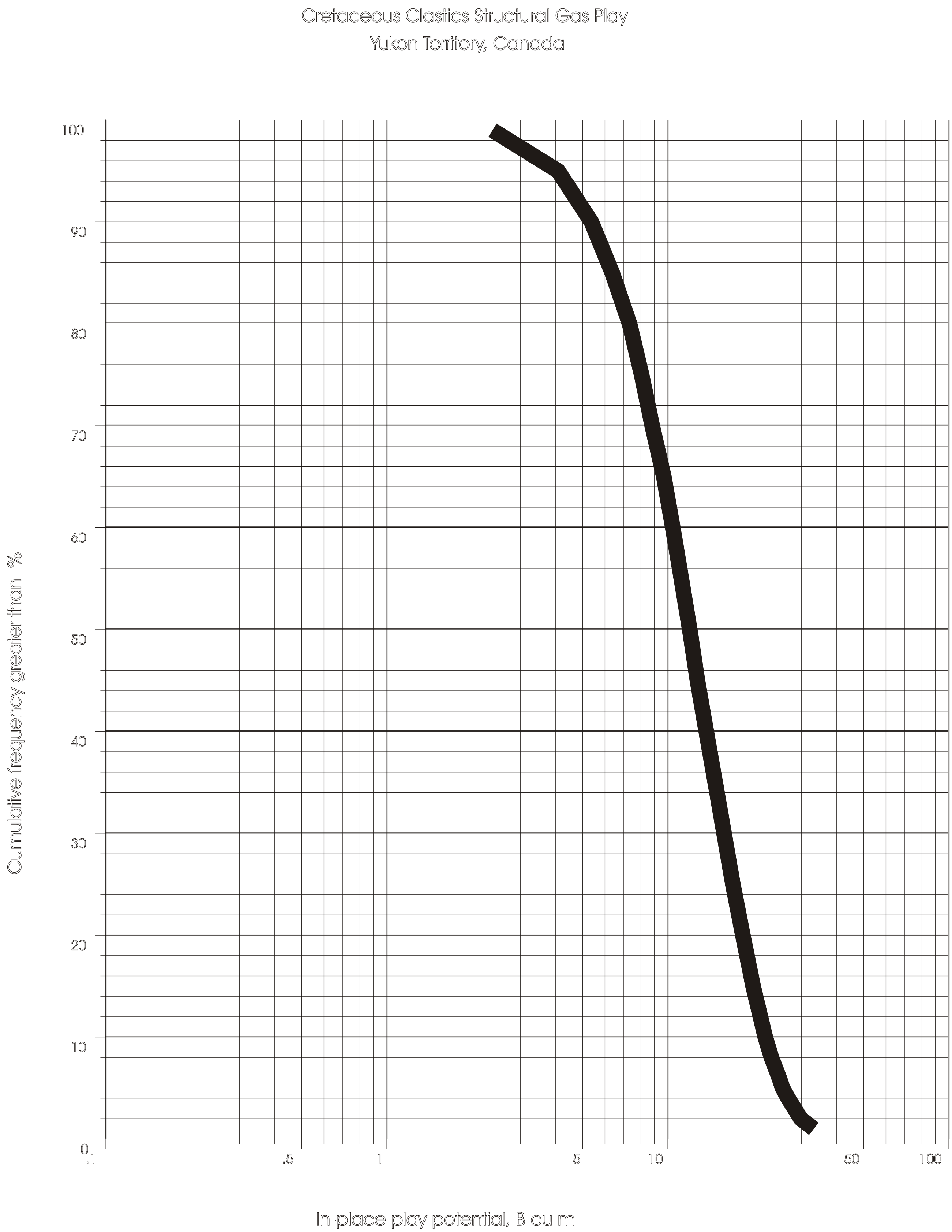

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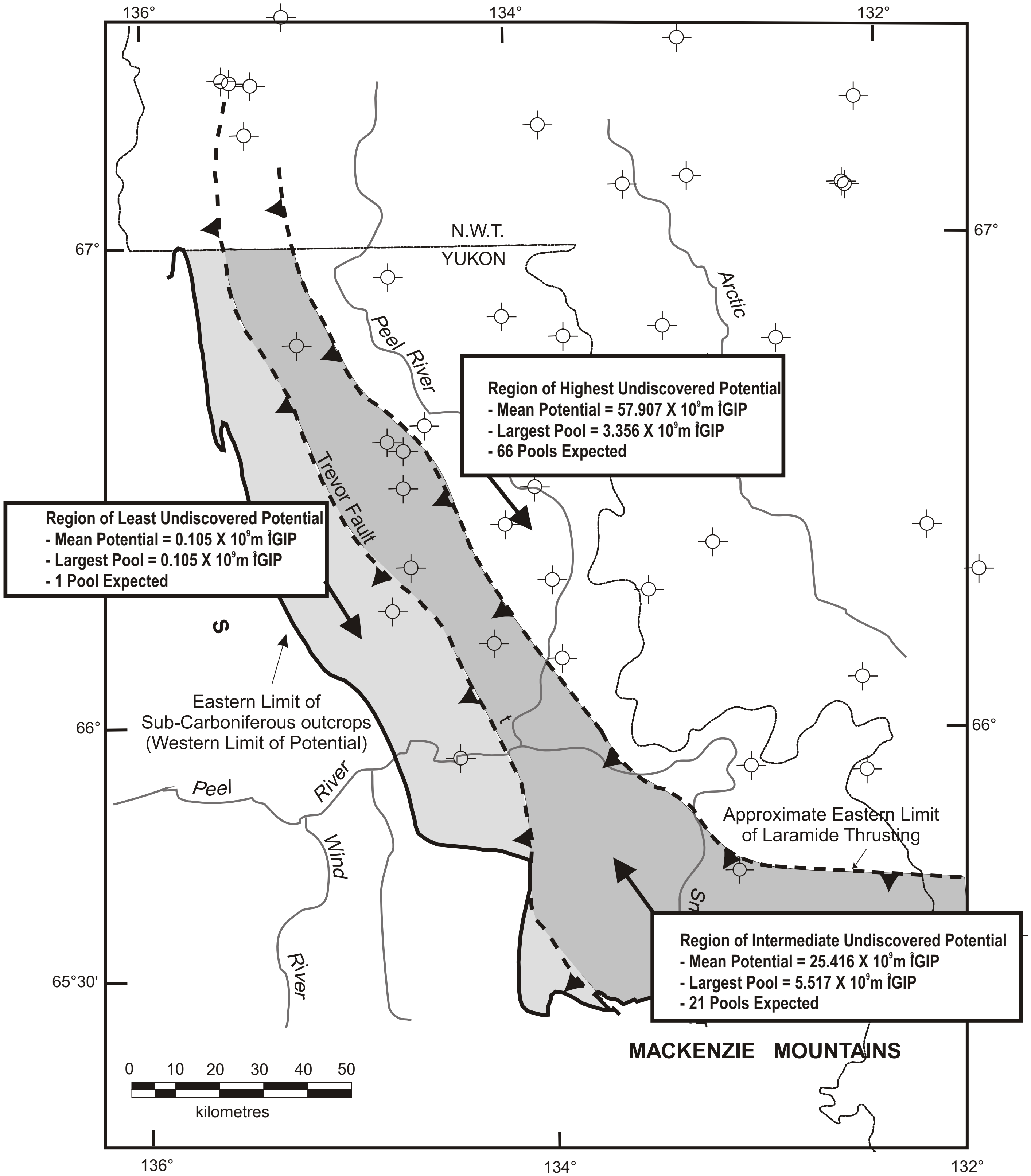

Figure 39: Summary of Peel Plateau and Plain petroleum resource assessment indicating key inferred characteristics of the undiscovered petroleum potential resulting from this analysis.

