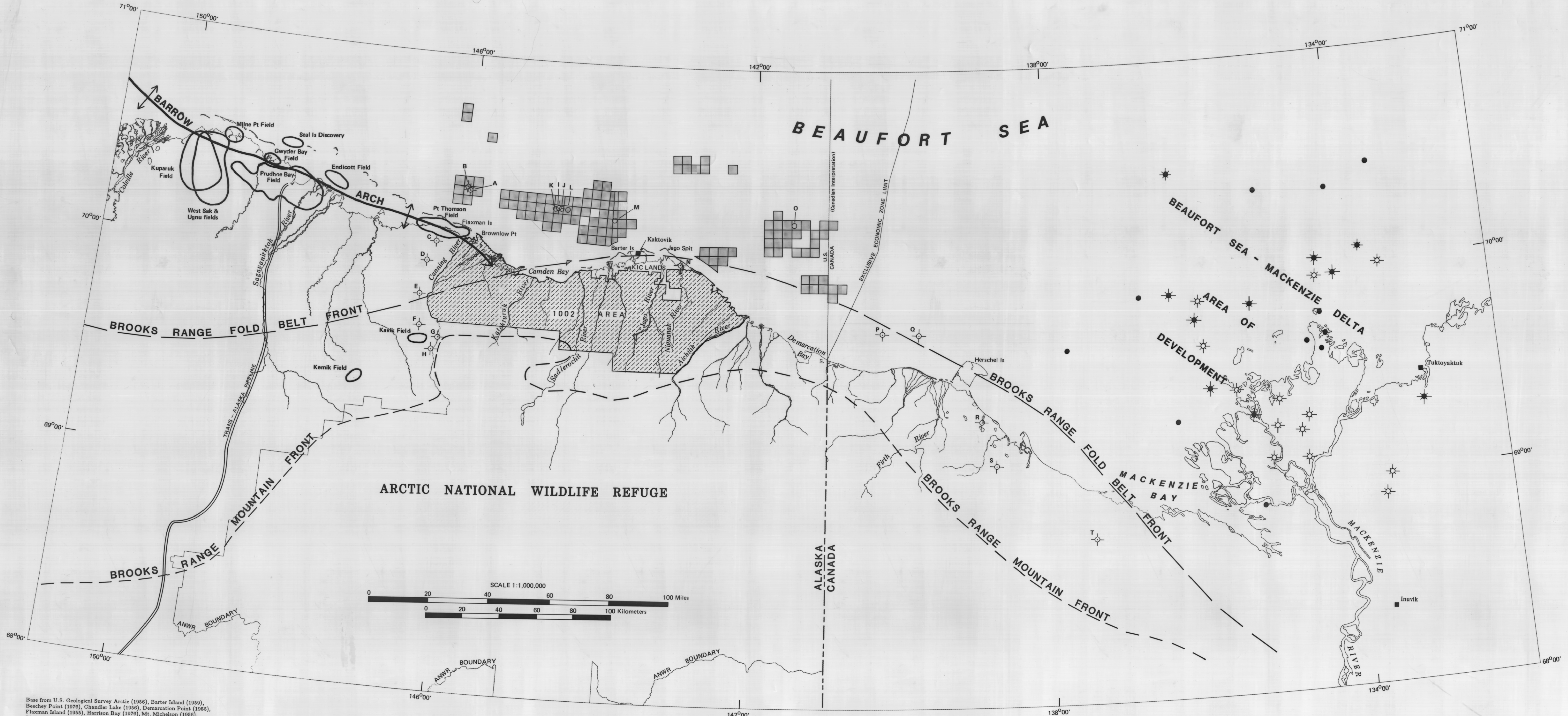




Base from U.S. Geological Survey Arctic (1966), Barter Island (1959), Beechey Point (1970), Chaudier Lake (1966), Demarcation Point (1966), Flaxman Island (1966), Harrison Bay (1970), Mt. Michel (1966), Phillips Smith Mountains (1970), Suprenant (1970), Table Mountain (1966), and Umlin (1966) Quadrangles, Alaska, and Canada Department of Energy, Mines and Resources, Survey and Mapping Branch, Thomson River (1975) Quadrangle, Canada, 1:1,000,000 International Map of the World.

