Chukchi Sea Planning Area (Alaska) – Province Summary

2006 Oil and Gas Assessment

Location

The Chukchi Sea Planning Area is located offshore northwestern Alaska, as shown in figures 1 and 2. The east boundary of the planning area lies along 156º west longitude (near Point Barrow) and the three-mile offshore limit of State of Alaska northwest coast waters. The west boundary of the planning area lies along 169° west longitude or the boundary with Russian waters of the Chukchi shelf. The planning area extends from 68º20' north latitude (near Point Hope) northward to 75º north latitude. Water depths within the Chukchi Sea Planning Area range up to 12,500 ft (3,800 m), with the greatest depths over the Canada basin in the northeast corner of the planning area (Perry and Fleming, 1987). Water depths across most of the Chukchi shelf (within the 100 m or 330-ft isobath) are typically about 160 ft, except in the Barrow submarine canyon, where water depths range from 50 to 200 m (165-660 ft; fig. 2).

The northern parts of the planning area extend over the deep Canada basin-Beaufort slope and the deep basins and submarine ridges of the Chukchi borderland. In prior oil and gas assessments by the Minerals Management Service, because of considerations of geology and the operational adversity of the deep Arctic Ocean environment, the deep water areas were assessed with negligible technically recoverable oil and gas resources (Sherwood, 1998, tbl. 12.1). Likewise today, in the current (2006) oil and gas assessment, all of the technically recoverable oil and gas resources of the Chukchi Sea Planning area are considered to be located south of the 100 m isobath west of Hanna submarine canyon or the 500 m isobath east of the canyon (fig. 2).

Leasing and Exploration History

Four lease sales were held for different parts of Chukchi shelf in 1988 and 1991. Two lease sales (109, 126) were held in the pre-1996 Chukchi Sea Planning Area (located in fig. 3) while two sales were also held in 1988 and 1991 in the adjacent pre-1996 Beaufort Sea Planning Area (sales 97, 124). The four sales issuing leases on Chukchi shelf together collected $512 million in total high bids on 483 tracts (approximately 2.7 million acres). Figure 3 locates all of the leases ever issued on Chukchi shelf (1988 to 1991) and the pre-1996 planning area boundary. Of the 483 leases active on Chukchi shelf in 1992, none remain active today. Industry, primarily Shell Oil, invested most capital on just a few of the 42 prospects leased on Chukchi shelf. Eighty-five percent of the $512 million dollars bid in all four sales targeted the five prospects that were eventually drilled (Burger, Klondike, Crackerjack, Popcorn, Diamond; fig. 3).

The MMS draft proposal for the 2007-2012 leasing program (MMS, 2006) initiates the environmental studies and public process that could lead to future lease sales in the Chukchi Sea Planning Area. The draft plan proposes Chukchi Sea lease sales for years 2007, 2010, and 2012, contingent upon the public review process, favorable resolution of environmental issues, and final approval by the Secretary of the U.S. Department of the Interior.

Industry investigations of the U.S. Chukchi shelf sparked by the 1988 and 1991 lease offerings resulted in the collection of 100,000 line-miles of high quality seismic reflection data. In addition, comprehensive gravimetric, magnetic, thermal, and geochemical surveys were also conducted on the U.S. Chukchi shelf. In anticipation of future lease sales, three-dimensional seismic surveys are reportedly planned for the 2006 open-water season (late summer-fall) in Chukchi Sea (PNA, 2006, p. A11).

A total of 5 exploratory wells, at an average cost of $35 million apiece (Tarrant, 1991), were drilled on Chukchi shelf from 1989 to 1991 ("Klondike" OCS Y-1482-1 [1989]; "Burger" OCS Y-1413-1 [1989-1990]; "Popcorn" OCS Y-1275-1 [1989-1990]; "Crackerjack" OCS Y-1320-1 [1990-1991]; and "Diamond" OCS Y-0996-1 [1991]. Three wells were drilled over two open-water seasons. Four of the wells (Burger, Klondike, Crackerjack, and Popcorn) encountered pooled hydrocarbons. Burger prospect is estimated to contain discovered resources of 14.038 Tcf gas and 724 Mmb of condensate; it has been estimated that a U.S. Midwest gas price of $5.30/Mcf is required for a "breakeven" economic development project (Craig and Sherwood, 2004).

Previous investigations of the Chukchi and contiguous Arctic continental shelves were carried out primarily by Arthur Grantz and colleagues of the U.S. Geological Survey. These pioneer studies, including those of Grantz et al. (1975; 1979; 1981; 1982a; 1982b; 1987, 1990), Grantz and Eittreim (1979), Grantz and May (1982, 1987), and Eittreim and Grantz (1979) established the framework from which all subsequent studies have been extended. Published studies based on industry data by Thurston and Theiss (1987), Craig et al. (1985), Hubbard et al. (1987), Haimla et al. (1990), and Sherwood et al. (2002) have improved our understanding of the region.

<u>Geological Setting of Chukchi Sea Planning Area</u>

The rocks that underlie Chukchi shelf may be simplified into four main groups for purposes of introduction to regional stratigraphy (fig. 4). These include the Franklinian, Ellesmerian, Rift, and Brookian sequences.

In northern Alaska and most of U.S. Chukchi shelf, acoustic basement is mostly represented by highly-deformed and metamorphosed rocks (mostly flysch) of Late Devonian and older age that offer negligible potential for oil and gas. The metamorphic rocks which form acoustic basement beneath Arctic Alaska are generally assigned to the ***Franklinian sequence*** (Lerand, 1973), shown as synonymous with acoustic basement in figure 4. The Franklinian rocks which underlie the Arctic platform were deformed by a regional event, widely recognized in many parts of Arctic North America, termed the Ellesmerian orogeny (Late Devonian). One exception among the hydrocarbon-barren metamorphites may be a body of relatively undeformed rocks that underlie the northeastern Chukchi shelf. This enigmatic feature was termed the Northeast Chukchi "basin" by Craig and others (1985) and located and illustrated in cross section in figure 5. The Northeast Chukchi "basin" is not actually a basin in the usual sense. It appears to be fault-bounded and may be a tectonic fragment of the Franklinian basin of Arctic Canada, with which it was once continuous, but now is isolated because of rifting, continental breakup, and formation of the oceanic Canada basin (Sherwood, 1994). Other regional elements of the "basement" beneath Chukchi shelf are reviewed by Sherwood et al. (2002).

Deposition of the ***Ellesmerian***

sequences began in Late Devonian or Early Mississippian time, and in Arctic Alaska, Ellesmerian strata rest unconformably upon deformed Franklinian rocks. The east-trending basin beneath the Alaska North Slope in which Ellesmerian strata accumulated is termed the Arctic Alaska basin (located in fig. 6). Beneath Chukchi shelf, the Ellesmerian sequence fills a north-trending rift basin called Hanna trough (Grantz and others, 1982a). Hanna trough began to subside in Late Devonian(?) or Early Mississippian time, with an early (rift) phase of fault-driven subsidence (Late Devonian to Permian time) corresponding to the ***Lower Ellesmerian sequence***. When faulting ceased, a second phase of subsidence related to cooling and thermal contraction (Permian to Late Jurassic time) governed deposition of the ***Upper Ellesmerian sequence***. Hanna trough subsidence and the Ellesmerian cycle of sedimentation is capped by a regional unconformity we term the "Jurassic unconformity", or "JU", that marks the base of the overlying “Rift” sequence (fig. 4).

Rifting along the Beaufort continental margin extended into the northern Chukchi shelf in mid-Jurassic time and opened a new rift that spawned and then was ultimately buried beneath the North Chukchi and Nuwuk basins. Tectonic disturbance of the crust near the active rift zone influenced patterns of sedimentation far to the south of the zone, as shown in the map of the rift system in figure 7. Grabens and flexural down-warps near the rift were filled with thick sequences of clastic sediments, some probably of local derivation and possibly rich in detritus recycled from Ellesmerian rocks exposed on uplifts within the rift zone. These strata represent a distinct tectonic process and have been variously distinguished as the ***Rift sequence*** (Craig and others, 1985), the ***Beaufortian sequence*** (Hubbard and others, 1987), or the ***Barrovian sequence*** (Carman and Hardwick, 1983). Because it is more general, we adopt the term "Rift sequence" for rocks deposited during the rifting in northern Chukchi shelf. The Rift sequence ranges in age from Late Jurassic to Early Cretaceous (Aptian to Albian) on Chukchi shelf and we extend the term to include rocks deposited at the same time to the south and beyond the influence of the rift zone (“stable shelf” and “deep basin” areas of fig. 7).

The Brookian-Chukotkan orogeny, ranging in possible age from Middle Jurassic to Early Cretaceous (ca. 175 to 115 Ma), ended the Jurassic to Cretaceous rift-controlled phase of sedimentation south of North Chukchi basin and completely reorganized the tectonic framework of northern Alaska and Chukchi shelf. Cretaceous and Tertiary rocks of the ***Brookian sequence***, consisting mostly of sediments shed from mountain belts created during the Brookian-Chukotkan orogeny, fill several (Colville, Nuwuk, North Chukchi) basins beneath Chukchi shelf (fig. 8). Continuing deformations folded the rocks in southern Colville basin and reactivated north-trending faults that complexly structured Brookian strata on Chukchi platform (fig. 9).

Both ***Hope*** and ***Kotzebue*** basins are Tertiary-ages transtensional pull-apart basins that may be related to right-lateral movement along the Kobuk fault (fig.10). Basin extension and subsidence probably began in the early Tertiary and the basin fill correlates to the Upper Brookian sequence of the Chukchi shelf. Sediments penetrated by the Cape Espenberg and Nimiuk Point wells in Kotzebue basin range from Eocene through Quaternary in age (fig. 4). Two stages of rifting (presumably originating with Kobuk fault shear), during the Eocene and Miocene, caused pervasive extensional faulting in Hope basin (Tolson, 1987).

Exploration Drilling Targets and Results

Klondike Well (OCS Y 1482 No. 1): Klondike well was drilled to test Sadlerochit-equivalent rocks truncated beneath the Jurassic unconformity in a large anticline on the east flank of Chukchi platform. The test failed because Sadlerochit-equivalent rocks are in a shale (Otuk) facies and no reservoir is present. Oil was swabbed into the wellbore from rocks equivalent to the Fire Creek or Shublik Formations. A Rift sequence (Kuparuk) sandstone at 9,000 feet appears (logs and shows) to contain oil pay and oil shows were associated with turbiditic Brookian sandstones near the base of the Torok Formation. Minor oil shows were noted in several sandstones below 2,800 feet.

Burger Well (OCS Y 1413 No. 1): Burger well was drilled to test Rift sequence rocks equivalent to the Kuparuk Formation in a large dome on the east flank of Hanna trough. This feature was originally identified as the "Wainwright dome" by Thurston and Theiss (1987, fig. 22, pl. 4). Burger well discovered and sampled (by repeat formation tester[1]) a pool of gas within a Kuparuk-equivalent Rift sequence sandstone 107 feet in thickness (Craig et al., 1993). Craig and Sherwood (2004) estimated gas resources at Burger prospect to range from 7.6 to 27.5 trillions of cubic feet, with a most likely resource of 14.038 trillion cubic feet. Discovered condensate resources are estimated to range between 393 and 1,404 millions of barrels, with a most likely condensate resource of 724 million barrels. An economic study of Burger gas resources marketed to the U.S. Midwest (through a hypothetical gas pipeline) found a "break-even" gas price of $5.30 per thousand cubic feet (Craig and Sherwood, 2004). A "topset" Brookian sandstone 36 feet in thickness within the Nanushuk Group also appears (logs, shows) to contain gas pay

Popcorn Well (OCS Y 1275 No. 1): Popcorn well targeted Sadlerochit-equivalent and older rocks on a horst along an extension of the Barrow arch that separates North Chukchi and Colville basins (fig. 7). The test failed because no reservoir was present. Sadlerochit-equivalent rocks are truncated at the Jurassic unconformity that seals the prospect. Permian carbonates and shales of the Lisburne Group were found directly beneath the unconformity. Gas and condensate were recovered by repeat formation test from a (Rift sequence) sandstone 20 feet thick that lies directly upon the Jurassic unconformity. Oil shows were noted in turbiditic sandstones of the Torok Formation and within Permian and Pennsylvanian carbonates of the Lisburne Group.

Crackerjack Well (OCS Y 1320 No. 1): Crackerjack well targeted Sadlerochit-equivalent rocks in a stratigraphic wedge beneath the Jurassic unconformity on the flank (1,700 feet below the crest!) of the tilted fault block that forms Crackerjack structure. The test was unsuccessful because no porous reservoir is present. Sadlerochit-equivalent rocks are mostly truncated at the Jurassic unconformity. Spiculitic siltstones equivalent to the Permian

[1] *A wireline device that inserts a probe into the formation, measures pressure, and that may recover 1-2 gallons of formation fluid into a sample chamber*

Echooka Formation (Micropaleo Consultants, Inc., 1990) appear (from logs) to contain gas pay. In addition, turbiditic sandstones near the base of the Early Cretaceous Torok Formation appear (logs) to contain oil pay. Minor oil shows were also noted in Nanushuk Group sandstones. No sampling for formation fluids was conducted on the apparent pay zones in either the Echooka Formation or the Torok Formation in Crackerjack well.

Diamond Well (OCS Y 0996 No. 1): Diamond well targeted Sadlerochit-equivalent rocks in a stratigraphic wedge trap truncated and sealed beneath the Lower Cretaceous unconformity (LCU) on the east flank of Hanna trough. Although reservoir rocks of the Sadlerochit Group (mostly Permian Echooka Formation) were present in abundance, the prospect failed because insufficient petroleum migrated to the trap. Trace oil shows were logged in sandstones of the Torok Formation, Ivishak Formation, Echooka Formation, and carbonates of the Lisburne Group.

Potential Traps

The Chukchi Sea Planning Area is underlain by 5 distinct basins that are varyingly deformed by listric faults, transtensional faults, rift-extension faults, and a fold and thrust belt. This complexity has produced a large number of petroleum prospects that can be readily mapped in conventional two-dimensional seismic data. The current MMS inventory contains 856 mapped prospects (generally anticlines, fault traps, or stratigraphic wedge-outs) that remain to be drilled in the Chukchi Sea Planning Area (an additional 7 mapped structures were tested by the 5 exploration wells). These prospects range in mapped closure areas from hundreds of acres to hundreds of thousands of acres, with nearly a dozen larger than the major oil fields of the Alaska North Slope, as illustrated by the prospect rank plot of figure 11. Eleven prospects exceed 150,000 acres in area and 83 prospects exceed 40,000 acres in area.