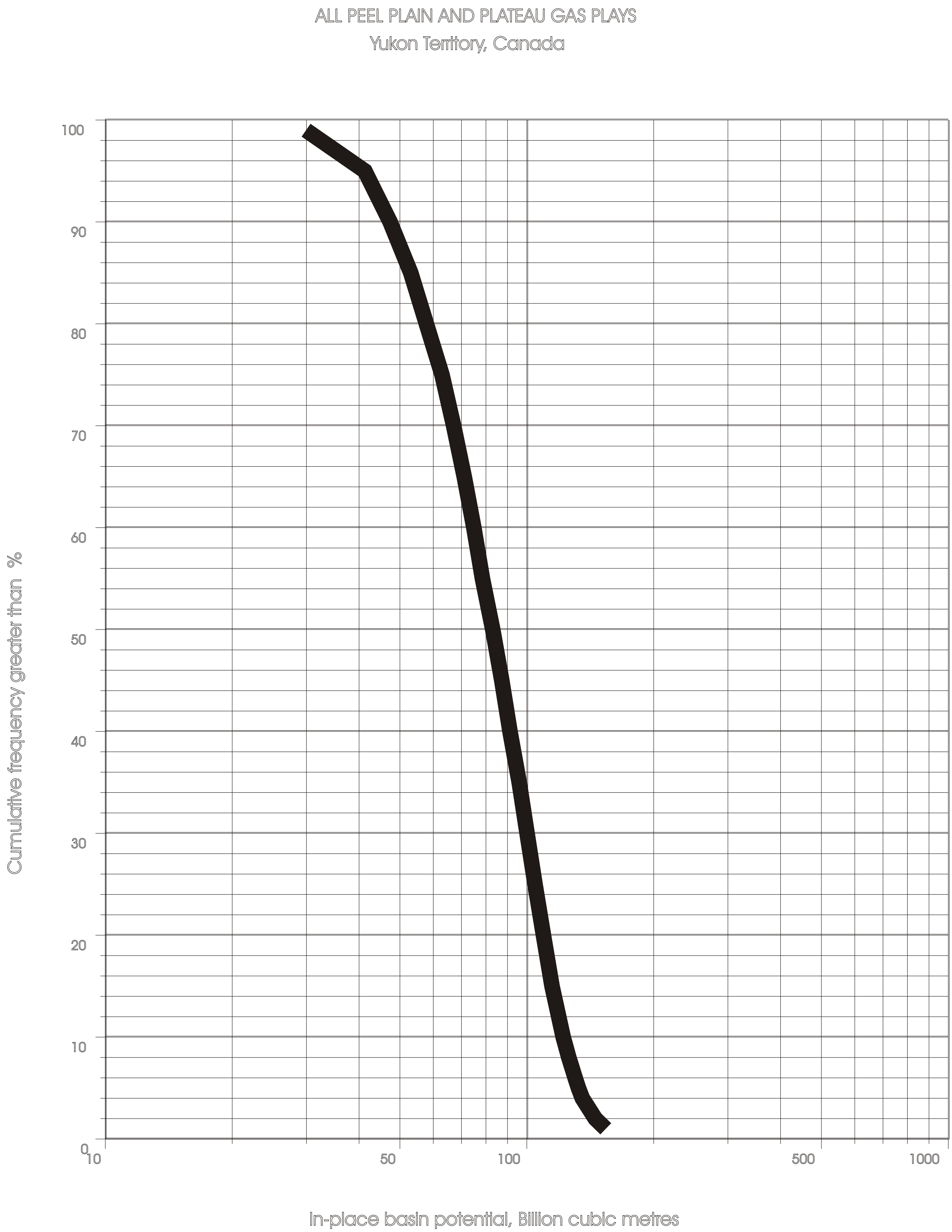

Figure 40: Summary petroleum potential for all of the plays combined in the Peel Plateau and Plain petroleum resource assessment. 83.428 X 10^9 m^3 initial raw gas in place (~3 TCF) in approximately 88 pools. The largest expected pool of 3.36 X 10^9 m^3 gas is expected to occur in Mesozoic clastics of the Peel Plain.

Table Captions

Table 1: Executive Summary of the petroleum potenial of the Peel Plateau and Plain.

Table 2: Schedule of petroleum exploration wells in the Peel Plateau and Plain region. The table illustrates the location, Kelly Bushing Elevation (KBE) and spud date of 43 wells discussed in the text.

Table 3: C5580111 - Upper Paleozoic Clastics Play Input Parameters

Table 4: C5580111 - Upper Paleozoic Clastics Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 5: C5580111 - Upper Paleozoic Clastics Play Number of Pools Distribution

Table 6: C5580111 - Upper Paleozoic Clastics Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 7: C5560111- Paleozoic Carbonate Platform Play Input Parameters

Table 8: C5560111- Paleozoic Carbonate Platform Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 9: C5560111- Paleozoic Carbonate Platform Play Number of Pools Distribution

Table 10: C5560111- Paleozoic Carbonate Platform Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 11: C5550111- Horn Plateau Reef Play Input Parameters

Table 12: C5550111- Horn Plateau Reef Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 13: C5550111- Horn Plateau Reef Play Number of Pools Distribution

Table 14: C5550111- Horn Plateau Reef Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 15: C5530111 - Upper Paleozoic Clastics Play Input Parameters

Table 16: C5530111 - Upper Paleozoic Clastics Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 17: C5530111 - Upper Paleozoic Clastics Play Number of Pools Distribution

Table 18: C5530111 - Upper Paleozoic Clastics Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 19: Mesozoic Clastics - C5520111 Play Input Parameters

Table 20: Mesozoic Clastics - C5520111 Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 21: Mesozoic Clastics - C5520111 Play Number of Pools Distribution

Table 22: Mesozoic Clastics - C5520111 Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 23: C5570111 - Paleozoic Carbonate Margin Play Input Parameters

Table 24: C5570111 - Paleozoic Carbonate Margin Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 25: C5570111 - Paleozoic Carbonate Margin Play Number of Pools Distribution

Table 26: C5570111 - Paleozoic Carbonate Margin Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 27: C5540111 - Upper Paleozoic Clastics Play Input Parameters

Table 28: C5540111 - Upper Paleozoic Clastics Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 29: C5540111 - Upper Paleozoic Clastics Play Number of Pools Distribution

Table 30: C5540111 - Upper Paleozoic Clastics Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 31: Mesozoic Clastics C5510111 Play Input Parameters

Table 32: Mesozoic Clastics C5510111 Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic m initial in place)

Table 33: Mesozoic Clastics C5510111 Play Number of Pools Distribution

Table 34: Mesozoic Clastics C5510111 Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Table 35: Summary Petroleum Resource Endowment of the Peel Plateau and Plain in the Yukon Territory, indicating the assessed Play Name, expected number of accumulations, their median and mean play potentials and the median size of the largest undiscovered accumulation in each play. Note the Peel Plain Arnica/Manetoe Dolostone Play was previously assessed, but it is no longer inferred to exist (see the discussion in the text).

Table 1: Executive Summary of the petroleum potenial of the Peel Plateau and Plain.

