PETROLEUM RESOURCE ASSESSMENT OF THE YUKON NORTH COAST, YUKON TERRITORY, CANADA

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Yukon
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■ FOREWORD

On November 19, 1998, the Government of Canada transferred to the Government of Yukon the administrative legislative powers and responsibilities of managing onshore oil and gas resources. Yukon oil and gas resources are now governed under the Yukon *Oil and Gas Act.*

A study of the petroleum resources of the Old Crow Basin in the Yukon Territory was undertaken by Geological Survey of Canada (GSC) in response to a request from the Government of Yukon. Assessment of petroleum resource potential is important for forming regulatory policies for these resources and for providing a basis for planning and issuing exploration rights.

▮ EXECUTIVE SUMMARY

This study was undertaken by the Geological Survey of Canada on behalf of the Yukon government as part of its ongoing oil and gas resources management program. The objective of the study was to investigate the hydrocarbon resource potential of the northern Arctic Coast in the Yukon Territory. A quantitative analysis was utilized to derive a numerical estimate of resources that may exist in the area. Due to the scarcity of defined pools with established reserves, probability distributions of reservoir parameters and marginal risk factors were employed to generate a range of hydrocarbon potential estimates. The predicted wide ranges of resource potential reveal the uncertainties involved in the analysis of frontier exploration plays.

Numerous regional tectonic and structural elements occur beneath the coastal lowland and shallow waters of the Beaufort Sea on the North Coast of the Yukon. The area west of the northern Richardson Mountains and extending into the Beaufort Sea consists of highly deformed strata of the Cordilleran Foldbelt. Structures, including compressional folds and strike-slip faults formed during the Laramide Orogeny, are underlain by older tectonic features such as the Cache Creek Uplift and Rapid Depression which originated as Mesozoic fault-bounded structures. North of Rapid Depression, several significant large-scale tectonic features, such as Blow River and Herschel highs, are cored by closely spaced anticlines. On the south flank of Herschel High, there lies a large synclinal structure filled with Eocene and younger strata called the Demarcation Subbasin.

The hydrocarbon potential volumes were derived using the Geological Survey of Canada's PETRIMES assessment methodology system. This resource study embraced analyses of six conceptual and immature plays, each of which incorporated estimations of field size parameters, numbers of prospects and exploration risks. The median estimate for total oil and gas potential for all coastal lowland plays are 39.8 million m^3 and 38.6 billion m^3, respectively. There are no discovered reserves in the Yukon portion of the assessment region. The assessment results indicate that four gas fields greater than 3,000 million m^3 (100 BCF) are expected in the region. No oil fields larger than 160 million m^3 (1 billion bbls.) are predicted beneath Yukon North Coast. Even though geological risk factors are substantial, significant gas potential is predicted for the Herschel play.

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■ INTRODUCTION

This study was undertaken by the Geological Survey of Canada on behalf of the Yukon Territorial Government as part of its ongoing oil and gas resource management program. The objective of this study was to investigate the hydrocarbon resource potential of the North Coast in the Yukon Territory (Fig. 1). A quantitative analysis was utilized to derive a numerical estimate of resources that may exist in the region. Due to the scarcity of defined pools with established reserves, probability distributions of reservoir parameters and marginal risk factors were adopted to generate a range of hydrocarbon potential estimates indicative of the uncertainties involved in the analysis of frontier conceptual and immature plays.

Regional petroleum resource assessments have been prepared periodically for numerous sedimentary basins in Canada by the Geological Survey of Canada. These studies incorporate systematic basin analysis with subsequent statistical resource evaluations (Podruski, *et al.*, 1988; Wade, *et al.*, 1989; Sinclair, *et al.*, 1992; Reinson, *et al.*, 1993; Bird, *et al.*, 1994; Dixon, *et al.*, 1994; Hannigan, *et al.*, 1998, 1999; Hannigan, in press (a), (b) and (c)).

This report provides an overview of the petroleum geology of the Yukon North Coast region and presents quantitative estimates of the oil and gas resources contained therein. The geological and resource framework for the region will assist government agencies in evaluating land-use and moratorium issues and petroleum industry companies in pursuing future exploration opportunities.
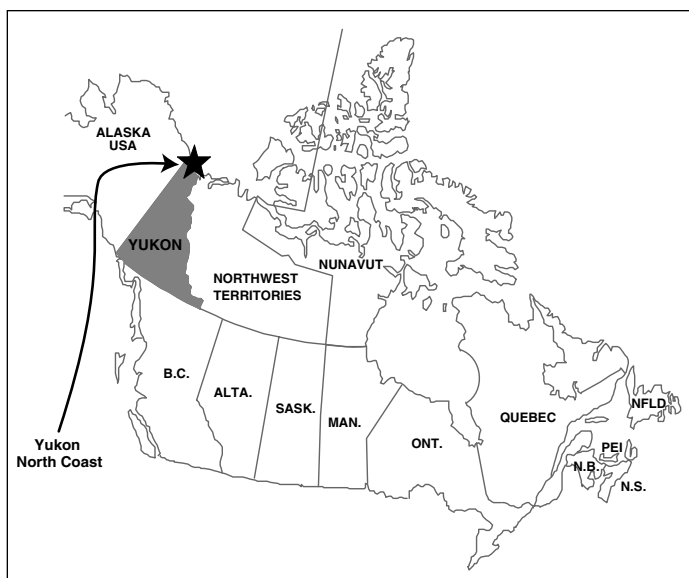
Figure 1. Map of northwestern Canada showing study area location.

ACKNOWLEDGEMENTS

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TERMINOLOGY

The terminology and procedures used in this report follow those outlined in Reinson, *et al.* (1993) and are summarized below.

Oil is defined as any naturally occurring liquid that, at the conditions under which it is measured or estimated, is primarily composed of hydrocarbon molecules and is readily producible from a borehole.

Natural gas is defined as any gas (at standard pressure and temperature, 101.33 kPa and 15oC) of natural origin, comprised mostly of hydrocarbon molecules, producible from a borehole (Potential Gas Committee, 1990). Natural gas may contain significant amounts of non-hydrocarbon gas such as H2S, CO2 or He. In this study, non-hydrocarbon gas was not considered due to lack of information on gas compositions in these basins.

Condensate is a mixture, mainly of pentanes and heavier hydrocarbons, that can be recovered from an underground reservoir that may be gaseous in its virgin reservoir state

but is liquid at the conditions under which its volume is measured (Alberta Energy and Utilities Board, 1999).

Raw gas is unprocessed natural gas, containing methane, inert and acid gases, impurities and other hydrocarbons, some of which can be recovered as liquids. *Non-associated gas* is natural gas that is not in contact with oil in a reservoir. *Associated gas* is natural gas that occurs in oil reservoirs as free gas. *Solution gas* is natural gas that is dissolved in crude oil in reservoirs. In this report, insufficient information is available in order to differentiate non-associated, associated, and solution gas. All gas figures reported represent initial raw gas volumes.

Resource indicates all hydrocarbon accumulations known or inferred to exist. *Resource, resource endowment and endowment* are synonymous and can be used interchangeably. *Reserves* are that portion of the resource that has been discovered, while *potential* represents the portion of the resource that is not discovered but is inferred to exist. The terms *potential* and *undiscovered resources* are synonymous and may be used interchangeably.

Gas-in-place indicates the gas volume found in the ground, regardless of what portion is recoverable. *Initial in-place volume* is the gross volume of raw gas, before production. *Recoverable in-place volume* represents the volume expected to be recovered using current technology and costs. These definitions can be applied to oil volumes as well.

A *prospect* is defined as an untested exploration target within a single stratigraphic interval; it may or may not contain hydrocarbons. A prospect is not synonymous with an undiscovered pool. An undiscovered pool is a prospect that contains hydrocarbons but has not been tested as yet. A *pool* is defined as a discovered accumulation of oil or gas typically within a single stratigraphic interval that is separate, hydrodynamically or otherwise, from another hydrocarbon accumulation. A *field* consists of one or more oil and/or gas pools within a single structure or trap. Similar to most frontier regions, the assessment of petroleum resources of the Yukon North Coast is based on estimates of field rather than pool sizes. A *play* is defined as a family of pools and/or prospects that share a common history of hydrocarbon generation, migration, reservoir development and trap configuration.

Plays are grouped into two categories: *established* and *conceptual* plays. *Established plays* are demonstrated to exist due to the discovery of pools with established reserves. *Conceptual plays* are those that have no discoveries or reserves, but which geological analyses indicate may exist. Established plays are categorized further into *ma-ture* and *immature* plays depending on the adequacy of play data for statistical analysis. Mature plays are those plays that have sufficient numbers of discoveries within the discovery sequence so that the *discovery process model* of the PETRIMES assessment procedure is of practical use (Lee and Tzeng, 1989; Lee and Wang, 1990; Lee, 1993). Immature plays do not have a sufficient number of discoveries with established reserves to properly apply the model. Subjective probability play analysis was applied exclusively in this study due to the scarce number of discovered pools with established reserves.

METHOD AND CONTENT

This report incorporates two essential components, geological basin analysis and statistical assessment. Basin analysis fundamentally describes and characterizes the exploration play. Fields and prospects in a play form a natural geological population that can be delimited areally. Once a play is properly defined, a numerical and statistical resource assessment is undertaken using relevant geological data and information for that specific play.

◼ RESOURCE ASSESSMENT PROCEDURE

The analysis of the North Coast area began with the compilation and synthesis of information on regional geology and hydrocarbon occurrence. This included a survey of pertinent publications.

The aim of this data compilation was to initiate basin analysis in order to provide background for the definition of hydrocarbon occurrence models. Play models in the study area were developed by examining the hydrocarbon systems and, when possible, using analogues to extrapolate certain parameters.

Play definition and estimation of reservoir parameters formed the input for a systematic statistical analysis which allowed a quantitative analysis of the undiscovered resource.

GEOLOGICAL PLAY DEFINITION

Definitions of play type and area are essential components of geological basin analysis preceding any numerical resource evaluation procedure. A properly defined play will possess a single population of pools and/or prospects that satisfies the assumption that geological parameters within a play can be approximated by a family of lognormal distributions. Mixed populations derived from improperly defined plays add uncertainty to the resource estimate. Pools and/or prospects in a specific play form a natural geological population characterized by one or more of the following: age, depositional model, structural style, trapping mechanism, geometry, and diagenesis. Prospects or areas within a basin or region can be assigned to specific plays on the basis of a commonality of some or all of these geological elements.

COMPILATION OF PLAY DATA

For conceptual and immature plays, probability distributions of reservoir parameters such as prospect area, reservoir thickness, porosity, trap fill and hydrocarbon fraction are needed. Prospect size can then be calculated using the standard "pool"- size equation. Seismic, well, and outcrop data prove particularly useful in identifying the limits for sizes of prospect area and reservoir thickness as well as porosity limits. Geochemical data are useful in identifying prospective areas as well as the composition of the hydrocarbon accumulations, ie. oil-vs.-gas proneness. Research in similar hydrocarbon-bearing basins is also important in order to provide reasonable constraints on reservoir parameters as well as contribute further information on other aspects of petroleum geology that may prove useful in the study.

SUBJECTIVE PROBABILITY ANALYSIS

There are several methods for estimating the quantity of hydrocarbons that may exist in a play, region or basin (White and Gehman, 1979; Masters, 1984; Rice, 1986; Lee, 1993). Petroleum assessments undertaken by the Geological Survey of Canada are currently based on probabilistic methods (Lee and Wang, 1990) that are developed in the Petroleum Exploration and Resource Evaluation System, PETRIMES (Lee and Tzeng, 1989). The immature and conceptual hydrocarbon plays defined in the North Coast region were analysed by applying a subjective probability approach to the various reservoir parameters. The lognormal option in PETRIMES was used since experience

indicates that geological populations of pool parameters can adequately be represented by lognormal distributions.

Resource assessments in frontier regions use field-size estimates rather than pool-size predictions as derived from mature and immature play analysis in mature basins. A field consists of one or more oil/gas pools or prospects in a single structure or trap. Probability distributions of oil and gas field sizes are computed by combining probability distributions of reservoir parameters, including prospect area, reservoir thickness, porosity, trap fill, hydrocarbon fraction, oil shrinkage and gas expansion.

Probability distributions of oil and gas field sizes are then combined with estimates of numbers of prospects (from seismic and play area mapping) and exploration risks to calculate play potential and to estimate sizes of undiscovered fields.

Exploration risks at a play or prospect level are determined on the basis of the presence or adequacy of geological factors necessary for the formation of petroleum accumulations. Essential factors are reservoir, seal, source rock, timing of hydrocarbon generation, trap closure and preservation. Appropriate marginal probabilities are assigned to each geological parameter. The Yukon coastal plain plays are expected to exist (the low play-level risk of 1.0 was assigned to each play). Within each play, certain prospect-level risks are high and these are assigned appropriate risk factors. Exploration risk is an estimate, incorporating all risk factors, of the percentage of prospects within a play that are expected to contain hydrocarbon accumulations.

Uncertainties in oil and gas play potential and pool-size estimates of a given range of probabilities are necessarily greater than the ranges derived by discovery process analysis used for assessing mature plays. This is due to the nature of frontier assessment results and because few discovered pool sizes are available to constrain sizes of undiscovered accumulations.

REGIONAL GEOLOGY

Two distinct structural and genetic regional geological regimes are represented in northern Yukon. The vast majority of northern Yukon occupies a portion of the Cordilleran Orogen. An area of northeastern Yukon, specifically Peel Plateau, lies on the ancestral North American craton where little Phanerozoic deformation has taken place. This area of ancestral North America is known as the Interior Platform.

There are two major geological provinces lying within the Cordilleran Orogen of northern Yukon. They are separated by the northwest-trending Tintina fault. The area southwest of the fault consists of amalgamated and accreted geological terranes that contain younger, fairly complex assemblages of varying rock-types. The northeastern region, which is part of the morphogeological Frontal Belt, includes a thick assemblage of older sedimentary rocks deposited on the relatively stable ancient North America margin (Hart, 1999).

The western edge of the ancient North America craton extended far out into the ancient Pacific Ocean. This submerged continental shelf of crystalline basement rock is at least 1.7 billion years old and is present throughout northern Yukon beneath both the Interior Platform and the Cordilleran Orogen. These rocks, in part, provided the stable continental platform, upon which sediments, dominantly limestone and sandstone, were deposited over a period of a billion years (Hart, 1999). Shale, sandstone and chert accumulated in basinal regions of deeper water. Thus, the two depositional environments (platform and basin) gave rise to distinct sedimentary packages, dominated by limestone and shale, respectively. These shale and limestone packages are now in fault contact with each other. The Interior Platform amassed thicknesses of between 5 and 25 kilometres of dominant limestone and sandstone. Limestone accumulated during quiescent times in warm, shallow and clear water. The sandstone consists of detritus eroded from the Canadian Shield.
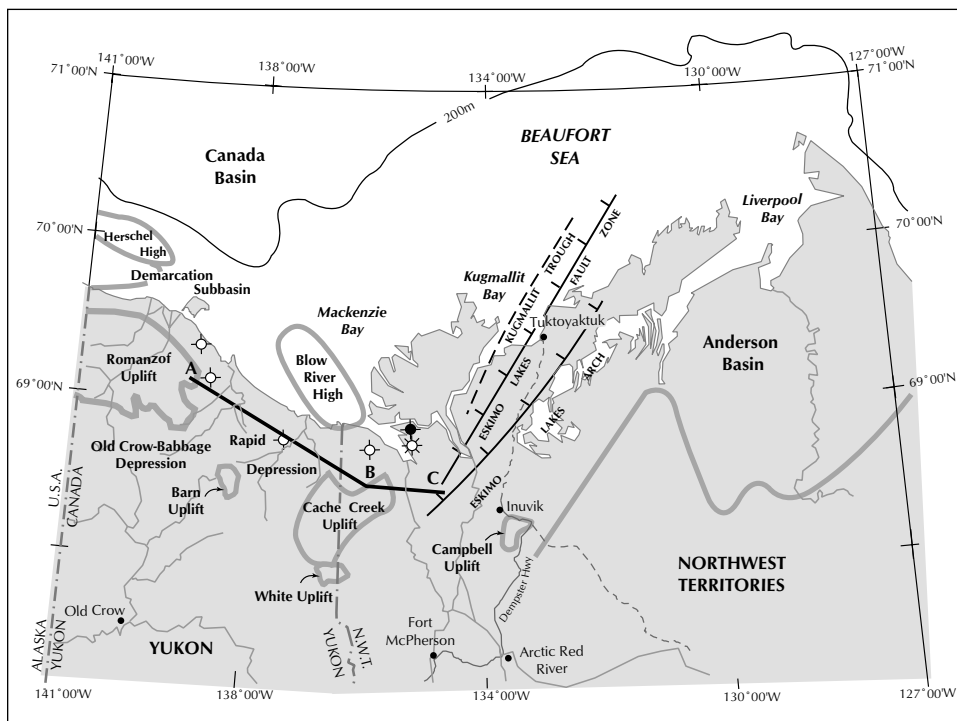
Figure 2. *The major structural elements in the region (from Dixon, et al., 1994).*

A complex folded and faulted terrain, part of the Frontal morphogeological belt of the Cordilleran Foldbelt, underlies the Arctic coastal region of northern Yukon. Structures such as compressional folds and strike-slip faults, formed during the Laramide Orogeny, are underlain by older tectonic features such as the Cache Creek Uplift and Rapid Depression which originated as Mesozoic fault-bounded structures. Other significant older tectonic and structural elements in the region are the Barn and Romanzof uplifts, Blow River and Herschel highs and the Demarcation Subbasin (Fig. 2; Dixon, *et al.*, 1994).

The Rapid Depression (Lane, 1998) is defined on the basis of its Albian fill, with older sediments bounding it to the east, west and south (Dixon, 1996a). To the north, the Blow River High contains Tertiary strata. The Depression is a structurally controlled trough which terminates up-plunge at the upper reaches of the Blow River (Norris, 1997a). Within the trough, more than 5,000 m of Lower Cretaceous turbiditic sandstone and conglomerate were deposited. On the flanks of the trough, this flyschoid succession thins dramatically where it lies unconformably on Ellesmerian units. On top of the flysch, more than 1,200 m of Upper Cretaceous and Tertiary clastics accumulated (Norris, 1997a).

The Cache Creek Uplift underlying southwest Mackenzie Delta is a fault-bounded entity containing rocks ranging in age from at least Middle Devonian to early Tertiary. Middle Devonian or older massive carbonate units in the core of the complex are overlain unconformably by Carboniferous and Permian limestone and sandstone (Norris, 1997a). Deformation in the core appears to be related to the Ellesmerian Orogeny. The Upper Paleozoic rocks are disconformably overlain by Jurassic and Cretaceous shales and sandstones on the northwestern flank of the structure, which, in turn, are covered by lower Tertiary strata (Norris, 1997a).

West of the Rapid Depression lies the Barn Uplift (Fig. 2). It is cored by highly compressed Lower Paleozoic strata, coeval with Road River Formation occurring within the Richardson Mountains to the south. The succession consists of shales, cherts, quartzites, siltstones and limestones (Dyke, 1974). These rocks are overlain unconformably by coarse clastics of the Early Carboniferous Kekiktuk Formation. The rocks in the Uplift are deformed into a series of highly folded, generally steeply dipping panels (Norris, 1997a).

The Romanzof Uplift underlies the British Mountains straddling the Canada-USA border. Isoclinally folded and thrust faulted strata of the Neruokpuk and Road River formations occur within the complex. In Canada, the northern limit of the uplift is in fault contact with the Rapid Depression (Norris, 1997a).

The tectonic elements in the offshore area are principally Late Cretaceous and Tertiary in origin (Dixon, 1996a). The Blow River and Herschel highs are cored by tightly folded Tertiary strata and both have structural elevations higher than the surrounding areas. The Herschel High also contains high-angle reverse faults. A prominent areally large synclinal structure on the south flank of the Herschel High is called the Demarcation Subbasin which is filled with Eocene and younger strata (Dixon, 1996a).

STRATIGRAPHY AND DEPOSITIONAL SETTING

Four major tectono-stratigraphic assemblages are recognized in the Mackenzie Delta–Beaufort Sea region. They include Inuvikian embracing Proterozoic strata, Franklinian encompassing Cambrian to Devonian strata, Ellesmerian which consists of Mississippian to upper Hauterivian rocks, and Brookian comprising upper Hauterivian to modern sediments. Major regional unconformities separate the four assemblages. Significant changes in tectonic regime and activity are designated by these regional unconformities. Another major unconformity is recognized lying beneath Upper Cretaceous strata dividing the Brookian assemblage into an upper and lower subdivision. Most of the oil and gas discovered to date in the Beaufort–Mackenzie area are found in the upper Brookian assemblage (Dixon, *et al.*, 1994).

Figure 3 depicts the stratigraphy and correlative relationships in the Beaufort Sea, Mackenzie Delta and Northern Yukon. Potential reservoir and source rocks in the assessment area are indicated. A schematic cross-section depicting the complex stratigraphic relationships within Upper Jurassic to Paleocene strata beneath the Yukon Arctic coastal plain is depicted in Fig. 4.

INUVIKIAN (PROTEROZOIC)

Interbedded quartzites, argillites, cherts, and limestones of the Hadrynian Neruokpuk Formation are exposed in the core and on the southwest flank of the Romanzof Uplift. The formation is interpreted to also occur beneath the Rapid Depression to the north and east (Norris and Dyke, 1997). Significant discoveries of Paleozoic fossils on the northern flank of the Romanzof Uplift has resulted in reinterpretation of the stratigraphy of the area where previously mapped Precambrian Neruokpuk Formation (Norris, 1981a, b) is now thought to represent strata equivalent to the Road River Group (Lane and Dietrich, 1996). Previous definitions of Neruokpuk strata have included all pre-Mississippian strata in northern Yukon and Alaska (such as, Brosge, *et al.*, 1962; Reed, 1968; Dutro, *et al.*, 1972; Sable, 1977). Lane (1991) argued that Neruokpuk strata should be limited to Proterozoic strata and restricted to the quartzite-dominant unit of that age. These Proterozoic sediments have undergone metamorphism and represent an effective economic basement in the region.

FRANKLINIAN (LOWER PALEOZOIC)

Paleogeographic reconstructions in northern Yukon indicate that Lower Paleozoic strata are generally represented by a basinal facies (Norford, 1997; Lane, 1998). Cambrian to Silurian phyllites, cherts, quartzites and volcanics unconformably overlie the metasedimentary Hadrynian Neruokpuk Formation. These rocks are coeval with Road River Group strata to the south but have sufficient differences in lithologies to warrant separate nomenclature. However, present knowledge of these strata is inadequate for formal nomenclature, so this assemblage of basinal rocks is unnamed (Norford, 1997). There are red and green cherty argillites, shales and phyllites, conglomerates, sandstones and minor limestones in the succession and they are interpreted to have substantial similarities to rocks in Selwyn Basin more than 1,000 km to the south (Cecile, 1988). Thicknesses in northern Yukon are unknown and the rocks are structurally complex. A major unconformity on top of the assemblage locally places Carboniferous, Jurassic or Lower Cretaceous rocks on the Franklinian succession. Lower Paleozoic basinal strata are probably overmature but may retain some potential as a source rock for gas.
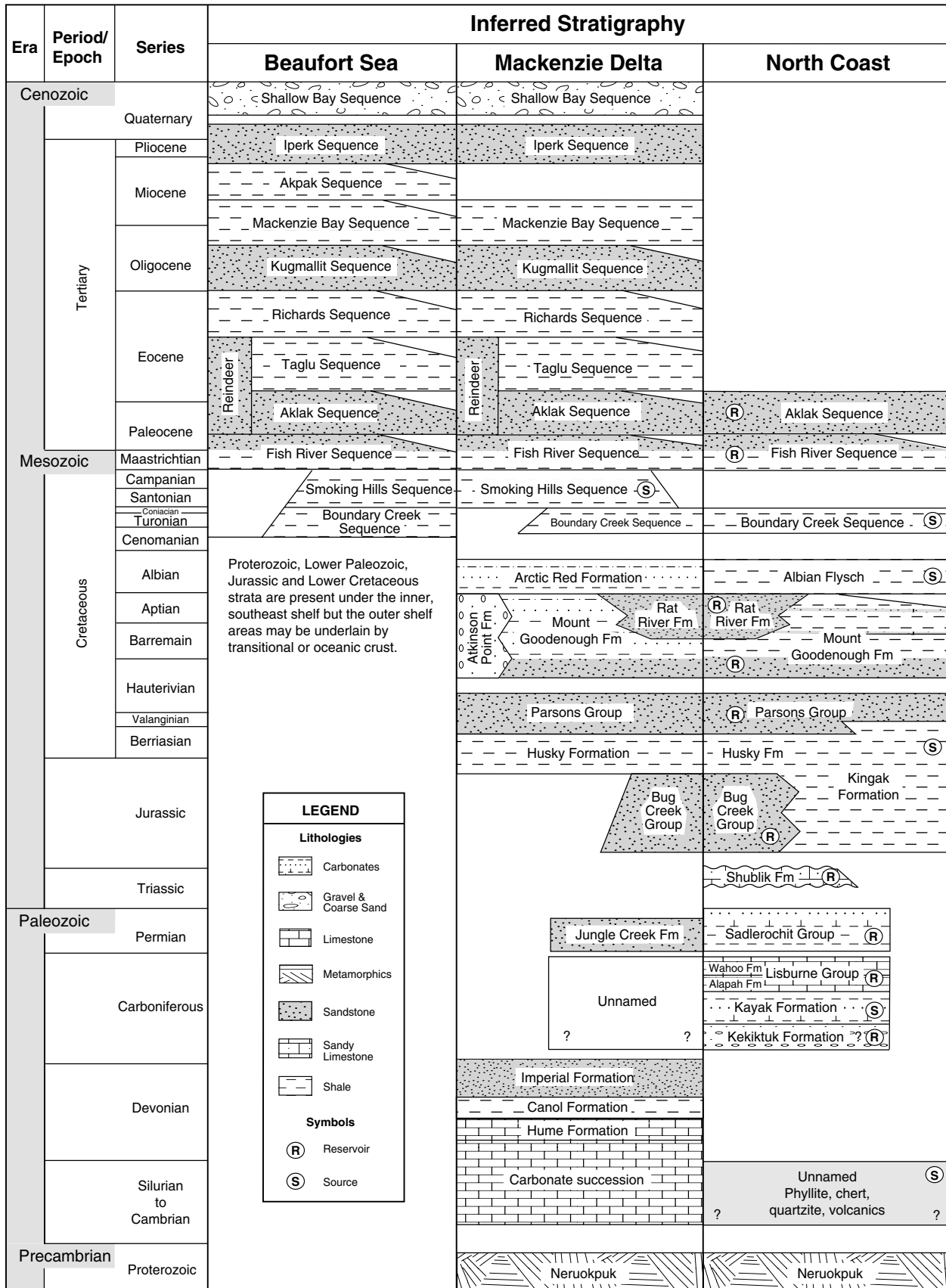
Figure 3. *Stratigraphic chart, Beaufort-Mackenzie area (from Dietrich and Dixon, 1997). Potential reservoirs and source rocks in northern Yukon are shown.*

ELLESMERIAN (CARBONIFEROUS TO MIDDLE HAUTERIVIAN)

The lowermost Carboniferous sediments are interbedded chert conglomerates and conglomeratic sandstones of the Kekiktuk Formation that unconformably overlie older strata in the area (Fig. 3; Richards, *et al.,* 1997). Chert, quartz and quartzite clasts are encased in a tight siliceous matrix. This poorly exposed laterally discontinuous unit is exposed in British and Barn mountains and likely occurs through most of northern Yukon. Permian and Carboniferous strata are truncated northeastwards by sub-Triassic and sub-Jurassic unconformities. The Kekiktuk Formation varies in thickness from one to 50 m, averaging about 25 m (Richards, *et al.,* 1997). Lithologies and regional relationships in the Kekiktuk Formation suggest deposition in braided stream and fan delta settings. An underlying regional subaerial erosion surface together with the overlying coastal plain facies of the Kayak Formation infers a continental environment during Kekiktuk deposition. The absence of marine fossils in most of the formation is also indicative of a terrestrial depositional setting. Locally derived, texturally immature sediments with conglomerate channel fills infer the braided stream/fan delta depositional setting (Richards, *et al.,* 1997). Kekiktuk conglomerates are identified as potential reservoir units in the Old Crow plain and on the Alaskan North Slope. Quality of reservoir is unknown beneath the coastal region of the Yukon.

Upper Visean siliciclastics and minor carbonates of the Kayak Formation conformably overlie Kekiktuk rocks. The Kayak Formation consists of basal sandstone with coal seams, a middle shale-dominated unit and an upper interval consisting of shale with subordinate limestone. Thicknesses range from 220 to 375 m in the study area. These clastic formations depict a transgressive, deepening-upward succession where coal-bearing siliciclastics of the basal unit, deposited in shoreline and coastal environments, succeeded fluvial and deltaic sediments in the underlying Kekiktuk Formation (Richards, *et al.,* 1997). Successive shale and carbonate units were deposited in shallow marine to intertidal environments. Coeval carbonate deposition of lowermost Lisburne Group took place in the British Mountains.

In northern Yukon, a widespread Carboniferous carbonate succession consisting of the Alapah and Wahoo formations of the Lisburne Group conformably overlies the
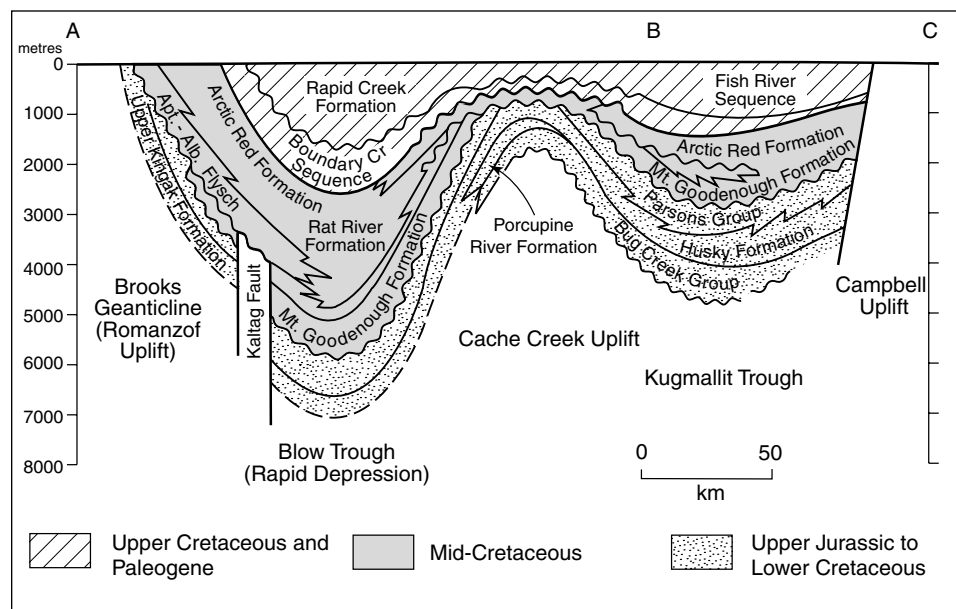
Figure 4. Schematic cross-section (see Fig. 2 for location) illustrating three clastic assemblages in Upper Jurassic to Paleocene strata of Blow and Kugmallit troughs (after Yorath, 1991).

Kayak Formation. The Alapah Formation is the thickest and most extensively preserved carbonate unit in northern Yukon. It is more than 1,300 m thick in the western British Mountains and thins to the northeast (Richards, *et al.*, 1997). Lower Alapah carbonates in the British Mountains consist of lime mudstones and wackestones, while skeletal lime grainstones and packstones dominate the upper part. The older carbonates were deposited in restricted to protected shelf environments, while upper Alapah rocks were laid down in a shelf margin setting. Another carbonate unit, called the Wahoo Formation, immediately overlies Alapah carbonates. This formation ranges in thickness from 130 to 225 m in the British Mountains (Richards, *et al.*, 1997). Lime grainstones and packstones dominate this cyclic succession. Deposition probably occurred on protected shelf to shelf margin marine environments. Carboniferous carbonates have been identified as prominent potential reservoir units on the Alaskan North Slope and in Eagle Plain. Dolomitic facies within Lisburne Group carbonates contain significant reserves of hydrocarbons at Prudhoe Bay.

An unconformity separates Carboniferous strata from overlying Permian strata. In the western British Mountains, there is a thin (~200 m), poorly known succession called the Sadlerochit Group that was deposited in a Permian basin which developed north of the Ancestral Aklavik Arch (Fig. 3; Richards, *et al.*, 1997). Local erosional remnants have been preserved in the British Mountains. Shales, sandstone and minor carbonate of the Sadlerochit Group also occur eastward in the Cache Creek Uplift and under southwestern Mackenzie Delta (Dixon, *et al.*, 1994). This unit likely contains a shallow marine facies, including shelf sandstones which may include potential reservoir horizons.

The unconformity-bounded Middle and Upper Triassic Shublik Formation is locally preserved in northwestern Yukon in British and Barn mountains. A nearshore, inner shelf depositional environment is interpreted for Shublik rocks in northern Yukon (Norris, 1997b). This nearshore facies is very heterogeneous with rapid lateral changes in lithology. Basal conglomerate and conglomeratic limestone grade into sandstone, limestone, siltstone, and chert from one exposure to another (Norris, 1997b). Only about 150 m of strata is preserved on the southwest flank of British Mountains. There may be potential for reservoir development among the coarse clastic units in this thin succession in northern Yukon. The Shublik Formation oversteps progressively older formations to the northeast and is erosionally truncated at the sub-Jurassic unconformity. These stratigraphic relationships infer that the southeastward extensions of Permian and Triassic reservoirs at Prudhoe Bay in Alaska do not reach into the Yukon Territory (Norris, 1997b).

Fundamental changes in depositional style and paleogeography took place at the commencement of Jurassic sedimentation. A series of northwestward prograding wedges originated from an arenaceous belt that developed on the southeastern margin of a Jurassic-Neocomian basin ('Brooks-Mackenzie Basin' in Poulton, 1997). These sandstone units grade laterally into shale-dominant units to the northwest and west, away from the exposed North American craton from which they were derived. Interdigitation of arenaceous and argillaceous units in the basin-marginal areas record numerous transgressive and regressive episodes in the overall subsiding shelf regime (Poulton, 1997). In ascending order, the formations within the arenaceous belt in northeastern Yukon and southern Mackenzie Delta are the Bug Creek Group consisting mostly of sandstone, Husky Formation which is shale-dominant, and the Parsons Group which contains the sandstone-dominant Martin Creek Formation, the shales of the McGuire Formation and the sandstone-rich Kamik Formation. In northwestern Yukon, the Bug Creek to McGuire interval is represented singly by the shale succession called the Kingak Formation. The arenaceous belt is interpreted to occur at the basin margin or within

the inner shelf facies, while the argillaceous Kingak succession occupies the outer shelf to the northwest.

Jurassic Husky and Kingak shales have been recognized as potential source rocks in Beaufort-Mackenzie Basin and the Alaskan North Slope. Davies and Poulton (1989) report elevated Thermal Alteration Indices (T.A.I.) and vitrinite reflectance values in outcrop in the western Richardson Mountains. These source rocks have passed through the oil window making them overmature and resulting possibly in the generation of dry gas, which may still be taking place.

BROOKIAN (UPPER HAUTERIVIAN TO EOCENE)

A major regional unconformity occurs at the base of the Upper Hauterivian to Barremian Mount Goodenough Formation. Another major unconformity separates Upper Cretaceous strata from Lower Cretaceous rocks. The mid-Cretaceous unconformity distinguishes two tectono-stratigraphic sequences: a lower assemblage consisting of easterly to southeasterly craton-derived sediments deposited in shoreline and shelf environments, and an upper assemblage derived from the Cordilleran Orogen to the south and southwest. The younger assemblage consists of Upper Cretaceous sediments deposited in a cratonic foreland basin overlain by Tertiary rocks that accumulated in a subsiding continental margin (Dixon, 1997).