In the National Petroleum Reserve-Alaska (NPRA), BLM geophysicist Dick Foland has mapped a large number of "geobodies" using seismic attributes in three dimensional seismic data. These geobodies are believed to represent, at least in part, sandstones isolated within shales. As such, the geobodies represent potential prospects. Geobody mapping was conducted for the Brookian topset, Brookian turbidites (clinoform and bottomset seismic facies), and the Rift sequence (Kingak, Miluveach, Kuparuk, Kalubik, Pebble Shale, and HRZ Formations) and this information was shared with the Chukchi assessment team. The densities of these prospects on an area basis in the NPRA mapping were used to extrapolate the potential numbers of geobodies in the equivalent stratigraphic sequences offshore in the Chukchi Sea. These hypothesized geobodies then comprised the "unidentified" prospects for several Chukchi Sea plays that involve the correlative stratigraphic sequences.

The unidentified prospects are used to construct probability distributions of prospect numbers in the MMS play assessment models. The convention used to construct a prospect numbers probability distribution was to: 1) set the number of actual mapped prospects as the minimum (F99); 2) set the sum of mapped plus unidentified prospects as the maximum (F00); and 3) to construct a line between the two data points on log-probability graph paper. NPRA geobody mapping was used in this manner to extrapolate the numbers of unidentified prospects in plays 7, 8, and 9 (Rift sequence), 17 (Brookian turbidites-Arctic platform), and 18 (Brookian topset-

Arctic platform).

Source Rocks Beneath Chukchi Shelf

Rocks equivalent to most of the oil source sequences recognized in northern Alaska were penetrated and sampled by the five exploratory wells on Chukchi shelf. These include the Lower Cretaceous "HRZ" and Pebble Shale, the Jurassic to Cretaceous Kuparuk and upper Kingak Formations, and the Upper Triassic Shublik Formation of northern Alaska. One important unit that was not sampled is the lower part of the Jurassic Kingak Formation (fig. 4). These rocks, surely present in abundance in Hanna trough, were simply missed at drilling sites because of truncation at those uplifted prospects by the overlying Jurassic unconformity (JU). The HRZ is only present at Diamond well (42 ft) and is absent in the other 4 Chukchi Sea wells (Sherwood et al., 2002, pl. 5).

Klondike well obtained the most complete sampling of all potential source units, including important Triassic oil source rocks. Much of the discussion will therefore focus on Klondike well, with exceptions noted where appropriate.

From the standpoint of organic carbon content, most shale sequences at Klondike classify as "fair" to "excellent" sources. Figure 12 plots organic carbon content against generation potential (S1 + S2, from Rock-Eval pyrolysis). The geometric symbols are from Klondike well, and represent averages of all analyses for each stratigraphic unit. The gray-shaded areas are data clouds representing some of the same stratigraphic units from onshore northern Alaska. It should be noted that the generation potentials for onshore northern Alaska samples in the gray-shaded areas of figure 12 represent less than full original potential because many of those samples are thermally mature to overmature (Ro%>>0.60) and have already exhausted some fraction of their capacity for oil generation.

In figure 12, four stratigraphic units at Klondike well stand out as potential oil sources. These include carbonate and shale members of the Upper Triassic Shublik Formation, shown as two diamonds, shales equivalent to the Lower Triassic Fire Creek Formation of the Sadlerochit Group, represented by the hour glass, and some shales equivalent to the Lower Triassic Ledge or Ivishak Formation of the Sadlerochit Group, shown as a dot. All other shales penetrated by Klondike well, including the Kingak Formation and Pebble Shale, are primarily gas sources. The thin HRZ sequence, normally an oil prone source, at Diamond well has cuttings organic carbon contents of 1.95 percent but hydrogen indices of only 109, indicating a gas source.

Figure 13 assembles modified Van Krevelen diagrams for the Kuparuk/Kingak shale (A), four Triassic-age oil source units (B,C), and the Permian Kavik shales (D). The Shublik, Fire Creek, and Ivishak (equivalent) Formations at the Klondike well have vitrinite reflectances ranging between 0.66 and 0.78 percent (R_o%), indicating that the samples retain most of their original potential to generate oil and gas.

The Shublik carbonates and shales (fig. 13B) and the Fire Creek (equivalent) shales (fig. 13C) all have hydrogen indices well in excess of 300 and should be excellent oil sources. Ivishak-equivalent shales (fig. 13C) have hydrogen indices in the range from 200 to 300, and should form modest sources for liquid hydrocarbons and possibly gas. At Klondike, these oil source units are together quite thick. The three richest oil-prone units are altogether 465 feet thick, and when the Ivishak-equivalent rocks are included, we obtain a total of 1,030 feet of oil-prone source rocks.

The only other offshore penetration of Triassic source units was at Diamond well, 100 miles northeast of Klondike. There, Rock-Eval analyses found hydrogen indices for Shublik Formation shales and carbonates scarcely reaching 150. At Diamond, unlike at Klondike, the Ledge- or Ivishak-equivalent rocks are mostly sandstones and offer no source potential. With a vitrinite reflectance of 0.84%, the Triassic rocks at Diamond are thermally mature and have surely lost some of their original generative potential.

The apparent northward decline in organic richness within the Shublik Formation from Klondike well to Diamond well is consistent with the facies mapping within the Shublik Formation published by Judith Parrish. Parrish (1987) recognized a northern, "glauconitic" facies characterized by glauconitic sandstones and shales poor in organic carbon. The glauconitic facies is succeeded to the south by rocks rich in phosphate nodules. South of the "phosphatic" facies, the Shublik Formation is dominated by organic-rich shales, which form Parrish's "Organic-Rich" facies. The "Organic-Rich" facies probably extends south to include the carbon-rich Early Triassic to Middle Jurassic Otuk Formation exposed in the Brooks Range (Blome and others, 1988; Bodnar, 1989). Parrish (1987) ascribed the development of these facies belts to the existence of an upwelling zone centered above the belt of phosphatic Shublik rocks in Triassic time.

The Shublik Formation at Klondike (and probably at Tunalik) is clearly in Parrish's "Organic-Rich" facies, and the presence of Lower to Middle Triassic (Ivishak-equivalent) source rocks is unique to the two well sites and the Otuk Formation of the Brooks Range. Containing neither phosphate nor glauconite in prominent quantities, it is difficult to assign the Triassic rocks at Diamond well to any of Parrish's facies belts. However, the occurrence of Triassic rocks relatively poor in organic carbon and oil generation potential at Diamond is consistent with the regional pattern of northward decline of source potential in the Shublik Formation.

Thermal Maturity of Triassic Oil Source Rocks in Chukchi Sea

Based on statistical fits of exponential functions to vitrinite reflectance data in the offshore wells (Sherwood et al., 1998, fig. 13.18; tbl. 13.6), and incorporating the interpretations of onshore wells by Johnsson and others (1993), we have mapped the structure of key isograds offshore. This mapping is presented by Sherwood et al. (1998, figs. 13.19 through 13.21). Figure 14 shows the structure of the isograd at the top of the depth interval for oil generation (0.60 R_o%). This map and others prepared by Sherwood et al. (1998, figs. 13.19-13.21) formed the basis for mapping the thermal maturity levels in key source rock units. The isograd structure maps are dominated by a trough that plunges northwest into the North Chukchi basin. All isograds are breached at the seafloor offshore along the Herald thrust and onshore along the front of the Brooks Range thrust belt. Rather than regional variations in thermal gradients, most of the structure of these isograd surfaces reflects elevation of known tectonic uplifts such as the North Chukchi high, the Barrow arch (Northeast Chukchi basin area), the Herald thrust and Herald thrust zone, and the Brooks Range.

Figure 15 is based on MMS seismic mapping offshore and USGS mapping onshore and unites in one map the regional structure of the top of the Shublik Formation (offshore) and the top of the Sadlerochit Group[2] (onshore). The general pattern is

[2] *corresponds to base of Shublik Formation*

one of southward and eastward dip toward a depth maximum of 30,000 feet just offshore from Point Lay. On the west, the Triassic source rock sequence is truncated at the Jurassic unconformity (JU). On the north, the sequence is truncated at the Lower Cretaceous unconformity (LCU) or simply laps out against basement, as between the Diamond well and the community of Barrow.

We have mapped the lines of intersection between the key isograd surfaces and the Triassic source rocks in order to define levels of thermal maturity within the source rock sequence. South of the 1.35 percent vitrinite isograd (red area) in figure 15 the Triassic oil source rocks are completely expended with respect to generation of oil. Given gravitational drainage up present-day structure (mostly established by 92 Ma), as hypothesized by the green arrows in figure 15, at least some of the oil expelled from the exhausted Triassic oil sources should have migrated west and north, respectively, into traps on Chukchi platform and the Arctic platform. Petroleum generated from Triassic oil source rocks outside of this area should have migrated to other areas to the south (Brooks Range) or north (Barrow arch). Sherwood et al. (1998, p. 144) estimated that the oil-generative area for Triassic rocks that might "charge" Chukchi shelf (highlighted with hypothetical migration paths in fig. 15) could have created 2.97 trillion barrels of oil. The Triassic rocks charging the Chukchi shelf are merely the western third of the larger Ellesmerian![3] petroleum system of Arctic Alaska, with an estimated charge potential of 8 trillion barrels (Bird, 1994). The 2006 assessment of *petroleum liquids* in the Chukchi Sea Planning Area forecasts a mean potential of 15 billion barrels ranging up to 40 billion barrels. These volumes represent a mere 0.5% to 1.3% of the estimated 2.97 trillion-barrel potential Triassic-sourced charge to Chukchi shelf prospects.

Petroleum Charging Systems for Chukchi Sea Planning Area

Most high-potential plays in the Chukchi Sea are considered to be charged by the petroleum system involving Triassic oil source rocks in Hanna trough. This system is identified as the "Hanna Trough Charge Area" in figure 16. The "charge area" includes the area of potential petroleum creation and the areas of prospects that might be reached by the migration of the petroleum. Based on the estimated 2.97 trillion-barrel generation potential for Triassic rocks in western Hanna trough, this play charging system is viewed as the most robust and prolific of the five systems proposed to provide petroleum to prospects in the Chukchi Sea Planning Area.

Little is known about the North Chukchi basin, Nuwuk basin, or Colville basin charge areas mapped in figure 16, but they are probably endowed with smaller volumes of oil source rocks. Also, the source rocks in the North Chukchi basin, Nuwuk basin, and Colville basin charge areas formed in deltaic systems with high sedimentation rates, and, are probably generally more gas-prone and lean with respect to convertible organic matter.

Potential source rocks in Hope basin are known to be lean and gas-prone from two wells in Kotzebue Sound. Only the central parts of Hope and Kotzebue basins reach thermal maturities sufficient to have generated oil or gas. Vertical migration typically dominates petroleum movement patterns in highly-faulted rift or wrench basins (Demaison and Huizinga, 1991). Figure 16 identifies two charge areas within northern Hope basin, including a central

[3] *"!") denotes a proven petroleum system (Magoon and Dow, 1994, p. 12)*

(gray) area where prospects might be charged by thermogenic petroleum (most likely methane) from the basin floor, and a larger (pink) area where the basin fill is thin and where biogenic methane is the only likely resource.

Play Definition Criteria

At the most fundamental level, the Chukchi Sea plays are organized around the five major tectonostratigraphic sequences recognized beneath Chukchi shelf, shown in the "Chukchi Shelf Sequence" column in figure 4. These major sequences and associated reservoir formations identify the play groups within the Chukchi Sea Planning Area. These include the ***Lower Ellesmerian, Upper Ellesmerian, Rift, Lower Brookian, and Upper Brookian*** play groups. The Hope basin fill is correlative to the Upper Brookian sequence (fig. 4) and is included with the Upper Brookian play group in figure 8.

Within each play group north of Hope basin, individual plays are distinguished on the basis of paleogeographic setting (opposite sides of basin, with different sediment source terranes), reservoir facies (e.g., carbonates versus various types of clastic deposits), structural setting (trap type), play petroleum charging system, or reservoir fluid content (plays offering only gas are set apart).

The sedimentary fill of Hope and Kotzebue basins is divided into two regionally stacked geologic play sequences on the basis of the observed contrast in reservoir characteristics of the two principal stratigraphic sequences sampled by the Kotzebue basin wells. The Oligocene-Pliocene sequence, offering abundant high-quality reservoir sandstones, hosts play 26, the "Late Sequence" play. The Eocene(?) sequence, offering relatively thin, modest-quality reservoir sandstones, hosts play 27, the "Early Sequence" play. The cross section of figure 10B illustrates the distribution and relationship if these two sequences. Two additional plays in Hope basin are based upon the sandstones hypothesized to occur at the base of the sedimentary fill in Hope and Kotzebue basins, marking the onset of basin rifting and subsidence (analogy to known occurrences in Norton Basin COST No. 2 well; Turner et al., 1983). The basal sandstone plays are referred to as play 28, the "Shallow (<10,000 ft) Basal Sand" play, and play 29, the "Deep (>10,000 ft) Basal Sand" play. Plays 28 and 29 are differentiated on the basis of burial depth and related issues of reservoir quality.

Oil and Gas Resources of Chukchi Sea Planning Area

The 2006 assessment of the Chukchi Sea OCS Planning Area identified 29 exploration plays. As reported in tables 1, 3, and 4 and shown graphically in figure 17, the risked, technically-recoverable, undiscovered hydrocarbon energy endowment of the Chukchi Sea Planning Area ranges up to 77,357 Mmboe (F05), with a mean value or expectation of 29,041 Mmboe. The planning area is oil-prone, with fifty-three percent of the undiscovered hydrocarbon energy endowment consisting of oil and condensate (from gas). Mean

Chukchi Sea OCS Planning Area, 2006 Assessment, Undiscovered Technically-Recoverable Oil & Gas			
Assessment Results as of November 2005			
Resource Commodity (Units)	Resources *		
	F95	Mean	F05
BOE (Mmboe)	4,152	29,041	77,357
Total Gas (Tcfg)	10.316	76.772	209.527
Total Liquids (Mmbo)	2,317	15,380	40,075
Free Gas** (Tcfg)	8.070	57.140	156.879
Solution Gas (Tcfg)	2.246	19.632	52.648
Oil (Mmbo)	1,895	12,381	31,841
Condensate (Mmbc)	421	2,999	8,234

** Risked, Technically-Recoverable*

*** Free Gas Includes Gas Cap and Non-Associated Gas*

F95 = 95% chance that resources will equal or exceed the given quantity

F05 = 5% chance that resources will equal or exceed the given quantity

BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas

Mmb = millions of barrels

Tcf = trillions of cubic feet

Table 1

risked, undiscovered total gas (sum of free gas and solution gas in oil) resources total 76.772 Tcf but could range up to a maximum (F05) potential of 209.527 Tcf. Mean risked, undiscovered liquid petroleum (sum of free oil and condensate from gas) resources are estimated at 15,380 Mmb but could range up to a maximum (F05) potential of 40,075 Mmb. Table 5 reports the detailed assessment results by commodity for the Chukchi Sea.