INTRODUCTION

This is a non-technical report utilizing nonconfidential data to show that the coastal plain of the Arctic National Wildlife Refuge (ANWR) has high potential for containing large deposits of oil and gas.

Geographical Location

ANWR lies in the northeastern corner of Alaska and is bounded by Canada on the east, the Canning River on the west and the Beaufort Sea on the north. Its 10 million acres of land range from coastal-plain tundra remaining relatively flat coastal plain extends 15 to 50 mi inland from the Beaufort Sea. Approximately 1.5 million acres of this area -- the 1002 area -- may be opened to leasing and drilling.

History of ANWR

1960 Arctic National Wildlife Range (8.9 million acres) was established.

1980 Arctic National Wildlife Range was redesignated refuge status under the Alaska National Interest Lands Conservation Act (ANILCA); site was increased to 10 million acres.

1987 U.S. Department of the Interior reports its findings to the U.S. Congress concerning the oil and gas potential of the 1002 area along with its recommendations regarding leasing. Congress will decide whether to allow oil and gas exploration in this area.

Alaska Interest

If the 1002 area is made available for oil exploration under federal law, the State of Alaska currently would receive a 90 percent statutory share of all royalties, bonuses, and rentals derived from oil and gas leasing. The submerged lands within 3 mi of the coastal plain and the barrier islands belong to the State. Oil and gas lease sales 50 (Canning Bay) and 55 (Demarcation Point) are scheduled for this area during June 1987 and June 1988, respectively. Ownership of the 1002 area is in litigation between the state and federal governments and will be decided by the U.S. Supreme Court.

Native Corporation Interest

The Makovik Inupiat Corporation (KIC) and the Arctic Slope Regional Corporation (ASRC) own the rights for 110,000 acres of the coastal plain. The subsurface rights were conveyed to ASRC by the U.S. Department of the Interior in exchange for land in the Arctic National Park. The State of Alaska is no longer entitled to the 90 percent revenue share for these Native Corporation Lands, nor would the State land exchanges in the ANWR coastal plain for which federal title is relinquished in the future. Further action on the ANWR coastal plain between the U.S. Department of the Interior and various Native Corporations are being planned.

Data Available

Geologists and geophysicists in the Alaska Division of Mining and Geological and Geophysical Surveys have conducted subsurface and surface studies in and adjacent to ANWR. The database for these studies includes the following:

- Surface outcrop studies consisting of stratigraphic, structural, rock-property, age, geothermal, and lithologic analyses.
- Exploratory well information including logs, tests, and sample analyses for geochemistry, age, lithology, and rock properties.
- Seismic and gravity surveys.

The State is planning to conduct additional field studies for the 1987 and 1988 field seasons. New data will be integrated as they become available. Critical data not available to the State include seismic surveys and exploratory well data on KIC lands.

Gravity and aeromagnetic data in and adjacent to ANWR are the only nonconfidential geological data available for release. These data were collected by the U.S. Geological Survey and several universities. State geophysicists have interpreted the gravity data to determine the regional basement.

The U.S. Geological Survey reprocessed a portion of the 1300 mi of proprietary seismic data collected by drill report on ANWR (Patton and Christiansen, 1986), but the seismic data are not yet available to the general public.

HYDROCARBON FORMATION AND ACCUMULATION

The existence of hydrocarbons in ANWR has been known since the early 1900s when early explorers, including Leffingwell in 1910, found oil seeps and oil-stained sandstones at the surface. More recently, State geologic field parties sampled seeps and documented oil staining in the Ivishak Formation in the Sadlerochit Mountains (Robinson and others, 1986) and in the Kakulik Formation along Leffingwell Ridge. Upper Cretaceous and Tertiary oil-stained sandstones are found near the Kakulik River, and only sediments crop out near the Jago River. Whether or not there are economic accumulations of oil and gas under the ANWR coastal plain depends on the presence of certain types of rocks and on subsurface conditions that allow the generation, movement, and accumulation of these hydrocarbons.