Upper Hauterivian and Barremian strata are embodied by the shale-dominant Mount Goodenough Formation. This unit is present throughout northern Yukon and in the subsurface of Mackenzie Delta and the Beaufort Sea. A basal sandstone is locally developed which may contain reservoir facies. This sandstone is especially well-developed adjacent to and upon positive tectonic elements such as the Cache Creek and Romanzof uplifts. Gradationally overlying Mount Goodenough shales in the northern Richardson Mountains are interbedded sandstones and shales of the Rat River Formation. This formation is Barremian to Aptian in age. The basin margin, or shoreline facies, of the Rat River Formation grades laterally to the northwest into the shale-dominant shelf area represented by the Mount Goodenough Formation.

Late Aptian and Albian rocks are designated Albian Flysch in northern Yukon. Thick accumulations of Albian sediment were deposited in grabens and half-grabens such as Blow Trough in the Rapid Depression (Dixon, 1997). Within the Albian Flysch succession, shale is dominant but there are also significant stratal intervals containing sandstone and conglomerate derived from the ancestral Brooks Geanticline to the west. These flysch deposits also underlie the Yukon North Coast to the northwest. The flysch was deposited as sediment gravity-flow deposits in slope, submarine and basinal environments (Dixon, *et al.*, 1994).

The major unconformity separating Lower and Upper Cretaceous strata marks a profound change from the deep-water basins, mud-rich shelf areas and poorly defined foreland basins prominent during Albian time, to the post-Albian emergence of well-defined foreland basins filled with coarse clastics from the Cordilleran Orogen (Dixon, 1997). This unconformity is especially prominent west of Richardson Mountains where shales containing thin beds of bentonite of the Boundary Creek sequence abruptly overlie the Albian Flysch. These shales were deposited within outer shelf to slope environments (Dixon, *et al.*, 1994). The Boundary Creek shales are rich in organic matter, averaging 3 to 5% TOC. The slightly younger Smoking Hills strata present in Mackenzie Delta and the Beaufort Sea are especially rich in organic matter, but are eroded west of Richardson Mountains. The Maastrichtian to Paleocene Fish River Sequence unconformably overlies

the Boundary Creek Sequence in northern Yukon. This unconformity marks a significant shift from cratonic sedimentation to continental margin deposition.

The late Maastrichtian-Tertiary continental margin deposits consist of a series of prograding deltaic complexes. The earliest delta complex was centred over the western Beaufort shelf, whereas subsequent delta centres tended to shift eastward (Dixon, 1997). The earliest delta is defined by the Fish River Sequence in northern Yukon. The younger late Paleocene-early Eocene Aklak sequence, conformably lying on top of Fish River strata, is also centred in the western part of the Beaufort Sea. Both the Fish River and Aklak sequences form an extensive belt of sandstone-rich strata.

Every Tertiary sequence contains a thick succession of interbedded sandstone and shale at the basin margins, distributed in delta plain and delta front deposits. Basinward, the amount of shale increases. The early to middle Eocene Taglu sequence is centred under Richards Island with deltaic deposits extending westward into the shallow waters of Beaufort Shelf in northern Yukon (Dietrich and Dixon, 1997). A thin cover of late Pleistocene-Holocene Shallow Bay basinal shales is present on the northern Yukon continental shelf overlying a Late Miocene unconformity (Dietrich and Dixon, 1997).

STRUCTURAL GEOLOGY

To the west of the Richardson Mountains and extending into western Beaufort Sea, highly deformed strata of the Cordilleran Foldbelt occur (Norris, 1981a, b; Lane and Dietrich, 1996). These compressional and strike-slip structures were formed in late Cretaceous to Tertiary time during the Laramide Orogeny. The arcuate trend of the offshore fold and thrust belt is marked onshore by the eastward to southeastward strike of structures in northwestern Yukon, while further east in Blow Trough and in the Richardson Mountains, the structures trend north-south. Brookian deformation taking place during Eocene time produced these prominent structures which overprint Paleozoic compressional and Jurassic-Cretaceous extensional structures in the study area (Lane and Dietrich, 1996). Tertiary extensional faults are also common throughout the Beaufort-Mackenzie Basin. Older structural features, such as the Rapid Depression and Cache Creek Uplift, probably originated as Mesozoic fault-bounded structures. In the Blow Trough, the rift setting is not apparent due to the lack of preservation of associated structures. Chevron folds and local thrust faults, which may be contiguous with Brookian structures interpreted offshore (Lane, 1988), are present. Blow River and Herschel highs are large-scale tectonic features cored by closely spaced anticlines (Fig. 2).

Rocks on the Yukon North Coast were extensively deformed during Paleocene to early Eocene time (Lane, 1998). Folds and thrust faults observed in Paleocene outcrop (Norris, 1981a), as well as continuity of structures with known Eocene structures offshore, constrain this major deformational event.

█ PETROLEUM GEOLOGY

EXPLORATION HISTORY

Seismic survey activity in the Mackenzie Delta area in the early 1960s delineated large structures in favourable stratigraphic sections. These early surveys led to the drilling of two dry wells in 1962. Further exploration resulted in the initial discovery of oil in Cretaceous sandstones at Atkinson Point in 1969. In 1970, a major gas find was made in Kamik sands at Parsons Lake and in the same year oil was discovered in carbonates at Mayogiak. In 1977, the focus of exploration switched offshore to Tertiary targets. In the Beaufort-Mackenzie region, 53 oil and gas discoveries, both onshore and offshore, have been made. Forty-four of these discoveries occur in the Tertiary basin. A total of 247 wells has been completed to date in the Beaufort-Mackenzie region. Drilling on the Yukon North Coast to the west has been very limited. Three wells were completed showing no hydrocarbons and limited reservoir potential.

RESERVOIRS

CARBONIFEROUS

A gas discovery was made in Carboniferous carbonates at Unak L-28 in west-central Mackenzie Delta. This discovery exhibits an instance when the generally poor primary porosity development of Carboniferous carbonates was enhanced by fracture development in the south delta. Dolomitized facies and leached zones adjacent to unconformities occasionally produce porous horizons in marine Upper Carboniferous Alapah and Wahoo carbonate formations of the Lisburne Group. There have been discoveries of hydrocarbons in equivalent rocks on the Alaskan North Slope and in southern Eagle Plain (Hamblin, 1990). Porosity development in the subsurface of the Yukon is unknown but surface exposures indicate that primary porosity is generally poor. Secondary porosity development may be significant but patchy.

A possible reservoir interval that may be present in the Yukon Arctic coastal region is the Lower Carboniferous Kekiktuk Formation (Fig. 3). This formation, containing quartz, chert, quartzite and granitic clasts, generally occurs in a tight siliceous matrix. Even though porosity development in this unit is commonly poor in the subsurface, leaching has produced significant reservoirs in Alaska, specifically at the Endicott Field (Craig, *et al.*, 1985). Primary porosity is very low or absent, but secondary, patchy porosity development may occur.

PERMO-TRIASSIC

Permian and Middle to Upper Triassic potential reservoir strata, represented by Echooka sandstones of the Sadlerochit Group and coarse clastics of the Shublik Formation, respectively, exhibit good porosity development in Eagle Plain and the Alaskan North Slope. Paleogeographic reconstructions (Bamber and Waterhouse, 1971) indicate that these potential reservoir units may occur beneath the North Coast of the Yukon. Young (1981) considers the Sadlerochit Formation to be a prime prospect for future hydrocarbon discoveries in northern Yukon. Primary and secondary porosity may develop in both conglomerate and sandstone units.

JURASSIC

Northwest-prograding clastic wedges of the Jurassic arenaceous belt, located in northern Richardson Mountains and in the subsurface beneath southern Mackenzie Delta, have potential as reservoir rock. Bug Creek sandstones in the area retain fair potential as reservoir-quality rock, although these rocks are typically tight and no discoveries have been made. Porosity exceeds 10% in some of the cleaner facies but there is low permeability in the coarse clastics (Northern Oil and Gas Directorate, 1995a). To the northwest along the Yukon North Coast, the Jurassic Brooks-Mackenzie Basin deepens, whereupon finer-grained clastics are deposited, substantially reducing reservoir potential.

CRETACEOUS

Hauterivian Kamik sandstones of the Parsons Group are excellent potential reservoir horizons in the Mackenzie Delta. Both oil and gas have been recovered from this thick, extensively developed unit. Average porosity at Parsons Lake is 15%. Kamik sands in the Yukon Territory occupy a sandy inner to mid-shelf belt which likely has inferior reservoir qualities compared to the interpreted beach and inner shelf environment of the Delta to the east (Dixon, 1986).

There is a thin basal sandstone with local lenses of coarser material in the Mount Goodenough Formation that seems to be fairly persistent throughout the area. A minor oil discovery was made in this interval proving the reservoir potential in this strata. Late Barremian to Aptian Rat River sands, which are interpreted as representing a regressive pulse, contain excellent potential reservoir horizons in western Mackenzie Delta, as indicated by the gas discovery at Unak L-28 (Dixon, 1986).

There is little or no reservoir potential in Upper Cretaceous strata. Albian sedimentation is dominated by fine-grained deep-water clastics deposited during increased rifting and subsidence. Blow Trough, a depositional precursor of the Rapid Depression, extended over a large area of northern Yukon and provided a major site for Albian deposition. Cenomanian to Turonian Boundary Creek rocks also comprise a shale-rich basinal sequence, indicating poor reservoir potential.

TERTIARY

Most Tertiary reservoirs occur offshore but there is some potential for reservoir occurrence along the Arctic coastal plain, if trapping conditions are favourable. Oil staining occurs in similar Tertiary sands in Alaska. Sandstone members in the Maastrichtian-Lower Paleocene Fish River Sequence are potential reservoirs. The Fish River deltaic complex seems to be centred over the western part of the Mackenzie Delta, specifically in the Mackenzie Bay area (Dixon and Dietrich, 1996). The bulk of the sandstone-dominant part of the sequence underlies the western Beaufort shelf which remains to be tested by drillholes. Deltaic rocks of the overlying Paleocene-Lower Eocene Aklak Sequence are recognized in the western Beaufort Sea shelf area. Oil and gas have been recovered from this sequence further east in the Mackenzie Delta area. Delta-front deposits of the Aklak sequence at Adlartok in Yukon offshore waters to the north are characterized by highly variable porosity and permeability due to grain size. Coarser beds exhibit a porosity range of 20 to 24% while finer-grained laminated units vary from 15 to 18% (Northern Oil and Gas Directorate, 1995b).

SEALS

The laterally and vertically extensive Jurassic and Lower Cretaceous Kingak shale provides excellent top seal for Upper Paleozoic and Triassic reservoir strata. Additional Lower Cretaceous marine shale-rich units such as the Mount Goodenough Formation and the Albian Flysch are effective top seals for potential Cretaceous sandstone reservoirs. Another efficient top seal for all pre-Tertiary reservoirs in northern Yukon is the widespread Boundary Creek shale-rich sequence. Intraformational shales form localized top and lateral seals for Tertiary reservoirs.

Numerous unconformities in the study area seal underlying reservoir units by juxtaposing permeable and impermeable formations. Young (1981) indicated that the pre- Upper Triassic unconformity in northern Yukon may effectively seal older strata in broad areas and numerous updip traps may be developed along the edges of pre-Upper Triassic structures.

TRAPS

A variety of structural, stratigraphic and combination traps occur within Phanerozoic sedimentary strata throughout the region. Pre-Laramide traps are more favourable for accumulating hydrocarbons since the primary episode of hydrocarbon generation probably took place in Mesozoic and Tertiary time when maximum load was imposed. In southern Mackenzie Delta, trap types are dominantly structural where closure often occurs against normal faults. Further west, thrust faults complicate the pre-existing pattern of tilted fault blocks. Along the Yukon North Coast, numerous structural features have been recognized. There are broad anticlinal features, domes, and normal and reverse faults, along with horst and graben structures. In Herschel and Blow River Highs, folds are closely spaced and have large amplitudes. Reverse fault traps are also present. Unconformity-related combination traps occur throughout the assessment area.

SOURCE ROCKS

Numerous potential source rocks for oil and gas have been identified in the Beaufort-Mackenzie region. Upper Cretaceous mudstones and shales of the Boundary Creek Sequence are considered to be significant source rock for oil. The sequence is rich in organic matter with TOC ranging from 3 to 5%. The richer oil-prone Smoking Hills Sequence (2 to 10% TOC) has been eroded in western Mackenzie Delta and does not appear to extend into the Yukon Territory (Dixon, 1996b). Smoking Hills-sourced oil constitutes the Kugpik O-13 Cretaceous discovery and there are reasonable expectations that Smoking Hills-sourced oils may have migrated further west into Yukon Territory.

The Jurassic Kingak and Husky shale succession is a significant gas-prone source rock in the area. Langhus (1980) indicates that the terrestrially dominant organic matter present in these rocks is consistent with a gas-prone source rock which may have provided the charge for gas accumulations at Parsons Lake. At Unak L-28, gas was recovered from both Carboniferous carbonates and the Lower Cretaceous Rat River Formation. It is believed that gas for both of these accumulations is derived from the Jurassic-Cretaceous shale succession.

Oil and gas found in Tertiary deltaic reservoirs in the central Beaufort region are most likely derived from the basal portion of the Richards shale sequence (Brooks, 1986). However, to the west, specifically at Adlartok, oil geochemistry indicates that

the Richards-type biomarker is not present. Oil at Adlartok may have been derived from Paleocene shales. Organic matter is not particularly concentrated in these Tertiary prodelta depositional environments (infrequently exceeding 2% TOC), but the source rock intervals are thick. Tertiary-derived oils are generally good quality (ranging from 25 to 35° API). There are also significant condensate volumes associated with some of the onshore gas discoveries.

Argillites and shales of the unnamed Cambrian to Silurian succession coeval with Road River Formation basinal shales may be locally organic-rich in the Arctic coastal plain area. Link, *et al.*, (1989), however, rated the overall source rock potential of this formation in northern Yukon as poor. Hydrocarbons generated by Road River-equivalent strata were available for migration during Devonian to Carboniferous time well before the significant Laramide deformational event. Lower Paleozoic strata in this area are overmature and possibly supermature, but may retain limited potential for gas generation. In southern Mackenzie Delta, the Lower Paleozoic shales have moderate organic quality but poor source potential due to low TOC (Link, *et al.*, 1989).

Carboniferous shales are reported to be an important source rock in surrounding areas, specifically beneath the Alaskan North Slope and in Eagle Plain (Craig, *et al.*, 1985; Link, *et al.*, 1989; Utting, 1989). In the Alaskan North Slope area, Kayak Formation shales are lean and gas-prone with some potential for oil generation. In Eagle Plain, the equivalent Carboniferous shales are characterized as fair to good source rocks for gas with some oil potential (Link, *et al.*, 1989). Comparable shales found in the Yukon North Coast area, therefore, are expected to have at least fair potential to generate gas if maturities are equivalent. Thermal maturities of these rocks are likely high and probably well beyond the oil window. No Kayak samples have reported vitrinite reflectance values of less than 2.5% and Thermal Alteration Indices (TAIs) range from 3+ to 5 in British and Barn mountains south of the North Coast (Cameron, *et al.*, 1986; Utting, 1989).

Although the Late Triassic Shublik Formation is considered to be a significant oil source at Prudhoe Bay (Claypool and Magoon, 1985), the high-energy carbonate facies, occurring only in extreme northwestern Yukon, is unlikely to be a source rock of comparable quality.

TIMING OF HYDROCARBON GENERATION

There are numerous Tertiary organic-rich horizons that exhibit hydrocarbon source rock potential in the Beaufort-Mackenzie area such as occurrences in Boundary Creek, Smoking Hills and Richards sequences. Maximum burial probably occurred during middle Eocene time when hydrocarbons were likely generated. Several stages of Tertiary contractional deformation are identified in Tertiary sediments in nearshore areas of the Yukon North Coast. Maturity of organic-rich Tertiary sediments was likely reached contemporaneously with later stages of the Laramide orogeny and previous to subsequent pulses of tectonic deformation. At least some structures formed during the early stages of the Laramide deformation were available for accumulating hydrocarbons.

Modelling by Link and Bustin (1989) of Paleozoic and Mesozoic source rocks in northern Yukon indicate that they passed through the 'oil window' before the end of Mesozoic time. This implies that the most effective trapping configurations for pre-Tertiary hydrocarbons are structures formed previous to the Late Cretaceous–Tertiary Laramide orogeny, when hydrocarbons generated during the period of active oil migration were trapped in pre-Mesozoic traps. Seeking Paleozoic and Mesozoic targets

based on Laramide anticlinal structures may not represent the most efficient exploration strategy for this region. Pre-Tertiary traps and reservoirs are more favourable sites for accumulation of hydrocarbons generated during late Paleozoic to Mesozoic times.

Stratigraphically trapped Jurassic sandstone and Paleozoic sandstone and carbonate reservoirs on the Yukon North Coast are located updip of the Tertiary hydrocarbon kitchen buried in the deep sedimentary pile to the north beneath the Tertiary deltas.

HYDROCARBON SHOWS

The most direct indication of oil and gas potential in a frontier region are hydrocarbon pools and shows. Hydrocarbon shows and recoveries have been made in Paleozoic carbonates, Lower Cretaceous sandstones and Tertiary sandstones in the Beaufort-Mackenzie region. All Paleozoic and Lower Cretaceous reservoirs are found in southern Mackenzie Delta and along the Arctic coastal plain, and Tertiary discoveries are mostly concentrated in the central Beaufort-Mackenzie Basin. West Beaufort Sea shows potential with the discovery of oil at Adlartok in Paleocene and Eocene sands.

Limited discoveries have been made in Paleozoic carbonate reservoirs: a total of three hydrocarbon accumulations throughout the basin. Oil was discovered in the eastern portion of the basin, while at Unak L-28 in southwestern Mackenzie Delta, gas was recovered from Paleozoic reservoirs. The Unak trap features closure against a thrust fault. The gas is likely derived from overlying Jurassic and Cretaceous shale.

Oil and gas has also been recovered from Lower Cretaceous sandstones throughout the onshore portion of the Beaufort-Mackenzie Basin. Oil is found in the Parsons Group sands, the Atkinson Point Formation and the Mount Goodenough Formation. In western Mackenzie Delta, the Kugpik O-13 well produced oil from the Parsons Group sandstone reservoir. Smoking Hills shales are interpreted to contain oil-prone organic matter for Cretaceous reservoirs. Gas was found in the Lower Cretaceous Rat River sandstone at Unak L-28. Source for Cretaceous Unak gas is unknown although the thick Jurassic-Cretaceous shale succession certainly has potential.

Most of the hydrocarbon discoveries in the basin occur in Tertiary strata. Widespread and thick deltaic coarse clastic deposits provide ample potential reservoir horizons. Interbedded and widespread organic-rich shale layers provide significant oil and gas source material. Oil and gas have been recovered from the Fish River, Aklak, Taglu, Kugmallit and Mackenzie Bay sequences. There seems to be a general trend of oil-prone hydrocarbons occurring basinward, although numerous deviations off this trend have been observed from discoveries made. Richards shales and organic-rich horizons in Paleocene shales are possible oil sources. The Tertiary succession is dominated by Type III terrestrial organic matter. Conventionally, this type of organic matter produces gas. In Beaufort-Mackenzie, large volumes of oil are encountered in Tertiary reservoirs as well as significant quantities of gas. Snowdon and Powell (1979) suggested that these oils were generated from resin-rich terrestrial organic matter. The resinous matter can also generate hydrocarbons at lower levels of organic maturity which is consistent with the interpreted thermal regime (Dixon, *et al.*, 1994). No Tertiary discoveries have been made in the Yukon portion of the North Coast study area. Oil was recovered from Paleocene and Eocene reservoirs at Adlartok in Yukon waters north of the study area.

HYDROCARBON ASSESSMENT

The Yukon North Coast petroleum resource assessment was undertaken in order to generate quantitative estimates of total oil and gas potential and possible sizes of undiscovered fields. Hydrocarbon assessments of basins or regions are usually based on analyses of a number of exploration plays. In the North Coast region, six exploration plays were defined based on various petroleum geological considerations such as structural style, dominant reservoir lithology and thermal maturity. Three immature and three conceptual oil and gas plays were identified in the study area. The conceptual and immature plays had sufficient information to attempt a statistical analysis in order to obtain ranges of estimates of resource potential and sizes of individual undiscovered fields.

Table 1. *Hydrocarbon potential in Yukon North Coast assessment region.*

Play Name	Expected number of fields (mean)	Median play potential (million m³)	Remaining median play potential (million m³)	Median of largest field size (million m³)	Median of largest remaining field size (million m³)
Oil Plays					
South Delta–Mesozoic	4	2.8	2.4	1.5	0.7
Herschel	5	34.6	34.6	15.5	15.5
All oil plays	9	39.8*			
Gas Plays					
South Delta–Mesozoic	8	2,040	1,217	750	391
South Delta–Paleozoic	15	6,661	6,370	1,720	1,720
Herschel	5	16,095	16,095	7,146	7,146
Yukon Coastal Plain	3	8,463	8,463	5,998	5,998
All gas plays	31	38,565*			

Condensate volumes	Average liquid content (m³/million m³) (million m³)	Median play potential (million m³)	Remaining median play potential		
South Delta–Paleozoic	10.7	0.71	0.68		

* The total oil and gas potential are statistically derived. They are retrieved from the basin empirical distribution in Appendix 2. The median total of basin potential is the value at 50%.

Table 2. *Hydrocarbon play potential in Yukon Territory*

Play Name	Remaining median play potential (in-place) (million m³)	Median of largest remaining field size (in-place) (million m³)	Play potential in Yukon (Scenario 1) (million m³)	Play potential in Yukon (Scenario 2) (million m³)
Oil Plays				
South Delta–Mesozoic	2.4	0.7	0.74	0.04
Herschel	34.6	15.5	31	15.5
Gas Plays				
South Delta–Mesozoic	1,217	391	412	21
South Delta–Paleozoic	6,370	1,720	1,836	116
Herschel	16,095	7,146	14,395	7,249
Yukon Coastal Plain	8,463	5,998	8,463	N/A

Scenario 1: Largest undiscovered field is assumed to occur in the Yukon Territory.
Scenario 2: Largest undiscovered field is assumed to occur outside the Yukon Territory.

SOUTH DELTA–MESOZOIC OIL AND GAS PLAY

HYDROCARBON PLAYS

Play definition

The South Delta-Mesozoic play encompasses all oil and gas prospects occupying structural and stratigraphic traps involving reservoirs in Jurassic and Lower Cretaceous sandstones underlying the southern part of the Mackenzie Delta (Figs. 5, 6). The play area is bounded to the east by the Caribou Hills, west by the northern Richardson Mountains, south by the Eskimo Lakes Fault Zone and north by the Kugpik area in the Mackenzie Delta. Most of the play area occurs in the Northwest Territories with the remainder occupying a small portion of northeastern Yukon North Coast (Fig. 5). About 2.5% of the play area occurs in the Yukon Territory.

Geology

A thick succession of interlayered shale- and sandstone-dominant strata of Jurassic to Early Cretaceous age underlies the play area. Thickness of the prospect succession varies from 10 to 1500 m and occurs at depths ranging from 10 to 3,750 m. Numerous potential reservoirs are present in the play, such as Bug Creek Group, Parsons Group, basal sandstone of the Mount Goodenough Formation and the Rat River Formation (Fig. 3).

There are two major unconformities within the succession that prove crucial in delineating reservoir units in the play area due to the truncation of reservoir horizons. At the base of the Mount Goodenough Formation, a major unconformity signifies an erosional episode that has removed substantial strata of the Parsons Group in the south especially adjacent to the Eskimo Lakes Fault Zone and next to the Cache Creek Complex (Fig. 2). The other unconformity separating Upper from Lower Cretaceous strata
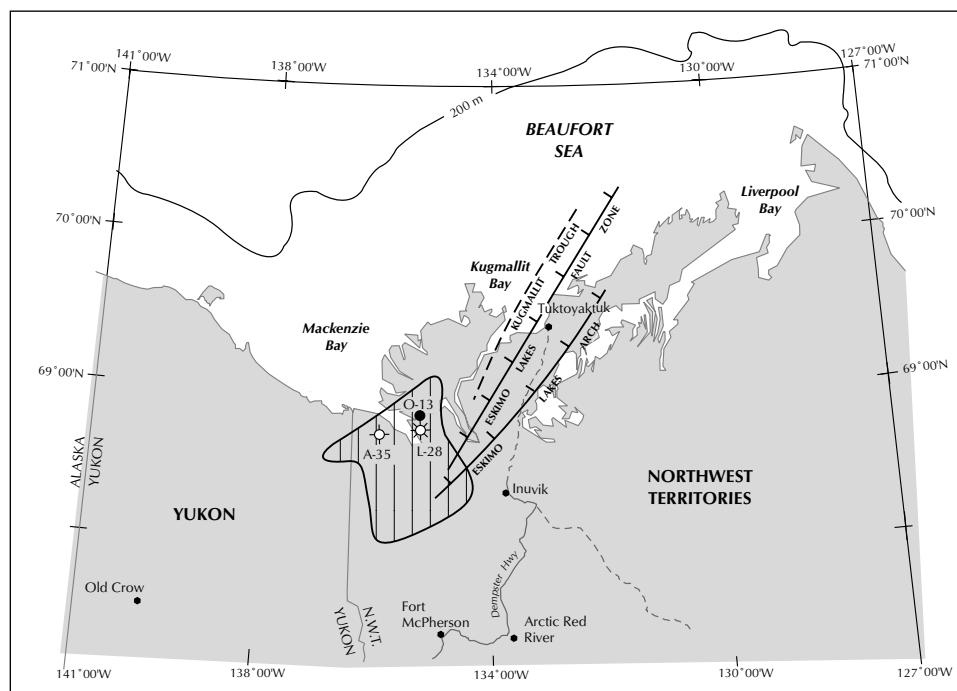
Figure 5. South Delta–Mesozoic oil and gas plays (from Dixon, et al., 1988). Wells discussed in report are shown (1–Kugpik O-13, 2–Unak L-28, 3–Ulu A-35).

has removed Hauterivian to Albian strata in the northern part of the play area, placing Upper Cretaceous strata directly on top of Parsons Group sands.

Sandstones of the Lower to Middle Jurassic Bug Creek Group have fair reservoir potential in the area. These coarse units were deposited as shelf sandstones prior to rifting and subsidence. Porosity exceeds 10% in the cleaner facies, but permeability is low. The distribution of the Group is profoundly affected by the two unconformities and there is also a depositional pinchout to the east.

The thickest and most widespread potential reservoir interval is the Berriasian to Hauterivian Parsons Group. Formations within the Group are Martin Creek, McGuire and Kamik units. Originally, this Group underlay the whole play area but erosion has locally removed strata and modified thickness trends. One oil pool and gas show were discovered in Kamik sands in the Kugpik O-13 well and oil was recovered during a drill-stem test in a Kamik reservoir unit in the Unak L-28 well.

The late Barremian to early Aptian Rat River Formation consists of a set of coarsening-upward sequences characteristic of marine bars or shoals. Prospective strata are limited to the northwestern portion of the play area due to erosion and facies change to argillaceous rocks further south and northeast. One gas pool at Unak L-28 has been discovered in the Rat River Formation.

The Albian Flysch is not generally regarded as containing significant reservoir-quality sands but a gas show was noted in these strata in the Fish River B-60 well.

Dominant trap types in the play are structural with closure against faults representing the most common configuration (Fig. 6). Normal fault traps are important but Unak L-28 shows repeated Mesozoic units which imply thrust faulting complicating the arrangement of tilted fault blocks. Thrust faults are only present in the northwestern part of the play area although seismic reflection data of poor quality in other parts of the play area may mask thrust faults and their related closures (Dixon, *et al.*, 1994).

The Upper Cretaceous Boundary Creek and Smoking Hills sequences are the richest oil-prone source rocks in the region. Erosion, however, has removed this rock from southern parts of the play area. Total organic carbon (TOC) in Boundary Creek/Smoking Hills

Figure 6. *Schematic sketch of the trap-types in the South Delta–Mesozoic oil and gas plays (from Dixon, et al., 1994).*
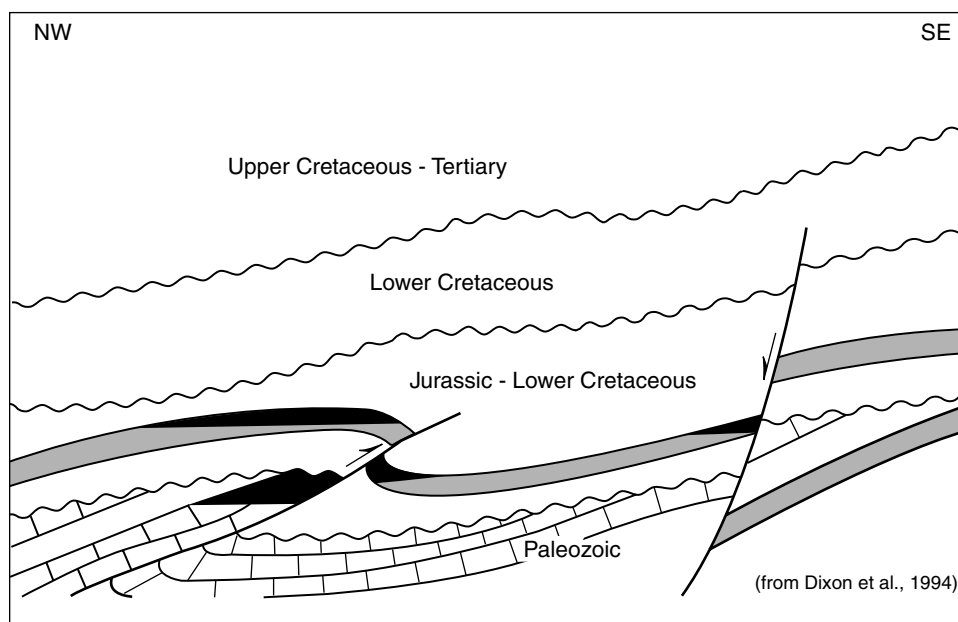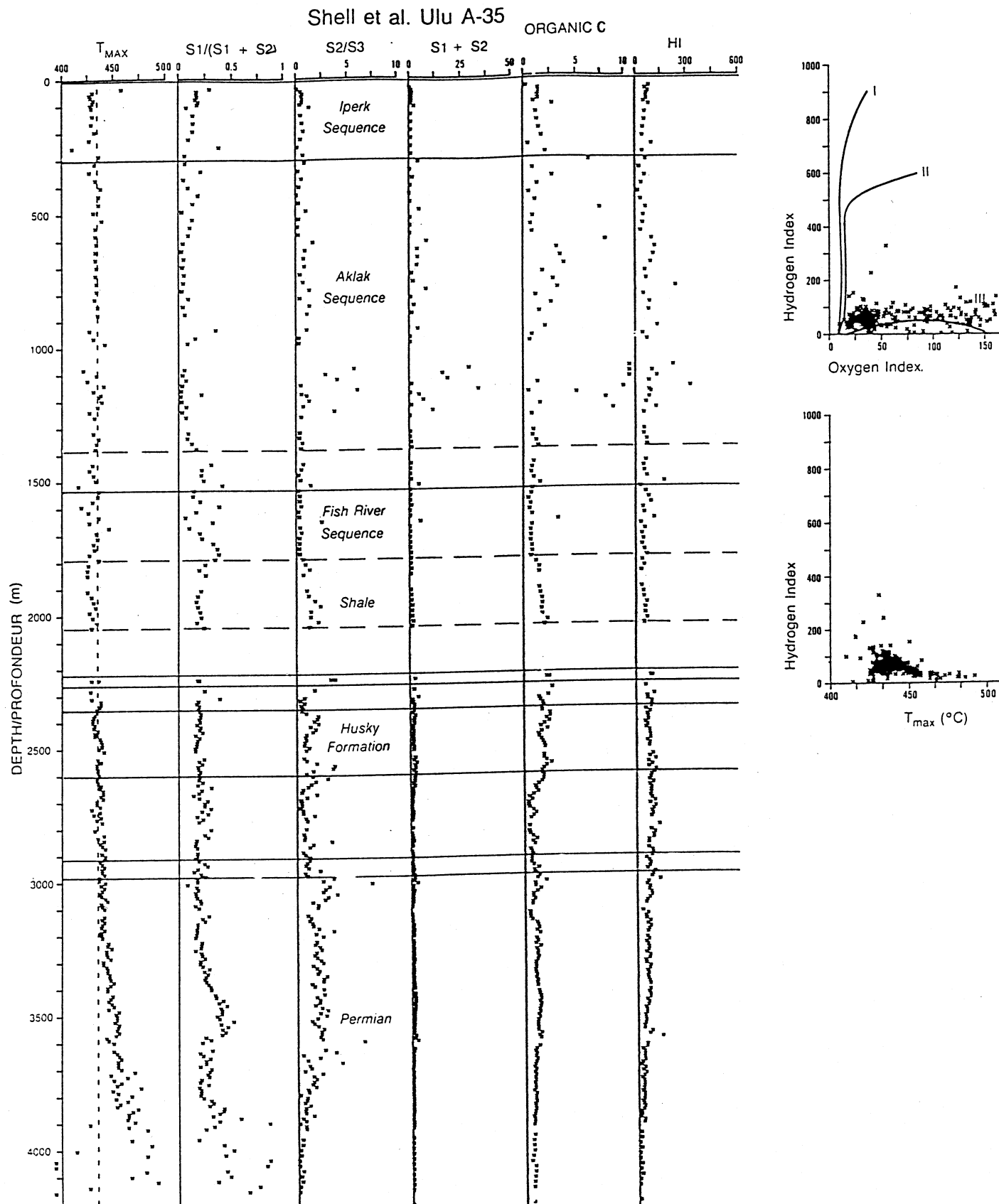
Figure 7. *Rock-eval/TOC analyses for Ulu A-35 well (from Snowdon, 1990).*

sequences range from 2 to 10%. Another potential oil source is found in organic-rich marine shales of the Albian Arctic Red Formation which are coeval with the Albian Flysch succession (Fig. 3). These rocks are immature due to shallow burial in the area. Terrestrially derived organic matter, generally indicative of gas-prone source material, predominate in Jurassic and Lower Cretaceous shales. The Ulu A-35 well represents one of the 14 wells penetrating the succession. A Rock-eval/TOC analysis was completed on this well (Fig. 7; Snowdon, 1990; 1996). The well was collared in the Plio-Pleistocene Iperk Sequence and penetrated the lower Tertiary sequence, specifically Aklak and Fish River sequences, as well as Cretaceous, Jurassic and Permian strata. The Tertiary succession is marginally mature to mature with the top of the conventional oil window occurring at a depth of 1,370 m. Basal Tertiary, Cretaceous, Jurassic and upper Permian strata occur within the conventional oil window. Depths greater than 3,500 m have samples that are overmature. Hydrogen indices (HI) and TOC values decline accordingly with increases in maturity. The Smoking Hills and Boundary Creek TOC values in the well are somewhat lower than values obtained elsewhere in the basin (averages of 2.33

Figure 8. *Estimate of in-place oil potential of the South Delta–Mesozoic play. Median value of probabilistic assessment is 2.8 million m³ of in-place oil distributed in 4 fields.*
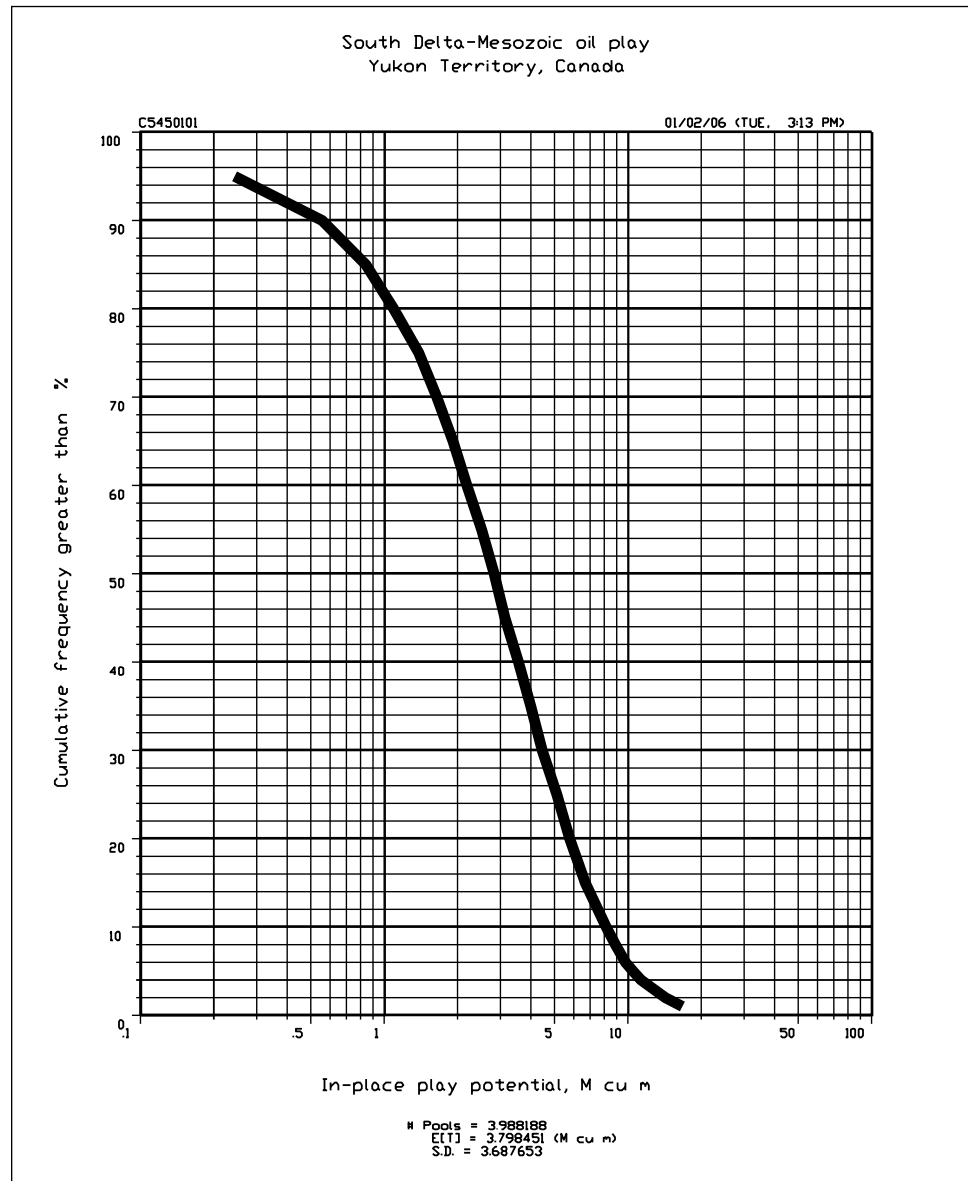
and 1.95%, respectively). Husky Formation TOC average values in the well (1.95%) are comparable to Smoking Hills and Boundary Creek sequence total values. Hydrogen index values in Husky shales are only slightly lower than Cretaceous units (Snowdon, 1996).