The 27 quantified plays (plays 10 and 29 were assigned negligible resources) in the Chukchi Sea Planning Area are estimated to contain a maximum of 1,406 pools. Seven of these pools are estimated to contain mean conditional resources in excess of 1,000 Mmboe. Dees (1991) estimated that a 1,000 to 3,000 Mmbo field would be required to spark development in the Chukchi Sea. The

Chukchi Sea OCS Planning Area, Alaska, 2006 Assessment, Conditional BOE Sizes of Ten Largest Pools				
Assessment Results as of November 2005				
Pool Rank	Play Number	BOE Resources * (Mmboe)		
		F95	Mean	F05
1	7	475	2183	5940
2	1	530	1985	5375
3	8	202	1862	7670
4	14	115	1694	5787
5	6	273	1276	3355
6	21	311	1075	2766
7	1	298	1029	2147
8	7	280	984	2126
9	11	268	856	2100
10	25	178	794	2217

** Conditional, Technically-Recoverable, Millions of Barrels Energy-Equivalent (Mmboe), from "PSRK.out" file*

F95 = 95% chance that resources will equal or exceed the given quantity

F05 = 5% chance that resources will equal or exceed the given quantity

BOE = total hydrocarbon energy, expressed in barrels-of-oil-equivalent, where 1 barrel of oil = 5,620 cubic feet of natural gas

Table 2

largest pool is found in play 7, which also hosts the Burger gas discovery (tbl. 2). The mean conditional (un-risked) size of the largest undiscovered pool in the Chukchi Sea Planning Area is 2,183 Mmboe. (Burger prospect discovered resources of 14.038 Tcfg and 724 Mmbc are estimated to sum to 3,222 Mmboe.) At maximum (F05) size, the largest undiscovered pool in the Chukchi Sea Planning Area is estimated to contain conditional resources of 5,940 Mmboe.

Table 6 and table 7 report the assessment results for Chukchi Sea plays ranked on mean BOE resources. The top 8 of the 29 plays (plays 7, 1, 8, 11, 21, 6, 14 and 5, ranked respectively on mean risked BOE) carry 85 percent of the province liquid (free oil and condensate from gas) endowment and 79 percent of the gas endowment.

These eight plays dominate the resource endowment because they offer many large prospects, ready access to petroleum charging systems, broad areas of shallow burial with commensurate extensive preservation of reservoir pore systems, and in some cases (5, 7, 8, 9 and 11) proven geological success. These eight plays will likely form the primary objectives of any future exploration programs on Chukchi shelf.

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Links to Summaries for Individual Plays and Appended Items

2006 Assessment Results for Chukchi Sea OCS Planning Area

Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005

		BOE Resources (Mmbo)			Oil Resources (Mmbo)			Gas-Condensate Liquid Resources (Mmbo)			Free* Gas Resources (Tcfg)			Solution Gas Resources (Tcfg)			Total Liquid Resources (Mmbo)			Total Gas Resources (Tcfg)		
Play Number	**Play Name**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**
1	**Endicott-Chukchi Platform**	0	4,829	10,910	0	2,255	5,469	0	377	753	0.000	6.976	13.175	0.000	5.371	13.173	0	2,632	6,222	0.000	12.347	26.348
2	**Endicott-Arctic Platform**	0	122	516	0	9	37	0	26	110	0.000	0.475	2.013	0.000	0.016	0.058	0	35	147	0.000	0.491	2.072
3	**Lisburne Carbonates**	0	213	933	0	103	462	0	13	55	0.000	0.249	1.013	0.000	0.295	1.326	0	116	517	0.000	0.544	2.339
4	**Ellesmerian-Deep Gas**	0	198	719	0	0	0	0	25	90	0.000	0.977	3.539	0.000	0.000	0.000	0	25	90	0.000	0.977	3.539
5	**Sadlerochit Gp.-Chukchi Platform**	357	1,378	2,880	129	439	892	36	166	355	0.702	3.065	6.597	0.374	1.279	2.582	165	605	1,247	1.076	4.344	9.179
6	**Sadlerochit Gp.-Arctic Platform**	0	1,573	4,933	0	539	1,513	0	202	678	0.000	3.719	12.755	0.000	0.953	2.658	0	741	2,191	0.000	4.672	15.413
7 * **	**Rift Sequence-Active Margin**	1,953	6,251	12,902	1,052	3,354	6,799	162	541	1,172	3.145	10.034	21.216	1.008	3.209	6.496	1,214	3,895	7,971	4.153	13.243	27.712
8	**Rift Sequence-Stable Shelf**	521	3,787	10,841	217	1,654	4,716	51	356	1,021	0.983	6.609	18.856	0.437	3.384	9.825	268	2,009	5,737	1.421	9.993	28.681
9	**Rift Sequence-Deep Gas**	0	48	237	0	0	0	0	6	29	0.000	0.237	1.168	0.000	0.000	0.000	0	6	29	0.000	0.237	1.168
10	**Herald Arch-Thrust Zone**	Play 10 Assessed with Negligible Resources																				
11	**Foreland Foldbelt (Lower Brookian)**	1,238	2,853	5,077	456	1,075	1,928	166	381	707	3.095	6.992	12.172	0.369	0.862	1.556	621	1,455	2,634	3.464	7.854	13.728
12	**Torok Turbidites (Lower Brookian)-Chukchi Wrench Zone**	51	500	1,353	22	172	419	5	62	183	0.095	1.142	3.357	0.044	0.353	0.866	26	234	602	0.138	1.496	4.222
13	**Nanushuk Topset Sandstones (Lower Brookian)-Chukchi Wrench Zone**	0	325	1,280	0	131	516	0	32	130	0.000	0.595	2.319	0.000	0.313	1.243	0	163	647	0.000	0.908	3.562
14	**Brookian Sandstones-North Chukchi High**	0	1,455	5,309	0	485	1,840	0	174	612	0.000	3.206	11.058	0.000	1.268	4.998	0	659	2,452	0.000	4.474	16.056
15	**Topset Sandstones (Lower Brookian)-North Chukchi Basin**	0	414	1,356	0	61	165	0	74	255	0.000	1.360	4.703	0.000	0.209	0.560	0	135	420	0.000	1.569	5.263
16	**Brookian (Upper and Lower)-Deep Gas**	0	94	531	0	0	0	0	12	65	0.000	0.464	2.619	0.000	0.000	0.000	0	12	65	0.000	0.464	2.619
17	**Torok Turbidites (Lower Brookian)-Arctic Platform**	0	139	338	0	65	150	0	14	38	0.000	0.257	0.658	0.000	0.081	0.188	0	79	187	0.000	0.337	0.846
18	**Nanushuk Topset Sandstones (Lower Brookian)-Arctic Platform**	33	510	1,436	19	350	992	3	27	76	0.050	0.505	1.388	0.013	0.242	0.684	22	377	1,068	0.063	0.747	2.071
19	**Sag Sequence (Upper Brookian)-North Chukchi Basin**	0	22	133	0	9	50	0	3	17	0.000	0.050	0.334	0.000	0.007	0.041	0	12	67	0.000	0.058	0.376

Table 3. Summary of Chukchi Sea province assessment results for ultimate technically recoverable resources (UTRR), by play, for plays 1-19.

2006 Assessment Results for Chukchi Sea OCS Planning Area

Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005

		BOE Resources (Mmbo)			Oil Resources (Mmbo)			Gas-Condensate Liquid Resources (Mmbo)			Free* Gas Resources (Tcfg)			Solution Gas Resources (Tcfg)			Total Liquid Resources (Mmbo)			Total Gas Resources (Tcfg)		
Play Number	**Play Name**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**
20	**Upper Brookian Turbidites-North Chukchi Basin**	0	73	292	0	13	50	0	12	48	0.000	0.220	0.885	0.000	0.053	0.207	0	25	98	0.000	0.273	1.092
21	**Upper Brookian Paleo-Valleys**	0	1,612	5,532	0	871	3,114	0	139	435	0.000	2.558	8.220	0.000	0.827	2.926	0	1,010	3,548	0.000	3.386	11.146
22	**Upper Brookian Intervalley Highs**	0	410	1,125	0	296	873	0	22	46	0.000	0.401	0.809	0.000	0.118	0.349	0	318	919	0.000	0.519	1.158
23	**Northeast Chukchi Basin-Franklinian**	0	332	1,360	0	39	180	0	66	276	0.000	1.219	4.814	0.000	0.058	0.267	0	105	456	0.000	1.277	5.081
24	**Lower Brookian-Nuwuk Basin**	0	568	2,245	0	139	554	0	90	349	0.000	1.661	6.581	0.000	0.243	0.964	0	230	902	0.000	1.904	7.545
25	**Upper Brookian-Nuwuk Basin**	0	1,000	3,644	0	299	1,002	0	144	570	0.000	2.665	10.064	0.000	0.470	1.575	0	442	1,573	0.000	3.135	11.639
26	**Late Sequence (Oligocene-Pliocene)-Hope Basin**	0	132	617	0	11	64	0	15	68	0.000	0.588	2.685	0.000	0.008	0.045	0	26	132	0.000	0.596	2.730
27	**Early Sequence (Eocene)-Hope Basin**	0	127	557	0	7	38	0	15	64	0.000	0.584	2.511	0.000	0.009	0.044	0	22	102	0.000	0.593	2.555
28	**Shallow (<10,000 ft) Basal Sandstones-Hope Basin**	0	72	301	0	4	19	0	8	34	0.000	0.331	1.370	0.000	0.004	0.018	0	13	54	0.000	0.335	1.388
29	**Deep (>10,000 ft) Basal Sandstones-Hope Basin**	Play 29 Assessed with Negligible Resources																				
Sum of All Plays**		**4,152**	**29,041**	**77,357**	**1,895**	**12,381**	**31,841**	**421**	**2,999**	**8,234**	**8.070**	**57.140**	**156.879**	**2.246**	**19.632**	**52.648**	**2,317**	**15,380**	**40,075**	**10.316**	**76.772**	**209.527**

** Free gas, occurring as gas caps associated with oil and as oil-free gas pools (non-associated gas).*

*** Values as reported out of Basin Level Analysis-Geologic Scenario aggregation module in GRASP, "Volume Ordered" aggregation option. Total liquids and total gas values were obtained by summing resource values for means and fractiles of component commodities. Play resource values are rounded and may not sum to totals reported from basin aggregation.*

**** Results for play 7 do not exclude discovered gas and condensate resources at Burger gas pool (14.038 Tcfg + 724 Mmbc). Use of the GRASP discovery process "Match" modules to remove Burger discovered resources reduces the mean BOE for play 7 to 5,799 Mmboe, the mean total liquids to 3,573 Mmb and the mean total gas to 12.506 Tcf.*

BOE, total energy, in millions of barrels (5,620 cubic feet of gas per barrel of oil, energy-equivalent); Mmbo, millions of barrels of oil or liquids; Tcfg, trillions of cubic feet of natural gas

Table 4. Summary of Chukchi Sea province assessment results for ultimate technically recoverable resources (UTRR), by play, for plays 20-29.

Province Resources - Technically Recoverable, Risked, By Product

Geological Resources Assessment Program-GRASP-Version					8.29.2005	
The	Current	UAI	AAAAAD			
	is	for				
World	Level	-	World	Level	Resources	
Country	Level	-	UNITED	STATES	OF	AMERICA
Region	Level	-	MMS	-	ALASKA	REGION
Basin	**Level**	**-**	**CHUKCHI**	**SEA**		

Basin Level Aggregation of Risked, Technically Recoverable Resources By Product (Province Aggregation ".out" file)

Volume Ordered (Play Aggregation Method)

RandomSeed = 653794

Number of Trials = 10000

Greater Than Percentage	BOE (Mboe)	Oil (Mbo)	Condensate (Mbc)	Solution Gas (Mmcfg)	Free (Gas Cap & Nonassociated) Gas (Mmcfg)
99	2,313,948.97	1,069,215.67	234,366.67	1,177,945.45	4,500,315.03
98	2,986,290.54	1,384,987.07	301,518.81	1,564,048.51	5,740,741.26
97	3,447,915.98	1,562,140.36	358,698.07	1,788,407.68	6,793,768.13
96	3,822,898.44	1,757,679.92	389,666.33	2,051,360.43	7,365,242.90
95	4,152,250.79	1,895,461.53	421,255.61	2,245,567.94	8,070,131.24
90	5,632,483.62	2,534,860.44	582,727.90	3,141,697.66	10,992,013.85
85	8,067,745.11	3,743,861.98	783,500.07	5,378,690.20	14,518,262.59
80	9,603,542.11	4,362,625.27	926,622.16	6,568,127.22	17,678,208.85
75	11,051,513.27	5,024,018.04	1,085,975.43	7,556,494.63	20,214,846.63
70	12,336,040.82	5,763,073.34	1,168,003.91	8,675,422.15	21,700,473.13
65	13,640,529.35	6,226,880.51	1,336,669.89	9,302,187.08	24,850,434.66
60	15,224,265.48	6,886,162.58	1,478,300.87	10,544,743.03	28,007,344.38
55	17,783,980.49	7,917,913.90	1,740,076.47	12,512,521.85	33,155,542.65
50	20,126,773.63	9,012,161.74	1,978,647.18	13,958,459.34	37,385,662.38
45	24,204,499.78	10,676,398.54	2,435,558.45	16,773,192.89	45,566,897.54
40	27,785,165.03	12,007,736.08	2,852,881.13	18,819,910.18	53,816,048.58
35	31,597,619.06	13,704,683.06	3,219,191.22	21,488,980.92	60,977,464.74
30	35,646,769.42	15,486,485.22	3,580,682.72	24,718,949.55	68,458,410.79
25	40,159,787.00	16,696,426.04	4,251,237.47	26,740,465.87	81,231,668.15
20	45,537,856.21	19,286,566.44	4,671,135.41	31,185,578.63	90,094,888.88
15	52,052,160.26	21,709,545.71	5,418,557.08	34,635,869.54	105,437,333.44
10	61,362,878.86	25,499,013.32	6,356,109.31	41,180,087.83	124,653,502.20
5	77,357,214.89	31,840,764.70	8,234,153.39	52,647,834.90	156,878,673.13
4	83,044,165.93	33,718,182.10	8,949,865.52	55,724,374.67	171,189,410.21
3	90,986,300.40	37,010,224.54	9,768,655.88	61,088,119.99	187,357,580.33
2	103,474,718.04	42,260,705.23	11,092,426.57	68,930,476.90	212,752,837.81
1	125,823,161.98	52,739,559.38	13,139,957.98	87,183,829.60	249,699,453.15
Mean	29,040,732.41	12,381,173.66	2,999,072.68	19,631,966.05	57,139,965.67
Rep	29,036,622.16	12,242,210.01	3,056,137.53	20,733,333.23	56,475,770.14
Min	203,881.31	65,574.16	34,725.69	60,521.79	521,606.02
Max	287,564,980.94	130,858,310.00	28,132,967.26	251,960,652.89	470,623,562.45

Table 5. Detailed report of ultimate technically recoverable resources (UTRR) by commodity, as reported in province aggregation file by *GRASP* computer model.