Source Rocks

Source rocks are formed when organic materials, both animal and vegetable matter, are concentrated in sediments in an oxygen-free environment, usually in an enclosed area having no drainage outlet (a closed basin). These sediments must be buried and subjected to heat and pressure for the generation of the source rocks. Sampling indicates good to excellent source rocks crop out in ANWR (Lytle and others, 1980) and ongoing Cretaceous and Lower Tertiary units (the Hushe and Canning Formations of Patton and Christiansen, 1986) may be potential oil and gas source rocks (Patton and Christiansen, 1986). According to Patton and Christiansen (1986), the maturity threshold for oil in the depth below which oil can be generated from source rocks in this region is reported to be about 12,000 feet. The generation of oil has occurred in the past, as evidenced by the sedimentary basins in and adjacent to ANWR, exceed this threshold depth, as Point Thomson, Flaxman Island, Kemik, and Kavik fields.

Reservoir Rocks

Any rocks in the subsurface that have significant interconnected pore spaces or voids can be considered as potential reservoir rocks. Hydrocarbons migrate (flow) from source rocks into reservoir rocks. Rocks in ANWR range from Precambrian (over 570 million yrs) to Quaternary (less than 2 million yrs) in age. The most promising reservoir rocks overlie the folded pre-Mississippian rocks and consist of Mississippian to Tertiary limestones, dolomites, and sandstones, many of which are oil-bearing. The Arctic Slope of Canada and Alaska. Several producing formations in the Prudhoe Bay and adjacent areas, namely the Liaburne Group, Ivishak Formation, and the Kakulik Formation are found within ANWR.

Structural and Stratigraphic Traps

Large traps in which hydrocarbons can accumulate with an overlying seal that prevents their escape are required to form significant reservoirs. A structural trap is the result of folding, faulting, or other deformation; a stratigraphic trap is the result of changes in lithology (rock type). According to Patton and Christiansen (1986), 35 structural traps are mapped on the coastal plain. They consist of given a 20 percent probability of economically recoverable resources being present, two prospects have a 5 percent chance of containing resources equivalent to those found at other prospects could exist some of the other large fields found in North America. Except for the northwest quadrant of the ANWR coastal plain, the subsurface structure is complexly faulted and folded. This contrasts to the simple structure that underlies the coastal plain west of ANWR, in the Prudhoe Bay area. Geophysical observations of the complexity of the coastal plain are supported by field observations of steeply dipping beds in the Marsh Creek structure and Nigunak River area. Stratigraphic traps could also occur in ANWR; none have been defined because of the complexity of the subsurface.

Timing

The final key ingredient for the accumulation of large reservoirs of hydrocarbons is favorable timing that allows migrating oil to be trapped. The folding, faulting, and lithologic changes that form traps in reservoir basins must occur prior to or concurrent with the expulsion of hydrocarbons from source beds and their migration into reservoir rocks. The primary source rock in ANWR, the Lower Cretaceous Hushe Shale, occurs at various burial depths and sedimentation stages (Patton and Christiansen, 1986), so it appears likely that the oil generation stage was long enough to charge both early and late formed traps.

REGIONAL GEOLOGIC FEATURES

Barrow Arch

The Barrow Arch is a major subsurface feature that trends parallel to the present coastline from Barrow to Point Thomson and projects into ANWR. This arch is an important structural feature in controlling the Bay and the Point Thomson fields lie along the top of the Barrow Arch. The seal island discovery lies just to the north of the arch.

Brooks Range Fold Belt

This belt of disturbed rocks extends through the ANWR coastal plain into the Beaufort Sea; in outcrop it is distinguished by steeply dipping and folded beds. These folds can form the traps into which oil and gas may accumulate.

Camden and Demarcation Basins

The Camden Basin, identified by gravity data (Kosowski and others, 1978), lies west of Barter Island under age, and consists of deep to shallow marine deposits (Craig and others, 1982) that are at least 20,000 ft thick. A pre-Mississippian cycle is defined as the base of the Camden Basin. The Demarcation Basin, also identified by gravity data (Kosowski and others, 1978), lies southeast of Barter Island under (advance and retreat of the sea over land areas) analogous to the Mackenzie Delta region of Canada (Craig and others, 1982). The Tertiary fill of this basin also probably exceeds 20,000 ft.

Basement Highs

Gravity data (Kosowski and others, 1978) reveal two primary areas of anomalous basement highs. The Nigunak High is centered southeast of Barter Island. This arch is an important structural feature in controlling the Bay and the Point Thomson fields lie along the top of the Barrow Arch. The seal island discovery lies just to the north of the arch.