Exploration risks

All of the Yukon North Coast immature and conceptual plays are inferred to exist (implicated by a play-level marginal probability of 1.0). However, within each play, geological risk factors at the prospect level are evaluated in order to derive the exploration risk for the entire play. Significant prospect-level risks associated with this play are presence of closure, and adequate porosity, source and preservation (Appendix 1). Closure risk is related to significant difficulty in mapping and interpreting closures against thrust faults in the Unak area. Well-cemented sandstones are common in the play making porosity generally low and increasing the risk for reservoir facies in certain prospects. High risk was assigned to source since potential source material may be eroded and

Figure 9. *Estimate of in-place gas potential of the South Delta–Mesozoic play. Median value of probabilistic assessment is 2.0 billion m³ of in-place gas distributed in 8 fields.*

removed over large portions of the play area. Cretaceous erosional events may also remove reservoir facies in parts increasing the risk of adequate preservation in the play.

On the other hand, low risk, or high marginal probability, was assigned to seal and timing (Appendix 1). Thick shale successions separate sandy formations providing effective top seal for most of the prospects. Most structures, particularly closures against normal faults, seem to have formed previous to the main episode of hydrocarbon generation when maximum burial was achieved, thus, providing structural traps before hydrocarbon migration took place. Younger thrust fault structures in the north, however, may have post-dated the main episode of hydrocarbon generation.

Play potential

The South Delta–Mesozoic play has estimated in-place median oil and gas resource values of 2.8 million m^3 and 2.0 billion m^3, respectively (50 percentile values in Figs. 8, 9; Table 1). If the 95 and 5 upper percentiles representing the range of expected resource are specified,

Figure 10. *Field-size-by-rank plot of the South Delta–Mesozoic oil play. Median value of the largest predicted field size is 2.4 million m^3 of in-place oil.*
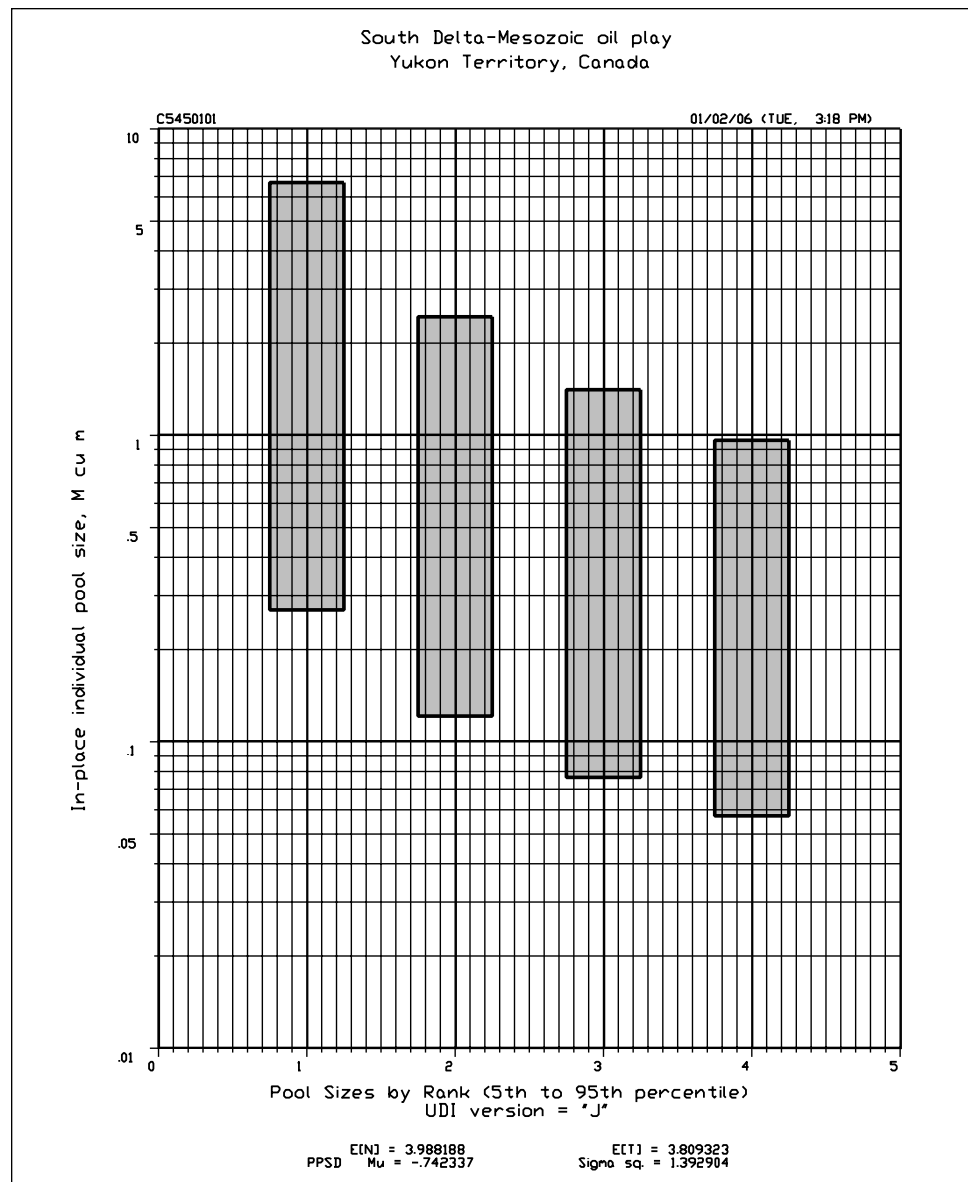
then there is a 90% chance that the resource potential of oil resides within the range of 0.2 to 10.5 million m^3 in-place (Fig. 8). The range for in-place natural gas of expected resource potential is 0.5 to 5.7 billion m^3 in-place (Fig. 9). In the Kugpik O-13 well, one oil pool has been discovered. It has an in-place volume of 6.7 million m^3. The in-place median play potential conditioned on this discovery is reduced to 2.4 million m^3. Similarly, one gas pool was discovered in the play at Unak L-28, containing an in-place volume of 1,578 million m^3. The conditioned median potential for gas resource is 1.2 billion m^3.

The mean value of the number of predicted fields for the oil play is four. The largest field is expected to contain 1.5 million m^3 of oil (median value of first box in Fig. 10, Table 1). The Kugpik O-13 pool, with a volume of 6.7 million m^3, matches with the fifth upper percentile of the largest predicted field size (see Appendix 2 for computation outputs). Therefore, the largest pool or field has already been discovered and three more fields are predicted. The median of the largest remaining field size is 0.7 million m^3 in-place (median value of second box in Fig. 10; Appendix 2). No fields with volumes greater than 160 million m^3 of oil are predicted to occur in this clastic play. This threshold value,

Figure 11. *Field-size-by-rank plot of the South Delta–Mesozoic gas play. Median value of the largest predicted field size is 750 million m3 of in-place gas.*

160 million m³ (1 billion bbls), is an arbitrary in-place oil volume defined as the minimum individual field size needed in a specified play on a stand alone basis in a frontier region of Canada that may spark interest among explorationists for initiation of exploration activities in that region.

In the gas play, the expected number of natural gas fields is 8. The median in-place size of the largest predicted field size is 750 million m³ of gas (Fig. 11, Table 1). The discovered gas pool at Unak L-28 with a volume of 1,578 million m³ lies well within the 95/5 upper percentile range for the largest predicted field size. The largest gas field, therefore, has been discovered in the play and seven smaller fields are predicted. The largest remaining field has a median estimate of 391 million m³ (Fig. 11, Appendix 2). A threshold volume of 3,000 million m³ or 100 BCF has been arbitrarily defined as a minimum field size needed to spark sufficient interest for exploration of a single play in a frontier region. No fields of this minimum size are predicted for this play.

The method employed in this study where oil and gas assessments of the same play are run separately, does not reveal how the oil and gas is distributed among the twelve predicted fields of both plays. It is not known what proportion of individual oil and gas accumulations occur as saturated or undersaturated pools in the same prospect or as separate pools in different prospects.

Hydrocarbon plays in this assessment area often occupy areas spanning political boundaries such as the Yukon/Northwest Territories and Yukon/Alaska borders. If it can be assumed that the hydrocarbon resource is evenly distributed throughout the total play area, the proportion of resource occurring in the Yukon can be estimated by comparing play areas among the various political jurisdictions. The location of the largest remaining field cannot be determined, so two scenarios are proposed; scenario 1 where the largest field is assumed to occur in the Yukon, and scenario 2 where the largest field is present outside the Yukon Territory. Table 2 itemizes the diminished oil and gas potential for the North Coast region in the Yukon Territory under the two proposed scenarios. Only about 2.5% of the play area of the South Delta–Mesozoic oil and gas play is located in the Yukon (Fig. 5), so the amount of oil and gas predicted if the largest undiscovered field is assumed to occur in the Yukon is 0.74 million m³ and 412 million m³, respectively (Scenario 1). If, however, the largest remaining field is assumed to reside in the Northwest Territories, then the potential is reduced substantially to 0.04 million and 21 million m³ of oil and gas, respectively (Scenario 2; Table 2).

SOUTH DELTA–PALEOZOIC GAS PLAY

HYDROCARBON PLAYS

Play definition

This exploration play contains all structures and prospects occurring in Upper Carboniferous to Permian reservoir strata in the southern Mackenzie Delta (Fig. 12). The play area coincides with the South Delta–Mesozoic oil and gas play (Figs. 5, 12). Gas is the principal hydrocarbon. Only 2.5% of the play area occurs in the Yukon Territory.

Geology

Prospective targets in this Upper Paleozoic succession are dolomitic facies and leached zones adjacent to unconformities within marine limestones of the Upper Carboniferous Lisburne Group as well as local coarser strata among interbedded sandstones and shales of the Permian Sadlerochit Group. The prospect succession may attain thicknesses up to 500 m and it occurs at depths ranging from 1,200 to 4,000 m. Ten wells have penetrated Paleozoic strata in the play area resulting in one discovered gas pool at Unak L-28 occurring in Lisburne carbonates. Condensate was also recovered from Carboniferous strata in the same well. Porosity and permeability of the Upper Paleozoic succession is generally poor, but sufficient secondary porosity development resulting from fracturing has created some reservoir potential.

Structural traps are likely dominant, with closure against normal faults most common (Fig. 13). In the northwestern part of the play area including the area in the Yukon Territory, thrust faulting is present which complicates the tilted fault block pattern. Unconformity-related stratigraphic traps are also likely present. Marine shales in Jurassic and Lower Cretaceous strata provide effective top seal for these traps in Paleozoic strata. Most of these structures developed during the Laramide orogeny. Hydrocarbon
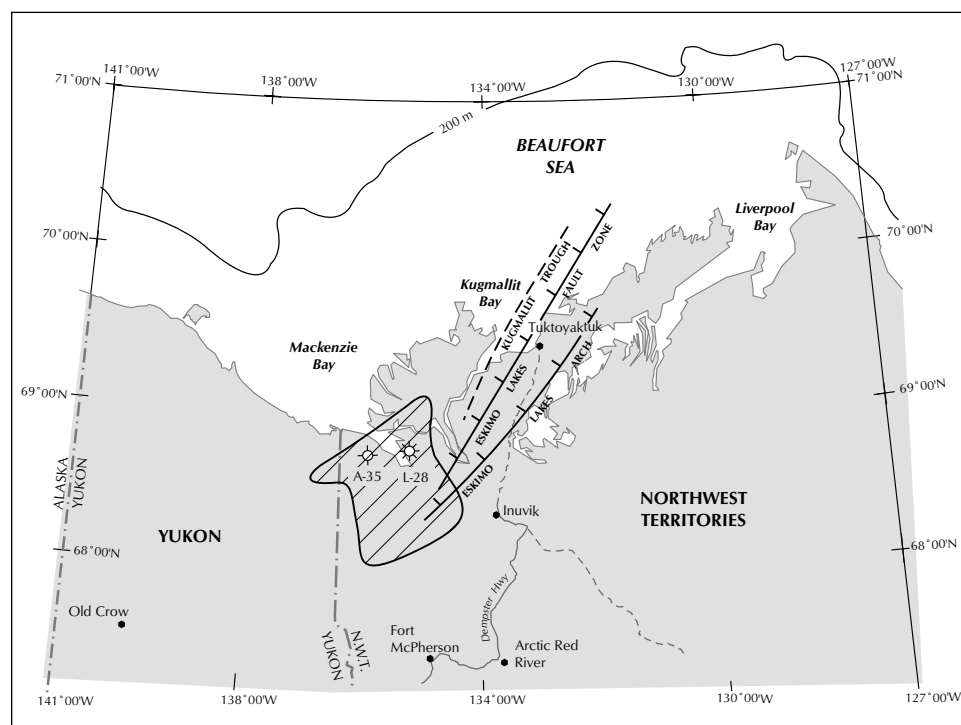
Figure 12. *South Delta–Paleozoic gas play (from Dixon, et al., 1988). Wells discussed in report are shown (1–Unak L-28, 2–Ulu A-35).*

generation likely occurred during the latter stages of the orogeny when maximum burial was achieved. Therefore, most structures were formed previous to or contemporaneous with the main episode of hydrocarbon generation. Younger thrust-related structures seem to have developed subsequent to the main phase of hydrocarbon generation. Renewed burial of organic-rich sediments by thrusting episodes may have induced a secondary phase of thermogenic gas generation.

Beneath the Mackenzie Delta, Upper Paleozoic source rocks have not been identified. The juxtaposition of Paleozoic reservoir against Mesozoic organic-rich shales by faulting produces favourable trapping configurations. In the Ulu A-35 well (Fig. 7), Rock-eval analyses indicate that Upper Permian strata lie within the lower portion of the conventional oil window, meaning that organic matter occurring in Lower Permian strata is overmature (Snowdon, 1990, 1996). This implies that any hydrocarbon generated from Paleozoic source rock in the area is likely dry gas only. In the well, most organic matter seems to be terrestrially derived (Type III; Fig. 7). Type III organic matter usually indicates gas-prone strata. HI and TOC values also decrease with depth as maturity increases. Little or no oil is expected in this play.

Exploration risks

Heightened risk factors integrated into the analysis of this exploration play are presence of closure and adequacy of porosity (Appendix 1). Porosity development is generally poor and inadequate reservoir quality may be widespread. Closure integrity may be affected by erosion. Adequate seal, timing, preservation and source are expected for most prospects in this play.

Play potential

This play has an estimated median resource potential of 6.7 billion m^3 of in-place natural gas (Fig. 14; Table 1). The range of estimates for resource potential is 1.7 to 16.5 billion m^3 in-place. The expected number of gas fields in the play is 15 (mean value) with the largest field having a volume of 1.7 billion m^3 (Fig. 15; Table 1). No fields are expected with volumes greater than three billion m^3 in this play (Appendix 2). One

Figure 13. Schematic sketch of the trap-types in the South Delta-Paleozoic gas play (from Dixon, et al., 1994).
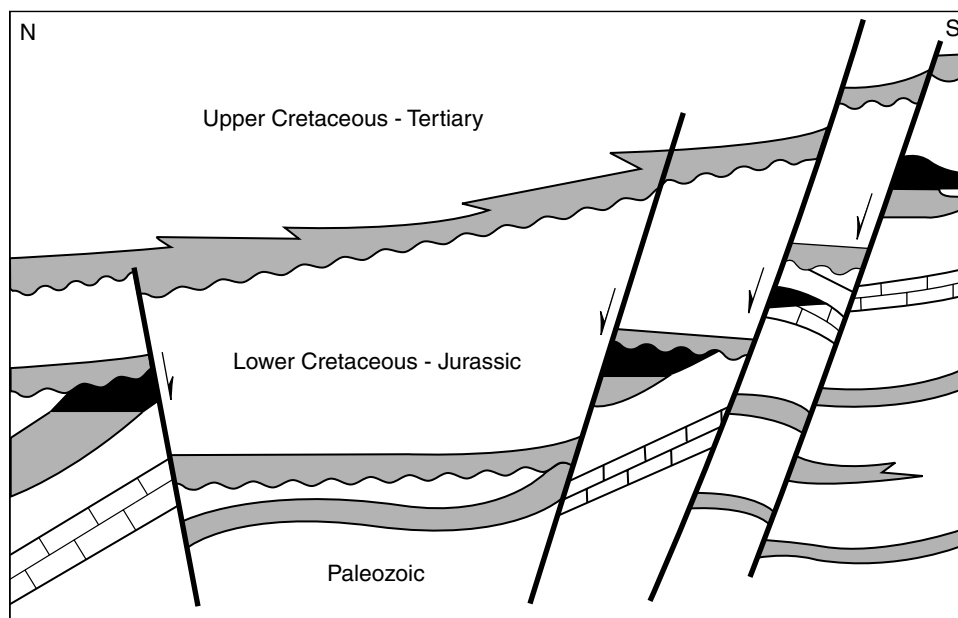
gas pool was discovered at Unak L-28 in the Northwest Territories having an initial in-place volume of 311 million m³. This pool was discovered in Carboniferous carbonates. The expected median estimate of the play potential conditioned on this discovery is 6.4 billion m³ (Appendix 2). The gas discovery matches closely with the median volume retrieved for the seventh largest predicted field size. Six larger field sizes, therefore, are predicted to occur in this play. Condensate was also recovered at Unak in Carboniferous carbonates. An average liquid content of 10.7 cubic metres of condensate per million cubic metres of gas in the Unak gas pool gives a median potential of 0.71 million m³ of condensate in the play. Remaining median potential, discounting the Unak discovery, is 0.68 million m³ (Table 1).

Only 2.5% of the play area is defined in the Yukon Territory (Fig. 12). If the largest undiscovered field is assumed to occur within this small area, then the play potential in the Yukon is 1.8 billion m³ (Scenario 1; Table 2). If the undiscovered field remains to be found in Northwest Territories (which is much more likely), the play potential in the Yukon is much reduced, to 116 million m³ in-place (Scenario 2; Table 2).
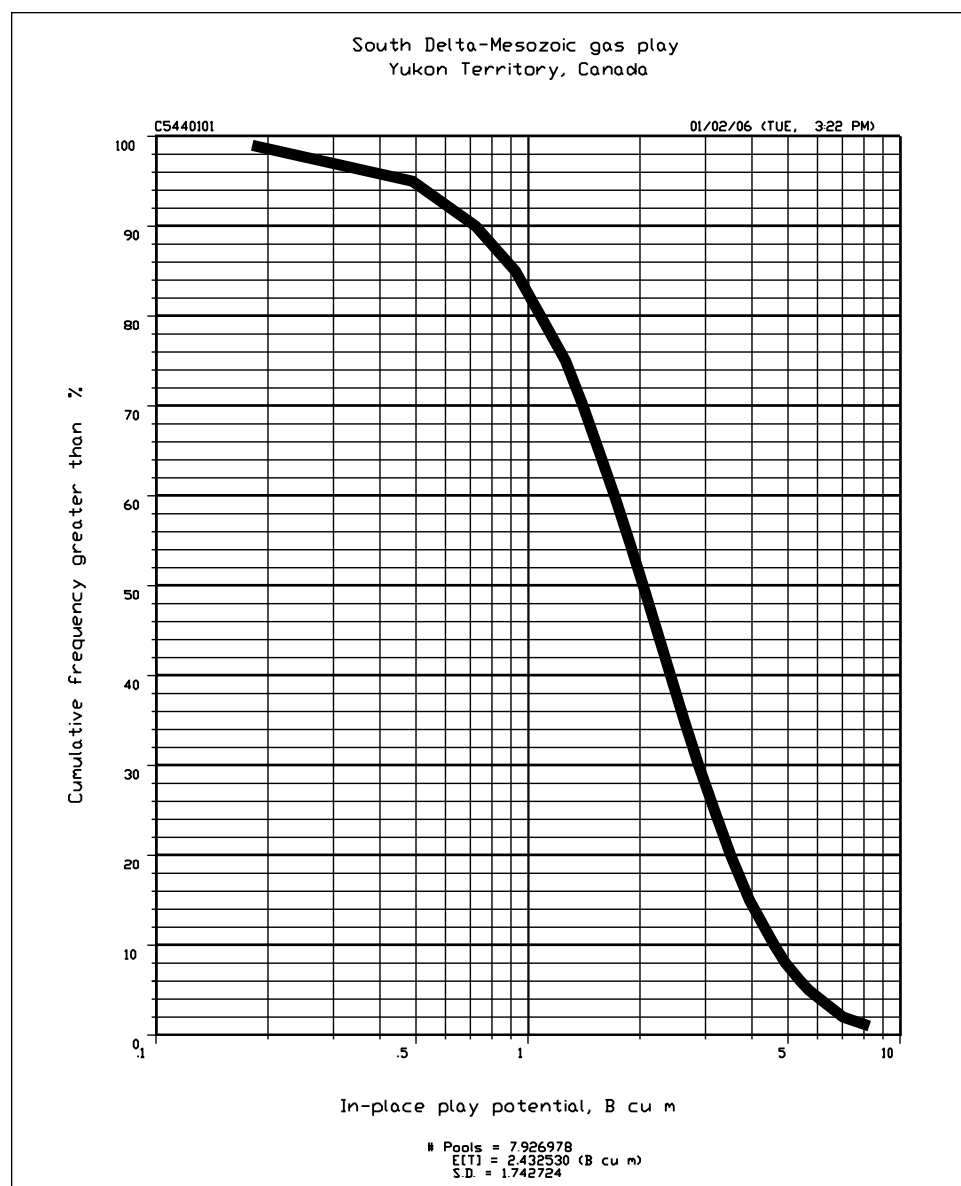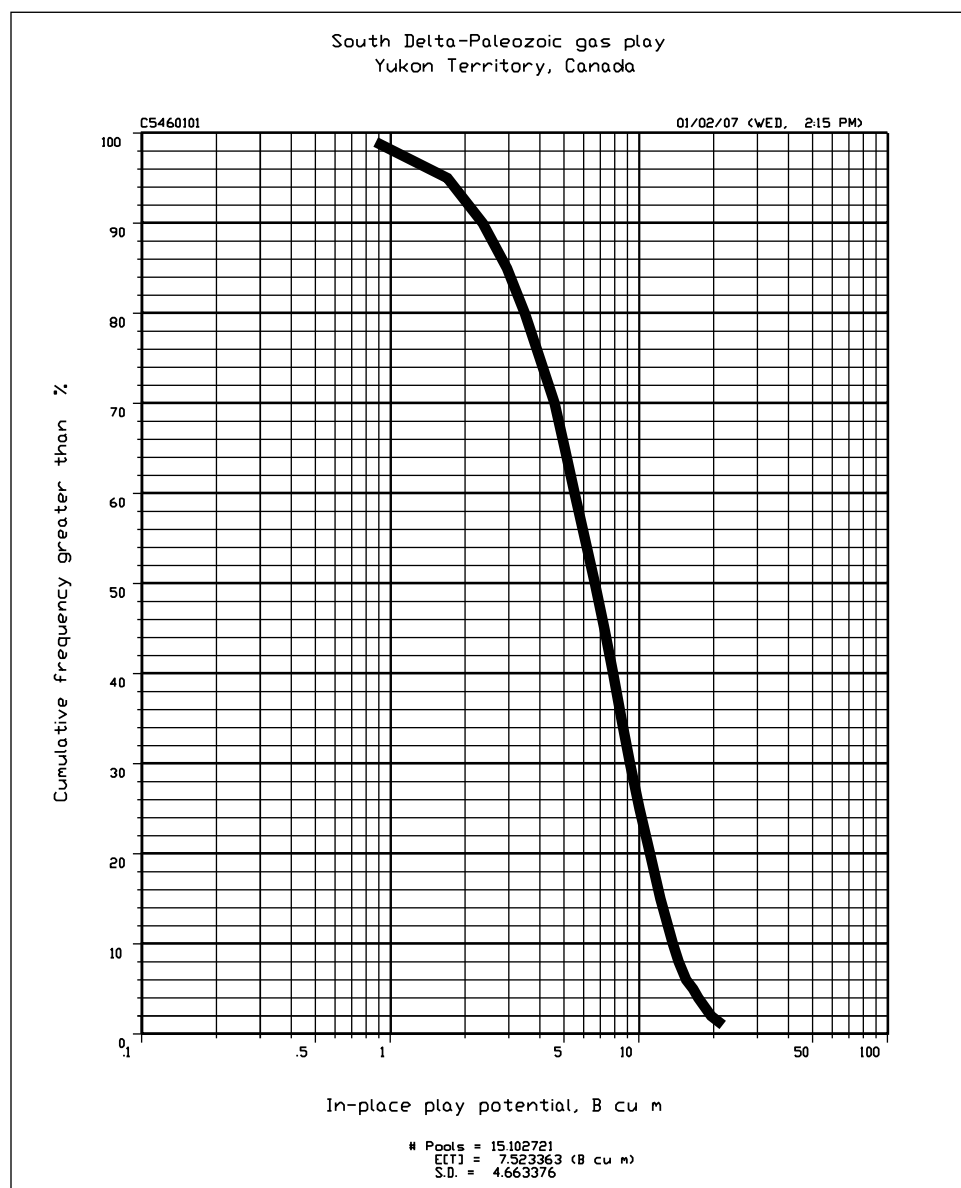

Figure 14. *Estimate of in-place gas potential of the South Delta–Paleozoic play. Median value of probabilistic assessment is 6.7 billion m³ of in-place gas distributed in 15 fields.*

HERSCHEL OIL AND GAS PLAY

HYDROCARBON PLAYS

Play definition

The Herschel play includes all Paleocene to Early Eocene Fish River and Aklak sequence oil and gas prospects present in Herschel and Blow River highs (Figs. 2, 16). These two structural complexes, containing highly deformed Tertiary strata, occur beneath the shallow waters of the southwestern Beaufort shelf. The Blow River High extends onshore beneath the coastal plain near the Yukon-Northwest Territory boundary. The Herschel High continues westwards into Alaska offshore waters. Much of the play area occurs in the Yukon Territory (about 81%) (Fig. 16).

Geology

Paleocene and Early Eocene strata are intensely folded and faulted within cores of two structurally elevated complexes that form part of the west Beaufort Tertiary fold belt. High-amplitude, closely spaced folds and reverse faults represent the most common structural trap type in the play (Fig. 17). Sandstones may subcrop unconformities forming small stratigraphic traps. Within these deformed Tertiary strata, potential reservoir units include delta-front and delta plain sandstones. Thickness of this succession ranges from 5,000 to 7,000 m in the play area. Depths of prospects vary from 1,500 to 8,000 m. Deep erosion of sub-middle Eocene strata has occurred over the crests of these highs. No wells and no hydrocarbon shows are recorded in the play.

Several stages of Tertiary contractional deformation have been identified within the play area. A major tectonic pulse, affecting lower Tertiary strata, commenced in Early Eocene and culminated in Middle Eocene time. Folds and thrust faults were formed at this time. Post middle Eocene deformation significantly overprinted this earlier stage

Figure 16. *Herschel oil and gas plays (from Dixon, et al., 1988).*
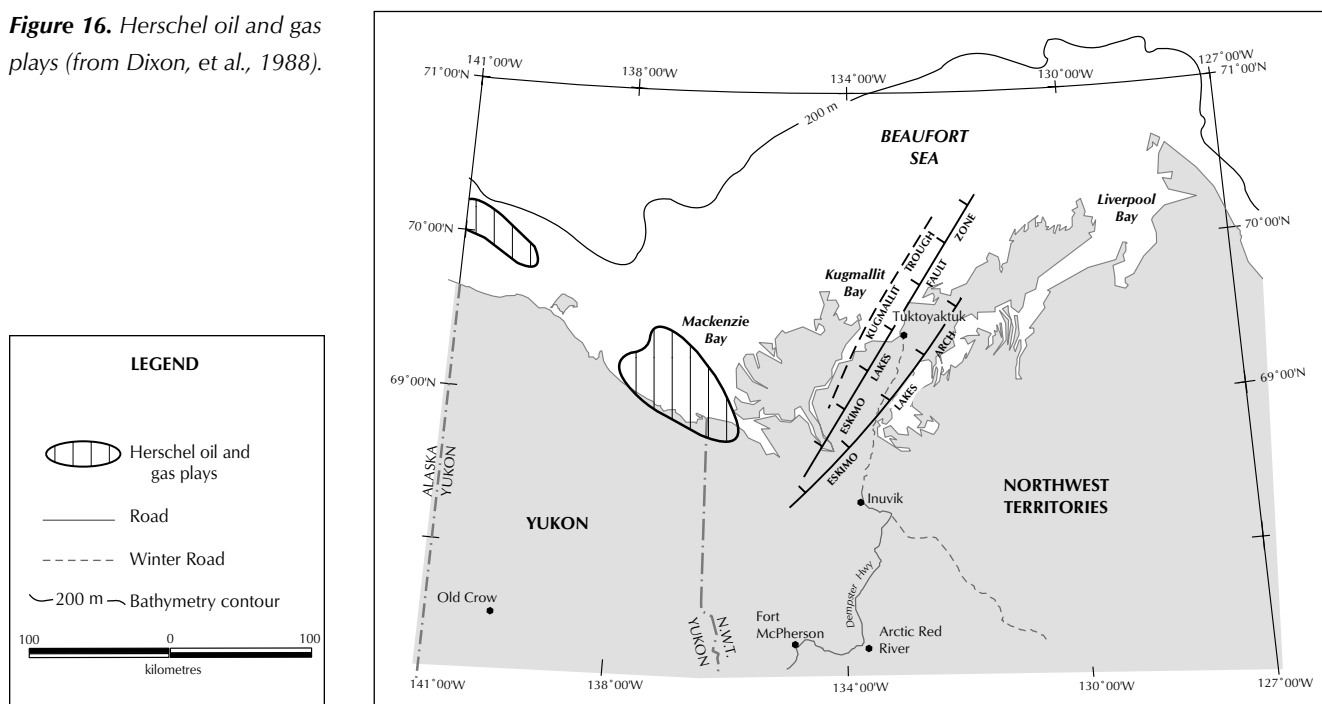
of deformation. Identifiable deformational stages occur in late Eocene, Oligocene and late Miocene time. Maturation of potential hydrocarbon sources was reached prior to completion of structural deformation. Maximum burial likely took place at about 85 Ma, previous to the start of Laramide deformation at 78 Ma. Migration of hydrocarbons was initially controlled by depositional geometries. Hydrocarbons trapped during these initial stages may have subsequently re-migrated into anticlinal and fault-related traps following deformational episodes.

Oil and gas source rocks are found in Upper Cretaceous Boundary Creek and upper Eocene Richards shales. Oil-prone strata are also found in the lower Fish River sequence. The organic matter is dominantly Type III terrestrial-dominated material. The organic matter is mature, however, TOC values are generally quite low with many intervals containing only 1–2% TOC. Conventionally, Type III organic matter generates gas but the oils interpreted to be derived from these organic-rich horizons may be produced from resin-rich terrestrial organic matter.

Exploration risks

Significant risk factors attributed to the Herschel play are the presence of closure and adequate seal and source (Appendix 1). Lack of seal and closures are related to the deep erosion of Fish River and Reindeer strata over the structurally elevated features. Steep internal structural dips severely reduce closure areas, which result in reduced potential.

Play potential

Estimates of potential for the Herschel oil play indicate a median in-place volume of 34.6 million m^3 (Fig. 18; Table 1). Predicted resource potential for gas in the Herschel play is 16.1 billion m^3 (median volume) (Fig. 19; Table 1). Predictive ranges of oil and gas resource potential vary from 2.8 to 107.9 million m^3 and 1.3 to 49.5 billion m^3, respectively. The mean number of predicted fields in both plays is 5.