Ranking of Plays-2006 Assessment Results for Chukchi Sea OCS Planning Area

Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005

			BOE Resources (Mmbo)			Oil Resources (Mmbo)			Gas-Condensate Liquid Resources (Mmbo)			Free* Gas Resources (Tcfg)			Solution Gas Resources (Tcfg)			Total Liquid Resources (Mmbo)			Total Gas Resources (Tcfg)		
Play Rank (Mean BOE)	**Play Number**	**Play Name**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**
1	**7**	**Rift Sequence-Active Margin**	1,953	6,251	12,902	1,052	3,354	6,799	162	541	1,172	3.145	10.034	21.216	1.008	3.209	6.496	1,214	3,895	7,971	4.153	13.243	27.712
2	**1**	**Endicott-Chukchi Platform**	0	4,829	10,910	0	2,255	5,469	0	377	753	0.000	6.976	13.175	0.000	5.371	13.173	0	2,632	6,222	0.000	12.347	26.348
3	**8**	**Rift Sequence-Stable Shelf**	521	3,787	10,841	217	1,654	4,716	51	356	1,021	0.983	6.609	18.856	0.437	3.384	9.825	268	2,009	5,737	1.421	9.993	28.681
4	**11**	**Foreland Foldbelt (Lower Brookian)**	1,238	2,853	5,077	456	1,075	1,928	166	381	707	3.095	6.992	12.172	0.369	0.862	1.556	621	1,455	2,634	3.464	7.854	13.728
5	**21**	**Upper Brookian Paleo-Valleys**	0	1,612	5,532	0	871	3,114	0	139	435	0.000	2.558	8.220	0.000	0.827	2.926	0	1,010	3,548	0.000	3.386	11.146
6	**6**	**Sadlerochit Gp.-Arctic Platform**	0	1,573	4,933	0	539	1,513	0	202	678	0.000	3.719	12.755	0.000	0.953	2.658	0	741	2,191	0.000	4.672	15.413
7	**14**	**Brookian Sandstones-North Chukchi High**	0	1,455	5,309	0	485	1,840	0	174	612	0.000	3.206	11.058	0.000	1.268	4.998	0	659	2,452	0.000	4.474	16.056
8	**5**	**Sadlerochit Gp.-Chukchi Platform**	357	1,378	2,880	129	439	892	36	166	355	0.702	3.065	6.597	0.374	1.279	2.582	165	605	1,247	1.076	4.344	9.179
9	**25**	**Upper Brookian-Nuwuk Basin**	0	1,000	3,644	0	299	1,002	0	144	570	0.000	2.665	10.064	0.000	0.470	1.575	0	442	1,573	0.000	3.135	11.639
10	**24**	**Lower Brookian-Nuwuk Basin**	0	568	2,245	0	139	554	0	90	349	0.000	1.661	6.581	0.000	0.243	0.964	0	230	902	0.000	1.904	7.545
11	**18**	**Nanushuk Topset Sandstones (Lower Brookian)-Arctic Platform**	33	510	1,436	19	350	992	3	27	76	0.050	0.505	1.388	0.013	0.242	0.684	22	377	1,068	0.063	0.747	2.071
12	**12**	**Torok Turbidites (Lower Brookian)-Chukchi Wrench Zone**	51	500	1,353	22	172	419	5	62	183	0.095	1.142	3.357	0.044	0.353	0.866	26	234	602	0.138	1.496	4.222
13	**15**	**Topset Sandstones (Lower Brookian)-North Chukchi Basin**	0	414	1,356	0	61	165	0	74	255	0.000	1.360	4.703	0.000	0.209	0.560	0	135	420	0.000	1.569	5.263
14	**22**	**Upper Brookian Intervalley Highs**	0	410	1,125	0	296	873	0	22	46	0.000	0.401	0.809	0.000	0.118	0.349	0	318	919	0.000	0.519	1.158
15	**23**	**Northeast Chukchi Basin-Franklinian**	0	332	1,360	0	39	180	0	66	276	0.000	1.219	4.814	0.000	0.058	0.267	0	105	456	0.000	1.277	5.081

Table 6. Chukchi Sea play endowments ranked on mean BOE, for plays 1-15.

Ranking of Plays-2006 Assessment Results for Chukchi Sea OCS Planning Area

Risked, Undiscovered, Technically Recoverable Oil and Gas Resources, as of November 2005

			BOE Resources (Mmbo)			Oil Resources (Mmbo)			Gas-Condensate Liquid Resources (Mmbo)			Free* Gas Resources (Tcfg)			Solution Gas Resources (Tcfg)			Total Liquid Resources (Mmbo)			Total Gas Resources (Tcfg)		
Play Rank (Mean BOE)	**Play Number**	**Play Name**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**	**F95**	**Mean**	**F05**
16	**13**	**Nanushuk Topset Sandstones (Lower Brookian)-Chukchi Wrench Zone**	0	325	1,280	0	131	516	0	32	130	0.000	0.595	2.319	0.000	0.313	1.243	0	163	647	0.000	0.908	3.562
17	**3**	**Lisburne Carbonates**	0	213	933	0	103	462	0	13	55	0.000	0.249	1.013	0.000	0.295	1.326	0	116	517	0.000	0.544	2.339
18	**4**	**Ellesmerian-Deep Gas**	0	198	719	0	0	0	0	25	90	0.000	0.977	3.539	0.000	0.000	0.000	0	25	90	0.000	0.977	3.539
19	**17**	**Torok Turbidites (Lower Brookian)-Arctic Platform**	0	139	338	0	65	150	0	14	38	0.000	0.257	0.658	0.000	0.081	0.188	0	79	187	0.000	0.337	0.846
20	**26**	**Late Sequence (Oligocene-Pliocene)-Hope Basin**	0	132	617	0	11	64	0	15	68	0.000	0.588	2.685	0.000	0.008	0.045	0	26	132	0.000	0.596	2.730
21	**27**	**Early Sequence (Eocene)-Hope Basin**	0	127	557	0	7	38	0	15	64	0.000	0.584	2.511	0.000	0.009	0.044	0	22	102	0.000	0.593	2.555
22	**2**	**Endicott-Arctic Platform**	0	122	516	0	9	37	0	26	110	0.000	0.475	2.013	0.000	0.016	0.058	0	35	147	0.000	0.491	2.072
23	**16**	**Brookian (Upper and Lower)-Deep Gas**	0	94	531	0	0	0	0	12	65	0.000	0.464	2.619	0.000	0.000	0.000	0	12	65	0.000	0.464	2.619
24	**20**	**Upper Brookian Turbidites-North Chukchi Basin**	0	73	292	0	13	50	0	12	48	0.000	0.220	0.885	0.000	0.053	0.207	0	25	98	0.000	0.273	1.092
25	**28**	**Shallow (<10,000 ft) Basal Sandstones-Hope Basin**	0	72	301	0	4	19	0	8	34	0.000	0.331	1.370	0.000	0.004	0.018	0	13	54	0.000	0.335	1.388
26	**9**	**Rift Sequence-Deep Gas**	0	48	237	0	0	0	0	6	29	0.000	0.237	1.168	0.000	0.000	0.000	0	6	29	0.000	0.237	1.168
27	**19**	**Sag Sequence (Upper Brookian)-North Chukchi Basin**	0	22	133	0	9	50	0	3	17	0.000	0.050	0.334	0.000	0.007	0.041	0	12	67	0.000	0.058	0.376
28	**10**	**Herald Arch-Thrust Zone**	Play 10 Assessed with Negligible Resources																				
29	**29**	**Deep (>10,000 ft) Basal Sandstones-Hope Basin**	Play 29 Assessed with Negligible Resources																				
	Sum of All Plays**		**4,152**	**29,041**	**77,357**	**1,895**	**12,381**	**31,841**	**421**	**2,999**	**8,234**	**8.070**	**57.140**	**156.879**	**2.246**	**19.632**	**52.648**	**2,317**	**15,380**	**40,075**	**10.316**	**76.772**	**209.527**

Table 7. Chukchi Sea play endowments ranked on mean BOE, for plays 16-29.

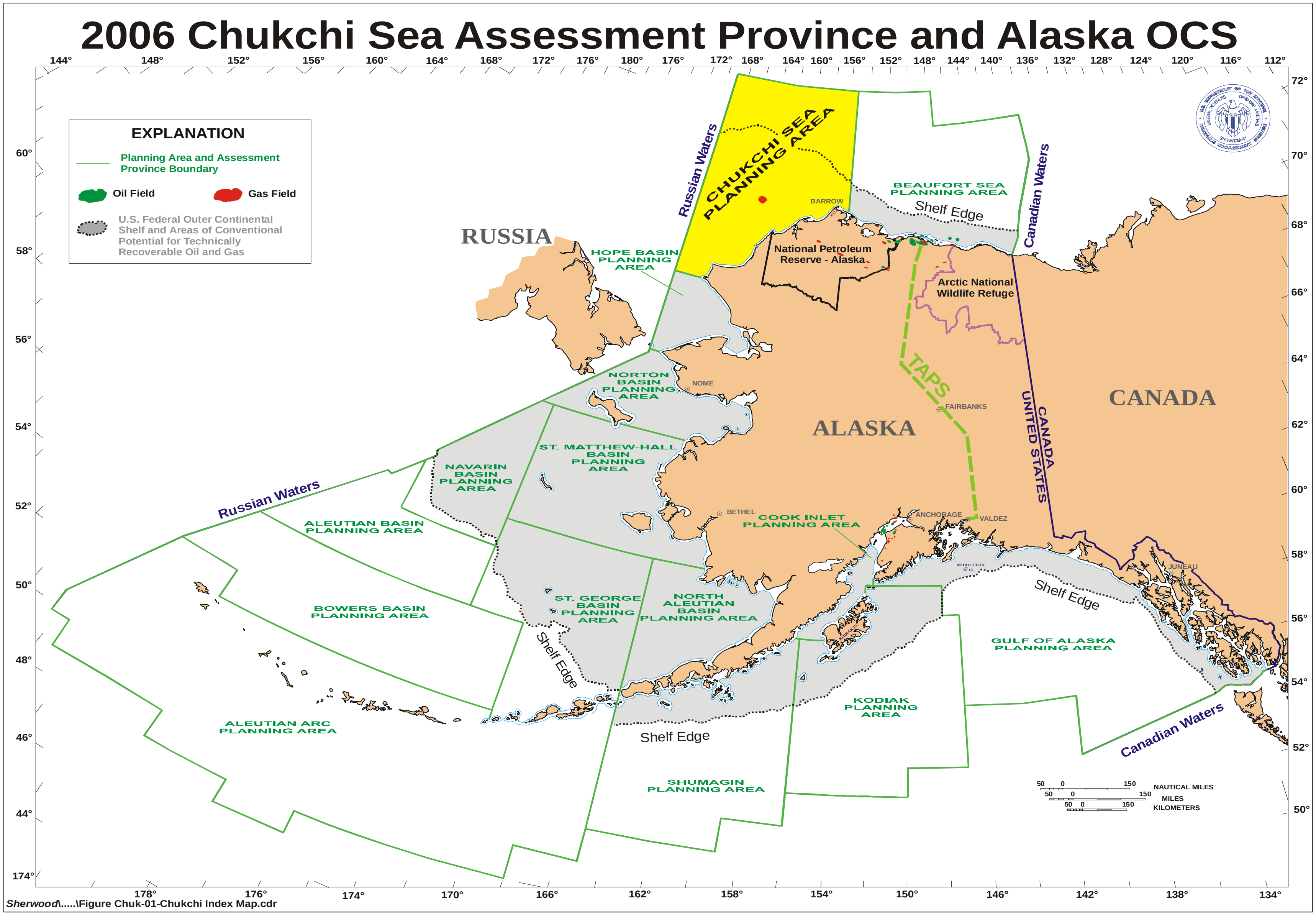

Figure 1. Location of Chukchi Sea Planning area and assessment province.

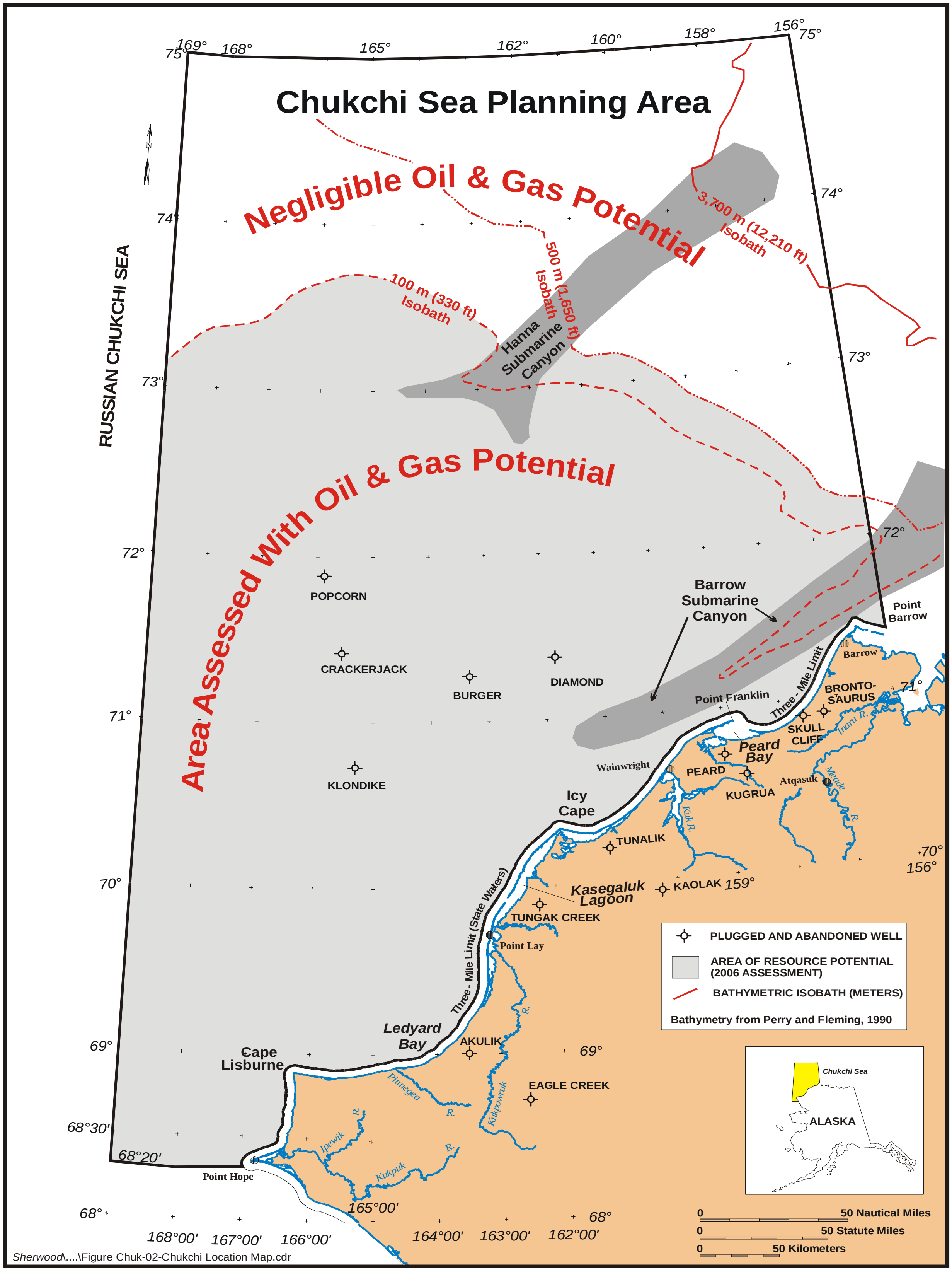

Figure 2. Location of continental shelf area with the Chukchi Sea Panning Area assessed as offering potential for technically recoverable oil and gas in 2006 assessment.