Basin Age	Proterozoic to Cretaceous with economic basement in the Lower Cambrian
Basin Area in Yukon	10,300 km^2
Depth to Target Zones	Mesozoic: surface to 1000 m Carboniferous: surface to 2,500 m Devonian shale: surface to 3,500 m Paleozoic carbonate: 1,500m to 4000 m
Maximum Phanerozaic Thickness	~4,500 m stratigraphic thickness, thickened by Cordilleran thrusting and folding
Hydrocarbon Traces	1. Shell Peel River YT B-06 (gas to surface, too small to measure, gas-cut mud) 2. MCD GCO Northrup Taylor Lake YT K-15 (gassy fresh water) 3. Pacific et al Peel YT F-37 (gassy muddy salt water) 4. Gulf Mobil Caribou YT N-25 (gas-cut mud) 5. Shell Peel River YT M-69 (gas to surface, too small to measure) Swan Lake Surface Gas Seepage (106 N4/1) estimated 700 cf/d (Norris, 1997, p. 383
First Discovery	No discoveries
Potential Resources	Oil: No potential can be estimated due to an inferred lack of oil prone sources in strata of suitable maturity. Gas: Sum of mean play potentials 83.428 X 10^9 m^3 gas (~3 TCF) in approximately 88 pools. Largest expected pool of 3.36 X 10^9 m^3 gas is expected to occur Mesozoic clastics of the Peel Plain. In general, petroleum potential is inferred to decrease both westward and with increasing depth and stratigraphic age.
Basin Type	Coupled Cordilleran (Aptian-Eocene) thick-skinned Foreland thrust and fold belt and Foreland basin overlying a Paleozoic succession of Franklinian (Middle Devonian-Carboniferous) flysch/molasse, Taghanic (Upper Silurian to Middle Devonian) Carbonate Platform and Basin deposited on an Early Paleozoic (Lower Cambrian to Lower Silurian) intra-cratonic rift basin.
Depositional Setting	Shallow- to deep-water Paleozoic carbonate platform, rift basin and orogenic foreland, and Mesozoic orogenic foreland and clastic shelf
Potential Reservoirs	Basal sandstone and sand bodies with the shale and siltstone dominated Mesozoic succession, Dolostone and limestone carbonate ramps within the Paleozoic, with possible internal biostromal buildups. There is a slight chance for an abrupt margin carbonate build-up growing off the drowned

	surface of the Hume Platform, like Horn Plateau reefs.
Regional Structure	Thick skinned and associated thin-skinned Laramide north and east verging thrust and fold belt. In the west, the fold and thrust belt is an inversion of extensional fault structures of an early Paleozoic intracratonic rift basin (Richardson Anticlinorium and Trevor Fault). Between the Trevor Fault and the eastern limit of the deformation, just west of the Peel River, the fold and thrust belt incorporates the Paleozoic succession as well as cannibalizing its own Foreland Basin succession. The early Paleozoic intracratonic rift is probably linked to formation of the Paleopacific margin, but the duration of subsidence indicates that other tectonic mechanisms, not yet elucidated, explain the Upper Ordovician to Carboniferous successions. Large epeirogenic uplift and erosion events of uncertain origin and only roughly known age are responsible for the formation of major erosional surfaces at the present outcrop and to of the Paleozoic succession.
Seals	External; Road River Gp., Canol Fm. Imperial Formation; Internal; Paleozoic carbonate ramps, Imperial/Tuttle flysch-foreland succession, Martin House/Arctic Red foreland succession
Petroleum Systems	No data available in study region for either source rock potential or thermal maturity. Results from surrounding area suggest a number of potential source rocks in the Paleozoic basinal facies, all of which reached late stages of petroleum generation during burial by the Late Paleozoic succession. Potential sources in the Mesozoic succession, while within the oil window, are inferred dominated by gas prone organic facies. Organic-rich mid to outer shelf mudrocks, possible oil sources, occur within the Upper Cretaceous succession just north of the study region, in the N.W.T., but they are situated unfavorably to allow for oil migration into the study area.
Depth to Oil/Gas Window	Based on regional patterns of thermal maturity, the start of the oil window is inferred for surface outcrops of Mesozoic strata in the undeformed Plains increasing to the outcrop of the over mature gas zone inferred for the Paleozoic strata in the region west of the Trevor Fault. Still the region lacks any specific data from outcrops and wells within the study area.
Wells in Study Area	19 D&A

	WELL_NAME		LAT	LONG	KBE	SPUD
1	RO CORP ET AL POINT SEPARATION #1 A-05	nwt	67.57	-134.00	18.90	07/31/1960
2	ATLANTIC ET AL ONTARATUE H-34	nwt	66.39	-132.10	141.70	12/20/1963
3	IOE CLARE F-79	nwt	67.14	-133.24	108.80	6/20/1965
4	SHELL PEEL RIVER YT J-21	yt	66.51	-134.07	45.70	07/31/1965
5	SHELL PEEL RIVER YT K-76	yt	66.43	-134.24	76.50	10/07/1965
6	IOE STONY I-50	nwt	67.50	-135.38	321.90	12/10/1965
7	SHELL PEEL RIVER YT L-01	yt	66.51	-134.77	394.70	12/12/1965
8	IOE NEVEJO M-05	nwt	67.25	-134.03	74.40	02/01/1966
9	SHELL PEEL RIVER YT I-21	yt	66.18	-134.31	381.30	02/20/1966
10	SHELL PEEL RIVER YT L-19	yt	66.81	-135.31	95.10	04/11/1966
11	IOE MARTIN HOUSE L-50	nwt	66.83	-133.40	88.10	04/17/1966
12	SHELL PEEL RIVER YT B-06	yt	66.59	-134.76	65.20	12/14/1966
13	SHELL PEEL RIVER YT B-06A	yt	66.59	-134.76	66.40	01/03/1967
14	IOE SATAH RIVER YT G-72	yt	66.86	-134.23	89.60	01/13/1967
15	SHELL PEEL RIVER YT K-09	yt	66.31	-134.02	349.60	02/06/1967
16	IOE SWAN LAKE K-28	nwt	67.13	-133.58	89.60	3/2/1967
17	SHELL PEEL RIVER YT H-59	yt	66.64	-134.66	33.50	03/13/1967
18	IOE TREE RIVER H-38	nwt	67.29	-132.35	79.60	4/23/1967
19	IOE STONEY CORE HOLE F-52	nwt	67.36	-135.67	304.80	07/27/1967
20	IOE STONEY CORE HOLE F-42	yt	67.36	-135.64	327.70	08/02/1967
21	IOE STONEY CORE HOLE 2F-52	yt	67.36	-135.68	304.80	08/13/1967
22	IOE STONEY CORE HOLE C-02	yt	67.35	-135.52	275.80	08/23/1967
23	TOLTEC PEEL RIVER YT N-77	yt	65.95	-134.49	148.40	10/07/1968
24	MCD GCO NORTHUP TAYLOR LAKE YT K-15	yt	65.91	-133.05	468.80	02/05/1969
25	INC NCO MOBIL ATTOE LAKE I-06	nwt	67.43	-133.25	86.30	12/16/1969
NORTH	BANFF AQUIT ARCO RAT PASS K-35	nwt	67.91	-135.37	24.70	10/21/1970
NORTH	BANFF AQUIT ARCO TREELESS CREEK I-51	nwt	67.85	-135.41	28.30	12/18/1970
26	IOE TREE RIVER F-57	nwt	67.11	-132.43	98.00	12/12/1970
27	SHELL ARCTIC RED RIVER O-27	nwt	66.78	-132.83	136.60	12/26/1970
28	SHELL TREE RIVER EAST H-57	nwt	67.11	-132.41	108.20	3/17/1971
29	SHELL ARCTIC RED WEST G-55	nwt	66.74	-133.17	44.50	03/31/1971
30	UNION AMOCO MCPHERSON B-25	nwt	67.23	-135.57	492.30	01/08/1972
31	SHELL SAINVILLE RIVER K-63	nwt	66.38	-133.20	138.70	01/12/1972
32	AMOCO PCP A-1 CRANSWICK A-22	nwt	65.52	-131.82	768.40	01/25/1972
33	AMOCO PCP B-1 CRANSWICK YT A-42	yt	65.69	-133.13	620.00	04/14/1972
34	SKELLY-GETTY MOBIL ARCTIC RED C-60	yt	66.82	-133.92	92.00	01/15/1972
NORTH	SKELLY-GETTY AMOCO FT MCPHERSON C-78	nwt	67.62	-134.24	19.80	04/09/1972
35	PACIFIC ET AL PEEL YT F-37	yt	66.94	-134.87	54.60	02/13/1972
NORTH	DOME UNION IOE STONY G-06	nwt	67.59	-135.26	56.70	12/13/1972
NORTH	BLUEMOUNT ET AL GULF S DELTA J-80	nwt	67.66	-134.73	15.20	12/21/1972
EAST	CANDEL ET AL TEXACO ARCTIC RED F-47	nwt	65.61	-130.90	790.70	12/23/1972
EAST	CANDEL MOBIL ET AL N RAMPARTS A-59	nwt	65.47	-130.66	580.30	01/22/1973
36	DECAL TRANS OCEAN EXCO ONTARATUE I-38	nwt	66.29	-131.85	144.50	11/6/1972
37	INEXCO ET AL WELDON CREEK O-65	nwt	66.08	-132.45	222.80	03/05/1973
EAST	CANDEL MOBIL ET AL S RAMPARTS I-77	nwt	65.44	-130.97	595.60	03/14/1973
38	SHELL TRAIL RIVER YT H-37	yt	66.60	-134.85	393.20	11/27/1973
39	DOME TEXACO IMP SOUTH PEEL D-64	nwt	65.88	-132.46	558.10	04/04/1973
40	ARCO SHELL SAINVILLE RIVER D-08	nwt	66.29	-133.53	203.00	01/09/1974
41	GULF MOBIL CARIBOU YT N-25	yt	66.25	-134.83	495.30	05/01/1974
42	SHELL PEEL RIVER YT M-69	yt	66.15	-133.97	291.70	10/06/1974
43	MOBIL GULF PEEL YT H-71	yt	66.34	-134.73	513.00	02/03/1977
EAST	CHEVRON RAMPARTS RIVER F-46	nwt	65.76	-130.15	215.60	02/24/1991