The largest individual field sizes predicted for oil and gas are 15.5 million m^3 and 7.1 billion m^3, respectively (Figs. 20, 21; Table 1). No oil fields greater than 160 million m^3
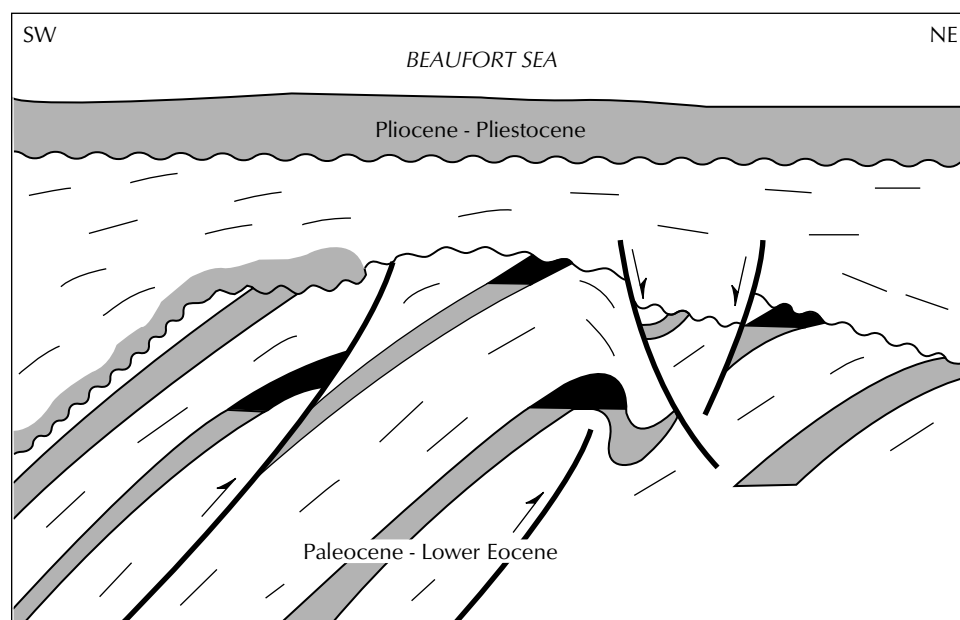
Figure 17. *Schematic sketch of the trap-types in the Herschel play (from Dixon, et al., 1994).*

are expected to be present in the Herschel or Blow River highs. However, two gas fields with median estimates greater than 3 billion m³ have been predicted.

About 81% of the play area occurs in the Yukon Territory. Under Scenario 1, where the largest undiscovered field is assumed to occur in the Yukon, the expected play potential for oil and gas is 31 million m³ and 14.4 billion m³, respectively (Table 2). If, however, the largest predicted field is presumed to occur either in the Northwest Territories or Alaska, the potential is reduced to 15.5 million m³ oil and 7.2 billion m³ gas (Table 2).

Figure 18. *Estimate of in-place oil potential of the Herschel play. Median value of probabilistic assessment is 34.6 million m³ of in-place oil distributed in 5 fields.*
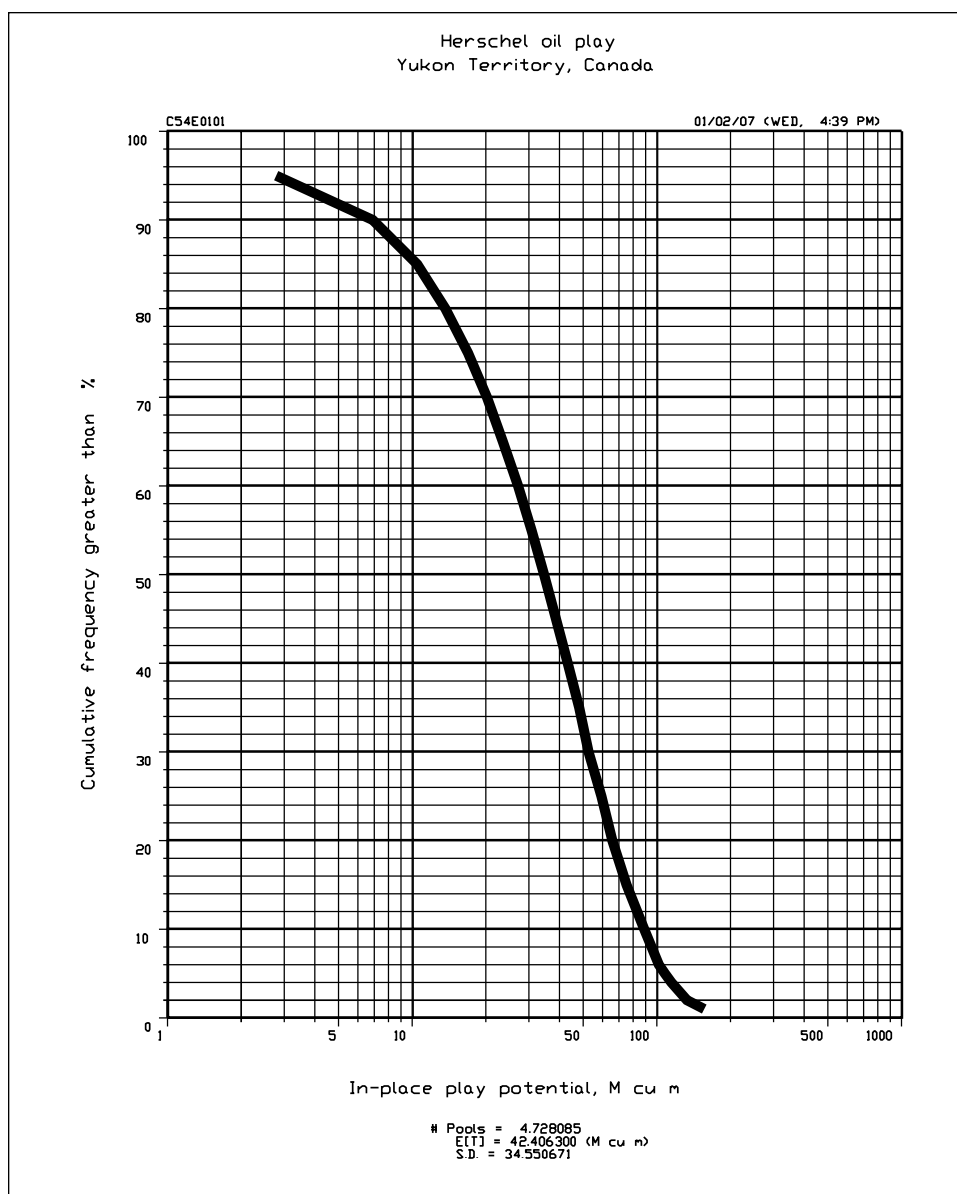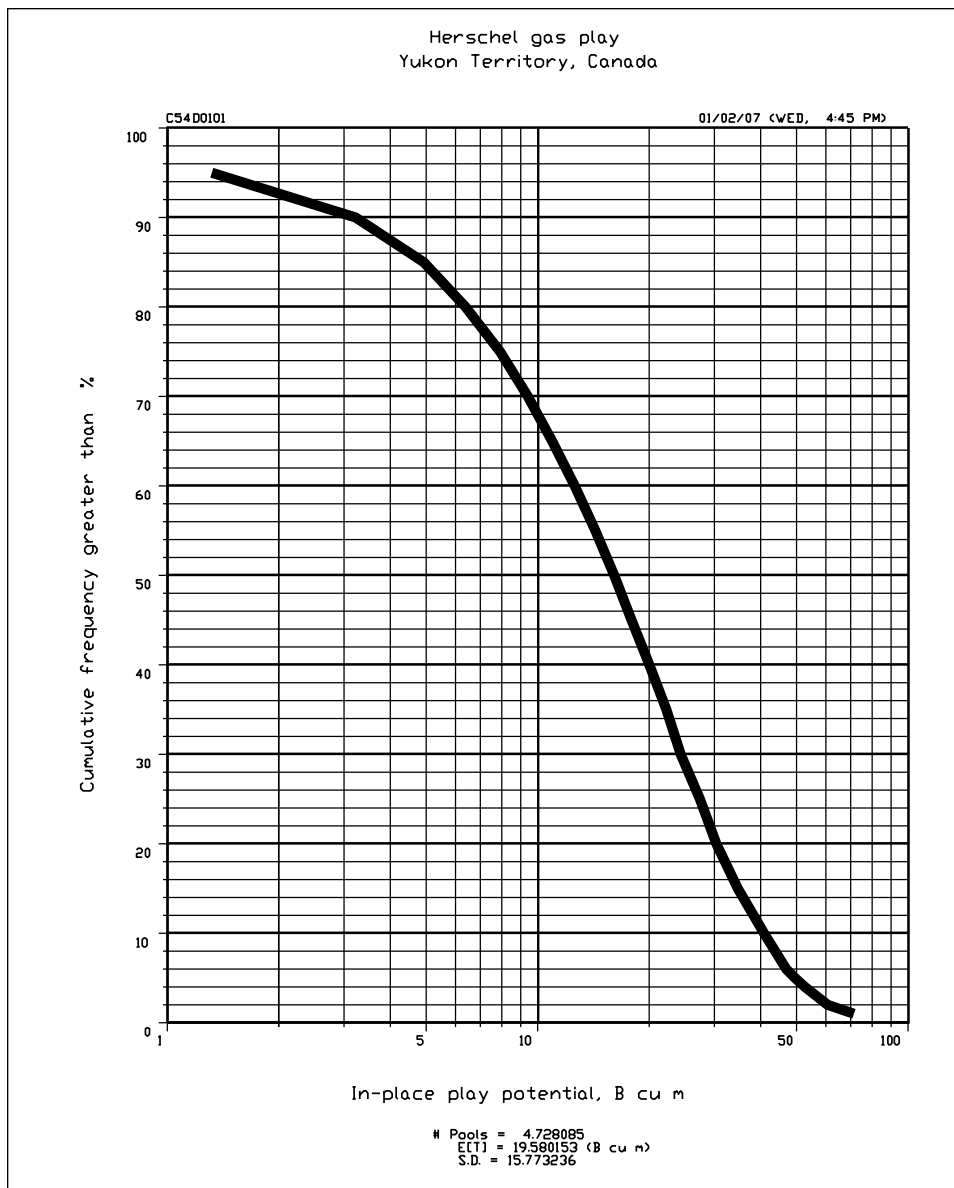
Figure 19. *Estimate of in-place gas potential of the Herschel play. Median value of probabilistic assessment is 16.1 billion m³ of in-place oil distributed in 5 fields.*
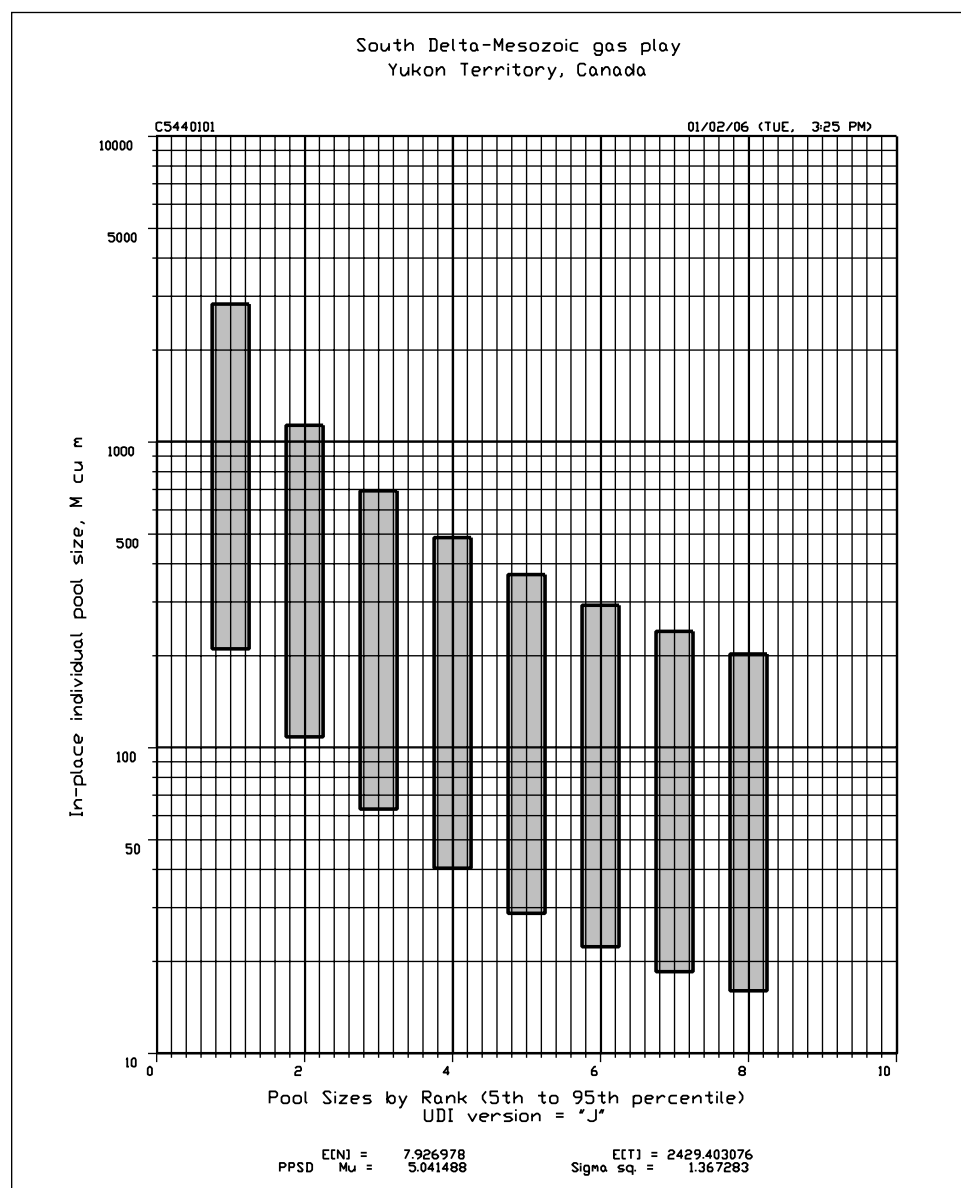
Figure 20. Field-size-by-rank plot of the Herschel oil play. Median value of the largest predicted field size is 15.5 million m³ of in-place oil.
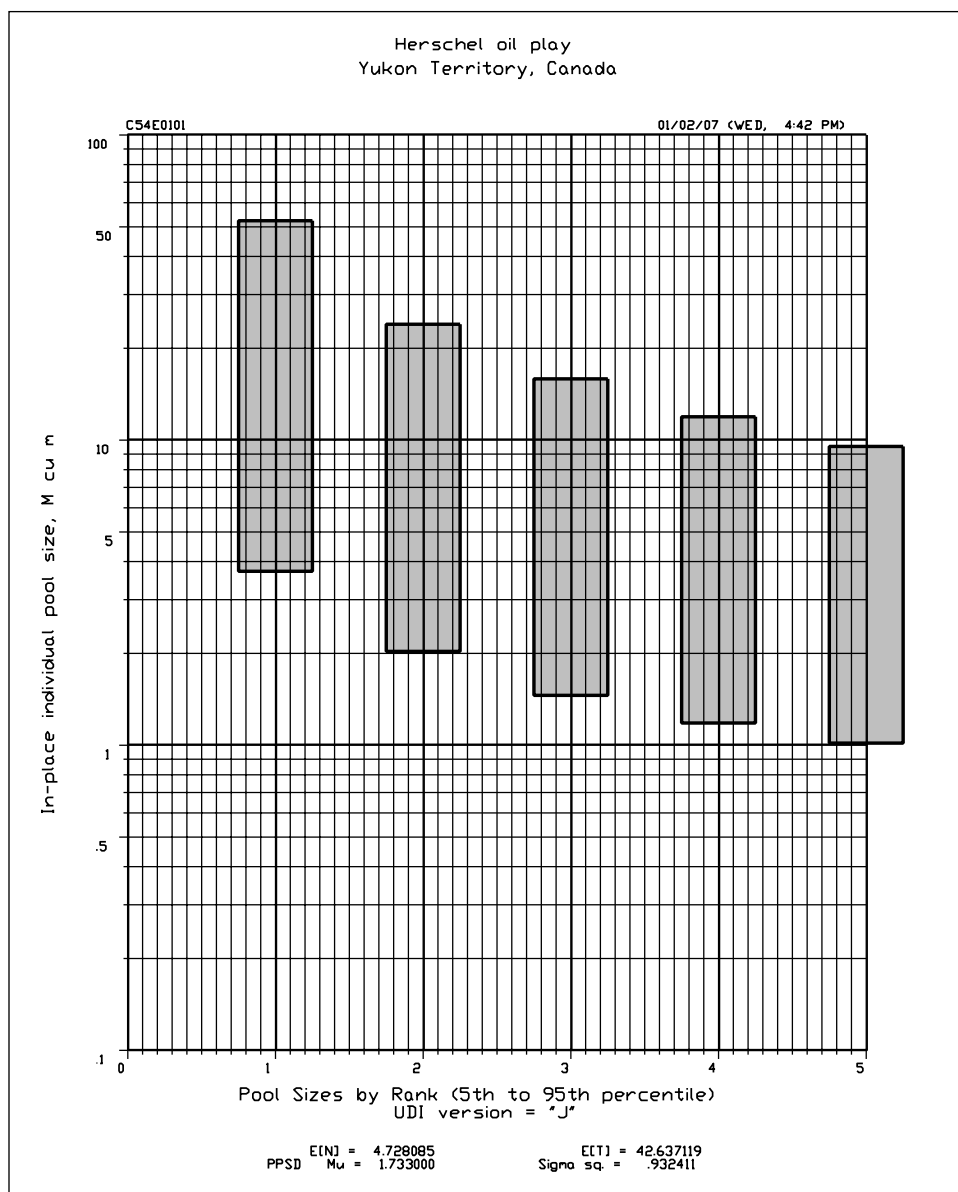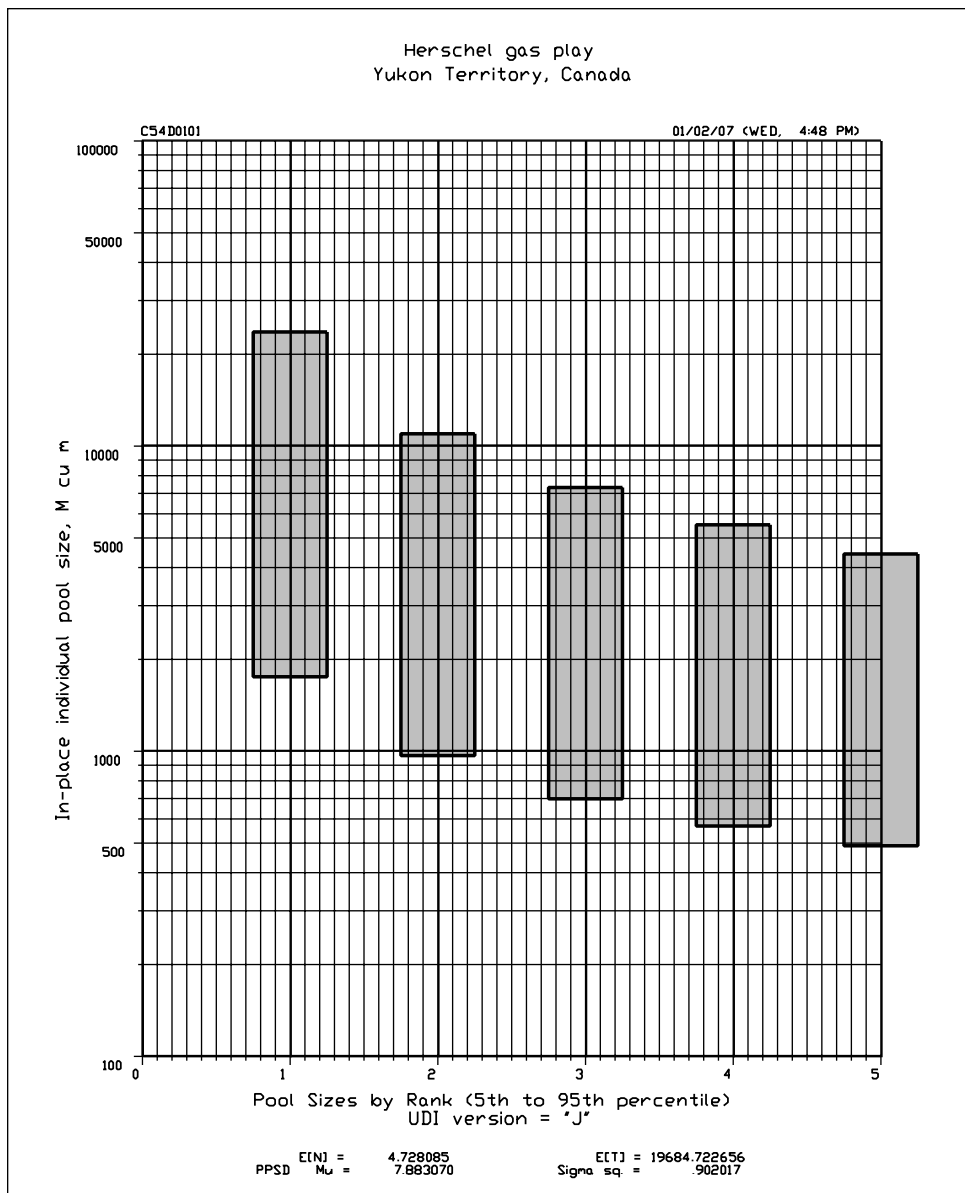
Figure 21. Field-size-by-rank plot of the Herschel gas play. Median value of the largest predicted field size is 7.1 billion m^3 of in-place gas.

YUKON COASTAL PLAIN GAS PLAY

HYDROCARBON PLAYS

Play definition

This conceptual play includes all pre-Cenomanian natural gas traps along the Yukon coastal plain extending from the northern end of the Richardson Mountains westwards to the British Mountains (Fig. 22). The play area also includes a narrow strip of inshore waters of the Beaufort Sea. It extends southward to the Barn Mountains and includes the upper reaches of the Blow River. Figure 22 shows the play may extend into Alaska to the west. However, insufficient information is available to accurately map the play boundary extensions in Alaska. Therefore, in this play assessment, all of the predictions obtained assume the play occurs exclusively in the Yukon. Gas is expected to be the principal hydrocarbon in the play.

Geology

The coastal plain play basically occupies the Rapid Depression along the Arctic coast of northern Yukon (Fig. 2). The precursory Blow Trough occupies the Rapid Depression between Cache Creek Uplift and Barn Mountains. There is a thick Mesozoic accumulation of clastic sediments in the Rapid Depression. Interbedded shale and sandstone of Jurassic to Albian age occupy the depression. These Mesozoic strata attain thicknesses of 5,000 to 10,000 m. Surrounding mountains expose Paleozoic to Proterozoic sedimentary strata. In the Barn and British mountains (Romanzof Uplift), Lower Paleozoic basinal shales, sandstone, thin-bedded carbonates and chert, Carboniferous Kayak and Kekiktuk clastic sediments and Lisburne carbonates, and Permian clastics and carbonates of the Sadlerochit Group are exposed. The thickness of the total prospect succession, including Mesozoic and Paleozoic strata, may be on the order of 5,000 to 15,000 m. Depths of this prospect succession may range from surface to 18,000 m.

Figure 22. Yukon coastal plain gas play (from Dixon, et al., 1988). Wells discussed in the report are shown (1–Roland Bay L-41, 2–Spring River N-58, 3–Blow River E-47).
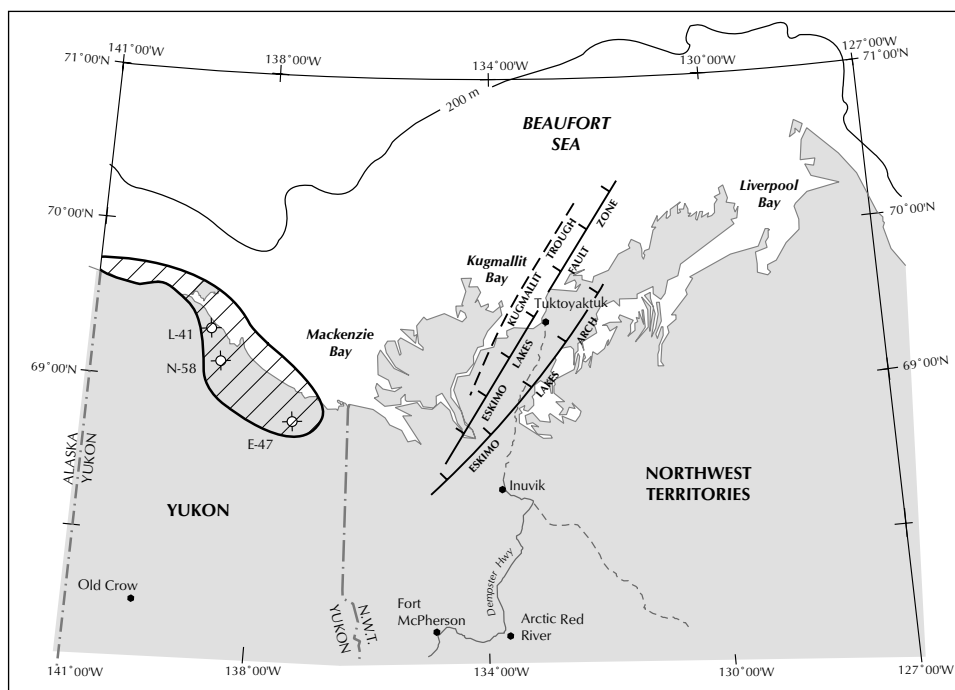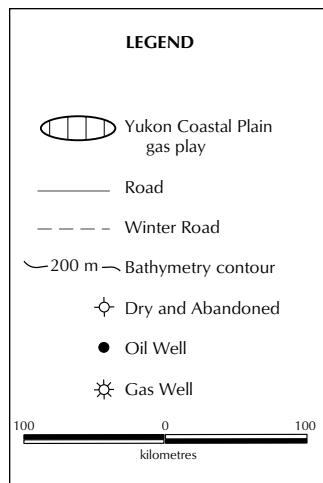
In the Rapid Depression, Jurassic through Valanginian strata contain dominant shales of the Kingak Formation. Both the prograding clastic wedges of the sandstone-rich Bug Creek Group and the Martin Creek Formation in the Blow Trough shale-out to the west. Kamik sands are more widespread in northern Yukon except in the British Mountains to the west where an equivalent shale facies has been deposited. Late Barremian-Aptian Rat River Formation sandstones are only present on the eastern side of the Blow Trough. To the west, Rat River sands have been removed by erosion. Sediment gravity-flow deposits consisting of interbedded conglomerate, sandstone and shale of Albian age occur in the Blow Trough.

Even though the potential reservoir facies in the play seem numerous, the clastics are generally well-cemented with silica resulting in tight, low-quality reservoirs. Carbonates also exhibit low porosity characteristics but fracturing can be extensive.

Surface mapping and seismic interpretation indicate that the area is structurally complex with numerous trapping configurations occurring in association with thrust faults, normal and strike-slip faults and associated folds (Fig. 23). The major episode of deformation seems to have taken place during the Laramide orogeny, although older events have affected present trends. This implies that at least some of the structures formed prior to hydrocarbon generation and migration. Maximum burial depth when hydrocarbon generation was optimal occured during Tertiary time, so pre-existing structural traps would have captured migrating gas.

Three wells have been drilled in the play area, all in the early 1970s. All wells were dry and abandoned. Blow River E-47 in the Blow Trough stopped drilling in Albian Flysch at a depth of 4,267 m. Spring River N-58 completed drilling in Paleozoic strata at 2,136 m. The third well is designated as Roland Bay L-41 and was drilled to a total depth of 2,752 m, bottoming in Jurassic Kingak Formation. This well penetrated about 2,000 m of Jurassic and Lower Cretaceous strata of the Kingak and Mount Goodenough formations (Fig. 24, Dietrich, 1986). These dominant shale successions are unconformably overlain by the organic-rich Boundary Creek Sequence. The high vitrinite reflectance profile for all Cretaceous and Jurassic strata indicates overmature organic matter (Fig. 24). Any potential source rock, therefore, regardless of its organic type, will produce dry gas
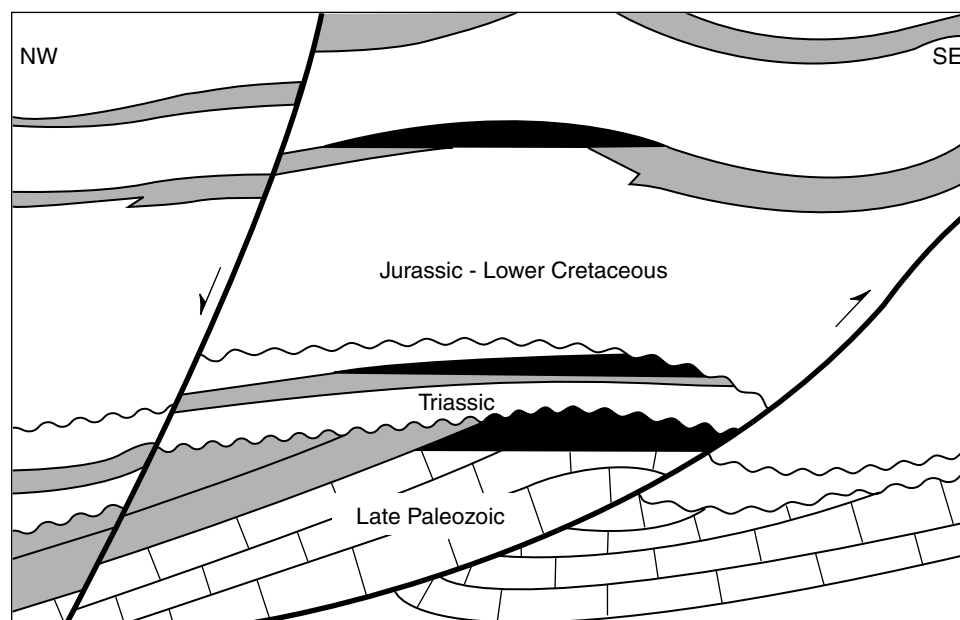
Figure 23. *Schematic sketch of the trap-types in the Yukon coastal plain play (from Dixon, et al., 1994).*

only. Subsequent to completion of these wells, a moratorium on drilling in the area was imposed, culminating in 1987 with the establishment of a national park extending from Babbage River westward to the Alaskan border.

Many similarities are evident when comparing the Yukon coastal plain play with the Folded Ellesmerian/Pre-Mississippian play in the Arctic National Wildlife Refuge in Alaska (Dolton, *et al.*, 1987). By using the Alaskan play as an analog in this particular play assessment, some reservoir parameters and risk factors can be used.

Exploration risks

Significant marginal probabilities were assigned to presence of closure, adequate porosity, timing and preservation at the prospect level (Appendix 1). The risk for closure occurs when insufficient deformation occurs in fault-related traps for complete closure. Porosity has a high risk of being inadequate due to the well-cemented nature of many of the clastic units. Timing was considered to be a significant risk factor due to the

Figure 24. Geological and geochemical summary of the Roland Bay L-41 well (from Dietrich, 1986).
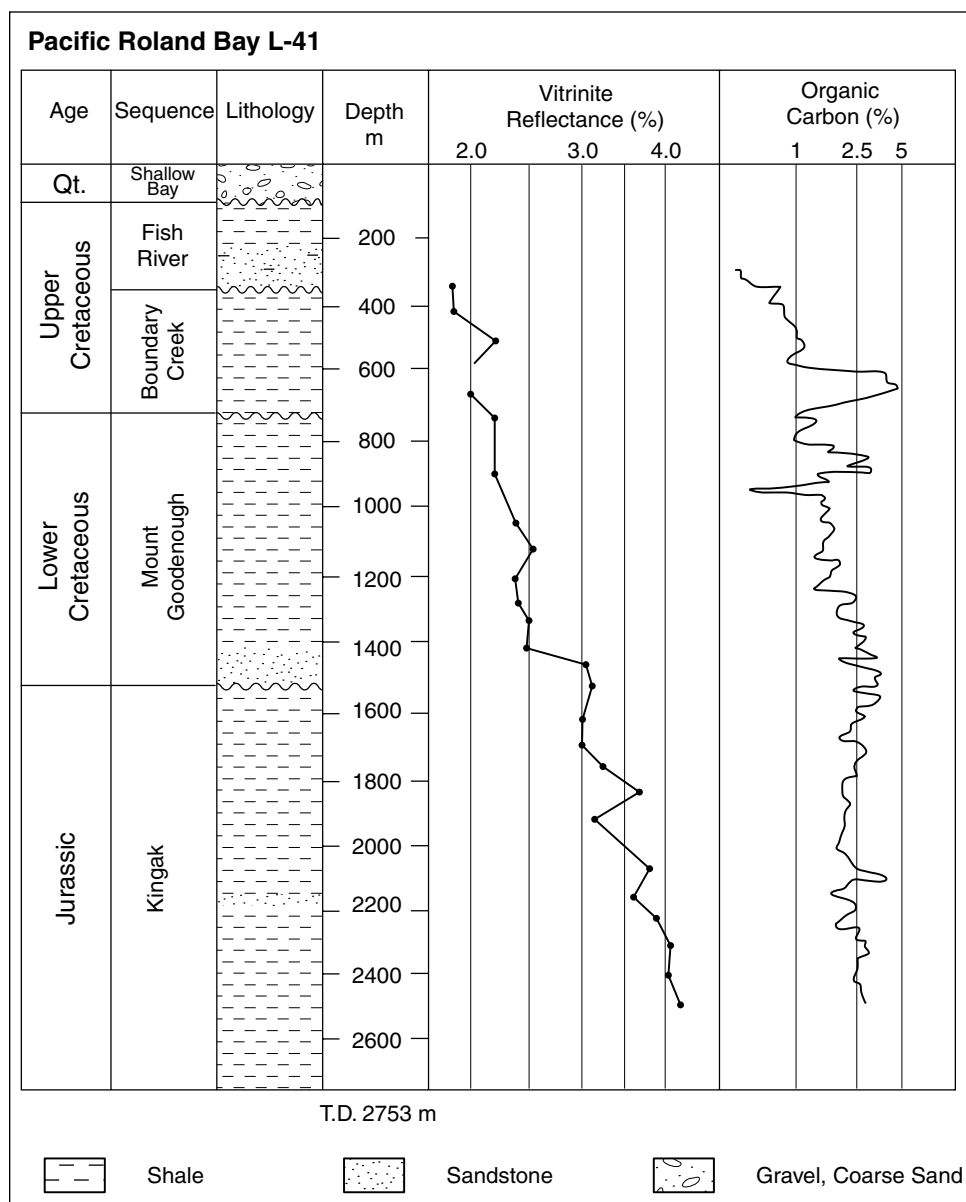
contemporaneous relationship of the Laramide deformational episode with a major period of hydrocarbon generation during maximum burial. Some structures were not formed before the main hydrocarbon migration episode. Uplift and deep erosion of pre-Cenomanian reservoirs during the mid-Tertiary is reflected in the high risk assigned to adequate preservation. Source and seal is most likely adequate in most prospects for gas accumulation due to the thick Jurassic and Lower Cretaceous shale succession occurring throughout the play area.