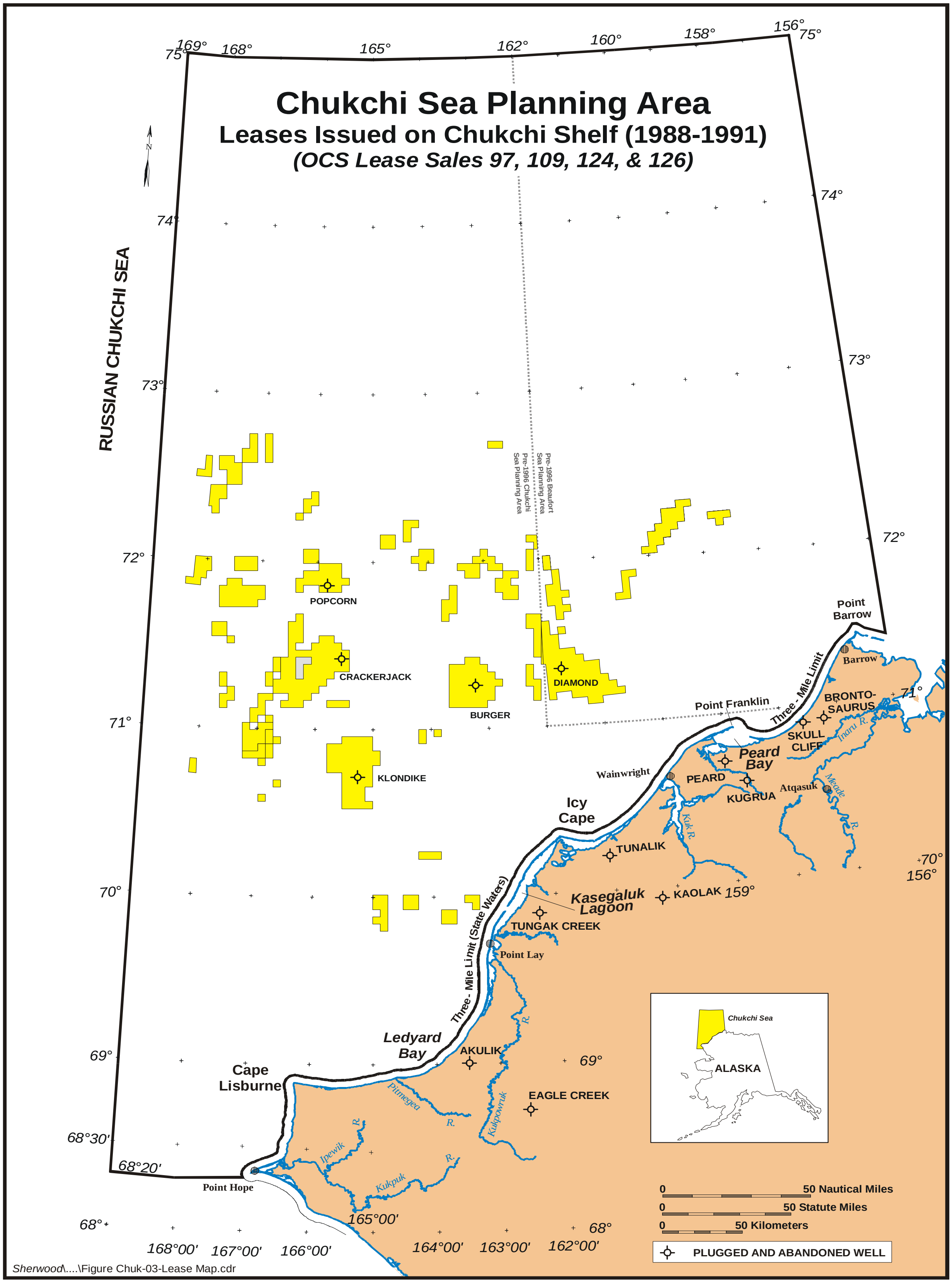

Figure 3. Leases issued on Chukchi shelf from 1988-1991 (OCS lease sales 97, 109, 124, and 126). All leases were relinquished by 1996 and none remain active in 2006.

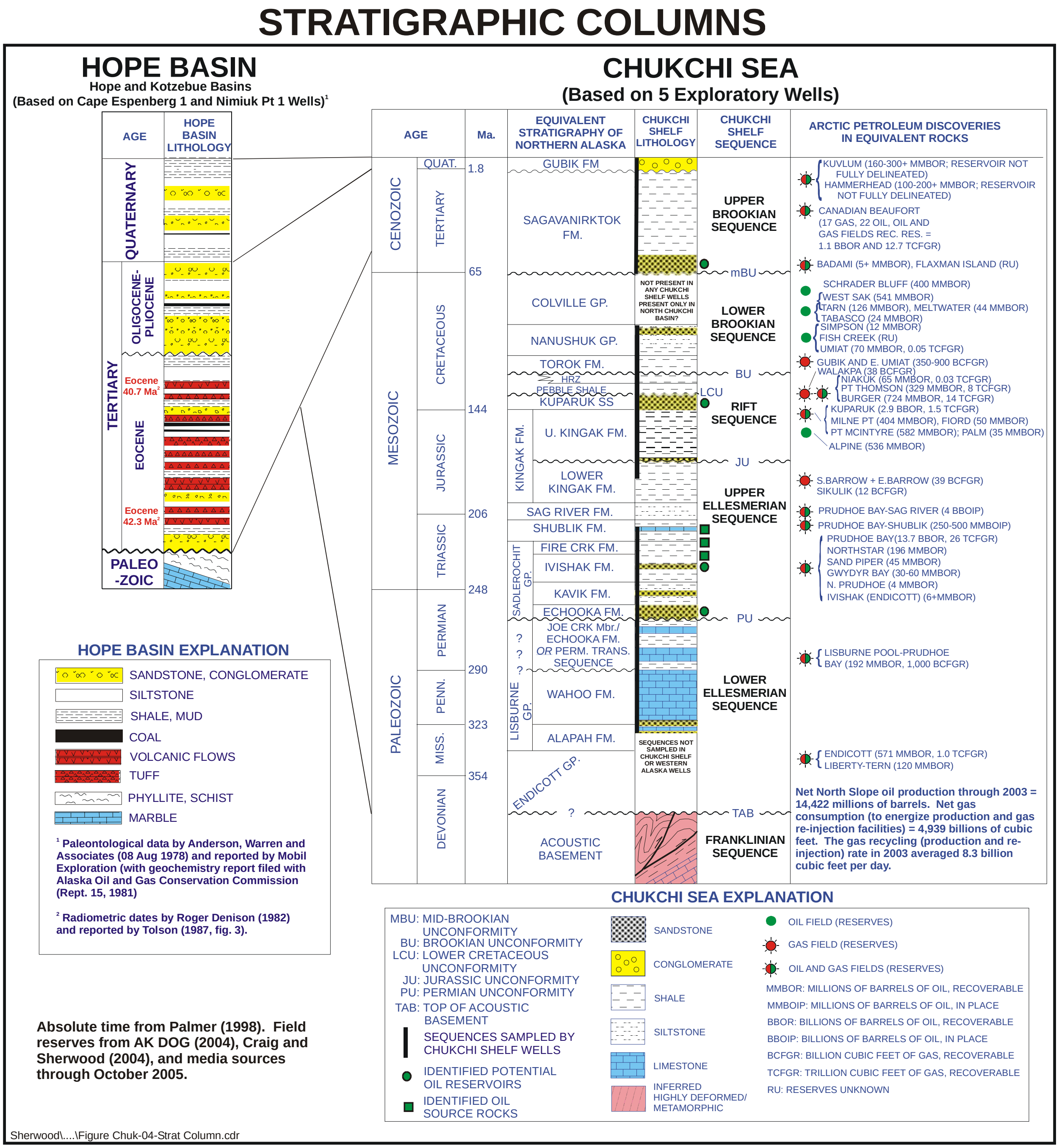

Figure 4. Stratigraphic columns for Hope basin and Chukchi shelf basins north of the Herald arch.

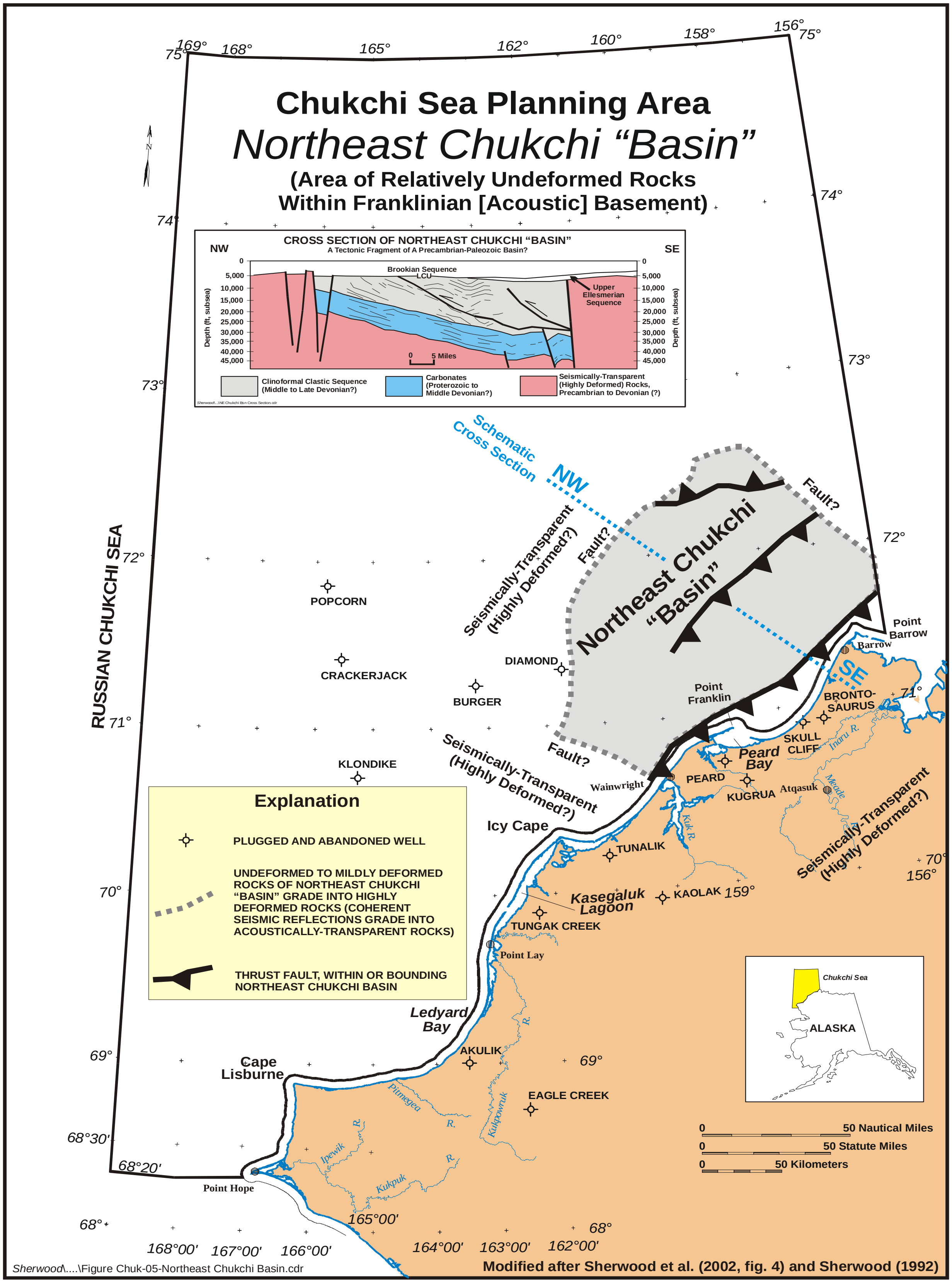

Figure 5. Location of Northeast Chukchi basin, a fault-bounded area of relatively undeformed rocks within Franklinian basement beneath Chukchi shelf.

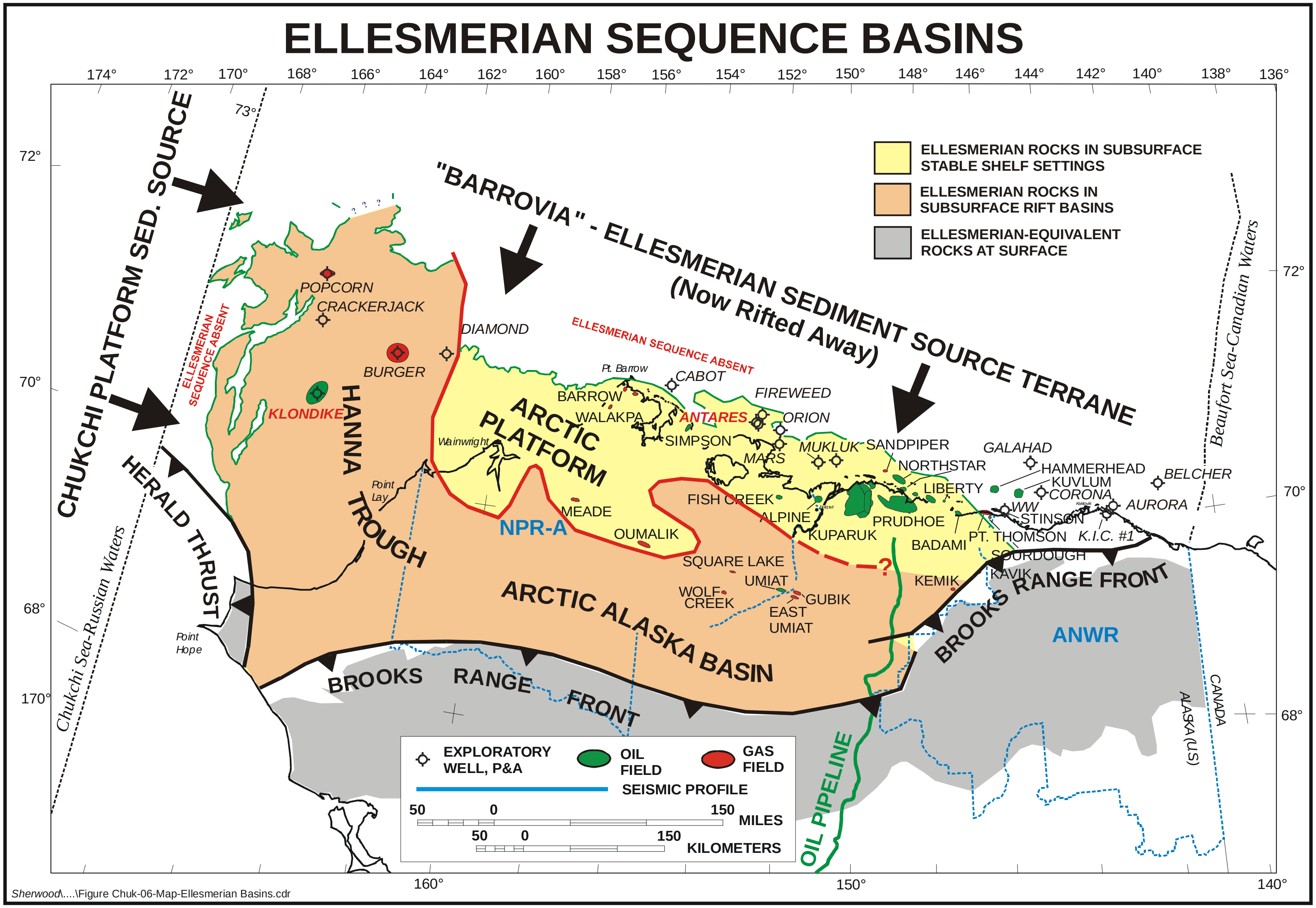

Figure 6. Ellesmerian sequence depositional systems and tectonic setting, Arctic Alaska and Arctic offshore.