Table 2: Schedulue of petroleum exploration wells in the Peel Plateau and Plain region. The table illustrates the the location, Kelly Bushing Elevation (KBE) and spud date of 43 wells discussed in the text.

Table 3: C5580111 - Upper Paleozoic Clastics Play Input Parameters

Peel Plateau U. Paleozoic Clastics West of Trevor F. - C5580111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.4	5	50	90
Net pay	m	5	25	35	40
Porosity	decimal fraction	0.09	0.12	0.15	0.17
Gas saturation	decimal fraction	0.50	0.70	0.85	0.90
Gas compressibility factor	decimal fraction	0.84	0.85	0.86	0.90
Reservoir temperature	^{o}C	37	50	80	110
Reservoir pressure	kPa	10000	15000	20000	25000

Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.7		X		
Presence of reservoir facies	0.3	X			

Adequate seal	0.5	X			
Appropriate timing	0.05		X		
Adequate source	0.6		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	20	100	200		

Table 4: C5580111 - Upper Paleozoic Clastics Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 6.3516   Expected (Mean) Value   = 794.32

Sigma Squared= .65187   Standard Deviation   = 761.52

Upper Percentiles pf the Prospect Size Distribution (Precentile = Value)

99.99% = 28.471	60.00% = 467.32	15.00% = 1323.9
99.00% = 87.645	55.00% = 518.06	10.00% = 1613.7
95.00% = 151.95	50.00% = 573.38	8.00% = 1782.9
90.00% = 203.74	45.00% = 634.61	6.00% = 2011.9
85.00% = 248.33	40.00% = 703.52	5.00% = 2163.7
80.00% = 290.63	35.00% = 782.62	4.00% = 2356.7
75.00% = 332.61	30.00% = 875.63	2.00% = 3010.1
70.00% = 375.46	25.00% = 988.44	1.00% = 3751.1
65.00% = 420.08	20.00% = 1131.2	.01% = 11547.

Table 5: C5580111 - Upper Paleozoic Clastics Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 5

Expected Number of Pools .13242

Standard Deviation= .36963

Summary Statistics for 4000 Simulations

Play Resource: (million cubic metres)

Minimum = 0.0

Maximum = 5873.068

Expectation = 104.8084

Standard Deviation= 404.9322

Play Potential Greater Than (million cubic metres)

100.00	0.0
10.00	257.53
8.00	446.59
6.00	620.84
5.00	735.90
4.00	854.67
2.00	1365.0
1.00	2031.6
.01	5691.4
.00	5854.9

Table 6: C5580111 - Upper Paleozoic Clastics Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

Expected (Mean) Value = 822.52 Standard Deviation = 780.58 P(N>=r) = .12219

99%	= 89.839	75%	= 345.86	10%	= 1668.1
95%	= 156.68	50%	= 597.43	5%	= 2229.1
90%	= 210.81	25%	= 1027.1	1%	= 3842.3

Table 7: C5560111- Paleozoic Carbonate Platform Play Input Parameters

Peel Plain Paleozoic Carbonate Platform - C5560111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.4	5	20	45
Net pay	m	2	10	35	40
Porosity	decimal fraction	0.02	0.06	0.12	0.20
Gas saturation	decimal fraction	0.70	0.77	0.80	0.81
Gas compressibility factor	decimal fraction	0.94	0.96	0.98	0.98
Reservoir temperature	^oC	70	110	120	125
Reservoir pressure	kPa	20000	25000	30000	33000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.2		X		
Presence of reservoir facies	0.8		X		
Adequate seal	0.5		X		

Appropriate timing	0. 2		X		
Adequate source	0.5		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	30	150	300		

Table 8: C5560111- Paleozoic Carbonate Platform Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 5.0562 Expected (Mean) Value = 211.69

Sigma Squared = .59778 Standard Deviation = 191.47

99.99% = 8.8539	60.00% = 129.07	15.00% = 349.88
99.00% = 25.987	55.00% = 142.46	10.00% = 422.88
95.00% = 44.014	50.00% = 157.00	8.00% = 465.26
90.00% = 58.288	45.00% = 173.02	6.00% = 522.35
85.00% = 70.451	40.00% = 190.97	5.00% = 560.03
80.00% = 81.903	35.00% = 211.49	4.00% = 607.78
75.00% = 93.201	30.00% = 235.50	2.00% = 768.26
70.00% = 104.67	25.00% = 264.47	1.00% = 948.51
65.00% = 116.55	20.00% = 300.95	.01% = 2784.0

Table 9: C5560111- Paleozoic Carbonate Platform Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 11

Expected Number of Pools 1.25916

Standard Deviation= 1.28291

Play Resource: (millions of cubic metres)

Minimum = 0.0

Maximum = 2779.982

Expectation = 271.6128

Standard Deviation= 351.8854

Play Potential Greater Than (millions of cubic metres)

100.00	0.0
65.00	39.658
60.00	78.761
55.00	116.01
50.00	153.46
45.00	192.73
40.00	232.88
35.00	280.80
30.00	338.07
25.00	408.19
20.00	486.22
15.00	578.89
10.00	725.79
8.00	808.45
6.00	912.42
5.00	995.62
4.00	1095.4

2.00	1328.8
1.00	1564.5
.01	2727.9
.00	2774.8

Table 10: C5560111- Paleozoic Carbonate Platform Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 278.72 Standard Deviation = 229.56 P(N>=r)= .65924

99%	= 32.580	75%	= 130.47	10%	= 541.62
95%	= 58.240	50%	= 218.45	5%	= 698.81
90%	= 79.281	25%	= 354.23	1%	= 1134.9

Table 11: C5550111- Horn Plateau Reef Play Input Parameters

Peel Plain Horn Plateau Reef - C5550111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	1	5	8	10
Net pay	m	1	10	50	250
Porosity	decimal fraction	0.03	0.05	0.10	0.20
Gas saturation	decimal fraction	0.70	0.77	0.81	0.85
Gas compressibility factor	decimal fraction	0.94	0.96	0.98	0.98
Reservoir temperature	^oC	70	110	120	125
Reservoir pressure	kPa	20000	25000	30000	33000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.9		X		
Presence of reservoir facies	0.1	X			
Adequate seal	0.9		X		

Appropriate timing	1.0		X		
Adequate source	0.9		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	1	10	40		

Table 12: C5550111- Horn Plateau Reef Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 6.1684 Expected (Mean) Value = 755.76

Sigma Squared = .91860 Standard Deviation = 927.39

99.99% = 13.517	60.00% = 374.50	15.00% = 1289.2
99.00% = 51.355	55.00% = 423.26	10.00% = 1630.6
95.00% = 98.685	50.00% = 477.43	8.00% = 1835.5
90.00% = 139.79	45.00% = 538.54	6.00% = 2118.7
85.00% = 176.81	40.00% = 608.65	5.00% = 2309.8
80.00% = 213.10	35.00% = 690.71	4.00% = 2556.4
75.00% = 250.13	30.00% = 789.20	2.00% = 3418.0
70.00% = 288.82	25.00% = 911.30	1.00% = 4438.5
65.00% = 330.01	20.00% = 1069.6	.01% = 16863.