Play potential

The Yukon coastal plain play is expected to have a resource potential for gas of 8.5 billion m³ in-place at the median value (Fig. 25; Table 1). The largest predicted field size is 5.6 billion m³ (Fig. 26; Table 1). Three gas fields are expected in this play. Two of three fields are expected to be larger than the arbitrary 3.0 billion m³ selected as minimum significant field size for natural gas accumulations in frontier regions of Canada. These potential volumes are applicable to the Yukon Territory only.
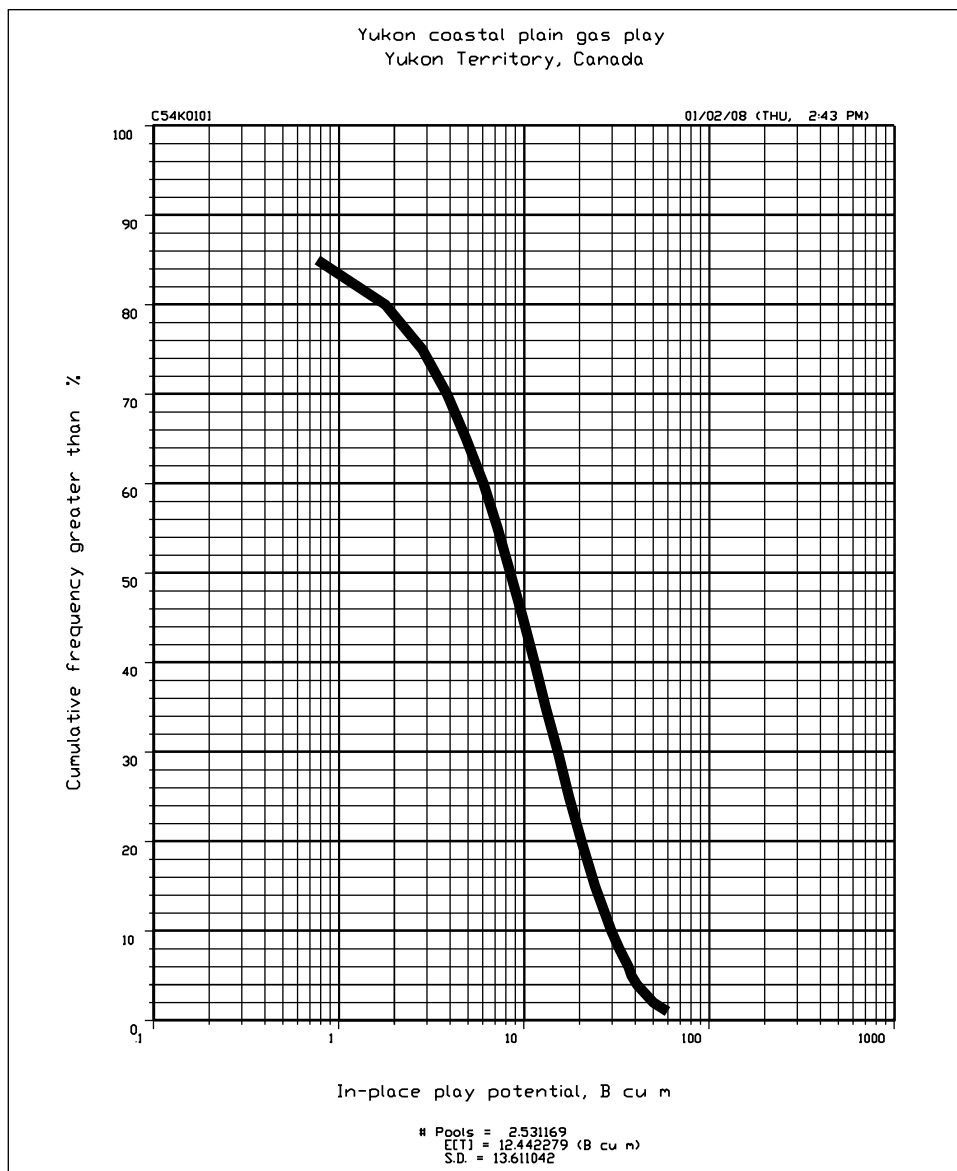
Figure 25. *Estimate of in-place gas potential of the Yukon coastal plain play. Median value of probabilistic assessment is 8.5 billion m³ of in-place oil distributed in 3 fields.*

DISCUSSION OF ASSESSMENT RESULTS

RESOURCE POTENTIAL

The in-place median estimate of total oil potential for the North Coast region (including all immature and conceptual plays) is 39.8 million m^3 (250 million bbls) (Table 1; Fig. 27). (Note that the total median estimate for all oil plays is not arithmetically derived by summing the hydrocarbon potentials of individual plays. This number is derived using statistical techniques). High confidence (95% probability) and speculative (5% probability) estimates of total oil potential are 6.7 and 111 million m^3 (42 and 698 million barrels), respectively (Fig. 27). Individual field-size estimates in each play display similar probability-dependent variations. The wide range of estimates of total potential and field sizes are typical of frontier region assessments and reflect the geological uncertainties in quantifying lightly explored or conceptual exploration plays.

The median natural gas potential for all plays in the North Coast region is 38.6 billion m^3 (1.4 TCF) (Fig. 28; Table 1). The high confidence and speculative estimates for all gas

Figure 26. Field-size-by-rank plot of the Yukon coastal plain gas play. Median value of the largest predicted field size is 6.0 billion m^3 of in-place gas.
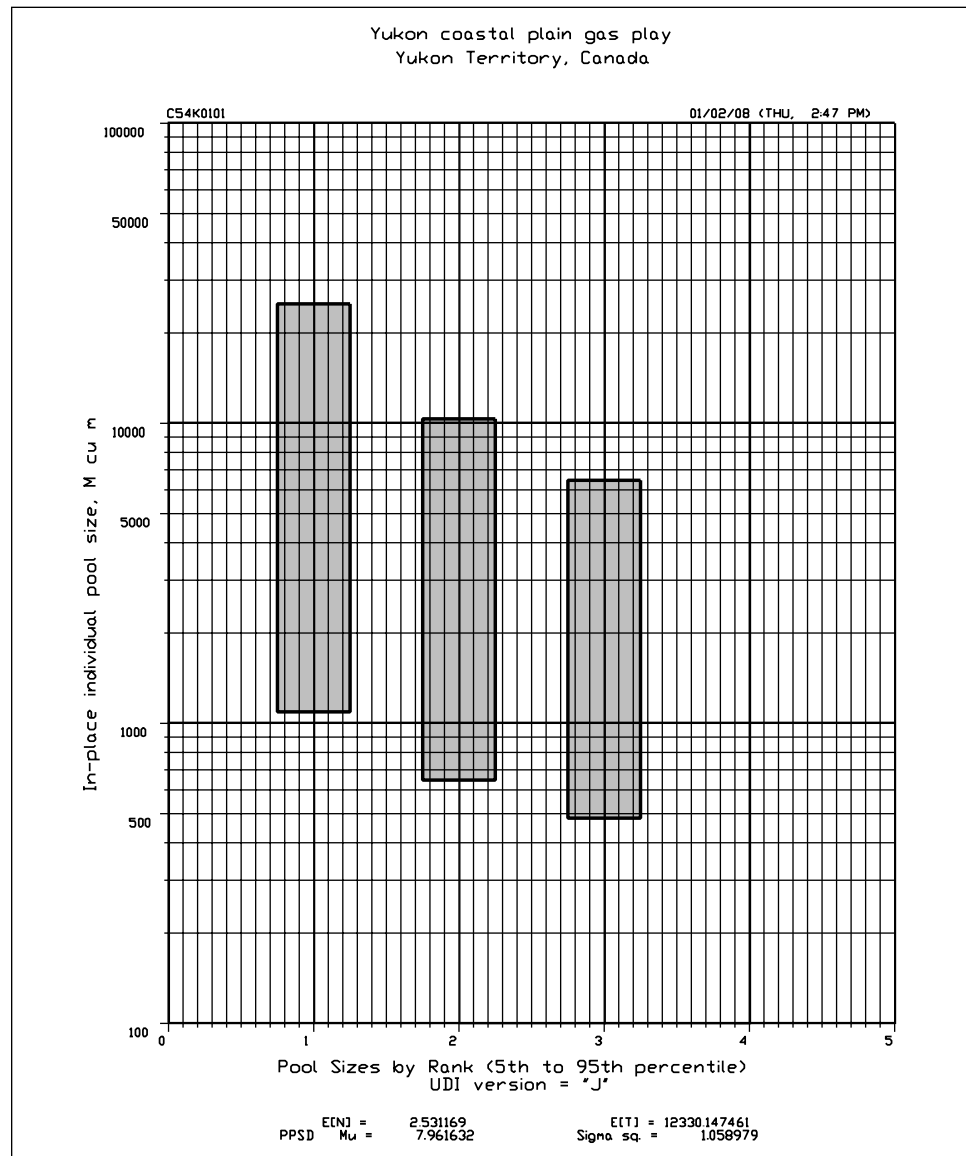
plays in the assessment area is 14.5 and 81.8 billion m³ in-place (0.5 and 2.9 TCF) (Fig. 28).

Condensate occurs in a single play (South Delta–Paleozoic) where the median potential is expected to be 0.71 million m³ or 4.5 million barrels (Table 1).

RESOURCE DISTRIBUTIONS

The greatest oil potential or volume occurs in the Herschel play (Table 1). The largest individual oil field is expected to occur in the same play, having a median size estimate of 15.5 million m³ (97 million barrels) of in-place oil. The Herschel play also has the largest gas potential and field size in the North Coast assessment (16.1 and 7.1 billion m³, respectively; equivalent to 0.6 and 0.25 TCF).

Taking into consideration the expected potential in the Yukon Territory alone under the two proposed scenarios (Table 2), it is clear that the Herschel play is the most significant oil and gas play with respect to both resource potential and field sizes. Under Scenario 1 where the largest predicted field is expected to occur in the Yukon Territory, 97% of the
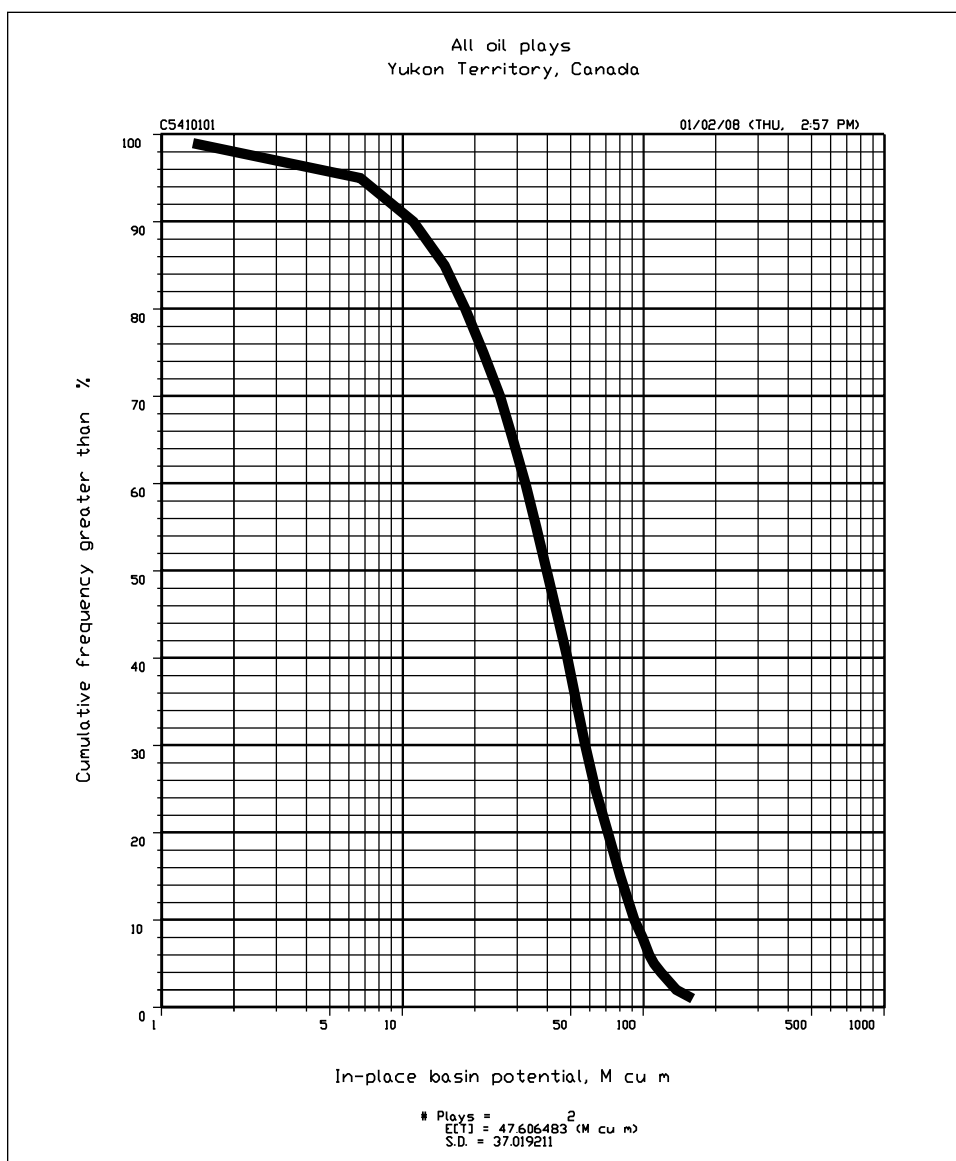
Figure 27. *Estimate of total oil potential for the North Coast area. Median value of probabilistic assessment is 39.8 million m³ of in-place oil distributed in 9 fields.*

oil resource and 57% of the gas resource occur in the Herschel play. When the largest field is assumed to lie outside Yukon's borders, then the proportion of gas in the Herschel play changes substantially, mostly because of the elimination of the Yukon coastal plain play in the calculation. Under Scenario 2, 98% of both the oil and gas resource occurs in the Herschel play. In any case, these calculations indicate the importance of the Herschel play in this particular assessment area. This single play, consisting of highly deformed Tertiary reservoirs and occurring disproportionately in offshore areas, infers the much greater expected oil and gas potential in the offshore region compared to onshore areas, at least in the Yukon part of the basin. No doubt, if all the other offshore plays were included as part of the assessment, this relationship would become more obvious. The relative richness of offshore plays probably reflects the proximity to the hydrocarbon kitchen adjacent to very porous and widespread Tertiary delta complexes.

Figure 28. Estimate of total gas potential for the North Coast area. Median value of probabilistic assessment is 38.6 billion m³ of in-place oil distributed in 31 fields.
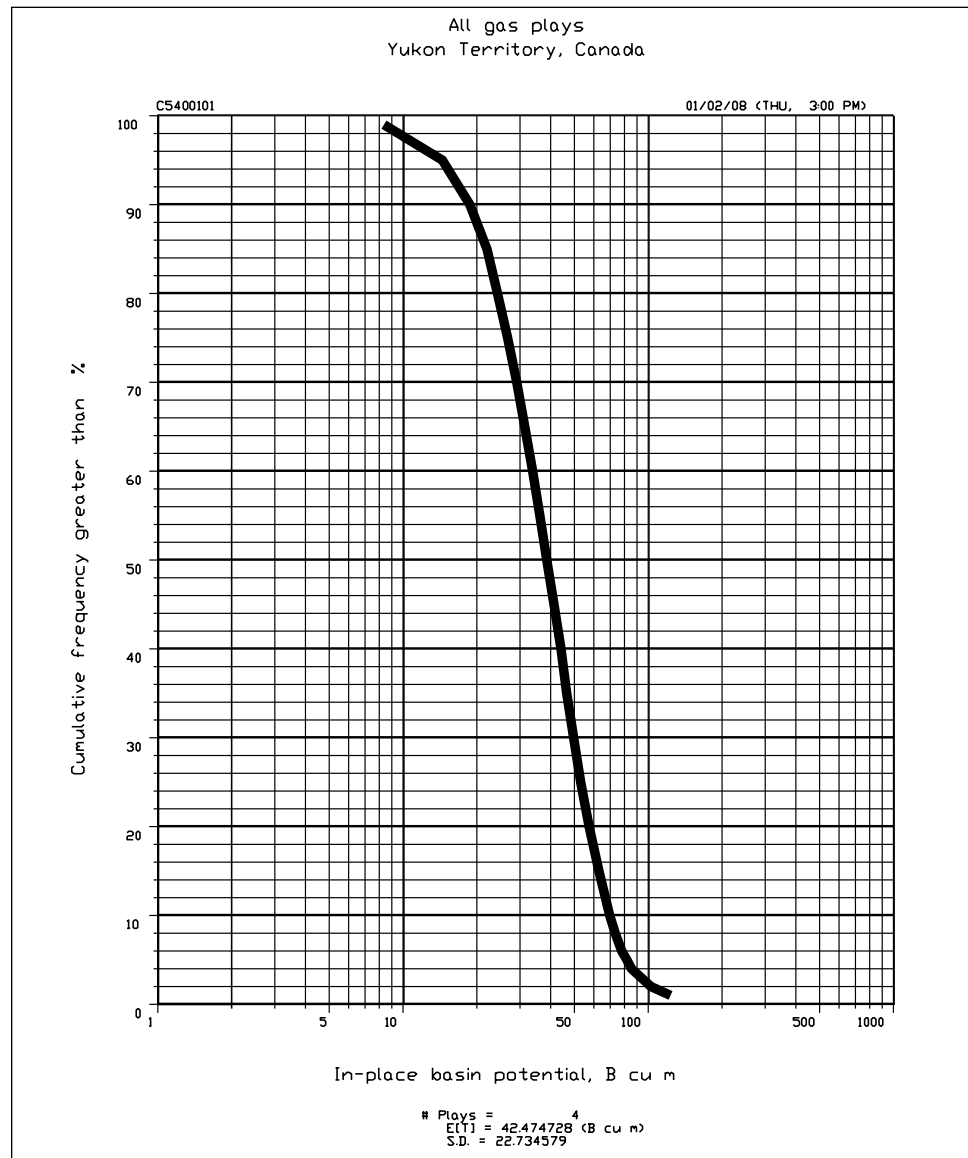
ASSESSMENT RESULTS AND EXPLORATION HISTORY

The exploration risks calculated in this assessment suggest success rates for exploratory drilling in the North Coast area of the Yukon should average about 1 in 7. The absence of discoveries among the 3 wells drilled to date in Yukon Territory is reasonable. Historically, the first significant hydrocarbon in a frontier region is often preceded by many unsuccessful exploration wells due to incomplete knowledge of the petroleum geology in the area. This predicted success rate seems to be reasonably comparable to other frontier regions in northern Yukon (Hannigan, *et al.*, 1999; Hannigan, in press(a), (b), and (c)). The reconnaissance nature of the seismic data and the lack of wells, along with the inherent difficulty in estimating numbers of prospects associated with both structural and stratigraphic traps, make the presumption of the number of prospects quite arbitrary. Incorporating relevant future exploration data, such as improved and dense seismic survey coverage or exploratory drilling, will provide a greater degree of confidence in hydrocarbon potential estimates.

■ CONCLUSIONS

The hydrocarbon resource potential of the Yukon North Coast area has been evaluated through regional hydrocarbon play assessments. The quantitative assessments were derived using the Geological Survey of Canada's (PETRIMES) assessment methodology system. The Arctic coastal region of northern Yukon is underlain by a complex folded and faulted terrain: part of the Frontal morphogeological belt of the Cordilleran Fold Belt. Major tectonic and structural elements in the assessment region are the Rapid Depression, Cache Creek, Barn and Romanzof uplifts, Blow River and Herschel highs and Demarcation Subbasin. Structures such as compressional folds and strike-slip faults that were formed during the Laramide Orogeny are underlain by older tectonic features such as the Cache Creek Uplift and the Rapid Depression which originated as Mesozoic fault-bounded structures. North of the Rapid Depression are several significant large-scale tectonic features, such as the Blow River and Herschel highs and the Demarcation Subbasin.

The petroleum resource assessments include analyses of six immature and conceptual oil and gas plays, each of which incorporated the calculation or estimation of field-size parameters, numbers of prospects and exploration risks. Hydrocarbon volumes reported for these plays are total statistical estimates of the resource present 'in the ground', not the volumes that are economically producible. Individual field-size determinations are important in identifying which plays are attractive for future exploration programs.

The potential for significant hydrocarbon accumulations in the North Coast assessment region is derived by the combined presence of numerous and diverse trapping configurations, good to excellent petroleum source rocks in favourable stratal positions and reservoir-quality strata in parts of the stratigraphic succession. However, significant risks associated with lack of porosity development in Paleozoic and Mesozoic strata, and thermal maturity considerations, reduce overall hydrocarbon potential. Significant gas potential is predicted for the Herschel play in the study area. The complex geology and anticipated high exploration risks associated with all defined exploration plays in the region suggest that considerable seismic survey work and exploration drilling are required to properly evaluate the North Coast hydrocarbon potential.

The median estimate for total gas potential for all North Coast plays is 38.6 billion m^3 of in-place gas (Fig. 28; Table 1). Four fields with median sizes greater than 3 billion m^3 of in-place gas are expected in two plays, two each in the Herschel and Yukon coastal plain plays.

Total potential for oil in all North Coast plays is predicted to be 39.8 million m^3 in-place (Fig. 27; Table 1). No oil field sizes greater than 160 million m^3 are predicted to occur in the region.

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■ APPENDIX 1

INPUT DATA FOR NORTH COAST HYDROCARBON ASSESSMENTS

The following tables present the probability distributions of reservoir parameters, number of prospects, and marginal probabilities of geological risk factors used as input for the various immature and conceptual statistical analyses discussed in this paper. These estimates are based on subjective opinion, partly constrained by reservoir data and information from analogous hydrocarbon-bearing basins.

1. SOUTH DELTA–MESOZOIC OIL PLAY

Table 1.1a. Probability distributions of reservoir parameters

Geological variable	Unit of measurement	Probability in upper percentiles 1.00	Probability in upper percentiles 0.50	Probability in upper percentiles 0.01	Probability in upper percentiles 0.00
Area of pool	km^2	0.11	0.7	27	34
Net pay	m	1	17	102	114
Porosity	decimal fraction	0.05	0.1	0.15	0.2
Oil saturation	decimal fraction	0.35	0.5	0.6	0.65
Oil formation volume factor		1.02	1.25	1.45	1.53

Table 1.1b. Marginal probabilities of geological risk factors

Geological factors	Marginal probability	Play level	Prospect level
Presence of closure	0.6		x
Presence of porosity	0.50		x
Adequate seal	0.9		x
Adequate timing	0.8		x
Adequate source	0.66		x
Adequate preservation	0.7		x

Table 1.1c Probability distribution for number of prospects

Geological variable	Probability in upper percentiles 0.99	Probability in upper percentiles 0.5	Probability in upper percentiles 0.00
Number of prospects	29	35	59

2. SOUTH DELTA–MESOZOIC GAS PLAY

Table 1.2a. Probability distributions of reservoir parameters

Geological variable	Unit of measurement	Probability in upper percentiles 1.00	Probability in upper percentiles 0.50	Probability in upper percentiles 0.01	Probability in upper percentiles 0.00
Area of pool	km²	0.11	0.7	27	34
Net pay	m	1	17	102	114
Porosity	decimal fraction	0.05	0.1	0.15	0.2
Gas saturation	decimal fraction	0.45	0.65	0.85	0.9
Gas formation volume factor	0.003	0.005	0.006	0.007	

Table 1.2b. Marginal probabilities of geological risk factors

Geological factors	Marginal probability	Play level	Prospect level
Presence of closure	0.6		x
Presence of porosity	0.50		x
Adequate seal	0.9		x
Adequate timing	0.8		x
Adequate source	0.66		x
Adequate preservation	0.7		x

Table 1.2c. Probability distribution for number of prospects

Geological variable	Probability in upper percentiles 0.99	Probability in upper percentiles 0.5	Probability in upper percentiles 0.00
Number of prospects	58	70	118

3. SOUTH DELTA–PALEOZOIC GAS PLAY

Table 1.3a. Probability distributions of reservoir parameters

Geological variable	Unit of measurement	Probability in upper percentiles 1.00	Probability in upper percentiles 0.50	Probability in upper percentiles 0.01	Probability in upper percentiles 0.00
Area of pool	km^2	0.11	0.7	27	32
Net pay	m	4	22	87	96
Porosity	decimal fraction	0.05	0.1	0.2	0.25
Gas saturation	decimal fraction	0.6	0.85	0.9	0.95
Gas formation volume factor	0.002	0.005	0.007	0.008	

Table 1.3b. Marginal probabilities of geological risk factors

Geological factors	Marginal probability	Play level	Prospect level
Presence of closure	0.6		x
Presence of porosity	0.5		x
Adequate seal	0.9		x
Adequate timing	0.8		x
Adequate source	0.8		x
Adequate preservation	0.8		x

Table 1.3c. Probability distribution for number of prospects

Geological variable	Probability in upper percentiles 0.99	Probability in upper percentiles 0.5	Probability in upper percentiles 0.00
Number of prospects	46	95	200

4. HERSCHEL OIL PLAY

Table 1.4a. Probability distributions of reservoir parameters

Geological variable	Unit of measurement	Probability in upper percentiles 1.00	Probability in upper percentiles 0.50	Probability in upper percentiles 0.01	Probability in upper percentiles 0.00
Area of pool	km^2	0.5	5	21	50
Net pay	m	3	40	200	500
Porosity	decimal fraction	0.03	0.17	0.28	0.32
Hydrocarbon saturation	decimal fraction	0.4	0.52	0.6	0.62
Oil fraction	decimal fraction	0	0.4	0.72	1
Oil formation volume factor	1.13	1.25	1.35	1.37	

Table 1.4b. Marginal probabilities of geological risk factors

Geological factors	Marginal probability	Play level	Prospect level
Presence of closure	0.7		x
Presence of porosity	0.90		x
Adequate seal	0.6		x
Adequate timing	0.8		x
Adequate source	0.7		x
Adequate preservation	0.8		x

Table 1.4c. Probability distribution for number of prospects

Geological variable	Probability in upper percentiles 0.99	Probability in upper percentiles 0.5	Probability in upper percentiles 0.00
Number of prospects	10	25	50

5. HERSCHEL GAS PLAY

Table 1.5a. Probability distributions of reservoir parameters

Geological variable	Unit of measurement	Probability in upper percentiles 1.00	Probability in upper percentiles 0.50	Probability in upper percentiles 0.01	Probability in upper percentiles 0.00
Area of pool	km²	0.5	5	21	50
Net pay	m	3	40	200	500
Porosity	decimal fraction	0.03	0.17	0.28	0.32
Hydrocarbon saturation	decimal fraction	0.4	0.52	0.6	0.62
Gas fraction	decimal fraction	0	0.6	0.85	1
Gas formation volume factor		0.003	0.004	0.005	0.006

Table 1.5b. Marginal probabilities of geological risk factors

Geological factors	Marginal probability	Play level	Prospect level
Presence of closure	0.7		x
Presence of porosity	0.90		x
Adequate seal	0.6		x
Adequate timing	0.8		x
Adequate source	0.7		x
Adequate preservation	0.8		x

Table 1.5c. Probability distribution for number of prospects

Geological variable	Probability in upper percentiles 0.99	Probability in upper percentiles 0.5	Probability in upper percentiles 0.00
Number of prospects	10	25	50

6. YUKON COASTAL PLAIN GAS PLAY

Table 1.6a. Probability distributions of reservoir parameters

Geological variable	Unit of measurement	Probability in upper percentiles 1.00	Probability in upper percentiles 0.50	Probability in upper percentiles 0.01	Probability in upper percentiles 0.00
Area of closure	km²	1	9	60	185
Reservoir thickness	m	1.5	75	220	400
Trap fill	decimal fraction	0.01	0.25	0.62	1
Porosity	decimal fraction	0.03	0.1	0.17	0.22
Gas saturation	decimal fraction	0.6	0.85	0.9	0.95
Gas formation volume factor	0.002	0.005	0.007	0.008	

Table 1.6b. Marginal probabilities of geological risk factors

Geological factors	Marginal probability	Play level	Prospect level
Presence of closure	0.7		x
Presence of porosity	0.65		x
Adequate seal	0.8		x
Adequate timing	0.6		x
Adequate source	0.8		x
Adequate preservation	0.6		x

Table 1.6c. Probability distribution for number of prospects

Geological variable	Probability in upper percentiles 0.99	Probability in upper percentiles 0.5	Probability in upper percentiles 0.00
Number of prospects	5	25	40

■ APPENDIX 2

OUTPUT FOR NORTH COAST HYDROCARBON ASSESSMENTS

The following text presents the output generated by the PETRIMES hydrocarbon assessment program using the conceptual play analysis procedure. For each play, the PPSD, MPRO, PSRK, PSUM and PPPS modules are presented. PPSD generates the pool-size distribution using the lognormal simulation. MPRO generates the number of pools distribution and risks for the play. PSRK gives the individual pool sizes by rank and PSUM indicates the Monte Carlo simulation for the pool-ksize distribution. Immature plays with discoveries have an additional module (PPPS) which generates the play potential conditioned on the sum of discovered reserves. (Note: In text, field sizes are indicated rather than pools. In frontier conceptual plays, insufficient geological and engineering information is available to define individual pool accumulations in single structures). A PSUM module for total oil and gas potential on a basin-scale is also presented.

PETRIMES MODULE PPSD

```
PROSPECT OR POOL SIZE DISTRIBUTION USING
LOGNORMAL OR MONTE CARLO SIMULATION
****************************************

UAI        C5450101
PLAY       South Delta-Mesozoic oil play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   FRI, FEB 2, 2001,  9:40 AM


USER SUPPLIED PARAMETERS
-----------------------
  DO YOU WANT TO STORE ON DB?            >   Y
  OIL (O) OR GAS (G) ?                   >   O
  BRITISH OR S.I. UNIT OF MEASUREMENT?   >  SI
  RECOVERABLE RESOURCES?                 >   N
  DO YOU WANT TO HONOR A PERCENTILE?     >  Y
  UPPER PERCENTILE TO BE HONORED?        > .10000E-01


A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)


B) Input Constant(s)
   -----------------

   No input constant.

C) Summary
   -------

   Variable                  Lognormal Approximation

   IN-PLACE    mu  =-.74234    MEAN  = .95515
   POOL SIZE   sig. sq= 1.3929  S.D.  = 1.6617
   (DERIVED)   99.99% = .59073E-02 60.00% = .35298    15.00% = 1.6175
               99.00% = .30564E-01 55.00% = .41039    10.00% = 2.1601
               95.00% = .68316E-01 50.00% = .47600     8.00% = 2.4991
               90.00% = .10489     45.00% = .55210     6.00% = 2.9821
               85.00% = .14008     40.00% = .64189     5.00% = 3.3166
               80.00% = .17629     35.00% = .75008     4.00% = 3.7578
               75.00% = .21473     30.00% = .88388     2.00% = 5.3737
               70.00% = .25634     25.00% = 1.0552     1.00% = 7.4131
               65.00% = .30207     20.00% = 1.2853      .01% = 38.355


D) Pool Size Equation
   ------------------

   NO. OF GEO-VARIABLES= 5

   POOL SIZE =      1.00000
                   * AREA OF     * NET PAY    * POROSITY    * HYDROCARBON
                     POOL                                     SATURATION

                   -------------------------------------------------------------
                     OIL FMN
                     VOLUME
                     FACTOR
```

```
GEOLOGICAL VARIABLES
--------------------
A) Variables Used
   -------------

   VARIABLE     UNIT OF    O/G VERSION TYPE NO. OF    UAI
                MEASUREMENT                 POINTS
                SYMBOL                      USED

   AREA OF        sq km    Oil   1      2     4    C5450101
   POOL

   NET PAY          m      Oil   1      2     4    C5450101

   POROSITY     dec fr     Oil   1      2     4    C5450101

   HYDROCARBON  dec fr     Oil   1      2     4    C5450101
   SATURATION

   OIL FMN                 Oil   1      2     4    C5450101
   VOLUME
   FACTOR

B) Summary
   -------

   Variable                  Lognormal Approximation

   AREA OF    mu    =-.35667   MEAN   = 1.2066
   POOL       sig. sq= 1.0890  S.D.   = 1.6941
              99.99% = .14441E-01 60.00% = .53738    15.00% = 2.0645
              99.00% = .61770E-01 55.00% = .61397    10.00% = 2.6663
              95.00% = .12579     50.00% = .70000     8.00% = 3.0331
              90.00% = .18378     45.00% = .79808     6.00% = 3.5460
              85.00% = .23734     40.00% = .91184     5.00% = 3.8955
              80.00% = .29085     35.00% = 1.0465     4.00% = 4.3503
              75.00% = .34627     30.00% = 1.2099     2.00% = 5.9686
              70.00% = .40498     25.00% = 1.4151     1.00% = 7.9326
              65.00% = .46824     20.00% = 1.6847      .01% = 33.930

   NET PAY    mu    = 2.8332    MEAN   = 19.375
              sig. sq= .26154   S.D.   = 10.593
              99.99% = 2.5378    60.00% = 14.934    15.00% = 28.883
              99.00% = 5.1733    55.00% = 15.942    10.00% = 32.740
              95.00% = 7.3304    50.00% = 17.000     8.00% = 34.875
              90.00% = 8.8270    45.00% = 18.128     6.00% = 37.650
              85.00% = 10.006    40.00% = 19.352     5.00% = 39.425
              80.00% = 11.054    35.00% = 20.703     4.00% = 41.618
              75.00% = 12.040    30.00% = 22.229     2.00% = 48.595
              70.00% = 13.001    25.00% = 24.002     1.00% = 55.864
              65.00% = 13.959    20.00% = 26.144      .01% = 113.88

   POROSITY   mu    =-2.3026    MEAN   = .10174
              sig. sq= .34487E-01 S.D.   = .19058E-01
              99.99% = .50125E-01 60.00% = .95404E-01 15.00% = .12122
              99.00% = .64920E-01 55.00% = .97693E-01 10.00% = .12687
              95.00% = .73678E-01 50.00% = .10000     8.00% = .12981
              90.00% = .78821E-01 45.00% = .10236     6.00% = .13347
              85.00% = .82492E-01 40.00% = .10482     5.00% = .13572
              80.00% = .85531E-01 35.00% = .10742     4.00% = .13842
              75.00% = .88227E-01 30.00% = .11023     2.00% = .14643
              70.00% = .90721E-01 25.00% = .11334     1.00% = .15404
              65.00% = .93094E-01 20.00% = .11692      .01% = .19950
```

```
HYDROCARBON   mu    =-.69315     MEAN  = .50124
SATURATION    sig. sq= .49477E-02 S.D.   = .35301E-01
              99.99% = .38491      60.00% = .49117     15.00% = .53781
              99.00% = .42453      55.00% = .49560     10.00% = .54717
              95.00% = .44537      50.00% = .50000      8.00% = .55194
              90.00% = .45690      45.00% = .50444      6.00% = .55778
              85.00% = .46485      40.00% = .50899      5.00% = .56133
              80.00% = .47126      35.00% = .51374      4.00% = .56552
              75.00% = .47683      30.00% = .51879      2.00% = .57771
              70.00% = .48189      25.00% = .52429      1.00% = .58889
              65.00% = .48663      20.00% = .53049       .01% = .64950


OIL FMN       mu    = .22314     MEAN  = 1.2518
VOLUME        sig. sq= .29385E-02 S.D.   = .67910E-01
FACTOR        99.99% = 1.0218      60.00% = 1.2330     15.00% = 1.3222
              99.00% = 1.1019      55.00% = 1.2415     10.00% = 1.3399
              95.00% = 1.1434      50.00% = 1.2500      8.00% = 1.3489
              90.00% = 1.1661      45.00% = 1.2585      6.00% = 1.3599
              85.00% = 1.1817      40.00% = 1.2673      5.00% = 1.3666
              80.00% = 1.1943      35.00% = 1.2764      4.00% = 1.3744
              75.00% = 1.2051      30.00% = 1.2860      2.00% = 1.3972
              70.00% = 1.2150      25.00% = 1.2965      1.00% = 1.4180
              65.00% = 1.2242      20.00% = 1.3083       .01% = 1.5292
```

C) Covariance Matrix

```
VARIABLE

AREA OF        1.08899
POOL

NET PAY         .00000    .26154

POROSITY        .00000    .00000    .03449

HYDROCARBON     .00000    .00000    .00000    .00495
SATURATION

OIL FMN         .00000    .00000    .00000    .00000    .00294
VOLUME
FACTOR
```

D) Correlation Matrix

```
VARIABLE

AREA OF        1.00000
POOL

NET PAY         .00000   1.00000

POROSITY        .00000    .00000   1.00000

HYDROCARBON     .00000    .00000    .00000   1.00000
SATURATION

OIL FMN         .00000    .00000    .00000    .00000   1.00000
VOLUME
FACTOR
```

PETRIMES MODULE MPRO

NO. OF POOLS DISTRIBUTION AND RISKS
****

```
UAI        C5450101
PLAY       South Delta-Mesozoic oil play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   WED, JAN 17, 2001, 12:12 PM
```