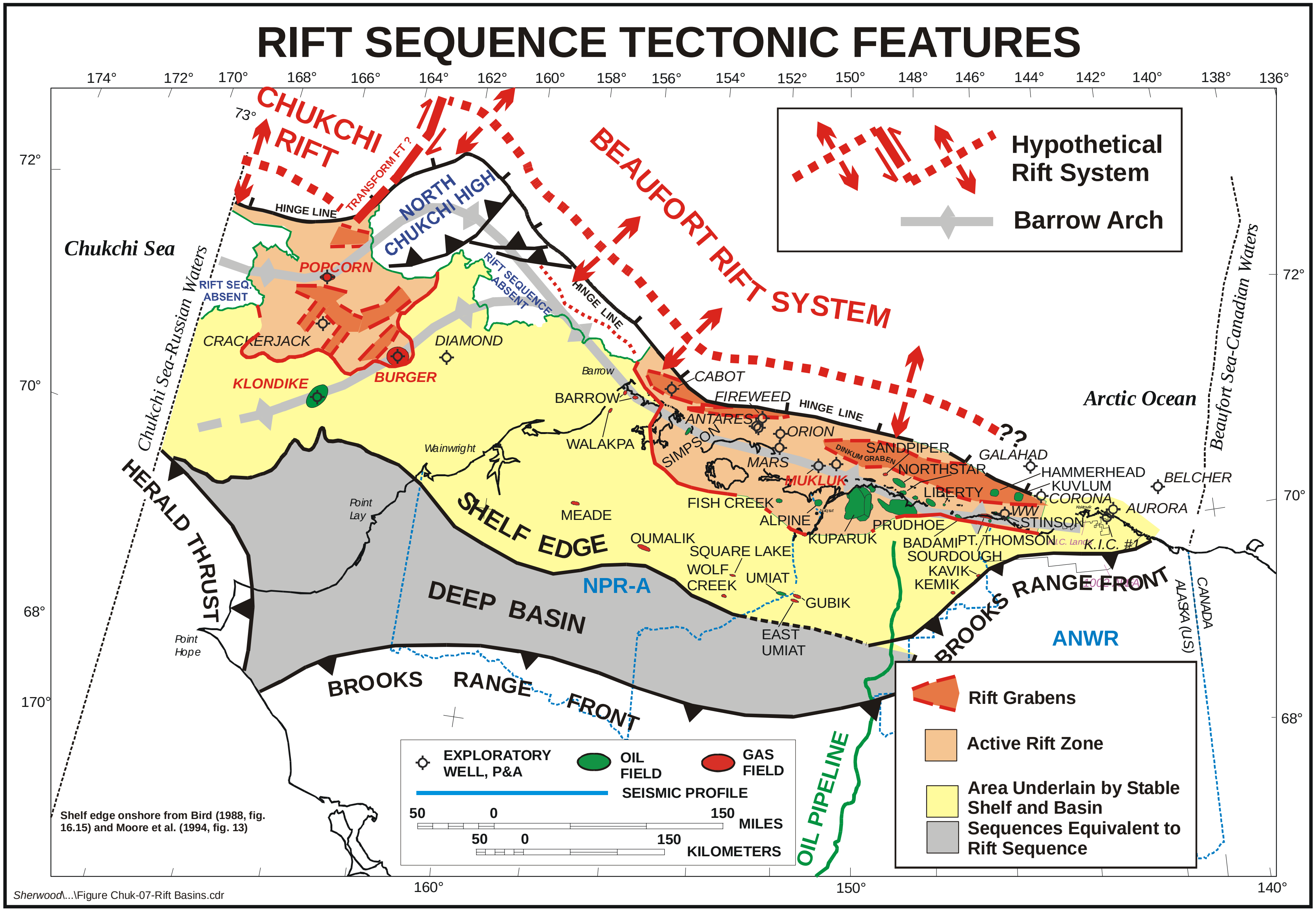

Figure 7. Rift sequence depositional systems and tectonic setting, Arctic Alaska and Arctic offshore.

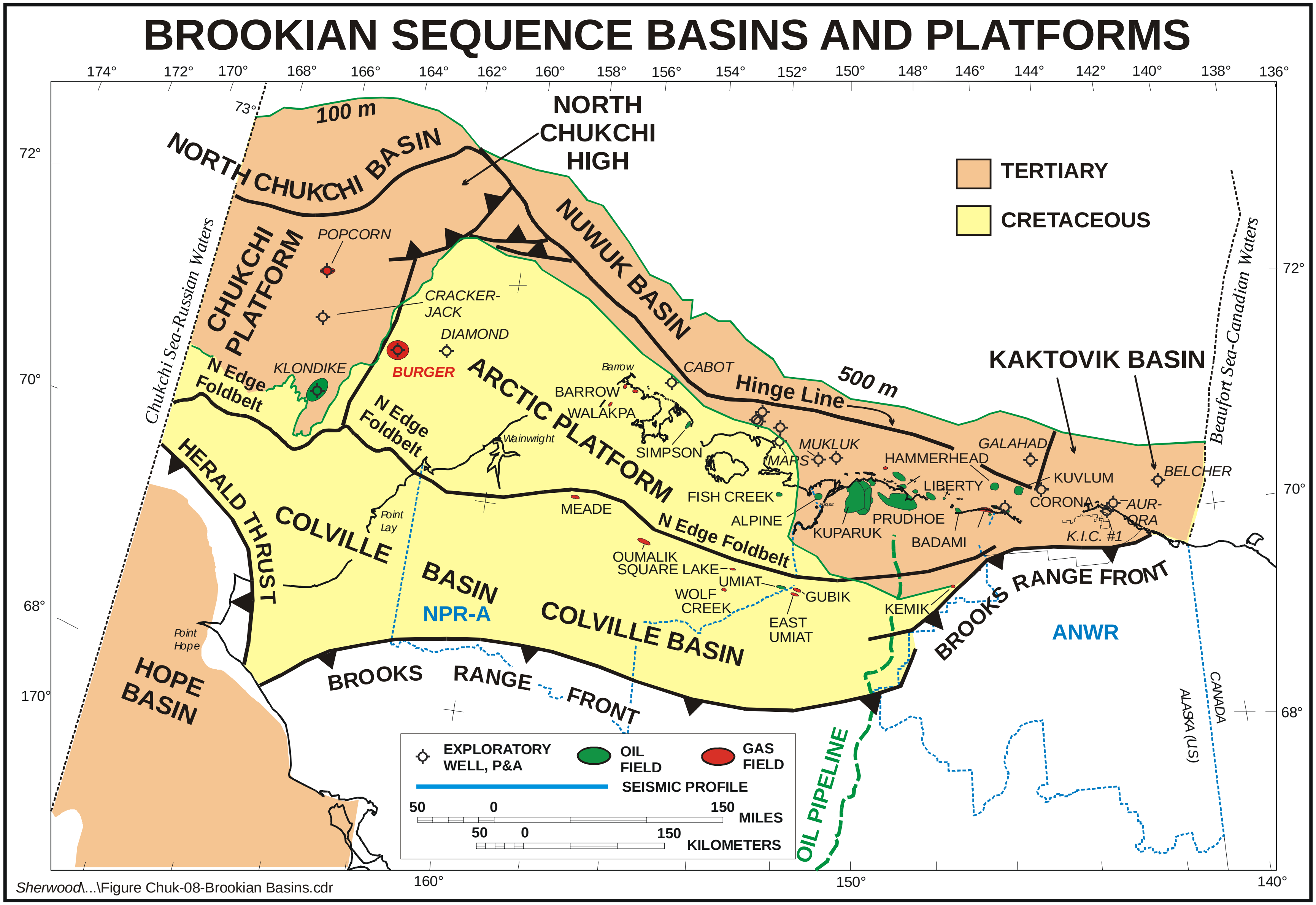

Figure 8. Brookian sequence depositional systems and tectonic setting, Arctic Alaska and Arctic offshore.

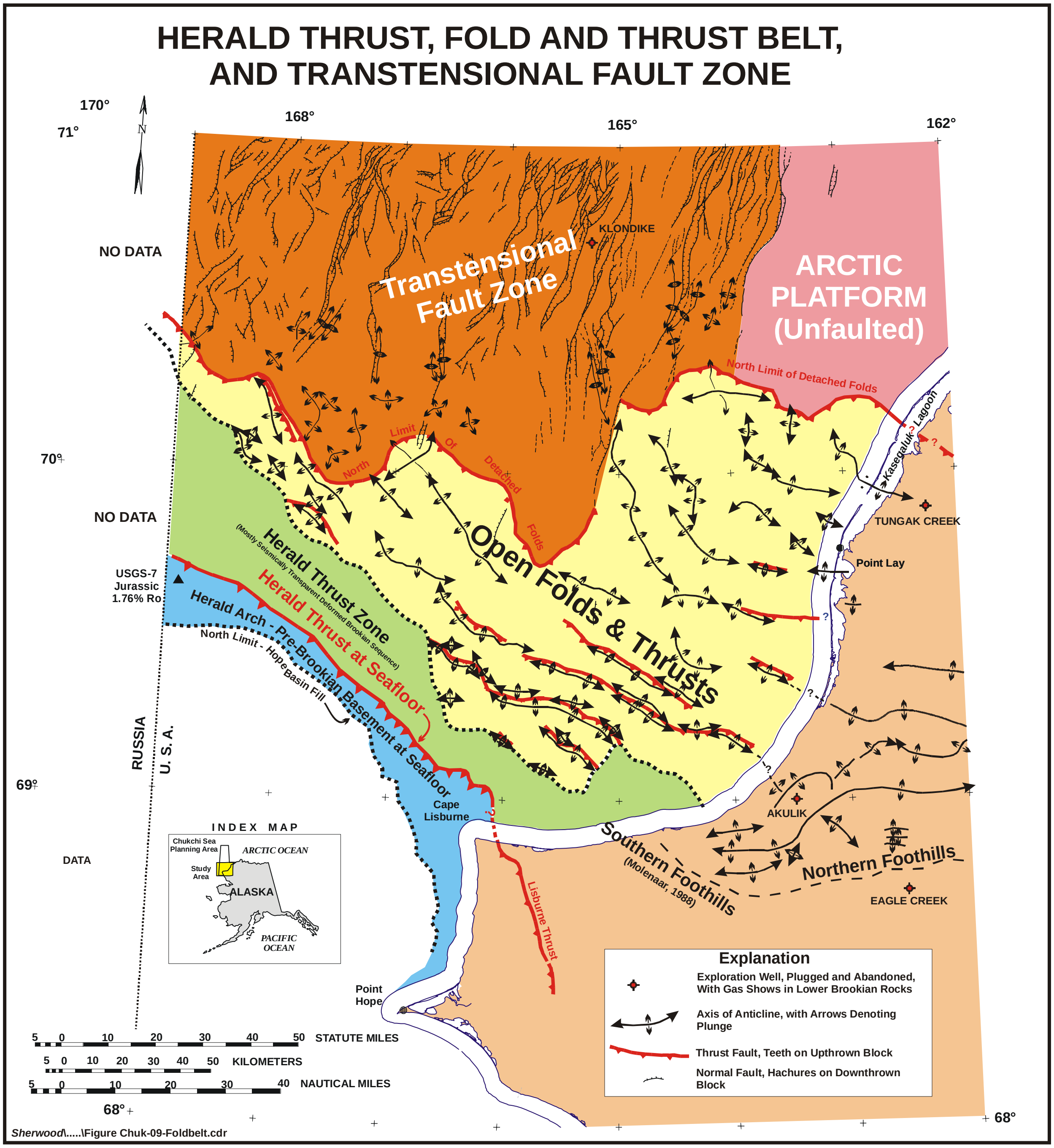

Figure 9. Map of structural provinces affecting lower Brookian sequence in southern part of Chukchi Sea Planning Area.