Table 13: C5550111- Horn Plateau Reef Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 37

Expected Number of Pools 1.14453

Standard Deviation= 4.40238

Play Resource: (billions of cubic metres)

Minimum = 0.0

Maximum = 32.37705

Expectation = .8881077

Standard Deviation= 3.504533

Play Potential Greater Than (billions of cubic metres)

100.00	0.0
8.00	2.2546
6.00	4.9818
5.00	6.7448
4.00	9.2399
2.00	16.084
1.00	19.307
.01	31.480
.00	32.287

Table 14: C5550111- Horn Plateau Reef Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 2381.5 Standard Deviation = 1956.3 P(N>=r)= .99180E-01

99%	= 192.56	75%	= 1135.4	10%	= 4543.1
95%	= 439.67	50%	= 1922.7	5%	= 5836.3
90%	= 644.53	25%	= 3033.6	1%	= 9591.6

Table 15: C5530111 - Upper Paleozoic Clastics Play Input Parameters

Peel Plain Upper Paleozoic Clastics - C5530111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.4	5	15	20
Net pay	m	2	10	35	40
Porosity	decimal fraction	0.05	0.06	0.08	0.15
Gas saturation	decimal fraction	0.70	0.77	0.80	0.91
Gas compressibility factor	decimal fraction	0.94	0.96	0.98	0.98
Reservoir temperature	^oC	50	70	70	110
Reservoir pressure	kPa	20000	21000	22000	23000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.5		X		
Presence of reservoir facies	0.7		X		
Adequate seal	0.4		X		

Appropriate timing	0. 5		X		
Adequate source	0.5		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	60	250	500		

Table 16: C5530111 - Upper Paleozoic Clastics Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 6.5331 Expected (Mean) Value = 772.34

Sigma Squared = .23273 Standard Deviation = 395.36

99.99% = 114.31	60.00% = 608.41	15.00% = 1133.5
99.00% = 223.81	55.00% = 647.06	10.00% = 1275.8
95.00% = 310.92	50.00% = 687.50	8.00% = 1354.1
90.00% = 370.48	45.00% = 730.47	6.00% = 1455.5
85.00% = 416.99	40.00% = 776.88	5.00% = 1520.2
80.00% = 458.08	35.00% = 827.95	4.00% = 1599.8
75.00% = 496.54	30.00% = 885.40	2.00% = 1851.7
70.00% = 533.83	25.00% = 951.89	1.00% = 2111.9
65.00% = 570.88	20.00% = 1031.8	.01% = 4134.8

Table 17: C5530111 - Upper Paleozoic Clastics Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 36

Expected Number of Pools 9.25908

Standard Deviation= 5.39641

Play Resource: (billions of cubic metres)

Minimum = .0000000E+00Maximum = 27.59620

Expectation = 7.260026 Standard Deviation= 4.380226

Play Potential Greater Than (billions of cubic metres)

100.00	0.0
99.00	.33379
95.00	1.1521
90.00	1.9489
85.00	2.5999
80.00	3.1681
75.00	3.7273
70.00	4.2834
65.00	4.8640
60.00	5.5146
55.00	6.1362
50.00	6.7263
45.00	7.3981
40.00	8.0641
35.00	8.7398
30.00	9.5145
25.00	10.306
20.00	11.024
15.00	11.920

10.00	13.208
8.00	13.924
6.00	14.700
5.00	15.162
4.00	15.627
2.00	17.323
1.00	18.724
.01	26.776
.00	27.514

Table 18: C5530111 - Upper Paleozoic Clastics Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 1417.5 Standard Deviation = 514.16 P(N>=r)= .99044

99% = 475.23 75% = 1074.3 10% = 2061.9

95% = 709.27 50% = 1351.5 5% = 2343.0

90% = 843.51 25% = 1682.3 1% = 3020.9

2 Expected (Mean) Value = 1068.9 Standard Deviation = 339.51 P(N>=r)= .96095

99% = 355.00 75% = 839.72 10% = 1499.6

95% = 533.68 50% = 1054.5 5% = 1649.1

90% = 645.45 25% = 1277.1 1% = 1975.5

3 Expected (Mean) Value = 908.56 Standard Deviation = 280.84 P(N>=r)= .91119

99% = 304.31 75% = 716.47 10% = 1265.3

95% = 449.31 50% = 905.88 5% = 1376.7

90% = 544.52 25% = 1091.4 1% = 1608.0

4 Expected (Mean) Value = 809.00 Standard Deviation = 246.57 P(N>=r)= .84812

99% = 276.94 75% = 638.21 10% = 1123.0

95% = 401.54 50% = 809.78 5% = 1215.6

90% = 484.50 25% = 974.19 1% = 1402.3

5 Expected (Mean) Value = 738.29 Standard Deviation = 222.15 P(N>=r)= .77902

99% = 259.29 75% = 583.00 10% = 1022.0

95% = 370.41 50% = 739.91 5% = 1103.1

90% = 444.34 25% = 889.38 1% = 1263.4

6 Expected (Mean) Value = 683.75 Standard Deviation = 203.18 P(N>=r)= .70848

99%   = 246.35   75%   = 540.85   10%   = 944.08

95%   = 347.65   50%   = 685.25   5%   = 1017.3

90%   = 414.64   25%   = 823.05   1%   = 1159.8

7   Expected (Mean) Value   = 639.32   Standard Deviation   = 187.74   P(N>=r)= .63880

99%   = 235.97   75%   = 506.73   10%   = 880.64

95%   = 329.58   50%   = 640.31   5%   = 947.92

90%   = 390.99   25%   = 768.53   1%   = 1077.7

8   Expected (Mean) Value   = 601.73   Standard Deviation   = 174.78   P(N>=r)= .57109

99%   = 227.15   75%   = 477.93   10%   = 827.12

95%   = 314.40   50%   = 602.07   5%   = 889.80

90%   = 371.15   25%   = 722.18   1%   = 1009.8

9   Expected (Mean) Value   = 569.07   Standard Deviation   = 163.68   P(N>=r)= .50587

99%   = 219.34   75%   = 452.86   10%   = 780.83

95%   = 301.12   50%   = 568.71   5%   = 839.79

90%   = 353.86   25%   = 681.83   1%   = 952.01

Table 19: Mesozoic Clastics - C5520111 Play Input Parameters

Peel Plain Mesozoic Clastics - C5520111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.4	5	15	20
Net pay	m	2	10	35	40
Porosity	decimal fraction	0.05	0.06	0.08	0.15
Gas saturation	decimal fraction	0.70	0.77	0.80	0.91
Gas compressibility factor	decimal fraction	0.94	0.96	0.98	0.98
Reservoir temperature	^oC	50	70	70	110
Reservoir pressure	kPa	20000	21000	22000	23000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.5		X		
Presence of reservoir facies	0.7		X		
Adequate seal	0.4		X		

Appropriate timing	0. 5		X		
Adequate source	0.5		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	60	250	500		

Table 20: Mesozoic Clastics - C5520111 Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 6.5819 Expected (Mean) Value = 920.40