USER SUPPLIED PARAMETERS

```
DO YOU WANT TO STORE ON DB?        >    Y
OIL (O) OR GAS (G) ?               >    O
```

A) Risks

	GEOLOGICAL FACTOR		MARGINAL PROBABILITY
	-----------------		--------------------
PLAY LEVEL	Overall Play Level Risk	=	1.00
PROSPECT LEVEL	Presence of Closure	(1)	.60
	Presence of Porosity	(3)	.50
	Adequate Seal	(4)	.90
	Adequate Timing	(5)	.80
	Adequate Source	(6)	.66
	Adequacy of Recovery	(9)	.70
	--		
	Overall Prospect Level Risk	=	.10
EXPLORATION RISK:		=	.10

B) No. of Prospects Distribution

```
Minimum     =    29
Maximum     =    59
Mean        =  39.97
S.D.        =   9.07
```

C) No. of Pools Distribution

```
Minimum     =     0
Maximum     =    17
Mean        =  3.99
S.D.        =  2.10
```

Note: The no. of pools distribution is saved in the database with UDI= 6201OB4

Frequency	No. of Prospects	Frequency	No. of Pools
99.00	29	97.88	0
95	30	95	1
90	31	90	1
80	32	80	2
75	32	75	2
60	34	60	3
50	35	50	4
40	40	40	4
25	47	25	5
20	50	20	6
10	55	10	7
5	57	5	8
1	59	1	10
0	59	0	1

PETRIMES MODULE PSRK

```
INDIVIDUAL POOL SIZES BY RANK
WHERE N IS A RANDOM VARIABLE
*****************************

UAI        C5450101
PLAY       South Delta-Mesozoic oil play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   TUE, JAN 23, 2001, 12:20 PM


USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE ON DB ?          > Y
   DO YOU WANT TO USE MPRO OUTPUT?       > Y
   MIN. AND MAX. POOL RANKS?             >    1    4
   DO YOU USE LOGNORNAL ASSUMPTION?      > Y
   DO YOU WANT TO USE PPSD OUTPUT?       > Y


A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)


B) Lognormal Pool Size Distribution
   --------------------------------
   Summary     mu   =-.74234   MEAN  = .95515
   Statistics  sig. sq= 1.3929  S.D.  = 1.6617

   Upper       99.99% = .59073E-02 60.00% = .35298   15.00% = 1.6175
   Percentiles 99.00% = .30564E-01 55.00% = .41039   10.00% = 2.1601
               95.00% = .68316E-01 50.00% = .47600    8.00% = 2.4991
               90.00% = .10489     45.00% = .55210    6.00% = 2.9821
               85.00% = .14008     40.00% = .64189    5.00% = 3.3166
               80.00% = .17629     35.00% = .75008    4.00% = 3.7578
               75.00% = .21473     30.00% = .88388    2.00% = 5.3737
               70.00% = .25634     25.00% = 1.0552    1.00% = 7.4131
               65.00% = .30207     20.00% = 1.2853     .01% = 38.355


C) No. of Pools Distribution
   -------------------------
   Lower Support    =   0
   Upper Support    =  17
   Expectation      =   3.99
   Standard Deviation=  2.10


D) Pool Sizes By Rank
   ------------------

   Pool Rank                Distribution

       1    MEAN  = 2.2504   S.D.  = 2.8140   P(N>=r)= .97882
            99%   = .10481   75%   = .78069   10%   = 4.7286
            95%   = .26939   50%   = 1.4679    5%   = 6.6840
            90%   = .41474   25%   = 2.7018    1%   = 13.140

       2    MEAN  = .90190   S.D.  = .83927   P(N>=r)= .89821
            99%   = .50141E-01 75% = .36188   10%   = 1.8576
            95%   = .12133   50%   = .67353    5%   = 2.4376
            90%   = .18819   25%   = 1.1677    1%   = 4.0505
```

```
       3    MEAN  = .53469   S.D.  = .46272   P(N>=r)= .74551
            99%   = .34026E-01 75% = .22023   10%   = 1.0970
            95%   = .76540E-01 50% = .41050    5%   = 1.4094
            90%   = .11591   25%   = .70567    1%   = 2.2203

       4    MEAN  = .37112   S.D.  = .30938   P(N>=r)= .55203
            99%   = .26794E-01 75% = .15664   10%   = .75721
            95%   = .57328E-01 50% = .28836    5%   = .96375
            90%   = .84734E-01 25% = .49222    1%   = 1.4812


E) The mean of the potential =  3.6164
```

PETRIMES MODULE PSUM

MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
****

```
UAI       C5450101
PLAY      South Delta-Mesozoic oil play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  TUE, JAN 23, 2001, 12:22 PM
```

USER SUPPLIED PARAMETERS

```
DO YOU WANT TO STORE IN DATA BASE ?   >    Y
OIL (O) OR GAS (G) ?                  >    O
BRITISH OR S.I. UNIT OF MEASUREMENT?  >    SI
RECOVERABLE RESOURCES?                >    N
DO YOU WANT TO USE MPRO OUTPUT?       >    Y
DO YOU ASSUME LOGNORMAL DISTRIBUTION? >    Y
DO YOU WANT TO USE PPSD OUTPUT?       >    Y
DO YOU COMPUTE CONDITIONAL POTENTIAL? >    N
```

A) Basic Information

```
TYPE OF RESOURCE     =Oil In-place
SYSTEM OF MEASUREMENT =S.I.
UNIT OF MEASUREMENT   =M cu m  (19)
```

B) Lognormal Pool Size Distribution

```
Summary     mu  =-.74234    MEAN  = .95515
Statistics  sig. sq= 1.3929    S.D.  = 1.6617

Upper       99.99% = .59073E-02 60.00% = .35298    15.00% = 1.6175
Percentiles 99.00% = .30564E-01 55.00% = .41039    10.00% = 2.1601
            95.00% = .68316E-01 50.00% = .47600     8.00% = 2.4991
            90.00% = .10489     45.00% = .55210     6.00% = 2.9821
            85.00% = .14008     40.00% = .64189     5.00% = 3.3166
            80.00% = .17629     35.00% = .75008     4.00% = 3.7578
            75.00% = .21473     30.00% = .88388     2.00% = 5.3737
            70.00% = .25634     25.00% = 1.0552     1.00% = 7.4131
            65.00% = .30207     20.00% = 1.2853      .01% = 38.355
```

C) NO. OF POOLS DISTRIBUTION

```
Lower Support   =    0
Upper Support   =   17
Expectation     =     3.98819
Standard Deviation=   2.09991
```

D) Summary Statistics for 4000 Simulations

```
Play Resource:   (   M cu m  )
-----------------------------
 Minimum   = .0000000E+00Maximum      = 47.66905
 Expectation = 3.798451    Standard Deviation= 3.687653

EMPERICAL DISTRIBUTION:
-----------------------
```

```
Greater than  Play
Percentage    Potential
------------  ----------
 100.00        .00000E+00
  95.00        .24337
  90.00        .55668
  85.00        .84104
  80.00       1.0941
  75.00       1.3875
  70.00       1.6443
  65.00       1.9165
  60.00       2.1850
  55.00       2.5113
  50.00       2.8268
  45.00       3.1302
  40.00       3.5563
  35.00       3.9955
  30.00       4.4510
  25.00       5.1129
  20.00       5.7703
  15.00       6.6875
  10.00       8.1451
   8.00       8.8912
   6.00       9.7734
   5.00      10.497
   4.00      11.326
   2.00      14.251
   1.00      16.738
    .01      46.342
    .00      47.536
```

PETRIMES MODULE PPPS

**PLAY POTENTIAL CONDITION ON
TOTAL SUM OF DISCOVERED RESERVE**
****

```
UAI        C5450101
PLAY       South Delta-Mesozoic oil play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   TUE, JAN 23, 2001, 12:35 PM
```

USER SUPPLIED PARAMETERS

```
   DO YOU WANT TO STORE IN DATA BASE?  >    Y
   OIL (O) OR GAS (G)?              >    O
   BRITISH OR S.I. UNIT OF MEASUREMENT?>   SI
   RECOVERABLE RESOURCES?          >    N
   CONDITION VALUE AND ITS UNIT?   >    6.7000    19
```

A) Basic Information

```
   TYPE OF RESOURCE      =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT   =M cu m  (19)
```

B) PLAY RESOURCE DISTRIBUTION

```
   Summary    MEAN   = 3.7985    S.D.  = 3.6877
   Statistics   M cu m

   Upper     100.00% = .00000E+00 55.00% = 2.5113    10.00% = 8.1451
   Percentiles 95.00% = .24337    50.00% = 2.8268     8.00% = 8.8912
               90.00% = .55668    45.00% = 3.1302     6.00% = 9.7734
               85.00% = .84104    40.00% = 3.5563     5.00% = 10.497
               80.00% = 1.0941    35.00% = 3.9955     4.00% = 11.326
               75.00% = 1.3875    30.00% = 4.4510     2.00% = 14.251
               70.00% = 1.6443    25.00% = 5.1129     1.00% = 16.738
               65.00% = 1.9165    20.00% = 5.7703      .01% = 46.342
               60.00% = 2.1850    15.00% = 6.6875      .00% = 47.536
```

C) Summary Statistics for 5000 Simulations

```
----------------------------------------
Play Potential: (   M cu m )
------------------------------
 Minimum   = .5783903E-03Maximum      = 40.52534
 Expectation = 4.371518    Standard Deviation= 6.344550

EMPERICAL DISTRIBUTION:
----------------------

 Greater than    Play
 Percentage      Potential
 ------------    ----------
  100.00         .57839E-03
   99.00         .43201E-01
   95.00         .20000
   90.00         .39156
   85.00         .60200
   80.00         .83888
   75.00        1.0402
   70.00        1.2497
   65.00        1.5095
   60.00        1.7966
   55.00        2.0800
   50.00        2.3751
   45.00        2.6841
   40.00        2.9948
   35.00        3.5396
   30.00        4.1592
   25.00        4.9526
   20.00        6.1670
   15.00        7.2779
   10.00        8.8598
    8.00        9.5118
    6.00       13.113
    5.00       17.099
    4.00       21.722
    2.00       30.495
    1.00       34.259
     .01       40.276
     .00       40.500
```

PETRIMES MODULE PPSD

```
PROSPECT OR POOL SIZE DISTRIBUTION USING
LOGNORMAL OR MONTE CARLO SIMULATION
*****************************************

UAI      C5440101
PLAY     South Delta-Mesozoic gas play
Assessor  Peter Hannigan
Geologist  Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, FEB 2, 2001, 10:31 AM


USER SUPPLIED PARAMETERS
------------------------

   DO YOU WANT TO STORE ON DB?          >   Y
   OIL (O) OR GAS (G) ?                 >   G
   BRITISH OR S.I. UNIT OF MEASUREMENT? >   SI
   RECOVERABLE RESOURCES?               >   N
   DO YOU WANT TO HONOR A PERCENTILE?   > Y
   UPPER PERCENTILE TO BE HONORED?      > .10000E-01


A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)


B) Input Constant(s)
   -----------------

   No input constant.


C) Summary
   -------

   Variable                   Lognormal Approximation

   IN-PLACE    mu   = 5.0415    MEAN  = 306.47
   POOL SIZE   sig. sq= 1.3673   S.D.  = 524.12
   (DERIVED)   99.99% = 1.9993    60.00% = 115.04      15.00% = 519.78
               99.00% = 10.189    55.00% = 133.56      10.00% = 692.30
               95.00% = 22.604    50.00% = 154.70       8.00% = 799.87
               90.00% = 34.569    45.00% = 179.19       6.00% = 952.89
               85.00% = 46.043    40.00% = 208.04       5.00% = 1058.7
               80.00% = 57.822    35.00% = 242.75       4.00% = 1198.2
               75.00% = 70.302    30.00% = 285.62       2.00% = 1707.8
               70.00% = 83.789    25.00% = 340.42       1.00% = 2348.9
               65.00% = 98.586    20.00% = 413.89        .01% = 11970.


D) Pool Size Equation
   ------------------

   NO. OF GEO-VARIABLES= 5

   POOL SIZE =      1.00000
              * AREA OF    * NET PAY    * POROSITY    * HYDROCARBON
                POOL                                   SATURATION

              ----------------------------------------------------
                       GAS FMN
                       VOLUME
                       FACTOR
```

```
GEOLOGICAL VARIABLES
--------------------

A) Variables Used
   --------------

   VARIABLE    UNIT OF     O/G VERSION TYPE NO. OF   UAI
               MEASUREMENT                   POINTS
               SYMBOL                        USED

   AREA OF     sq km       Gas   1      2     4    C5440101
   POOL

   NET PAY       m         Gas   1      2     4    C5440101

   POROSITY    dec fr      Gas   1      2     4    C5440101

   HYDROCARBON dec fr      Gas   1      2     4    C5440101
   SATURATION

   GAS FMN                 Gas   1      2     4    C5440101
   VOLUME
   FACTOR


B) Summary
   -------

   Variable                   Lognormal Approximation

   AREA OF    mu    =-.35667    MEAN  = 1.1866
   POOL       sig. sq= 1.0555    S.D.  = 1.6241
              99.99% = .15336E-01 60.00% = .53958     15.00% = 2.0302
              99.00% = .64138E-01 55.00% = .61522     10.00% = 2.6116
              95.00% = .12918     50.00% = .70000      8.00% = 2.9650
              90.00% = .18762     45.00% = .79646      6.00% = 3.4579
              85.00% = .24135     40.00% = .90811      5.00% = 3.7932
              80.00% = .29483     35.00% = 1.0400      4.00% = 4.2289
              75.00% = .35007     30.00% = 1.1997      2.00% = 5.7737
              70.00% = .40843     25.00% = 1.3997      1.00% = 7.6398
              65.00% = .47117     20.00% = 1.6619       .01% = 31.950

   NET PAY    mu    = 2.8332     MEAN  = 19.375
              sig. sq= .26154    S.D.  = 10.593
              99.99% = 2.5378     60.00% = 14.934     15.00% = 28.883
              99.00% = 5.1733     55.00% = 15.942     10.00% = 32.740
              95.00% = 7.3304     50.00% = 17.000      8.00% = 34.875
              90.00% = 8.8270     45.00% = 18.128      6.00% = 37.650
              85.00% = 10.006     40.00% = 19.352      5.00% = 39.425
              80.00% = 11.054     35.00% = 20.703      4.00% = 41.618
              75.00% = 12.040     30.00% = 22.229      2.00% = 48.595
              70.00% = 13.001     25.00% = 24.002      1.00% = 55.864
              65.00% = 13.959     20.00% = 26.144       .01% = 113.88

   POROSITY   mu    =-2.3026     MEAN  = .10174
              sig. sq= .34487E-01 S.D.  = .19058E-01
              99.99% = .50125E-01 60.00% = .95404E-01 15.00% = .12122
              99.00% = .64920E-01 55.00% = .97693E-01 10.00% = .12687
              95.00% = .73678E-01 50.00% = .10000      8.00% = .12981
              90.00% = .78821E-01 45.00% = .10236      6.00% = .13347
              85.00% = .82492E-01 40.00% = .10482      5.00% = .13572
              80.00% = .85531E-01 35.00% = .10742      4.00% = .13842
              75.00% = .88227E-01 30.00% = .11023      2.00% = .14643
              70.00% = .90721E-01 25.00% = .11334      1.00% = .15404
              65.00% = .93094E-01 20.00% = .11692       .01% = .19950
```

```
HYDROCARBON  mu    =-.43078    MEAN   = .65248
SATURATION   sig. sq= .76305E-02 S.D.   = .57105E-01
             99.99% = .46971   60.00% = .63577   15.00% = .71159
             99.00% = .53047   55.00% = .64290   10.00% = .72699
             95.00% = .56301   50.00% = .65000    8.00% = .73488
             90.00% = .58116   45.00% = .65717    6.00% = .74455
             85.00% = .59374   40.00% = .66455    5.00% = .75044
             80.00% = .60393   35.00% = .67225    4.00% = .75741
             75.00% = .61281   30.00% = .68047    2.00% = .77773
             70.00% = .62090   25.00% = .68945    1.00% = .79647
             65.00% = .62849   20.00% = .69959     .01% = .89950

GAS FMN      mu    =-5.2983    MEAN   = .50203E-02
VOLUME       sig. sq= .81160E-02 S.D.   = .45320E-03
FACTOR       99.99% = .35765E-02 60.00% = .48872E-02 15.00% = .54893E-02
             99.00% = .40546E-02 55.00% = .49437E-02 10.00% = .56119E-02
             95.00% = .43114E-02 50.00% = .50000E-02  8.00% = .56747E-02
             90.00% = .44548E-02 45.00% = .50569E-02  6.00% = .57518E-02
             85.00% = .45543E-02 40.00% = .51154E-02  5.00% = .57986E-02
             80.00% = .46349E-02 35.00% = .51766E-02  4.00% = .58542E-02
             75.00% = .47052E-02 30.00% = .52419E-02  2.00% = .60162E-02
             70.00% = .47693E-02 25.00% = .53132E-02  1.00% = .61658E-02
             65.00% = .48294E-02 20.00% = .53938E-02   .01% = .69900E-02
```

C) Covariance Matrix

```
VARIABLE

AREA OF         1.05551
POOL

NET PAY          .00000     .26154

POROSITY         .00000     .00000     .03449

HYDROCARBON      .00000     .00000     .00000     .00763
SATURATION

GAS FMN          .00000     .00000     .00000     .00000     .00812
VOLUME
FACTOR
```

D) Correlation Matrix

```
VARIABLE

AREA OF         1.00000
POOL

NET PAY          .00000    1.00000

POROSITY         .00000     .00000    1.00000

HYDROCARBON      .00000     .00000     .00000    1.00000
SATURATION

GAS FMN          .00000     .00000     .00000     .00000    1.00000
VOLUME
FACTOR
```

PETRIMES MODULE MPRO

NO. OF POOLS DISTRIBUTION AND RISKS
```
*********************************
UAI        C5440101
PLAY       South Delta-Mesozoic gas play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   MON, JAN 22, 2001, 2:08 PM
```

USER SUPPLIED PARAMETERS

```
   DO YOU WANT TO STORE ON DB?            >    Y
   OIL (O) OR GAS (G) ?                   >    G
```

A) Risks

	GEOLOGICAL FACTOR		MARGINAL PROBABILITY
	-----------------		--------------------
PLAY LEVEL	Overall Play Level Risk	=	1.00
PROSPECT LEVEL	Presence of Closure	(1)	.60
	Presence of Porosity	(3)	.50
	Adequate Seal	(4)	.90
	Adequate Timing	(5)	.80
	Adequate Source	(6)	.66
	Adequate Preservation	(8)	.70
	--		
	Overall Prospect Level Risk	=	.10
EXPLORATION RISK:		=	.10

B) No. of Prospects Distribution

```
Minimum    =    58
Maximum    =   118
Mean       =  79.44
S.D.       =  18.14
Frequency  No. of Prospects
---------  ----------------
 99.00          58
 95             59
 90             61
 80             63
 75             64
 60             68
 50             70
 40             80
 25             94
 20             99
 10            109
  5            114
  1            118
  0            118
```

C) No. of Pools Distribution

```
Minimum    =     0
Maximum    =    27
Mean       =   7.93
S.D.       =   3.23
Frequency  No. of Pools
---------  ------------
 99.93          0
 99             2
 95             3
 90             4
 80             5
 75             6
 60             7
 50             8
 40             8
 25            10
 20            11
 10            12
  5            14
  1            17
  0            27
```

Note: The no. of pools distribution is saved in the database with UDI= 6201GB4

PETRIMES MODULE PSRK

```
INDIVIDUAL POOL SIZES BY RANK
WHERE N IS A RANDOM VARIABLE
*****************************

UAI        C5440101
PLAY       South Delta-Mesozoic gas play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   FRI, FEB 2, 2001, 10:38 AM


USER SUPPLIED PARAMETERS
------------------------
    DO YOU WANT TO STORE ON DB ?        > Y
    DO YOU WANT TO USE MPRO OUTPUT?     > Y
    MIN. AND MAX. POOL RANKS?           >     1    8
    DO YOU USE LOGNORNAL ASSUMPTION?    > Y
    DO YOU WANT TO USE PPSD OUTPUT?     > Y

A) Basic Information
   -----------------
    TYPE OF RESOURCE    =Gas In-place
    SYSTEM OF MEASUREMENT =S.I.
    UNIT OF MEASUREMENT  =M cu m  (19)

B) Lognormal Pool Size Distribution
   --------------------------------
    Summary     mu  = 5.0415    MEAN  = 306.47
    Statistics  sig. sq= 1.3673    S.D.  = 524.12

    Upper       99.99% = 1.9993    60.00% = 115.04    15.00% = 519.78
    Percentiles 99.00% = 10.189    55.00% = 133.56    10.00% = 692.30
                95.00% = 22.604    50.00% = 154.70     8.00% = 799.87
                90.00% = 34.569    45.00% = 179.19     6.00% = 952.89
                85.00% = 46.043    40.00% = 208.04     5.00% = 1058.7
                80.00% = 57.822    35.00% = 242.75     4.00% = 1198.2
                75.00% = 70.302    30.00% = 285.62     2.00% = 1707.8
                70.00% = 83.789    25.00% = 340.42     1.00% = 2348.9
                65.00% = 98.586    20.00% = 413.89      .01% = 11970.

C) No. of Pools Distribution
   -------------------------
    Lower Support   =  0
    Upper Support   = 27
    Expectation     =  7.93
    Standard Deviation=  3.23
```

```
D) Pool Sizes B*y Rank
   ------------------

Pool Rank                    Distribution

   1    MEAN  = 1048.4    S.D.  = 1097.6    P(N>=r)= .99932
        99%   = 110.68    75%   = 452.73    10%   = 2067.1
        95%   = 210.70    50%   = 749.83     5%   = 2828.6
        90%   = 283.91    25%   = 1259.3     1%   = 5280.9

   2    MEAN  = 478.39    S.D.  = 357.60    P(N>=r)= .99449
        99%   = 50.098    75%   = 244.42    10%   = 897.91
        95%   = 108.59    50%   = 391.46     5%   = 1135.1
        90%   = 151.28    25%   = 608.32     1%   = 1778.3

   3    MEAN  = 300.07    S.D.  = 209.53    P(N>=r)= .97730
        99%   = 26.910    75%   = 155.46    10%   = 560.97
        95%   = 63.025    50%   = 253.50     5%   = 692.82
        90%   = 91.763    25%   = 390.33     1%   = 1025.2

   4    MEAN  = 210.49    S.D.  = 146.35    P(N>=r)= .93669
        99%   = 17.320    75%   = 106.51    10%   = 397.67
        95%   = 40.378    50%   = 178.93     5%   = 487.12
        90%   = 60.222    25%   = 278.15     1%   = 703.63

   5    MEAN  = 157.70    S.D.  = 110.85    P(N>=r)= .86476
        99%   = 12.772    75%   = 77.518    10%   = 301.71
        95%   = 28.740    50%   = 133.56     5%   = 368.68
        90%   = 42.906    25%   = 210.52     1%   = 526.65

   6    MEAN  = 124.05    S.D.  = 88.041    P(N>=r)= .76239
        99%   = 10.294    75%   = 59.761    10%   = 239.55
        95%   = 22.343    50%   = 104.41     5%   = 292.62
        90%   = 33.025    25%   = 166.47     1%   = 415.72

   7    MEAN  = 101.44    S.D.  = 72.232    P(N>=r)= .63972
        99%   = 8.7883    75%   = 48.483    10%   = 196.77
        95%   = 18.517    50%   = 84.971     5%   = 240.38
        90%   = 27.036    25%   = 136.33     1%   = 340.42

   8    MEAN  = 85.531    S.D.  = 60.723    P(N>=r)= .51147
        99%   = 7.7909    75%   = 40.973    10%   = 165.96
        95%   = 16.036    50%   = 71.512     5%   = 202.70
        90%   = 23.146    25%   = 114.86     1%   = 286.35

E) The mean of the potential = 2353.5
```

PETRIMES MODULE PSUM

```
MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
**************************

UAI      C5440101
PLAY     South Delta-Mesozoic gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks  Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, FEB  2, 2001, 10:39 AM


USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE IN DATA BASE ?  >    Y
   OIL (O) OR GAS (G) ?                  >    G
   BRITISH OR S.I. UNIT OF MEASUREMENT? >   SI
   RECOVERABLE RESOURCES?               >    N
   DO YOU WANT TO USE MPRO OUTPUT?      >    Y
   DO YOU ASSUME LOGNORMAL DISTRIBUTION? >   Y
   DO YOU WANT TO USE PPSD OUTPUT?      >    Y
   DO YOU COMPUTE CONDITIONAL POTENTIAL? >   N


A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT =M cu m  (19)


B) Lognormal Pool Size Distribution
   --------------------------------
   Summary    mu   = 5.0415    MEAN  = 306.47
   Statistics sig. sq= 1.3673    S.D.  = 524.12

   Upper      99.99% = 1.9993    60.00% = 115.04    15.00% = 519.78
   Percentiles 99.00% = 10.189   55.00% = 133.56    10.00% = 692.30
               95.00% = 22.604   50.00% = 154.70     8.00% = 799.87
               90.00% = 34.569   45.00% = 179.19     6.00% = 952.89
               85.00% = 46.043   40.00% = 208.04     5.00% = 1058.7
               80.00% = 57.822   35.00% = 242.75     4.00% = 1198.2
               75.00% = 70.302   30.00% = 285.62     2.00% = 1707.8
               70.00% = 83.789   25.00% = 340.42     1.00% = 2348.9
               65.00% = 98.586   20.00% = 413.89      .01% = 11970.


C) NO. OF POOLS DISTRIBUTION
   -------------------------
   Lower Support    =    0
   Upper Support    =   27
   Expectation      =    7.92698
   Standard Deviation=   3.22706


D) Summary Statistics for 4000 Simulations
   ---------------------------------------
   Play Resource:   ( B cu m   )
   -----------------------------
   Minimum    = .0000000E+00Maximum        = 20.30180
   Expectation = 2.432530   Standard Deviation= 1.742724

   EMPERICAL DISTRIBUTION:
   ----------------------
```

Greater than Percentage	Play Potential
100.00	.00000E+00
99.00	.18142
95.00	.48941
90.00	.72355
85.00	.92550
80.00	1.0815
75.00	1.2620
70.00	1.4062
65.00	1.5508
60.00	1.7089
55.00	1.8698
50.00	2.0402
45.00	2.2209
40.00	2.4170
35.00	2.6301
30.00	2.8758
25.00	3.1710
20.00	3.5065
15.00	3.9387
10.00	4.5919
8.00	4.9254
6.00	5.3993
5.00	5.6884
4.00	6.0976
2.00	7.0300
1.00	8.2659
.01	18.688
.00	20.140-

PETRIMES MODULE PPSD

```
PROSPECT OR POOL SIZE DISTRIBUTION USING
LOGNORMAL OR MONTE CARLO SIMULATION
*****************************************

UAI        C5460101
PLAY       South Delta-Paleozoic gas play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   TUE, JAN 23, 2001,  9:42 AM


USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE ON DB?            >   Y
   OIL (O) OR GAS (G) ?                   >   G
   BRITISH OR S.I. UNIT OF MEASUREMENT?   >   SI
   RECOVERABLE RESOURCES?                 >   N
   DO YOU WANT TO HONOR A PERCENTILE?     > Y
   UPPER PERCENTILE TO BE HONORED?        > .10000E-01


A) Basic Information
   -----------------
   TYPE OF RESOURCE      =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT   =M cu m  (19)


B) Input Constant(s)
   -----------------

   No input constant.


C) Summary
   -------

   Variable                    Lognormal Approximation

   IN-PLACE    mu    = 5.5676      MEAN  = 498.85
   POOL SIZE   sig. sq= 1.2895     S.D.  = 809.13
   (DERIVED)   99.99% = 3.8362     60.00% = 196.35      15.00% = 849.37
               99.00% = 18.651     55.00% = 226.99      10.00% = 1122.0
               95.00% = 40.438     50.00% = 261.80       8.00% = 1290.9
               90.00% = 61.088     45.00% = 301.95       6.00% = 1530.1
               85.00% = 80.694     40.00% = 349.07       5.00% = 1694.9
               80.00% = 100.67     35.00% = 405.50       4.00% = 1911.3
               75.00% = 121.71     30.00% = 474.88       2.00% = 2696.5
               70.00% = 144.33     25.00% = 563.12       1.00% = 3674.8
               65.00% = 169.02     20.00% = 680.81        .01% = 17867.


D) Pool Size Equation
   ------------------

   NO. OF GEO-VARIABLES= 5

   POOL SIZE =     1.00000
                  * AREA OF     * NET PAY    * POROSITY    * HYDROCARBON
                    POOL                                     SATURATION

                  --------------------------------------------------------
                       GAS FMN
                       VOLUME
                       FACTOR
```

```
GEOLOGICAL VARIABLES
--------------------
A) Variables Used
   --------------

   VARIABLE     UNIT OF     O/G VERSION TYPE NO. OF   UAI
                MEASUREMENT                   POINTS
                SYMBOL                        USED

   AREA OF       sq km      Gas   1     2      4   C5460101
   POOL

   NET PAY        m         Gas   1     2      4   C5460101

   POROSITY     dec fr      Gas   1     2      4   C5460101

   HYDROCARBON  dec fr      Gas   1     2      4   C5460101
   SATURATION

   GAS FMN                  Gas   1     2      4   C5460101
   VOLUME
   FACTOR


B) Summary
   -------

   Variable                   Lognormal Approximation

   AREA OF    mu    =-.35667     MEAN  = 1.1866
   POOL       sig. sq= 1.0555    S.D.  = 1.6241
              99.99% = .15336E-01 60.00% = .53958     15.00% = 2.0302
              99.00% = .64138E-01 55.00% = .61522     10.00% = 2.6116
              95.00% = .12918     50.00% = .70000      8.00% = 2.9650
              90.00% = .18762     45.00% = .79646      6.00% = 3.4579
              85.00% = .24135     40.00% = .90811      5.00% = 3.7932
              80.00% = .29483     35.00% = 1.0400      4.00% = 4.2289
              75.00% = .35007     30.00% = 1.1997      2.00% = 5.7737
              70.00% = .40843     25.00% = 1.3997      1.00% = 7.6398
              65.00% = .47117     20.00% = 1.6619       .01% = 31.950


   NET PAY    mu    = 3.0910     MEAN  = 23.793
              sig. sq= .15674    S.D.  = 9.8014
              99.99% = 5.0464     60.00% = 19.900     15.00% = 33.161
              99.00% = 8.7586     55.00% = 20.932     10.00% = 36.540
              95.00% = 11.471     50.00% = 22.000      8.00% = 38.371
              90.00% = 13.246     45.00% = 23.122      6.00% = 40.714
              85.00% = 14.596     40.00% = 24.321      5.00% = 42.193
              80.00% = 15.766     35.00% = 25.626      4.00% = 43.998
              75.00% = 16.844     30.00% = 27.076      2.00% = 49.607
              70.00% = 17.875     25.00% = 28.734      1.00% = 55.260
              65.00% = 18.887     20.00% = 30.699       .01% = 95.910


   POROSITY   mu    =-2.3026     MEAN  = .10307
              sig. sq= .60438E-01 S.D.  = .25726E-01
              99.99% = .40080E-01 60.00% = .93962E-01 15.00% = .12902
              99.00% = .56444E-01 55.00% = .96958E-01 10.00% = .13703
              95.00% = .66739E-01 50.00% = .10000      8.00% = .14126
              90.00% = .72975E-01 45.00% = .10314      6.00% = .14655
              85.00% = .77507E-01 40.00% = .10643      5.00% = .14984
              80.00% = .81310E-01 35.00% = .10994      4.00% = .15379
              75.00% = .84720E-01 30.00% = .11376      2.00% = .16568
              70.00% = .87904E-01 25.00% = .11804      1.00% = .17717
              65.00% = .90962E-01 20.00% = .12299       .01% = .24950
```

```
HYDROCARBON    mu    =-.16252      MEAN   = .85038
SATURATION     sig. sq= .88600E-03 S.D.   = .25318E-01
               99.99% = .76093       60.00% = .84361      15.00% = .87663
               99.00% = .79313       55.00% = .84683      10.00% = .88305
               95.00% = .80939       50.00% = .85000       8.00% = .88630
               90.00% = .81819       45.00% = .85319       6.00% = .89026
               85.00% = .82418       40.00% = .85643       5.00% = .89265
               80.00% = .82897       35.00% = .85981       4.00% = .89547
               75.00% = .83311       30.00% = .86337       2.00% = .90358
               70.00% = .83684       25.00% = .86724       1.00% = .91094
               65.00% = .84031       20.00% = .87156        .01% = .94950


GAS FMN        mu    =-5.2983       MEAN   = .50399E-02
VOLUME         sig. sq= .15887E-01 S.D.   = .63777E-03
FACTOR         99.99% = .31289E-02 60.00% = .48429E-02 15.00% = .56978E-02
               99.00% = .37293E-02 55.00% = .49214E-02 10.00% = .58765E-02
               95.00% = .40638E-02 50.00% = .50000E-02  8.00% = .59687E-02
               90.00% = .42542E-02 45.00% = .50798E-02  6.00% = .60824E-02
               85.00% = .43877E-02 40.00% = .51622E-02  5.00% = .61519E-02
               80.00% = .44968E-02 35.00% = .52488E-02  4.00% = .62345E-02
               75.00% = .45925E-02 30.00% = .53416E-02  2.00% = .64773E-02
               70.00% = .46802E-02 25.00% = .54437E-02  1.00% = .67037E-02
               65.00% = .47630E-02 20.00% = .55596E-02   .01% = .79900E-02
```

C) Covariance Matrix

```
VARIABLE

AREA OF        1.05551
POOL

NET PAY         .00000     .15674

POROSITY        .00000     .00000     .06044

HYDROCARBON     .00000     .00000     .00000     .00089
SATURATION

GAS FMN         .00000     .00000     .00000     .00000     .01589
VOLUME
FACTOR
```

D) Correlation Matrix

```
VARIABLE

AREA OF        1.00000
POOL

NET PAY         .00000    1.00000

POROSITY        .00000     .00000    1.00000

HYDROCARBON     .00000     .00000     .00000    1.00000
SATURATION

GAS FMN         .00000     .00000     .00000     .00000    1.00000
VOLUME
FACTOR
```

PETRIMES MODULE MPRO

```
NO. OF POOLS DISTRIBUTION AND RISKS
***********************************

UAI       C5460101
PLAY      South Delta-Paleozoic gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  TUE, JAN 23, 2001,  9:47 AM
```

USER SUPPLIED PARAMETERS
```
-----------------------
   DO YOU WANT TO STORE ON DB?        >   Y
   OIL (O) OR GAS (G) ?               >   G
```

A) Risks
```
   -----
```

GEOLOGICAL FACTOR		MARGINAL PROBABILITY
-----------------		--------------------
PLAY LEVEL Overall Play Level Risk =		1.00
PROSPECT LEVEL Presence of Closure (1)		.60
Presence of Porosity (3)		.50
Adequate Seal (4)		.90
Adequate Timing (5)		.80
Adequate Source (6)		.80
Adequate Preservation (8)		.80

Overall Prospect Level Risk =		.14
EXPLORATION RISK: =		.14

B) No. of Prospects Distribution
```
----------------------------
Minimum      =    46
Maximum      =   200
Mean         = 109.25
S.D.         =  45.44

Frequency   No. of Prospects
---------   ----------------

  99.00           46
  95              51
  90              56
  80              66
  75              71
  60              86
  50              95
  40             116
  25             148
  20             158
  10             179
   5             190
   1             198
   0             200
```