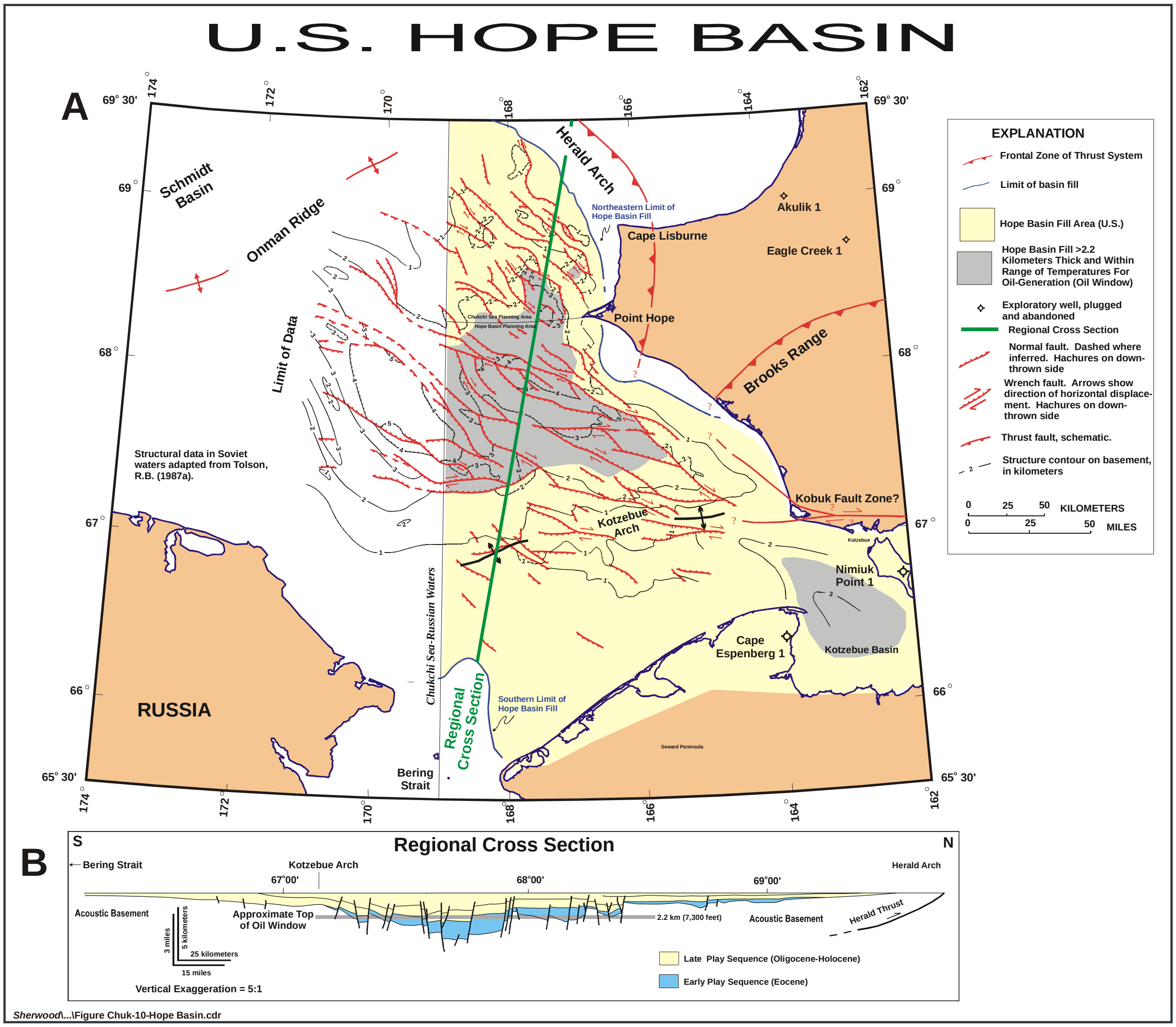

Figure 10. Map (A) and cross section (B) illustrating faulted structure of Hope basin and areas of thermally-mature basin fill.

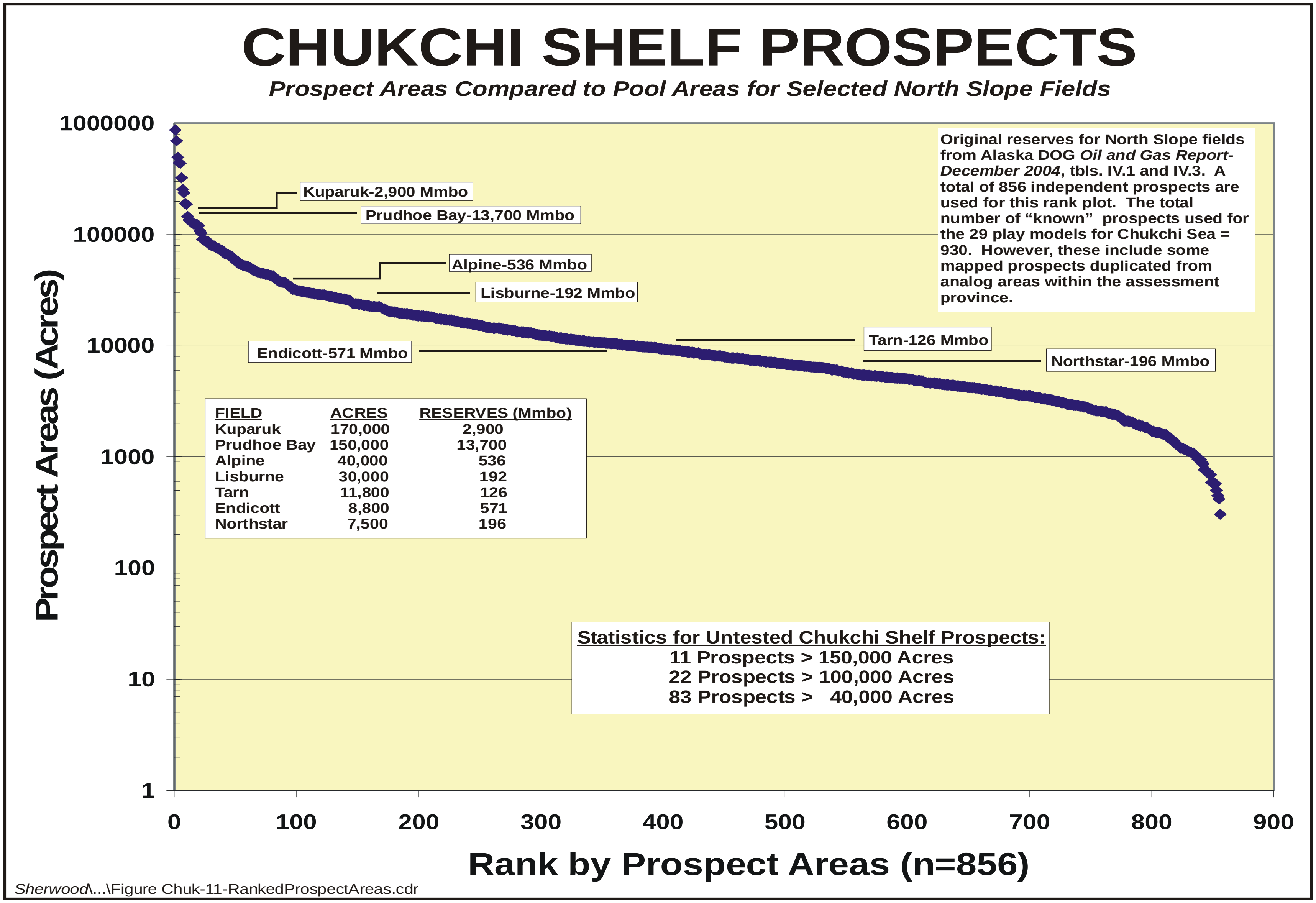

Figure 11. Rank plot for areas within closure (maximum potential productive area) of prospects mapped within Chukchi Sea Planning Area and comparison to productive areas of Prudhoe Bay and other producing fields in northern Alaska.

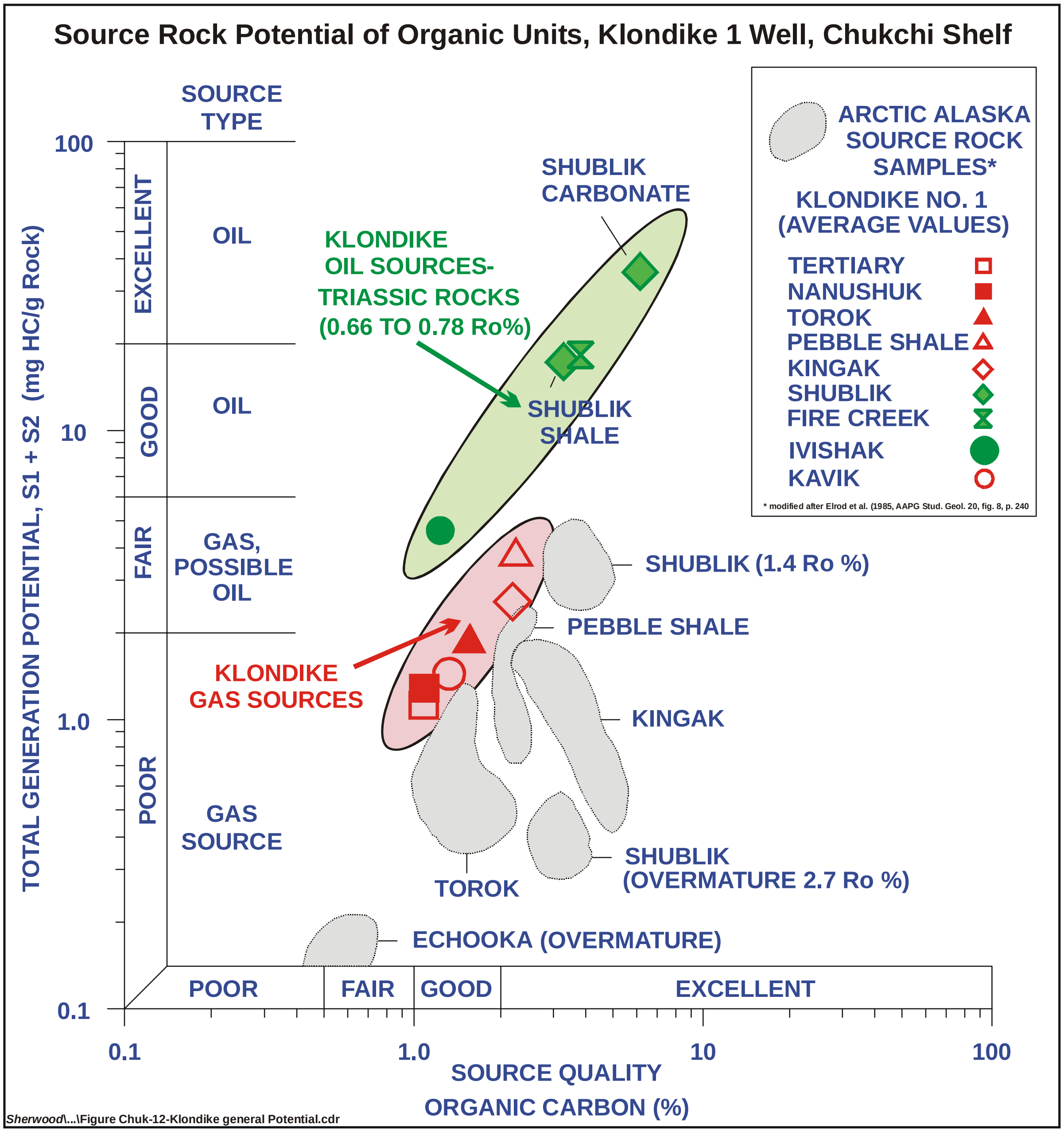

Figure 12. Crossplot for generation potential ($S_1 + S_2$) versus organic carbon content for shale sequences penetrated by Klondike 1 well on Chukchi shelf.

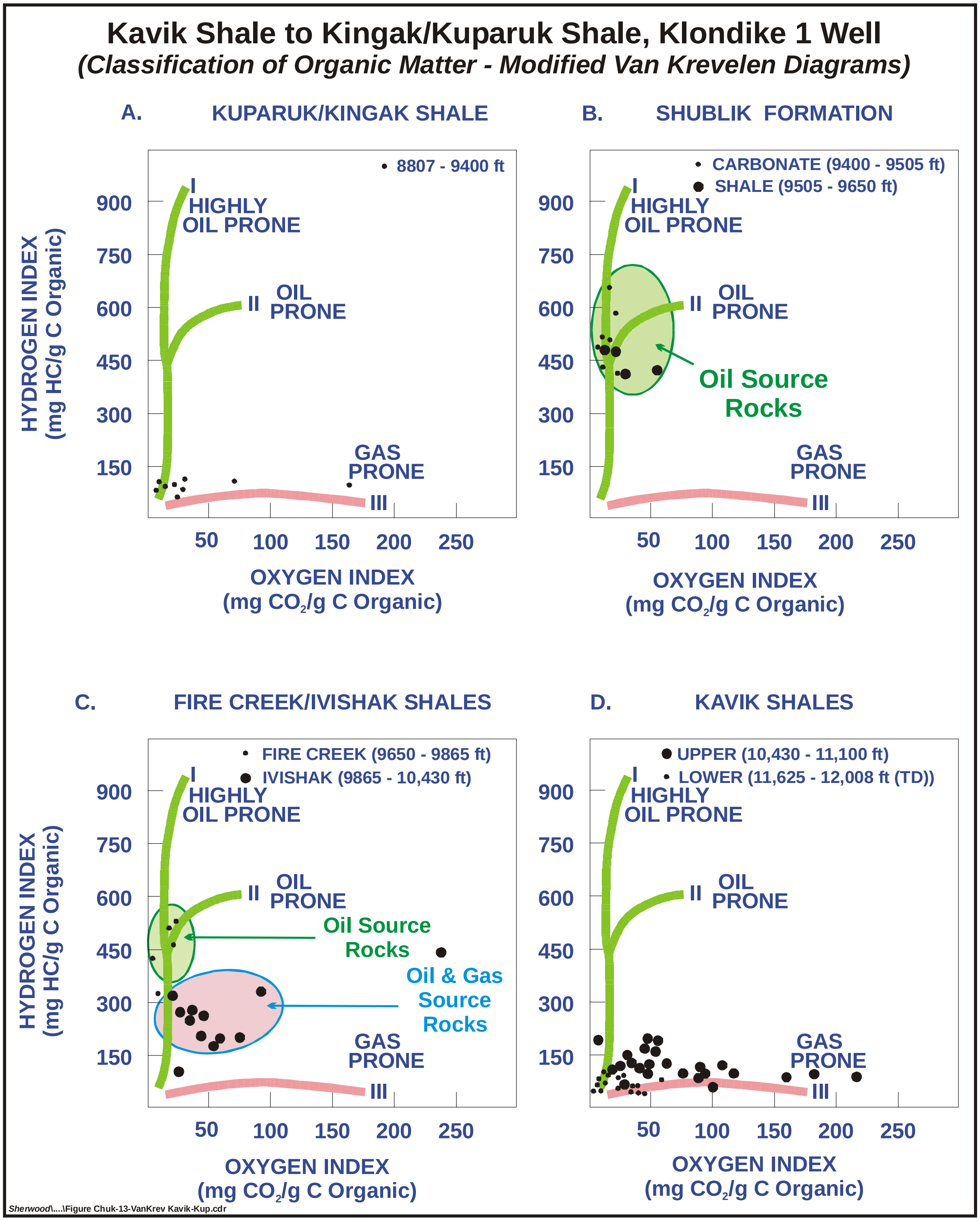

Figure 13. Modified Van Krevelen diagram for hydrogen index versus oxygen index for four oil-source sequences penetrated by Klondike 1 well (Shublik carbonate, Shublik shale, Fire Creek-equivalent shale, and Ivishak-equivalent shale). Kuparuk/Kingak and Kavik shales are gas prone.