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HYDROCARBON ESTIMATES

Two independent assessments of the potential hydrocarbon resources beneath the ANWR coastal plain were recently released. These assessments give the probability distributions for the amount of oil and gas present in the ANWR coastal plain, summarized as follows:

State of Alaska (Hansen and Kornbrath, 1986)

Probability Level	Oil (BBO)	Gas (TCF)
95%	0.08	2.74
75%	1.28	0.71
50%	3.77	8.64
25%	13.15	17.77
10%	25.52	43.62
Average	7.22	13.69

U.S. Department of the Interior (Patton and Christiansen, 1986)

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50%	3.77	8.64
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For comparison, proven in-place reserves around Prudhoe Bay are nearly 60 billion barrels of oil (BBO) and 45 trillion cubic feet (TCF) of gas (Patton and Christiansen, 1986). Estimates from the Canadian Beaufort-Mackenzie Delta area are 18.6 BBO and 145 TCF of gas (Procter, et al, 1985).

EXPLORATION

On August 22, 1984 the U.S. Department of the Interior Minerals Management Service held Outer Continental Shelf (OCS) Lease Sale 87, which consisted of 1477 blocks covering 7.8 million acres in the Beaufort Sea. The sale area included acreage from offshore Dease Inlet (southeast of Barrow, Alaska) to the Beaufort Economic Zone Limit that separates U.S. waters from Canadian waters. The oil industry spent \$877 million for the right to explore for and produce hydrocarbons that may be located beneath these blocks. Of this indication of the considerable segment as to the high potential for hydrocarbon accumulations in the area.

Three wells were drilled in the federal OCS offshore ANWR since this sale, and a number of wells will be permitted for this area. The information from these offshore wells is being held confidential and has not been permitted for this area. The information from the offshore Jago River #1 (KIC) well is also confidential, and may remain so indefinitely, because it is situated on private (Do) lands.

SUMMARY

The ANWR coastal plain, situated between the oil- and gas-rich Canadian Beaufort Sea-Mackenzie Delta province to the east and the Prudhoe Bay, Kuparuk and Point Thomson field complex to the west, is considered to have very high oil and gas resource potential (Hansen and Kornbrath, 1986; Patton and Christiansen, 1986). The coastal plain is on trend with regional structural and stratigraphic elements that have yielded giant oil and gas fields, has documented occurrences of oil seeps and oil-stained rocks, and lies adjacent to the Beaufort Sea where industry has acquired very expensive leases and is actively drilling. ANWR has all the key geologic ingredients necessary to become a major petroleum province.