C) No. of Pools Distribution
```
----------------------------
Minimum      =     0
Maximum      =    49
Mean         =  15.10
S.D.         =   7.24

Frequency   No. of Pools
---------   ------------

  99.99           0
  99              3
  95              5
  90              7
  80              9
  75              9
  60             12
  50             14
  40             16
  25             20
  20             22
  10             26
   5             28
   1             33
   0             49
```

Note: The no. of pools distribution is saved in the database with UDI= 6201GB4

PETRIMES MODULE PSRK

```
INDIVIDUAL POOL SIZES BY RANK
WHERE N IS A RANDOM VARIABLE
*****************************

UAI       C5460101
PLAY      South Delta-Paleozoic gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  TUE, JAN 23, 2001, 10:37 AM
```

USER SUPPLIED PARAMETERS
```
-----------------------
   DO YOU WANT TO STORE ON DB ?       > Y
   DO YOU WANT TO USE MPRO OUTPUT?    > Y
   MIN. AND MAX. POOL RANKS?          >    1    15
   DO YOU USE LOGNORNAL ASSUMPTION?   > Y
   DO YOU WANT TO USE PPSD OUTPUT?    > Y
```

A) Basic Information
```
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT   =M cu m  (19)
```

B) Lognormal Pool Size Distribution
```
   --------------------------------
   Summary    mu   = 5.5676    MEAN  = 498.85
   Statistics sig. sq= 1.2895  S.D.  = 809.13

   Upper        99.99% = 3.8362   60.00% = 196.35   15.00% = 849.37
   Percentiles  99.00% = 18.651   55.00% = 226.99   10.00% = 1122.0
                95.00% = 40.438   50.00% = 261.80    8.00% = 1290.9
                90.00% = 61.088   45.00% = 301.95    6.00% = 1530.1
                85.00% = 80.694   40.00% = 349.07    5.00% = 1694.9
                80.00% = 100.67   35.00% = 405.50    4.00% = 1911.3
                75.00% = 121.71   30.00% = 474.88    2.00% = 2696.5
                70.00% = 144.33   25.00% = 563.12    1.00% = 3674.8
                65.00% = 169.02   20.00% = 680.81     .01% = 17867.
```

C) No. of Pools Distribution
```
   ----------------------------
   Lower Support    =   0
   Upper Support    =  49
   Expectation      =  15.10
   Standard Deviation=  7.24
```

D) Pool Sizes By Rank
```
   ------------------

   Pool Rank              Distribution

      1    MEAN  = 2253.7    S.D.  = 2029.1   P(N>=r)= .99992
           99%   = 322.85    75%   = 1097.2   10%   = 4254.7
           95%   = 555.12    50%   = 1720.    5%    = 5652.0
           90%   = 722.72    25%   = 2728.0   1%    = 10012.

      2    MEAN  = 1170.3    S.D.  = 752.62   P(N>=r)= .99928
           99%   = 177.76    75%   = 662.55   10%   = 2081.9
           95%   = 328.80    50%   = 1006.2   5%    = 2557.3
           90%   = 434.86    25%   = 1481.3   1%    = 3805.1

      3    MEAN  = 807.22    S.D.  = 482.81   P(N>=r)= .99658
```

```
                99%   = 105.19     75%   = 465.17     10%   = 1422.8
                95%   = 216.05     50%   = 716.43     5%    = 1704.7
                90%   = 295.23     25%   = 1042.6     1%    = 2389.8

  4     MEAN  = 612.90     S.D.  = 364.58     P(N>=r)= .98907
                99%   = 66.299     75%   = 347.15     10%   = 1088.8
                95%   = 148.54     50%   = 550.16     5%    = 1290.3
                90%   = 210.80     25%   = 805.76     1%    = 1757.9

  5     MEAN  = 490.12     S.D.  = 296.26     P(N>=r)= .97327
                99%   = 45.850     75%   = 269.28     10%   = 882.61
                95%   = 106.76     50%   = 441.23     5%    = 1040.2
                90%   = 156.41     25%   = 654.76     1%    = 1394.3

  6     MEAN  = 406.18     S.D.  = 250.43     P(N>=r)= .94640
                99%   = 34.789     75%   = 215.98     10%   = 741.58
                95%   = 81.022     50%   = 365.31     5%    = 871.17
                90%   = 120.99     25%   = 549.95     1%    = 1155.8

  7     MEAN  = 346.13     S.D.  = 216.79     P(N>=r)= .90759
                99%   = 28.411     75%   = 179.02     10%   = 638.82
                95%   = 65.097     50%   = 310.70     5%    = 748.83
                90%   = 97.891     25%   = 473.42     1%    = 986.26

  8     MEAN  = 301.73     S.D.  = 190.66     P(N>=r)= .85828
                99%   = 24.483     75%   = 153.19     10%   = 560.55
                95%   = 55.003     50%   = 270.59     5%    = 655.90
                90%   = 82.687     25%   = 415.46     1%    = 859.09

  9     MEAN  = 267.91     S.D.  = 169.54     P(N>=r)= .80152
                99%   = 21.926     75%   = 134.91     10%   = 498.79
                95%   = 48.382     50%   = 240.46     5%    = 582.66
                90%   = 72.471     25%   = 370.17     1%    = 759.73

 10     MEAN  = 241.32     S.D.  = 151.98     P(N>=r)= .74096
                99%   = 20.183     75%   = 121.69     10%   = 448.56
                95%   = 43.877     50%   = 217.17     5%    = 523.15
                90%   = 65.414     25%   = 333.65     1%    = 679.58

 11     MEAN  = 219.72     S.D.  = 137.05     P(N>=r)= .67987
                99%   = 18.949     75%   = 111.81     10%   = 406.60
                95%   = 40.693     50%   = 198.46     5%    = 473.52
                90%   = 60.370     25%   = 303.31     1%    = 613.23

 12     MEAN  = 201.57     S.D.  = 124.16     P(N>=r)= .62071
                99%   = 18.036     75%   = 104.03     10%   = 370.75
                95%   = 38.341     50%   = 182.78     5%    = 431.22
                90%   = 56.598     25%   = 277.36     1%    = 557.10

 13     MEAN  = 185.82     S.D.  = 112.90     P(N>=r)= .56500
                99%   = 17.323     75%   = 97.503     10%   = 339.50
                95%   = 36.495     50%   = 169.06     5%    = 394.50
                90%   = 53.590     25%   = 254.64     1%    = 508.78

 14     MEAN  = 171.78     S.D.  = 102.99     P(N>=r)= .51340
                99%   = 16.718     75%   = 91.630     10%   = 311.85
                95%   = 34.919     50%   = 156.64     5%    = 362.16
                90%   = 50.982     25%   = 234.35     1%    = 466.56

 15     MEAN  = 159.01     S.D.  = 94.235     P(N>=r)= .46594
                99%   = 16.153     75%   = 86.056     10%   = 287.10
                95%   = 33.443     50%   = 145.15     5%    = 333.36
                90%   = 48.521     25%   = 215.98     1%    = 429.28
```

E) The mean of the potential = 7203.4

PETRIMES MODULE PSUM

```
MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
****************************

UAI       C5460101
PLAY      South Delta-Paleozoic gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  TUE, JAN 23, 2001, 10:39 AM


USER SUPPLIED PARAMETERS
-----------------------
    DO YOU WANT TO STORE IN DATA BASE ?    >    Y
    OIL (O) OR GAS (G) ?                    >    G
    BRITISH OR S.I. UNIT OF MEASUREMENT?   >    SI
    RECOVERABLE RESOURCES?                  >    N
    DO YOU WANT TO USE MPRO OUTPUT?         >    Y
    DO YOU ASSUME LOGNORMAL DISTRIBUTION?   >    Y
    DO YOU WANT TO USE PPSD OUTPUT?         >    Y
    DO YOU COMPUTE CONDITIONAL POTENTIAL?  >    N

A) Basic Information
   -----------------
    TYPE OF RESOURCE     =Gas In-place
    SYSTEM OF MEASUREMENT =S.I.
    UNIT OF MEASUREMENT   =M cu m  (19)

B) Lognormal Pool Size Distribution
   --------------------------------
    Summary     mu   = 5.5676     MEAN  = 498.85
    Statistics  sig. sq= 1.2895    S.D.  = 809.13

    Upper        99.99% = 3.8362    60.00% = 196.35    15.00% = 849.37
    Percentiles  99.00% = 18.651    55.00% = 226.99    10.00% = 1122.0
                 95.00% = 40.438    50.00% = 261.80    8.00% = 1290.9
                 90.00% = 61.088    45.00% = 301.95    6.00% = 1530.1
                 85.00% = 80.694    40.00% = 349.07    5.00% = 1694.9
                 80.00% = 100.67    35.00% = 405.50    4.00% = 1911.3
                 75.00% = 121.71    30.00% = 474.88    2.00% = 2696.5
                 70.00% = 144.33    25.00% = 563.12    1.00% = 3674.8
                 65.00% = 169.02    20.00% = 680.81     .01% = 17867.

C) NO. OF POOLS DISTRIBUTION
   ------------------------------
    Lower Support    =    0
    Upper Support    =   49
    Expectation      =   15.10272
    Standard Deviation=    7.24418


D) Summary Statistics for 4000 Simulations
   ---------------------------------------

    Play Resource:   ( B cu m   )
    ------------------------------
    Minimum    = .1544554    Maximum       = 33.45845
    Expectation = 7.523363    Standard Deviation= 4.663376


    EMPERICAL DISTRIBUTION:
    ---------------------
```

Greater than Percentage	Play Potential
100.00	.15446
99.00	.87468
95.00	1.6994
90.00	2.3555
85.00	2.9483
80.00	3.4788
75.00	3.9972
70.00	4.5850
65.00	5.0365
60.00	5.5197
55.00	6.0653
50.00	6.6614
45.00	7.2674
40.00	7.8857
35.00	8.5103
30.00	9.2216
25.00	10.064
20.00	11.098
15.00	12.215
10.00	13.715
8.00	14.470
6.00	15.512
5.00	16.536
4.00	17.344
2.00	19.535
1.00	21.752
.01	33.164
.00	33.429

PETRIMES MODULE PPPS

PLAY POTENTIAL CONDITION ON
TOTAL SUM OF DISCOVERED RESERVE
****

```
UAI       C5460101
PLAY      South Delta-Paleozoic gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  TUE, JAN 23, 2001, 10:41 AM
```

USER SUPPLIED PARAMETERS

```
    DO YOU WANT TO STORE IN DATA BASE?  >    Y
    OIL (O) OR GAS (G)?                  >    G
    BRITISH OR S.I. UNIT OF MEASUREMENT?>   SI
    RECOVERABLE RESOURCES?              >    N
    CONDITION VALUE AND ITS UNIT?       >    311.00    19
```

A) Basic Information

```
    TYPE OF RESOURCE     =Gas In-place
    SYSTEM OF MEASUREMENT =S.I.
    UNIT OF MEASUREMENT   =M cu m  (19)
```

B) PLAY RESOURCE DISTRIBUTION

```
    Summary     MEAN  = 7.5234    S.D.  = 4.6634
    Statistics  B cu m
```

Upper Percentiles				
100.00% = .15446	55.00% = 6.0653	8.00% = 14.470
99.00% = .87468	50.00% = 6.6614	6.00% = 15.512
95.00% = 1.6994	45.00% = 7.2674	5.00% = 16.536
90.00% = 2.3555	40.00% = 7.8857	4.00% = 17.344
85.00% = 2.9483	35.00% = 8.5103	2.00% = 19.535
80.00% = 3.4788	30.00% = 9.2216	1.00% = 21.752
75.00% = 3.9972	25.00% = 10.064	.01% = 33.164
70.00% = 4.5850	20.00% = 11.098	.00% = 33.429
65.00% = 5.0365	15.00% = 12.215	
60.00% = 5.5197	10.00% = 13.715	

C) Summary Statistics for 5000 Simulations

```
-------**-------------------------------
Play Potential:  (  B cu m   )
------------------------------
 Minimum    = .1047840E-01Maximum       = 32.41308
 Expectation = 7.279167    Standard Deviation= 4.818757

EMPERICAL DISTRIBUTION:
----------------------

   Greater than   Play
   Percentage     Potential
   ------------   ----------
      100.00      .10478E-01
       99.00      .60054
       95.00      1.3824
       90.00      2.0107
       85.00      2.5747
       80.00      3.1288
       75.00      3.6557
       70.00      4.2706
       65.00      4.7228
       60.00      5.1871
       55.00      5.8006
       50.00      6.3701
       45.00      7.0142
       40.00      7.6513
       35.00      8.2200
       30.00      8.9133
       25.00      9.8504
       20.00      10.863
       15.00      12.036
       10.00      13.482
        8.00      14.405
        6.00      15.598
        5.00      16.573
        4.00      17.544
        2.00      19.687
        1.00      21.719
         .01      32.318
         .00      32.404
```

PETRIMES MODULE PPSD

```
PROSPECT OR POOL SIZE DISTRIBUTION USING
LOGNORMAL OR MONTE CARLO SIMULATION
****************************************

UAI       C54E0101
PLAY      Herschel oil play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, JAN 26, 2001, 12:08 PM


USER SUPPLIED PARAMETERS
------------------------

   DO YOU WANT TO STORE ON DB?          >    Y
   OIL (O) OR GAS (G) ?                 >    O
   BRITISH OR S.I. UNIT OF MEASUREMENT? >   SI
   RECOVERABLE RESOURCES?               >    N
   DO YOU WANT TO HONOR A PERCENTILE?   > Y
   UPPER PERCENTILE TO BE HONORED?      > .10000E-01

A) Basic Information
   -----------------

   TYPE OF RESOURCE     =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT   =M cu m  (19)

B) Input Constant(s)
   -----------------

   No input constant.

C) Summary
   -------

   Variable                 Lognormal Approximation

   IN-PLACE    mu   = 1.7330    MEAN  = 9.0178
   POOL SIZE   sig. sq= .93241   S.D.  = 11.193
   (DERIVED)   99.99% = .15596   60.00% = 4.4298    15.00% = 15.391
               99.00% = .59848   55.00% = 5.0111    10.00% = 19.501
               95.00% = 1.1557   50.00% = 5.6576     8.00% = 21.972
               90.00% = 1.6413   45.00% = 6.3875     6.00% = 25.389
               85.00% = 2.0797   40.00% = 7.2256     5.00% = 27.696
               80.00% = 2.5101   35.00% = 8.2077     4.00% = 30.676
               75.00% = 2.9497   30.00% = 9.3874     2.00% = 41.105
               70.00% = 3.4097   25.00% = 10.851     1.00% = 53.482
               65.00% = 3.8998   20.00% = 12.752      .01% = 205.23

D) Pool Size Equation
   ------------------

   NO. OF GEO-VARIABLES= 6

   POOL SIZE =       1.00000
                  * AREA OF     * NET PAY    * POROSITY    * HYDROCARBON
                    POOL                                     SATURATION
                  * OIL FRACTION
                    OIL FMN
                    VOLUME
                    FACTOR
```

```
GEOLOGICAL VARIABLES
--------------------
A) Variables Used
   --------------

   VARIABLE        UNIT OF     O/G VERSION TYPE NO. OF  UAI
                   MEASUREMENT              POINTS
                   SYMBOL                   USED

   AREA OF         sq km    Oil  1      2    4   C54E0101
   POOL

   NET PAY          m       Oil  1      2    4   C54E0101

   POROSITY        dec fr   Oil  1      2    4   C54E0101

   HYDROCARBON     dec fr   Oil  1      2    4   C54E0101
   SATURATION

   OIL FRACTION    dec fr   Oil  1      2    4   C54E0101

   OIL FMN                  Oil  1      2    4   C54E0101
   VOLUME
   FACTOR


B) Summary
   -------

   Variable               Lognormal Approximation

   AREA OF    mu   = 1.6094   MEAN  = 6.0505
   POOL       sig. sq= .38140  S.D.  = 4.1229
              99.99% = .50292  60.00% = 4.2758    15.00% = 9.4831
              99.00% = 1.1886  55.00% = 4.6266    10.00% = 11.033
              95.00% = 1.8105  50.00% = 5.0000     8.00% = 11.908
              90.00% = 2.2659  45.00% = 5.4035     6.00% = 13.061
              85.00% = 2.6363  40.00% = 5.8468     5.00% = 13.808
              80.00% = 2.9733  35.00% = 6.3433     4.00% = 14.741
              75.00% = 3.2966  30.00% = 6.9122     2.00% = 17.775
              70.00% = 3.6168  25.00% = 7.5836     1.00% = 21.034
              65.00% = 3.9412  20.00% = 8.4081      .01% = 49.710

   NET PAY    mu   = 3.6889   MEAN  = 50.320
              sig. sq= .45903  S.D.  = 38.406
              99.99% = 3.2193  60.00% = 33.691    15.00% = 80.728
              99.00% = 8.2708  55.00% = 36.735    10.00% = 95.312
              95.00% = 13.124  50.00% = 40.000     8.00% = 103.63
              90.00% = 16.787  45.00% = 43.555     6.00% = 114.69
              85.00% = 19.820  40.00% = 47.490     5.00% = 121.91
              80.00% = 22.616  35.00% = 51.932     4.00% = 130.97
              75.00% = 25.328  30.00% = 57.064     2.00% = 160.83
              70.00% = 28.039  25.00% = 63.172     1.00% = 193.45
              65.00% = 30.809  20.00% = 70.746      .01% = 497.00

   POROSITY   mu   =-1.7720   MEAN  = .17247
              sig. sq= .28812E-01 S.D.  = .29487E-01
              99.99% = .90426E-01 60.00% = .16284  15.00% = .20270
              99.00% = .11454  55.00% = .16641    10.00% = .21131
              95.00% = .12859  50.00% = .17000     8.00% = .21579
              90.00% = .13677  45.00% = .17367     6.00% = .22134
              85.00% = .14258  40.00% = .17747     5.00% = .22475
              80.00% = .14737  35.00% = .18149     4.00% = .22883
              75.00% = .15161  30.00% = .18583     2.00% = .24091
              70.00% = .15552  25.00% = .19062     1.00% = .25231
              65.00% = .15924  20.00% = .19611      .01% = .31960
```

```
HYDROCARBON  mu   =-.65393   MEAN  = .52058
SATURATION   sig. sq= .22286E-02 S.D.  = .24589E-01
             99.99% = .43627  60.00% = .51382    15.00% = .54608
             99.00% = .46592  55.00% = .51692    10.00% = .55243
             95.00% = .48115  50.00% = .52000     8.00% = .55566
             90.00% = .48947  45.00% = .52309     6.00% = .55960
             85.00% = .49517  40.00% = .52626     5.00% = .56199
             80.00% = .49974  35.00% = .52955     4.00% = .56480
             75.00% = .50370  30.00% = .53303     2.00% = .57294
             70.00% = .50728  25.00% = .53682     1.00% = .58036
             65.00% = .51063  20.00% = .54108      .01% = .61980

OIL FRACTION mu   =-.91629   MEAN  = .41225
             sig. sq= .60332E-01 S.D.  = .10281
             99.99% = .16045  60.00% = .37587    15.00% = .51597
             99.00% = .22589  55.00% = .38784    10.00% = .54798
             95.00% = .26705  50.00% = .40000     8.00% = .56486
             90.00% = .29198  45.00% = .41254     6.00% = .58602
             85.00% = .31010  40.00% = .42568     5.00% = .59913
             80.00% = .32530  35.00% = .43971     4.00% = .61491
             75.00% = .33893  30.00% = .45499     2.00% = .66243
             70.00% = .35166  25.00% = .47207     1.00% = .70831
             65.00% = .36388  20.00% = .49186      .01% = .99720

OIL FMN      mu   = .22314   MEAN  = 1.2504
VOLUME       sig. sq= .60560E-03 S.D.  = .30775E-01
FACTOR       99.99% = 1.1407  60.00% = 1.2422    15.00% = 1.2823
             99.00% = 1.1804  55.00% = 1.2461    10.00% = 1.2901
             95.00% = 1.2004  50.00% = 1.2500     8.00% = 1.2940
             90.00% = 1.2112  45.00% = 1.2539     6.00% = 1.2988
             85.00% = 1.2185  40.00% = 1.2578     5.00% = 1.3016
             80.00% = 1.2244  35.00% = 1.2619     4.00% = 1.3050
             75.00% = 1.2294  30.00% = 1.2662     2.00% = 1.3148
             70.00% = 1.2340  25.00% = 1.2709     1.00% = 1.3236
             65.00% = 1.2382  20.00% = 1.2762      .01% = 1.3698

C) Covariance Matrix
   -----------------

   VARIABLE

   AREA OF        .38140
   POOL

   NET PAY        .00000    .45903

   POROSITY       .00000    .00000    .02881

   HYDROCARBON    .00000    .00000    .00000    .00223
   SATURATION

   OIL FRACTION   .00000    .00000    .00000    .00000    .06033

   OIL FMN        .00000    .00000    .00000    .00000    .00000
   VOLUME
   FACTOR


   VARIABLE

   OIL FMN        .00061
   VOLUME
   FACTOR
```

D) **Correlation Matrix**

```
VARIABLE

AREA OF      1.00000
POOL

NET PAY        .00000    1.00000

POROSITY       .00000     .00000   1.00000

HYDROCARBON    .00000     .00000    .00000   1.00000
SATURATION

OIL FRACTION   .00000     .00000    .00000    .00000   1.00000

OIL FMN        .00000     .00000    .00000    .00000    .00000
VOLUME
FACTOR


VARIABLE

OIL FMN      1.00000
VOLUME
FACTOR
```

PETRIMES MODULE MPRO

```
NO. OF POOLS DISTRIBUTION AND RISKS
***********************************

UAI       C54E0101
PLAY      Herschel oil play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, JAN 26, 2001, 12:09 PM
```

USER SUPPLIED PARAMETERS

```
DO YOU WANT TO STORE ON DB?            >    Y
OIL (O) OR GAS (G) ?                   >    O
```

A) **Risks**

	GEOLOGICAL FACTOR		MARGINAL PROBABILITY
	-----------------		--------------------
PLAY LEVEL	Overall Play Level Risk	=	1.00
PROSPECT LEVEL	Presence of Closure	(1)	.70
	Presence of Porosity	(3)	.90
	Adequate Seal	(4)	.60
	Adequate Timing	(5)	.80
	Adequate Source	(6)	.70
	Adequate Preservation	(8)	.80
	Overall Prospect Level Risk	=	.17
EXPLORATION RISK:		=	.17

B) **No. of Prospects Distribution**

```
Minimum    =    10
Maximum    =    50
Mean       =    27.92
S.D.       =    11.72
```

Frequency	No. of Prospects
---------	----------------
99.00	10
95	12
90	13
80	16
75	18
60	22
50	25
40	30
25	38
20	40
10	45
5	48
1	50
0	50

C) **No. of Pools Distribution**

```
Minimum    =    0
Maximum    =    21
Mean       =    4.73
S.D.       =    2.80
```

Frequency	No. of Pools
---------	------------
97.40	0
95	1
90	1
80	2
75	3
60	4
50	4
40	5
25	6
20	7
10	9
5	10
1	12
0	21

Note: The no. of
pools distribution
is saved in the
database with UDI=
6201OB4

PETRIMES MODULE PSRK

```
INDIVIDUAL POOL SIZES BY RANK
WHERE N IS A RANDOM VARIABLE
*****************************

UAI       C54E0101
PLAY      Herschel oil play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, JAN 26, 2001, 12:10 PM


USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE ON DB ?      > Y
   DO YOU WANT TO USE MPRO OUTPUT?   > Y
   MIN. AND MAX. POOL RANKS?         >    1    5
   DO YOU USE LOGNORNAL ASSUMPTION?  > Y
   DO YOU WANT TO USE PPSD OUTPUT?   > Y

A) Basic Information
   -----------------
   TYPE OF RESOURCE     =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)

B) Lognormal Pool Size Distribution
   --------------------------------
   Summary      mu    = 1.7330    MEAN  = 9.0178
   Statistics   sig. sq= .93241   S.D.  = 11.193

   Upper        99.99% = .15596   60.00% = 4.4298     15.00% = 15.391
   Percentiles  99.00% = .59848   55.00% = 5.0111     10.00% = 19.501
                95.00% = 1.1557   50.00% = 5.6576      8.00% = 21.972
                90.00% = 1.6413   45.00% = 6.3875      6.00% = 25.389
                85.00% = 2.0797   40.00% = 7.2256      5.00% = 27.696
                80.00% = 2.5101   35.00% = 8.2077      4.00% = 30.676
                75.00% = 2.9497   30.00% = 9.3874      2.00% = 41.105
                70.00% = 3.4097   25.00% = 10.851      1.00% = 53.482
                65.00% = 3.8998   20.00% = 12.752       .01% = 205.23

C) No. of Pools Distribution
   -------------------------
   Lower Support    =  0
   Upper Support    = 21
   Expectation      =  4.73
   Standard Deviation=  2.80
```

```
D) Pool Sizes By Rank
   ------------------

   Pool Rank                 Distribution

      1    MEAN  = 20.290   S.D.  = 18.379   P(N>=r)= .97399
           99%   = 1.6600   75%   = 9.2188   10%   = 39.684
           95%   = 3.7164   50%   = 15.499    5%   = 52.367
           90%   = 5.3906   25%   = 25.345    1%   = 90.150

      2    MEAN  = 10.240   S.D.  = 7.3619   P(N>=r)= .89343
           99%   = .96181   75%   = 5.1390   10%   = 19.342
           95%   = 2.0305   50%   = 8.5941    5%   = 23.977
           90%   = 2.9513   25%   = 13.382    1%   = 35.835

      3    MEAN  = 6.9831   S.D.  = 4.7122   P(N>=r)= .76446
           99%   = .72994   75%   = 3.5827   10%   = 13.058
           95%   = 1.4571   50%   = 5.9920    5%   = 15.878
           90%   = 2.0780   25%   = 9.2387    1%   = 22.637

      4    MEAN  = 5.3403   S.D.  = 3.4743   P(N>=r)= .61665
           99%   = .61565   75%   = 2.7948   10%   = 9.8998
           95%   = 1.1827   50%   = 4.6277    5%   = 11.927
           90%   = 1.6555   25%   = 7.0817    1%   = 16.619

      5    MEAN  = 4.3322   S.D.  = 2.7386   P(N>=r)= .47506
           99%   = .54402   75%   = 2.3146   10%   = 7.9583
           95%   = 1.0163   50%   = 3.7785    5%   = 9.5351
           90%   = 1.4008   25%   = 5.7350    1%   = 13.111

E) The mean of the potential =  39.601
```

PETRIMES MODULE PSUM

```
MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
***************************

UAI        C54E0101
PLAY       Herschel oil play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   FRI, JAN 26, 2001, 12:13 PM


USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE IN DATA BASE ?   >   Y
   OIL (O) OR GAS (G) ?                   >   O
   BRITISH OR S.I. UNIT OF MEASUREMENT?   >   SI
   RECOVERABLE RESOURCES?                 >   N
   DO YOU WANT TO USE MPRO OUTPUT?        >   Y
   DO YOU ASSUME LOGNORMAL DISTRIBUTION?  >   Y
   DO YOU WANT TO USE PPSD OUTPUT?        >   Y
   DO YOU COMPUTE CONDITIONAL POTENTIAL?  >   N


A) Basic Information
   -----------------
   TYPE OF RESOURCE     =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)

B) Lognormal Pool Size Distribution
   -------------------------------
   Summary    mu   = 1.7330    MEAN  = 9.0178
   Statistics sig. sq= .93241  S.D.  = 11.193

   Upper      99.99% = .15596   60.00% = 4.4298    15.00% = 15.391
   Percentiles 99.00% = .59848   55.00% = 5.0111   10.00% = 19.501
              95.00% = 1.1557    50.00% = 5.6576    8.00% = 21.972
              90.00% = 1.6413    45.00% = 6.3875    6.00% = 25.389
              85.00% = 2.0797    40.00% = 7.2256    5.00% = 27.696
              80.00% = 2.5101    35.00% = 8.2077    4.00% = 30.676
              75.00% = 2.9497    30.00% = 9.3874    2.00% = 41.105
              70.00% = 3.4097    25.00% = 10.851    1.00% = 53.482
              65.00% = 3.8998    20.00% = 12.752     .01% = 205.23
```

```
C) NO. OF POOLS DISTRIBUTION
   -------------------------
   Lower Support    =    0
   Upper Support    =   21
   Expectation      =    4.72808
   Standard Deviation=   2.80484


D) Summary Statistics for 4000 Simulations
   ----------------------------------------
   Play Resource:   (  M cu m  )
   -----------------------------
   Minimum    = .0000000E+00Maximum      = 349.0305
   Expectation = 42.40630    Standard Deviation= 34.55067

   EMPERICAL DISTRIBUTION:
   ----------------------
   Greater than   Play
   Percentage     Potential
   ------------   -----------
     100.00        .00000E+00
      95.00        2.7805
      90.00        6.8992
      85.00       10.490
      80.00       13.667
      75.00       16.913
      70.00       20.214
      65.00       23.473
      60.00       27.095
      55.00       30.753
      50.00       34.605
      45.00       38.698
      40.00       43.242
      35.00       48.156
      30.00       52.590
      25.00       59.358
      20.00       65.791
      15.00       75.218
      10.00       88.821
       8.00       95.161
       6.00      101.91
       5.00      107.90
       4.00      114.67
       2.00      132.80
       1.00      156.25
        .01      324.33
        .00      346.56
```

PETRIMES MODULE PPSD

PROSPECT OR POOL SIZE DISTRIBUTION USING
LOGNORMAL OR MONTE CARLO SIMULATION
****

```
UAI        C54D0101
PLAY       Herschel gas play
Assessor   Peter Hannigan
Geologist  Peter Hannigan
Remarks    Yukon North Slope Hydrocarbon Assessment Project
Run date   FRI, JAN 26, 2001, 11:13 AM
```

USER SUPPLIED PARAMETERS

```
DO YOU WANT TO STORE ON DB?          >   Y
OIL (O) OR GAS (G) ?                  >   G
BRITISH OR S.I. UNIT OF MEASUREMENT? >   SI
RECOVERABLE RESOURCES?               >   N
DO YOU WANT TO HONOR A PERCENTILE?   > Y
UPPER PERCENTILE TO BE HONORED?      > .10000E-01
```

A) Basic Information

```
TYPE OF RESOURCE     =Gas In-place
SYSTEM OF MEASUREMENT =S.I.
UNIT OF MEASUREMENT  =M cu m  (19)
```

B) Input Constant(s)

```
No input constant.
```

C) Summary

```
Variable                   Lognormal Approximation

IN-PLACE    mu   = 7.8831    MEAN  = 4163.4
POOL SIZE   sig. sq= .90202  S.D.  = 5038.5
(DERIVED)   99.99% = 77.552  60.00% = 2084.9   15.00% = 7096.9
            99.00% = 291.09  55.00% = 2353.7   10.00% = 8957.2
            95.00% = 556.06  50.00% = 2652.0    8.00% = 10072.
            90.00% = 785.19  45.00% = 2988.2    6.00% = 11611.
            85.00% = 991.01  40.00% = 3373.4    5.00% = 12648.
            80.00% = 1192.4  35.00% = 3823.9    4.00% = 13985.
            75.00% = 1397.5  30.00% = 4363.9    2.00% = 18650.
            70.00% = 1611.7  25.00% = 5032.5    1.00% = 24161.
            65.00% = 1839.2  20.00% = 5898.2     .01% = 90689.
```

D) Pool Size Equation

```
NO. OF GEO-VARIABLES= 6

POOL SIZE =      1.00000
             * AREA OF     * NET PAY    * POROSITY    * HYDROCARBON
               POOL                                     SATURATION

         * GAS FRACTION


         ------------------------------------------------------------
          GAS FMN
          VOLUME
          FACTOR
```

GEOLOGICAL VARIABLES

A) Variables Used

```
VARIABLE        UNIT OF     O/G VERSION TYPE NO. OF   UAI
                MEASUREMENT                  POINTS
                SYMBOL                       USED

AREA OF         sq km   Gas   1     2      4   C54D0101
POOL

NET PAY         m       Gas   1     2      4   C54D0101

POROSITY    dec fr      Gas   1     2      4   C54D0101

HYDROCARBON  dec fr     Gas   1     2      4   C54D0101
SATURATION

GAS FRACTION  dec fr    Gas   1     2      4   C54D0101

GAS FMN                 Gas   1     2      4   C54D0101
VOLUME
FACTOR
```

B) Summary

```
Variable                   Lognormal Approximation

AREA OF     mu   = 1.6094    MEAN  = 6.0505
POOL        sig. sq= .38140  S.D.  = 4.1229
            99.99% = .50292  60.00% = 4.2758   15.00% = 9.4831
            99.00% = 1.1886  55.00% = 4.6266   10.00% = 11.033
            95.00% = 1.8105  50.00% = 5.0000    8.00% = 11.908
            90.00% = 2.2659  45.00% = 5.4035    6.00% = 13.061
            85.00% = 2.6363  40.00% = 5.8468    5.00% = 13.808
            80.00% = 2.9733  35.00% = 6.3433    4.00% = 14.741
            75.00% = 3.2966  30.00% = 6.9122    2.00% = 17.775
            70.00% = 3.6168  25.00% = 7.5836    1.00% = 21.034
            65.00% = 3.9412  20.00% = 8.4081     .01% = 49.710

NET PAY     mu   = 3.6889    MEAN  = 50.320
            sig. sq= .45903  S.D.  = 38.406
            99.99% = 3.2193  60.00% = 33.691   15.00% = 80.728
            99.00% = 8.2708  55.00% = 36.735   10.00% = 95.312
            95.00% = 13.124  50.00% = 40.000    8.00% = 103.63
            90.00% = 16.787  45.00% = 43.555    6.00% = 114.69
```

```
              85.00% = 19.820    40.00% = 47.490     5.00% = 121.91
              80.00% = 22.616    35.00% = 51.932     4.00% = 130.97
              75.00% = 25.328    30.00% = 57.064     2.00% = 160.83
              70.00% = 28.039    25.00% = 63.172     1.00% = 193.45
              65.00% = 30.809    20.00% = 70.746      .01% = 497.00

POROSITY      mu     =-1.7720    MEAN  = .17247
              sig. sq= .28812E-01 S.D.  = .29487E-01
              99.99% = .90426E-01 60.00% = .16284    15.00% = .20270
              99.00% = .11454    55.00% = .16641    10.00% = .21131
              95.00% = .12859    50.00% = .17000     8.00% = .21579
              90.00% = .13677    45.00% = .17367     6.00% = .22134
              85.00% = .14258    40.00% = .17747     5.00% = .22475
              80.00% = .14737    35.00% = .18149     4.00% = .22883
              75.00% = .15161    30.00% = .18583     2.00% = .24091
              70.00% = .15552    25.00% = .19062     1.00% = .25231
              65.00% = .15924    20.00% = .19611      .01% = .31960

HYDROCARBON   mu     =-.65393    MEAN  = .52058
SATURATION    sig. sq= .22286E-02 S.D.  = .24589E-01
              99.99% = .43627    60.00% = .51382    15.00% = .54608
              99.00% = .46592    55.00% = .51692    10.00% = .55243
              95.00% = .48115    50.00% = .52000     8.00% = .55566
              90.00% = .48947    45.00% = .52309     6.00% = .55960
              85.00% = .49517    40.00% = .52626     5.00% = .56199
              80.00% = .49974    35.00% = .52955     4.00% = .56480
              75.00% = .50370    30.00% = .53303     2.00% = .57294
              70.00% = .50728    25.00% = .53682     1.00% = .58036
              65.00% = .51063    20.00% = .54108      .01% = .61980

GAS FRACTION  mu     =-.51083    MEAN  = .60565
              sig. sq= .18756E-01 S.D.  = .83335E-01
              99.99% = .36054    60.00% = .57954    15.00% = .69151
              99.00% = .43630    55.00% = .58976    10.00% = .71511
              95.00% = .47898    50.00% = .60000     8.00% = .72731
              90.00% = .50342    45.00% = .61042     6.00% = .74238
              85.00% = .52060    40.00% = .62118     5.00% = .75159
              80.00% = .53468    35.00% = .63251     4.00% = .76257
              75.00% = .54706    30.00% = .64468     2.00% = .79488
              70.00% = .55842    25.00% = .65806     1.00% = .82512
              65.00% = .56916    20.00% = .67330      .01% = .99850

GAS FMN       mu     =-5.5215    MEAN  = .40236E-02
VOLUME        sig. sq= .11789E-01 S.D.  = .43816E-03
FACTOR        99.99% = .26711E-02 60.00% = .38915E-02 15.00% = .44764E-02
              99.00% = .31072E-02 55.00% = .39458E-02 10.00% = .45972E-02
              95.00% = .33458E-02 50.00% = .40000E-02  8.00% = .46592E-02
              90.00% = .34804E-02 45.00% = .40549E-02  6.00% = .47356E-02
              85.00% = .35743E-02 40.00% = .41116E-02  5.00% = .47821E-02
              80.00% = .36507E-02 35.00% = .41709E-02  4.00% = .48374E-02
              75.00% = .37175E-02 30.00% = .42344E-02  2.00% = .49992E-02
              70.00% = .37786E-02 25.00% = .43039E-02  1.00% = .51494E-02
              65.00% = .38361E-02 20.00% = .43827E-02   .01% = .59900E-02
```