Sigma Squared = .48592 Standard Deviation = 728.03

99.99% = 54.022	60.00% = 605.01	15.00% = 1486.7
99.00% = 142.62	55.00% = 661.33	10.00% = 1763.7
95.00% = 229.35	50.00% = 721.87	8.00% = 1922.3
90.00% = 295.45	45.00% = 787.96	6.00% = 2133.8
85.00% = 350.50	40.00% = 861.31	5.00% = 2272.1
80.00% = 401.49	35.00% = 944.31	4.00% = 2446.0
75.00% = 451.10	30.00% = 1040.4	2.00% = 3021.4
70.00% = 500.85	25.00% = 1155.2	1.00% = 3653.7
65.00% = 551.84	20.00% = 1297.9	.01% = 9646.1

Table 21: Mesozoic Clastics - C5520111 Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 138

Expected Number of Pools 55.01390

Standard Deviation= 27.23049

Play Resource: (billions of cubic metres)

Minimum = 0.0

Maximum = 139.1178

Expectation = 49.48738

Standard Deviation= 25.81436

Play Potential Greater Than (billions of cubic metres)

100.00	0.0
99.00	7.1327
95.00	12.975
90.00	16.682
85.00	20.495
80.00	24.165
75.00	27.931
70.00	31.707
65.00	35.430
60.00	39.197
55.00	42.768
50.00	46.447
45.00	51.235
40.00	55.609
35.00	60.557
30.00	65.401
25.00	70.118

20.00	74.641
15.00	79.168
10.00	84.661
8.00	87.846
6.00	91.343
5.00	93.114
4.00	95.001
2.00	99.913
1.00	107.67
.01	138.94
.00	139.10

Table 22: Mesozoic Clastics - C5520111 Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 3633.1 Standard Deviation = 1463.5 P(N>=r)=1.00000

99% = 1437.8 75% = 2665.8 10% = 5404.6

95% = 1875.4 50% = 3356.3 5% = 6305.9

90% = 2149.2 25% = 4265.5 1% = 8655.7

2 Expected (Mean) Value = 2683.3 Standard Deviation = 828.45 P(N>=r)=1.00000

99% = 1143.2 75% = 2112.7 10% = 3738.6

95% = 1490.6 50% = 2600.0 5% = 4156.2

90% = 1708.8 25% = 3148.6 1% = 5122.5

3 Expected (Mean) Value = 2271.0 Standard Deviation = 652.01 P(N>=r)=1.00000

99% = 961.95 75% = 1818.0 10% = 3105.0

95% = 1265.9 50% = 2237.7 5% = 3394.6

90% = 1458.7 25% = 2672.7 1% = 4026.6

4 Expected (Mean) Value = 2014.3 Standard Deviation = 567.75 P(N>=r)= .99999

99% = 828.12 75% = 1618.1 10% = 2738.1

95% = 1105.9 50% = 2004.0 5% = 2967.9

90% = 1283.6 25% = 2382.4 1% = 3451.5

5 Expected (Mean) Value = 1830.1 Standard Deviation = 517.94 P(N>=r)= .99997

99% = 720.33 75% = 1467.6 10% = 2487.1

95% = 981.01 50% = 1833.3 5% = 2681.7

90% = 1148.9 25% = 2177.6 1% = 3080.7

6 Expected (Mean) Value = 1687.4 Standard Deviation = 484.95 P(N>=r)= .99989

99% = 628.96 75% = 1347.3 10% = 2299.2

95% = 878.21 50% = 1699.6 5% = 2470.3

90% = 1039.3 25% = 2020.9 1% = 2814.2

7 Expected (Mean) Value = 1571.3 Standard Deviation = 461.46 P(N>=r)= .99965

99% = 549.22 75% = 1247.6 10% = 2150.4

95% = 790.66 50% = 1590.2 5% = 2304.6

90% = 947.08 25% = 1894.9 1% = 2609.4

8 Expected (Mean) Value = 1474.0 Standard Deviation = 443.77 P(N>=r)= .99910

99% = 479.02 75% = 1162.7 10% = 2028.0

95% = 714.63 50% = 1497.8 5% = 2169.3

90% = 867.69 25% = 1790.1 1% = 2444.8

9 Expected (Mean) Value = 1390.6 Standard Deviation = 429.67 P(N>=r)= .99797

99% = 418.00 75% = 1089.4 10% = 1924.7

95% = 648.13 50% = 1418.3 5% = 2055.7

90% = 798.62 25% = 1700.7 1% = 2308.3

10 Expected (Mean) Value = 1318.3 Standard Deviation = 417.74 P(N>=r)= .99592

99% = 366.62 75% = 1025.5 10% = 1835.6

95% = 590.27 50% = 1348.8 5% = 1958.2

90% = 738.48 25% = 1623.1 1% = 2192.3

11 Expected (Mean) Value = 1255.0 Standard Deviation = 407.00 P(N>=r)= .99261

99% = 325.11 75% = 969.61 10% = 1757.5

95% = 540.67 50% = 1287.5 5% = 1873.2

90% = 686.50 25% = 1554.8 1% = 2092.0

12 Expected (Mean) Value = 1199.5 Standard Deviation = 396.80 P(N>=r)= .98776

99% = 292.85 75% = 920.83 10% = 1688.4

95% = 499.08 50% = 1233.1 5% = 1798.1

90% = 642.14 25% = 1494.2 1% = 2003.9

13 Expected (Mean) Value = 1150.5 Standard Deviation = 386.79 P(N>=r)= .98123

99% = 268.47 75% = 878.26 10% = 1626.5

95% = 465.00 50% = 1184.5 5% = 1731.0

90% = 604.82 25% = 1439.8 1% = 1925.6

14 Expected (Mean) Value = 1107.2 Standard Deviation = 376.82 P(N>=r)= .97307

99% = 250.33 75% = 841.12 10% = 1570.6

95% = 437.60 50% = 1141.1 5% = 1670.4

90% = 573.75 25% = 1390.6 1% = 1855.4

15 Expected (Mean) Value = 1068.5 Standard Deviation = 366.89 P(N>=r)= .96349

99% = 236.88 75% = 808.55 10% = 1519.7

95% = 415.76 50% = 1101.9 5% = 1615.4

90% = 547.96 25% = 1345.8 1% = 1791.8

Table 23: C5570111 - Paleozoic Carbonate Margin Play Input Parameters

Peel Plateau Paleozoic Carbonate Margin - C5570111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.4	5	40	90
Net pay	m	20	30	40	41
Porosity	decimal fraction	0.02	0.06	0.12	0.20
Gas saturation	decimal fraction	0.70	0.77	0.80	0.81
Gas compressibility factor	decimal fraction	0.94	0.96	0.98	0.98
Reservoir temperature	^oC	70	110	120	125
Reservoir pressure	kPa	20000	25000	30000	35000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.8		X		
Presence of reservoir facies	0.5		X		
Adequate seal	0.8		X		

Appropriate timing	0. 2		X		
Adequate source	1.0		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	10	100	200		

Table 24: C5570111 - Paleozoic Carbonate Margin Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 6.1549 Expected (Mean) Value = 675.53

Sigma Squared = .72128 Standard Deviation = 694.54

99.99% = 20.013	60.00% = 379.82	15.00% = 1135.8
99.00% = 65.309	55.00% = 423.32	10.00% = 1398.6
95.00% = 116.50	50.00% = 471.00	8.00% = 1553.3
90.00% = 158.61	45.00% = 524.05	6.00% = 1763.9
85.00% = 195.32	40.00% = 584.07	5.00% = 1904.2
80.00% = 230.46	35.00% = 653.35	4.00% = 2083.3
75.00% = 265.61	30.00% = 735.26	2.00% = 2694.8
70.00% = 301.72	25.00% = 835.22	1.00% = 3396.8
65.00% = 339.55	20.00% = 962.60	.01% = 11085.