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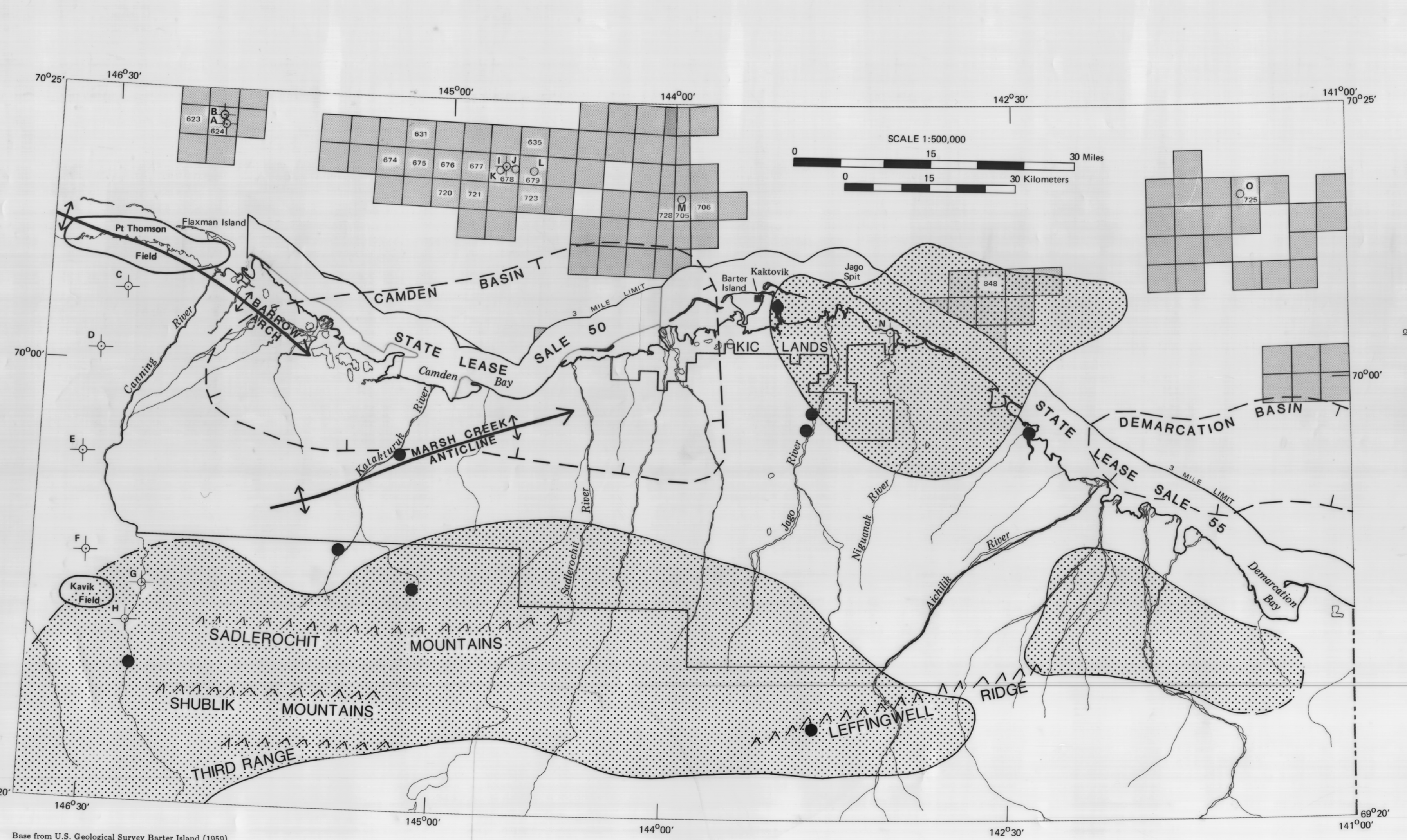
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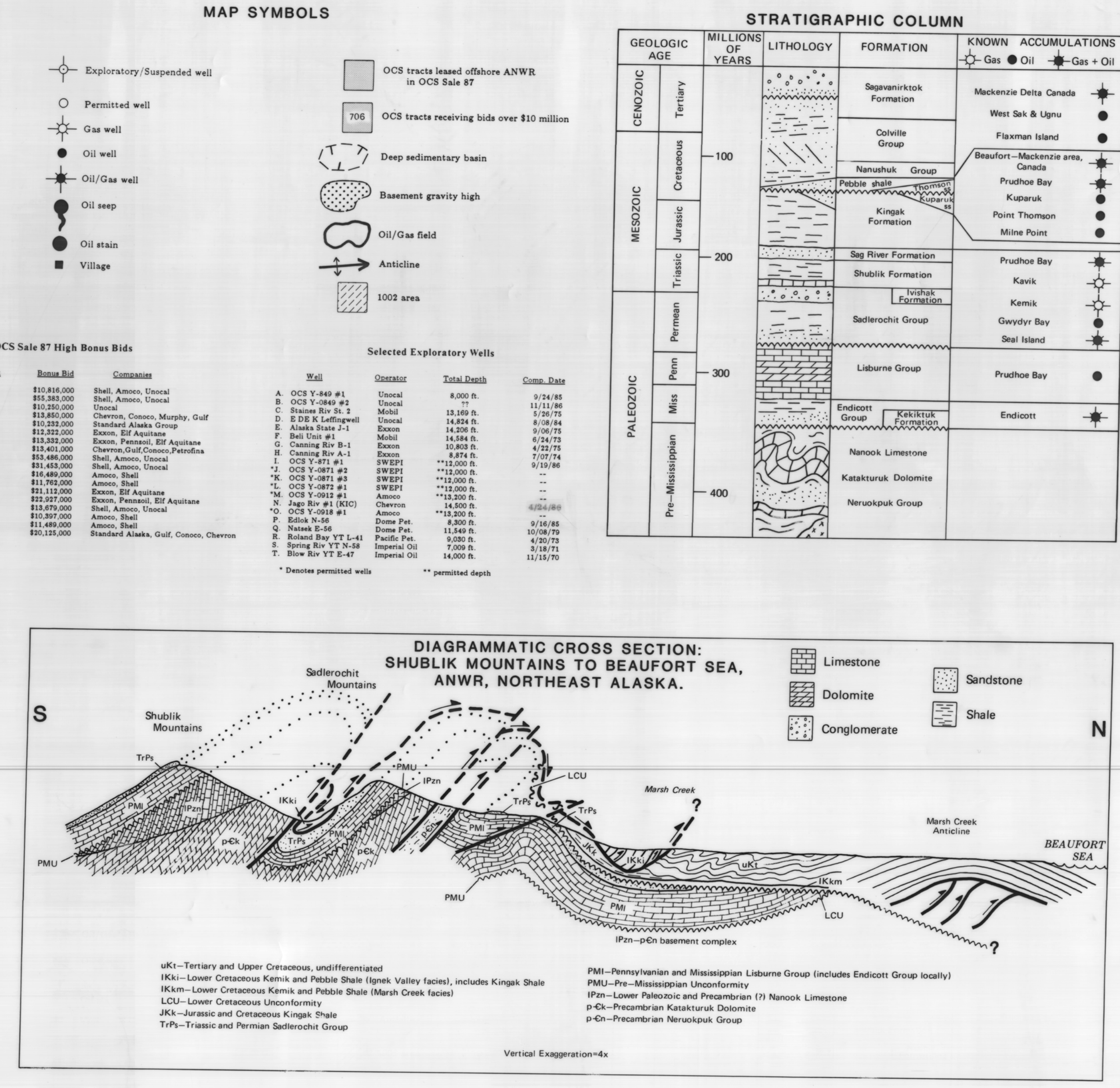
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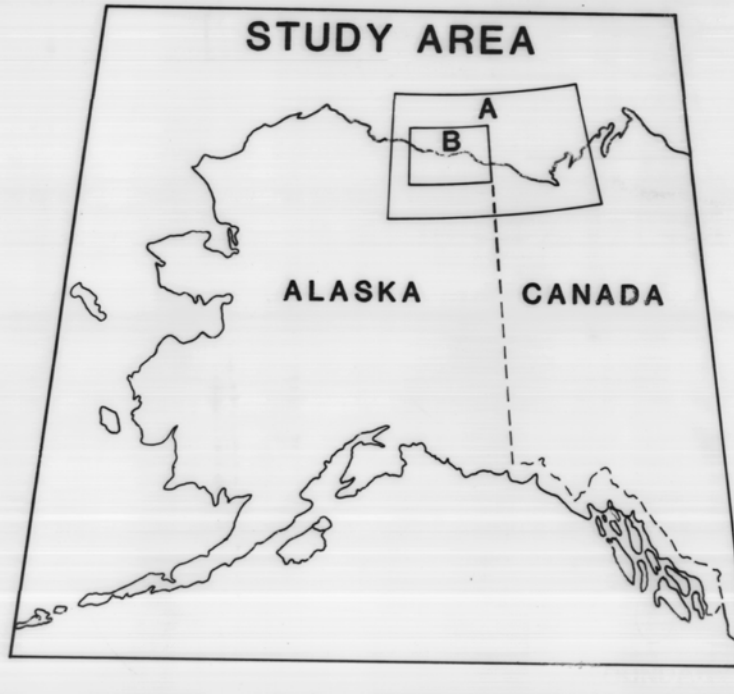
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Base from U.S. Geological Survey Barter Island (1959), Demarcation Point (1966), Flaxman Island (1966), and Mt. Michel (1966) Quadrangles, Alaska.



This report is a preliminary publication of DMGOS. The authors are solely responsible for its content and will appreciate candid comments on the accuracy of the data as well as suggestions to improve the report.



OVERVIEW OF THE HYDROCARBON POTENTIAL OF THE ARCTIC NATIONAL WILDLIFE REFUGE COASTAL PLAIN, ALASKA

J.J. Hansen, R.W. Kornbrath, J.F. Meyer, M.S. Robinson, T.N. Smith