C) Covar*iance Matrix

```
   VARIABLE

   AREA OF        .38140
   POOL

   NET PAY        .00000     .45903

   POROSITY       .00000     .00000     .02881

   HYDROCARBON    .00000     .00000     .00000     .00223
   SATURATION

   GAS FRACTION   .00000     .00000     .00000     .00000     .01876

   GAS FMN        .00000     .00000     .00000     .00000     .00000
   VOLUME
   FACTOR


   VARIABLE

   GAS FMN        .01179
   VOLUME
   FACTOR
```

D) Correlation Matrix

```
   VARIABLE

   AREA OF       1.00000
   POOL

   NET PAY        .00000    1.00000

   POROSITY       .00000     .00000    1.00000

   HYDROCARBON    .00000     .00000     .00000    1.00000
   SATURATION

   GAS FRACTION   .00000     .00000     .00000     .00000    1.00000

   GAS FMN        .00000     .00000     .00000     .00000     .00000
   VOLUME
   FACTOR


   VARIABLE

   GAS FMN       1.00000
   VOLUME
   FACTOR
```

PETRIMES MODULE MPRO

```
NO. OF POOLS DISTRIBUTION AND RISKS
***********************************

UAI       C54D0101
PLAY      Herschel gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, JAN 26, 2001, 12:26 PM
```

USER SUPPLIED PARAMETERS
```
-----------------------
   DO YOU WANT TO STORE ON DB?       >   Y
   OIL (O) OR GAS (G) ?              >   G
```

A) Risks
```
   -----

             GEOLOGICAL FACTOR              MARGINAL PROBABILITY
             -----------------              --------------------


   PLAY LEVEL     Overall Play Level Risk     =     1.00

   PROSPECT LEVEL Presence of Closure    ( 1)    .70
                  Adequate Seal          ( 4)    .90
                  Adequate Timing        ( 5)    .60
                  Adequate Source        ( 6)    .80
                  Adequate Maturation    ( 7)    .70
                  Adequacy of Recovery   ( 9)    .80
                  ------------------------------------------
                  Overall Prospect Level Risk  =    .17

   EXPLORATION RISK:                      =    .17
```

B) No. of Prospects Distribution
```
---------------------------

   Minimum     =    10
   Maximum     =    50
   Mean        =    27.92
   S.D.        =    11.72

   Frequency  No. of Prospects
   ---------  ----------------

    99.00        10
    95           12
    90           13
    80           16
    75           18
    60           22
    50           25
    40           30
    25           38
    20           40
    10           45
     5           48
     1           50
     0           50
```

C) No. of Pools Distribution
```
---------------------------

   Minimum     =     0
   Maximum     =    21
   Mean        =    4.73
   S.D.        =    2.80

   Frequency  No. of Pools
   ---------  ------------
    97.40        0
    95           1
    90           1
    80           2
    75           3
    60           4
    50           4
    40           5
    25           6
    20           7
    10           9
     5          10
     1          12
     0          21
```

Note: The no. of pools distribution is saved in the database with UDI= 6201GB4

PETRIMES MODULE PSRK

```
INDIVIDUAL POOL SIZES BY RANK
WHERE N IS A RANDOM VARIABLE
*****************************

UAI       C54D0101
PLAY      Herschel gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, JAN 26, 2001, 12:27 PM
```

USER SUPPLIED PARAMETERS
```
-----------------------
   DO YOU WANT TO STORE ON DB ?      > Y
   DO YOU WANT TO USE MPRO OUTPUT?   > Y
   MIN. AND MAX. POOL RANKS?         >    1    5
   DO YOU USE LOGNORNAL ASSUMPTION?  > Y
   DO YOU WANT TO USE PPSD OUTPUT?   > Y
```

A) Basic Information
```
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)
```

B) Lognormal Pool Size Distribution
```
-------------------------------
   Summary    mu    = 7.8831    MEAN  = 4163.4
   Statistics sig. sq= .90202   S.D.  = 5038.5


   Upper        99.99% = 77.552    60.00% = 2084.9    15.00% = 7096.9
   Percentiles  99.00% = 291.09    55.00% = 2353.7    10.00% = 8957.2
                95.00% = 556.06    50.00% = 2652.0     8.00% = 10072.
                90.00% = 785.19    45.00% = 2988.2     6.00% = 11611.
                85.00% = 991.01    40.00% = 3373.4     5.00% = 12648.
                80.00% = 1192.4    35.00% = 3823.9     4.00% = 13985.
                75.00% = 1397.5    30.00% = 4363.9     2.00% = 18650.
                70.00% = 1611.7    25.00% = 5032.5     1.00% = 24161.
                65.00% = 1839.2    20.00% = 5898.2      .01% = 90689.
```

C) No. of Pools Distribution
```
------------------------
   Lower Support     =   0
   Upper Support     =  21
   Expectation       =   4.73
   Standard Deviation=   2.80
```

```
D) Pool Sizes By Rank
   ------------------

Pool Rank                    Distribution

     1    MEAN  = 9269.1    S.D.  = 8208.5    P(N>=r)= .97399
          99%   = 793.97    75%   = 4286.8    10%   = 18016.
          95%   = 1754.1    50%   = 7145.8    5%    = 23666.
          90%   = 2528.8    25%   = 11591.    1%    = 40378.

     2    MEAN  = 4736.3    S.D.  = 3343.4    P(N>=r)= .89343
          99%   = 464.17    75%   = 2412.7    10%   = 8885.1
          95%   = 967.94    50%   = 4000.9    5%    = 10976.
          90%   = 1398.3    25%   = 6184.8    1%    = 16296.

     3    MEAN  = 3251.1    S.D.  = 2156.4    P(N>=r)= .76446
          99%   = 353.87    75%   = 1692.0    10%   = 6037.4
          95%   = 698.41    50%   = 2806.1    5%    = 7317.5
          90%   = 990.25    25%   = 4295.9    1%    = 10372.

     4    MEAN  = 2497.8    S.D.  = 1597.8    P(N>=r)= .61665
          99%   = 299.30    75%   = 1325.3    10%   = 4598.1
          95%   = 568.84    50%   = 2176.4    5%    = 5522.6
          90%   = 791.83    25%   = 3307.3    1%    = 7653.6

     5    MEAN  = 2033.5    S.D.  = 1264.1    P(N>=r)= .47506
          99%   = 265.01    75%   = 1101.0    10%   = 3709.6
          95%   = 490.02    50%   = 1783.0    5%    = 4431.4
          90%   = 671.85    25%   = 2687.7    1%    = 6061.7
```

E) The mean of the potential = 18251.

PETRIMES MODULE PSUM

```
MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
***************************

UAI       C54D0101
PLAY      Herschel gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, JAN 26, 2001, 12:28 PM


USER SUPPLIED PARAMETERS
------------------------

   DO YOU WANT TO STORE IN DATA BASE ?   >   Y
   OIL (O) OR GAS (G) ?                   >   G
   BRITISH OR S.I. UNIT OF MEASUREMENT?  >   SI
   RECOVERABLE RESOURCES?                 >   N
   DO YOU WANT TO USE MPRO OUTPUT?        >   Y
   DO YOU ASSUME LOGNORMAL DISTRIBUTION?  >   Y
   DO YOU WANT TO USE PPSD OUTPUT?        >   Y
   DO YOU COMPUTE CONDITIONAL POTENTIAL?  >   N

A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT   =M cu m  (19)


B) Lognormal Pool Size Distribution
   --------------------------------
   Summary     mu   = 7.8831    MEAN  = 4163.4
   Statistics  sig. sq= .90202  S.D.  = 5038.5

   Upper       99.99% = 77.552   60.00% = 2084.9   15.00% = 7096.9
   Percentiles 99.00% = 291.09   55.00% = 2353.7   10.00% = 8957.2
               95.00% = 556.06   50.00% = 2652.0    8.00% = 10072.
               90.00% = 785.19   45.00% = 2988.2    6.00% = 11611.
               85.00% = 991.01   40.00% = 3373.4    5.00% = 12648.
               80.00% = 1192.4   35.00% = 3823.9    4.00% = 13985.
               75.00% = 1397.5   30.00% = 4363.9    2.00% = 18650.
               70.00% = 1611.7   25.00% = 5032.5    1.00% = 24161.
               65.00% = 1839.2   20.00% = 5898.2     .01% = 90689.

C) NO. OF POOLS DISTRIBUTION
   -------------------------
   Lower Support    =    0
   Upper Support    =   21
   Expectation      =    4.72808
   Standard Deviation=   2.80484
```

```
D) Summary Statistics for 4000 Simulations
   ---------------------------------------

   Play Resource:   ( B cu m   )
   -----------------------------
    Minimum    = .0000000E+00Maximum       = 154.6978
    Expectation = 19.58015    Standard Deviation= 15.77324

   EMPERICAL DISTRIBUTION:
   ----------------------
   Greater than   Play
   Percentage     Potential
   ------------   -----------
      100.00        .00000E+00
       95.00       1.3186
       90.00       3.2235
       85.00       4.9252
       80.00       6.3871
       75.00       7.9166
       70.00       9.4051
       65.00      10.943
       60.00      12.589
       55.00      14.314
       50.00      16.095
       45.00      17.924
       40.00      20.023
       35.00      22.259
       30.00      24.335
       25.00      27.416
       20.00      30.370
       15.00      34.706
       10.00      40.845
        8.00      43.780
        6.00      46.897
        5.00      49.528
        4.00      52.672
        2.00      60.664
        1.00      71.442
         .01     144.59

         .00     153.69
```

PETRIMES MODULE PPSD

```
PROSPECT OR POOL SIZE DISTRIBUTION USING
LOGNORMAL OR MONTE CARLO SIMULATION
*****************************************

UAI       C54K0101
PLAY      Yukon coastal plain gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Operator  Y
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, FEB  2, 2001, 12:00 PM


USER SUPPLIED PARAMETERS
------------------------
  DO YOU WANT TO STORE ON DB?          >   Y
  OIL (O) OR GAS (G) ?                 >   G
  BRITISH OR S.I. UNIT OF MEASUREMENT? >   SI
  RECOVERABLE RESOURCES?               >   N
  DO YOU WANT TO HONOR A PERCENTILE?   > Y
  UPPER PERCENTILE TO BE HONORED?      > .10000E-01
```

A) Basic Information
```
   -----------------
   TYPE OF RESOURCE   =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT  =M cu m  (19)
```

B) Input Constant(s)
```
   -----------------

   No input constant.
```

C) Summary
```
   -------

   Variable                    Lognormal Approximation

   IN-PLACE     mu   = 7.9616    MEAN  = 4871.3
   POOL SIZE    sig. sq= 1.0590  S.D.  = 6685.3
   (DERIVED)    99.99% = 62.459  60.00% = 2210.4    15.00% = 8334.8
                99.00% = 261.82  55.00% = 2520.8    10.00% = 10726.
                95.00% = 527.93  50.00% = 2868.8     8.00% = 12180.
                90.00% = 767.26  45.00% = 3264.8     6.00% = 14209.
                85.00% = 987.40  40.00% = 3723.2     5.00% = 15589.
                80.00% = 1206.6  35.00% = 4264.8     4.00% = 17382.
                75.00% = 1433.0  30.00% = 4921.0     2.00% = 23744.
                70.00% = 1672.4  25.00% = 5742.9     1.00% = 31433.
                65.00% = 1929.7  20.00% = 6820.7      .01% = .13176E+06
```

D) Pool Size Equation

    NO. OF GEO-VARIABLES= 6

    POOL SIZE =   1.00000
            * AREA OF   * FORMATION   * POROSITY   * TRAP FILL
              CLOSURE   THICKNESS

            * HYDROCARBON
              SATURATION

              GAS FMN
              VOLUME
              FACTOR

GEOLOGICAL VARIABLES

A) Variables Used

    VARIABLE   UNIT OF   O/G VERSION TYPE NO. OF   UAI
                  MEASUREMENT   POINTS
                  SYMBOL   USED

    AREA OF   sq km   Gas   1   2   4   C54K0101
    CLOSURE

    FORMATION   m   Gas   1   2   4   C54K0101
    THICKNESS

    POROSITY   dec fr   Gas   1   2   4   C54K0101

    TRAP FILL   dec fr   Gas   1   2   4   C54K0101

    HYDROCARBON   dec fr   Gas   1   2   4   C54K0101
    SATURATION

    GAS FMN   Gas   1   2   4   C54K0101
    VOLUME
    FACTOR

B) Summary

    Variable   Lognormal Approximation

    AREA OF   mu   = 2.1972   MEAN = 12.505
    CLOSURE   sig. sq= .65782   S.D. = 12.063
                99.99% = .44082   60.00% = 7.3283   15.00% = 20.860
                99.00% = 1.3640   55.00% = 8.1279   10.00% = 25.448
                95.00% = 2.3706   50.00% = 9.0000   8.00% = 28.130
                90.00% = 3.1829   45.00% = 9.9656   6.00% = 31.761
                85.00% = 3.8830   40.00% = 11.053   5.00% = 34.168
                80.00% = 4.5477   35.00% = 12.302   4.00% = 37.231
                75.00% = 5.2079   30.00% = 13.771   2.00% = 47.605
                70.00% = 5.8820   25.00% = 15.553   1.00% = 59.385
                65.00% = 6.5844   20.00% = 17.811   .01% = 183.75

FORMATION   mu   = 4.3175   MEAN = 82.950
THICKNESS   sig. sq= .20151   S.D. = 39.194
              99.99% = 14.126   60.00% = 66.938   15.00% = 119.43
              99.00% = 26.395   55.00% = 70.886   10.00% = 133.32
              95.00% = 35.842   50.00% = 75.000   8.00% = 140.92
              90.00% = 42.191   45.00% = 79.352   6.00% = 150.72
              85.00% = 47.098   40.00% = 84.034   5.00% = 156.94
              80.00% = 51.402   35.00% = 89.162   4.00% = 164.58
              75.00% = 55.407   30.00% = 94.906   2.00% = 188.56
              70.00% = 59.269   25.00% = 101.52   1.00% = 213.11
              65.00% = 63.087   20.00% = 109.43   .01% = 398.20

POROSITY   mu   =-2.3026   MEAN = .10226
              sig. sq= .44688E-01 S.D. = .21861E-01
              99.99% = .45558E-01 60.00% = .94785E-01 15.00% = .12450
              99.00% = .61154E-01 55.00% = .97379E-01 10.00% = .13112
              95.00% = .70630E-01 50.00% = .10000   8.00% = .13458
              90.00% = .76268E-01 45.00% = .10269   6.00% = .13891
              85.00% = .80324E-01 40.00% = .10550   5.00% = .14158
              80.00% = .83701E-01 35.00% = .10849   4.00% = .14479
              75.00% = .86711E-01 30.00% = .11172   2.00% = .15437
              70.00% = .89507E-01 25.00% = .11532   1.00% = .16352
              65.00% = .92177E-01 20.00% = .11947   .01% = .21950

TRAP FILL   mu   =-1.3863   MEAN = .26788
              sig. sq= .13819   S.D. = .10312
              99.99% = .62738E-01 60.00% = .22753   15.00% = .36751
              99.00% = .10529   55.00% = .23859   10.00% = .40257
              95.00% = .13564   50.00% = .25000   8.00% = .42148
              90.00% = .15525   45.00% = .26196   6.00% = .44560
              85.00% = .17007   40.00% = .27469   5.00% = .46078
              80.00% = .18284   35.00% = .28850   4.00% = .47926
              75.00% = .19456   30.00% = .30381   2.00% = .53642
              70.00% = .20572   25.00% = .32124   1.00% = .59362
              65.00% = .21664   20.00% = .34183   .01% = .99620

HYDROCARBON   mu   =-.16252   MEAN = .85038
SATURATION   sig. sq= .88600E-03 S.D. = .25318E-01
              99.99% = .76093   60.00% = .84361   15.00% = .87663
              99.00% = .79313   55.00% = .84683   10.00% = .88305
              95.00% = .80939   50.00% = .85000   8.00% = .88630
              90.00% = .81819   45.00% = .85319   6.00% = .89026
              85.00% = .82418   40.00% = .85643   5.00% = .89265
              80.00% = .82897   35.00% = .85981   4.00% = .89547
              75.00% = .83311   30.00% = .86337   2.00% = .90358
              70.00% = .83684   25.00% = .86724   1.00% = .91094
              65.00% = .84031   20.00% = .87156   .01% = .94950

GAS FMN   mu   =-5.2983   MEAN = .50399E-02
VOLUME   sig. sq= .15887E-01 S.D. = .63777E-03
FACTOR   99.99% = .31289E-02 60.00% = .48429E-02 15.00% = .56978E-02
              99.00% = .37293E-02 55.00% = .49214E-02 10.00% = .58765E-02
              95.00% = .40638E-02 50.00% = .50000E-02 8.00% = .59687E-02
              90.00% = .42542E-02 45.00% = .50798E-02 6.00% = .60824E-02
              85.00% = .43877E-02 40.00% = .51622E-02 5.00% = .61519E-02
              80.00% = .44968E-02 35.00% = .52488E-02 4.00% = .62345E-02
              75.00% = .45925E-02 30.00% = .53416E-02 2.00% = .64773E-02
              70.00% = .46802E-02 25.00% = .54437E-02 1.00% = .67037E-02
              65.00% = .47630E-02 20.00% = .55596E-02   .01% = .79900E-02

C) Covariance Matrix

VARIABLE

AREA OF   .65782
CLOSURE

FORMATION   .00000   .20151
THICKNESS

POROSITY   .00000   .00000   .04469

TRAP FILL   .00000   .00000   .00000   .13819

HYDROCARBON   .00000   .00000   .00000   .00000   .00089
SATURATION

GAS FMN   .00000   .00000   .00000   .00000   .00000
VOLUME
FACTOR

VARIABLE

GAS FMN   .01589
VOLUME
FACTOR

D) Correlation Matrix

VARIABLE

AREA OF   1.00000
CLOSURE

FORMATION   .00000   1.00000
THICKNESS

POROSITY   .00000   .00000   1.00000

TRAP FILL   .00000   .00000   .00000   1.00000

HYDROCARBON   .00000   .00000   .00000   .00000   1.00000
SATURATION

GAS FMN   .00000   .00000   .00000   .00000   .00000
VOLUME
FACTOR

VARIABLE

GAS FMN   1.00000
VOLUME
FACTOR

PETRIMES MODULE MPRO

NO. OF POOLS DISTRIBUTION AND RISKS
****

UAI   C54K0101
PLAY   Yukon coastal plain gas play
Assessor   Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date   FRI, FEB 2, 2001, 11:47 AM

USER SUPPLIED PARAMETERS

  DO YOU WANT TO STORE ON DB?   >   Y
  OIL (O) OR GAS (G) ?   >   G

A) Risks

                    GEOLOGICAL FACTOR   MARGINAL PROBABILITY
                    -----------------   --------------------

   PLAY LEVEL   Overall Play Level Risk   =   1.00

   PROSPECT LEVEL Presence of Closure   (1)   .70
                  Presence of Porosity   (3)   .65
                  Adequate Seal   (4)   .80
                  Adequate Timing   (5)   .60
                  Adequate Source   (6)   .80
                  Adequate Preservation   (8)   .60

                  Overall Prospect Level Risk   =   .10

   EXPLORATION RISK: =   .10

B) No. of Prospects Distribution

Minimum   =   5
Maximum   =   40
Mean   =   24.15
S.D.   =   10.25

Frequency	No. of Prospects
99.00	5
95	7
90	9
80	13
75	15
60	21
50	25
40	28
25	33
20	34
10	37
5	39
1	40
0	40

C) No. of Pools Distribution

Note: The no. of pools distribution is saved in the database with UDI= 6201GB4

Minimum   =   0
Maximum   =   14
Mean   =   2.53
S.D.   =   1.85

Frequency	No. of Pools
87.27	0
80	1
75	1
60	2
50	2
40	3
25	4
20	4
10	5
5	6
1	8
0	14

PETRIMES MODULE PSRK

```
INDIVIDUAL POOL SIZES BY RANK
WHERE N IS A RANDOM VARIABLE
******************************
UAI      C54K0101
PLAY     Yukon coastal plain gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, FEB 2, 2001, 12:02 PM
```

```
USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE ON DB ?        > Y
   DO YOU WANT TO USE MPRO OUTPUT?     > Y
   MIN. AND MAX. POOL RANKS?           >    1    3
   DO YOU USE LOGNORNAL ASSUMPTION?    > Y
   DO YOU WANT TO USE PPSD OUTPUT?     > Y
```

```
A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT =M cu m (19)
```

```
B) Lognormal Pool Size Distribution
   --------------------------------
   Summary      mu   = 7.9616    MEAN  = 4871.3
   Statistics   sig. sq= 1.0590  S.D.  = 6685.3
   Upper       99.99% = 62.459   60.00% = 2210.4   15.00% = 8334.8
   Percentiles 99.00% = 261.82   55.00% = 2520.8   10.00% = 10726.
               95.00% = 527.93   50.00% = 2868.8    8.00% = 12180.
               90.00% = 767.26   45.00% = 3264.8    6.00% = 14209.
               85.00% = 987.40   40.00% = 3723.2    5.00% = 15589.
               80.00% = 1206.6   35.00% = 4264.8    4.00% = 17382.
               75.00% = 1433.0   30.00% = 4921.0    2.00% = 23744.
               70.00% = 1672.4   25.00% = 5742.9    1.00% = 31433.
               65.00% = 1929.7   20.00% = 6820.7     .01% = .13176E+06
```

```
C) No. of Pools Distribution
   -------------------------
   Lower Support    =   0
   Upper Support    =  14
   Expectation      =  2.53
   Standard Deviation=  1.85
```

```
D) Pool Sizes By Rank
   ------------------
   Pool Rank              Distribution
       1   MEAN  = 8704.3   S.D.  = 9663.2   P(N>=r)= .87266
           99%   = 475.24   75%   = 3186.3   10%   = 18198.
           95%   = 1092.3   50%   = 5998.4    5%   = 25009.
           90%   = 1670.0   25%   = 10790.    1%   = 46181.
       2   MEAN  = 3994.3   S.D.  = 3404.2   P(N>=r)= .66507
           99%   = 311.26   75%   = 1717.3   10%   = 8047.4
           95%   = 647.01   50%   = 3093.3    5%   = 10348.
           90%   = 946.04   25%   = 5211.9    1%   = 16478.
       3   MEAN  = 2601.7   S.D.  = 2023.4   P(N>=r)= .45238
           99%   = 245.65   75%   = 1194.3   10%   = 5132.0
           95%   = 483.20   50%   = 2085.8    5%   = 6457.0
           90%   = 685.68   25%   = 3422.8    1%   = 9775.8
```

```
E) The mean of the potential = 11429.
```

PETRIMES MODULE PSUM

```
MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
***************************
UAI      C54K0101
PLAY     Yukon coastal plain gas play
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, FEB 2, 2001, 12:03 PM
```

```
USER SUPPLIED PARAMETERS
------------------------
   DO YOU WANT TO STORE IN DATA BASE ? >   Y
   OIL (O) OR GAS (G) ?                >   G
   BRITISH OR S.I. UNIT OF MEASUREMENT? >  SI
   RECOVERABLE RESOURCES?              >   N
   DO YOU WANT TO USE MPRO OUTPUT?     >   Y
   DO YOU ASSUME LOGNORMAL DISTRIBUTION? > Y
   DO YOU WANT TO USE PPSD OUTPUT?     >   Y
   DO YOU COMPUTE CONDITIONAL POTENTIAL? > N
```

```
A) Basic Information
   -----------------
   TYPE OF RESOURCE    =Gas In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT =M cu m (19)
```

```
B) Lognormal Pool Size Distribution
   --------------------------------
   Summary      mu   = 7.9616    MEAN  = 4871.3
   Statistics   sig. sq= 1.0590  S.D.  = 6685.3

   Upper       99.99% = 62.459   60.00% = 2210.4   15.00% = 8334.8
   Percentiles 99.00% = 261.82   55.00% = 2520.8   10.00% = 10726.
               95.00% = 527.93   50.00% = 2868.8    8.00% = 12180.
               90.00% = 767.26   45.00% = 3264.8    6.00% = 14209.
               85.00% = 987.40   40.00% = 3723.2    5.00% = 15589.
               80.00% = 1206.6   35.00% = 4264.8    4.00% = 17382.
               75.00% = 1433.0   30.00% = 4921.0    2.00% = 23744.
               70.00% = 1672.4   25.00% = 5742.9    1.00% = 31433.
               65.00% = 1929.7   20.00% = 6820.7     .01% = .13176E+06
```

```
C) NO. OF POOLS DISTRIBUTION
   -------------------------
   Lower Support    =   0
   Upper Support    =  14
   Expectation      =   2.53117
   Standard Deviation=  1.84960
```

D) *Summary Statistics for 4000 Simulations

Play Resource: (B cu m   )

 Minimum   = .0000000E+00Maximum   = 157.3106
 Expectation = 12.44228   Standard Deviation= 13.61104

EMPERICAL DISTRIBUTION:

 Greater than   Play
 Percentage   Potential
 -----------   -----------
   100.00   .00000E+00
    85.00   .76783
    80.00   1.7893
    75.00   2.8329
    70.00   3.8510
    65.00   4.8850
    60.00   6.0649
    55.00   7.2271
    50.00   8.4634
    45.00   9.8860
    40.00   11.438
    35.00   13.128
    30.00   15.289
    25.00   17.542
    20.00   20.512
    15.00   24.260
    10.00   29.722
     8.00   32.826
     6.00   36.776
     5.00   38.204
     4.00   40.867
     2.00   50.116
     1.00   59.716
      .01   151.39

      .00   156.72

PETRIMES MODULE PSUM

MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
****

UAI   C5410101
PLAY   All oil plays
Assessor Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date MON, JAN 29, 2001, 2:16 PM

USER SUPPLIED PARAMETERS

 DO YOU WANT TO STORE IN DATA BASE ?   >   Y
 OIL (O) OR GAS (G) ?   >   O
 BRITISH OR S.I. UNIT OF MEASUREMENT? >   SI
 RECOVERABLE RESOURCES?   >   N
 DO YOU COMPUTE CONDITIONAL POTENTIAL? >   N

A) Basic Information

   TYPE OF RESOURCE   =Oil In-place
   SYSTEM OF MEASUREMENT =S.I.
   UNIT OF MEASUREMENT   =M cu m (19)

B) PLAY POTENTIAL DISTRIBUTION

   Summary   MEAN = 3.7985   S.D. = 3.6877
   Statistics   M cu m

   Upper   100.00% = .00000E+00 55.00% = 2.5113   10.00% = 8.1451
   Percentiles 95.00% = .24337   50.00% = 2.8268   8.00% = 8.8912
               90.00% = .55668   45.00% = 3.1302   6.00% = 9.7734
               85.00% = .84104   40.00% = 3.5563   5.00% = 10.497
               80.00% = 1.0941   35.00% = 3.9955   4.00% = 11.326
               75.00% = 1.3875   30.00% = 4.4510   2.00% = 14.251
               70.00% = 1.6443   25.00% = 5.1129   1.00% = 16.738
               65.00% = 1.9165   20.00% = 5.7703   .01% = 46.342
               60.00% = 2.1850   15.00% = 6.6875   .00% = 47.536

   Summary   MEAN = 42.406   S.D. = 34.551
   Statistics   M cu m

   Upper   100.00% = .00000E+00 55.00% = 30.753   10.00% = 88.821
   Percentiles 95.00% = 2.7805   50.00% = 34.605   8.00% = 95.161
               90.00% = 6.8992   45.00% = 38.698   6.00% = 101.91
               85.00% = 10.490   40.00% = 43.242   5.00% = 107.90
               80.00% = 13.667   35.00% = 48.156   4.00% = 114.67
               75.00% = 16.913   30.00% = 52.590   2.00% = 132.80
               70.00% = 20.214   25.00% = 59.358   1.00% = 156.25
               65.00% = 23.473   20.00% = 65.791   .01% = 324.33
               60.00% = 27.095   15.00% = 75.218   .00% = 346.56

C) NO. OF PLAYS DISTRIBUTION

   Lower Support   =   2
   Upper Support   =   2
   Expectation   =   2.00000
   Standard Deviation=   .00000

D) Summary Statistics for 4000 Simulations

Basin Resource: (M cu m)

  Minimum   = .0000000E+00Maximum   = 328.2340
  Expectation = 47.60648   Standard Deviation= 37.01921

EMPERICAL DISTRIBUTION:

  Greater than   Basin
  Percentage   Potential
  ------------   -----------
    100.00   .00000E+00
     99.00   1.3516
     95.00   6.6909
     90.00   11.123
     85.00   14.978
     80.00   18.259
     75.00   21.697
     70.00   25.456
     65.00   28.812
     60.00   32.447
     55.00   35.995
     50.00   39.767
     45.00   43.931
     40.00   48.463
     35.00   52.726
     30.00   57.466
     25.00   63.285
     20.00   71.387
     15.00   80.399
     10.00   91.935
      8.00   99.354
      6.00   105.94
      5.00   110.98
      4.00   118.50
      2.00   137.32
      1.00   160.43
       .01   326.42

       .00   328.05

PETRIMES MODULE PSUM

```
MONTE CARLO SUM SIMULATION
POOL SIZE DISTRIBUTION
***************************

UAI       C5400101
PLAY      All gas plays
Assessor  Peter Hannigan
Geologist Peter Hannigan
Remarks   Yukon North Slope Hydrocarbon Assessment Project
Run date  FRI, FEB  2, 2001, 12:09 PM
```

USER SUPPLIED PARAMETERS

  DO YOU WANT TO STORE IN DATA BASE ?   >   Y
  OIL (O) OR GAS (G) ?   >   G
  BRITISH OR S.I. UNIT OF MEASUREMENT? > SI
  RECOVERABLE RESOURCES?   >   N
  DO YOU COMPUTE CONDITIONAL POTENTIAL? >   N

A) Basic Information

  TYPE OF RESOURCE   =Gas In-place
  SYSTEM OF MEASUREMENT =S.I.
  UNIT OF MEASUREMENT   =M cu m (19)

B) PLAY POTENTIAL DISTRIBUTION

```
Summary      MEAN  = 2.4325    S.D.   = 1.7427
Statistics   B cu m

Upper      100.00% = .00000E+00 55.00% = 1.8698      8.00% = 4.9254
Percentiles 99.00% = .18142     50.00% = 2.0402      6.00% = 5.3993
            95.00% = .48941     45.00% = 2.2209      5.00% = 5.6884
            90.00% = .72355     40.00% = 2.4170      4.00% = 6.0976
            85.00% = .92550     35.00% = 2.6301      2.00% = 7.0300
            80.00% = 1.0815     30.00% = 2.8758      1.00% = 8.2659
            75.00% = 1.2620     25.00% = 3.1710       .01% = 18.688
            70.00% = 1.4062     20.00% = 3.5065       .00% = 20.140
            65.00% = 1.5508     15.00% = 3.9387
            60.00% = 1.7089     10.00% = 4.5919


Summary      MEAN  = 7.5234    S.D.   = 4.6634
Statistics   B cu m

Upper      100.00% = .15446     55.00% = 6.0653      8.00% = 14.470
Percentiles 99.00% = .87468     50.00% = 6.6614      6.00% = 15.512
            95.00% = 1.6994     45.00% = 7.2674      5.00% = 16.536
            90.00% = 2.3555     40.00% = 7.8857      4.00% = 17.344
            85.00% = 2.9483     35.00% = 8.5103      2.00% = 19.535
            80.00% = 3.4788     30.00% = 9.2216      1.00% = 21.752
            75.00% = 3.9972     25.00% = 10.064       .01% = 33.164
            70.00% = 4.5850     20.00% = 11.098       .00% = 33.429
            65.00% = 5.0365     15.00% = 12.215
            60.00% = 5.5197     10.00% = 13.715


Summary      MEAN  = 19.580    S.D.   = 15.773
Statistics   B cu m
Upper      100.00% = .00000E+00 55.00% = 14.314     10.00% = 40.845
Percentiles 95.00% = 1.3186     50.00% = 16.095      8.00% = 43.780
            90.00% = 3.2235     45.00% = 17.924      6.00% = 46.897
            85.00% = 4.9252     40.00% = 20.023      5.00% = 49.528
```

```
            80.00% = 6.3871      35.00% = 22.259      4.00% = 52.672
            75.00% = 7.9166      30.00% = 24.335      2.00% = 60.664
            70.00% = 9.4051      25.00% = 27.416      1.00% = 71.442
            65.00% = 10.943      20.00% = 30.370       .01% = 144.59
            60.00% = 12.589      15.00% = 34.706       .00% = 153.69

Summary     MEAN  = 12.442    S.D.   = 13.611
Statistics  B cu m

Upper      100.00% = .00000E+00 45.00% = 9.8860      6.00% = 36.776
Percentiles 85.00% = .76783     40.00% = 11.438      5.00% = 38.204
            80.00% = 1.7893     35.00% = 13.128      4.00% = 40.867
            75.00% = 2.8329     30.00% = 15.289      2.00% = 50.116
            70.00% = 3.8510     25.00% = 17.542      1.00% = 59.716
            65.00% = 4.8850     20.00% = 20.512       .01% = 151.39
            60.00% = 6.0649     15.00% = 24.260       .00% = 156.72
            55.00% = 7.2271     10.00% = 29.722
            50.00% = 8.4634      8.00% = 32.826
```

C) NO. OF PLAYS DISTRIBUTION
```
------------------------------
Lower Support    =    4
Upper Support    =    4
Expectation      =      4.00000
Standard Deviation=       .00000
```

D) Summary Statistics for 4000 Simulations
```
----------------------------------------

Basin Resource:  ( B cu m   )
------------------------------
 Minimum    = 3.050182   Maximum          = 194.6945
 Expectation = 42.47473  Standard Deviation= 22.73458

EMPERICAL DISTRIBUTION:
----------------------
 Greater than    Basin
 Percentage      Potential
 ------------    ----------
   100.00        3.0502
    99.00        8.3587
    95.00       14.470
    90.00       18.727
    85.00       21.995
    80.00       24.276
    75.00       26.703
    70.00       29.099
    65.00       31.370
    60.00       33.781
    55.00       36.138
    50.00       38.565
    45.00       41.272
    40.00       44.074
    35.00       46.502
    30.00       49.632
    25.00       53.034
    20.00       57.403
    15.00       62.927
    10.00       69.636
     8.00       73.341
     6.00       77.939
     5.00       81.829
     4.00       85.455
     2.00      102.55
     1.00      123.30
      .01      194.01
      .00      194.63
```