Table 25: C5570111 - Paleozoic Carbonate Margin Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 29

Expected Number of Pools 6.56288

Standard Deviation= 4.32511

Play Resource: (billions of cubic metres)

Minimum = 0.0

Maximum = 22.28020

Expectation = 4.459507

Standard Deviation= 3.445769

Play Potential Greater Than (billions of cubic metres)

100.00	0.0
90.00	.47541
85.00	.85890
80.00	1.2871
75.00	1.7286
70.00	2.1535
65.00	2.5039
60.00	2.9304
55.00	3.4309
50.00	3.9029
45.00	4.3781
40.00	4.8487
35.00	5.3115
30.00	5.8657
25.00	6.5147
20.00	7.2689
15.00	8.1095

10.00	9.1523
8.00	9.7657
6.00	10.395
5.00	10.759
4.00	11.323
2.00	13.041
1.00	14.371
.01	22.206
.00	22.273

Table 26: C5570111 - Paleozoic Carbonate Margin Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 1603.8 Standard Deviation = 1176.6 P(N>=r)= .95375

99% = 166.98 75% = 853.44 10% = 2942.3

95% = 361.80 50% = 1336.7 5% = 3717.3

90% = 519.40 25% = 2020.0 1% = 5895.6

2 Expected (Mean) Value = 947.62 Standard Deviation = 557.36 P(N>=r)= .87829

99% = 116.51 75% = 554.35 10% = 1654.1

95% = 236.23 50% = 855.09 5% = 1971.9

90% = 335.89 25% = 1226.2 1% = 2747.6

3 Expected (Mean) Value = 705.67 Standard Deviation = 387.85 P(N>=r)= .79491

99% = 96.003 75% = 423.50 10% = 1210.8

95% = 185.66 50% = 650.41 5% = 1416.3

90% = 259.40 25% = 919.32 1% = 1887.5

4 Expected (Mean) Value = 569.07 Standard Deviation = 302.68 P(N>=r)= .71078

99% = 83.623 75% = 345.69 10% = 968.26

95% = 156.20 50% = 528.59 5% = 1122.7

90% = 214.81 25% = 742.87 1% = 1464.6

5 Expected (Mean) Value = 477.97 Standard Deviation = 249.30 P(N>=r)= .62750

99% = 74.810 75% = 292.57 10% = 809.31

95% = 135.97 50% = 445.17 5% = 934.09

90% = 184.47 25% = 624.00 1% = 1204.4

6 Expected (Mean) Value = 411.65 Standard Deviation = 211.89 P(N>=r)= .54575

99% = 67.989 75% = 253.42 10% = 694.77

95% = 120.82 50% = 383.56 5% = 799.97

90% = 162.00 25% = 536.92 1% = 1024.4

7 Expected (Mean) Value = 360.74 Standard Deviation = 183.88 P(N>=r)= .46627

99% = 62.448 75% = 223.16 10% = 607.40

95% = 108.86 50% = 335.91 5% = 698.53

90% = 144.48 25% = 469.80 1% = 891.01

Table 27: C5540111 - Upper Paleozoic Clastics Play Input Parameters

Peel Plateau U. Paleozoic Clastics - C5540111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.4	5	50	90
Net pay	m	15	25	35	40
Porosity	decimal fraction	0.09	0.13	0.18	0.20
Gas saturation	decimal fraction	0.50	0.70	0.85	0.90
Gas compressibility factor	decimal fraction	0.78	0.80	0.82	0.92
Reservoir temperature	^{o}C	37	50	80	110
Reservoir pressure	kPa	20100	22100	23100	25000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.3		X		
Presence of reservoir facies	0.5		X		
Adequate seal	0.4		X		

Appropriate timing	0.25		X		
Adequate source	0.5		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	40	200	400		

Table 28: C5540111 - Upper Paleozoic Clastics Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 8.3146 Expected (Mean) Value = 4851.6

Sigma Squared = .34496 Standard Deviation = 3113.9

99.99% = 459.57	60.00% = 3518.5	15.00% = 7505.0
99.00% = 1041.3	55.00% = 3792.5	10.00% = 8667.1
95.00% = 1553.9	50.00% = 4083.0	8.00% = 9319.2
90.00% = 1923.5	45.00% = 4395.8	6.00% = 10176.
85.00% = 2221.3	40.00% = 4738.1	5.00% = 10729.
80.00% = 2490.6	35.00% = 5120.0	4.00% = 11417.
75.00% = 2747.5	30.00% = 5555.8	2.00% = 13641.
70.00% = 3000.7	25.00% = 6067.7	1.00% = 16009.
65.00% = 3256.1	20.00% = 6693.6	.01% = 36275.

Table 29: C5540111 - Upper Paleozoic Clastics Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 13

Expected Number of Pools 1.57271

Standard Deviation= 1.47677

Play Resource: (billions of cubic metres)

Minimum = 0.0

Maximum = 62.13422

Expectation = 7.799449

Standard Deviation= 8.224876

Play Potential Greater Than (billions of cubic metres)

100.00	0.0
70.00	2.0023
65.00	2.8683
60.00	3.8776
55.00	4.7777
50.00	5.6841
45.00	6.6630
40.00	7.7021
35.00	8.9801
30.00	10.389
25.00	12.046
20.00	13.813
15.00	16.001
10.00	19.156
8.00	20.694
6.00	22.545
5.00	23.842

4.00	25.707
2.00	30.410
1.00	34.442
.01	61.286
.00	62.049

Table 30: C5540111 - Upper Paleozoic Clastics Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 6278.5 Standard Deviation = 3661.6 P(N>=r)= .72551

99% = 1288.2 75% = 3750.0 10% = 10832.

95% = 2021.9 50% = 5517.1 5% = 13097.

90% = 2565.4 25% = 7900.5 1% = 18823.

2 Expected (Mean) Value = 4157.9 Standard Deviation = 2005.1 P(N>=r)= .43770

99% = 1053.9 75% = 2708.0 10% = 6785.4

95% = 1571.0 50% = 3820.8 5% = 7890.2

90% = 1935.9 25% = 5223.8 1% = 10411.

Table 31: Mesozoic Clastics C5510111 Play Input Parameters

Peel Plateau Mesozoic Clastics C5510111	Probability distributions of reservoir parameters				
Geological variable	Unit of measurement	Value at an upper percentile probability = 1.00	Value at an upper percentile probability = 0.50	Value at an upper percentile probability = 0.01	Value at an upper percentile probability = 0.00
Area of closure	km^2	0.1	5	50	105
Net pay	m	2	10	20	30
Porosity	decimal fraction	0.03	0.06	0.09	0.10
Gas saturation	decimal fraction	0.70	0.77	0.80	0.91
Gas compressibility factor	decimal fraction	0.76	0.78	0.8	0.8
Reservoir temperature	^{o}C	50	80	90	120
Reservoir pressure	kPa	20000	21000	22000	23000
Marginal probabilities of geological risk factors	Marginal probability	Play level	Prospect level		
Presence of closure	0.75		X		
Presence of reservoir facies	0.5		X		
Adequate seal	.70		X		

Appropriate timing	1.0				
Adequate source	0.9		X		
Probability distribution for number of prospects	Probability in upper percentiles	Probability in upper percentiles	Probability in upper percentiles		
	0.99	0.5	0.00		
Number of prospects	30	45	90		

Table 32: Mesozoic Clastics C5510111 Play Calculated Prospect Size Using the Lognormal Approximation (millions of cubic metres initial in place)

Logarithmic Mean = 6.5685 Expected (Mean) Value = 1050.2

Sigma Squared = .77653 Standard Deviation = 1137.9

99.99% = 26.878	60.00% = 569.79	15.00% = 1775.5
99.00% = 91.700	55.00% = 637.64	10.00% = 2203.6
95.00% = 167.18	50.00% = 712.31	8.00% = 2456.9
90.00% = 230.26	45.00% = 795.72	6.00% = 2803.4
85.00% = 285.77	40.00% = 890.49	5.00% = 3035.0
80.00% = 339.30	35.00% = 1000.3	4.00% = 3331.7
75.00% = 393.13	30.00% = 1130.7	2.00% = 4351.6
70.00% = 448.72	25.00% = 1290.6	1.00% = 5533.1
65.00% = 507.23	20.00% = 1495.4	.01% = 18878.