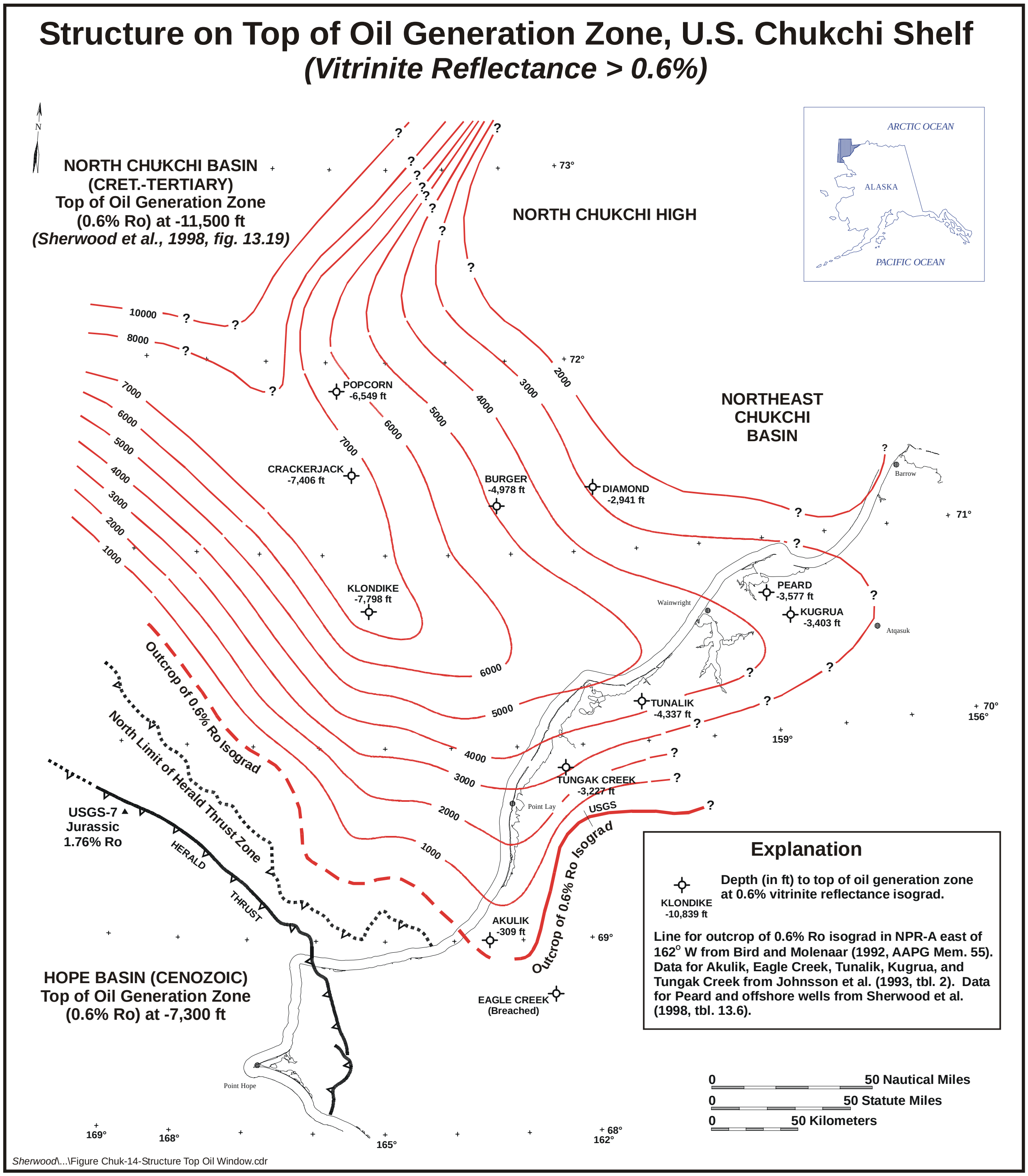

Figure 14. Structure-contour map on top of oil generation zone (0.6% vitrinite reflectance), Chukchi shelf.

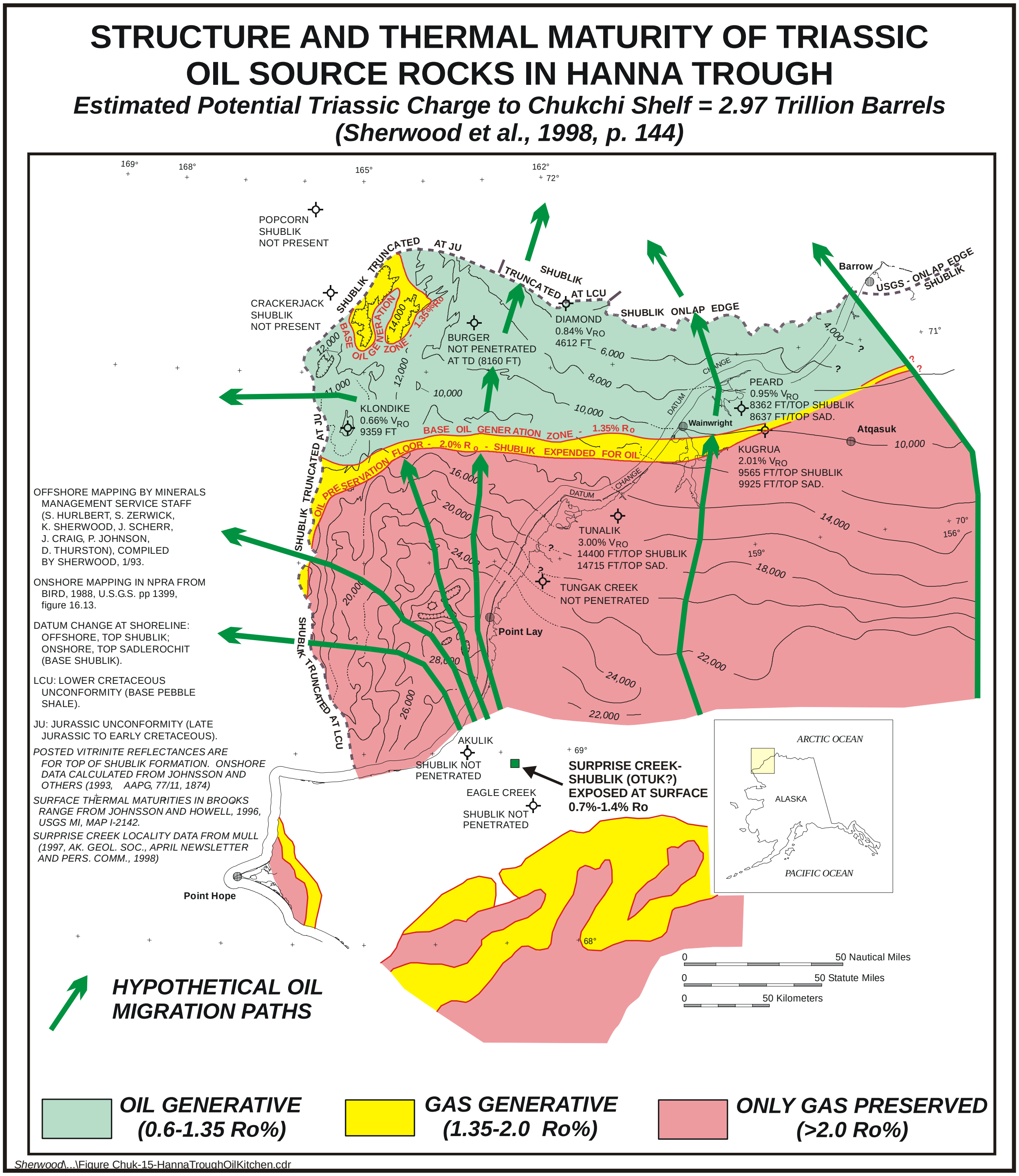

Figure 15. Structure map on top of Shublik Formation (Triassic) with zones of thermal maturity (oil-generative versus oil-expended) for Triassic oil source rocks based on vitrinite reflectance mapping.

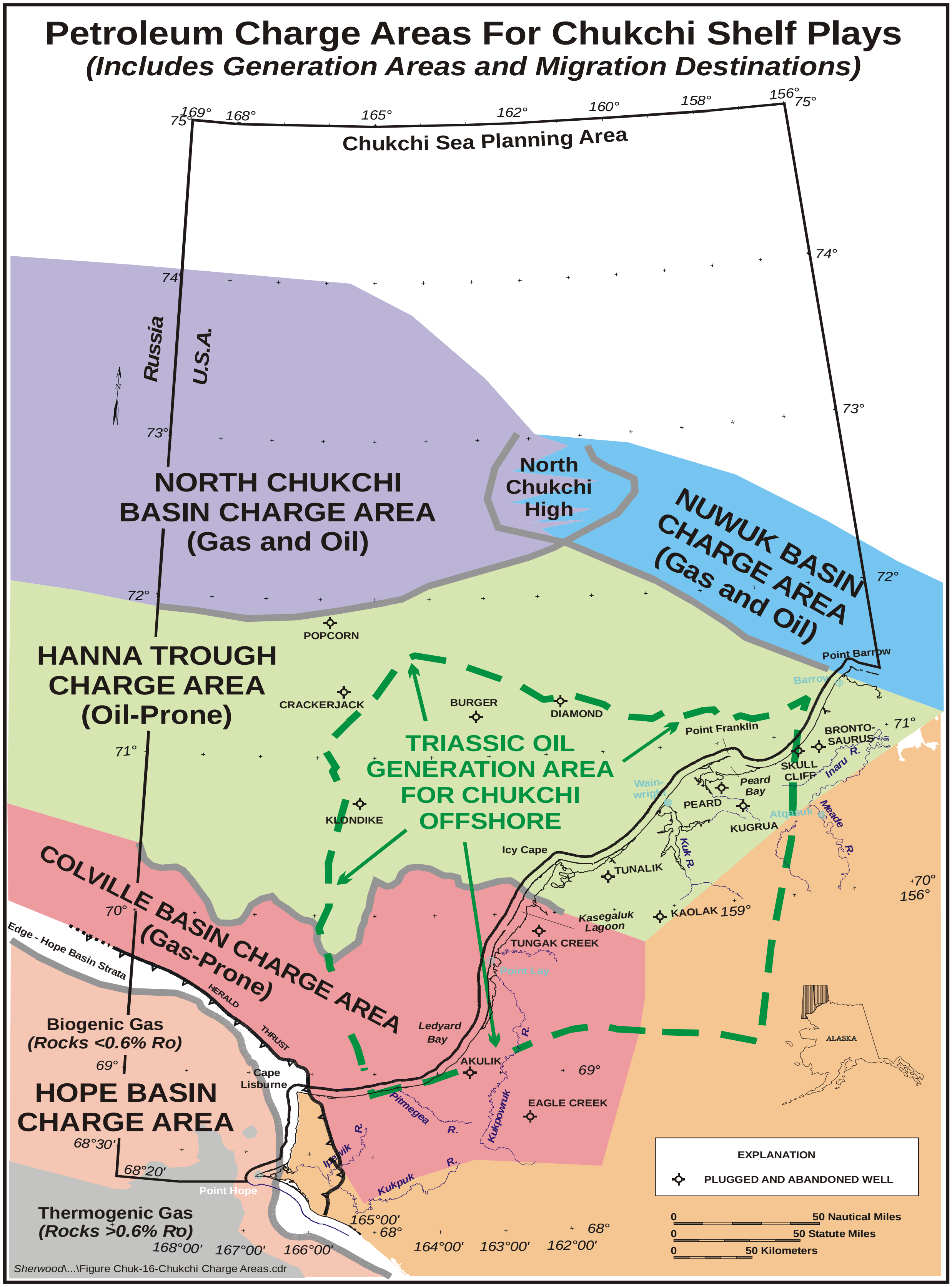

Figure 16. Map of petroleum charge areas used to model Chukchi shelf plays in 2006 assessment.

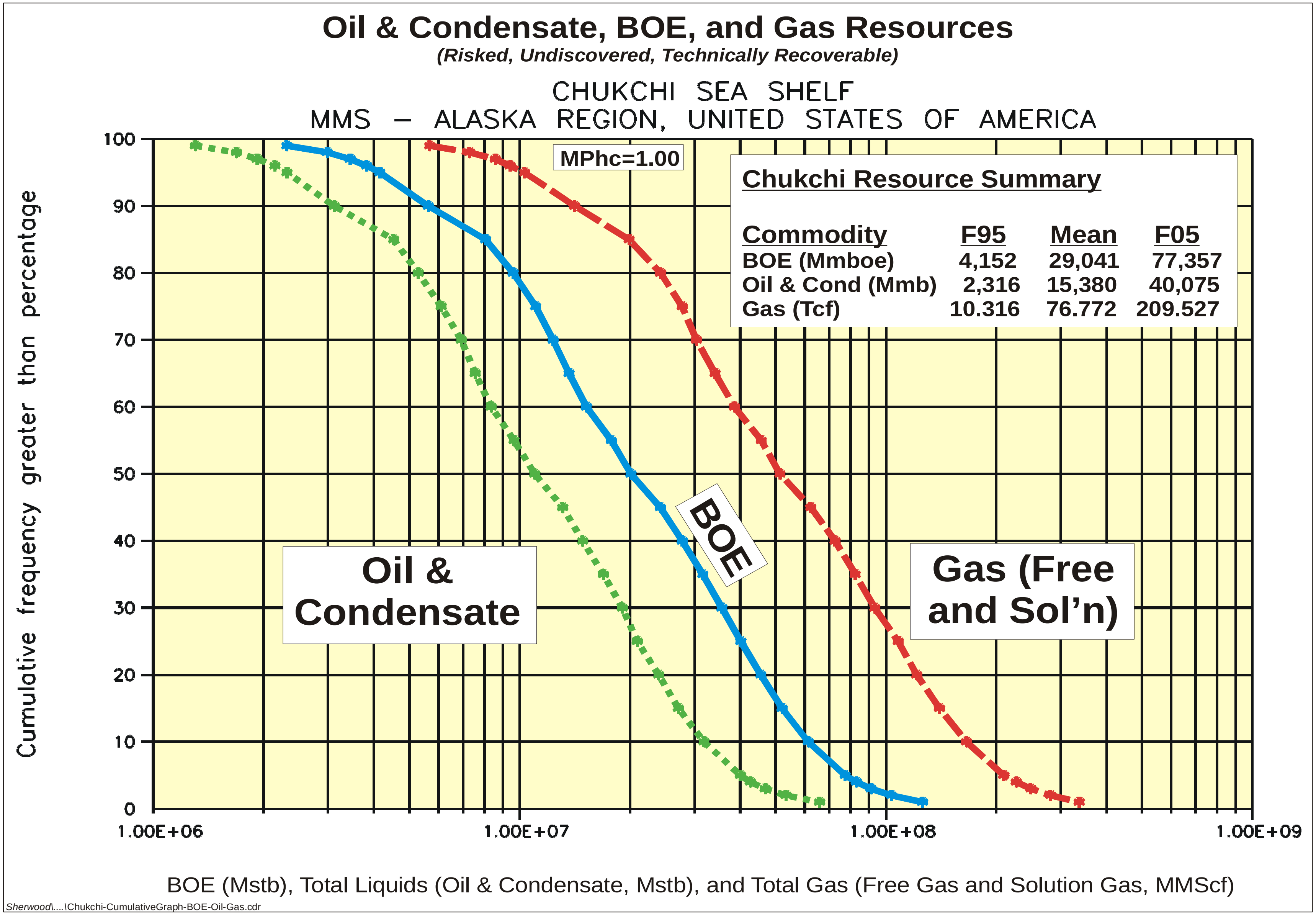

Figure 17. Cumulative probability plot for undiscovered, technically recoverable oil and gas resources for Chukchi Sea Planning Area, 2006 assessment.