Table 33: Mesozoic Clastics C5510111 Play Number of Pools Distribution

Minimum Number of Pools 0

Maximum Number of Pools 39

Expected Number of Pools 12.50235

Standard Deviation= 5.24344

Play Resource: (billions of cubic metres)

Minimum = .5068488 Maximum = 51.76637

Expectation = 13.15733 Standard Deviation= 6.809610

Play Potential Greater Than (billions of cubic metres)

100.00	.50685
99.00	2.3877
95.00	4.0868
90.00	5.3688
85.00	6.3688
80.00	7.3402
75.00	8.1008
70.00	8.8384
65.00	9.7182
60.00	10.462
55.00	11.217
50.00	12.018
45.00	12.800
40.00	13.758
35.00	14.807
30.00	15.919
25.00	17.114
20.00	18.570
15.00	20.202

10.00	22.316
8.00	23.468
6.00	25.013
5.00	25.718
4.00	26.910
2.00	29.845
1.00	33.223
.01	49.720
.00	51.562

Table 34: Mesozoic Clastics C5510111 Play; Pool Size Rank, Followed by a description of the individual Pool Size Distribution

1 Expected (Mean) Value = 3392.7 Standard Deviation = 2181.7 P(N>=r)= .99996

99% = 823.97 75% = 2020.7 10% = 5842.2

95% = 1216.0 50% = 2860.7 5% = 7311.9

90% = 1476.2 25% = 4111.6 1% = 11478.

2 Expected (Mean) Value = 2033.4 Standard Deviation = 987.53 P(N>=r)= .99960

99% = 528.32 75% = 1351.8 10% = 3276.8

95% = 813.65 50% = 1852.8 5% = 3858.7

90% = 994.03 25% = 2503.6 1% = 5292.6

3 Expected (Mean) Value = 1502.0 Standard Deviation = 687.66 P(N>=r)= .99772

99% = 352.60 75% = 1015.7 10% = 2392.4

95% = 586.18 50% = 1399.6 5% = 2763.9

90% = 731.96 25% = 1870.3 1% = 3622.2

4 Expected (Mean) Value = 1191.0 Standard Deviation = 548.43 P(N>=r)= .99144

99% = 240.95 75% = 797.28 10% = 1910.1

95% = 432.68 50% = 1119.8 5% = 2189.7

90% = 556.38 25% = 1503.1 1% = 2810.3

5 Expected (Mean) Value = 980.99 Standard Deviation = 465.06 P(N>=r)= .97596

99% = 174.64 75% = 641.87 10% = 1596.5

95% = 326.80 50% = 924.89 5% = 1824.4

90% = 432.05 25% = 1256.0 1% = 2316.0

6 Expected (Mean) Value = 830.42 Standard Deviation = 406.95 P(N>=r)= .94581

99% = 136.47 75% = 528.57 10% = 1373.7

95% = 256.33 50% = 782.16 5% = 1567.9

90% = 344.84 25% = 1077.3 1% = 1978.0

7 Expected (Mean) Value = 719.69 Standard Deviation = 362.41 P(N>=r)= .89742

99% = 113.86 75% = 446.62 10% = 1207.1

95% = 210.90 50% = 676.05 5% = 1377.2

90% = 285.40 25% = 943.44 1% = 1730.4

8 Expected (Mean) Value = 637.17 Standard Deviation = 326.25 P(N>=r)= .83122

99% = 99.855 75% = 388.38 10% = 1078.4

95% = 181.77 50% = 597.18 5% = 1229.7

90% = 245.71 25% = 841.04 1% = 1540.4

9 Expected (Mean) Value = 574.79 Standard Deviation = 295.84 P(N>=r)= .75195

99% = 90.866 75% = 347.56 10% = 976.03

95% = 162.90 50% = 538.45 5% = 1112.2

90% = 219.36 25% = 761.15 1% = 1389.3

10 Expected (Mean) Value = 526.42 Standard Deviation = 269.57 P(N>=r)= .66682

99% = 84.947 75% = 318.83 10% = 892.28

95% = 150.47 50% = 493.88 5% = 1015.6

90% = 201.73 25% = 697.02 1% = 1265.4

11 Expected (Mean) Value = 487.32 Standard Deviation = 246.45 P(N>=r)= .58289

99% = 80.926 75% = 297.83 10% = 821.49

95% = 142.01 50% = 458.41 5% = 933.87

90% = 189.54 25% = 643.50 1% = 1160.9

12 Expected (Mean) Value = 453.96 Standard Deviation = 225.88 P(N>=r)= .50504

99% = 77.985 75% = 281.04 10% = 759.79

95% = 135.78 50% = 428.13 5% = 862.81

90% = 180.38 25% = 596.87 1% = 1070.7

Table 35: Summary Petroleum Resource Endowment of the Peel Plateau and Plain in the Yukon Territory, indicating the assessed Play Name, expected number of accumulations, their median and mean play potentials and the median size of the largest undiscovered accumulation in each play. Note the Peel Plain Arncia/Manetoe Dolostone Play was previously assessed, but it is no longer inferred to exist (see the discussion in the text). Note also that the arithmetic sum of the mean play potentials differs slightly from the statistical total potential derived by a probabilistic summation of the contributing play potentials, as quoted in the text.

Hydrocarbon Potential in the Peel Plateau and Plain of the Yukon

Natural Gas Plays (In-place volumes)

Play Name	Expected no. of accumulations (mean)	Median play potential (in-place) (million m^3)	Mean play potential (in-place) (million m^3)	Median of largest field size (in-place) (million m^3)
Peel Plain Mesozoic Clastics - C5520111	55	46,447.0	49,487.0	3,356.0
Peel Plain Upper Paleozoic Clastics - C5530111	9	6,726.0	7,260.0	1,352.0
Peel Plain Post-Hume Reef (Horne Plateau) - C5550111	1	-	888.0	888.0
Peel Plain Arnica/Manetoe Dolostone -	0	0.0	0.0	0.0
Peel Plain Paleozoic Carbonate Platform - C5560111	1	153.0	272.0	218.0
Peel Plateau Mesozoic Clastics - C5510111	12	12,018.0	13,157.0	2,861.0
Peel Plateau Upper Paleozoic Clastics - C5540111	2	5,684.0	7,799.0	5,517.0
Peel Plateau Cambrian-Devonian Carbonate Margin - C5570111	7	3,903.0	4,460.0	1,337.0
Peel Plateau U. Paleozoic Clastics West of Trevor F. - C5580111	1	-	105.0	105.0
Peel Pleateau Cambrian-Devonian West of Trevor F. -	0	0.0	0.0	0.0

Appendix 1: Standard Units and Abbreviations

$10^6 m^3$ - million cubic metres
$10^9 m^3$ - billion cubic metres
ac-ft - acre feet
AOF - absolute open flow
Bbls - barrels
Bcf - billion cubic feet
BOE - barrels of oil equivalent
d - day
10^3 ;E3 - thousands
10^6 E6 - millions
10^9 E9 - billions
ft - feet
ft kb - feet below Kelly (drill platform)
GIP - gas in place
GOR - gas/oil ratio
Ha - hectares
IMG - marketable gas
km - kilometres
m - metres
md - millidarcies
mm - millimetres
mi - miles
mKb - m below Kelly (drill platform)
MMbbls - million barrels
MMcf - million cubic feet
MMlt - million long tons
psi - pounds per square inch
Tcf - trillion cubic feet